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Design and Simulation of a Mechanical Hand

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By

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A Thesis Submitted in Partial Fulfillment of the Requirement for Master of Science in
Mechanical Engineering

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i

Abstract

A variety of mechanical hand designs have been developed in the past few decades. The majority of the designs were made with the sole purpose of imitating the human hand and its capabilities; however, none of these designs have been equipped with all the motions and sensory capabilities of the human hand. The primary goal of this thesis project was to design a robotic hand with the required amount of degrees-of-freedom and necessary constraints to achieve all the motions of the human hand. Demonstration of the American Sign Language (ASL) alphabet, using a virtual design and controls platform, was used as a means of proving the dexterity of the designed hand.

The objectives of the thesis were accomplished using a combination of computerized 3-D modeling, kinematic modeling, and LabView programming. A mechanical hand model was designed using SolidWorks. Actuation methods were incorporated into the design based on the structure of the connecting tendons in the human hand. To analyze the motions of the mechanical hand model, finger assemblies were manufactured at two different scales (full and ¼ size) using rapid prototyping. These finger assemblies were used to study the developed forces within the joints prone to failure when subjected to actuation and spring forces. A free body diagram and an Ansys model were created to quantify the force and stress concentrations at the contact point of the pin joint in the distal interphalangeal joint, a location of failure in the rapid prototype assembly.

A complete kinematic model was then developed for the mechanical hand using the Denavit-Hartenberg principle to map all the joints of the hand and finger tips in a universal frame of reference. A program was developed using LabView and Matlab software tools to incorporate the developed kinematic model of the designed hand and plot the 3-D locations of all joints in the universal frame of reference for each letter of the ASL alphabet. The program was then interfaced with the SolidWorks hand assembly to virtually control the motions of the designed assembly and to optimize the hand motions. In summary, a mechanical human hand model and interacting software platform were developed to simulate the dexterity of a designed human hand and to implement virtual controls, based on kinematic modeling, to achieve the optimum motion patterns needed to demonstrate the ASL alphabet. The designed hand was capable of performing all the static gestures of the ASL alphabet.

Acknowledgement

Table of Content

List of Figures

List of Tables

List of Medical Terms

1. MIP :   Metacarpal Interphalangeal Joint
2. PIP :   Proximal Interphalangeal Joint
3. DIP :   Distal Interphalangeal Joint
4. Abduction: Moving away from the body.
5. Adduction: Moving towards the body.
6. Flexion: Bending the body part.
7. Extension: Stretching the body part.
8. Circumduction: Turning around.
9. Rotation: Rotating about axis.

1. Introduction

Robotics could easily be one of the most researched fields of modern technology. New inventions and innovations in the field have led to the whole new set of devices with intricate designs, a large number of degrees of freedom (DOF), pinpoint accuracy, rapid and reliable actuation and longer life span. One widely researched branch of robotics involves designing of biomimetic devices. The research in this area is driven by the clear goal of achieving design and control algorithms that will resemble those found in biological counterparts. In this research work, we are particularly interested in mimicking the motion of the human hand. The human hand is one of the most intricate mechanisms found in nature and possesses high complexity and utility. All the digits are required to act in unison to perform complex motions.

The field of "robotic hand design" has a very long and spectacular history. Earlier research was more focused upon gripping objects; hence the earlier designs are seen with less than 5 fingers. In reality, for gripping only 2 fingers and a thumb are sufficient for most applications [29]. The first published hand design was developed in 1965 by Rajho Tomovic [25, 29]. In the 1980's, the research on robotic hand development increased drastically, and is still growing rapidly. A simple 3 finger hand was developed in 1982 at Okada, but today we are seeing an almost exact replication of human hand [30]. One hand design developed by Shadow Robotics has 25 individual degrees of freedom and is actuated entirely by air muscles (Shadow, 2005) [30]. However, no construction of a robotic hand totally identical to the human hand in number and organization of joints, weight and dimensions and functionality, has been found. [29]

2. Literature Review

A significant amount of work has been done in the field of robotic hand design in the past few decades. A large amount of research has been done related to the human hand structure, its kinematics, joints, motions, angles of travels, density, volume, required forces for movement and grasping and actuation. There is also a vast amount of literature available on robotic hand design related to motion planning and control. The continuous progress of this field is pushing manufacturers to develop more dexterous devices with more degrees-of-freedom. Some of the developed robotic hands were summarized here. These robotic hands are arranged in the ascending order of their complexicity.

Da Vinci designed the first robotic arm in 1495 with four degrees of freedom and an analog on-board controller supplying power and programmability [1]. However, it wasn't until the past 50 years that the field of robotics started attracting engineers throughout the world. In 1961, Unimate developed the first industrial robotic arm that has subsequently evolved in the into PUMA arm [1].

Figure 1: de Vaucanson's flute player with details [1]
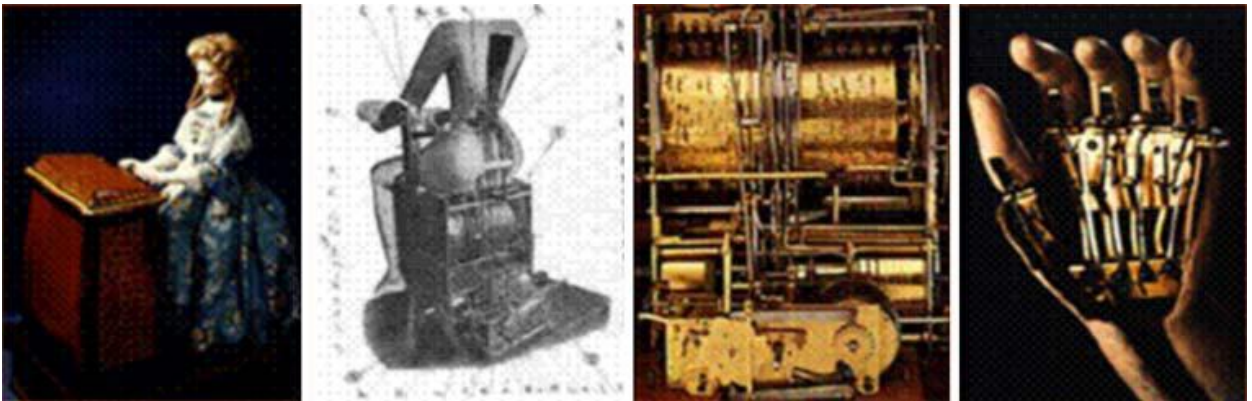
Figure 2: Jaquet-Droz's 1774 lady musician [1]
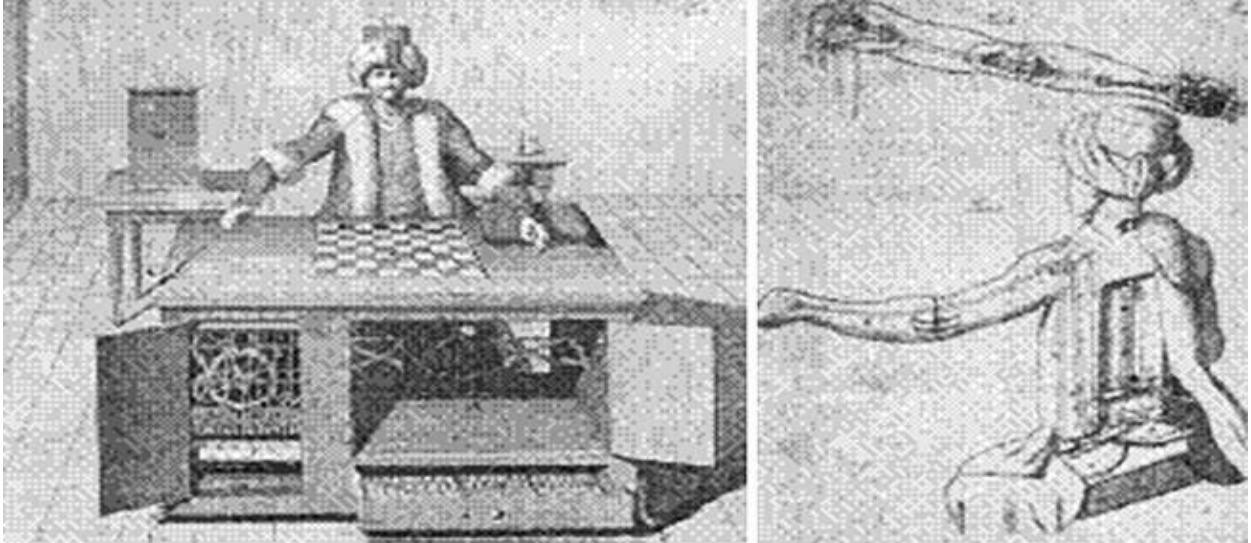
A flute player developed by de Vaucanson's is shown in the figure 1, with details of his design [1]. A musician lady developed by the Jaquet-droz's in 1774 is shown in the Figure 2. Also a chess playing turk, designed by Von Kempelen, with details of its moving left arm is shown in Figure 3. These were some earlier efforts made by the engineers to imitate the human hand motions for different dexterous applications.

Solis et al. [2] developed a Saxophonist Robot. Their aim was to develop a anthropomorphic saxophonist robot to mechanically reproduce the human organs involved during saxophone playing [2]. The robot consists of an artificial mouth with an air supply and fingering mechanisms. The Waseda Saxophonist Robot No.1 (WAS-1) was developed with 15 degrees-of-freedom. In particular, the finger assembly consisted of 11 degrees-of-freedom. A Waseda Saxophonist Robot No2 (WAS-2) was developed to increase the range of sound. The WAS-2 was developed with a total of 22 degrees-of-freedom is shown in Figure 4 and the finger assembly consisted of 16 degrees-of-freedom. The right hand had 6 DOFs and the left hand had 10 DOFs [2]. The additional information about WAS – 2 is found in Table 1.

The finger actuation mechanism on the WAS-1, found in Table 1, was developed with a link connecting directly to a RC motor axis. In order to control all the degrees-of-freedom, 11 motors were used. To reduce the weight of the actuation mechanism, WAS-2 was provided with a wire and pulley system. The finger actuating wires were connected to the RC motor through a pulley system [2]. The mechanical changes in the WAS-2 were implemented to enable it to play all the keys of the alto saxophone [2].

Simulated Organ	DOFs
Lungs	1-DOF (Air Pump)
	1-DOF (Air Valve)
Lips	3-DOFs
Tongue	1-DOFs
Fingers	16-DOFs

Table 1: System configuration of the WAS-2. [2]

a. [2]
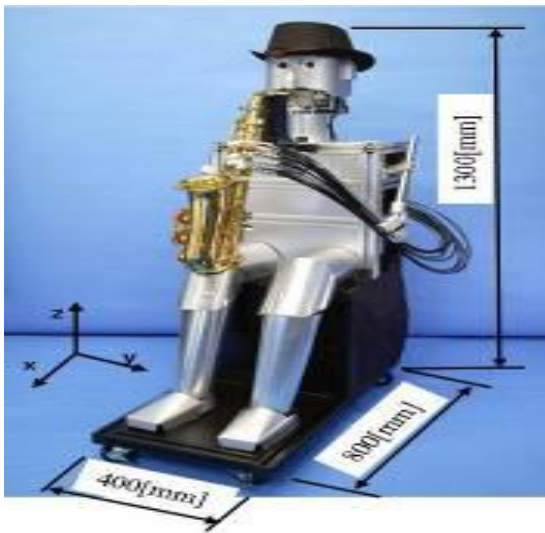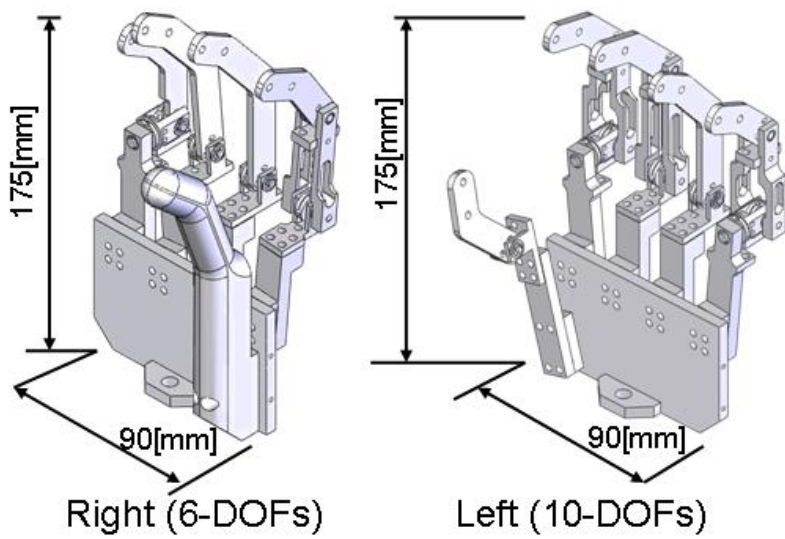
Right (6-DOFs)   Left (10-DOFs)   b [2]

Figure 4: (4a) Anthropomorphic Saxophonist Robot WAS-2, (4b) Finger mechanism for WAS-2. [2]

4

In 1985, an anthropomorphic mechanical hand was developed by the Center for Engineering Design at the University of Utah and the Artificial Intelligence Laboratory at the Massachusetts Institute of Technology (MIT) [3]. The developed hand was a four finger human size mechanism with 16 degrees-of-freedom. The three fingers and the thumb were placed anthropomorphically with the capacity to move five times faster than biological counterparts [3].

The hand consisted of 17 links and 16 joints. Pneumatic pistons were used in combination with antagonistic tendons/cables for actuation. These tendons and pistons were connected to each joint as actuators to control motions like bending and extension [3]. The motions of the hand were detected by four different types of sensors, (motor position sensor, joint position sensor, tendon tension sensor and a tactile sensor) [3]. Though the Utah/MIT Hand was able to perform various human hand motions, due to its antagonistic tendons and large amount of coupling in between finger joints, the entire assembly became complicated [3]. Despite having good capability for many human hand motions, like grasping, the Utah/MIT hand is unable to perform variety of the human hand gestures (eg. sign language application, writing, etc.). The developed Utah/MIT hand is shown in Figure (5).

Figure 5: Utah/MIT Hand [3]

NASA developed a humanoid robot "Robonaut" in 1999, to perform all the duties of an astronaut in a space environment. The "Robonaut" was equipped with the fine motion and force torque control to perform dexterous tasks needed in a space environment [3][4]. The developed hand is the same size as a suited astronaut hand.

The NASA hand was developed for space extravehicular activity (EVA) [3]. The hand consisted of a total of 14 degrees-of-freedom with five fingers and a palm and forearm assembly [3][4]. The hand design was designed for two separate sets of motions, dexterous

and grasping. The dexterous set consisted of index and middle fingers with an opposable thumb, having three degrees-of-freedom each. The grasping set consisted of ring and pinkie fingers, having one degree-of-freedom each [3][4]. All the fingers of the "Robonaut" hand were shock mounted to give it a rugged grasping option [4]. The developed hand and its details are shown in Figure 6.

Claudio et al. [5] at the University of Bologna developed a robotic hand version 2 in 1992. The robot was an effort to create an integrated manufacturing system by combining a three fingered hand with a robot arm. The robot design integrated work from various research fields such as sensors, actuators, mechanical design of hands and arms, control theory and computer science [5].

The actuation mechanism for the robot was developed with the n joints-n actuators method. All the required actuators for the hand, wrist and arm joints (DC motors and Tendons) were placed within the arm itself [5]. The hand joint actuation tendons connecting to the corresponding DC motor were routed through the wrist mechanism by means of a pulley system. Due to the motion of the wrist, varying tension was induced in these tendons. Variation in the pulley shaft position helped to compensate for the induced tension in the actuating tendons. In the UB Hand 2, induced tension compensation was achieved by a simple wrist driven cam mechanism [5].
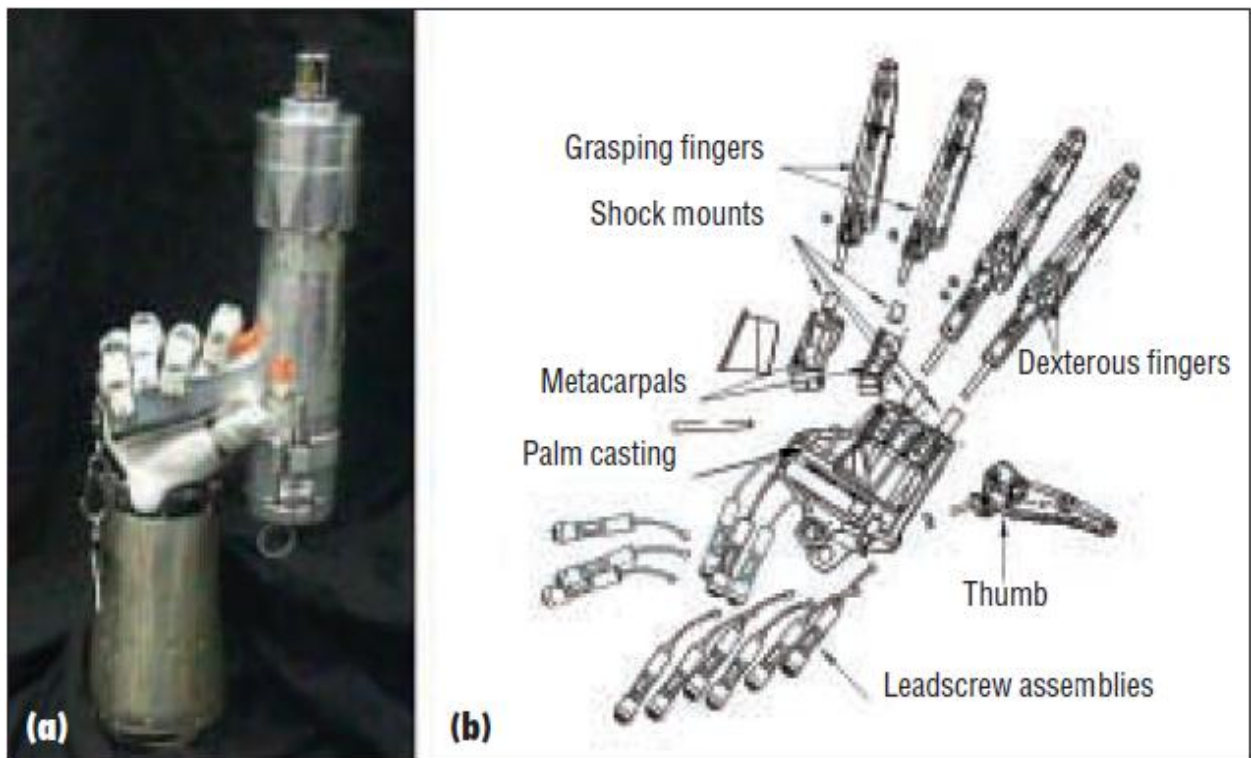
Figure 6: Robonaut Hand, (6a) Hand holding tool, (6b) Hand parts.[4]

The developed UB Hand 2 consisted of three digits (two fingers and one thumb) and a palm assembly. Each of the fingers was assembled separately with their actuator tendons routing and sheaths. Internal routing of the tendons from joint to actuator is a tedious process, but was simplified in the UB Hand 2 by grouping the actuators into two different packages that could separately mounted on the arm [5].

A new advanced sensory data acquisition subsystem was designed for the robot, to support amplification and conversion of signals [5]. With 12 Hall Effect sensors and 13 incremental encoders present in a hand/wrist system, the hand has a total of 72 signals needed to be acquired at every sampling period [5]. The motion delay introduced between the motor shaft and joint motion, due to the designed actuation system was reduced by implementing a new discontinuous control technique based on sliding mode regulator with an additional switching integral action [5]. This method reduced the chattering phenomenon introduced by the binary control system [5]. The developed UB hand with its actuators is shown in Figure (7).
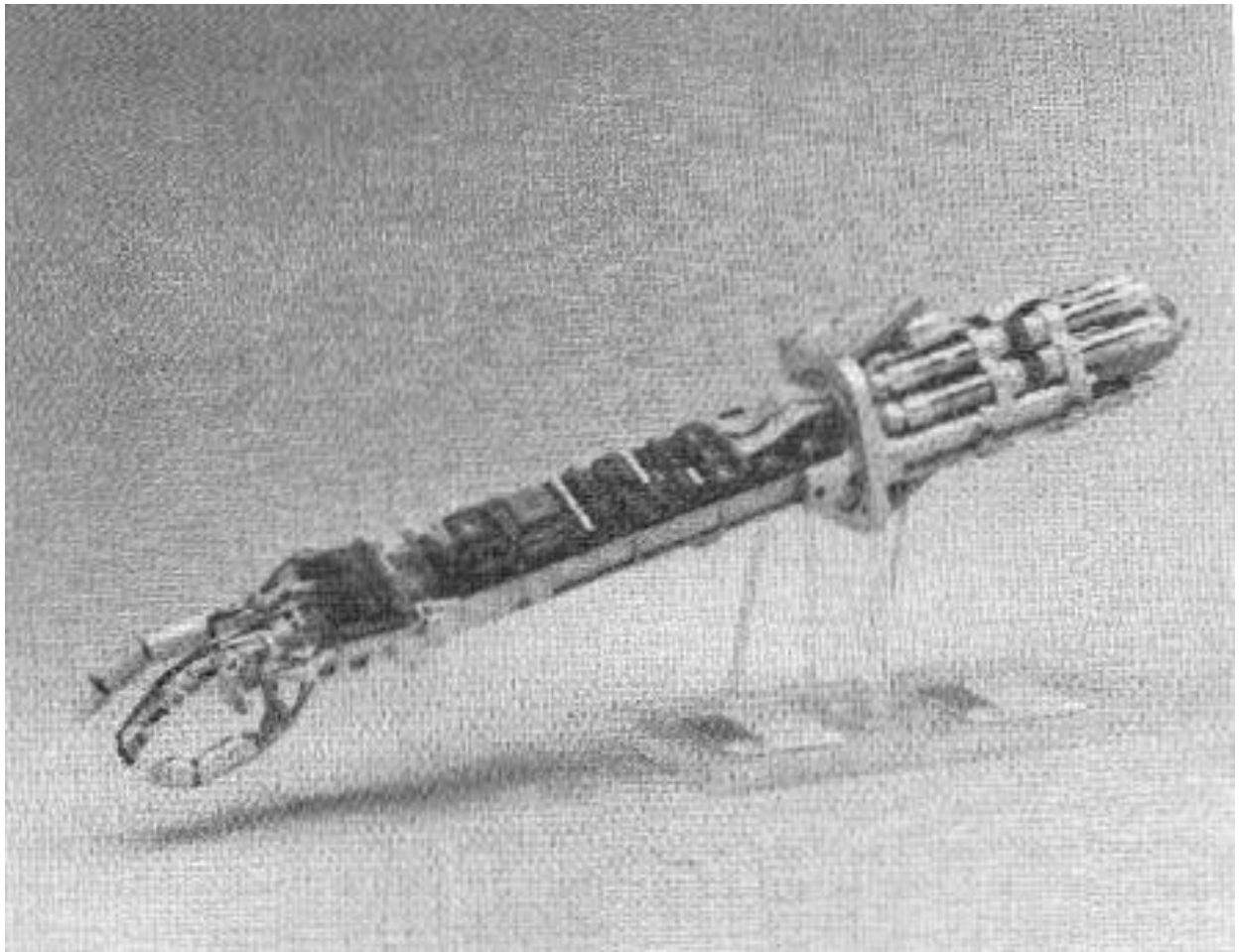
Figure 7: UB Hand 2 [5]

One of the greatest challenges in robotic hand design is space constraints. To developing a hand that is capable of all the functions of its biological counterpart, with equal or lesser weight and size, is the biggest problem engineers are facing today. Kevin et al. [6], developed a new hand to achieve a solution for the previously described problems. The hand by Kevin et al [6] is capable of 12 degrees-of-freedom. The hand consists of four fingers, a palm module, and a wrist joint.

For the actuation of the given finger joints, shape memory alloy bundles were used in combination with a spring assembly. This new approach reduced the bulkiness and noise caused by traditional electromechanical actuators. The design is based on a modular approach, with an emphasis on ease of assembly and ease of replacement of the SMA wires [6]. Figure (8a) shows the complete mechanical assembly of the hand by Kevin et al. [6].

Unlike previous designs, the finger joint actuation mechanism is mounted within the palmer module. Each finger has three joints, a metacarpophalangeal joint (MIP), a proximal interphalangeal joint (PIP) and distal interphalangeal joint (DIP).The lengths of the individual phalanx are consistent with those of average adult human hand fingers [6]. A pulley system with a combination of fixed and passive pulleys is used at every joint to route the actuating tendon wires and to provide increased rotational motion at the joints.

A mechanical dead stop was designed to restrict the motion of the MP joint at 80°, which is the angular motion capacity of the human hand. Similarly at the PIP and DIP joints, a mechanical stop was provided to restrict their motion to a 90° angle [6]. Figure (8b) and figure (8c) show the Index finger assembly and the pulley system used in the design [6].

(a)

(b)
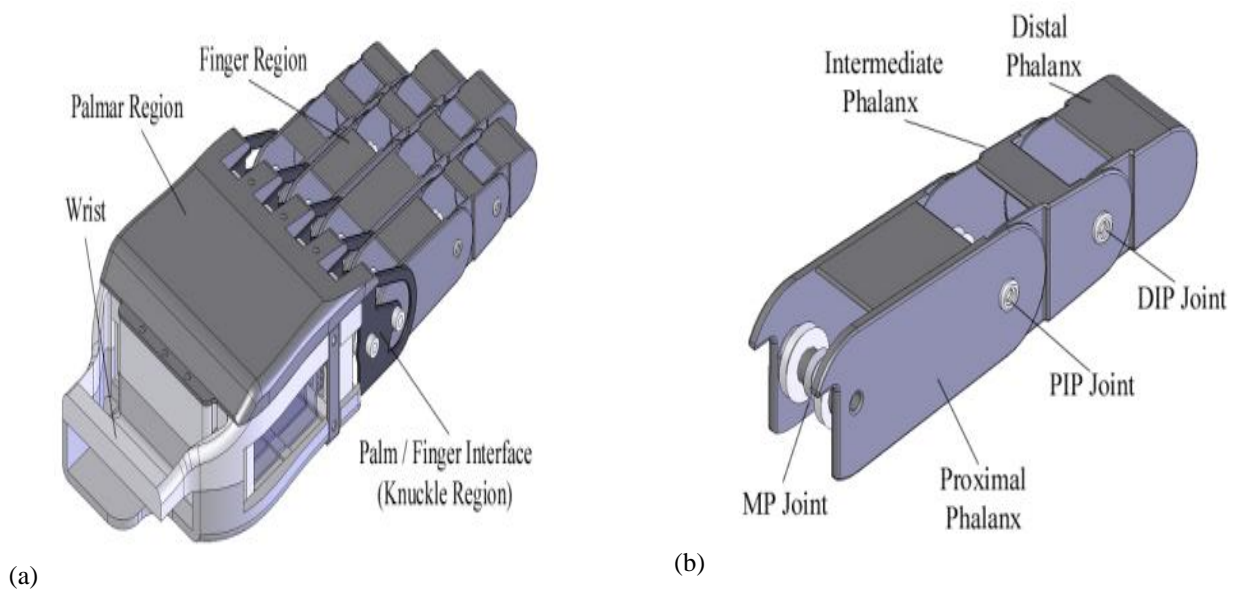
Fixed Pulley - F
Passive Pulley - P
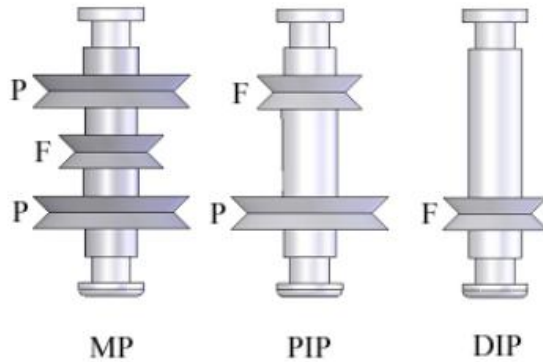
MP   PIP   DIP
(c)

Figure 8: (8a) Assembled mechanical hand by Kevin et al [6], (8b) Index finger assembly [6], (8c) Pulley system [6]

Engineers all over the world face a common problem of size constraint, when designing a dexterous mechanical or robotic hand that incorporates all of the required degrees-of-freedom of the human hand [8]. Zhang Y at Beijing University utilized custom designed actuators and drive trains to develop a hand in 2001 called BUAA Hand. The hand was designed to study the dexterous manipulation of the human hand [8].

The hand was designed with four equal length fingers (three fingers and an opposing thumb) and a palm and mechanical interface to a robotic arm. Each finger had four degrees-of-freedom and was actuated by separate DC servomotors, integrated within the finger assembly [8]. Each actuator was equipped with a magnetic encoder. To avoid any error in the position sensing due to the backlash or elasticity of gears, additional miniature potentiometers were mounted on the joint axis [8].
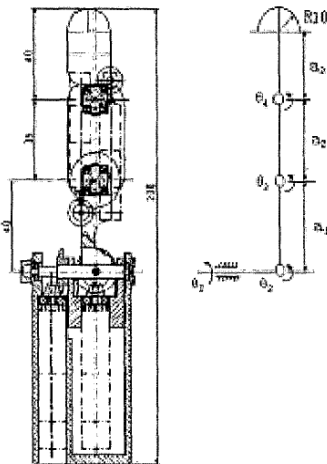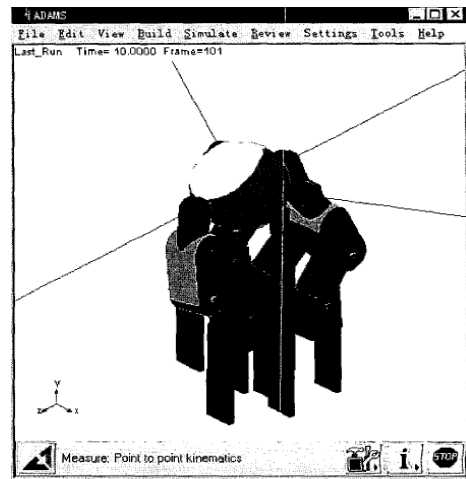
(a)   (b)

Figure 9: (9a) Finger Assembly (9b) Virtual grasping experiment [8]

9

A control system for the hand was divided into two parts, one part was PC microprocessor and the other part was a DSP card. At the PC level, command data was received and sent to servo controllers. This data was processed by the DSP and a feedback position signal was sent to the PC. Programming was done in C, C++ and assembler as per the requirements of the project. The hand design was created in ADAMS and simulations were performed to compute forward and inverse kinematics, to predict interference and to validate motion and manipulation.
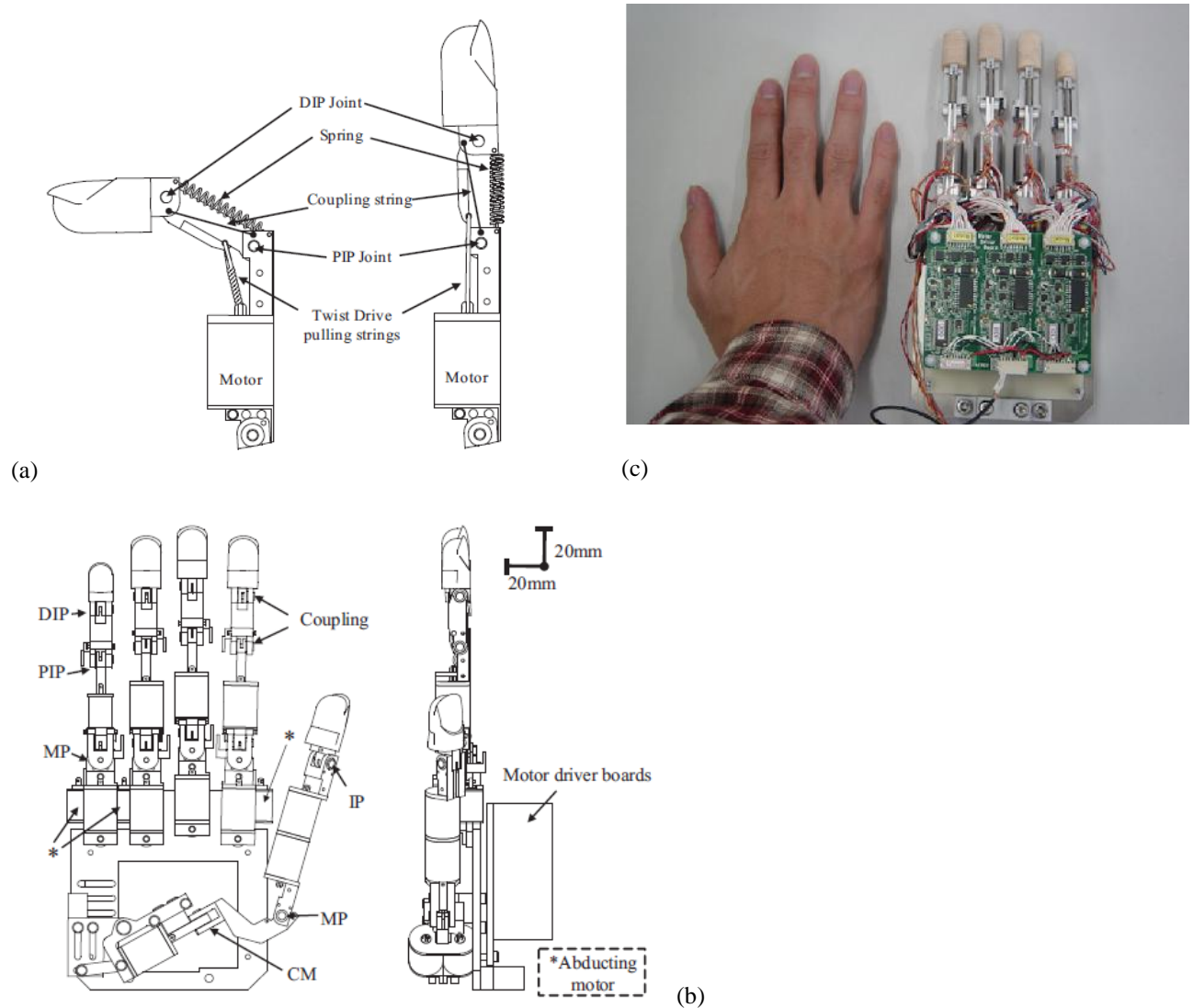
Figure 10: (10a) structure of finger's PIP and DIP joints, (10b) Prototype Design, (10c) Comparison of prototype hand with an adult human hand [9]

In recent times, an interesting design for a hand mechanism was developed by Sonoda and Godler [9]. A newly proposed power transmission method called 'Twist Drive' was used to actuate the finger joints of the developed hand. A prototype, as shown in Figure 10 was

created where 14 out of 18 joints were independently controlled by a Twist drive [9]. A prototype design and comparison of prototype with actual hand of the hand designed by Sonoda is shown in Figure 10 [9]. Twist drive is consists of two strings and a DC motor. Two strings are attached to the driving shaft of the DC motor with one end and the other end of both stings is attached to the driven link. The rotational motion of the motor develops a twist in-between two strings. This twisting motion transfers rotational motion into linear motion and motor torque into the pulling force. [9].

The twist drive string and driving DC motor were integrated within the first link of all four fingers. These actuator mechanisms, along with a coupling string, actuated the DIP and PIP joints together [9]. This method reduces the total number of degrees-of-freedom of the fingers. All the MP joints have 2 degrees-of-freedom, except the middle finger. Extension of all the finger joints is governed by springs since string actuators have unidirectional functionality. The arrangement reduces the number of required actuators in the mechanism. The developed hand design is simpler than most of its predecessors [9]. The total joint motion range for each finger for the Sonada is shown in Table 2 [9].

Finger	Joint and its motion range
Thumb	CM 85°, MP 65°, IP 78°
Index, Ring, Little	MP flex. 80°, MP abd. 30°, PIP 100°, DIP 50°
Middle	MP flex. 80°, MP abd. 0°, PIP 100°, DIP 50°

Table 2: Joint Motion Range for Sonoda's Hand [9]

Of all the mechanical hand designs that have been developed in the past, the 'Shadow Hand' developed by the 'Shadow Robot Company' is the most advanced design. With total 24 degrees-of-freedom available, the Shadow hand can mimic all the human hand gestures and motions. The hand was designed to be similar to an average adult human male hand size. The dimensions of the Shadow hand are shown in Table 3[63].

Finger length from tip of finger to middle of knuckle	102mm
Thumb length	102mm
Palm length from middle knuckle to wrist axis	99mm
Palm thickness	22mm
Palm width	84mm
Thumb base thickness	34mm
Forearm base to wrist axis	434mm

Table 3: Dimensions of Shadow Hand [63]

The Shadow Hand consists of four fingers, an opposing thumb, a palm, wrist joints and a forearm assembly. Each finger has two revolute joints and one universal joint giving it a total of four degrees-of-freedom. The little finger has an additional joint between the metacarpal link and palm, giving it an additional degree-of-freedom. This is a unique feature of the Shadow Hand. The additional joint allows the hand to perform a curling of the palm motion. The thumb has five degrees-of-freedom with one revolute and two universal joints [63]. The design and grasping capability of the Shadow hand are shown in Figure 11.

(a)

(b)

Figure 11: (11a) and (11b) Shadow Hand [63]

The hand is actuated using forty air muscles mounted in the forearm. These air muscles are connected to the joints via tendons [63]. Electronic controls, mounted on the bottom of the arm, control pneumatic valves that actuate each muscle [63]. The motion of the middle and distal phalanges was coupled to create human like characteristics. The total joint motion range for the Shadow hand is shown Table 4. Kinematics of the Shadow hand are shown in Figure 12 [63].

Joint	Connects	Range	Muscle Type
First, Middle, Ring finger			
1	Distal - Middle	0 - +90	Coupled pair
2	Middle - Proximal	0 - +90	
3	Proximal - Knuckle	0 - +90	Pair
4	Knuckle - Palm	-20 - +20	Pair
Little Finger			
1	Distal - Middle	0 - +90	Coupled Pair
2	Middle - Proximal	0 - +90	
3	Proximal - Knuckle	0 - +90	Pair
4	Knuckle - Metacarpal	-20 - +20	Pair
5	Metacarpal - Palm	0 - +40	Pair
Thumb			
1	Distal - Middle	0 - +90	Pair
2	Middle-Proximal 1	-28 - +28	Pair
3	Middle-Proximal 2	-12 - +12	Pair
4	Proximal-Palm 1	0 - +75	Pair
5	Proximal-Palm 2	-60 - +60	Pair
Wrist			
1	Palm-Wrist	-45 - +30	Pair
2	Wrist-Forearm	-28 - +8	Pair

Table 4: Joints and Ranges of motion of Shadow Hand [63]
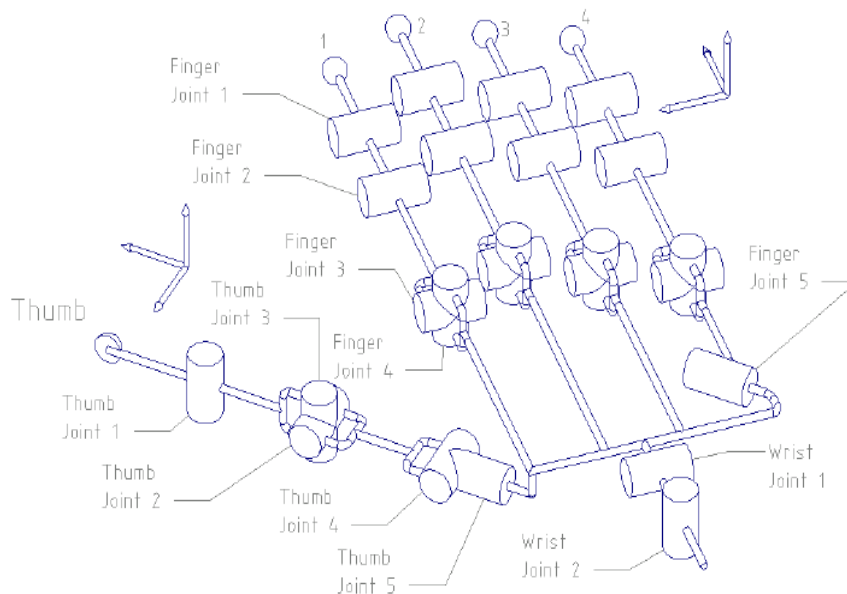
Figure 12: Kinematics of Shadow Hand [63]

A new concept of finger spelling was put forward in some of the recent works related to robotic hand and control development. Finger spelling is a method of conversation developed for the deaf and blind people. Communication takes place between two people by expressing

13

finger language in a hand of a partner. This particular method of communication is shown in Figure 13. This concept opens a whole new area of research involving the use of robotic hands.

Figure 13: Finger spelling for deaf and blind [56]

Tarauchi et al. [56], in 2008, presented a mechanical finger design, along with its control techniques, for a finger spelling robotic hand. These fingers were actuated with two different drive systems. The first joint of the fingers was driven with a DC servo motor drive and for the second and third joints; SMA wires were used, since these joints required a light weight and small actuators. The second and third joints were coupled to give them human like motions [56]. A control system that could apply time delays was developed for the second and third joints using the Smith method and system identification [56]. The developed mechanical finger and SMA wire actuation method are shown in Figure 14 and 15.
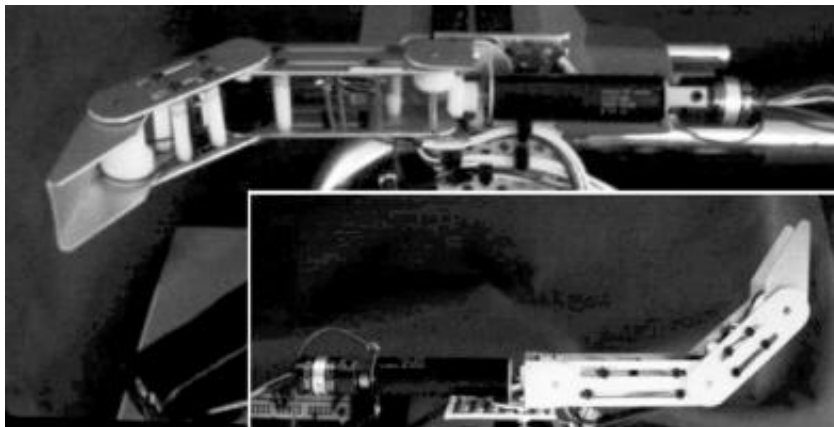
Figure 14: Mechanical finger assembly, [56]
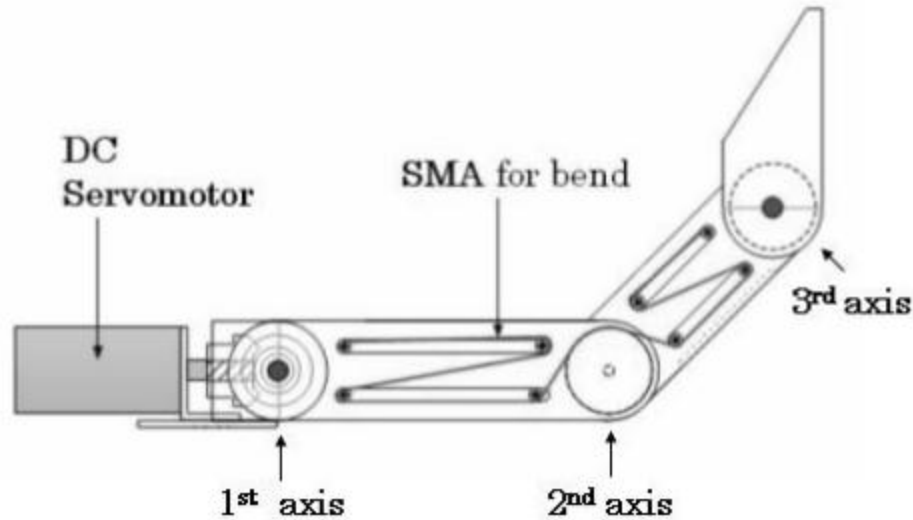
A review of mechanical hands developed over the years is shown in Table 5.

American Sign Language

In the 16th century, an Italian physician Geronimo Cardano discovered that the deaf people can be taught symbols by associating them with their representation. In America, Plains Indians developed signing symbols extensively; however the pioneer of American Sign Language (ASL) was Thomas Hopkins Gallaudet. He founded the first school for deaf people, in Hartford, Connecticut. [www.startASL.com]. All the American Sign Language alphabet are shown in Figure 16.

Different animation techniques have been developed for American Sign Language rendering using 3D models. The research was started in response to the needs of students. Many deaf students are unable to get a good education due to their inaccessibility to people who can convey basic concepts of sign language related to different subjects. A virtual hand was developed at the University of Nevada, Reno that can rapidly generate human hand gestures and animations and can be used as an ASL interpreter. [41]

In 2008, Nicoletta Adamo-villani did a comparative study of two animation techniques to determine the most effective technique for representing ASL [41]. Two main animation techniques, Keyframe Animation and Motion Capture Animation, were tested for their performance and repeatability.

Design Name	Research institute	year	Number of fingers (Thumb)	Number of Joints	Degree of Freedom	Actuation type	Reference
Okada Hand	Electro-Technical Laboratory Japan	1979	4(Y)	11	11	Electrical revolute motors	Okada 1986
Stanford/JP L Hand	Stanford University	1983	3(N)	9	9	Electrical revolute motors (DC)	Salisbusy 1983 Chase 1997 Fearing 1987
Utah/MIT Hand	Utah University	1985	4(Y)	16	16	Pneumatic actuator	Jacobsen 1986 McCam mon 1990
Belgrade/U SC Hand	University of Belgrade	1988	5(Y)	18	4	DC Motors	Bekey 1990
Barret Hand	Barret Technology, INC	1988	4(N)	8	4	Electrical revolute motors (Brushless)	Townsen d 2000 Barret hand webpage
UB Hand II	Bologna University	1992	4(N)	13	13	Electrical revolute motors	Melchior ri 1992/19 93 Bonivent o 1993
DLR Hand I	DLR-German Aerospace Center	1997	4(Y)	16	13	Electrical revolute motors	Butterfa ss 1999 Liu 1999
LMS Hand	Universite de Poities	1998	4(Y)	17	16	Electrical revolute motors	Gazeau 2001
DIST Hand	DIST - Universita de Genova	1998	5(Y)	16	16	Electrical revolute motors	Caffaz 1998 dist hand webpage
Robonaut Hand	NASA Johnson space center	1999	5(Y)	22	14	Electrical revolute motors (Brushless)	Lovchik 1999 Ambrose 2000 Robonau t webpage
Tokyo Hand	University of Tokyo	1999	5(y)	16	12	Pneumatic muscles	Lee 1999
DLR Hand II	DLR-German Aerospace Center	2000	4(Y)	17	13	Electric revolute motors	Butterfa ss 2001
Tuat/Karlsruhe Hand	Tokyo and Karlsruhe Univerities	2000	5(Y)	24	1	Electric revolute motors	Fukaya 2000
Ultralight Hand	Research Center of Karlsruhe	2000	5(Y)	18	13	Pneumatic	Kawasak i 2001
Gifu Hand	Gifu University	2001	5(Y)	20	16	Built in DC Maxon servomotors	Jacobsen 1986 McCam mon 1999
Shadow Hand	Shadow Robot Company LTD	2007	5(Y)	24	24	Pneumatic muscles	Shadow hand webpage
RIT Hand	Rochester Institute of Technology	2011	5(Y)	20	19	Any type of actuation can be used	Thesis

Table 5: Review of mechanical hands developed over the years [3]
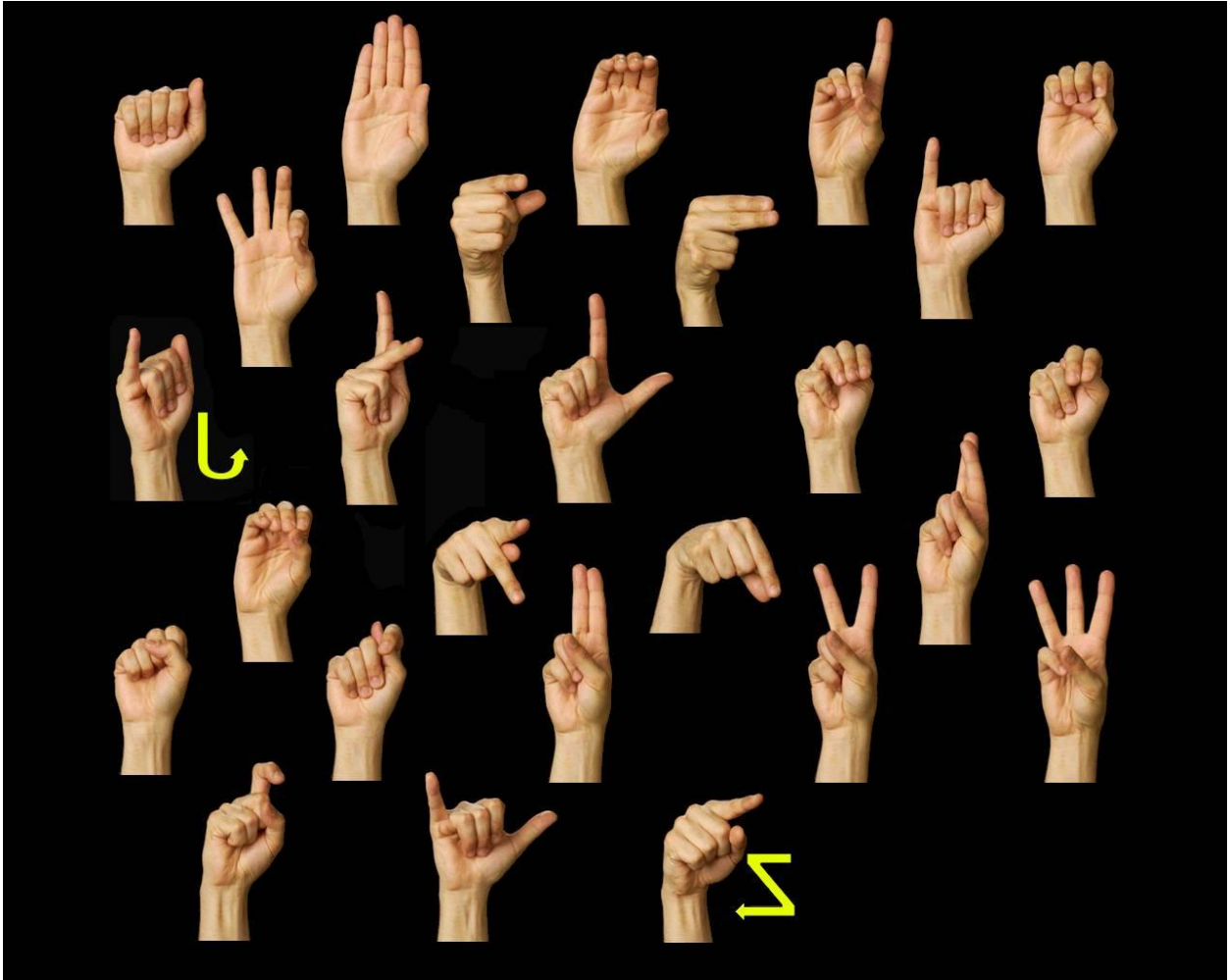
Figure 16 : American Sign Language Alphabet

The Keyframe Animation technique was first developed by the animators at Walt Disney Studios for efficient frame production. Most of the 3D animation softwares are based on this technique. First, the values of various object parameters, such as joint motion and position, are set and saved at a particular point related to the timeframe. These values are then used by the 3D software to develop in-between frame values to generate a continuous motion.

Success of this technique is dependent on the experience of the animator [41].
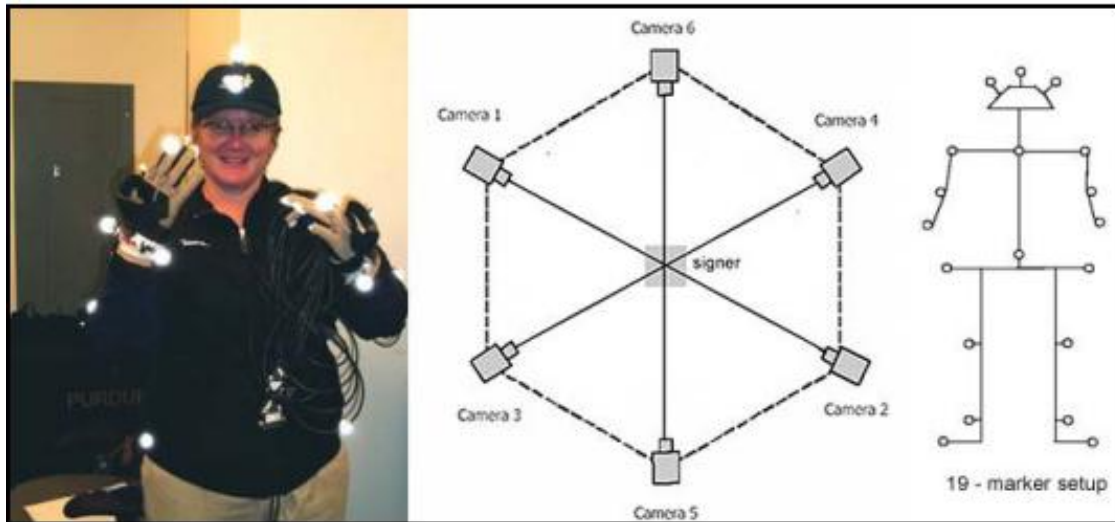
Figure 17: Signer with operating suit and Cyber glove; Setup Diagram [41]

The motion capturing technique consisted of capturing an actor's motion and position in space and generating an equal motion pattern in 3D environment by generating computer usable data. Various motion capture devices were used for this technique (Mechanical, optical and electromagnetic). These devices produced three dimensional rotational and translational data [41]. A signer with cyber glove and operating suit is shown in figure (16). A six camera set up and marker set up are also shown in Figure 16 [41]. The results of the testing showed that the Keyframe animation technique produced more accurate and reliable signs than the Motion Capture Animation Technique.

Jerome et al [42] designed and constructed an ASL spelling recognition system to translate an ASL letter into a corresponding printed or spoken English letter. These efforts were made with the goal of helping deaf and deaf-blind people achieve their potential [42]. The study was limited for the 24 ASL letters from A to Y. Due to their dynamic nature, the letters J and Z were omitted from the study.

A hand gesture sensing CyberGlove was used in combination with LabView and Matlab software to develop the system by Jerome et al [42]. LabView software was used to store 18 signals generated from position sensors. Matlab was used to process this 18X24 matrix and generate a 24X24 matrix correlating all the sensor values to the possible 24 ASL letters. Another LabView program was used to convert these recognized letters into audio files.

Though this system was capable of recognizing 90% of the finger spelling, it was only applicable for the user whose data was used to "train" the system.

Control System

Casalino et al. [62], in 2003, developed a mechanical hand (DIST-Hand) with an embedded FPGA (Field Programmable Gate Array) based control system. The mechanical hand was developed with four identical fingers with 4 degrees-of-freedom each. Each finger was actuated with six tendons and five DC motors using a pulley system. Each joint was provided with a solid-state Hall Effect position sensor for feedback. Also every DC motor had a rotational potentiometer to calculate the error in output. The preliminary purpose of the DIST hand was to perform grasping and fine manipulation [62]. A mechanical structure and schematic diagram of pulley system are shown in Figure 18.

(a)   (b)
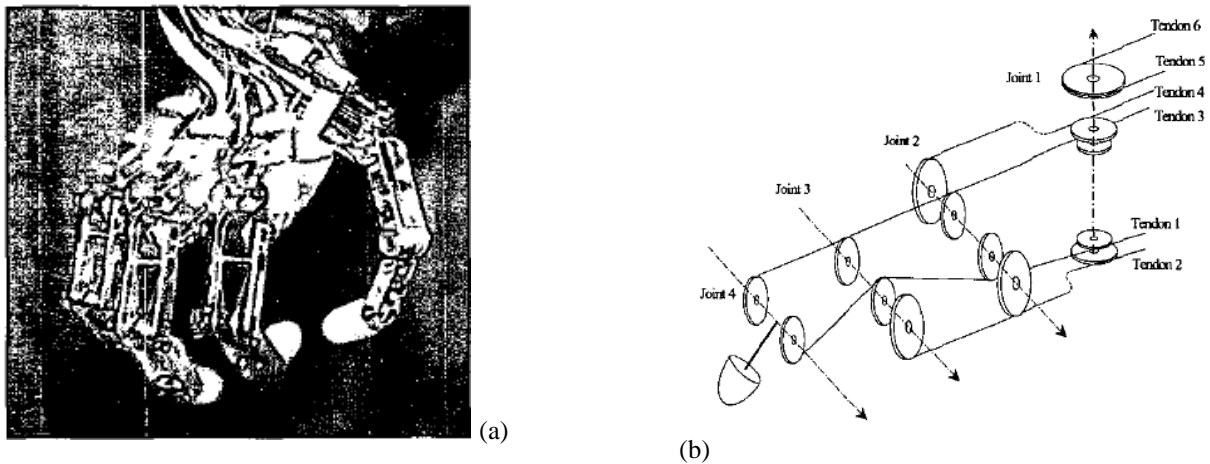
Figure 18: (18a) DIST-Hand (18b) Pulley system [62]

A multilayer hierarchical structure was introduced to develop the controller module for the DIST-Hand. The structure was divided into three main levels, which are MLC (Medium level control), LLC (Low Level Control) and VLLC (Very Low Level Control). LLC and VLLC are considered as the Inner Control Loop, dealing with robot related tasks only.

The MLC was mounted remotely to reduce the required size and intricacy of the design. The MLC was interfaced with the Human-Computer Interface to acquire the information for the particular position. The MLC provided LLC with Cartesian coordinates based on this information. The LLC generated the joint angle position and sent it to the VLLC. Once the position was acquired LLC sent the feedback to MLC. At the VLLC layer motor controller output was generated based on the feedback signals developed by the joint angle sensor and the motor angle sensor. The value of the motor angle associated with the angle of joint rotation in fingers based on the elongation in tendons and tension at the beginning was calculated by the VLLC. Together, the controller was able to reduce the joint position error to zero [62]. A schematic representation of control systems was shown Figure 19.

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particular position. The MLC provided LLC with Cartesian coordinates based on this information. The LLC generated the joint angle position and sent it to the VLLC. Once the position was acquired LLC sent the feedback to MLC. At the VLLC layer motor controller output was generated based on the feedback signals developed by the joint angle sensor and the motor angle sensor. The value of the motor angle associated with the angle of joint rotation in fingers based on the elongation in tendons and tension at the beginning was calculated by the VLLC. Together, the controller was able to reduce the joint position error to zero [62].

Figure 19: Controller multilayer hierarchical structure [62]

Summary

The previously developed mechanical hand designs were utilized as the basis for a new hand design. After careful evaluation of all the hand designs and their actuation mechanisms, the hand developed by the Shadow Robot Company [63], was decided as a bench mark for this project. The concept of finger spelling was used as a means of demonstrating the dexterity of the hand design and could ultimately enable the designed hand to be used as a virtual interpreter of for a variety for finger spelling applications, such as those described above [56].

20

3. Statement of Work

Various mechanical hand designs have been developed in the past few decades. The majority of the designs were made with the sole purpose of imitating the human hand and its capabilities. Most of these developed hand designs were made to achieve a particular motion or sets of motions or actions of the human hand. Few of these designs were equipped with almost the same dexterity as the human hand. There is still a need for further advancements in the scientific world to achieve a mechanical hand design with all the motions and sensory capabilities of the human hand.

At RIT, various efforts have been made to develop a functioning human hand replica. Though the designs developed at RIT are capable of certain motions, these designs lack the required full dexterity of the human hand. The primary goal of this thesis project was to develop a robotic hand design with the required amount of degrees-of-freedom and necessary constraints to achieve all the motions of the human hand. Demonstration of the ASL alphabet, using a virtual design and controls platform, was used as a means of proving the dexterity of the designed hand. The following were the primary goals of the thesis project:

1) To design a complete mechanical hand model using CAD tools, with all the required degrees-of-freedom for the ASL application.
2) To develop a complete kinematic model of the designed hand
3) To develop a program to simulate the ASL alphabet with the designed hand, by interfacing a virtual controls program with the CAD model.

The mechanical hand model was developed using the human hand as a bench mark. The total number of degrees-of-freedom available for the human hand is 23, however the required number of degrees-of freedom for the ASL alphabet was found to be lesser than the actual human hand. Based on observation, the required number of degrees-of-freedom for ASL was determined to be 20.

The developed mechanical hand designs were then verified. The verification of the designs was achieved by virtually simulating the required motions of the fingers to perform the ASL letters. Rapid prototyping of the finger assembly was also used to verify the design. To create a successful simulation it was required to map all the joint coordinates of the hand assembly. Thus, a complete kinematic model of the mechanical hand assembly was developed.

To simulate the ASL alphabet, using the CAD assembly, it was essential to develop a software interface between a CAD platform and a control program. The software interface was required to provide the user with real time control over the simulation of the CAD assembly. The simulation of the designed hand assembly, using the CAD tools, allowed for virtual testing of the mechanical assemblies prior to manufacturing.

4. Hand Design

The primary aim of this project was to design a complete mechanical hand system that can imitate human hand motions and constraints. To develop such a system, it is important to study the skeletal system of the human hand, its movement patterns, and different positions. It is also important to understand the tendons and muscles that are present in the human hand. The tendons and muscles are the actuators of the human hand. Understanding of their capability, interdependencies and constraints is immensely important before designing any mechanical system.

Hand Anatomy

The first step in the design of a biomimetic hand starts with the study of the anatomy and mechanics of the human hand [17]. The study of the human hand mechanics directs us towards the study of the bones and joints of the hand and wrist, muscles and tendons.
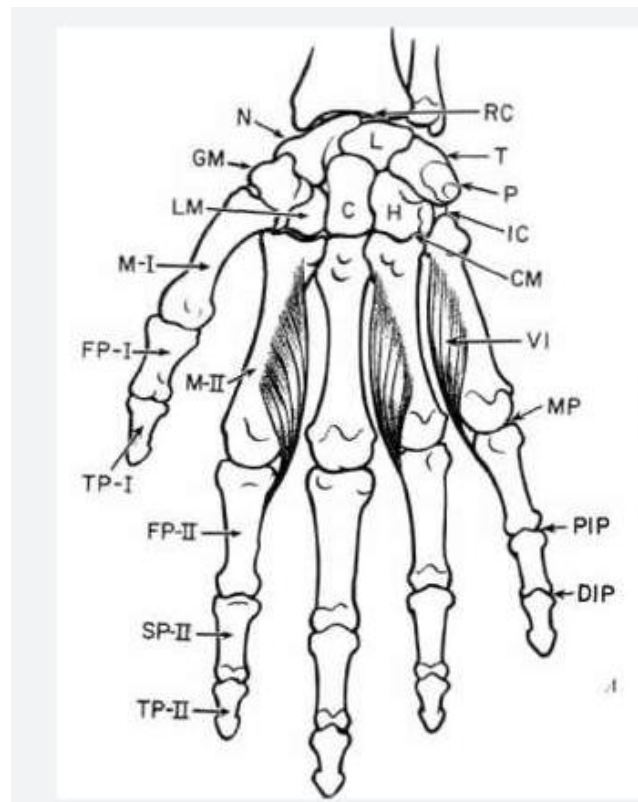
Figure 20: Bones and articulation of the hand, [17]

Figures 20 and 21 show the basic structure of the bones of the fingers and the wrist. Most of the muscles of the fingers and the wrist are located into the forearm. The bony linkages of the fingers and hand are connected with these muscles by narrow tendons which traverse through the wrist. The anatomical design of all the fingers is the same with the exception of the thumb. In the digits 2-5, all the metacarpophalangeal joints show small lateral rotation in addition to axial rotation. The lateral rotation, seen in the MP joint is not there in the other

phalangeal joints. The PIP and DIP are typical hinge joints. In the thumb, the second phalanx is missing but greater mobility is observed in the carpometacarpal joint articulation. The skeletal structure of the human hand finger consists of three joints, the DIP (distal interphalangeal joint),the PIP (proximal interphalangeal joint) and the MCP (metacarpophalangeal joint). The skeletal structure of the thumb also consists of three joints,the IP (Interphalangeal joint), the MCP (metacarpophalangeal joint) and CMC (carpometacarpal joint)
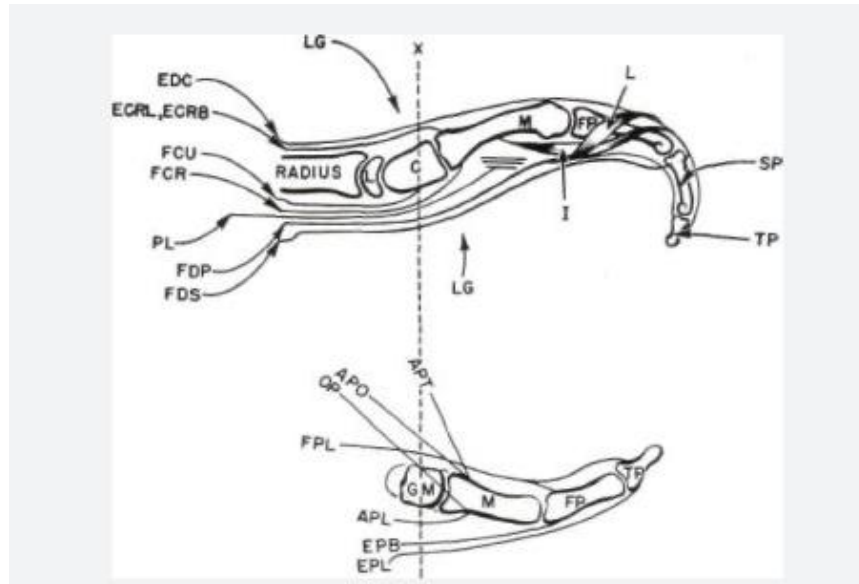
Figure 21: Essential relations of muscles and bones, [17]

Every finger has 4 degrees-of-freedom, 3 for flexion and extension and 1 for abduction and adduction. The thumb is the most intricate structure, having a total of 5 degrees-of-freedom. The wrist has 2 degrees of freedom. The elbow and shoulder have 2 and 3 degrees-of-freedom, respectively. In this particular study, the focus will be on the wrist and the finger joints. This leaves us focused on only 23 degrees-of-freedom [30]. Figure 22 shows the bone structure and the number of degrees-of-freedom associated with each joint [27].

The designed mechanical hand has a total of 20 degrees-of-freedom. The design contains four fingers, a thumb and a palm module. For the purpose of this study, only static gestures of ASL letters were considered. Letters Z and J have additional wrist motion, giving the hand a dynamic effect. Hence, the motion pattern of these letters was neglected and the wrist joint and its 2 degrees-of-freedom were not included in the design.

To mimic the fingers of the biological hand, all four fingers of the mechanical hand were designed with the dimensions of an average adult human hand. Each mechanical finger was designed with 3 joints and 4 degrees-of-freedom. Joint 2 (PIP) and Joint 3 (DIP) are revolute joints with one degree-of-freedom each. Joint 1 (MP) is a universal joint with 2 degrees-of-freedom. The designed assembly enables the fingers to perform all required motions (flexion, extension and abduction/adduction).
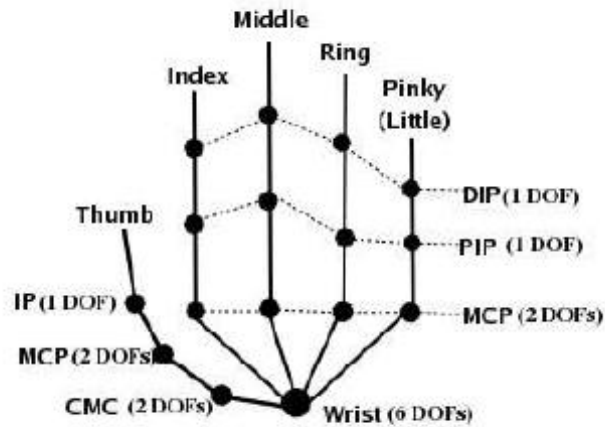
As stated previously, the human thumb has a total of 3 joints and 5 degrees-of-freedom. This characteristic of the thumb allows it to turn and face other fingers and maneuver around the objects while grasping. For the ASL application, it is not essential for the thumb to retain all the natural capabilities. Thus, the designed thumb has a total of 3 joints with 4 degrees-of-freedom. Similar to the finger assembly, the thumb also has 2 revolute joints (IP and MCP) and 1 universal joint (CMC). A complete 3D CAD model of the hand assembly is shown in Figure 23. These design features enabled the mechanical hand to perform all the basic ASL letters. Table 6 shows the lengths of all the designed fingers.
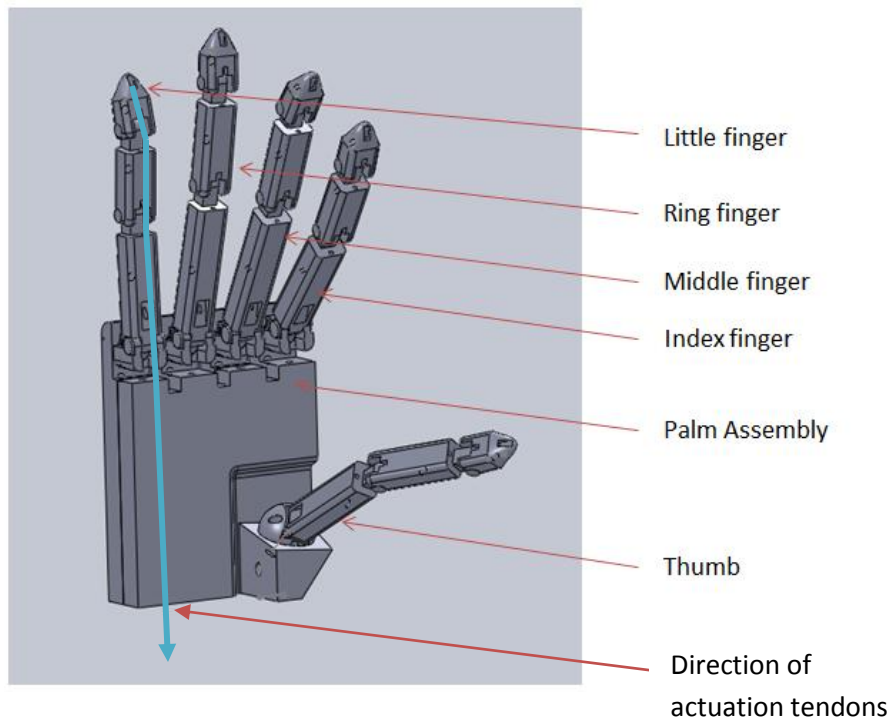
Figure 23: 3D CAD model of Hand Assembl

24

Column1	Link 3	Link 2	Link 1	Total Length (mm)
Index	20	32	51	103
Middle	20	38	58	116
Ring	20	38	57	115
Little	20	31	46	97
Thumb	20	38	60	118

Table 6: Finger dimensions

Finger Design:

The finger assembly has revolute joints. Joint 2 and joint 3 both are assembled with a simple pin joint giving them each 1 degree-of-freedom. All eight joints of the 4 fingers have a range of 100° with 90° flexion and 10° extension. Further motion is restricted through specially designed mechanical dead stops on both ends as shown in Figure 24.

(a)   (b)
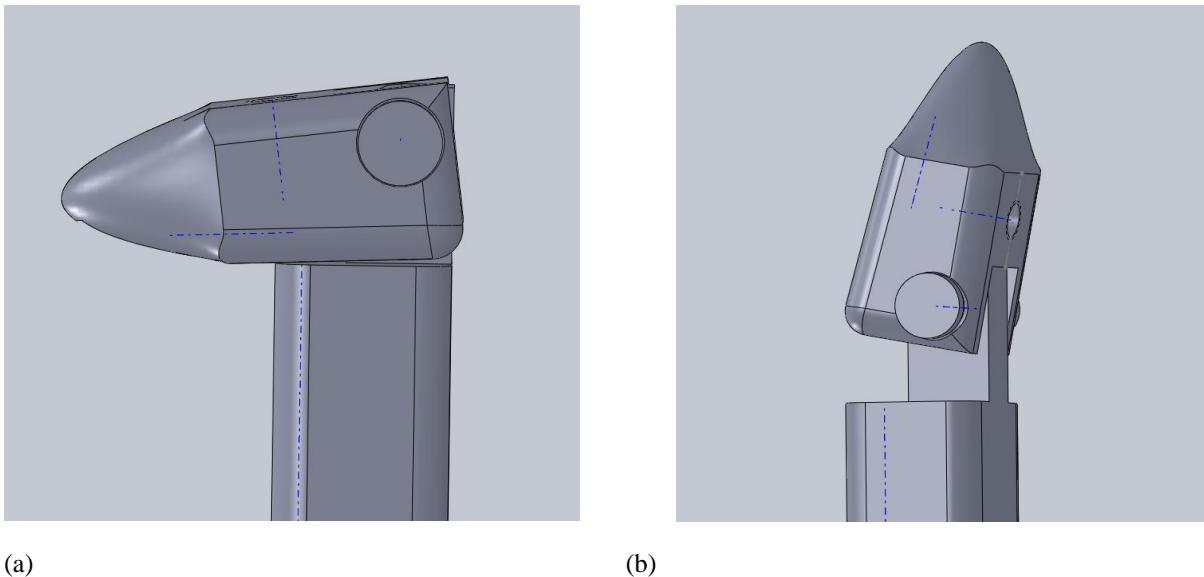
Figure 24: (24a) and (24b) Mechanical dead stops

Joint 1, the metacarpophalangeal joint, was designed as a universal joint to provide angular movement in two different directions. All four joints of the 4 fingers have a range of 90° in flexion/extension and 40° in abduction/adduction. Similar to joint 2 and joint 3, all the motion outside this range is restricted via provision of mechanical dead stops.

Each link is provided with a tunnel and a mounting arrangement for the actuator tendons to root through. These tendons will actuate each joint separately to achieve the required degree of flexion in the fingers. The tendon can only be pulled in one direction. Hence, to achieve angular movement in another direction, another set of actuators is needed. This can be achieved either by routing another set of tendons from the opposite direction of the joint or by providing a spring mechanism to do the same. Both methods are effective, but the spring return mechanism reduces the requirement of an extra set of actuators and simplifies the control systems requirements by reducing the number of required inputs.

For all three joints in each of the four fingers, a separate spring arrangement is provided to achieve extension. Every joint requires a different spring force, hence, all three springs are of different sizes and lengths. The spring force also varies with the material used for manufacturing and the frictional forces in each of the joints. To verify the design and its functionalities, a finger assembly was manufactured using the process of rapid prototyping. The manufactured assembly was tested for actuation by mounting springs and routing tendons for extension and flexion, respectively. Spring force calculations were done to obtain the required actuator forces and to achieve the angular displacement of the joints. The input values for the spring force calculations were based on spring constants of the implemented springs. The spring mounting screw arrangement in DIP joint is shown in Figure 25.

All the springs used in the design are simple coil extension springs. The force exerted by springs can be calculated using the spring force equation. The total spring force is the sum of the initial force required to separate spring coils F´ and force developed due to the extension of the spring (KdX). F and F' can be calculated as follows,

$$F = F' + KdX \qquad (1)$$

$$F' = (\pi \tau d^3)/(8D) \qquad (2)$$
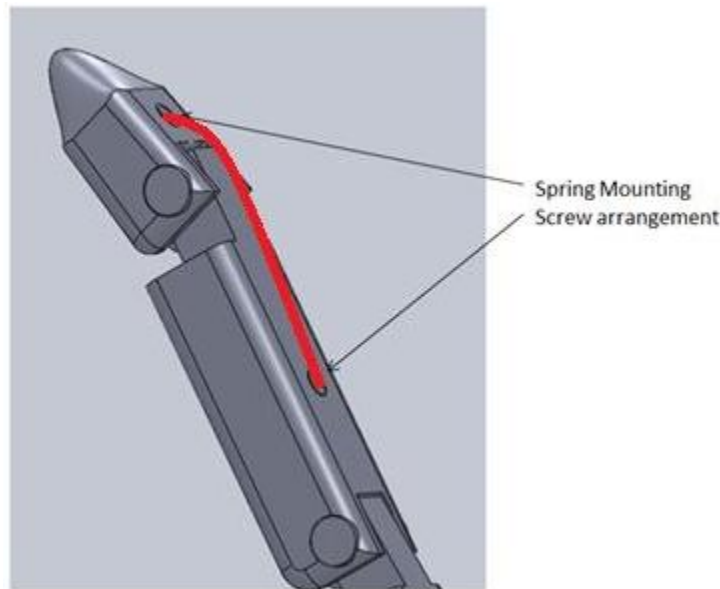
Figure 25 spring mounting holes in the finger assembly.

$$K = (G\ d^4)/(8D^3 n) \qquad (3)$$

where,

F = Final Spring Force

F' = Initial Force to Separate the Coil

K = Spring Constant

dX = Deflection of Spring

D = Spring Diameter

d = Wire Diameter

n = Number of Coils

G = Modulus of Rigidity

τ = Maximum Initial Stress

To find out force exerted by spring at every joint angle dX was replaced by,

$$dX = r \cdot \theta$$

(4)

where,

r = distance from joint axis to spring axis

θ = Joint angle (radians)

All the springs were assembled with some initial deflection to keep the finger joints in their extension state. The spring constant for the implemented spring at the DIP joint was calculated by inputting the implemented spring parameters. The calculated spring constant value was used to map the entire span of the spring force developed for the complete angular displacement of the DIP joint. The angular motion range of the DIP and PIP joints in the finger assembly is a little over 90°. Due to the given initial deflection, the starting force for the actuation was 2N. For the calculations, spring steel was assumed as the spring material. Using the equations 1, 2, 3 and 4 the developed force in the spring over the complete span of flexion of the DIP joint was calculated. It is shown in Figure 26. To achieve any given angular position, the force applied by the actuator, at the DIP joint was required to be higher than the calculated spring force values.
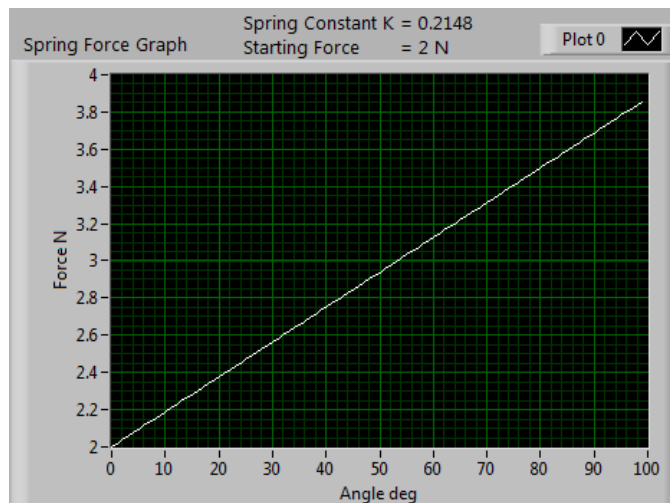
Figure 26: Spring Force developed in the DIP joint due to flexion

27

The metacarpophalangeal (MIP) joint in all four fingers is a universal joint with two directional motions. The joint is required to perform flexion/extension as are all the other joints the in finger assembly. The MIP also has abduction and adduction motion in the palm plane. The required range for flexion and extension is 90° and for abduction and adduction is 20°. Figure 27 shows the detailed design of the MP joint (joint 1). Link 1 is connected to the knuckle bracket through a pin joint. This feature provides the joint with 1 degree-of-freedom with a flexion/extension motion. The total designed range of this motion is 90°. At both ends of the motion, mechanical dead stops are designed to restrict further angular displacement. A knuckle bracket is connected to the palm assembly with a specially designed pin and ball bearing assembly.

Torsion Spring   Palm assembly   Ball Bearing   Connector Pin 1   Knuckle Bracket   Connector Pin 2   Link 1
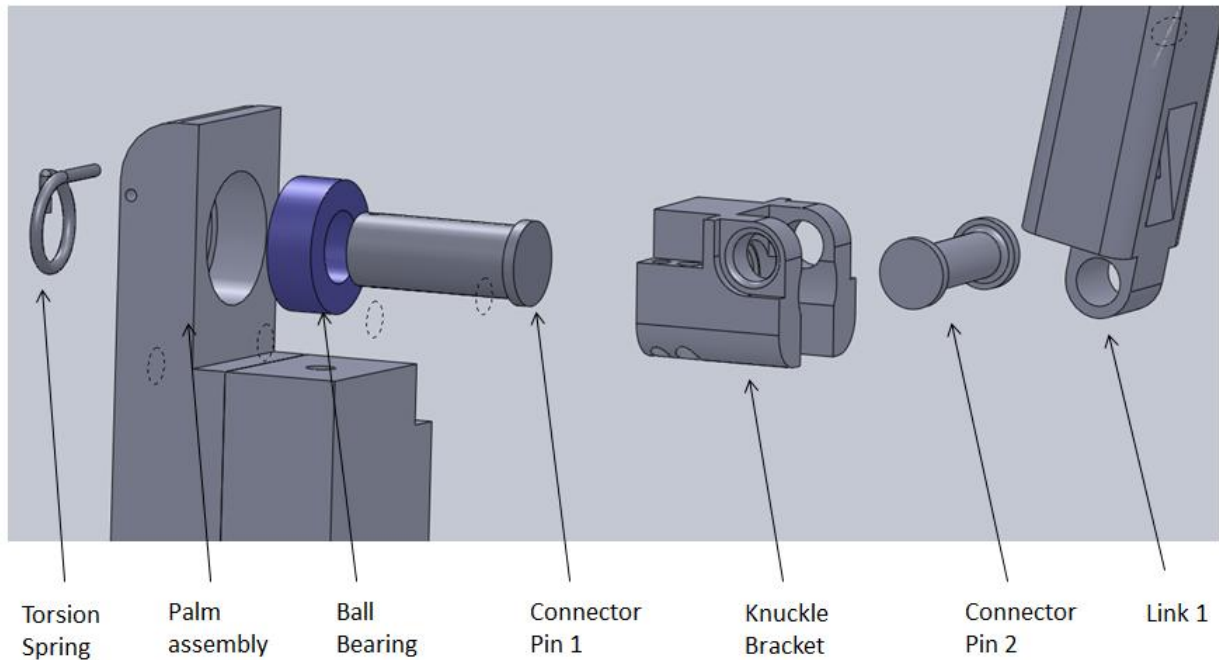
Figure 27: Joint 1 Assembly

The ball bearing assembly is included to reduce all the frictional losses that occur during the motion of the joint. Two different actuator location arrangements were designed to connect the actuating tendons. The design enabled joint 1 (MIP) to perform both abduction and adduction motions. A torsion spring was used to connect Connector Pin 1 with the palm assembly. The main purpose of this spring was to retain the entire finger assembly into its base position when no actuation forces are applied. The torsion spring and its mounting are shown in Figure 28 and Figure 29.

The force exerted by the torsion spring can be calculated by,

$$F = (\pi\, d^3\, \sigma)/\,(32\, r) \qquad\qquad (5)$$

The value of the bending stress, σ, can be calculated from equation 6,

$$\sigma = (\theta\, E\, d)/\,(2Dn180) \qquad\qquad (6)$$
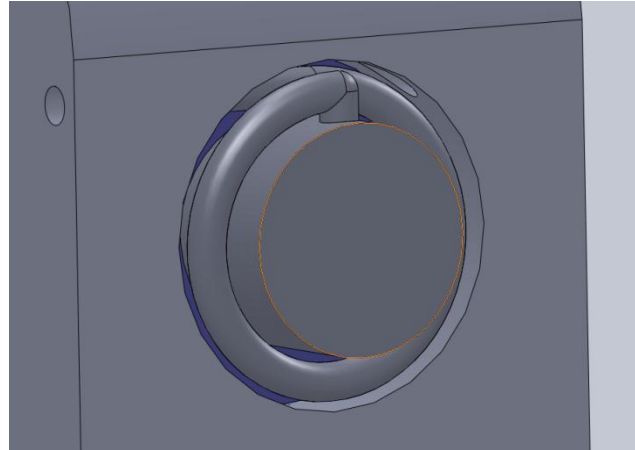
Figure 28: Torsion spring assembly

where,

F = Exerted Force

σ = Bending Stress

d = Wire Diameter

D = Spring Diameter

n = Number of Coils

θ = Angular Displacement

E = Modulus of Elasticity

r = Distance between Force Axis and Spring Axis
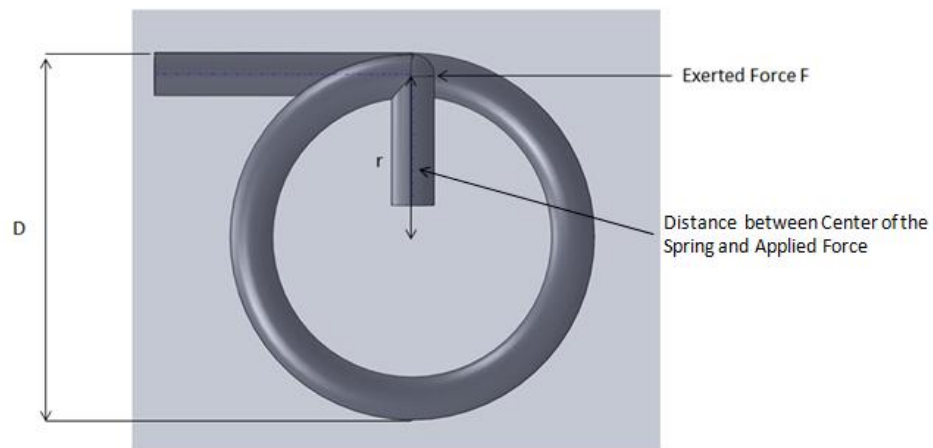
Figure 29: Designed torsion spring for the finger assembly

To retain the developed finger assembly into its starting position (vertical), the designed spring should overcome the moment generated by the finger assembly at the joint axis. The finger assembly resembles an inverse pendulum and its moment can be calculated using equation 7. For calculation purposes, the finger assembly was considered as a uniform cylinder, hence its center of gravity was assumed to be at the center of the finger. The force developed at the center was due to its own weight. The volume of the finger assembly was obtained from the SolidWorks model. The weight of the assembly was calculated by assuming ABS plastic (density 1 gm/cm$^{3)}$ as the manufacturing material. The developed vertically downwards force due to the weight was substituted into two perpendicular components. One component was along the axis of the assembly and the other was perpendicular to the assembly. The component along the assembly axis was neglected for the purpose of this study, as it does not affect any motions of the assembly. These calculations were performed for the middle finger assembly, since it was the largest finger. The force distribution is shown in Figure 30.
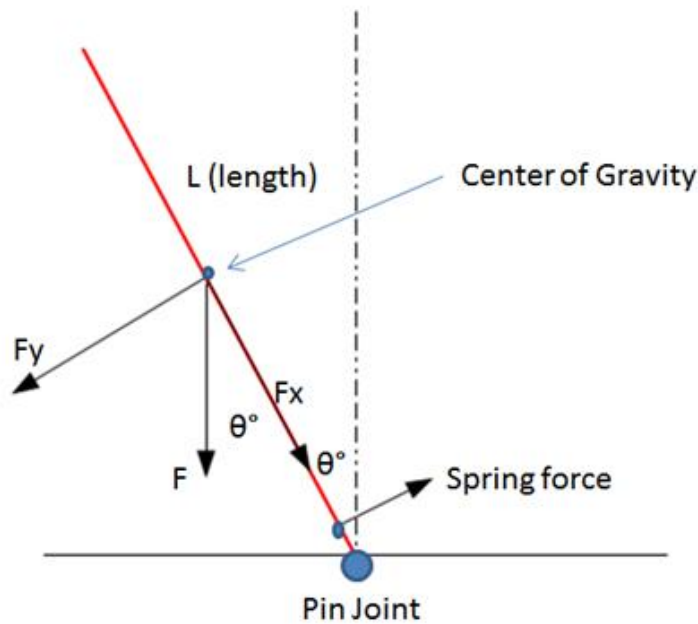
Figure 30: **Forces acting on the finger assembly**

$$M = lF_y \qquad (7)$$

where,

M = Moment

l = Distance between the force F_y and pin joint

To verify the torsion spring design, it's bending stress and the developed forces for the complete angular displacement were calculated. For the purpose of the computation, spring steel was assumed as the spring material. The designed spring dimensions were used as the input parameters for the spring force calculations. The calculated spring force was used to

obtain the moment developed at the joint axis. The moments developed at the joint axis by the finger assembly and the torsion spring are shown in Figure 31. As shown in Figure 31, the torque developed by the torsion spring is higher than the moment developed by the finger assembly. Thus it was established that the designed spring was capable of retaining the given finger assembly at the vertical position. It was also deduced that, the spring would need to be adjusted for different manufacturing materials (e.g. Aluminum)
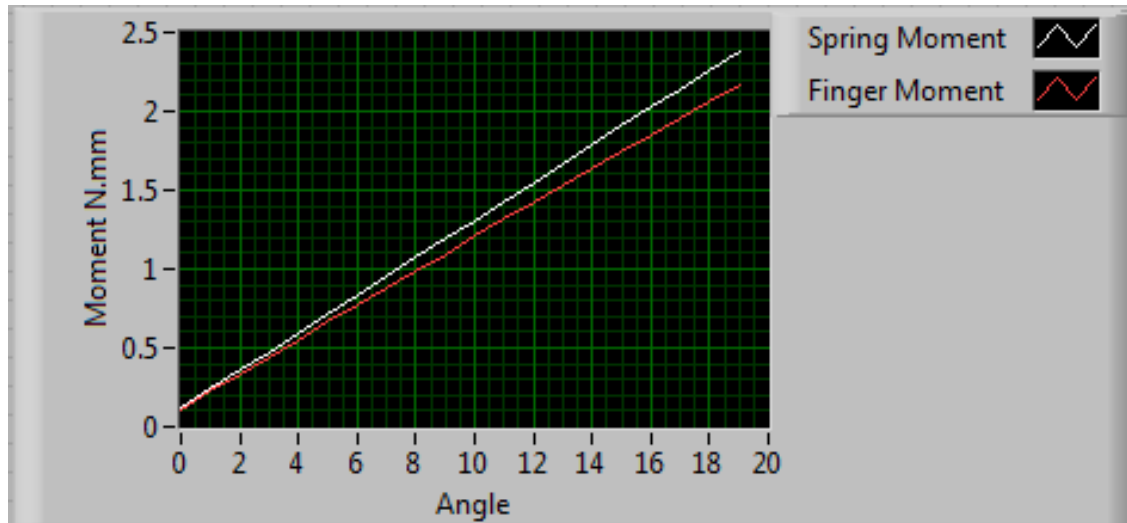
Figure 31: Moment developed by the torsion spring and the finger assembly over the span of the 20º

Thumb Design:

The designed thumb has a total of 4 degree-of-freedom with 3 joints. Thumb Joint 2 (IP) and Joint 3 (MCP) are same as the revolute joints designed in the other fingers. Both thumb joints are connected with a simple pin joint and have 1 degree-of-freedom. Their motion range is 100°. Joint 1 (CMC) in the thumb assembly is also a universal joint designed to give 2 degrees-of-freedom. The universal joint enables the thumb to perform two joint motions which are palmer abduction/adduction (60°) and ulnar abduction/adduction (45°). Joint 1 was developed as spherical ball joint to achieve the required capability for abduction/adduction in both planes. As shown in Figure 32a and 32b, the spherical end of the link 1 was placed inside the mounting bracket with a spherical groove of the same dimensions. These two parts were then connected together with a strong bending spring. This assembly ensures the return of the thumb assembly to its base position when actuating forces are removed.

(a)   (b)
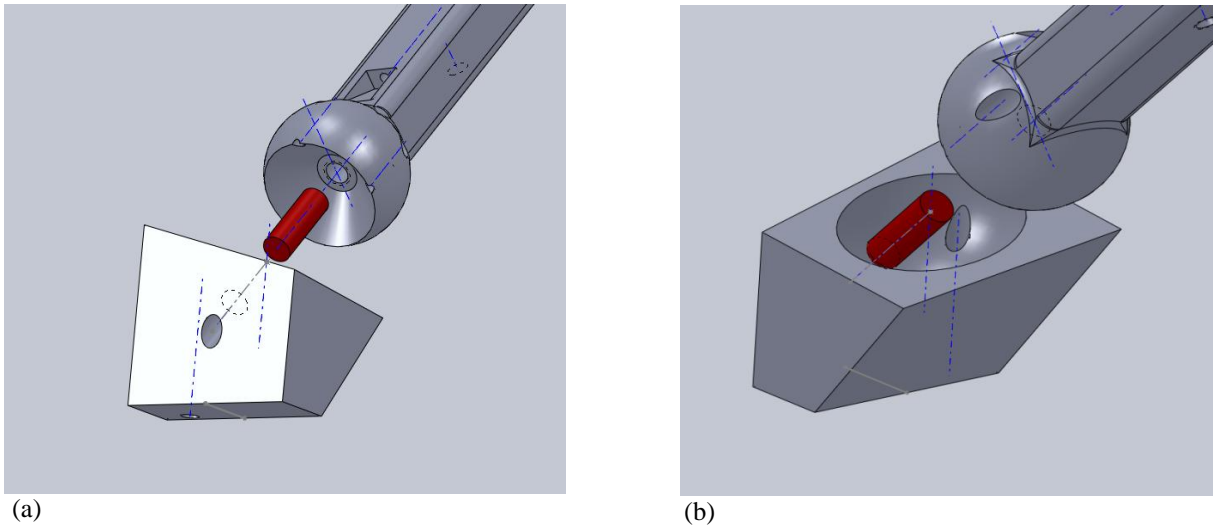
Palm Assembly Design:

The palm module is divided into two main parts; the top palm module and the bottom palm module. The use of two modules was done to increase the ease of assembling all four fingers with the palm module. The index and ring fingers are connected with the top palm module and the middle and little fingers are connected with the bottom palm module. These modules are assembled together with four countersink M4 screws. To route all connecting tendons of the joint actuators, tunnels are designed into the top palm module as shown in the Figure 33.

(a)   (b)

Direction of routed tendons
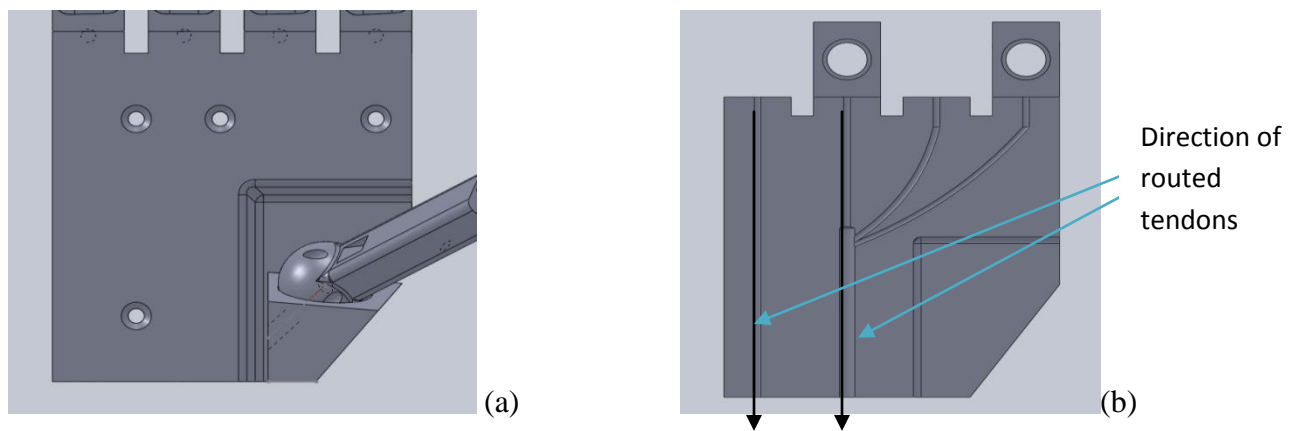
As shown in Table 5 various mechanical hand design concepts have been developed over the years, with a lot of design similarities as well as actuation mechanisms. The number of fingers on the hands ranged from 3-5 while the degrees of freedom ranged from 1-24. Many of these hands were also equipped with various sensors to calculate position, force and angle values. The developed hand design was consistent with the recent designs of five finger hand assemblies. The prime difference between the developed hand and the other designs was the design was not limited to any particular actuation method. Other very important advantages of the developed hand were its simplicity and the low manufacturing cost. Though it does

lack some of the functionalities of the recent hand designs (eg. Shadow Hand), the design is capable of most of the human hand motions and the motion associated with the static letters of the ASL alphabet.

Rapid Prototyping:

The finger assembly was manufactured using rapid prototyping techniques to validate the motion of the finger assemblies. The manufactured finger assemblies are shown in the Figure 34. In this method the entire component is formed by layering the manufacturing material. The orientation of the layering affects the strength of the formed component. The strength of the component varies with different orientation; hence it is difficult to consider these prototypes as a standard for stress analysis. Thus, for the stress analysis purpose, aluminum was considered as the manufacturing material.

Figure 34: Rapid prototyping of finger assembly (full and ¼ size)

Stress Analysis:

In the finger assembly, all the links are connected with each other by means of simple pin joints. As shown in the Figure 35, spring and tendons were assembled to the manufactured finger assembly. Due to the size constrains of the fingers, the cross-sectional areas at the joints are thin. Fracture, as shown in Figure 36 was observed at these cross-sections in a few of the manufactured finger assembly prototypes. These fractures occurred due to the applied force by the assembled spring in an extended position. To predict the viability of the designed finger assembly for manufacturing, a stress analysis was performed at these cross-sections.

Figure 35: Finger assembly with springs and actuating tendons

Figure 36: Fractured cross-sectional area at the joint

When the fingers are in a complete extension position, the joints, which are connecting two links, experience a force exerted by the retaining spring. This spring force at complete extension was calculated using a simple spring force calculation (Equation 1, 2 and 3). The input variables for the spring force calculation were taken from the spring implemented into the prototype finger assembly. The calculated force value was used to obtain the stress generation at the contact point. Several assumptions were made for the analysis:

1) No sliding occurs; hence there are no frictional forces.
2) No external forces are present.
3) No temperature changes are present.
4) The manufacturing material is aluminum alloy

34
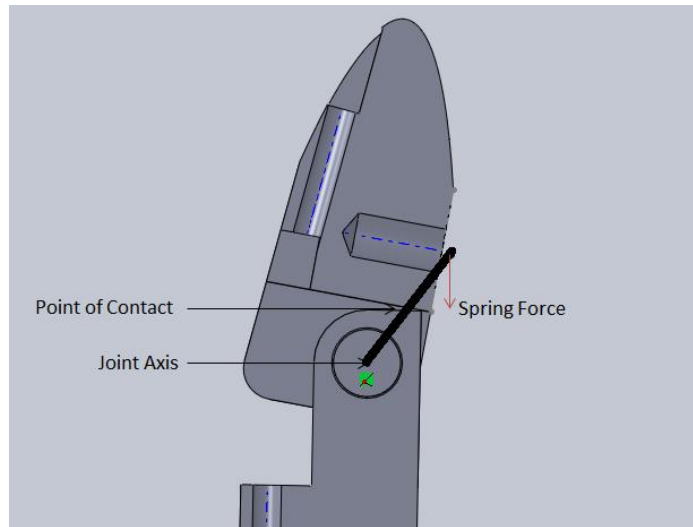
Figure 37: Sectional view of the DIP joint

Figure 37 shows the cross-sectional area of the finger assembly at the Distal Interphalangeal joint. A free body diagram of this joint shown in the Figure 38, was developed based on the observed geometry. The particular assembly considered, was a perpendicular link with a pin joint at the fixed end and an applied spring force at the free end. The link is in the resting position while maintaining angle θ with the vertical plane.
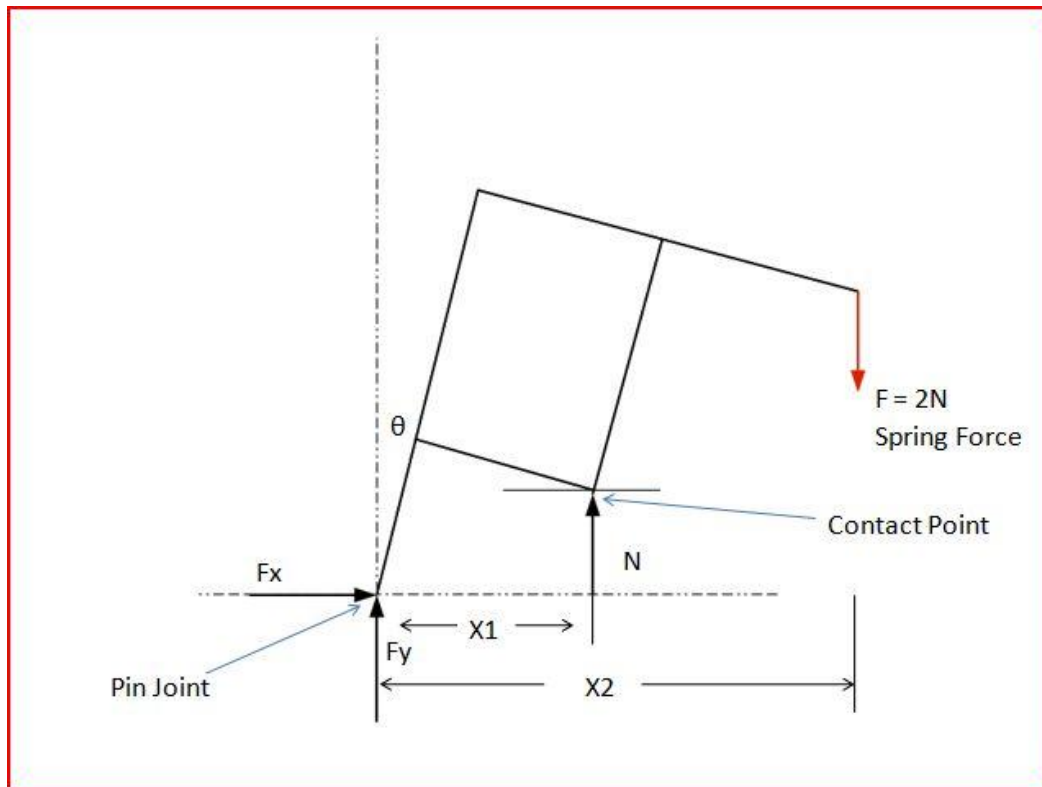
Figure 38: FBD of the distal interphalangeal joint assembly at rest

As shown in the Figure 38 the force developed at the contact point of the joint (N) due to the applied spring force, was calculated using moment Equation 8. X2 is the distance between the pin joint and the point of applied spring force and X_1 is the distance between the pin joint and normal force N. The spring force value was obtained from the spring force calculations, using the equations 1, 2, and 3. The input parameters (Number of coils, wire diameter and amount of deflection) were taken from the implemented spring. The value for angle θ was obtained from the CAD model of the finger assembly. Distances X_1 and X_2 were calculated from the CAD model dimensions and using simple trigonometric calculations. For the equilibrium, the total moment about the pin joint has to zero, such that,

$$\Sigma\ Mx = FX_2 - NX_1 = 0 \qquad\qquad (8)$$

Therefore,

$$NX_1 = FX_2 \qquad\qquad (9)$$

And the force developed at the contact point is,

$$N = 5.233\ \text{(Newtons)}$$

where,

F = 2 Newtons

$\theta = 10°$

$X_1 = 3.475$ mm

$X_2 = 9.093$ mm

The obtained values were used to calculate the forces developed at the pin joint due to the spring force. As shown in the FBD, there is no horizontal component of the spring force. For the simplification of the calculations, it was assumed that there are no frictional forces present. Hence the value of F_x was zero. The value of F_y was calculated using the equilibrium Equation 10.

$$\Sigma F_y = 0 \qquad\qquad (10)$$

The spring force F is working vertically downwards and the reaction forces Fy and N are working vertical upwards, such that,

$$F_y + N = F$$

$$F_y = -3.233\ N$$

The obtained force values were used as the input variables for the Ansys calculations. The obtained results from the Ansys calculations are shown in the Figure 39. The position of both forces and the fixed horizontal plane are shown in the Figure 39.
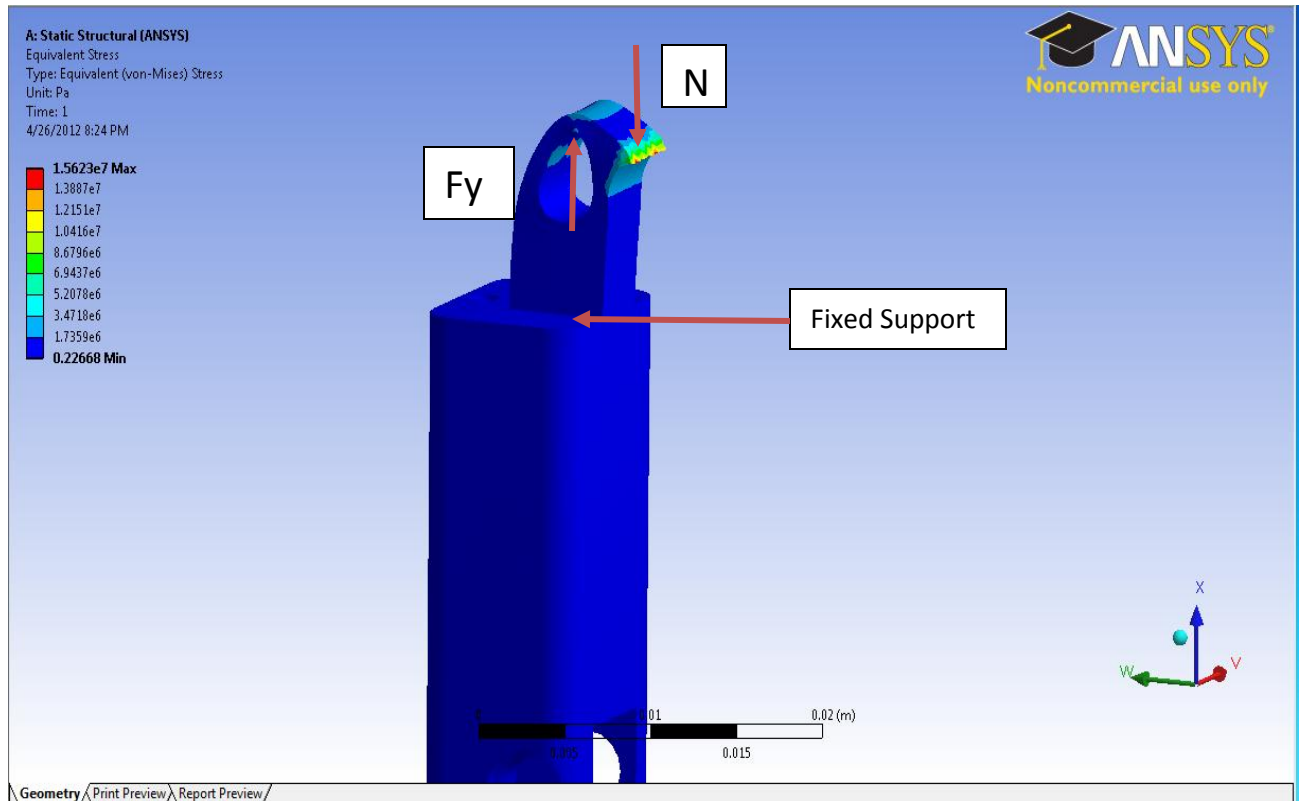
Figure 39: Ansys model results for induced stresses

Results indicate that the developed stress values are much smaller compared (1.56e+007) to the compressive yield strength of the material (Aluminum Alloy = 2.8e+008 Pa). These results indicate that the developed finger joint design would likely not fail for the given input variables, which are the selected manufacturing material (Aluminum) and implemented spring force. Thus, the failure that occurred in the particular rapid prototyped part would likely not occur in a part manufactured with Aluminum.

ASL Application:

The developed hand was capable of performing all the static positions of the ASL alphabet. Figure 40 shows the hand demonstrating two ASL letters, M and O. As can be seen in Figure 40, the hand is an accurate depiction of ASL letters, shown in Figure 16.
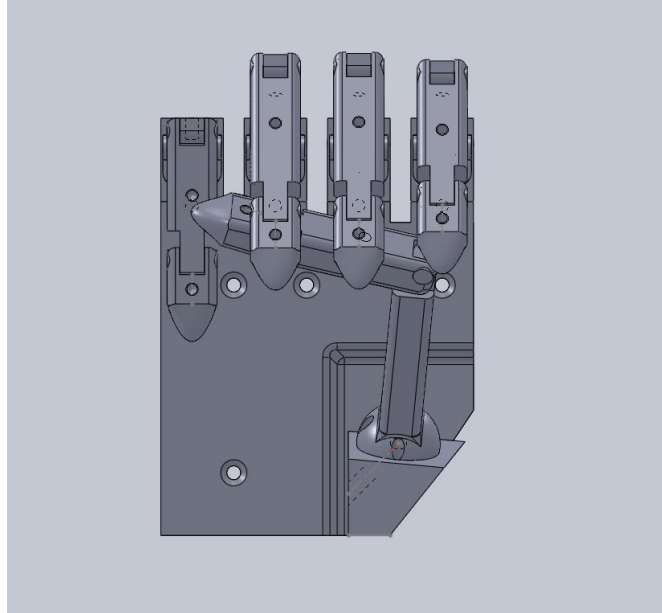
(a) ASL letter M
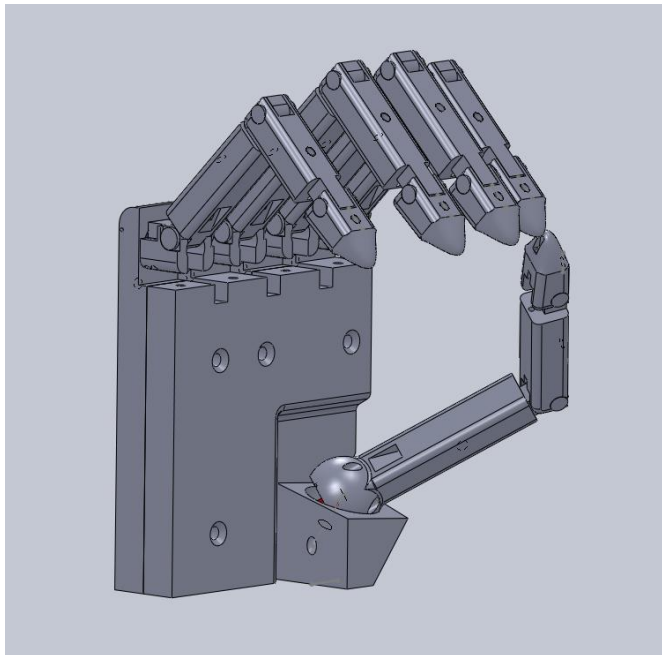
(b) ASL letter O

Figure 40: ASL letters (40a) ASL letter M, (40b) ASL letter O

5. Human Hand Kinematics

One of the primary objectives of this thesis project was to develop a complete kinematic model for the designed mechanical hand assembly. Kinematics is the branch of mechanics which deals with the motion of bodies and systems. The developed kinematic model was useful for understanding the positions of every joint in the hand assembly with respect to each other and in a global frame of reference at any particular instant. This model was based on the human hand skeleton and the study of the required movements to represent all 26 ASL alphabets. This kinematic model was developed using 15 links and 20 degrees-of-freedom.

The difference between the position and orientation of the fingers and thumb was considered and two different kinematics models were developed. One model was for the thumb and one was for the remaining four fingers. Since all the fingers (index, middle, ring and little) have the exact same orientation, the same kinematic model was used for each finger and was defined by 3 links and 4 degrees-of-freedom. In this configuration, the metacarpophalangeal joints (MCP) were modeled with 2 degrees-of-freedom and the proximal interphalangeal joints (PIP) and distal interphlangeal joints (DIP) were modeled with 1 degree-of-freedom. The kinematic model for the thumb was also created with 3 links and 4 degrees-of-freedom. The carpometacarpal joint was modeled with 2 degrees-of-freedom and the metacarpophalangeal joint (MCP) and the interphalangeal joint (IP) were modeled with 1 degree-of-freedom.

All of the robotic links can be described with four base parameters. Two of the parameters are used to define the links and two are used to describe their relation with the other links. These parameters are called 'Denavit-Hartenberg' parameters. These parameters are shown in Figure 41 [64].

Figure 41 D-H Parameters
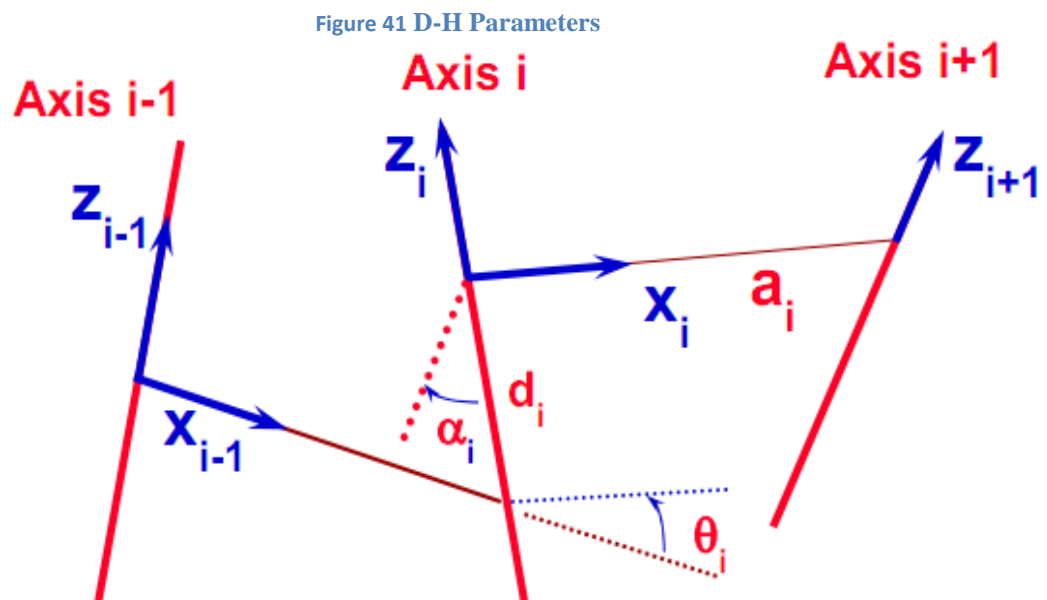
In Figure 40, a_i is the distance between the Z_i axis and the $Zi_{+1 \text{ axis}}$ along the X_i axis, α_i is the angle between the Z_i axis and the Z_{i+1} axis about the X_i axis, d_i is the distance between the X_{i-1} axis and the X_i axis along the Z_i axis, θ_i is the angle between the X_{i-1} axis the X_i axis about Z_i axis.
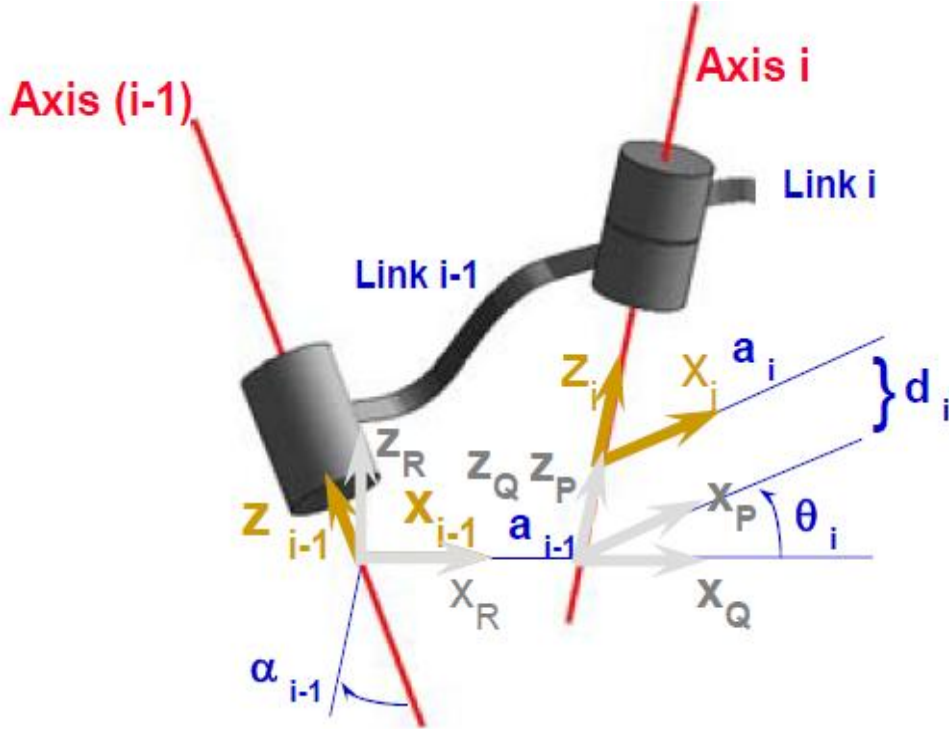
Figure 42 D-H parameters shown for a link [64]

A simple mechanical link is shown in figure 42. D-H parameters are shown at both ends of the link. The transformation matrix for the particular link can be obtain through following steps,

1) Translation along Z_i axis by distance d_i
2) Rotation about Z_i axis by angle θ_i
3) Translation along X_{i-1} axis by distance a_{i-1}
4) Rotation about X_{i-1} axis by angle α_{i-1}

Equation 11 shows the method of calculating the transformation matrix,

$$^{i-1}_{i}T = {}^{i-1}_{R}T.\ {}^{R}_{q}T.{}^{q}_{p}T.\ {}^{P}_{i}T \tag{11}$$

It can also be represented as following,

$$^{i-1}_{i}T\ (\alpha_{i-1},\ a_{i-1},\ \theta_i,\ d_i) = R_x(\alpha_{i-1}).\ D_x(a_{i-1}).\ R_z(\theta_i).\ D_z(d_i) \tag{12}$$

where R_x is the Rotational operator about the X axis, the D_x is the Translation operator along the X axis, R_z is the Rotational operator about the Z axis, D_z is the translation operator along

40

the Z axis. A complete transformation matrix can be obtained by substituting the R_x, D_x, R_z and D_z operators into Equation 12. The final transformation matrix is shown is shown below,

$$^{i-1}_{\;i}T = \begin{bmatrix} \cos(\theta i) & -\sin(\theta i) & 0 & ai-1 \\ \sin(\theta i)\cos(\alpha i-1) & \cos\theta i\cos(\alpha i-1) & -\sin(\alpha i-1) & -\sin(\alpha i-1)di \\ \sin(\theta i)\sin(\alpha i-1) & \cos\theta i\sin(\alpha i-1) & \cos(\alpha i-1) & \cos(\alpha i-1)di \\ 0 & 0 & 0 & 1 \end{bmatrix} \quad (13)$$

The transformation matrix was used to solve direct kinematic equations for the hand assembly. The positions of the finger tips and other joint positions were obtained in the global frame of reference, by substituting the D-H parameters of each finger into the Equation 13. Two different direct kinematic equations one for the finger assembly and one for the thumb assembly were solved for the complete solution.

Direct kinematic equations for the finger assembly:

The D-H parameters were used to define the index, middle, ring and little finger configurations. The four fingers, each consist of three joints: the metacarpophalangeal joint (MCP), the proximal interphalangeal joint (PIP) and the distal interphalangeal joint (DIP). The MCP joint is a universal joint and has 2 degrees-of-freedoms (DoF). This characteristic enables the universal joints to perform two different motions, abduction/adduction and extension/flexion. For calculation purposes, the MCP joint is modeled as two revolute joints with one degree-of-freedom given to each joint. The PIP and DIP are revolute joints with of one degree-of-freedom each.

The D-H parameters were derived for each joint of the finger assembly. Table 7 defines all the D-H parameters of the finger assembly. These values were used to form the transformation matrix for the finger assembly.

Frame	$\alpha i-1$ (deg)	ai-1	di	Θi (deg)
0	0	0	0	$\theta 0$
1	90°	0	0	0
2	0	0	0	$\theta 2$
3	0	L1	0	$\theta 3$
4	0	L2	0	$\theta 4$
5	0	L3	0	0

Table 7: DH parameters of the finger assembly

Here, Link Joints i = 0, 1, 2, 3, 4;

In base frame B and frame 0, values of d_i and α_{i-1} were 0, since the axis Z_B and axis Z_0 were coinciding. Axis X_B and X_0 were intersecting at the origin; hence the distance between them

a_{i-1} was 0. The only variable was the angle between the axis X_B and X_0 that is θ_0. Equation 14 was obtained by substituting these values in the Equation 13.

$$
{}^B_0T = \begin{bmatrix} cos\theta0 & -sin\theta0 & 0 & 0 \\ sin\theta0 & cos\theta0 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \tag{14}
$$

(a)

(b)

(c)
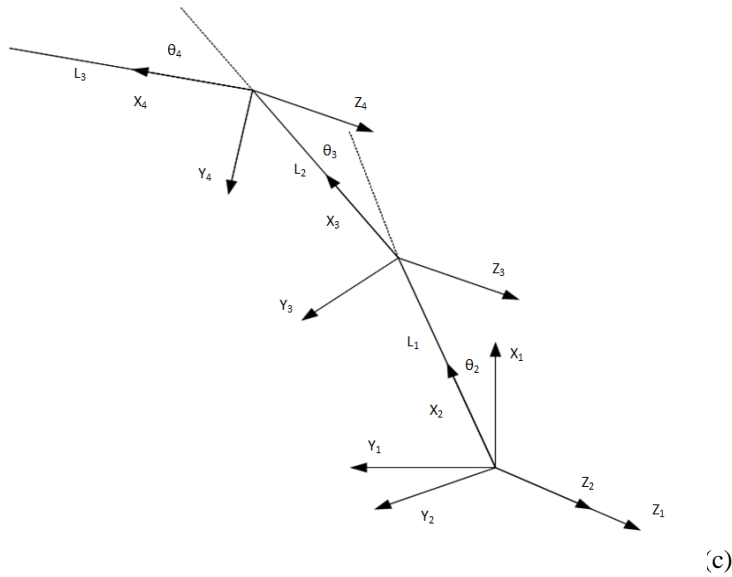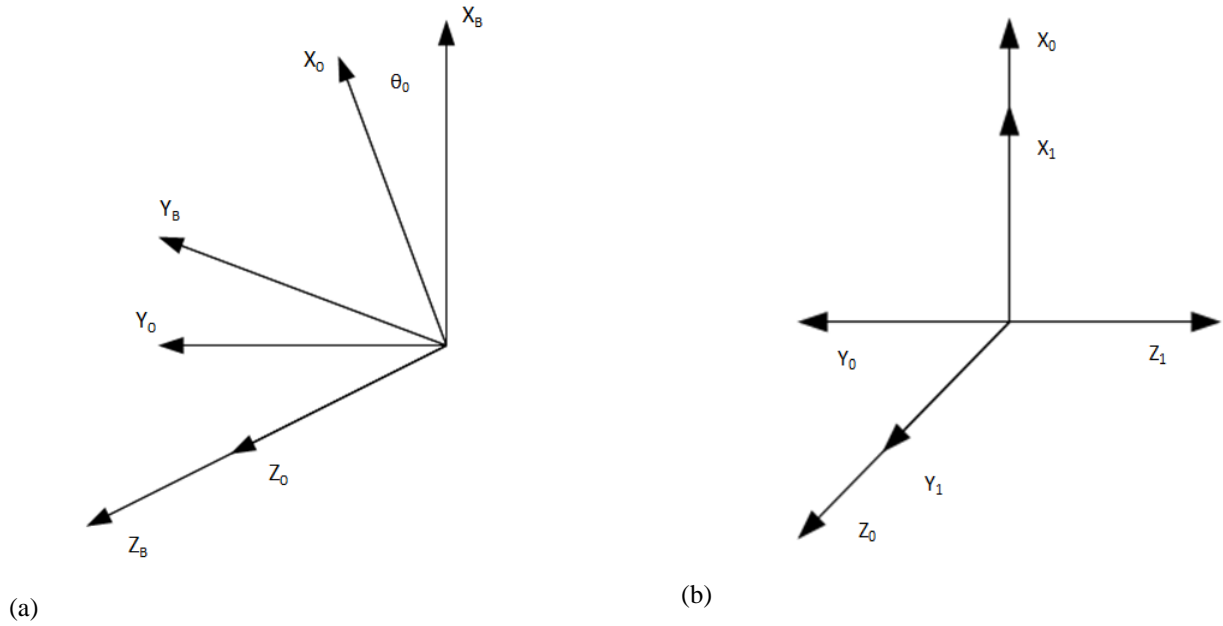
Figure 43: (43a), (43b) and (43c) D-H Parameters for the finger assembly

For frame 0 and frame 1 as shown in Figure 43a, the value α_{i-1} is constant. The axis Z_0 and Z_1 were intersecting at the origin and X_0 and X_1 were coinciding, hence the values of d_i, a_{i-1} and θ_1 were 0. The values of α_{i-1}, d_i, a_{i-1} and θ_1 were substituted in Equation 13 to obtain Equation 15

$$^0_1T = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 0 & -1 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \tag{15}$$

For frame 1 and frame 2 as shown in Figure 43b, values of d_i and α_{i-1} were 0, since the axis Z_1 and axis Z_2 were coinciding. Axis X_1 and X_2 were intersecting; hence the distance between them a_{i-1} was 0. The only variable was θ_i, the angle between the axis X_B and X_0 that was θ_2. The values of α_{i-1}, d_i, a_{i-1} and θ_1 were substituted in Equation 13 to obtain Equation 16.

$$^1_2T = \begin{bmatrix} cos\theta2 & -sin\theta2 & 0 & 0 \\ sin\theta2 & cos\theta2 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \tag{16}$$

For frame 2 and frame 3 as shown in Figure 43c, the value of α_{i-1} was 0, since the axis Z_2 and axis Z_3 were parallel to each other. Axis X_2 and X_3 were intersecting at the origin; hence the distance between them a_{i-1} was 0. The only two variables were θ_i, the angle between the axis X_2 and X_3 that is θ_3 and d_i, the distance between the axis Z_B and axis Z_0 that was L_1. The values of α_{i-1}, d_i, a_{i-1} and θ_i were substituted in Equation 13 to obtain Equation 17.

$$^2_3T = \begin{bmatrix} cos\theta3 & -sin\theta3 & 0 & L1 \\ sin\theta3 & cos\theta3 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \tag{17}$$

For frame 3 and frame 4 as shown in Figure 43c, value of α_{i-1} was 0, since the axis Z_3 and axis Z_4 were parallel to each other. Axis X_3 and X_4 were intersecting at the origin; hence the distance between them a_{i-1} was 0. The only two variables were θ_i, the angle between the axis X_3 and X_4 that is θ_4 and d_i, the distance between the axis Z_3 and axis Z_4 that was L_2. The values of α_{i-1}, d_i, a_{i-1} and θ_i were substituted in Equation 13 to obtain Equation 18.

$$^3_4T = \begin{bmatrix} cos\theta4 & -sin\theta4 & 0 & L2 \\ sin\theta4 & cos\theta4 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \tag{18}$$

To translation operator for the link 3 is shown in Equation 19.

$$^4_5T = \begin{bmatrix} L3 \\ 0 \\ 0 \\ 1 \end{bmatrix} \tag{19}$$

$$^B_5T = {}^B_0T. \, {}^0_1T. \, {}^1_2T. \, {}^2_3T. \, {}^3_4T. \, {}^4_5T \tag{20}$$
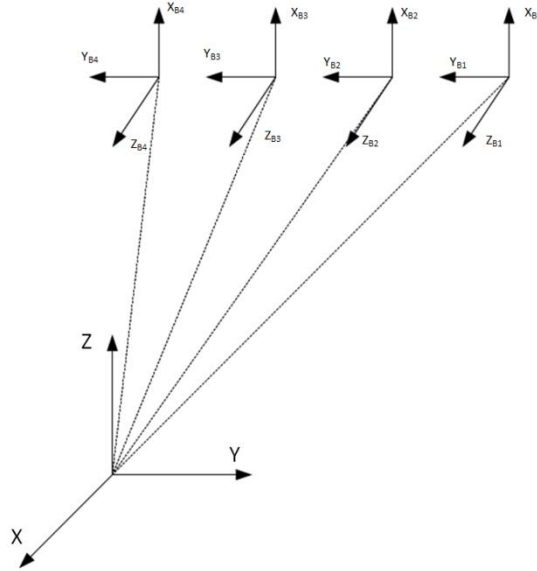
Figure 44: Kinematic configuration of four fingers with respect to Universal frame

Matrix equations 14, 15, 16, 17, 18 and 19 were substituted in equation 20 to solve the direct kinematic equations for position and orientation of each finger assembly. The position of the fingertip with respect to the base reference frame was obtained by using ^B_5T. These individual solutions for the four fingers were mapped into the universal reference frame by further solving the direct kinematics equations. The kinematic configuration of four fingers with respect to the universal reference frame is shown in Figure 44.

The base frame of the finger assembly was denoted as the frame 'B' and the global frame of reference was denoted as the frame 'A'. To obtain the homogeneous transformation matrix $^A_BT_f$ from frame 'B' to frame 'A', first the rotational operator $^A_BR_f$ and translational operator $^A_BP_f$ were calculated. The steps for obtaining the rotational operator are shown in Figure 46. The rotation matrix remained constant for all four fingers.

First the frame was rotated about the Y axis by a +90º angle (using right hand rule), as shown in Figure 45b. In next step, the X axis was negated to change its orientation, as shown in Figure 45c. In the third and last step, the Y axis was negated to change its orientation, as shown in Figure 45d. Equation 21 shows the final value of the calculated rotational operator for frame B.

$$^A_B R_f = \begin{bmatrix} 0 & 0 & 1 \\ 0 & -1 & 0 \\ 1 & 0 & 0 \end{bmatrix} \tag{21}$$

(a)

(c)

(b)

(d)
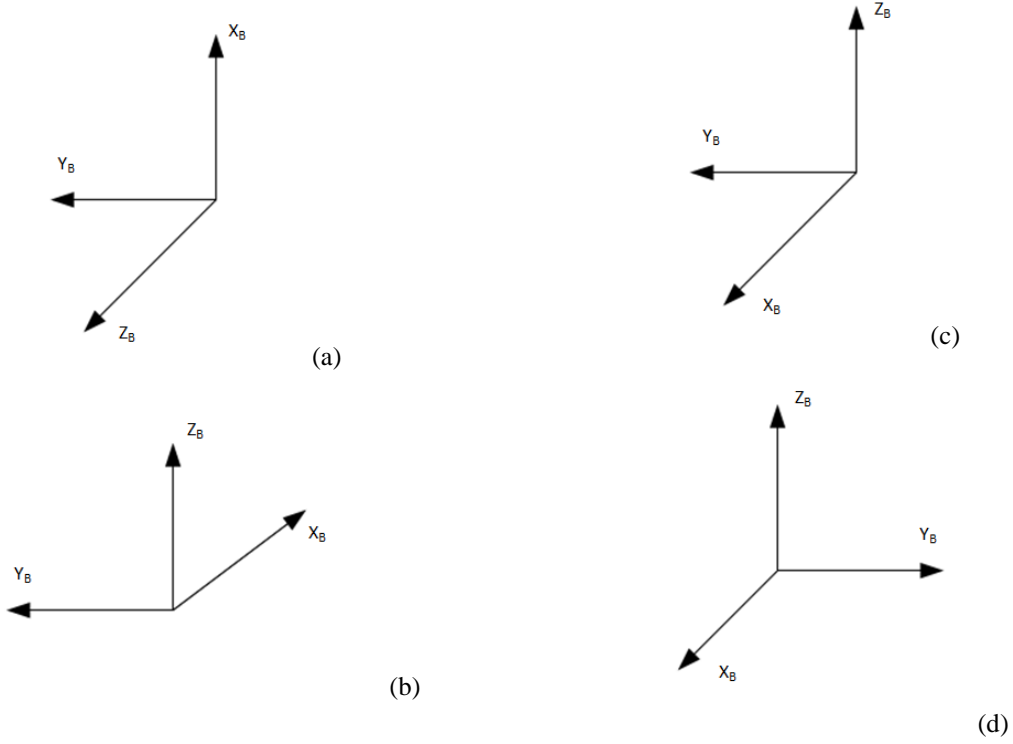
Figure 45: (45a) Base Frame, (45b) Step 1, (45c) Step 2, (45c) Step 3

Also, the translational operator $^A_B P_f$ was calculated for each finger, as shown in equation 22. In Equation 22, the values of X_i, Y_i and Z_i represent the position of the origin of the base reference frame 'B' of each finger with respect to origin of the universal reference frame 'A'.

$$^A_B P_f = \begin{bmatrix} Xi \\ Yi \\ Zi \\ 1 \end{bmatrix} \tag{22}$$

The transformation matrix $^A_B T_f$ was obtained from Equations 21 and 22, as shown in Equation 23.

$$^A_B T_f = \begin{bmatrix} 0 & 0 & 1 & Xi \\ 0 & -1 & 0 & Yi \\ 1 & 0 & 0 & Zi \\ 0 & 0 & 0 & 1 \end{bmatrix} \tag{23}$$

45

Direct Kinematic equations for thumb

The D-H parameters were also used to define the thumb assembly configuration. The thumb assembly consists of three bones, the distal phalanx, the proximal phalanx, and the metacarpal with three joints the carpometacarpal joint, the metacarpophalangeal joint and the interphalangeal joint. The Carpometacarpal joint is a universal joint and has 2 degrees of freedom (DoF). This characteristic enables the universal joint to perform two different motions, abduction/adduction and extension/flexion. The metacarpophalangeal joint (MCP) and interpalangeal joints are revolute joints and have one degree of freedom. The D-H parameters obtained for the thumb assembly were similar to the D-H parameters obtained for the fingers. Hence, the previous direct kinematic equations were used to obtain the thumb tip position and orientation with respect to the given joint angles.

Another homogeneous transformation matrix was developed and solved to obtain the position and orientation of the thumb tip into the universal reference frame. The base frame of the thumb assembly was denoted as the frame 'B' and the global frame of reference was denoted as the frame 'A'. To obtain the homogeneous transformation matrix $^A_BT_t$, the rotational operator $^A_BR_t$ and the translational operator $^A_BP_t$ were calculated. The steps for obtaining the rotation matrix are shown in Figure 47.

The first step was to rotate the base frame 'B' about the Y axis by a +45° angle (using right hand rule), as shown in Figure 46b. Second step was to rotate the base frame 'B' about the Z axis by a -90° angle (using right hand rule), as shown in figure 46c. The obtained the rotational operator is shown in Equation 24.

$$^A_BR_t = \begin{bmatrix} 0 & -1 & 0 \\ 0.7071 & 0 & -0.7071 \\ 0.7071 & 0 & 0.7071 \end{bmatrix} \tag{24}$$

The translational operator $^A_BP_t$ was also calculated. In Equation 25, values of X_t, Y_t and Z_t represent the position of the origin of the base reference frame 'B' of the thumb with respect to the origin of the universal reference frame 'A'. The values of X_t, Y_t and Z_t were obtained from the 3D CAD model of the designed hand.

$$^A_BP_t = \begin{bmatrix} Xt \\ Yt \\ Zt \\ 1 \end{bmatrix} \tag{25}$$

(a)

(b)

(c)
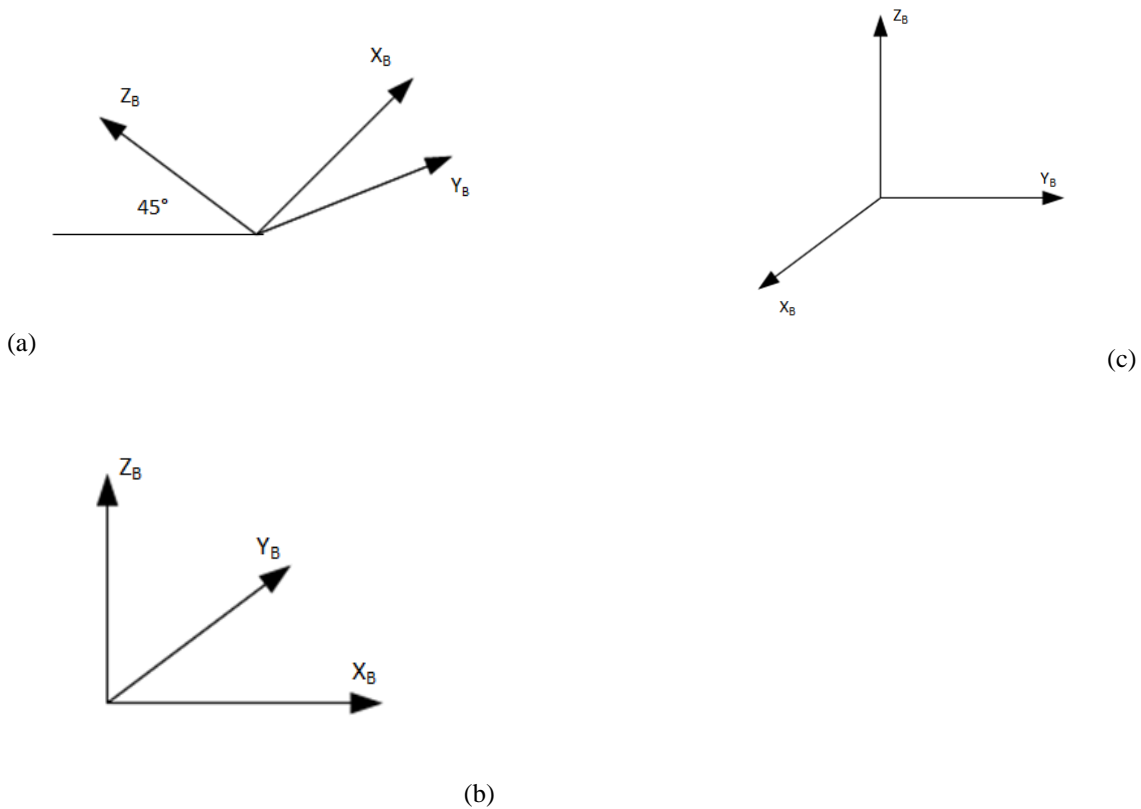
Figure 46: (46a) Base frame, (46b) Step 1, (46c) Step 2

The transformation matrix $^A_B T_t$ was obtained from Equations 24 and 25, as shown in Equation 26.

$$^A_B T_f = \begin{bmatrix} 0 & -1 & 0 & Xt \\ 0.7071 & 0 & -0.7071 & Yt \\ 0.7071 & 0 & 0.7071 & Zt \\ 0 & 0 & 0 & 1 \end{bmatrix} \tag{26}$$

Equations 19, 22 and 25 were used to map the entire joint and the fingertip of every finger and the thumb in the universal frame of reference.

The mapping was done by coding these equations in the LabView/Matlab code, as shown in Figure 51. The angles for each joint were obtained from the derived angle value data based on the ASL letter command. The entire LabView/Matlab code and the angle value data is described in next section. The mapped coordinates for two ASL letters (A and V) are shown in Figure 47. The 3D graphs displayed in Figure 47, show the universal frame of reference origin point and the individual joints. The mapped coordinates are color coded on the 3D graph for the Z-axis. The range of the points is visible on the color scale. In Figure 47, the representation of how the hand would depict the ASL letters can be observed Figure 16. For example, the 'V' shape that would be formed can clearly be seen in Figure 47(b)

47

(a)

(b)
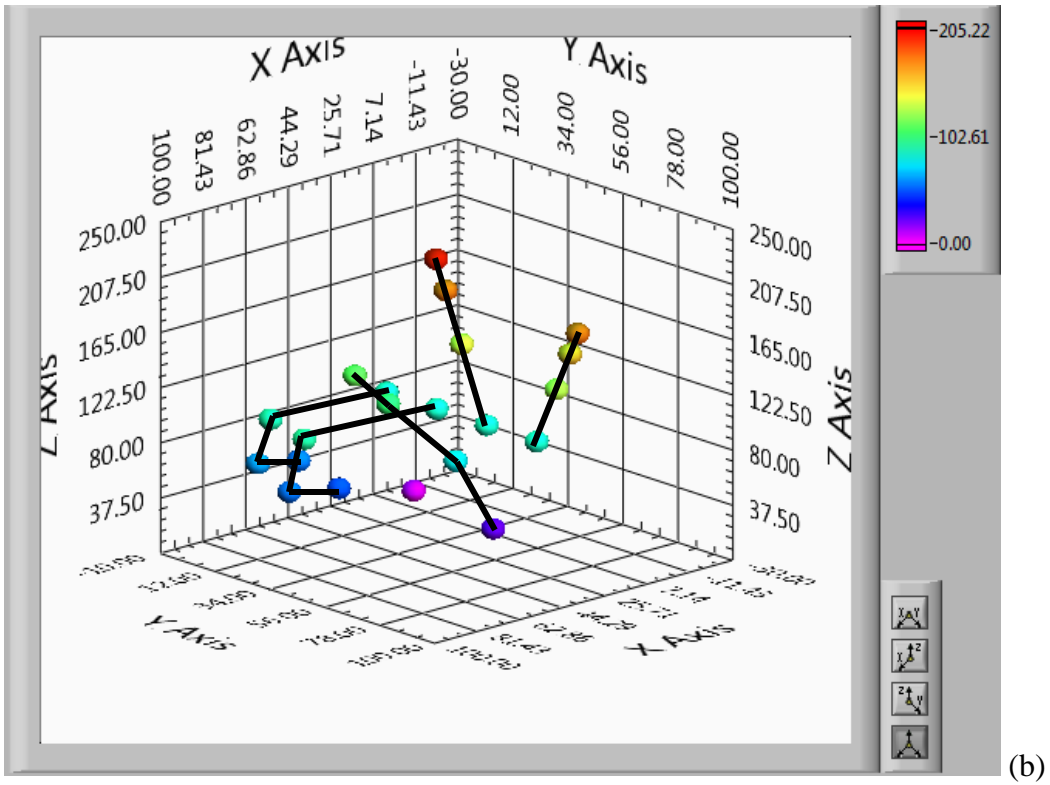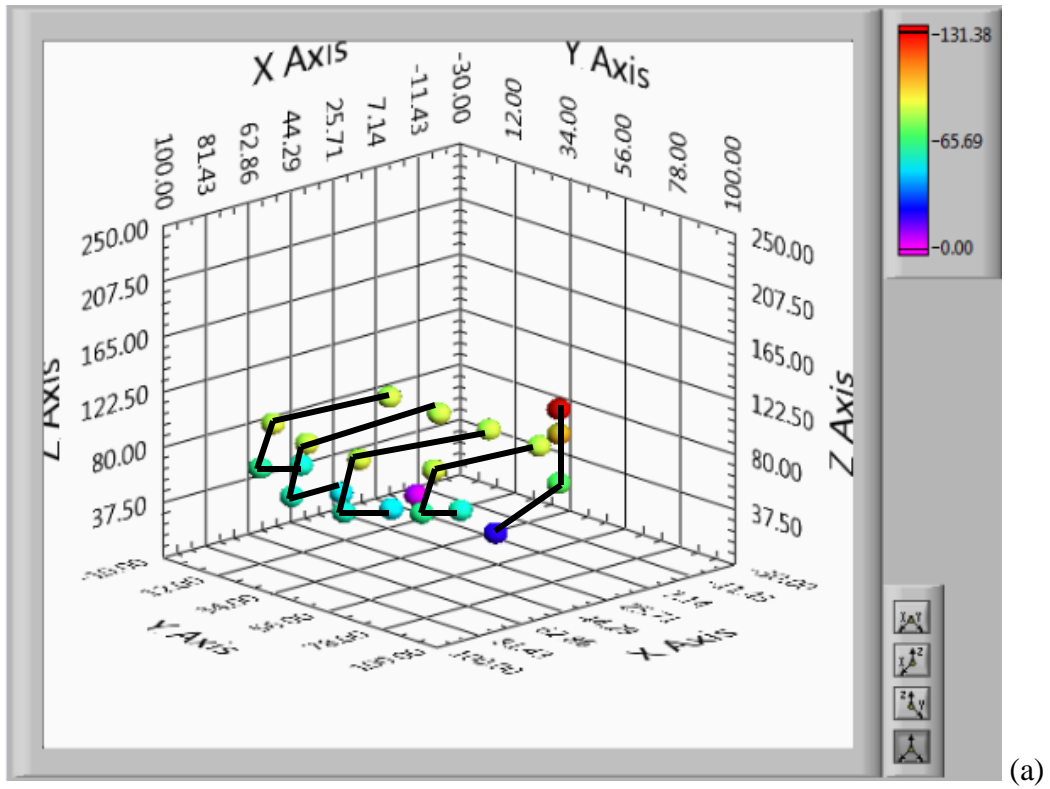
Figure 47: (47a) letter 'A', (47b) letter 'V'.

6. Control System Design

The goal of this project was to develop control software for the designed mechanical hand assembly, based on the kinematic modeling, so that the hand can perform the ASL alphabet. The aim of the software development process was to create an algorithm that could achieve optimum joint motions, while transitioning from one letter another. There are various methods of creating animation from the designed 3D CAD models. These methods are useful to verify the designed assembly and can provide a better understanding of the various joints motions in real life. These methods reduce the requirement of manufacturing assembly parts and subsequently reduce the cost. Also by coupling animation with developed controls software, it can allow for testing of control algorithms prior to manufacturing.

Motion Analysis

Solidworks 3D CAD software is provided with motion analysis tools for developed assemblies. These tools provide motion patterns and forces to designed assemblies so that various parts of the assembly can be moved with respect to each other. The motion analysis can imitate rotary motor motions, forces applied, gravity, and spring action and also can be used to describe the limits on each motion. The motion analysis could also be used to monitor the joint angle velocity. In this project the motion analysis tool was used to provide rotary motion to all 20 joints in the designed mechanical hand assembly.

The designed assembly was imported into the Motion analysis tool. Each joint in the hand assembly was assigned a rotary motor. All the rotary motor directions were defined based on the human hand motion. The PIP joint (joint 2) and the DIP joint (joint 3) in the finger assembly were driven by a single motor each, in a direction perpendicular to the plane of the hand. The MP joint (joint 1) was assigned with two motors, one perpendicular and one parallel to the hand plane.

Together these motors created the extension/flexion and the abduction/adduction motions in the finger assembly. Similar processes were carried out for the thumb assembly. The motor directions in the hand assembly are shown in the Figure 49. Motion analysis tool could easily be interfaced with the external software to develop any desired motion patterns and run time changes could also be made in the required position. In this project the motion analysis was interfaced with LabView softmotion tool to generate desired motion sequence.

LabView Softmotion:

Softmotion is a tool available with LabView software package that can create an interface between a third party software and hardware. This tool provides the user with run time control on the external software and hardware through simple LabView code. The Softmotion tool in LabView can be interfaced with the motion analysis tool in the Solidworks to generate desired motions in Solidworks assemblies to virtually test control algorithms. The interface is shown in Figure 48.

Figure 48: LabView code and Solidworks interfaced through Softmotion
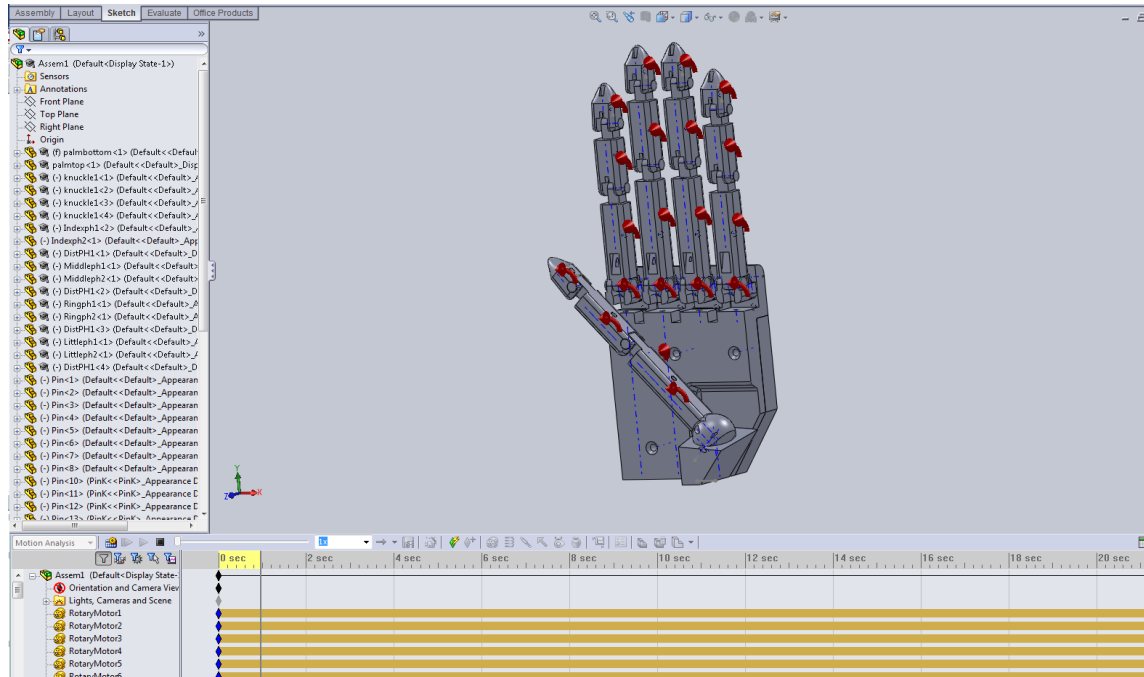
Figure 49: Rotary motor assigned to each joint according to the required motion.

In the motion analysis tool of the Solidworks, a rotary motor was assigned to every joint of the mechanical hand assembly. The assigned motors were designated for constant speed. These motors were imported into the LabView project through the Softmotion tool as a Softmotion axis. The motor axis was connected with the appropriate motion block of the Softmotion tool, in the LabView code, as shown in Figure 50. The angle values were converted into the required angular movements with the assigned angular velocities by the motion block. Twenty motors were assigned to the twenty different joints in the Solidworks hand assembly. These motors were imported into the LabView code, to provide a motion resource for the motion block. Based on observation of a human hand and the available literature, angle values were assigned to every joint of the hand assembly for all 26 letter gestures of the ASL alphabet. The assigned angle values are shown in the Table 9. Based on the selected letter by the user, appropriate angle values were then provided to the Softmotion blocks. Figure 51 shows the straight line move motion block of the Softmotion tool. These blocks were used in the project to interface with each motor in the Solidworks motion analysis. To operate the motion blocks, an execute command was used. Upon the completion of the given task the motion complete signal was obtained from the motion block.
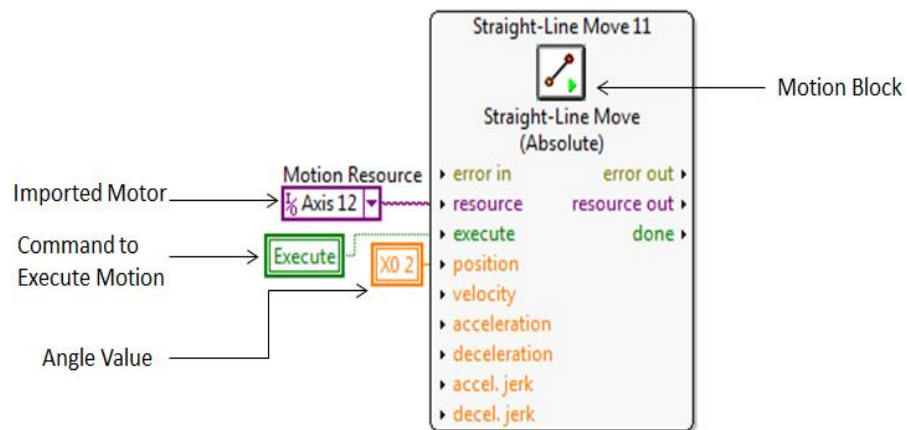
50

For the purpose of this study only static ASL letters were considered, J and Z are considered dynamic signs since these letters require motion of the wrist joint were omitted from this research. Table 8 contains a description of each of the ASL letters that was used to decide joint angles for all four fingers and the thumb.

• A / 10: fist with thumb touching index finger
• B: flat hand with fingers together
• C: curved hand, with thumb apart
• D: lotus hand with pointing index finger
• E: curled fingers with thumb along nails
• F: thumb touching index finger, other fingers straight
• G: thumb and index finger extended, other fingers curled to palm
• H: index and middle finger extended, other fingers curled to palm
• I: fist with pointing pinky finger
• K/P: victory sign with thumb in between index and middle fingers
• L: fist with thumb and index finger apart
• M: thumb tucked in fist between ring and pinky fingers
• N: thumb tucked in fist between ring and middle fingers
• O: thumb touching fingertips
• R: fist with crossed index and middle fingers
• S: fist with thumb folded on index and middle finger
• T: fist with thumb between index and middle finger
• U: fist with pointed index and middle fingers together
• V: fist with pointed index and middle fingers apart
• W: fist thumb touching pinky
• X: fist with hooked index finger
• Y: fist with pinky and thumb extended

Table 8: description of each of the ASL letters [45]

51

		THUMB	INDEX	MIDDLE	RING	LITTLE		THUMB	INDEX	MIDDLE	RING	LITTLE
A	Joint 1	0	0	0	0	0	**B**	0	0	0	0	0
	Joint 2	20	85	85	85	85		20	0	0		0
	Joint 3	25	85	85	85	85		25	0	0	0	0
	Joint 4	0	80	80	80	80		0	0	0	0	0
C	Joint 1	-30	0	0	0	0	**D**	-30	0	0	0	0
	Joint 2	25	45	45	45	45		25	0	45	45	45
	Joint 3	10	45	45	45	45		45	0	45	45	45
	Joint 4	10	10	10	10	10		15	0	10	10	10
E	Joint 1	0	0	0	0	0	**F**	-20	0	0	0	0
	Joint 2	35	45	45	45	45		25	45	0	0	0
	Joint 3	85	85	85	85	85		60	45	0	0	0
	Joint 4	20	80	80	80	80		10	10	0	0	0
G	Joint 1	-30	0	0	0	0	**H**	-20	0	0	0	0
	Joint 2	20	85	85	85	85		45	0	0	85	85
	Joint 3	0	0	85	85	85		85	0	0	85	85
	Joint 4	0	0	80	80	80		0	0	0	80	80
I	Joint 1	-20	0	0	0	0	**J**	-20	0	0	0	0
	Joint 2	10	85	85	85	0		10	85	85	85	0
	Joint 3	80	85	85	85	0		80	85	85	85	0
	Joint 4	0	80	80	80	0		0	80	80	80	0
K	Joint 1	-10	0	0	0	0	**L**	0	0	0	0	0
	Joint 2	10	0	45	85	85		0	0	85	85	85
	Joint 3	45	0	0	85	85		0	0	85	85	85
	Joint 4	0	0	0	80	80		0	0	80	80	80
M	Joint 1	-10	0	0	0	0	**N**	-10	0	0	0	0
	Joint 2	45	75	75	75	85		30	75	75	85	85
	Joint 3	85	75	75	75	85		60	75	75	85	85
	Joint 4	10	10	10	10	80		10	10	10	80	80
O	Joint 1	-30	0	0	0	0	**P**	-10	0	0	0	0
	Joint 2	25	60	60	60	60		10	0	45	85	85
	Joint 3	45	45	45	45	45		45	0	0	85	85
	Joint 4	45	10	10	10	10		0	0	0	80	80
Q	Joint 1	-30	0	0	0	0	**R**	-20	15	-5	0	0
	Joint 2	20	85	85	85	85		45	20	0	85	85
	Joint 3	0	0	85	85	85		45	0	0	85	85
	Joint 4	0	0	80	80	80		0	0	0	80	80
S	Joint 1	-20	0	0	0	0	**T**	0	-10	0	0	0
	Joint 2	30	85	85	85	85		20	60	85	85	85
	Joint 3	45	85	85	85	85		25	80	85	85	85
	Joint 4	45	80	80	80	80		0	45	80	80	80
U	Joint 1	-20	0	0	0	0	**V**	-20	-10	10	0	0
	Joint 2	45	0	0	85	85		45	0	0	85	85
	Joint 3	85	0	0	85	85		45	0	0	85	85
	Joint 4	0	0	0	80	80		0	0	0	80	80
W	Joint 1	-10	-10	0	10	0	**X**	-20	0	0	0	0
	Joint 2	45	0	0	0	85		30	0	85	85	85
	Joint 3	45	0	0	0	85		45	45	85	85	85
	Joint 4	0	0	0	0	80		0	45	80	80	80
Y	Joint 1	0	0	0	0	0	**Z**	-20	0	0	0	0
	Joint 2	0	85	85	85	0		30	0	85	85	85
	Joint 3	0	85	85	85	0		45	0	85	85	85
	Joint 4	0	80	80	80	0		0	0	80	80	80

Table 9: Joint angles for each ASL letter

The angle values as shown in Table 9 were then stored in the LabView code to be used with Softmotion. The developed kinematic model for the designed mechanical hand was then used to develop a Matlab code; to map all the joint positions of the designed hand assembly into one universal frame of reference. The Matlab code was then imported into the developed LabView code. This method was used to provide run time input value changes in the Matlab code and subsequently increase the speed of the LabView program by reducing the size. To map the joint positions of the entire mechanical hand into the universal frame of reference, the stored angle values of the hand gesture of each the ASL letters were provided to the Matlab code as input variables. The joints and finger tips positions in the mechanical hand were predicted for the starting and end gesture by application of this method. This information could be used as a base for the motion pattern decision making in the LabView code. The entire Matlab code and its input variables are shown in the Figure 51. In Figure 51, X_0, X_2, X_3, X_4 are the four input angle values for a finger assembly. These values are dependent on the ASL letter and the particular finger assembly. The shown Matlab code calculates the coordinates of each joint and fingertip using derived kinematic Equation 19. The calculated coordinate values are in the form of array output. The generated outputs are T_1, T_2, T_3 and Z_1.

MATLAB script

```
%syms X0 X1 X2 X3 X4 L1 L2;
L1 = 51;
L2 = 32;
X0 = (X0*pi/180);
X2 = (X2*pi/180);
X3 = (X3*pi/180);
X4 = (X4*pi/180);
Z = [0 0 1 20; 0 -1 0 7.5; 1 0 0 90; 0 0 0 1];
A = [cos(X0) -sin(X0) 0 0; sin(X0) cos(X0) 0 0; 0 0 1 0; 0 0 0 1];
B = [1 0 0 0; 0 0 -1 0; 0 1 0 0; 0 0 0 1];
C = [ cos(X2) -sin(X2) 0 0; sin(X2) cos(X2) 0 0; 0 0 1 0; 0 0 0 1];
D = [ cos(X3) -sin(X3) 0 L1; sin(X3) cos(X3) 0 0; 0 0 1 0; 0 0 0 1];
E = [ cos(X4) -sin(X4) 0 L2; sin(X4) cos(X4) 0 0; 0 0 1 0; 0 0 0 1];
T1 = A*B*C*[L1;0;0;1];
T2 = A*B*C*D*[L2;0;0;1];
T3 = A*B*C*D*E*[19;0;0;1];
T1 = Z*T1;
T2 = Z*T2;
T3 = Z*T3;
Z1 = Z*[0;0;0;1];
```

Input Angle Values

Output coordinate value array

Figure 51: Matlab Code within LabView program

The developed joint angles as shown in Table 9 were used for understanding the hand assembly positions for simulating ASL. All the ASL letter joint angles were observed and compared with each other to formulate a relation between them. Several ASL letters showed similar joint angles and posture of the fingers while a few letters in the ASL alphabet had identical finger positions for some of the fingers. To assess these relations and the complexity of the transitioning from one letter to another, a detailed chart of position transition was created for each ASL letter and transitioning from that letter to every other letter [Appendix C]. This process was carried out for all 26 letters in the ASL alphabet. These charts were analyzed to identify the simple, complex and no transition sets for all the ASL letters. For example, the joint angle transition from the letter A to the letter B vs the letter M

53

is shown in Table 10. The transition from letter A to letter B is simple than transition of letter A to letter M, since there is a possibility of interference of the moving fingers when going from A to M. Based on the results of the comparison study, an algorithm was developed to guide the software development. The algorithm is shown in Figure 54. In Table 10 values of the joint angles of each finger are shown. Each cell in the Table 10 shows two angle values (eg. 20—20). The value on the left is initial value and the value on the right is final value. Angle values are stored in degrees.

A->B	THUMB	INDEX	MIDDLE	RING	LITTLE	A->M	THUMB	INDEX	MIDDLE	RING	LITTLE
JOINT 1	0--0	0--0	0--0	0--0	0--0	JOINT 1	0--(-10)	0--0	0--0	0--0	0--0
JOINT 2	20--20	85--0	85--0	85--0	85--0	JOINT 2	20--45	85--75	85--75	85--75	85--85
JOINT 3	25--25	85--0	85--0	85--0	85--0	JOINT 3	25--85	85--75	85--75	85--75	85--85
JOINT 4	0--0	80--0	80--0	80--0	80--0	JOINT 4	0--10	80--10	80--10	80--10	80--80

Table 10: Transition of joint angles from one letter to the other

A complete LabView code was then created, using the developed algorithm as shown in Figure 54. The developed LabView software was then interfaced with the Solidworks hand assembly. The code and interface consisted of a total of 20 motion axes. The software was designed such way that it could move all the 20 joints of the designed mechanical hand assembly simultaneously. This method was applied to achieve a synchronized motion of all the joints in the finger assembly. The synchronized motion of 20 joints using the LabView/Softmotion interface has not been done to date [Personal communication with LabView support].

The software developed in the LabView programming platform is divided into to two parts, the front panel and the block diagram. The front panel was designed to provide all the controls for the model and to display model outputs. As shown in the Figure 52, a typed letter is an input and the associated ASL letter is shown on the front panel. The entire three dimensional graph of the hand geometry is also provided on the front panel. All the coordinates of the entire hand assembly are displayed in the graph based on the input command letter. All the numerical values of the X, Y and Z coordinates of every joint are also shown on the front panel. The complete interface and Solidworks model is shown in the Figure 53.

Although the synchronized motion of the hand proved to be an effective method for demonstrating dexterity, it was observed that this method demands exceptionally high computational capabilities. These requirements were one of the reasons for failure of the LabView and Solidworks interface for certain cases.
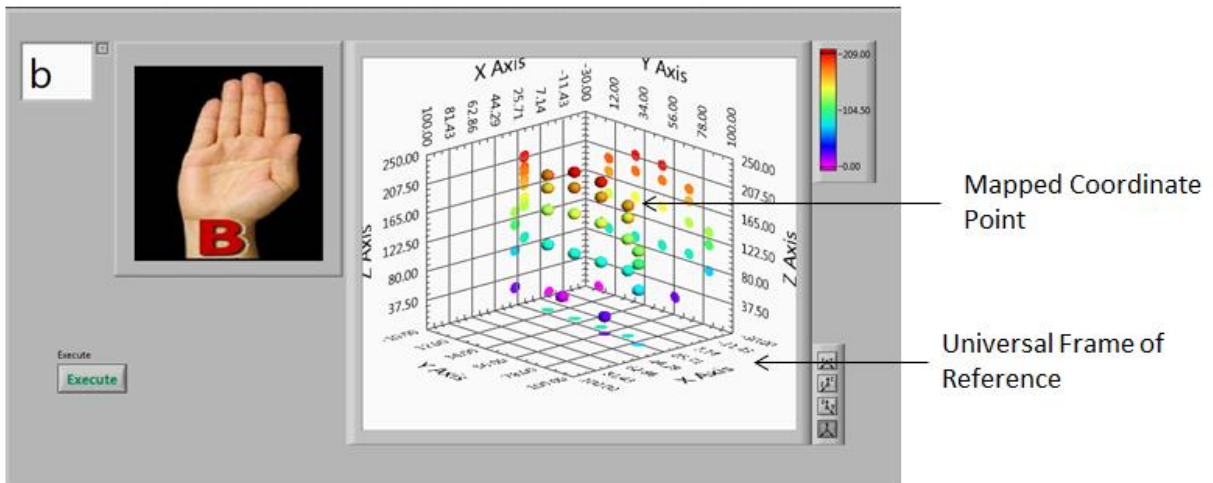
Figure 52: Front panel of the developed LabView Software
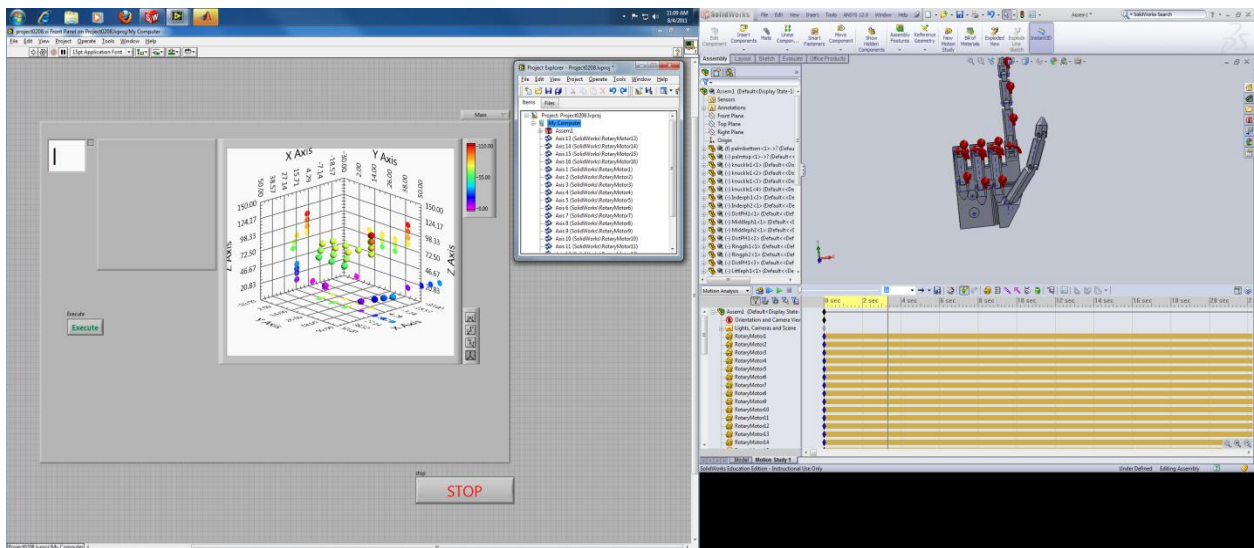
Figure 53: LabView code and Solidworks assembly

Steps of the LabView program:

The interface between the LabView code and the Solidworks assembly is activated first before running the program. This is carried out by switching the scan engine into the active mode. Once scan engine is switched to active, deploys all the motion axes from the LabView code to Solidworks assembly. After every softmotion axis is deployed by the scan engine into the Solidworks assembly, a run command is given to the LabView code. Once in run mode, the program will first look for a letter command. If the command box is empty, it will

read it as a default value, which is letter a in this condition. The default value can be set to any desired letter.

When provided with a letter value in the command box, the LabView code reads it and plays a corresponding audio file. Based on the provided letter, a set of all the joint angle values is selected from the stored ASL angle value data in LabView code. These angle values are used to perform the kinematic calculations to obtain the X, Y and Z coordinates of each joint and the finger tips of the designed mechanical assembly. The coordinate values are displayed in the 3D graph on the front panel.

The LabView program then checks for the execute command. If the command is false, the program will not perform any operation. If the command is true, program will compare the current thumb position with respect to all four fingers. The comparisons can be carried out by using either joint coordinates or the angle values itself. The results of the comparisons are divided into three different cases.

Case 1: The thumb is away from the fingers.
Case 2: The thumb is placed above one or multiple fingers.
Case 3: The thumb is placed below one or multiple fingers.

In the first case, the beginning letter will have no interference between the thumb and the fingers when transitioning between letters such as A, B, C, I, L etc. In this case all the joints in the hand assembly are moved to the intermediate optimum position simultaneously. These letters are simpler to simulate. In the second case, the thumb will be first moved to an optimum position first, and then the fingers are moved. Examples of this case are letters such as I, R, S, U, V. In the last case, the fingers will be moved to the optimum position followed by the thumb and any remaining fingers. Examples of this case are letters such as E, M, N, T.

The optimum positions for all the fingers and the thumb can be decided based on the designed assembly. Once all the joints reached the optimum position, the LabView program will check for the desired angle values. These values are obtained from the letter provided in the command box. The values of the thumb and the finger positions are calculated based on the input angle values [Table 9]. Once the positions are assessed, the motion to the hand assembly will be given in following steps.

1) Move the fingers placed below the thumb to the required position
2) Move the thumb to the required position
3) Move the fingers placed above the thumb to the required position

Once the motion is complete, the LabView will follow the entire process again until it is ended. LabView/Softmotion provides the necessary feedback when the desired positions are achieved. To end the LabView program a stop control was provided on the front panel. The complete flow chart is shown in Figure 54.

Flow chart:

```
                          ( Start )
                              |
                              v
                   +----------------------+
                   | Read the             |
                   |                      |
                   | Alphabet Command     |
                   +----------------------+
                              |
                              v
                         /         \
                        /    If     \  ----[ Yes ]----------------------+
                        \  Default  /                                   |
                         \         /                                    |
                              |                                         |
                          [ No ]                                        |
                              |               +----------+             |
                              |               |          |             |
                              v               v          |             |
              +------------------------+  +------------------+         |
              | Select the appropriate |  | Play the         |         |
              | angle values from stored|  | Audio File       |         |
              | data                   |  +------------------+         |
              +------------------------+                               |
                              |                                        |
                              v                                        |
              +------------------------+                               |
              | Perform Kinematic      |                               |
              | Calculations to obtain |                               |
              | position coordinate values|                            |
              +------------------------+                               |
                              |                                        |
                              v                                        |
              +------------------------+                               |
              | Display the 3D graph of|                               |
              | position coordinates   |                               |
              +------------------------+                               |
                              |                                        O
                              v
                           ( A )
```
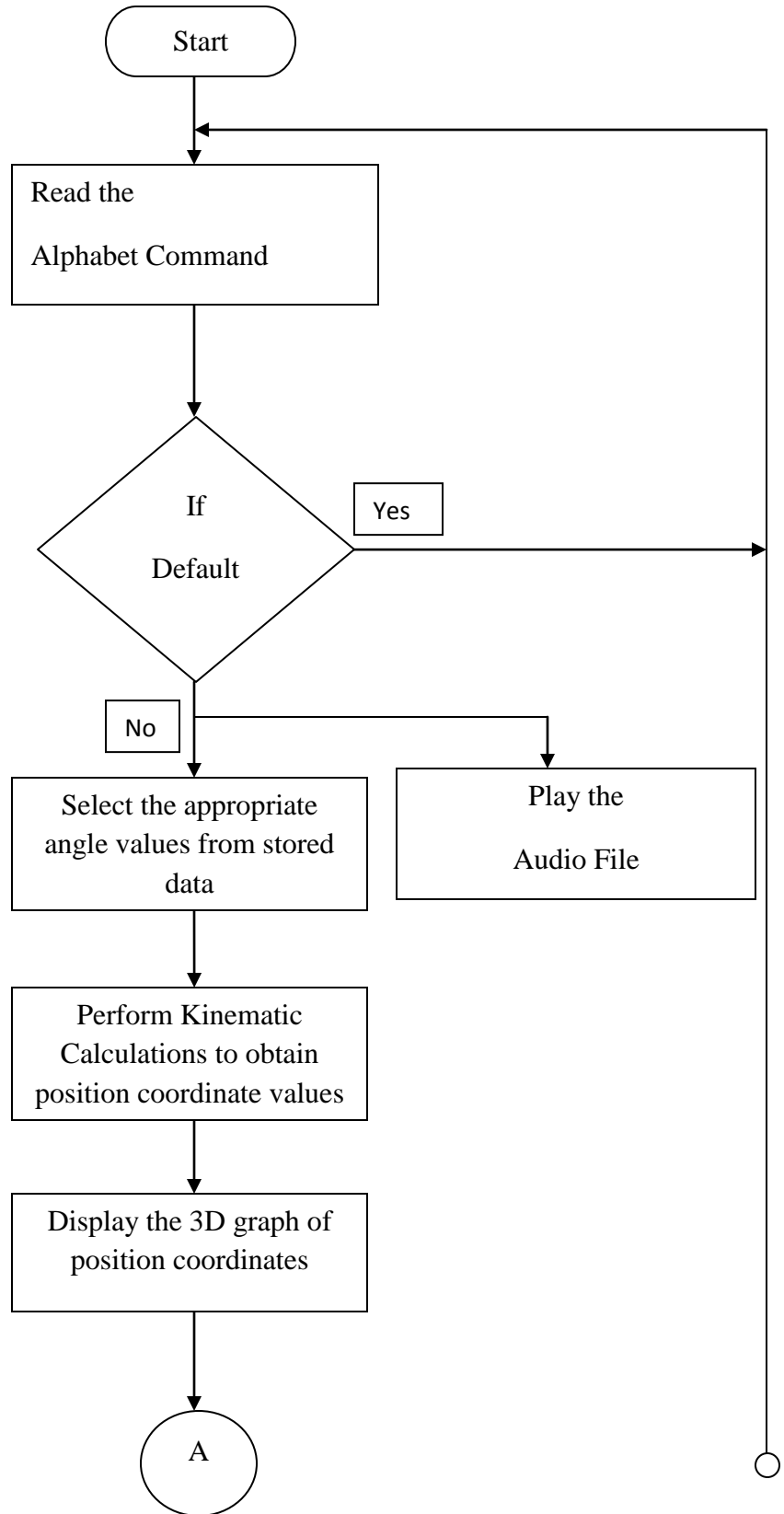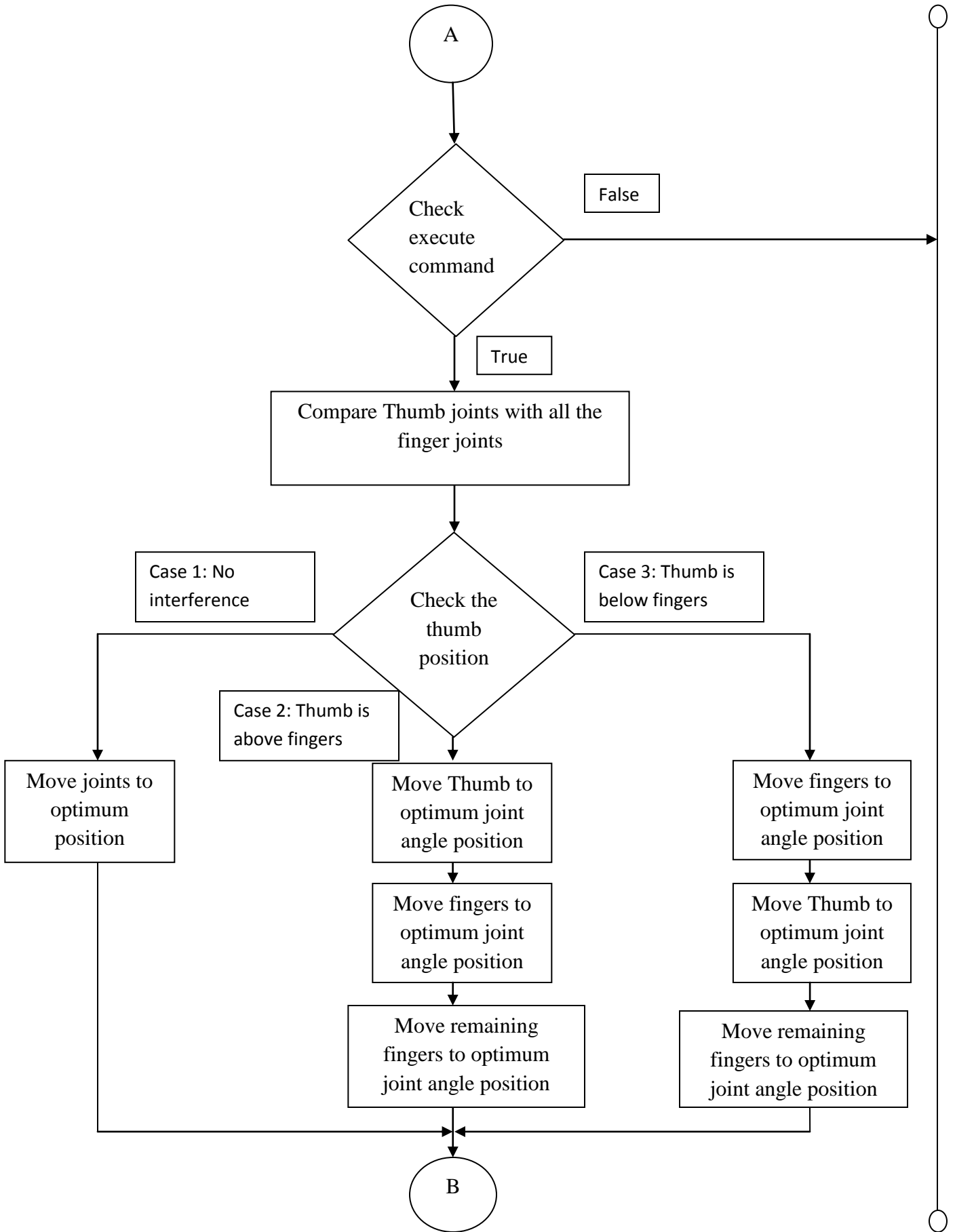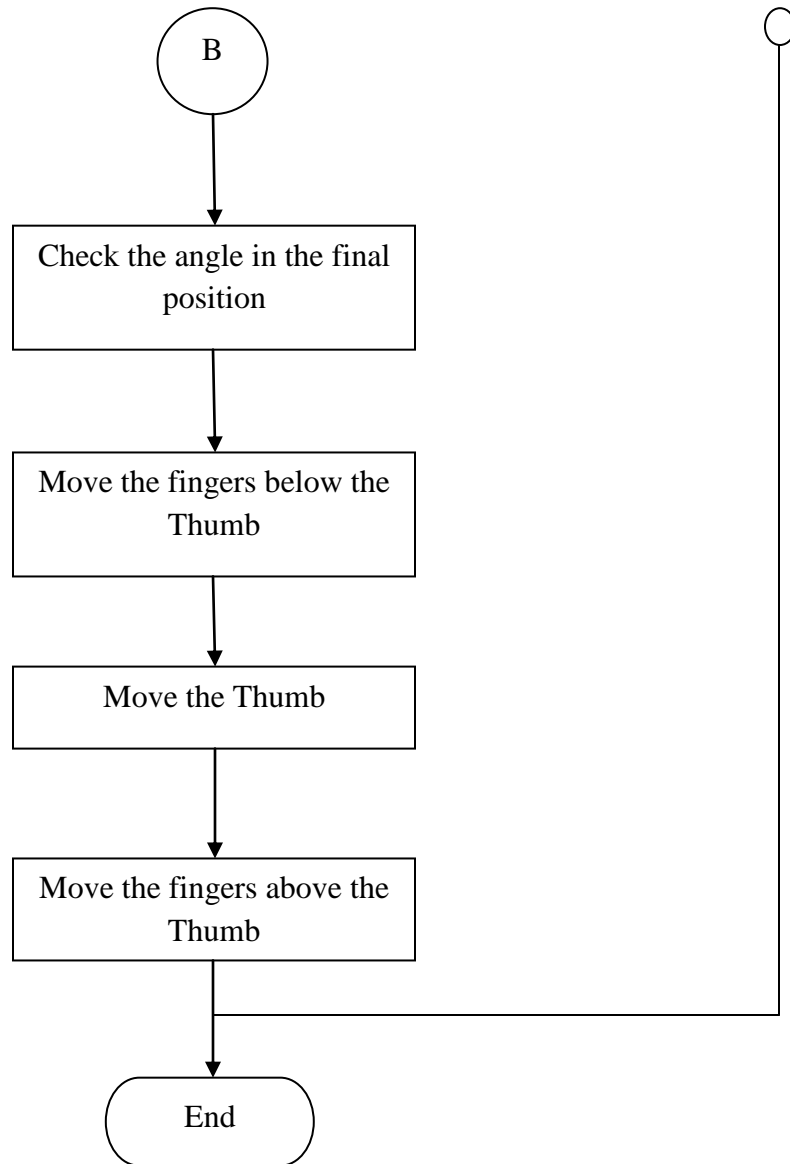
Results

The interface between the LabView code and the Solidwork assembly was successfully developed. Synchronized motion of all 20 joints in the Solidworks hand assembly was achieved. Although the interface was achieved, it was observed that the required processing capacity of the hardware was very high. To achieve the two directional motion of the spherical joint is very difficult. Due to these limitations of the interface, the Solidworks and the LabView software, complete simulation of the hand assembly was not achieved. The successful simulation of the letters A, B, Y and L is shown in the Figure 55 and Figure 56. A case where failure occurred is shown in the Figure 56.
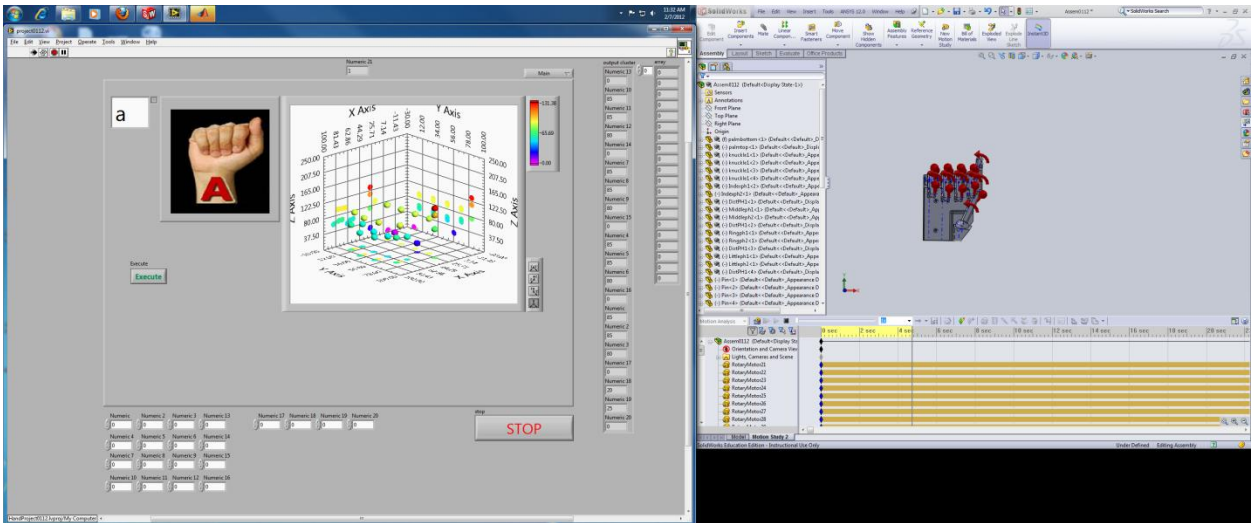
(a)
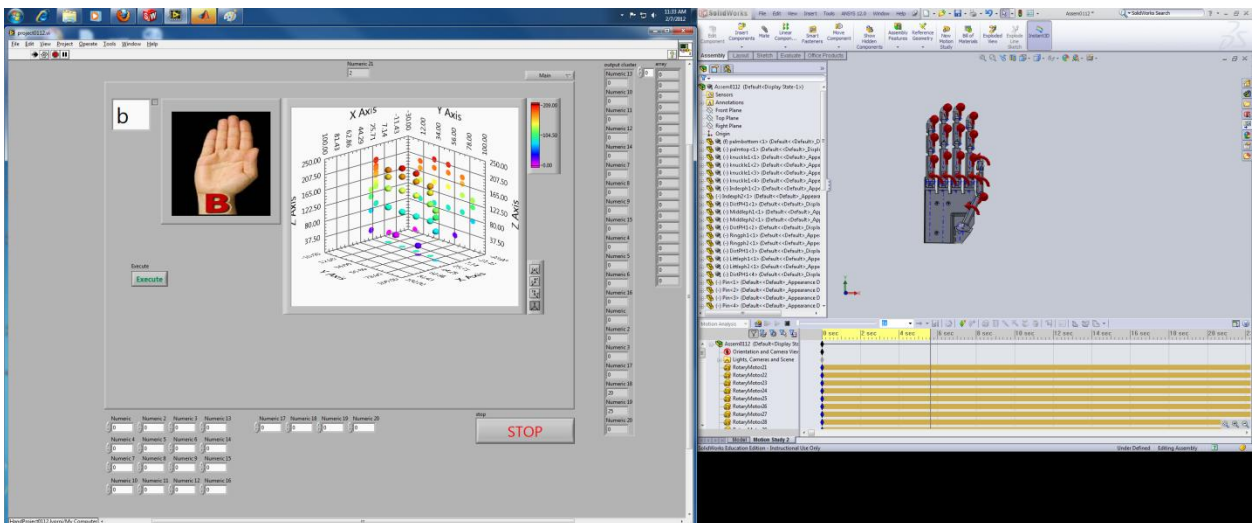
(b)

Figure 55 : (55a) Letter A, (55b) Letter B
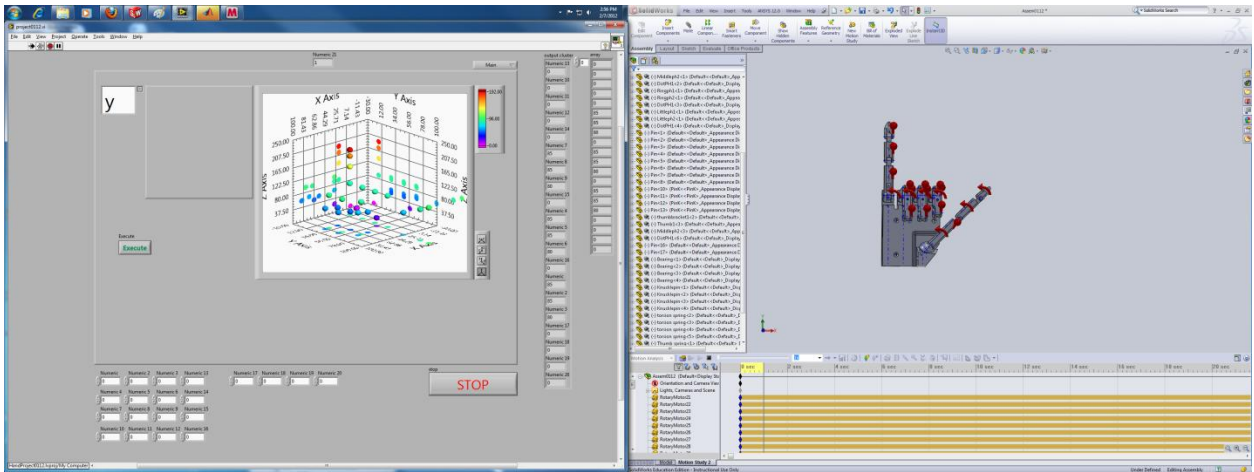
(c)
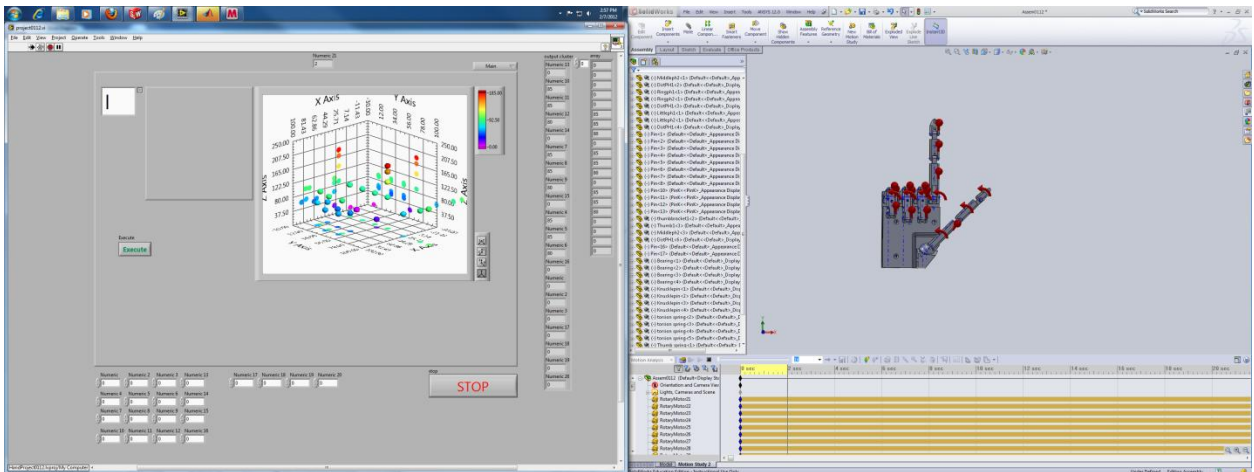
(d)

Figure 56: (56a) Letter Y and (56b) Letter L
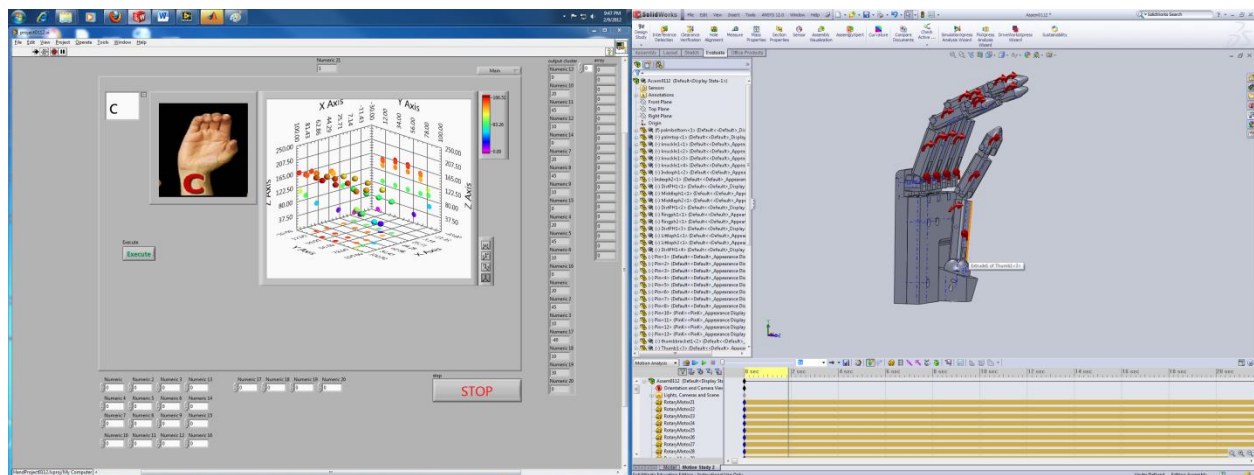
Figure 57: Letter C, simulation failed at CMC joint of the thumb

61

Transition of the mechanical hand assembly from its base position to letter A and from letter A to letter B is shown sequentially in Figures 58 to 63. These figures show that the in between transition only the required joints are moving to achieve the final position. It can also be observed from the Figures that all the motions were occurring simultaneously. For example it can be seen in Figures 60 to 63, that the from letter A to letter B only fingers are moving from their curled position to complete extension. Letters A and B are the accurate depiction of the ASL alphabet as shown in Figure 16.
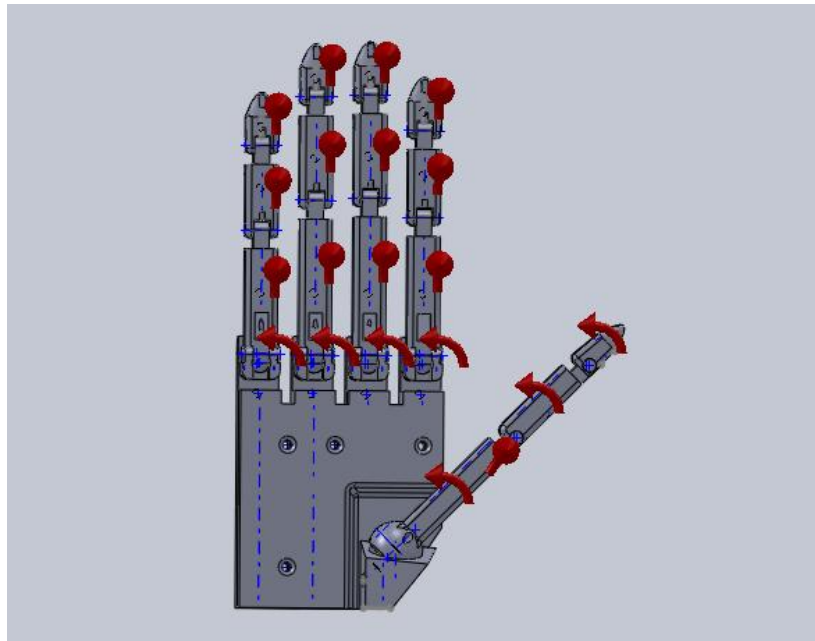
Figure 58 : Base Position for the simulation
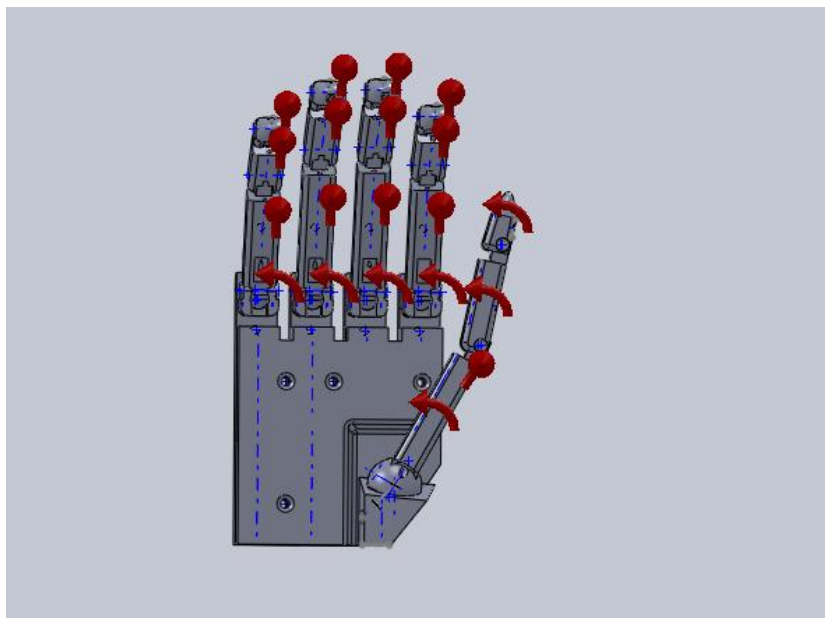
Figure 59 : Intermediate position between base and letter A
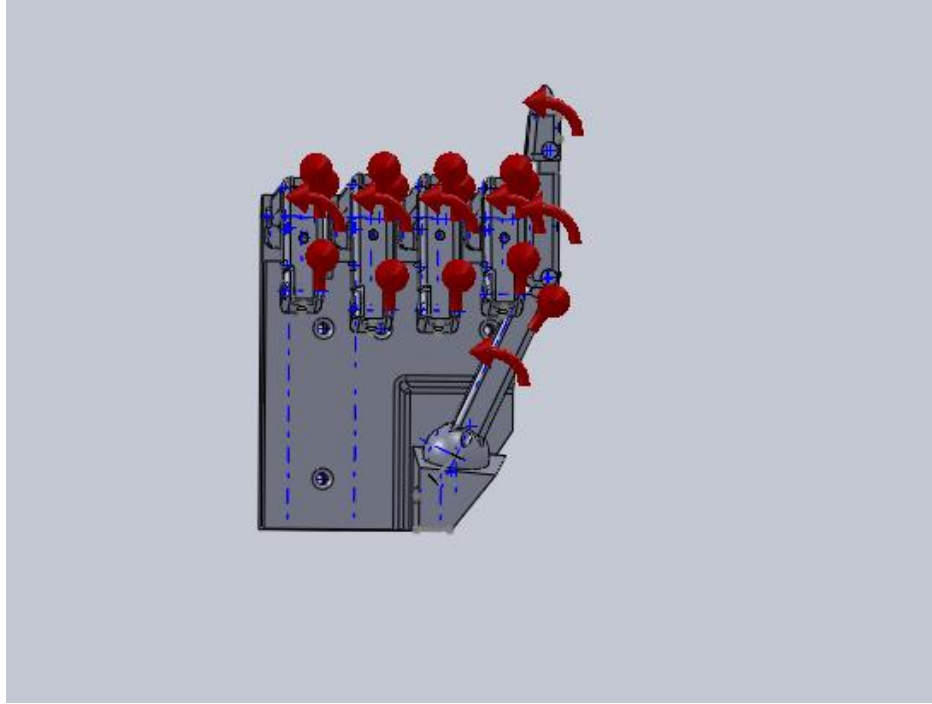
Figure 60 : Letter A
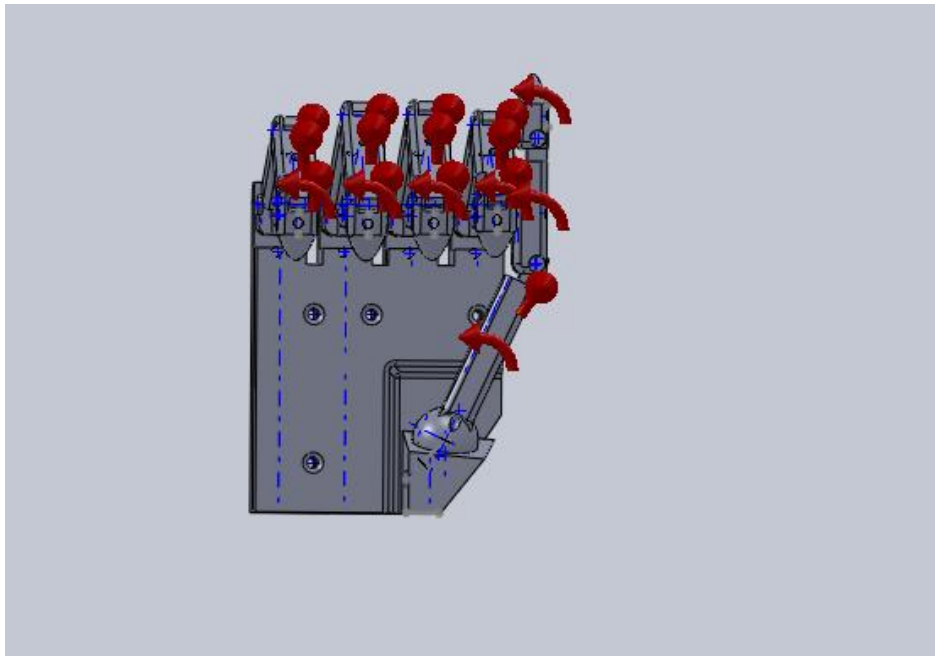
Figure 61 : First intermediate position between Letter A and Letter B
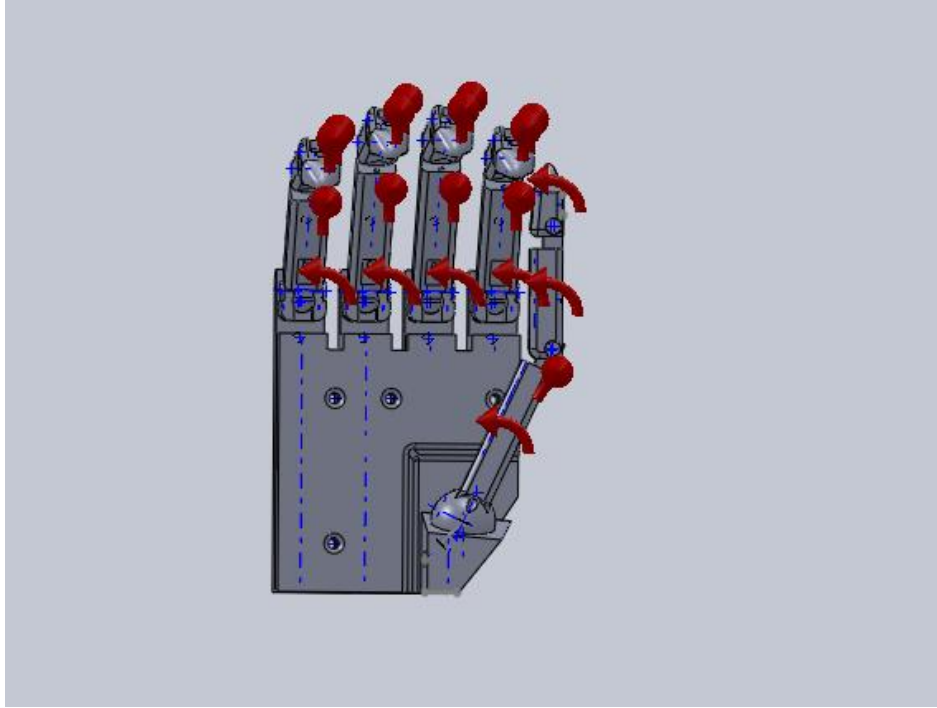
Figure 62 : Second intermediate position between letter A and letter B
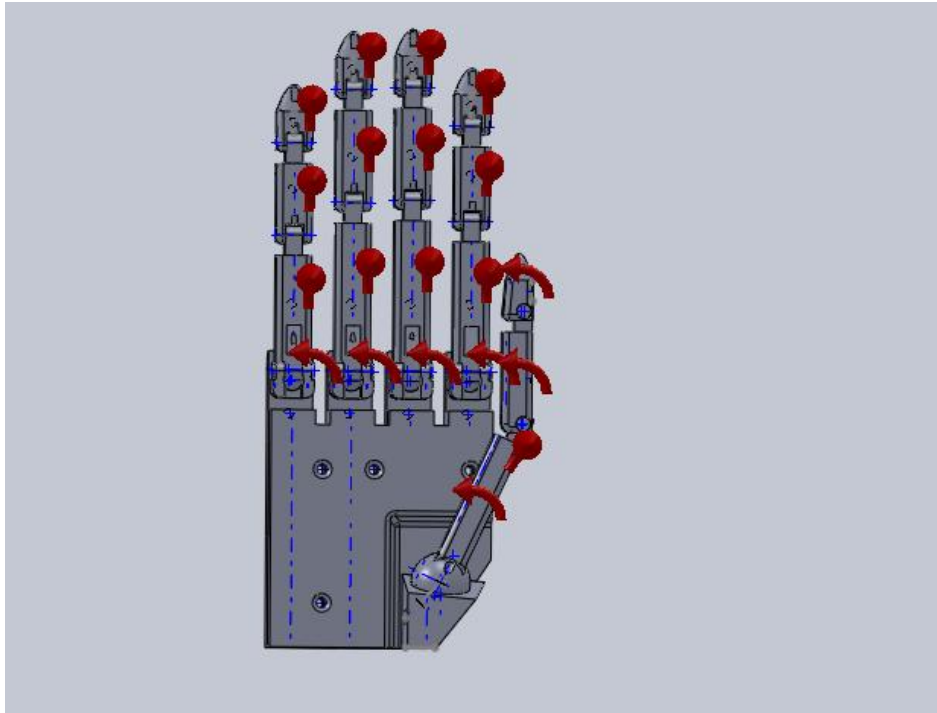
Figure 63 : Letter B

7. Discussion

The main aim of this mechanical hand design project was to study the human hand and its dexterity. The gathered knowledge was applied to develop a design that can imitate its human counterpart. Performing sign language letters requires a variety of human hand motions and some intricate positioning of the fingers. Hence the application of American Sign Language letters was used as a standard to map the dexterity of the designed mechanical hand.

Many of the recent designs are developed with a five finger hand assembly. These developed designs were dimensionally very alike to their biological counterpart. The goal of this project was to develop a design with similar dimensions while maintaining simplicity and low manufacturing cost. During the course of the project a mechanical hand was designed with a total of 20 degrees of freedom (DOF), providing 4 degrees of freedom in each finger and thumb. Intricate mechanical designs of the systems lead to the requirement of complex manufacturing processes and subsequently higher manufacturing costs. To avoid this in future, the thesis design was developed with comparatively easier manufacturing demands and simpler assembly requirements. The developed design could be manufactured within the RIT facility using rapid prototyping techniques or any other standard machining processes. Several fingers were rapid prototyped to check the manufacturability and the scalability of the designed mechanical hand.

Most of the joints in the human hand have interdependencies on other joints. This structure restricts the free motion of the individual joints. All the joints in the mechanical assembly were designed to be operated with an individual actuator, without creating any mechanical interdependencies. This simplified the mechanical design and made it easy for manufacturing and assembly. Human hand interdependencies can still be provided by incorporating them throug the control software.

One of the most recent and most well designed mechanical hands was developed by Shadow Robot Company [63]. The Shadow Hand designs are very close to the biological human hand in terms of the dexterity and the speed. The Shadow Hands have been developed with various actuation mechanisms. For the purpose of this design project the Shadow hand was considered as a bench mark. The hand designed during this project compares very closely with the Shadow hand in terms of number of fingers, dexterity and actuation method. Both hands have tendon driven actuation mechanisms with individual joint actuation. Though there are many similarities, the RIT hand does lack some of the abilities of the Shadow hand. The wrist joint is one of the differences between the two designs. The hand developed by shadow robotics has a wrist joint with 2 degrees of freedom. However, the developed RIT hand design is a major step up from the many of the previous designs developed in the past. These designs include designs like the UB hand [5], the BUAA hand [8] or other hands

previously designed at RIT. The advantages the new hand design has over these previously designed hands are its dexterity, number of fingers, and the ease of manufacturing.

A study of American Sign Language letters was conducted. Based on the observations of the human hand positions for every letter a complete set of hand joint angles was developed for every American Sign Language letter. The developed sets of joint angles provide a better picture of the range of the human hand motion and the dexterity of the human hand. This data can be used to learn the frequency of the certain angle values and the frequency of certain positions of the human hand. This set was verified against the designed mechanical hand using Solidworks 3D modeling software. The verified data was used to develop a matrix of joint angle values transitioning from one letter to other. The developed data set could be utilized for the future algorithm developments for hand controls, where the finger collision needed to be avoided during the transitions.

The developed mechanical hand consists of 20 individual joints and 20 degrees of freedom. To map the positions of every individual joint and finger tips in one universal frame of reference, a complete kinematic model was created using forward kinematics. The developed kinematic model of the mechanical hand and the documented joint angle data were used to create LabView software, to map all the calculated joint points in a 3D graph. The developed LabView software was interfaced with the Solidworks 3D model using the Softmotion tool for the LabView. The complete interface between LabView and Solidworks for 20 joints was a key unique aspect of the project since the interface had not previously been implemented for such a large number of joints. This project can become the basis for many future design and controls projects involving multiple degrees of freedom. Furthermore, the developed LabView software for the given Solidworks assembly could be used fully or partially with any mechanical hand design. The universal nature of the software could enables the user to design a hand per any sets of design requirements. The developed LabView software also serves as a universal platform for actuation, since it could be coupled to any actuation system with very few adjustments. With the designed hand and developed LabView software, the current project will be a very important milestone of the RIT's biomechanical research.

8. Conclusion

The main objective of this thesis project was to develop a mechanical hand, capable of performing ASL letters and to create a software platform to achieve these motions in an optimum way. A complete study of the human hand skeletal system, previous hand designs, RIT hand models and hand gesture in ASL was conducted. The study developed an understanding of human hand and helped to assist the requirements of the design. The assembly of the designed hand was created using SolidWorks. LabView and Matlab programming platforms were used to develop the control software for the assembly simulation.

The designed mechanical hand assembly consisted of 20 degrees-of-freedom. The design was based on the assessment of the required sets of motions and gestures of the assembly needed for ASL. The fingers in the mechanical hand assembly were designed with 4 degrees-of-freedom. This reduced the requirement of an additional controller and simplified the assembly. The Thumb was also designed similar to the other four fingers in terms of degrees-of-freedom. The additional degree-of-freedom at the metacarpal phalangeal joint of the Thumb was ignored in this design. The assembly was also provided with motion constraints similar to that of the human hand. An actuation mechanism was developed using a combination of springs and tendons. The springs were used to create extension in the fingers. To retain the fingers in a vertical position, a torsion spring was introduced in the system. The combination of the spring and tendon reduced the requirement of the joint actuators and simplified the design to a great extent. Also, since extension is carried out using a spring force; this immensely reduced the complexity of the control system.

To determine the functionality of the design, a finger assembly was manufactured using rapid prototyping. Figure 64 shows the developed finger assembly. Fracture was observed in some assemblies at the thin cross-sectional area of the joint due to the retracting spring force. The spring force value was determined by performing a simple spring calculation using given spring parameters. A free-body diagram was developed to calculate the spring force value at the point of contact in the joint. Using these values as the input parameters, a stress analysis was performed on the assembly. The stress values obtained through the analysis were found to be negligible for the common manufacturing material (Aluminum). The assembly was designed with the dimensions, closer to the actual average human hand dimensions. Although the assembly worked fine with full size, the attempt to create a ¼ scale replica of the finger assembly failed. To achieve the ¼ scale dimensions redesigning would be required.

A detailed study of the ASL alphabets and their gestures was conducted using the available literature and other sources. Based on this study, the joint angles for all twenty six letters were determined for all the twenty joints in the mechanical hand assembly, using these angle values, a complete study of the gesture transition from one letter to other was conducted. The most intricate transitions between two gestures were determined based on the results obtained from this study. These results were used to develop and test the control software for the assembly simulation.

A complete control software combination was created using the LabView and Matlab programming platforms. A kinematic model was developed and incorporated into the control software to determine and plot the position of every joint in a global frame of reference. The LabView Softmotion tool was used to interface the control software with the designed CAD assembly. Although a successful interface was created, further assessment of the software and implementation of the logical steps was found to be difficult due to the software and hardware limitations, such as speed and incapability to simulate the spherical joint. However the kinematic models and designs developed in this thesis project will provide a base for the future work.

9. Future Recommendations

The field of robotic research is an endless voyage. Biomimatic systems represent one of the fastest growing branches of robotics science. While this project provides methods for the dexterous hand design and control software, it will be unwise to stop at this point without exploring future opportunities. This section provides a brief summary of the areas that can be explored. Using the current and previous projects and literature as a starting point further research should be done to develop designs that can completely replicate human hand in terms of motions and tactile sensing.

Limitations:

It was observed during the course of the project, that the computational requirements for the LabView and Solidworks softwares were very high. The interface between the two software's-packages, demands very high processor speed and high memory graphics card. The availability of well configured system will increase the simulation speed. It was also observed that the failure in the simulation occurred at the spherical joint of the designed thumb assembly, where two motors are working simultaneously. It is necessary to locate the cause of the failure. The reason of this failure could be the limitations of the current hardware or they could be the limitation of the interface.

Hardware development:

In this thesis project, a complete mechanical hand assembly was developed using CAD tools. This assembly could be manufactured using the various manufacturing methods. One of those methods is rapid prototyping or 3D printing. This is a relatively new manufacturing process, which is based on creating models by laying down the layers of the required material in a succession. Materials used in this process are mainly plastic polymers. The strength of the component is dependent upon the material and the layer orientation. The main advantage of this process is, complex assemblies and shapes could be created.

LabView Softmotion tool was used in this project to develop the interface between the CAD assembly and the LabView program. This tool allows the software to narrate angle values for each joint along with its velocity to the Solidworks perform necessary motion. The same tool can be used to send the physical output signals through National Instrument hardware. Enabling the software developed in this project to be easily applied to mechanical hardware.

Sensor Glove Application:

Sensor gloves are widely used in field of computer graphics and game designing. Equipped with either strain gauges or potentiometers, these sensor gloves can provide angle values of

the human hand joint to the computing system. These values can be used to analyze the pattern or to recognize the gesture performed by the hand. A considerable amount of research has been done in this field. Various different types of gloves are available, which can be implanted. These gloves can be interfaced with the developed LabView software to provide either the angle values for each joint or to provide a command for any particular ASL letter.

Trajectory Generation

By default the motors in the Solidworks assembly move with constant velocity. To control the velocity output through the LabView Softmotion tool, trajectory generation could be carried out. The trajectory can be defined as the time history of position, velocity and acceleration for each degree of freedom of robotic arm. The trajectory specifies the movement of an actuator in terms of its position and its derivatives with respect to time. The position variable of any actuator depends upon its mechanism. For robotic arm with revolute and universal joints position variable is described in terms of the joint angle (θ_i). It is known as joint space scheme. For the prismatic joints position variable is described in terms of the displacement (d_i). All the joints in the human hand structure are either revolute or universal joints; hence for trajectory generation all the positions and orientations could be described in terms of the joint angles of each finger. The aim of the trajectory generation will be to achieve smooth and continuous actuator motion. For any actuator mechanism to avoid any wear and tear its motion should be without jerks and vibrations. This smooth motion should be ensured by trajectory generation. For human hand motion trajectory generation, joint space schemes can be utilized. There are two joint space schemes available.

1) Cubic polynomials
2) Linear function

By knowing the initial and final position of the manipulator in terms of the joint angles and time required to finish the motion, a smooth motion plan could be calculated using cubic polynomials. In general, joints do not move in linear pattern, thus using direct linear interpolation will cause the discontinuous velocity generation at the beginning and at the end and will cause jerks in the system. For American Sign Language (ASL) application human hand motions are in general starts and end with zero velocity. Also its joint angles for initial and final position are known. For this project application cubic polynomial solutions could be applied to obtain complete velocity pattern. Following Equations 26, 27 and 28 show a cubic polynomial equation and its first and second order derivatives with respect to time.

$$\theta(t) = a_0 + a_1 t + a_2 t^2 + a_3 t^3 \tag{26}$$

$$\dot{\theta}(t) = a_1 + 2a_2 t + 3a_3 t^2 \tag{27}$$

$$\ddot{\theta}(t) = 2a_2 + 6a_3 t \tag{28}$$

where,

$\theta(t)$ = Angular displacement

$\dot{\theta}(t)$ = Velocity

$\ddot{\theta}(t)$ = Accelerations

$\theta(0) = \theta_0$ initial angle

$\theta(t_f) = \theta_f$ final angle

Assuming time at start $t_0 = 0$, the above equations can be solved for four coefficient, a_0, a_1, a_2, a_3. This will generate following values for the coefficients,

$a_0 = \theta_0$

$a_1 = 0$

$a_2 = 3(\theta_f - \theta_0)/ t_f^2$

$a_3 = -2(\theta_f - \theta_0)/ t_f^3$

By substituting the values of a_0, a_1, a_2, a_3 in the equation 26, 27 and 28, and solving for time t_f the angular displacement, joint velocity and acceleration could be calculated. These equations could be applied to the entire joint in the hand assembly to calculate their velocity at any given time. Representative results for the joint angle and velocity of the motion for a joint over the span of 5 seconds are shown in Figure 65a and figure 65b respectively.
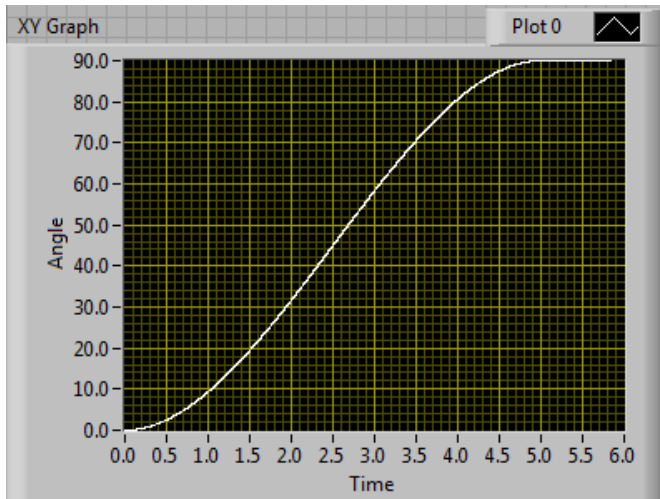
(a)
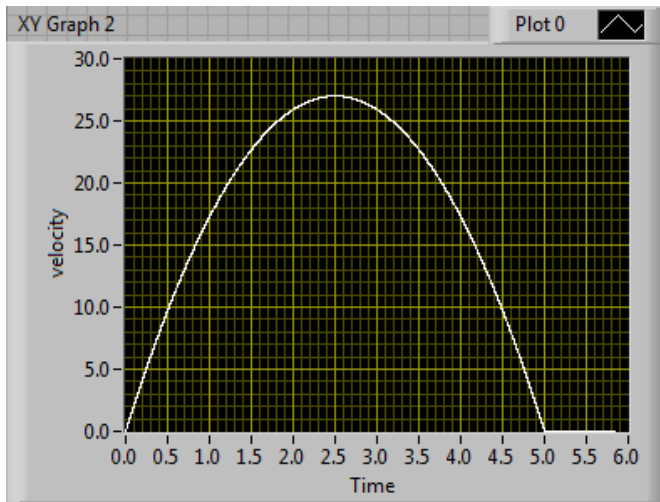
(b)

Figure 65: (65a) Joint angle, (65b) Velocity of motion

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Date=30-Jun-2010&view=c&wchp=dGLbVlk-
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Appendix A

LabView Code: Front Panel
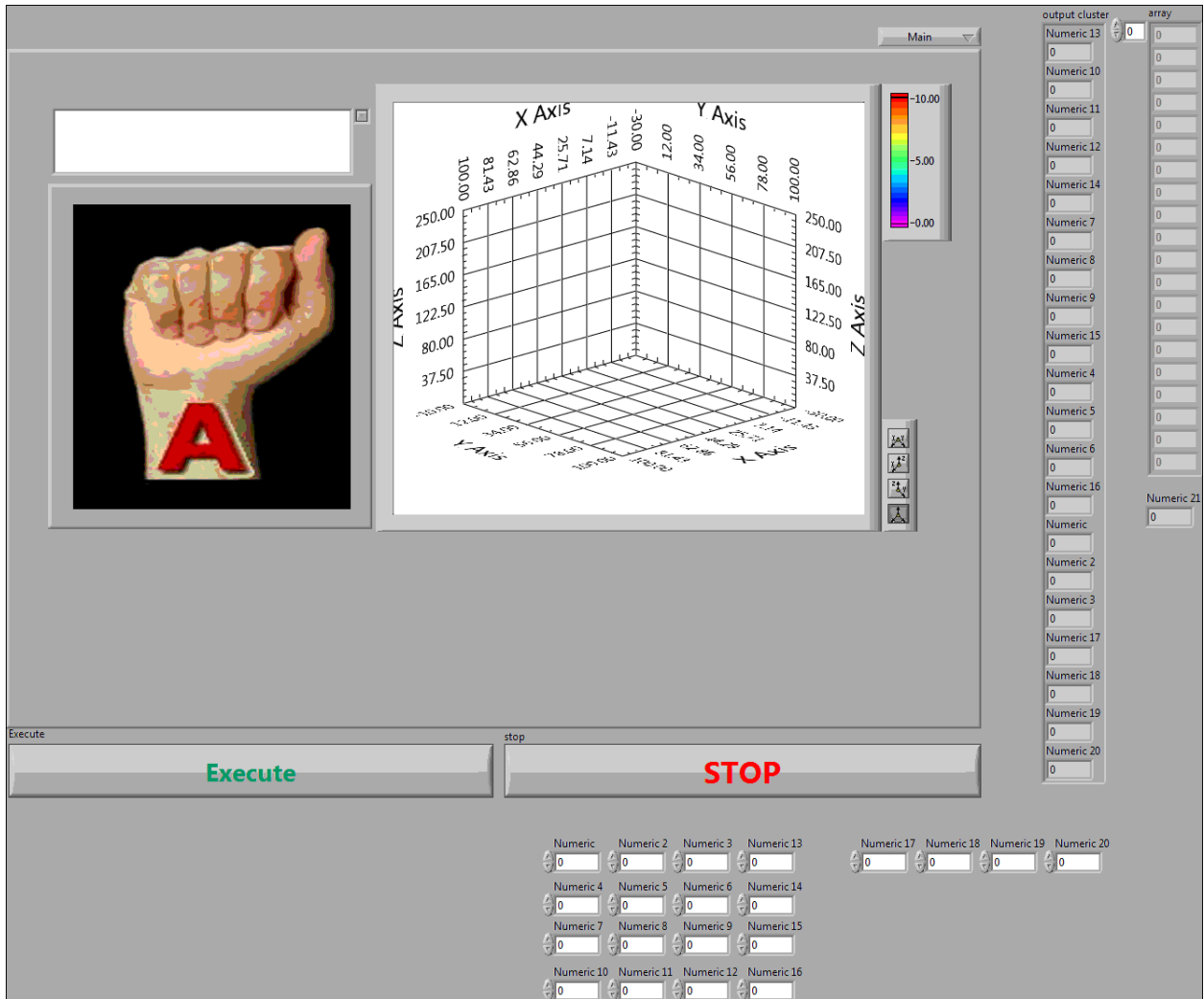
LabView Code: Block Diagram
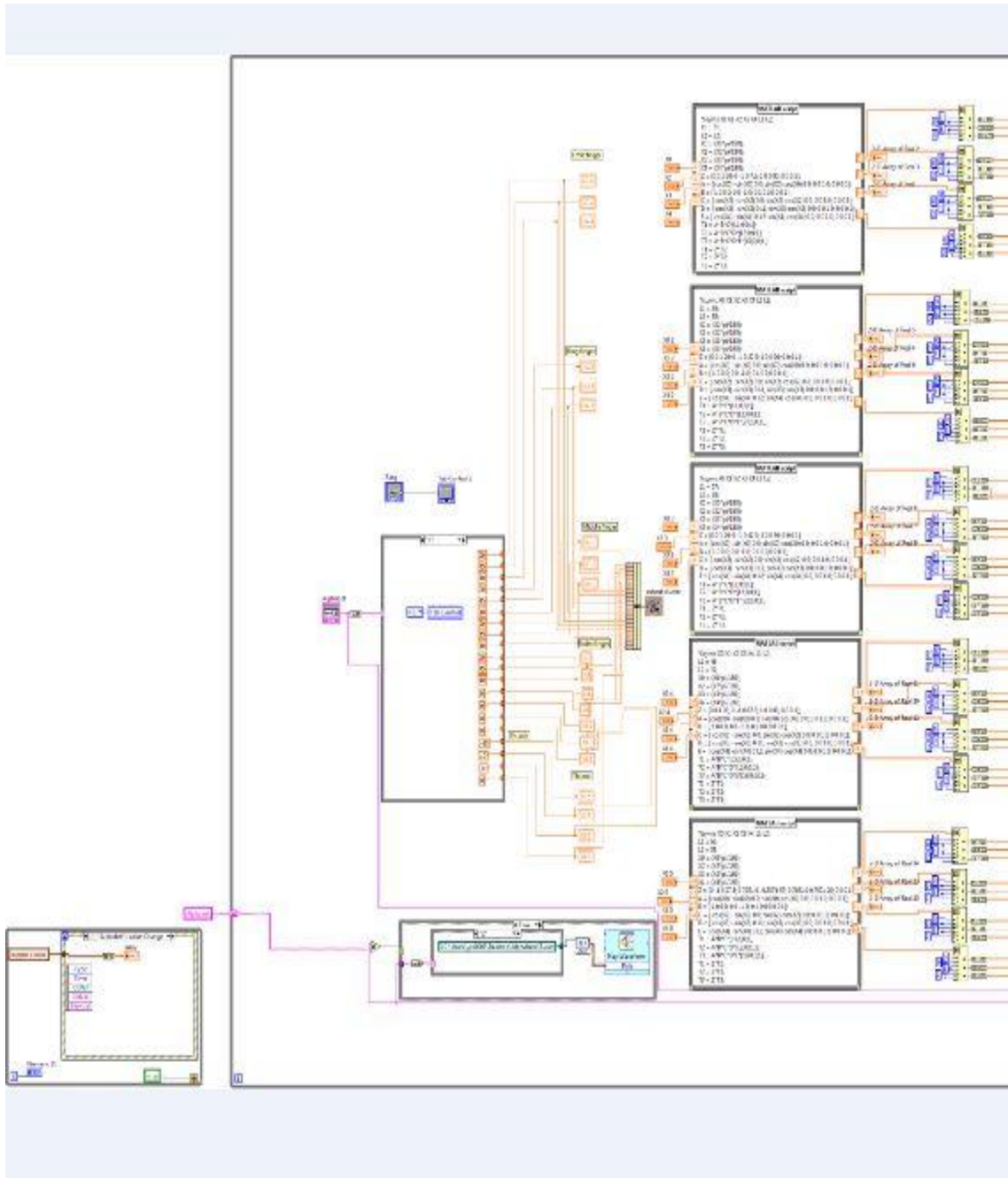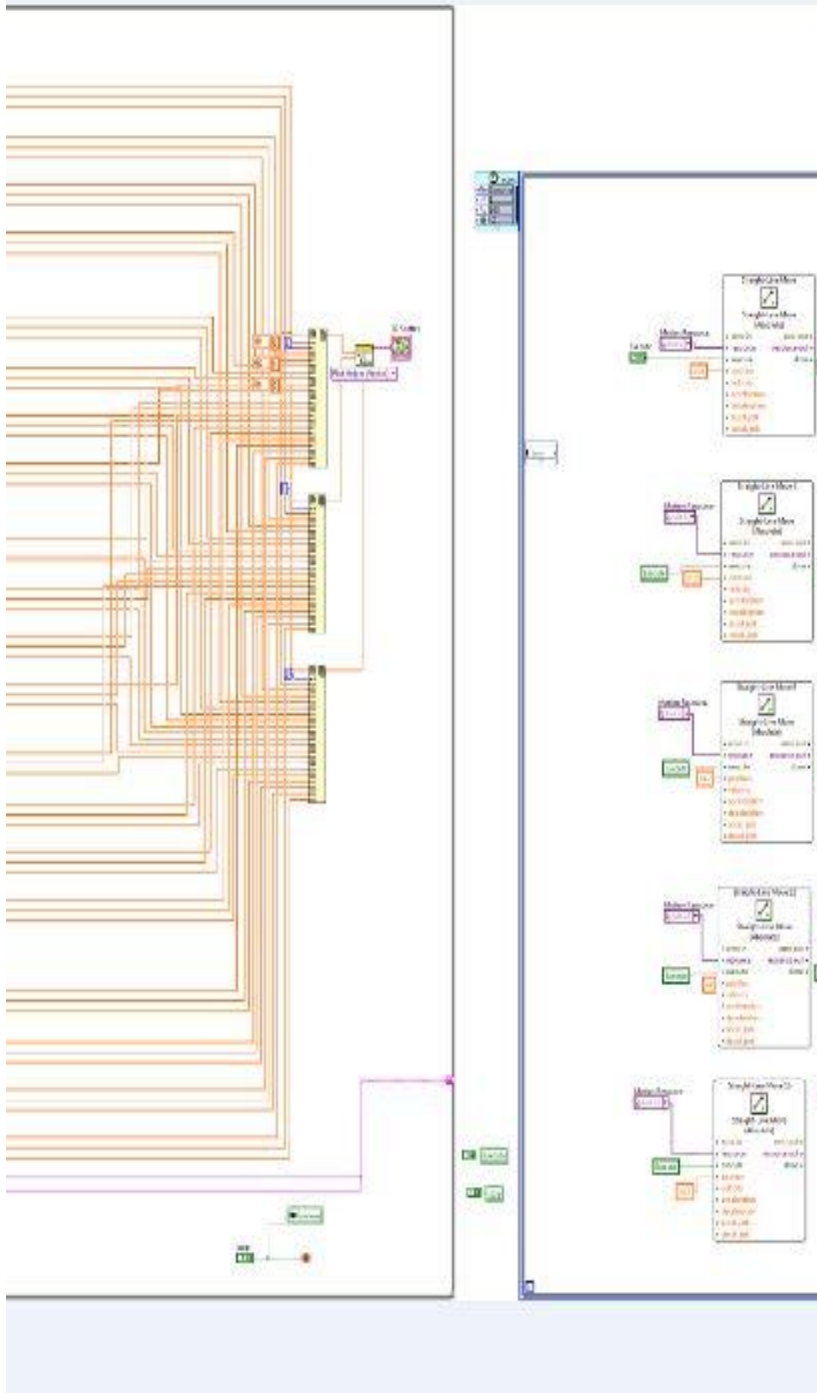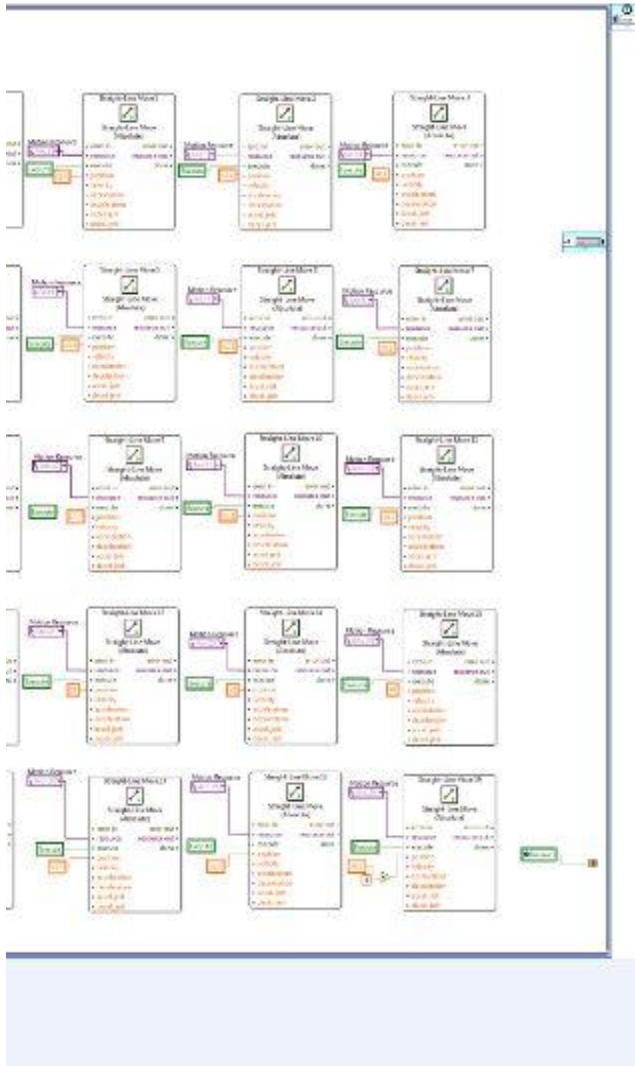
Appendix B

Angle transition values for Letter A

A-->B		THUMB	INDEX	MIDDLE	RING	LITTLE	A-->C		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	0--0	0--0	0--0	0--0	0--0		JOINT 1	0--(-30)	0--0	0--0	0--0	0--0
	JOINT 2	20--20	85--0	85--0	85--0	85--0		JOINT 2	20--25	85--45	85--45	85--45	85--45
	JOINT 3	25--25	85--0	85--0	85--0	85--0		JOINT 3	25--10	85--45	85--45	85--45	85--45
	JOINT 4	0--0	80--0	80--0	80--0	80--0		JOINT 4	0--10	80--10	80--10	80--10	80--10
A-->D		THUMB	INDEX	MIDDLE	RING	LITTLE	A-->E		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	0--(-30)	0--0	0--0	0--0	0--0		JOINT 1	0--0	0--0	0--0	0--0	0--0
	JOINT 2	20--25	85--0	85--45	85--45	85--45		JOINT 2	20--35	85--45	85--45	85--45	85--45
	JOINT 3	25--45	85--0	85--45	85--45	85--45		JOINT 3	25--85	85--85	85--85	85--85	85--85
	JOINT 4	0--15	80--0	80--10	80--10	80--10		JOINT 4	0--20	80--80	80--80	80--80	80--80
A-->F		THUMB	INDEX	MIDDLE	RING	LITTLE	A-->G		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	0--(-20)	0--0	0--0	0--0	0--0		JOINT 1	0--(-30)	0--0	0--0	0--0	0--0
	JOINT 2	20--25	85--45	85--0	85--0	85--0		JOINT 2	20--20	85--85	85--85	85--85	85--85
	JOINT 3	25--60	85--45	85--0	85--0	85--0		JOINT 3	25--0	85--0	85--85	85--85	85--85
	JOINT 4	0--10	80--10	80--0	80--0	80--0		JOINT 4	0--0	80--0	80--80	80--80	80--80
A-->H		THUMB	INDEX	MIDDLE	RING	LITTLE	A-->I		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	0--(-20)	0--0	0--0	0--0	0--0		JOINT 1	0--(-20)	0--0	0--0	0--0	0--0
	JOINT 2	20--45	85--0	85--0	85--85	85--85		JOINT 2	20--10	85--85	85--85	85--85	85--0
	JOINT 3	25--85	85--0	85--0	85--85	85--85		JOINT 3	25--80	85--85	85--85	85--85	85--0
	JOINT 4	0--0	80--0	80--0	80--80	80--80		JOINT 4	0--0	80--80	80--80	80--80	80--0
A-->J		THUMB	INDEX	MIDDLE	RING	LITTLE	A-->K		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	0--(-20)	0--0	0--0	0--0	0--0		JOINT 1	0--(-10)	0--0	0--0	0--0	0--0
	JOINT 2	20--10	85--85	85--85	85--85	85--0		JOINT 2	20--10	85--0	85--45	85--85	85--85
	JOINT 3	25--80	85--85	85--85	85--85	85--0		JOINT 3	25--45	85--0	85--0	85--85	85--85
	JOINT 4	0--0	80--80	80--80	80--80	80--0		JOINT 4	0--0	80--0	80--0	80--80	80--80
A-->L		THUMB	INDEX	MIDDLE	RING	LITTLE	A-->M		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	0--0	0--0	0--0	0--0	0--0		JOINT 1	0--(-10)	0--0	0--0	0--0	0--0
	JOINT 2	20--0	85--0	85--85	85--85	85--85		JOINT 2	20--45	85--75	85--75	85--75	85--85
	JOINT 3	25--0	85--0	85--85	85--85	85--85		JOINT 3	25--85	85--75	85--75	85--75	85--85
	JOINT 4	0--0	80--0	80--80	80--80	80--80		JOINT 4	0--10	80--10	80--10	80--10	80--80
A-->N		THUMB	INDEX	MIDDLE	RING	LITTLE	A-->O		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	0--(-10)	0--0	0--0	0--0	0--0		JOINT 1	0--(-30)	0--0	0--0	0--0	0--0
	JOINT 2	20--30	85--75	85--75	85--85	85--85		JOINT 2	20--25	85--60	85--60	85--60	85--60
	JOINT 3	25--60	85--75	85--75	85--85	85--85		JOINT 3	25--45	85--45	85--45	85--45	85--45
	JOINT 4	0--10	80--10	80--10	80--80	80--80		JOINT 4	0--45	80--10	80--10	80--10	80--10
A-->P		THUMB	INDEX	MIDDLE	RING	LITTLE	A-->Q		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	0--(-10)	0--0	0--0	0--0	0--0		JOINT 1	0--(-30)	0--0	0--0	0--0	0--0
	JOINT 2	20--10	85--0	85--45	85--85	85--85		JOINT 2	20--20	85--85	85--85	85--85	85--85

		THUMB	INDEX	MIDDLE	RING	LITTLE			THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 3	25--45	85--0	85--0	85--85	85--85		JOINT 3	25--0	85--0	85--85	85--85	85--85
	JOINT 4	0--0	80--0	80--0	80--80	80--80		JOINT 4	0--0	80--0	80--80	80--80	80--80
A-->R		THUMB	INDEX	MIDDLE	RING	LITTLE	A-->S		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	0--(-20)	0--15	0--(-5)	0--0	0--0		JOINT 1	0--(-20)	0--0	0--0	0--0	0--0
	JOINT 2	20--45	85--20	85--0	85--85	85--85		JOINT 2	20--30	85--85	85--85	85--85	85--85
	JOINT 3	25--45	85--0	85--0	85--85	85--85		JOINT 3	25--45	85--85	85--85	85--85	85--85
	JOINT 4	0--0	80--0	80--0	80--80	80--80		JOINT 4	0--45	80--80	80--80	80--80	80--80
A-->T		THUMB	INDEX	MIDDLE	RING	LITTLE	A-->U		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	0--0	0--(-10)	0--0	0--0	0--0		JOINT 1	0--(-20)	0--0	0--0	0--0	0--0
	JOINT 2	20--20	85--60	85--85	85--85	85--85		JOINT 2	20--45	85--0	85--0	85--85	85--85
	JOINT 3	25--25	85--80	85--85	85--85	85--85		JOINT 3	25--85	85--0	85--0	85--85	85--85
	JOINT 4	0--0	80--45	80--80	80--80	80--80		JOINT 4	0--0	80--0	80--0	80--80	80--80
A-->V		THUMB	INDEX	MIDDLE	RING	LITTLE	A-->W		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	0--(-20)	0--(-10)	0--10	0--0	0--0		JOINT 1	0--(-10)	0--(-10)	0--0	0--10	0--0
	JOINT 2	20--45	85--0	85--0	85--85	85--85		JOINT 2	20--45	85--0	85--0	85--0	85--85
	JOINT 3	25--45	85--0	85--0	85--85	85--85		JOINT 3	25--45	85--0	85--0	85--0	85--85
	JOINT 4	0--0	80--0	80--0	80--80	80--80		JOINT 4	0--0	80--0	80--0	80--0	80--80
A-->X		THUMB	INDEX	MIDDLE	RING	LITTLE	A-->Y		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	0--(-20)	0--0	0--0	0--0	0--0		JOINT 1	0--0	0--0	0--0	0--0	0--0
	JOINT 2	20--30	85--0	85--85	85--85	85--85		JOINT 2	20--0	85--85	85--85	85--85	85--0
	JOINT 3	25--45	85--45	85--85	85--85	85--85		JOINT 3	25--0	85--85	85--85	85--85	85--0
	JOINT 4	0--0	80--45	80--80	80--80	80--80		JOINT 4	0--0	80--80	80--80	80--80	80--0
A-->Z		THUMB	INDEX	MIDDLE	RING	LITTLE							
	JOINT 1	0--(-20)	0--0	0--0	0--0	0--0							
	JOINT 2	20--30	85--0	85--85	85--85	85--85							
	JOINT 3	25--45	85--0	85--85	85--85	85--85							
	JOINT 4	0--0	80--0	80--80	80--80	80--80							

Angle transition values for Letter B

B-->A		THUMB	INDEX	MIDDLE	RING	LITTLE	B-->C		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	0--0	0--0	0--0	0--0	0--0		JOINT 1	0--(-30)	0--0	0--0	0--0	0--0
	JOINT 2	20--20	0--85	0--85	0--85	0--85		JOINT 2	20--25	0--45	0--45	0--45	0--45
	JOINT 3	25--25	0--85	0--85	0--85	0--85		JOINT 3	25--10	0--45	0--45	0--45	0--45
	JOINT 4	0--0	0--80	0--80	0--80	0--80		JOINT 4	0--10	0--10	0--10	0--10	0--10
B-->D		THUMB	INDEX	MIDDLE	RING	LITTLE	B-->E		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	0--(-30)	0--0	0--0	0--0	0--0		JOINT 1	0--0	0--0	0--0	0--0	0--0
	JOINT 2	20--25	0--0	0--45	0--45	0--45		JOINT 2	20--35	0--45	0--45	0--45	0--45
	JOINT 3	25--45	0--0	0--45	0--45	0--45		JOINT 3	25--85	0--85	0--85	0--85	0--85
	JOINT 4	0--15	0--0	0--10	0--10	0--10		JOINT 4	0--20	0--80	0--80	0--80	0--80
B-->F		THUMB	INDEX	MIDDLE	RING	LITTLE	B-->G		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	0--(-20)	0--0	0--0	0--0	0--0		JOINT 1	0--(-30)	0--0	0--0	0--0	0--0
	JOINT 2	20--25	0--45	0--0	0--0	0--0		JOINT 2	20--20	0--85	0--85	0--85	0--85
	JOINT 3	25--60	0--45	0--0	0--0	0--0		JOINT 3	25--0	0--0	0--85	0--85	0--85
	JOINT 4	0--10	0--10	0--0	0--0	0--0		JOINT 4	0--0	0--0	0--80	0--80	0--80
B-->H		THUMB	INDEX	MIDDLE	RING	LITTLE	B-->I		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	0--(-20)	0--0	0--0	0--0	0--0		JOINT 1	0--(-20)	0--0	0--0	0--0	0--0
	JOINT 2	20--45	0--0	0--0	0--85	0--85		JOINT 2	20--10	0--85	0--85	0--85	0--0
	JOINT 3	25--85	0--0	0--0	0--85	0--85		JOINT 3	25--80	0--85	0--85	0--85	0--0
	JOINT 4	0--0	0--0	0--0	0--80	0--80		JOINT 4	0--0	0--80	0--80	0--80	0--0
B-->J		THUMB	INDEX	MIDDLE	RING	LITTLE	B-->K		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	0--(-20)	0--0	0--0	0--0	0--0		JOINT 1	0--(-10)	0--0	0--0	0--0	0--0
	JOINT 2	20--10	0--85	0--85	0--85	0--0		JOINT 2	20--10	0--0	85--45	0--85	0--85
	JOINT 3	25--80	0--85	0--85	0--85	0--0		JOINT 3	25--45	0--0	0--0	0--85	0--85
	JOINT 4	0--0	0--80	0--80	0--80	0--0		JOINT 4	0--0	0--0	0--0	0--80	0--80
B-->L		THUMB	INDEX	MIDDLE	RING	LITTLE	B-->M		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	0--0	0--0	0--0	0--0	0--0		JOINT 1	0--(-10)	0--0	0--0	0--0	0--0
	JOINT 2	20--0	0--0	0--85	0--85	0--85		JOINT 2	20--45	0--75	0--75	0--75	0--85
	JOINT 3	25--0	0--0	0--85	0--85	0--85		JOINT 3	25--85	0--75	0--75	0--75	0--85
	JOINT 4	0--0	0--0	0--80	0--80	0--80		JOINT 4	0--10	0--10	0--10	0--10	0--80
B-->N		THUMB	INDEX	MIDDLE	RING	LITTLE	B-->O		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	0--(-10)	0--0	0--0	0--0	0--0		JOINT 1	0--(-30)	0--0	0--0	0--0	0--0
	JOINT 2	20--30	0--75	0--75	0--85	0--85		JOINT 2	20--25	0--60	0--60	0--60	0--60
	JOINT 3	25--60	0--75	0--75	0--85	0--85		JOINT 3	25--45	0--45	0--45	0--45	0--45
	JOINT 4	0--10	0--10	0--10	0--80	0--80		JOINT 4	0--45	0--10	0--10	0--10	0--10
B-->P		THUMB	INDEX	MIDDLE	RING	LITTLE	B-->Q		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	0--(-10)	0--0	0--0	0--0	0--0		JOINT 1	0--(-30)	0--0	0--0	0--0	0--0
	JOINT 2	20--10	0--0	0--45	0--85	0--85		JOINT 2	20--20	0--85	0--85	0--85	0--85
	JOINT 3	25--45	0--0	0--0	0--85	0--85		JOINT 3	25--0	0--0	0--85	0--85	0--85
	JOINT 4	0--0	0--0	0--0	0--80	0--80		JOINT 4	0--0	0--0	0--80	0--80	0--80

B-->R		THUMB	INDEX	MIDDLE	RING	LITTLE	B-->S		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	0--(-20)	0--15	0--(-5)	0--0	0--0		JOINT 1	0--(-20)	0--0	0--0	0--0	0--0
	JOINT 2	20--45	0--20	0--0	0--85	0--85		JOINT 2	20--30	0--85	0--85	0--85	0--85
	JOINT 3	25--45	0--0	0--0	0--85	0--85		JOINT 3	25--45	0--85	0--85	0--85	0--85
	JOINT 4	0--0	0--0	0--0	0--80	0--80		JOINT 4	0--45	0--80	0--80	0--80	0--80
B-->T		THUMB	INDEX	MIDDLE	RING	LITTLE	B-->U		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	0--0	0--(-10)	0--0	0--0	0--0		JOINT 1	0--(-20)	0--0	0--0	0--0	0--0
	JOINT 2	20--20	0--60	0--85	0--85	0--85		JOINT 2	20--45	0--0	0--0	0--85	0--85
	JOINT 3	25--25	0--80	0--85	0--85	0--85		JOINT 3	25--85	0--0	0--0	0--85	0--85
	JOINT 4	0--0	0--45	0--80	0--80	0--80		JOINT 4	0--0	0--0	0--0	0--80	0--80
B-->V		THUMB	INDEX	MIDDLE	RING	LITTLE	B-->W		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	0--(-20)	0--(-10)	0--10	0--0	0--0		JOINT 1	0--(-10)	0--(-10)	0--0	0--10	0--0
	JOINT 2	20--45	0--0	0--0	0--85	0--85		JOINT 2	20--45	0--0	0--0	0--0	0--85
	JOINT 3	25--45	0--0	0--0	0--85	0--85		JOINT 3	25--45	0--0	0--0	0--0	0--85
	JOINT 4	0--0	0--0	0--0	0--80	0--80		JOINT 4	0--0	0--0	0--0	0--0	0--80
B-->X		THUMB	INDEX	MIDDLE	RING	LITTLE	B-->Y		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	0--(-20)	0--0	0--0	0--0	0--0		JOINT 1	0--0	0--0	0--0	0--0	0--0
	JOINT 2	20--30	0--0	0--85	0--85	0--85		JOINT 2	20--0	0--85	0--85	0--85	0--0
	JOINT 3	25--45	0--45	0--85	0--85	0--85		JOINT 3	25--0	0--85	0--85	0--85	0--0
	JOINT 4	0--0	0--45	0--80	0--80	0--80		JOINT 4	0--0	0--80	0--80	0--80	0--0
B-->Z		THUMB	INDEX	MIDDLE	RING	LITTLE							
	JOINT 1	0--(-20)	0--0	0--0	0--0	0--0							
	JOINT 2	20--30	0--0	0--85	0--85	0--85							
	JOINT 3	25--45	0--0	0--85	0--85	0--85							
	JOINT 4	0--0	0--0	0--80	0--80	0--80							

Angle transition values for Letter C

C-->A		THUMB	INDEX	MIDDLE	RING	LITTLE	C-->B		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-30)--0	0--0	0--0	0--0	0--0		JOINT 1	(-30)--0	0--0	0--0	0--0	0--0
	JOINT 2	25--20	45--85	45--85	45--85	45--85		JOINT 2	25--20	45--0	45--0	45--0	45--0
	JOINT 3	10--25	45--85	45--85	45--85	45--85		JOINT 3	10--25	45--0	45--0	45--0	45--0
	JOINT 4	10--0	10--80	10--80	10--80	10--80		JOINT 4	10--0	10--0	10--0	10--0	10--0
C-->D		THUMB	INDEX	MIDDLE	RING	LITTLE	C-->E		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-30)-(-30)	0--0	0--0	0--0	0--0		JOINT 1	(-30)--0	0--0	0--0	0--0	0--0
	JOINT 2	25--25	45--0	45--45	45--45	45--45		JOINT 2	25--35	45--45	45--45	45--45	45--45
	JOINT 3	10--45	45--0	45--45	45--45	45--45		JOINT 3	10--85	45--85	45--85	45--85	45--85
	JOINT 4	10--15	10--0	45--10	45--10	45--10		JOINT 4	10--20	10--80	10--80	10--80	10--80
C-->F		THUMB	INDEX	MIDDLE	RING	LITTLE	C-->G		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-30)-(-20)	0--0	0--0	0--0	0--0		JOINT 1	(-30)-(-30)	0--0	0--0	0--0	0--0
	JOINT 2	25--25	45--45	45--0	45--0	45--0		JOINT 2	25--20	45--85	45--85	45--85	45--85
	JOINT 3	10--60	45--45	45--0	45--0	45--0		JOINT 3	10--0	45--0	45--85	45--85	45--85
	JOINT 4	10--10	45--10	10--0	10--0	10--0		JOINT 4	10--0	10--0	10--80	10--80	10--80
C-->H		THUMB	INDEX	MIDDLE	RING	LITTLE	C-->I		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-30)-(-20)	0--0	0--0	0--0	0--0		JOINT 1	(-30)-(-20)	0--0	0--0	0--0	0--0
	JOINT 2	25--45	45--0	45--0	45--85	45--85		JOINT 2	25--10	45--85	45--85	45--85	45--0
	JOINT 3	10--85	45--0	45--0	45--85	45--85		JOINT 3	10--80	45--85	45--85	45--85	45--0
	JOINT 4	10--0	10--0	10--0	10--80	10--80		JOINT 4	10--0	10--80	10--80	10--80	10--0
C-->J		THUMB	INDEX	MIDDLE	RING	LITTLE	C-->K		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-30)-(-20)	0--0	0--0	0--0	0--0		JOINT 1	(-30)-(-10)	0--0	0--0	0--0	0--0
	JOINT 2	25--10	45--85	45--85	45--85	45--0		JOINT 2	25--10	45--0	45--45	45--85	45--85
	JOINT 3	10--80	45--85	45--85	45--85	45--0		JOINT 3	10--45	45--0	45--0	45--85	45--85
	JOINT 4	10--0	10--80	10--80	10--80	10--0		JOINT 4	10--0	10--0	10--0	10--80	10--80
C-->L		THUMB	INDEX	MIDDLE	RING	LITTLE	C-->M		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-30)-0	0--0	0--0	0--0	0--0		JOINT 1	(-30)-(-10)	0--0	0--0	0--0	0--0
	JOINT 2	25--0	45--0	45--85	45--85	45--85		JOINT 2	25--45	45--75	45--75	45--75	45--85
	JOINT 3	10--0	45--0	45--85	45--85	45--85		JOINT 3	10--85	45--75	45--75	45--75	45--85
	JOINT 4	10--0	10--0	10--80	10--80	10--80		JOINT 4	10--10	45--10	45--10	45--10	10--80
C-->N		THUMB	INDEX	MIDDLE	RING	LITTLE	C-->O		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-30)-(-10)	0--0	0--0	0--0	0--0		JOINT 1	(-30)-(-30)	0--0	0--0	0--0	0--0
	JOINT 2	25--30	45--75	45--75	45--85	45--85		JOINT 2	25--25	45--60	45--60	45--60	45--60
	JOINT 3	10--60	45--75	45--75	45--85	45--85		JOINT 3	10--45	45--45	45--45	45--45	45--45
	JOINT 4	10--10	45--10	45--10	10--80	10--80		JOINT 4	10--45	10--10	10--10	10--10	10--10
C-->P		THUMB	INDEX	MIDDLE	RING	LITTLE	C-->Q		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-30)-(-10)	0--0	0--0	0--0	0--0		JOINT 1	(-30)-(-30)	0--0	0--0	0--0	0--0
	JOINT 2	25--10	45--0	45--45	45--85	45--85		JOINT 2	25--20	45--85	45--85	45--85	45--85
	JOINT 3	10--45	45--0	45--0	45--85	45--85		JOINT 3	10--0	45--0	45--85	45--85	45--85
	JOINT 4	10--0	10--0	10--0	10--80	10--80		JOINT 4	10--0	10--0	10--80	10--80	10--80

C-->R		THUMB	INDEX	MIDDLE	RING	LITTLE	C-->S		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-30)-(-20)	0--15	0--(-5)	0--0	0--0		JOINT 1	(-30)-(-20)	0--0	0--0	0--0	0--0
	JOINT 2	25--45	45--20	45--0	45--85	45--85		JOINT 2	25--30	45--85	45--85	45--85	45--85
	JOINT 3	10--45	45--0	45--0	45--85	45--85		JOINT 3	10--45	45--85	45--85	45--85	45--85
	JOINT 4	10--0	10--0	10--0	10--80	10--80		JOINT 4	10--45	10--80	10--80	10--80	10--80
C-->T		THUMB	INDEX	MIDDLE	RING	LITTLE	C-->U		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-30)-0	0--(-10)	0--0	0--0	0--0		JOINT 1	(-30)-(-20)	0--0	0--0	0--0	0--0
	JOINT 2	25--20	45--60	45--85	45--85	45--85		JOINT 2	25--45	45--0	45--0	45--85	45--85
	JOINT 3	10--25	45--80	45--85	45--85	45--85		JOINT 3	10--85	45--0	45--0	45--85	45--85
	JOINT 4	10--0	10--45	10--80	10--80	10--80		JOINT 4	10--0	10--0	10--0	10--80	10--80
C-->V		THUMB	INDEX	MIDDLE	RING	LITTLE	C-->W		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-30)-(-20)	0--(-10)	0--10	0--0	0--0		JOINT 1	(-30)-(-10)	0--(-10)	0--0	0--10	0--0
	JOINT 2	25--45	45--0	45--0	45--85	45--85		JOINT 2	25--45	45--0	45--0	45--0	0--85
	JOINT 3	10--45	45--0	45--0	45--85	45--85		JOINT 3	10--45	45--0	45--0	45--0	0--85
	JOINT 4	10--0	10--0	10--0	10--80	10--80		JOINT 4	10--0	10--0	10--0	10--0	0--80
C-->X		THUMB	INDEX	MIDDLE	RING	LITTLE	C-->Y		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-30)-(-20)	0--0	0--0	0--0	0--0		JOINT 1	(-30)--0	0--0	0--0	0--0	0--0
	JOINT 2	25--30	0--0	0--85	0--85	0--85		JOINT 2	25--0	45--85	45--85	45--85	45--0
	JOINT 3	10--45	0--45	0--85	0--85	0--85		JOINT 3	10--0	45--85	45--85	45--85	45--0
	JOINT 4	10--0	80--45	0--80	0--80	0--80		JOINT 4	10--0	10--80	10--80	10--80	10--0
C-->Z		THUMB	INDEX	MIDDLE	RING	LITTLE							
	JOINT 1	(-30)-(-20)	0--0	0--0	0--0	0--0							
	JOINT 2	25--30	45--0	45--85	45--85	45--85							
	JOINT 3	10--45	45--0	45--85	45--85	45--85							
	JOINT 4	10--0	10--0	10--80	10--80	10--80							

Angle transition values for Letter D

D-->B		THUMB	INDEX	MIDDLE	RING	LITTLE	D-->C		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-30)--0	0--0	0--0	0--0	0--0		JOINT 1	(-30)-(-30)	0--0	0--0	0--0	0--0
	JOINT 2	25--20	0--0	45--0	45--0	45--0		JOINT 2	25--25	0--45	45--45	45--45	45--45
	JOINT 3	45--25	0--0	45--0	45--0	45--0		JOINT 3	45--10	0--45	45--45	45--45	45--45
	JOINT 4	15--0	0--0	10--0	10--0	10--0		JOINT 4	15--10	0--10	10--10	10--10	10--10
D-->A		THUMB	INDEX	MIDDLE	RING	LITTLE	D-->E		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-30)--0	0--0	0--0	0--0	0--0		JOINT 1	(-30)--0	0--0	0--0	0--0	0--0
	JOINT 2	25--20	0--0	45--85	45--85	45--85		JOINT 2	25--35	0--45	45--45	45--45	45--45
	JOINT 3	45--25	0--0	45--85	45--85	45--85		JOINT 3	45--85	0--85	45--85	45--85	45--85
	JOINT 4	15--0	0--0	10--80	10--80	10--80		JOINT 4	15--20	0--80	10--80	10--80	10--80
D-->F		THUMB	INDEX	MIDDLE	RING	LITTLE	D-->G		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-30)-(-20)	0--0	0--0	0--0	0--0		JOINT 1	(-30)-(-30)	0--0	0--0	0--0	0--0
	JOINT 2	25--25	0--45	45--0	45--0	45--0		JOINT 2	25--20	0--85	45--85	45--85	45--85
	JOINT 3	45--60	0--45	45--0	45--0	45--0		JOINT 3	45--0	0--0	45--85	45--85	45--85
	JOINT 4	15--10	0--10	10--0	10--0	10--0		JOINT 4	15--0	0--0	10--80	10--80	10--80
D-->H		THUMB	INDEX	MIDDLE	RING	LITTLE	D-->I		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-30)-(-20)	0--0	0--0	0--0	0--0		JOINT 1	(-30)-(-20)	0--0	0--0	0--0	0--0
	JOINT 2	25--45	0--0	45--0	45--85	45--85		JOINT 2	25--10	0--85	45--85	45--85	45--0
	JOINT 3	45--85	0--0	45--0	45--85	45--85		JOINT 3	45--80	0--85	45--85	45--85	45--0
	JOINT 4	15--0	0--0	10--0	10--80	10--80		JOINT 4	15--0	0--80	10--80	10--80	10--0
D-->J		THUMB	INDEX	MIDDLE	RING	LITTLE	D-->K		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-30)-(-20)	0--0	0--0	0--0	0--0		JOINT 1	(-30)-(-10)	0--0	0--0	0--0	0--0
	JOINT 2	25--10	0--85	45--85	45--85	45--0		JOINT 2	25--10	0--0	45--45	45--85	45--85
	JOINT 3	45--80	0--85	45--85	45--85	45--0		JOINT 3	45--45	0--0	45--0	45--85	45--85
	JOINT 4	15--0	0--80	10--80	10--80	10--0		JOINT 4	15--0	0--0	10--0	10--80	10--80
D-->L		THUMB	INDEX	MIDDLE	RING	LITTLE	D-->M		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-30)--0	0--0	0--0	0--0	0--0		JOINT 1	(-30)-(-10)	0--0	0--0	0--0	0--0
	JOINT 2	25--0	0--0	45--85	45--85	45--85		JOINT 2	25--45	0--75	45--75	45--75	45--85
	JOINT 3	45--0	0--0	45--85	45--85	45--85		JOINT 3	45--85	0--75	45--75	45--75	45--85
	JOINT 4	15--0	0--0	10--80	10--80	10--80		JOINT 4	15--10	0--10	10--10	10--10	10--80
D-->N		THUMB	INDEX	MIDDLE	RING	LITTLE	D-->O		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-30)-(-10)	0--0	0--0	0--0	0--0		JOINT 1	(-30)-(-30)	0--0	0--0	0--0	0--0
	JOINT 2	25--30	0--75	45--75	45--85	45--85		JOINT 2	25--25	0--60	45--60	45--60	45--60
	JOINT 3	45--60	0--75	45--75	45--85	45--85		JOINT 3	45--45	0--45	45--45	45--45	45--45
	JOINT 4	15--10	0--10	10--10	10--80	10--80		JOINT 4	15--45	0--10	10--10	10--10	10--10
D-->P		THUMB	INDEX	MIDDLE	RING	LITTLE	D-->Q		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-30)-(-10)	0--0	0--0	0--0	0--0		JOINT 1	(-30)-(-30)	0--0	0--0	0--0	0--0
	JOINT 2	25--10	0--0	45--45	45--85	45--85		JOINT 2	25--20	0--85	45--85	45--85	45--85
	JOINT 3	45--45	0--0	45--0	45--85	45--85		JOINT 3	45--0	0--0	45--85	45--85	45--85
	JOINT 4	15--0	0--0	10--0	10--80	10--80		JOINT 4	15--0	0--0	10--80	10--80	10--80

D-->R		THUMB	INDEX	MIDDLE	RING	LITTLE	D-->S		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-30)-(-20)	0--15	0--(-5)	0--0	0--0		JOINT 1	(-30)-(-20)	0--0	0--0	0--0	0--0
	JOINT 2	25--45	0--20	45--0	45--85	45--85		JOINT 2	25--30	0--0	45--85	45--85	45--85
	JOINT 3	45--45	0--0	45--0	45--85	45--85		JOINT 3	45--45	0--0	45--85	45--85	45--85
	JOINT 4	15--0	80--0	10--0	10--80	10--80		JOINT 4	15--45	0--0	10--80	10--80	10--80
D-->T		THUMB	INDEX	MIDDLE	RING	LITTLE	D-->U		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-30)--0	0--(-10)	0--0	0--0	0--0		JOINT 1	(-30)-(-20)	0--0	0--0	0--0	0--0
	JOINT 2	25--20	0--60	45--85	45--85	45--85		JOINT 2	25--45	0--0	45--0	45--85	45--85
	JOINT 3	45--25	0--80	45--85	45--85	45--85		JOINT 3	45--85	0--0	45--0	45--85	45--85
	JOINT 4	15--0	0--45	10--80	10--80	10--80		JOINT 4	15--0	0--0	10--0	10--80	10--80
D-->V		THUMB	INDEX	MIDDLE	RING	LITTLE	D-->W		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-30)-(-20)	0--(-10)	0--10	0--0	0--0		JOINT 1	(-30)-(-10)	0--(-10)	0--0	0--10	0--0
	JOINT 2	25--45	0--0	45--0	45--85	45--85		JOINT 2	25--45	0--0	45--0	45--0	45--85
	JOINT 3	45--45	0--0	45--0	45--85	45--85		JOINT 3	45--45	0--0	45--0	45--0	45--85
	JOINT 4	15--0	0--0	10--0	10--80	10--80		JOINT 4	15--0	0--0	10--0	10--0	10--80
D-->X		THUMB	INDEX	MIDDLE	RING	LITTLE	D-->Y		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-30)-(-20)	0--0	0--0	0--0	0--0		JOINT 1	(-30)--0	0--0	0--0	0--0	0--0
	JOINT 2	25--30	0--0	45--85	45--85	45--85		JOINT 2	25--0	0--85	45--85	45--85	45--0
	JOINT 3	45--45	0--45	45--85	45--85	45--85		JOINT 3	45--0	0--85	45--85	45--85	45--0
	JOINT 4	15--0	0--45	10--80	10--80	10--80		JOINT 4	15--0	0--80	10--80	10--80	10--0
D-->Z		THUMB	INDEX	MIDDLE	RING	LITTLE							
	JOINT 1	(-30)-(-20)	0--0	0--0	0--0	0--0							
	JOINT 2	25--30	0--0	45--85	45--85	45--85							
	JOINT 3	45--45	0--0	45--85	45--85	45--85							
	JOINT 4	15--0	0--0	10--80	10--80	10--80							

Angle transition values for Letter E

E-->B		THUMB	INDEX	MIDDLE	RING	LITTLE	E-->C		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	0--0	0--0	0--0	0--0	0--0		JOINT 1	0--(-30)	0--0	0--0	0--0	0--0
	JOINT 2	35--20	45--0	45--0	45--0	45--0		JOINT 2	35--25	45--45	45--45	45--45	45--45
	JOINT 3	85--25	85--0	85--0	85--0	85--0		JOINT 3	85--10	85--45	85--45	85--45	85--45
	JOINT 4	20--0	80--0	80--0	80--0	80--0		JOINT 4	20--10	80--10	80--10	80--10	80--10
E-->D		THUMB	INDEX	MIDDLE	RING	LITTLE	E-->A		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	0--(-30)	0--0	0--0	0--0	0--0		JOINT 1	0--0	0--0	0--0	0--0	0--0
	JOINT 2	35--25	45--0	45--45	45--45	45--45		JOINT 2	35--20	45--85	45--85	45--85	45--85
	JOINT 3	85--45	85--0	85--45	85--45	85--45		JOINT 3	85--25	85--85	85--85	85--85	85--85
	JOINT 4	20--15	80--0	80--10	80--10	80--10		JOINT 4	20--0	80--80	80--80	80--80	80--80
E-->F		THUMB	INDEX	MIDDLE	RING	LITTLE	E-->G		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	0--(-20)	0--0	0--0	0--0	0--0		JOINT 1	0--(-30)	0--0	0--0	0--0	0--0
	JOINT 2	35--25	45--45	45--0	45--0	45--0		JOINT 2	35--20	45--85	45--85	45--85	45--85
	JOINT 3	85--60	85--45	85--0	85--0	85--0		JOINT 3	85--0	85--0	85--85	85--85	85--85
	JOINT 4	20--10	80--10	80--0	80--0	80--0		JOINT 4	20--0	80--0	80--80	80--80	80--80
E-->H		THUMB	INDEX	MIDDLE	RING	LITTLE	E-->I		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	0--(-20)	0--0	0--0	0--0	0--0		JOINT 1	0--(-20)	0--0	0--0	0--0	0--0
	JOINT 2	35--45	45--0	45--0	45--85	45--85		JOINT 2	35--10	45--85	45--85	45--85	45--0
	JOINT 3	85--85	85--0	85--0	85--85	85--85		JOINT 3	85--80	85--85	85--85	85--85	85--0
	JOINT 4	20--0	80--0	80--0	80--80	80--80		JOINT 4	20--0	80--80	80--80	80--80	80--0
E-->J		THUMB	INDEX	MIDDLE	RING	LITTLE	E-->K		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	0--(-20)	0--0	0--0	0--0	0--0		JOINT 1	0--(-10)	0--0	0--0	0--0	0--0
	JOINT 2	35--10	45--85	45--85	45--85	45--0		JOINT 2	35--10	45--0	45--45	45--85	45--85
	JOINT 3	85--80	85--85	85--85	85--85	85--0		JOINT 3	85--45	85--0	85--0	85--85	85--85
	JOINT 4	20--0	80--80	80--80	80--80	80--0		JOINT 4	20--0	80--0	80--0	80--80	80--80
E-->L		THUMB	INDEX	MIDDLE	RING	LITTLE	E-->M		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	0--0	0--0	0--0	0--0	0--0		JOINT 1	0--(-10)	0--0	0--0	0--0	0--0
	JOINT 2	35--0	45--0	45--85	45--85	45--85		JOINT 2	35--45	45--75	45--75	45--75	45--85
	JOINT 3	85--0	85--0	85--85	85--85	85--85		JOINT 3	85--85	85--75	85--75	85--75	85--85
	JOINT 4	20--0	80--0	80--80	80--80	80--80		JOINT 4	20--10	80--10	80--10	80--10	80--80
E-->N		THUMB	INDEX	MIDDLE	RING	LITTLE	E-->O		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	0--(-10)	0--0	0--0	0--0	0--0		JOINT 1	0--(-30)	0--0	0--0	0--0	0--0
	JOINT 2	35--30	45--75	45--75	45--85	45--85		JOINT 2	35--25	45--60	45--60	45--60	45--60
	JOINT 3	85--60	85--75	85--75	85--85	85--85		JOINT 3	85--45	85--45	85--45	85--45	85--45
	JOINT 4	20--10	80--10	80--10	80--80	80--80		JOINT 4	20--45	80--10	80--10	80--10	80--10
E-->P		THUMB	INDEX	MIDDLE	RING	LITTLE	E-->Q		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	0--(-10)	0--0	0--0	0--0	0--0		JOINT 1	0--(-30)	0--0	0--0	0--0	0--0
	JOINT 2	35--10	45--0	45--45	45--85	45--85		JOINT 2	35--20	45--85	45--85	45--85	45--85
	JOINT 3	85--45	85--0	85--0	85--85	85--85		JOINT 3	85--0	85--0	85--85	85--85	85--85
	JOINT 4	20--0	80--0	80--0	80--80	80--80		JOINT 4	20--0	80--0	80--80	80--80	80--80

E-->R		THUMB	INDEX	MIDDLE	RING	LITTLE	E-->S		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	0--(-20)	0--15	0--(-5)	0--0	0--0		JOINT 1	0--(-20)	0--0	0--0	0--0	0--0
	JOINT 2	35--45	45--20	45--0	45--85	45--85		JOINT 2	35--30	45--85	45--85	45--85	45--85
	JOINT 3	85--45	85--0	85--0	85--85	85--85		JOINT 3	85--45	85--85	85--85	85--85	85--85
	JOINT 4	20--0	80--0	80--0	80--80	80--80		JOINT 4	20--45	80--80	80--80	80--80	80--80
E-->T		THUMB	INDEX	MIDDLE	RING	LITTLE	E-->U		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	0--0	0--(-10)	0--0	0--0	0--0		JOINT 1	0--(-20)	0--0	0--0	0--0	0--0
	JOINT 2	35--20	45--60	45--85	45--85	45--85		JOINT 2	35--45	45--0	45--0	45--85	45--85
	JOINT 3	85--25	85--80	85--85	85--85	85--85		JOINT 3	85--85	85--0	85--0	85--85	85--85
	JOINT 4	20--0	80--45	80--80	80--80	80--80		JOINT 4	20--0	80--0	80--0	80--80	80--80
E-->V		THUMB	INDEX	MIDDLE	RING	LITTLE	E-->W		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	0--(-20)	0--(-10)	0--10	0--0	0--0		JOINT 1	0--(-10)	0--(-10)	0--0	0--10	0--0
	JOINT 2	35--45	45--0	45--0	45--85	45--85		JOINT 2	35--45	45--0	45--0	45--0	45--85
	JOINT 3	85--45	85--0	85--0	85--85	85--85		JOINT 3	85--45	85--0	85--0	85--0	85--85
	JOINT 4	20--0	80--0	80--0	80--80	80--80		JOINT 4	20--0	80--0	80--0	80--0	80--80
E-->X		THUMB	INDEX	MIDDLE	RING	LITTLE	E-->Y		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	0--(-20)	0--0	0--0	0--0	0--0		JOINT 1	0--0	0--0	0--0	0--0	0--0
	JOINT 2	35--30	45--0	45--85	45--85	45--85		JOINT 2	35--0	45--85	45--85	45--85	45--0
	JOINT 3	85--45	85--45	85--85	85--85	85--85		JOINT 3	85--0	85--85	85--85	85--85	85--0
	JOINT 4	20--0	80--45	80--80	80--80	80--80		JOINT 4	20--0	80--80	80--80	80--80	80--0
E-->Z		THUMB	INDEX	MIDDLE	RING	LITTLE							
	JOINT 1	0--(-20)	0--0	0--0	0--0	0--0							
	JOINT 2	35--30	45--0	45--85	45--85	45--85							
	JOINT 3	85--45	85--0	85--85	85--85	85--85							
	JOINT 4	20--0	80--0	80--80	80--80	80--80							

Angle transition values for Letter F

F-->B		THUMB	INDEX	MIDDLE	RING	LITTLE	F-->C		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-20)--0	0--0	0--0	0--0	0--0		JOINT 1	(-20)-(-30)	0--0	0--0	0--0	0--0
	JOINT 2	25--20	45--0	0--0	0--0	0--0		JOINT 2	25--25	45--45	0--45	0--45	0--45
	JOINT 3	60--25	45--0	0--0	0--0	0--0		JOINT 3	60--10	45--45	0--45	0--45	0--45
	JOINT 4	10--0	10--0	0--0	0--0	0--0		JOINT 4	10--10	10--10	0--10	0--10	0--10
F-->D		THUMB	INDEX	MIDDLE	RING	LITTLE	F-->E		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-20)-(-30)	0--0	0--0	0--0	0--0		JOINT 1	(-20)--0	0--0	0--0	0--0	0--0
	JOINT 2	25--25	45--0	0--45	0--45	0--45		JOINT 2	25--35	45--45	0--45	0--45	0--45
	JOINT 3	60--45	45--0	0--45	0--45	0--45		JOINT 3	60--85	45--85	0--85	0--85	0--85
	JOINT 4	10--15	10--0	0--10	0--10	0--10		JOINT 4	10--20	10--80	0--80	0--80	0--80
F-->A		THUMB	INDEX	MIDDLE	RING	LITTLE	F-->G		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-20)--0	0--0	0--0	0--0	0--0		JOINT 1	(-30)-(-30)	0--0	0--0	0--0	0--0
	JOINT 2	25--20	45--85	0--85	0--85	0--85		JOINT 2	25--20	45--85	0--85	0--85	0--85
	JOINT 3	60--25	45--85	0--85	0--85	0--85		JOINT 3	60--0	45--0	0--85	0--85	0--85
	JOINT 4	10--0	10--80	0--80	0--80	0--80		JOINT 4	10--0	10--0	0--80	0--80	0--80
F-->H		THUMB	INDEX	MIDDLE	RING	LITTLE	F-->I		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	0--(-20)	0--0	0--0	0--0	0--0		JOINT 1	(-20)-(-20)	0--0	0--0	0--0	0--0
	JOINT 2	20--45	45--0	0--0	0--85	0--85		JOINT 2	25--10	45--85	0--85	0--85	0--0
	JOINT 3	25--85	45--0	0--0	0--85	0--85		JOINT 3	60--80	45--85	0--85	0--85	0--0
	JOINT 4	0--0	10--0	0--0	0--80	0--80		JOINT 4	10--0	10--80	0--80	0--80	0--0
F-->J		THUMB	INDEX	MIDDLE	RING	LITTLE	F-->K		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-20)-(-20)	0--0	0--0	0--0	0--0		JOINT 1	(-20)-(-10)	0--0	0--0	0--0	0--0
	JOINT 2	25--10	45--85	0--85	0--85	0--0		JOINT 2	25--10	45--0	0--45	0--85	0--85
	JOINT 3	60--80	45--85	0--85	0--85	0--0		JOINT 3	60--45	45--0	0--0	0--85	0--85
	JOINT 4	10--0	10--80	0--80	0--80	0--0		JOINT 4	10--0	10--0	0--0	0--80	0--80
F-->L		THUMB	INDEX	MIDDLE	RING	LITTLE	F-->M		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-20)--0	0--0	0--0	0--0	0--0		JOINT 1	(-20)-(-10)	0--0	0--0	0--0	0--0
	JOINT 2	25--0	45--0	0--85	0--85	0--85		JOINT 2	25--45	45--75	0--75	0--75	0--85
	JOINT 3	60--0	45--0	0--85	0--85	0--85		JOINT 3	60--85	45--75	0--75	0--75	0--85
	JOINT 4	10--0	10--0	0--80	0--80	0--80		JOINT 4	10--10	10--10	0--10	0--10	0--80
F-->N		THUMB	INDEX	MIDDLE	RING	LITTLE	F-->O		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-20)-(-10)	0--0	0--0	0--0	0--0		JOINT 1	(-20)-(-30)	0--0	0--0	0--0	0--0
	JOINT 2	25--30	45--75	0--75	0--85	0--85		JOINT 2	25--25	45--60	0--60	0--60	0--60
	JOINT 3	60--60	45--75	0--75	0--85	0--85		JOINT 3	60--45	45--45	0--45	0--45	0--45
	JOINT 4	10--10	10--10	0--10	0--80	0--80		JOINT 4	10--45	10--10	0--10	0--10	0--10
F-->P		THUMB	INDEX	MIDDLE	RING	LITTLE	F-->Q		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-20)-(-10)	0--0	0--0	0--0	0--0		JOINT 1	(-20)-(-30)	0--0	0--0	0--0	0--0
	JOINT 2	25--10	45--0	0--45	0--85	0--85		JOINT 2	25--20	45--85	0--85	0--85	0--85
	JOINT 3	60--45	45--0	0--0	0--85	0--85		JOINT 3	60--0	45--0	0--85	0--85	0--85
	JOINT 4	10--0	10--0	0--0	0--80	0--80		JOINT 4	10--0	10--0	0--80	0--80	0--80

F-->R		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-20)-(-20)	0--15	0--(-5)	0--0	0--0
	JOINT 2	25--45	45--20	0--0	0--85	0--85
	JOINT 3	60--45	45--0	0--0	0--85	0--85
	JOINT 4	10--0	10--0	0--0	0--80	0--80

F-->S		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-20)-(-20)	0--0	0--0	0--0	0--0
	JOINT 2	25--30	45--85	0--85	0--85	0--85
	JOINT 3	60--45	45--85	0--85	0--85	0--85
	JOINT 4	10--45	10--80	0--80	0--80	0--80

F-->T		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-20)--0	0--(-10)	0--0	0--0	0--0
	JOINT 2	25--20	45--60	0--85	0--85	0--85
	JOINT 3	60--25	45--80	0--85	0--85	0--85
	JOINT 4	10--0	10--45	0--80	0--80	0--80

F-->U		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-20)-(-20)	0--0	0--0	0--0	0--0
	JOINT 2	25--45	45--0	0--0	0--85	0--85
	JOINT 3	60--85	45--0	0--0	0--85	0--85
	JOINT 4	10--0	10--0	0--0	0--80	0--80

F-->V		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-20)-(-20)	0--(-10)	0--10	0--0	0--0
	JOINT 2	25--45	45--0	0--0	0--85	0--85
	JOINT 3	60--45	45--0	0--0	0--85	0--85
	JOINT 4	10--0	10--0	0--0	0--80	0--80

F-->W		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-20)-(-10)	0--(-10)	0--0	0--10	0--0
	JOINT 2	25--45	45--0	0--0	0--0	0--85
	JOINT 3	60--85	45--0	0--0	0--0	0--85
	JOINT 4	10--0	10--0	0--0	0--0	0--80

F-->X		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-20)-(-20)	0--0	0--0	0--0	0--0
	JOINT 2	25--30	45--0	0--85	0--85	0--85
	JOINT 3	60--45	45--45	0--85	0--85	0--85
	JOINT 4	10--0	10--45	0--80	0--80	0--80

F-->Y		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-20)--0	0--0	0--0	0--0	0--0
	JOINT 2	25--0	45--85	0--85	0--85	0--0
	JOINT 3	60--0	45--85	0--85	0--85	0--0
	JOINT 4	10--0	10--80	0--80	0--80	0--0

F-->Z		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-20)-(-20)	0--0	0--0	0--0	0--0
	JOINT 2	25--30	45--0	0--85	0--85	0--85
	JOINT 3	60--45	45--0	0--85	0--85	0--85
	JOINT 4	10--0	10--0	0--80	0--80	0--80

Angle transition values for Letter G

G-->B		THUMB	INDEX	MIDDLE	RING	LITTLE	G-->C		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(30)-0	0--0	0--0	0--0	0--0		JOINT 1	(-30)-(-30)	0--0	0--0	0--0	0--0
	JOINT 2	20--20	85--0	85--0	85--0	85--0		JOINT 2	20--25	85--45	85--45	85--45	85--45
	JOINT 3	0--25	0--0	85--0	85--0	85--0		JOINT 3	0--10	0--45	85--45	85--45	85--45
	JOINT 4	0--0	0--0	80--0	80--0	80--0		JOINT 4	0--10	0--10	80--10	80--10	80--10
G-->D		THUMB	INDEX	MIDDLE	RING	LITTLE	G-->E		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-30)-(-30)	0--0	0--0	0--0	0--0		JOINT 1	(-30)--0	0--0	0--0	0--0	0--0
	JOINT 2	20--25	85--0	85--45	85--45	85--45		JOINT 2	20--35	85--45	85--45	85--45	85--45
	JOINT 3	0--45	0--0	85--45	85--45	85--45		JOINT 3	0--85	0--85	85--85	85--85	85--85
	JOINT 4	0--15	0--0	80--10	80--10	80--10		JOINT 4	0--20	0--80	80--80	80--80	80--80
G-->F		THUMB	INDEX	MIDDLE	RING	LITTLE	G-->A		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-30)-(-20)	0--0	0--0	0--0	0--0		JOINT 1	(-30)--0	0--0	0--0	0--0	0--0
	JOINT 2	20--25	85--45	85--0	85--0	85--0		JOINT 2	20--20	85--85	85--85	85--85	85--85
	JOINT 3	0--60	0--45	85--0	85--0	85--0		JOINT 3	0--25	0--85	85--85	85--85	85--85
	JOINT 4	0--10	0--10	80--0	80--0	80--0		JOINT 4	0--0	0--80	80--80	80--80	80--80
G-->H		THUMB	INDEX	MIDDLE	RING	LITTLE	G-->I		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-30)-(-20)	0--0	0--0	0--0	0--0		JOINT 1	(-30)-(-20)	0--0	0--0	0--0	0--0
	JOINT 2	20--45	85--0	85--0	85--85	85--85		JOINT 2	20--10	85--85	85--85	85--85	85--0
	JOINT 3	0--85	0--0	85--0	85--85	85--85		JOINT 3	0--80	0--85	85--85	85--85	85--0
	JOINT 4	0--0	0--0	80--0	80--80	80--80		JOINT 4	0--0	0--80	80--80	80--80	80--0
G-->J		THUMB	INDEX	MIDDLE	RING	LITTLE	G-->K		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-30)-(-20)	0--0	0--0	0--0	0--0		JOINT 1	(-30)-(-10)	0--0	0--0	0--0	0--0
	JOINT 2	20--10	85--85	85--85	85--85	85--0		JOINT 2	20--10	85--0	85--45	85--85	85--85
	JOINT 3	0--80	0--85	85--85	85--85	85--0		JOINT 3	0--45	0--0	85--0	85--85	85--85
	JOINT 4	0--0	0--80	80--80	80--80	80--0		JOINT 4	0--0	0--0	80--0	80--80	80--80
G-->L		THUMB	INDEX	MIDDLE	RING	LITTLE	G->M		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-30)--0	0--0	0--0	0--0	0--0		JOINT 1	(-30)-(-10)	0--0	0--0	0--0	0--0
	JOINT 2	20--0	85--0	85--85	85--85	85--85		JOINT 2	20--45	85--75	85--75	85--75	85--85
	JOINT 3	0--0	0--0	85--85	85--85	85--85		JOINT 3	0--85	0--75	85--75	85--75	85--85
	JOINT 4	0--0	0--0	80--80	80--80	80--80		JOINT 4	0--10	0--10	80--10	80--10	80--80
G-->N		THUMB	INDEX	MIDDLE	RING	LITTLE	G-->O		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-30)-(-10)	0--0	0--0	0--0	0--0		JOINT 1	(-30)-(-30)	0--0	0--0	0--0	0--0
	JOINT 2	20--30	85--75	85--75	85--85	85--85		JOINT 2	20--25	85--60	85--60	85--60	85--60
	JOINT 3	0--60	0--75	85--75	85--85	85--85		JOINT 3	0--45	0--45	85--45	85--45	85--45
	JOINT 4	0--10	0--10	80--10	80--80	80--80		JOINT 4	0--45	0--10	80--10	80--10	80--10
G-->P		THUMB	INDEX	MIDDLE	RING	LITTLE	G-->Q		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-30)-(-10)	0--0	0--0	0--0	0--0		JOINT 1	(-30)-(-30)	0--0	0--0	0--0	0--0
	JOINT 2	20--10	85--0	85--45	85--85	85--85		JOINT 2	20--20	85--85	85--85	85--85	85--85
	JOINT 3	0--45	0--0	85--0	85--85	85--85		JOINT 3	0--0	0--0	85--85	85--85	85--85
	JOINT 4	0--0	0--0	80--0	80--80	80--80		JOINT 4	0--0	0--0	80--80	80--80	80--80

G-->R		THUMB	INDEX	MIDDLE	RING	LITTLE	G-->S		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-30)-(-20)	0--15	0--(-5)	0--0	0--0		JOINT 1	(-30)-(-20)	0--0	0--0	0--0	0--0
	JOINT 2	20--45	85--20	85--0	85--85	85--85		JOINT 2	20--30	85--85	85--85	85--85	85--85
	JOINT 3	0--45	0--0	85--0	85--85	85--85		JOINT 3	0--45	0--85	85--85	85--85	85--85
	JOINT 4	0--0	0--0	80--0	80--80	80--80		JOINT 4	0--45	0--80	80--80	80--80	80--80
G-->T		THUMB	INDEX	MIDDLE	RING	LITTLE	G-->U		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-30)-0	0--(-10)	0--0	0--0	0--0		JOINT 1	(-30)-(-20)	0--0	0--0	0--0	0--0
	JOINT 2	20--20	85--60	85--85	85--85	85--85		JOINT 2	20--45	85--0	85--0	85--85	85--85
	JOINT 3	0--25	0--80	85--85	85--85	85--85		JOINT 3	0--85	0--0	85--0	85--85	85--85
	JOINT 4	0--0	0--45	80--80	80--80	80--80		JOINT 4	0--0	0--0	80--0	80--80	80--80
G-->V		THUMB	INDEX	MIDDLE	RING	LITTLE	G->W		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-30)-(-20)	0--(-10)	0--10	0--0	0--0		JOINT 1	(-30)-(-10)	0--(-10)	0--0	0--10	0--0
	JOINT 2	20--45	85--0	85--0	85--85	85--85		JOINT 2	20--45	85--0	85--0	85--0	85--85
	JOINT 3	0--45	0--0	85--0	85--85	85--85		JOINT 3	0--45	0--0	85--0	85--0	85--85
	JOINT 4	0--0	0--0	80--0	80--80	80--80		JOINT 4	0--0	0--0	80--0	80--0	80--80
G-->X		THUMB	INDEX	MIDDLE	RING	LITTLE	G-->Y		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-30)-(-20)	0--0	0--0	0--0	0--0		JOINT 1	(-30)--0	0--0	0--0	0--0	0--0
	JOINT 2	20--30	85--0	85--85	85--85	85--85		JOINT 2	20--0	85--85	85--85	85--85	85--0
	JOINT 3	0--45	0--45	85--85	85--85	85--85		JOINT 3	0--0	0--85	85--85	85--85	85--0
	JOINT 4	0--0	0--45	80--80	80--80	80--80		JOINT 4	0--0	0--80	80--80	80--80	80--0
G-->Z		THUMB	INDEX	MIDDLE	RING	LITTLE							
	JOINT 1	(-30)-(-20)	0--0	0--0	0--0	0--0							
	JOINT 2	20--30	85--0	85--85	85--85	85--85							
	JOINT 3	0--45	0--0	85--85	85--85	85--85							
	JOINT 4	0--0	0--0	80--80	80--80	80--80							

Angle transition values for Letter H

H-->B		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-20)--0	0--0	0--0	0--0	0--0
	JOINT 2	45--20	0--0	0--0	85--0	85--0
	JOINT 3	85--25	0--0	0--0	85--0	85--0
	JOINT 4	0--0	0--0	0--0	80--0	80--0

H-->C		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-20)-(-30)	0--0	0--0	0--0	0--0
	JOINT 2	45--25	0--45	0--45	85--45	85--45
	JOINT 3	85--10	0--45	0--45	85--45	85--45
	JOINT 4	0--10	0--10	0--10	80--10	80--10

H-->D		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-20)-(-30)	0--0	0--0	0--0	0--0
	JOINT 2	45--25	0--0	0--45	85--45	85--45
	JOINT 3	85--45	0--0	0--45	85--45	85--45
	JOINT 4	0--15	0--0	0--10	80--10	80--10

H-->E		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-20)--0	0--0	0--0	0--0	0--0
	JOINT 2	45--35	0--45	0--45	85--45	85--45
	JOINT 3	85--85	0--85	0--85	85--85	85--85
	JOINT 4	0--20	0--80	0--80	80--80	80--80

H-->F		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-20)-(-20)	0--0	0--0	0--0	0--0
	JOINT 2	45--25	0--45	0--0	85--0	85--0
	JOINT 3	85--60	0--45	0--0	85--0	85--0
	JOINT 4	0--10	0--10	0--0	80--0	80--0

H-->G		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-20)-(-30)	0--0	0--0	0--0	0--0
	JOINT 2	45--20	0--85	0--85	85--85	85--85
	JOINT 3	85--0	0--0	0--85	85--85	85--85
	JOINT 4	0--0	0--0	0--80	80--80	80--80

H-->A		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-20)--0	0--0	0--0	0--0	0--0
	JOINT 2	45--20	0--85	0--85	85--85	85--85
	JOINT 3	85--25	0--85	0--85	85--85	85--85
	JOINT 4	0--0	0--80	0--80	80--80	80--80

H-->I		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-20)-(-20)	0--0	0--0	0--0	0--0
	JOINT 2	45--10	0--85	0--85	85--85	85--0
	JOINT 3	85--80	0--85	0--85	85--85	85--0
	JOINT 4	0--0	0--80	0--80	80--80	80--0

H-->J		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-20)-(-20)	0--0	0--0	0--0	0--0
	JOINT 2	45--10	0--85	0--85	85--85	85--0
	JOINT 3	85--80	0--85	0--85	85--85	85--0
	JOINT 4	0--0	0--80	0--80	80--80	80--0

H-->K		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-20)-(-10)	0--0	0--0	0--0	0--0
	JOINT 2	45--10	0--0	0--45	85--85	85--85
	JOINT 3	85--45	0--0	0--0	85--85	85--85
	JOINT 4	0--0	0--0	0--0	80--80	80--80

H-->L		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-20)--0	0--0	0--0	0--0	0--0
	JOINT 2	45--0	0--0	0--85	85--85	85--85
	JOINT 3	85--0	0--0	0--85	85--85	85--85
	JOINT 4	0--0	0--0	0--80	80--80	80--80

H->M		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-20)-(-10)	0--0	0--0	0--0	0--0
	JOINT 2	45--45	0--75	0--75	85--75	85--85
	JOINT 3	85--85	0--75	0--75	85--75	85--85
	JOINT 4	0--10	0--10	0--10	80--10	80--80

H-->N		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-20)-(-10)	0--0	0--0	0--0	0--0
	JOINT 2	45--30	0--75	0--75	85--85	85--85
	JOINT 3	85--60	0--75	0--75	85--85	85--85
	JOINT 4	0--10	0--10	0--10	80--80	80--80

H-->O		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-20)-(-30)	0--0	0--0	0--0	0--0
	JOINT 2	45--25	0--60	0--60	85--60	85--60
	JOINT 3	85--45	0--45	0--45	85--45	85--45
	JOINT 4	0--45	0--10	0--10	80--10	80--10

H-->P		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-20)-(-10)	0--0	0--0	0--0	0--0
	JOINT 2	45--10	0--0	0--45	85--85	85--85
	JOINT 3	85--45	0--0	0--0	85--85	85--85
	JOINT 4	0--0	0--0	0--0	80--80	80--80

H-->Q		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-20)-(-30)	0--0	0--0	0--0	0--0
	JOINT 2	45--20	0--85	0--85	85--85	85--85
	JOINT 3	85--0	0--0	0--85	85--85	85--85
	JOINT 4	0--0	0--0	0--80	80--80	80--80

H-->R		THUMB	INDEX	MIDDLE	RING	LITTLE	H-->S		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-20)-(-20)	0--15	0--(-5)	0--0	0--0		JOINT 1	(-20)-(-20)	0--0	0--0	0--0	0--0
	JOINT 2	45--45	0--20	0--0	85--85	85--85		JOINT 2	45--30	0--85	0--85	85--85	85--85
	JOINT 3	85--45	0--0	0--0	85--85	85--85		JOINT 3	85--45	0--85	0--85	85--85	85--85
	JOINT 4	0--0	0--0	0--0	80--80	80--80		JOINT 4	0--45	0--80	0--80	80--80	80--80
H-->T		THUMB	INDEX	MIDDLE	RING	LITTLE	H-->U		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-20)--0	0--(-10)	0--0	0--0	0--0		JOINT 1	(-20)-(-20)	0--0	0--0	0--0	0--0
	JOINT 2	45--20	0--60	0--85	85--85	85--85		JOINT 2	45--45	0--0	0--0	85--85	85--85
	JOINT 3	85--25	0--80	0--85	85--85	85--85		JOINT 3	85--85	0--0	0--0	85--85	85--85
	JOINT 4	0--0	0--45	0--80	80--80	80--80		JOINT 4	0--0	0--0	0--0	80--80	80--80
H-->V		THUMB	INDEX	MIDDLE	RING	LITTLE	H->W		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-20)-(-20)	0--(-10)	0--10	0--0	0--0		JOINT 1	(-20)-(-10)	0--(-10)	0--0	0--10	0--0
	JOINT 2	45--45	0--0	0--0	85--85	85--85		JOINT 2	45--45	0--0	0--0	85--0	85--85
	JOINT 3	85--45	0--0	0--0	85--85	85--85		JOINT 3	85--45	0--0	0--0	85--0	85--85
	JOINT 4	0--0	0--0	0--0	80--80	80--80		JOINT 4	0--0	0--0	0--0	80--0	80--80
H-->X		THUMB	INDEX	MIDDLE	RING	LITTLE	H-->Y		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-20)-(-20)	0--0	0--0	0--0	0--0		JOINT 1	(-20)--0	0--0	0--0	0--0	0--0
	JOINT 2	45--30	0--0	0--85	85--85	85--85		JOINT 2	45--0	0--85	0--85	85--85	85--0
	JOINT 3	85--45	0--45	0--85	85--85	85--85		JOINT 3	85--0	0--85	0--85	85--85	85--0
	JOINT 4	0--0	0--45	0--80	80--80	80--80		JOINT 4	0--0	0--80	0--80	80--80	80--0
H-->Z		THUMB	INDEX	MIDDLE	RING	LITTLE							
	JOINT 1	(-20)-(-20)	0--0	0--0	0--0	0--0							
	JOINT 2	45--30	0--0	0--85	85--85	85--85							
	JOINT 3	85--45	0--0	0--85	85--85	85--85							
	JOINT 4	0--0	0--0	0--80	80--80	80--80							

Angle transition values for Letter I

I-->B		THUMB	INDEX	MIDDLE	RING	LITTLE	I-->C		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-20)--0	0--0	0--0	0--0	0--0		JOINT 1	(-20)-(-30)	0--0	0--0	0--0	0--0
	JOINT 2	10--20	85--0	85--0	85--0	0--0		JOINT 2	10--25	85--45	85--45	85--45	0--45
	JOINT 3	80--25	85--0	85--0	85--0	0--0		JOINT 3	80--30	85--45	85--45	85--45	0--45
	JOINT 4	0--0	80--0	80--0	80--0	0--0		JOINT 4	0--10	80--10	80--10	80--10	0--10
I-->D		THUMB	INDEX	MIDDLE	RING	LITTLE	I-->E		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-20)-(-30)	0--0	0--0	0--0	0--0		JOINT 1	(-20)-0	0--0	0--0	0--0	0--0
	JOINT 2	10--25	85--0	85--45	85--45	0--45		JOINT 2	10--35	85--45	85--45	85--45	0--45
	JOINT 3	80--45	85--0	85--45	85--45	0--45		JOINT 3	80--85	85--85	85--85	85--85	0--85
	JOINT 4	0--15	80--0	80--10	80--10	0--10		JOINT 4	0--20	80--80	80--80	80--80	0--80
I-->F		THUMB	INDEX	MIDDLE	RING	LITTLE	I-->G		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-20)-(-20)	0--0	0--0	0--0	0--0		JOINT 1	(-20)-(-30)	0--0	0--0	0--0	0--0
	JOINT 2	10--25	85--45	85--0	85--0	0--0		JOINT 2	10--20	85--85	85--85	85--85	0--85
	JOINT 3	80--60	85--45	85--0	85--0	0--0		JOINT 3	80--0	85--0	85--85	85--85	0--85
	JOINT 4	0--10	80--10	80--0	80--0	0--0		JOINT 4	0--0	80--0	80--80	80--80	0--80
I-->H		THUMB	INDEX	MIDDLE	RING	LITTLE	I-->A		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-20)-(-20)	0--0	0--0	0--0	0--0		JOINT 1	(-20)--0	0--0	0--0	0--0	0--0
	JOINT 2	10--45	85--0	85--0	85--85	0--85		JOINT 2	10--20	85--85	85--85	85--85	0--85
	JOINT 3	80--85	85--0	85--0	85--85	0--85		JOINT 3	80--25	85--85	85--85	85--85	0--85
	JOINT 4	0--0	80--0	80--0	80--80	0--80		JOINT 4	0--0	80--80	80--80	80--80	0--80
I-->J		THUMB	INDEX	MIDDLE	RING	LITTLE	I-->K		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-20)-(-20)	0--0	0--0	0--0	0--0		JOINT 1	(-20)-(-10)	0--0	0--0	0--0	0--0
	JOINT 2	10--10	85--85	85--85	85--85	0--0		JOINT 2	10--10	85--0	85--45	85--85	0--85
	JOINT 3	80--80	85--85	85--85	85--85	0--0		JOINT 3	80--45	85--0	85--0	85--85	0--85
	JOINT 4	0--0	80--80	80--80	80--80	0--0		JOINT 4	0--0	80--0	80--0	80--80	0--80
I-->L		THUMB	INDEX	MIDDLE	RING	LITTLE	I-->M		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-20)--0	0--0	0--0	0--0	0--0		JOINT 1	(-20)-(-10)	0--0	0--0	0--0	0--0
	JOINT 2	10--0	85--0	85--85	85--85	0--85		JOINT 2	10--45	85--75	85--75	85--75	0--85
	JOINT 3	80--0	85--0	85--85	85--85	0--85		JOINT 3	80--85	85--75	85--75	85--75	0--85
	JOINT 4	0--0	80--0	80--80	80--80	0--80		JOINT 4	0--10	80--10	80--10	80--10	0--80
I-->N		THUMB	INDEX	MIDDLE	RING	LITTLE	I-->O		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-20)-(-10)	0--0	0--0	0--0	0--0		JOINT 1	(-20)-(-30)	0--0	0--0	0--0	0--0
	JOINT 2	10--30	85--75	85--75	85--85	0--85		JOINT 2	10--25	85--60	85--60	85--60	0--60
	JOINT 3	80--60	85--75	85--75	85--85	0--85		JOINT 3	80--45	85--45	85--45	85--45	0--45
	JOINT 4	0--10	80--10	80--10	80--80	0--80		JOINT 4	0--45	80--10	80--10	80--10	0--10
I-->P		THUMB	INDEX	MIDDLE	RING	LITTLE	I-->Q		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-20)-(-10)	0--0	0--0	0--0	0--0		JOINT 1	(-20)-(-30)	0--0	0--0	0--0	0--0
	JOINT 2	10--10	85--0	85--45	85--85	0--85		JOINT 2	10--20	85--85	85--85	85--85	0--85
	JOINT 3	80--45	85--0	85--0	85--85	0--85		JOINT 3	80--0	85--0	85--85	85--85	0--85
	JOINT 4	0--0	80--0	80--0	85--80	0--80		JOINT 4	0--0	80--0	80--80	80--80	0--80

I-->R		THUMB	INDEX	MIDDLE	RING	LITTLE	I-->S		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-20)-(-20)	0--15	0--(-5)	0--0	0--0		JOINT 1	(-20)-(-20)	0--0	0--0	0--0	0--0
	JOINT 2	10--45	85--20	85--0	85--85	0--85		JOINT 2	10--30	85--85	85--85	85--85	0--85
	JOINT 3	80--45	85--0	85--0	85--85	0--85		JOINT 3	80--45	85--85	85--85	85--85	0--85
	JOINT 4	0--0	80--0	80--0	80--80	0--80		JOINT 4	0--45	80--80	80--80	80--80	0--80
I-->T		THUMB	INDEX	MIDDLE	RING	LITTLE	I-->U		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-20)--0	0--(-10)	0--0	0--0	0--0		JOINT 1	(-20)-(-20)	0--0	0--0	0--0	0--0
	JOINT 2	10--20	85--60	85--85	85--85	0--85		JOINT 2	10--45	85--0	85--0	85--85	0--85
	JOINT 3	80--25	85--80	85--85	85--85	0--85		JOINT 3	80--85	85--0	85--0	85--85	0--85
	JOINT 4	0--0	80--45	80--80	80--80	0--80		JOINT 4	0--0	80--0	80--0	80--80	0--80
I-->V		THUMB	INDEX	MIDDLE	RING	LITTLE	I-->W		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-20)-(-20)	0--(-10)	0--10	0--0	0--0		JOINT 1	(-20)-(-10)	0--(-10)	0--0	0--10	0--0
	JOINT 2	10--45	85--0	85--0	85--85	0--85		JOINT 2	10--45	85--0	85--0	85--0	0--85
	JOINT 3	80--45	85--0	85--0	85--85	0--85		JOINT 3	80--85	85--0	85--0	85--0	0--85
	JOINT 4	0--0	80--0	80--0	80--80	0--80		JOINT 4	0--0	80--0	80--0	80--0	0--80
I-->X		THUMB	INDEX	MIDDLE	RING	LITTLE	I-->Y		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-20)-(-20)	0--0	0--0	0--0	0--0		JOINT 1	(-20)--0	0--0	0--0	0--0	0--0
	JOINT 2	10--30	85--0	85--85	85--85	0--85		JOINT 2	10--0	85--85	85--85	85--85	0--0
	JOINT 3	80--45	85--45	85--85	85--85	0--85		JOINT 3	80--0	85--85	85--85	85--85	0--0
	JOINT 4	0--0	80--45	80--80	80--80	0--80		JOINT 4	0--0	80--80	80--80	80--80	0--0
I-->Z		THUMB	INDEX	MIDDLE	RING	LITTLE							
	JOINT 1	(-20)-(-20)	0--0	0--0	0--0	0--0							
	JOINT 2	10--30	85--0	85--85	85--85	0--85							
	JOINT 3	80--45	85--0	85--85	85--85	0--85							
	JOINT 4	0--0	80--0	80--80	80--80	0--80							

Angle transition values for Letter J

J-->B		THUMB	INDEX	MIDDLE	RING	LITTLE	J-->C		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-20)--0	0--0	0--0	0--0	0--0		JOINT 1	(-20)-(-30)	0--0	0--0	0--0	0--0
	JOINT 2	10--20	85--0	85--0	85--0	0--0		JOINT 2	10--25	85--45	85--45	85--45	0--45
	JOINT 3	80--25	85--0	85--0	85--0	0--0		JOINT 3	80--30	85--45	85--45	85--45	0--45
	JOINT 4	0--0	80--0	80--0	80--0	0--0		JOINT 4	0--10	80--10	80--10	80--10	0--10
J-->D		THUMB	INDEX	MIDDLE	RING	LITTLE	J-->E		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-20)-(-30)	0--0	0--0	0--0	0--0		JOINT 1	(-20)-0	0--0	0--0	0--0	0--0
	JOINT 2	10--25	85--0	85--45	85--45	0--45		JOINT 2	10--35	85--45	85--45	85--45	0--45
	JOINT 3	80--45	85--0	85--45	85--45	0--45		JOINT 3	80--85	85--85	85--85	85--85	0--85
	JOINT 4	0--15	80--0	80--10	80--10	0--10		JOINT 4	0--20	80--80	80--80	80--80	0--80
J-->F		THUMB	INDEX	MIDDLE	RING	LITTLE	J-->G		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-20)-(-20)	0--0	0--0	0--0	0--0		JOINT 1	(-20)-(-30)	0--0	0--0	0--0	0--0
	JOINT 2	10--25	85--45	85--0	85--0	0--0		JOINT 2	10--20	85--85	85--85	85--85	0--85
	JOINT 3	80--60	85--45	85--0	85--0	0--0		JOINT 3	80--0	85--0	85--85	85--85	0--85
	JOINT 4	0--10	80--10	80--0	80--0	0--0		JOINT 4	0--0	80--0	80--80	80--80	0--80
J-->H		THUMB	INDEX	MIDDLE	RING	LITTLE	J-->I		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-20)-(-20)	0--0	0--0	0--0	0--0		JOINT 1	(-20)-(-20)	0--0	0--0	0--0	0--0
	JOINT 2	10--45	85--0	85--0	85--85	0--85		JOINT 2	10--10	85--85	85--85	85--85	0--0
	JOINT 3	80--85	85--0	85--0	85--85	0--85		JOINT 3	80--80	85--85	85--85	85--85	0--0
	JOINT 4	0--0	80--0	80--0	80--80	0--80		JOINT 4	0--0	80--80	80--80	80--80	0--0
J-->A		THUMB	INDEX	MIDDLE	RING	LITTLE	J-->K		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-20)--0	0--0	0--0	0--0	0--0		JOINT 1	(-20)-(-10)	0--0	0--0	0--0	0--0
	JOINT 2	10--20	85--85	85--85	85--85	0--85		JOINT 2	10--10	85--0	85--45	85--85	0--85
	JOINT 3	80--25	85--85	85--85	85--85	0--85		JOINT 3	80--45	85--0	85--0	85--85	0--85
	JOINT 4	0--0	80--80	80--80	80--80	0--80		JOINT 4	0--0	80--0	80--0	80--80	0--80
J-->L		THUMB	INDEX	MIDDLE	RING	LITTLE	J-->M		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-20)--0	0--0	0--0	0--0	0--0		JOINT 1	(-20)-(-10)	0--0	0--0	0--0	0--0
	JOINT 2	10--0	85--0	85--85	85--85	0--85		JOINT 2	10--45	85--75	85--75	85--75	0--85
	JOINT 3	80--0	85--0	85--85	85--85	0--85		JOINT 3	80--85	85--75	85--75	85--75	0--85
	JOINT 4	0--0	80--0	80--80	80--80	0--80		JOINT 4	0--10	80--10	80--10	80--10	0--80
J-->N		THUMB	INDEX	MIDDLE	RING	LITTLE	J-->O		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-20)-(-10)	0--0	0--0	0--0	0--0		JOINT 1	(-20)-(-30)	0--0	0--0	0--0	0--0
	JOINT 2	10--30	85--75	85--75	85--85	0--85		JOINT 2	10--25	85--60	85--60	85--60	0--60
	JOINT 3	80--60	85--75	85--75	85--85	0--85		JOINT 3	80--45	85--45	85--45	85--45	0--45
	JOINT 4	0--10	80--10	80--10	80--80	0--80		JOINT 4	0--45	80--10	80--10	80--10	0--10
J-->P		THUMB	INDEX	MIDDLE	RING	LITTLE	J-->Q		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-20)-(-10)	0--0	0--0	0--0	0--0		JOINT 1	(-20)-(-30)	0--0	0--0	0--0	0--0
	JOINT 2	10--10	85--0	85--45	85--85	0--85		JOINT 2	10--20	85--85	85--85	85--85	0--85
	JOINT 3	80--45	85--0	85--0	85--85	0--85		JOINT 3	80--0	85--0	85--85	85--85	0--85
	JOINT 4	0--0	80--0	80--0	85--80	0--80		JOINT 4	0--0	80--0	80--80	80--80	0--80

J-->R		THUMB	INDEX	MIDDLE	RING	LITTLE	J-->S		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-20)-(-20)	0--15	0--(-5)	0--0	0--0		JOINT 1	(-20)-(-20)	0--0	0--0	0--0	0--0
	JOINT 2	10--45	85--20	85--0	85--85	0--85		JOINT 2	10--30	85--85	85--85	85--85	0--85
	JOINT 3	80--45	85--0	85--0	85--85	0--85		JOINT 3	80--45	85--85	85--85	85--85	0--85
	JOINT 4	0--0	80--0	80--0	80--80	0--80		JOINT 4	0--45	80--80	80--80	80--80	0--80
J-->T		THUMB	INDEX	MIDDLE	RING	LITTLE	J-->U		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-20)--0	0--(-10)	0--0	0--0	0--0		JOINT 1	(-20)-(-20)	0--0	0--0	0--0	0--0
	JOINT 2	10--20	85--60	85--85	85--85	0--85		JOINT 2	10--45	85--0	85--0	85--85	0--85
	JOINT 3	80--25	85--80	85--85	85--85	0--85		JOINT 3	80--85	85--0	85--0	85--85	0--85
	JOINT 4	0--0	80--45	80--80	80--80	0--80		JOINT 4	0--0	80--0	80--0	80--80	0--80
J-->V		THUMB	INDEX	MIDDLE	RING	LITTLE	J-->W		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-20)-(-20)	0--(-10)	0--10	0--0	0--0		JOINT 1	(-20)-(-10)	0--(-10)	0--0	0--10	0--0
	JOINT 2	10--45	85--0	85--0	85--85	0--85		JOINT 2	10--45	85--0	85--0	85--0	0--85
	JOINT 3	80--45	85--0	85--0	85--85	0--85		JOINT 3	80--85	85--0	85--0	85--0	0--85
	JOINT 4	0--0	80--0	80--0	80--80	0--80		JOINT 4	0--0	80--0	80--0	80--0	0--80
J-->X		THUMB	INDEX	MIDDLE	RING	LITTLE	J-->Y		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-20)-(-20)	0--0	0--0	0--0	0--0		JOINT 1	(-20)--0	0--0	0--0	0--0	0--0
	JOINT 2	10--30	85--0	85--85	85--85	0--85		JOINT 2	10--0	85--85	85--85	85--85	0--0
	JOINT 3	80--45	85--45	85--85	85--85	0--85		JOINT 3	80--0	85--85	85--85	85--85	0--0
	JOINT 4	0--0	80--45	80--80	80--80	0--80		JOINT 4	0--0	80--80	80--80	80--80	0--0
J-->Z		THUMB	INDEX	MIDDLE	RING	LITTLE							
	JOINT 1	(-20)-(-20)	0--0	0--0	0--0	0--0							
	JOINT 2	10--30	85--0	85--85	85--85	0--85							
	JOINT 3	80--45	85--0	85--85	85--85	0--85							
	JOINT 4	0--0	80--0	80--80	80--80	0--80							

Angle transition values for Letter K

K-->B		THUMB	INDEX	MIDDLE	RING	LITTLE	K-->C		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-10)--0	0--0	0--0	0--0	0--0		JOINT 1	(-20)-(-30)	0--0	0--0	0--0	0--0
	JOINT 2	10--20	0--0	45--0	85--0	85--0		JOINT 2	10--25	0--45	45--45	85--45	85--45
	JOINT 3	45--25	0--0	0--0	85--0	85--0		JOINT 3	45--30	0--45	0--45	85--45	85--45
	JOINT 4	0--0	0--0	0--0	80--0	80--0		JOINT 4	0--10	0--10	0--10	80--10	80--10
K-->D		THUMB	INDEX	MIDDLE	RING	LITTLE	K-->E		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-10)-(-30)	0--0	0--0	0--0	0--0		JOINT 1	(-10)--0	0--0	0--0	0--0	0--0
	JOINT 2	10--25	0--0	45--45	85--45	85--45		JOINT 2	10--35	0--45	45--45	85--45	85--45
	JOINT 3	45--45	0--0	0--45	85--45	85--45		JOINT 3	45--85	0--85	0--85	85--85	85--85
	JOINT 4	0--15	0--0	0--10	80--10	80--10		JOINT 4	0--20	0--80	0--80	80--80	80--80
K-->F		THUMB	INDEX	MIDDLE	RING	LITTLE	K-->G		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-10)-(-20)	0--0	0--0	0--0	0--0		JOINT 1	(-10)-(-30)	0--0	0--0	0--0	0--0
	JOINT 2	10--25	0--45	45--0	85--0	85--0		JOINT 2	10--20	0--85	45--85	85--85	85--85
	JOINT 3	45--60	0--45	0--0	85--0	85--0		JOINT 3	45--0	0--0	0--85	85--85	85--85
	JOINT 4	0--10	0--10	0--0	80--0	80--0		JOINT 4	0--0	0--0	0--80	80--80	80--80
K-->H		THUMB	INDEX	MIDDLE	RING	LITTLE	K-->I		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-10)-(-20)	0--0	0--0	0--0	0--0		JOINT 1	(-10)-(-20)	0--0	0--0	0--0	0--0
	JOINT 2	10--45	0--0	85--0	85--85	85--85		JOINT 2	10--10	0--85	45--85	85--85	85--0
	JOINT 3	45--85	0--0	85--0	85--85	85--85		JOINT 3	45--80	0--85	0--85	85--85	85--0
	JOINT 4	0--0	0--0	80--0	80--80	80--80		JOINT 4	0--0	0--80	0--80	80--80	80--0
K-->J		THUMB	INDEX	MIDDLE	RING	LITTLE	K-->A		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-10)-(-20)	0--0	0--0	0--0	0--0		JOINT 1	(-10)--0	0--0	0--0	0--0	0--0
	JOINT 2	10--10	0--85	45--85	85--85	85--0		JOINT 2	10--20	0--85	45--85	85--85	85--85
	JOINT 3	45--80	0--85	0--85	85--85	85--0		JOINT 3	45--25	0--85	0--85	85--85	85--85
	JOINT 4	0--0	0--80	0--80	80--80	80--0		JOINT 4	0--0	0--80	0--80	80--80	80--80
K-->L		THUMB	INDEX	MIDDLE	RING	LITTLE	K-->M		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-10)--0	0--0	0--0	0--0	0--0		JOINT 1	(-10)-(-10)	0--0	0--0	0--0	0--0
	JOINT 2	10--0	0--0	45--85	85--85	85--85		JOINT 2	10--45	0--75	45--75	85--75	85--85
	JOINT 3	45--0	0--0	0--85	85--85	85--85		JOINT 3	45--85	0--75	0--75	85--75	85--85
	JOINT 4	0--0	0--0	0--80	80--80	80--80		JOINT 4	0--10	0--10	0--10	80--10	80--80
K-->N		THUMB	INDEX	MIDDLE	RING	LITTLE	K-->O		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-10)-(-10)	0--0	0--0	0--0	0--0		JOINT 1	(-10)-(-30)	0--0	0--0	0--0	0--0
	JOINT 2	10--30	0--75	45--75	85--85	85--85		JOINT 2	10--25	0--60	45--60	85--60	85--60
	JOINT 3	45--60	0--75	0--75	85--85	85--85		JOINT 3	45--45	0--45	0--45	85--45	85--45
	JOINT 4	0--10	0--10	0--10	80--80	80--80		JOINT 4	0--45	0--10	0--10	80--10	80--10
K-->P		THUMB	INDEX	MIDDLE	RING	LITTLE	K-->Q		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-10)-(-10)	0--0	0--0	0--0	0--0		JOINT 1	(-10)-(-30)	0--0	0--0	0--0	0--0
	JOINT 2	10--10	0--0	45--45	85--85	85--85		JOINT 2	10--20	0--85	45--85	85--85	85--85
	JOINT 3	45--45	0--0	0--0	85--85	85--85		JOINT 3	45--0	0--0	0--85	85--85	85--85
	JOINT 4	0--0	0--0	0--0	85--80	85--80		JOINT 4	0--0	0--0	0--80	80--80	80--80

K-->R		THUMB	INDEX	MIDDLE	RING	LITTLE	K-->S		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-10)-(-20)	0--15	0--(-5)	0--0	0--0		JOINT 1	(-10)-(-20)	0--0	0--0	0--0	0--0
	JOINT 2	10--45	0--20	45--0	85--85	85--85		JOINT 2	10--30	0--85	45--85	85--85	85--85
	JOINT 3	45--45	0--0	0--0	85--85	85--85		JOINT 3	45--45	0--85	0--85	85--85	85--85
	JOINT 4	0--0	0--0	0--0	80--80	80--80		JOINT 4	0--45	0--80	0--80	80--80	80--80
K-->T		THUMB	INDEX	MIDDLE	RING	LITTLE	K-->U		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-10)--0	0--(-10)	0--0	0--0	0--0		JOINT 1	(-10)-(-20)	0--0	0--0	0--0	0--0
	JOINT 2	10--20	0--60	45--85	85--85	85--85		JOINT 2	10--45	0--0	45--0	85--85	85--85
	JOINT 3	45--25	0--80	0--85	85--85	85--85		JOINT 3	45--85	0--0	0--0	85--85	85--85
	JOINT 4	0--0	0--45	0--80	80--80	80--80		JOINT 4	0--0	0--0	0--0	80--80	80--80
K-->V		THUMB	INDEX	MIDDLE	RING	LITTLE	K-->W		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-10)-(-20)	0--(-10)	0--10	0--0	0--0		JOINT 1	(-10)-(-10)	0--(-10)	0--0	0--10	0--0
	JOINT 2	10--45	0--0	45--0	85--85	85--85		JOINT 2	10--45	0--0	45--0	85--0	85--85
	JOINT 3	45--45	0--0	0--0	85--85	85--85		JOINT 3	45--45	0--0	0--0	85--0	85--85
	JOINT 4	0--0	0--0	0--0	80--80	80--80		JOINT 4	0--0	0--0	0--0	80--0	80--80
K-->X		THUMB	INDEX	MIDDLE	RING	LITTLE	K-->Y		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-10)-(-20)	0--0	0--0	0--0	0--0		JOINT 1	(-10)--0	0--0	0--0	0--0	0--0
	JOINT 2	10--30	0--0	45--85	85--85	85--85		JOINT 2	10--0	0--85	45--85	85--85	85--0
	JOINT 3	45--45	0--45	0--85	85--85	85--85		JOINT 3	45--0	0--85	0--85	85--85	85--0
	JOINT 4	0--0	0--45	0--80	80--80	80--80		JOINT 4	0--0	0--80	0--80	80--80	80--0
K-->Z		THUMB	INDEX	MIDDLE	RING	LITTLE							
	JOINT 1	(-10)-(-20)	0--0	0--0	0--0	0--0							
	JOINT 2	10--30	0--0	45--85	85--85	85--85							
	JOINT 3	45--45	0--0	0--85	85--85	85--85							
	JOINT 4	0--0	0--0	0--80	80--80	80--80							

Angle transition values for Letter L

L-->B		THUMB	INDEX	MIDDLE	RING	LITTLE	L-->C		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	0--0	0--0	0--0	0--0	0--0		JOINT 1	0--(-30)	0--0	0--0	0--0	0--0
	JOINT 2	0--20	0--0	85--0	85--0	85--0		JOINT 2	0--25	0--45	85--45	85--45	85--45
	JOINT 3	0--25	0--0	85--0	85--0	85--0		JOINT 3	0--30	0--45	85--45	85--45	85--45
	JOINT 4	0--0	0--0	80--0	80--0	80--0		JOINT 4	0--10	0--10	80--10	80--10	80--10
L-->D		THUMB	INDEX	MIDDLE	RING	LITTLE	L-->E		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	0--(-30)	0--0	0--0	0--0	0--0		JOINT 1	0--0	0--0	0--0	0--0	0--0
	JOINT 2	0--25	0--0	85--45	85--45	85--45		JOINT 2	0--35	0--45	85--45	85--45	85--45
	JOINT 3	0--45	0--0	85--45	85--45	85--45		JOINT 3	0--85	0--85	85--85	85--85	85--85
	JOINT 4	0--15	0--0	80--10	80--10	80--10		JOINT 4	0--20	0--80	80--80	80--80	80--80
L-->F		THUMB	INDEX	MIDDLE	RING	LITTLE	L-->G		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	0--(-20)	0--0	0--0	0--0	0--0		JOINT 1	0--(-30)	0--0	0--0	0--0	0--0
	JOINT 2	0--25	0--45	85--0	85--0	85--0		JOINT 2	0--20	0--85	85--85	85--85	85--85
	JOINT 3	0--60	0--45	85--0	85--0	85--0		JOINT 3	0--0	0--0	85--85	85--85	85--85
	JOINT 4	0--10	0--10	80--0	80--0	80--0		JOINT 4	0--0	0--0	80--80	80--80	80--80
L-->H		THUMB	INDEX	MIDDLE	RING	LITTLE	L-->I		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	0--(-20)	0--0	0--0	0--0	0--0		JOINT 1	0--(-20)	0--0	0--0	0--0	0--0
	JOINT 2	0--45	0--0	85--0	85--85	85--85		JOINT 2	0--10	0--85	85--85	85--85	85--0
	JOINT 3	0--85	0--0	85--0	85--85	85--85		JOINT 3	0--80	0--85	85--85	85--85	85--0
	JOINT 4	0--0	0--0	80--0	80--80	80--80		JOINT 4	0--0	0--80	80--80	80--80	80--0
L-->J		THUMB	INDEX	MIDDLE	RING	LITTLE	L-->K		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	0--(-20)	0--0	0--0	0--0	0--0		JOINT 1	0--(-10)	0--0	0--0	0--0	0--0
	JOINT 2	0--10	0--85	85--85	85--85	85--0		JOINT 2	0--10	0--0	85--45	85--85	85--85
	JOINT 3	0--80	0--85	85--85	85--85	85--0		JOINT 3	0--45	0--0	85--0	85--85	85--85
	JOINT 4	0--0	0--80	80--80	80--80	80--0		JOINT 4	0--0	0--0	80--0	80--80	80--80
L-->A		THUMB	INDEX	MIDDLE	RING	LITTLE	L-->M		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	0--0	0--0	0--0	0--0	0--0		JOINT 1	0--(-10)	0--0	0--0	0--0	0--0
	JOINT 2	0--20	0--85	85--85	85--85	85--85		JOINT 2	0--45	0--75	85--75	85--75	85--85
	JOINT 3	0--25	0--85	85--85	85--85	85--85		JOINT 3	0--85	0--75	85--75	85--75	85--85
	JOINT 4	0--0	0--80	80--80	80--80	80--80		JOINT 4	0--10	0--10	80--10	80--10	80--80
L-->N		THUMB	INDEX	MIDDLE	RING	LITTLE	L-->O		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	0--(-10)	0--0	0--0	0--0	0--0		JOINT 1	0--(-30)	0--0	0--0	0--0	0--0
	JOINT 2	0--30	0--75	85--75	85--85	85--85		JOINT 2	0--25	0--60	85--60	85--60	85--60
	JOINT 3	0--60	0--75	85--75	85--85	85--85		JOINT 3	0--45	0--45	85--45	85--45	85--45
	JOINT 4	0--10	0--10	80--10	80--80	80--80		JOINT 4	0--45	0--10	80--10	80--10	80--10
L-->P		THUMB	INDEX	MIDDLE	RING	LITTLE	L-->Q		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	0--(-10)	0--0	0--0	0--0	0--0		JOINT 1	0--(-30)	0--0	0--0	0--0	0--0
	JOINT 2	0--10	0--0	85--45	85--85	85--85		JOINT 2	0--20	0--85	85--85	85--85	85--85
	JOINT 3	0--45	0--0	85--0	85--85	85--85		JOINT 3	0--0	0--0	85--85	85--85	85--85
	JOINT 4	0--0	0--0	80--0	85--80	85--80		JOINT 4	0--0	0--0	80--80	80--80	80--80

L-->R		THUMB	INDEX	MIDDLE	RING	LITTLE	L-->S		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	0--(-20)	0--15	0--(-5)	0--0	0--0		JOINT 1	0--(-20)	0--0	0--0	0--0	0--0
	JOINT 2	0--45	0--20	85--0	85--85	85--85		JOINT 2	0--30	0--85	85--85	85--85	85--85
	JOINT 3	0--45	0--0	85--0	85--85	85--85		JOINT 3	0--45	0--85	85--85	85--85	85--85
	JOINT 4	0--0	0--0	80--0	80--80	80--80		JOINT 4	0--45	0--80	80--80	80--80	80--80
L-->T		THUMB	INDEX	MIDDLE	RING	LITTLE	L-->U		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	0--0	0--(-10)	0--0	0--0	0--0		JOINT 1	0--(-20)	0--0	0--0	0--0	0--0
	JOINT 2	0--20	0--60	85--85	85--85	85--85		JOINT 2	0--45	0--0	85--0	85--85	85--85
	JOINT 3	0--25	0--80	85--85	85--85	85--85		JOINT 3	0--85	0--0	85--0	85--85	85--85
	JOINT 4	0--0	0--45	80--80	80--80	80--80		JOINT 4	0--0	0--0	80--0	80--80	80--80
L-->V		THUMB	INDEX	MIDDLE	RING	LITTLE	L-->W		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	0--(-20)	0--(-10)	0--10	0--0	0--0		JOINT 1	0--(-10)	0--(-10)	0--0	0--10	0--0
	JOINT 2	0--45	0--0	85--0	85--85	85--85		JOINT 2	0--45	0--0	85--0	85--0	85--85
	JOINT 3	0--45	0--0	85--0	85--85	85--85		JOINT 3	0--45	0--0	85--0	85--0	85--85
	JOINT 4	0--0	0--0	80--0	80--80	80--80		JOINT 4	0--0	0--0	80--0	80--0	80--80
L-->X		THUMB	INDEX	MIDDLE	RING	LITTLE	L-->Y		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	0--(-20)	0--0	0--0	0--0	0--0		JOINT 1	0--0	0--0	0--0	0--0	0--0
	JOINT 2	0--30	0--0	85--85	85--85	85--85		JOINT 2	0--0	0--85	85--85	85--85	85--0
	JOINT 3	0--45	0--45	85--85	85--85	85--85		JOINT 3	0--0	0--85	85--85	85--85	85--0
	JOINT 4	0--0	0--45	80--80	80--80	80--80		JOINT 4	0--0	0--80	80--80	80--80	80--0
L-->Z		THUMB	INDEX	MIDDLE	RING	LITTLE							
	JOINT 1	0--(-20)	0--0	0--0	0--0	0--0							
	JOINT 2	0--30	0--0	85--85	85--85	85--85							
	JOINT 3	0--45	0--0	85--85	85--85	85--85							
	JOINT 4	0--0	0--0	80--80	80--80	80--80							

Angle transition values for Letter M

M-->B		THUMB	INDEX	MIDDLE	RING	LITTLE	M-->C		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-10)--0	0--0	0--0	0--0	0--0		JOINT 1	(-10)-(-30)	0--0	0--0	0--0	0--0
	JOINT 2	45--20	75--0	75--0	75--0	85--0		JOINT 2	45--25	75--45	75--45	75--45	85--45
	JOINT 3	85--25	75--0	75--0	75--0	85--0		JOINT 3	85--30	75--45	75--45	75--45	85--45
	JOINT 4	10--0	10--0	10--0	10--0	80--0		JOINT 4	10--10	70--10	70--10	70--10	80--10
M-->D		THUMB	INDEX	MIDDLE	RING	LITTLE	M-->E		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-10)-(-30)	0--0	0--0	0--0	0--0		JOINT 1	(-10)--0	0--0	0--0	0--0	0--0
	JOINT 2	45--25	75--0	75--45	75--45	85--45		JOINT 2	45--35	75--45	75--45	75--45	85--45
	JOINT 3	85--45	75--0	75--45	75--45	85--45		JOINT 3	85--85	75--85	75--85	75--85	85--85
	JOINT 4	10--15	10--0	70--10	70--10	80--10		JOINT 4	10--20	10--80	10--80	10--80	80--80
M-->F		THUMB	INDEX	MIDDLE	RING	LITTLE	M-->G		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-10)-(-20)	0--0	0--0	0--0	0--0		JOINT 1	(-10)-(-30)	0--0	0--0	0--0	0--0
	JOINT 2	45--25	75--45	75--0	75--0	85--0		JOINT 2	45--20	75--85	75--85	75--85	85--85
	JOINT 3	85--60	75--45	75--0	75--0	85--0		JOINT 3	85--0	75--0	75--85	75--85	85--85
	JOINT 4	10--10	70--10	10--0	10--0	80--0		JOINT 4	10--0	10--0	10--80	10--80	80--80
M-->H		THUMB	INDEX	MIDDLE	RING	LITTLE	M-->I		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-10)-(-20)	0--0	0--0	0--0	0--0		JOINT 1	(-10)-(-20)	0--0	0--0	0--0	0--0
	JOINT 2	45--45	75--0	75--0	75--85	85--85		JOINT 2	45--10	75--85	75--85	75--85	85--0
	JOINT 3	85--85	75--0	75--0	75--85	85--85		JOINT 3	85--80	75--85	75--85	75--85	85--0
	JOINT 4	10--0	10--0	10--0	10--80	80--80		JOINT 4	10--0	10--80	10--80	10--80	80--0
M-->J		THUMB	INDEX	MIDDLE	RING	LITTLE	M-->K		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-10)-(-20)	0--0	0--0	0--0	0--0		JOINT 1	(-10)-(-10)	0--0	0--0	0--0	0--0
	JOINT 2	45--10	75--85	75--85	75--85	85--0		JOINT 2	45--10	75--0	75--45	75--85	85--85
	JOINT 3	85--80	75--85	75--85	75--85	85--0		JOINT 3	85--45	75--0	75--0	75--85	85--85
	JOINT 4	10--0	10--80	10--80	10--80	80--0		JOINT 4	10--0	10--0	10--0	10--80	80--80
M-->L		THUMB	INDEX	MIDDLE	RING	LITTLE	M-->A		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-10)--0	0--0	0--0	0--0	0--0		JOINT 1	(-10)--0	0--0	0--0	0--0	0--0
	JOINT 2	45--0	75--0	75--85	75--85	85--85		JOINT 2	45--20	75--85	75--85	75--85	85--85
	JOINT 3	85--0	75--0	75--85	75--85	85--85		JOINT 3	85--25	75--85	75--85	75--85	85--85
	JOINT 4	10--0	10--0	10--80	10--80	80--80		JOINT 4	10--0	10--80	10--80	10--80	80--80
M-->N		THUMB	INDEX	MIDDLE	RING	LITTLE	M-->O		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-10)-(-10)	0--0	0--0	0--0	0--0		JOINT 1	(-10)-(-30)	0--0	0--0	0--0	0--0
	JOINT 2	45--30	75--75	75--75	75--85	85--85		JOINT 2	45--25	75--60	75--60	75--60	85--60
	JOINT 3	85--60	75--75	75--75	75--85	85--85		JOINT 3	85--45	75--45	75--45	75--45	85--45
	JOINT 4	10--10	10--10	10--10	10--80	80--80		JOINT 4	10--45	10--10	10--10	10--10	80--10
M-->P		THUMB	INDEX	MIDDLE	RING	LITTLE	M-->Q		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-10)-(-10)	0--0	0--0	0--0	0--0		JOINT 1	(-10)-(-30)	0--0	0--0	0--0	0--0
	JOINT 2	45--10	75--0	75--45	75--85	85--85		JOINT 2	45--20	75--85	75--85	75--85	85--85
	JOINT 3	85--45	75--0	75--0	75--85	85--85		JOINT 3	85--0	75--0	75--85	75--85	85--85
	JOINT 4	10--0	10--0	10--0	10--80	85--80		JOINT 4	10--0	10--0	10--80	10--80	80--80

M-->R		THUMB	INDEX	MIDDLE	RING	LITTLE	M-->S		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-10)-(-20)	**0--15**	**0--(-5)**	0--0	0--0		JOINT 1	(-10)-(-20)	0--0	0--0	0--0	0--0
	JOINT 2	45--45	75--20	75--0	75--85	85--85		JOINT 2	45--30	75--85	75--85	75--85	85--85
	JOINT 3	85--45	75--0	75--0	75--85	85--85		JOINT 3	85--45	75--85	75--85	75--85	85--85
	JOINT 4	10--0	10--0	10--0	10--80	80--80		JOINT 4	10--45	10--80	10--80	10--80	80--80
M-->T		THUMB	INDEX	MIDDLE	RING	LITTLE	M-->U		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-10)--0	**0--(-10)**	0--0	0--0	0--0		JOINT 1	(-10)-(-20)	0--0	0--0	0--0	0--0
	JOINT 2	45--20	75--60	75--85	75--85	85--85		JOINT 2	45--45	75--0	75--0	75--85	85--85
	JOINT 3	85--25	75--80	75--85	75--85	85--85		JOINT 3	85--85	75--0	75--0	75--85	85--85
	JOINT 4	10--0	10--45	10--80	10--80	80--80		JOINT 4	10--0	10--0	10--0	10--80	80--80
M-->V		THUMB	INDEX	MIDDLE	RING	LITTLE	M-->W		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-10)-(-20)	0--(-10)	0--10	0--0	0--0		JOINT 1	(-10)-(-10)	0--(-10)	0--0	0--10	0--0
	JOINT 2	45--45	75--0	75--0	75--85	85--85		JOINT 2	45--45	75--0	75--0	75--0	85--85
	JOINT 3	85--45	75--0	75--0	75--85	85--85		JOINT 3	85--45	75--0	75--0	75--0	85--85
	JOINT 4	10--0	10--0	10--0	10--80	80--80		JOINT 4	10--0	10--0	10--0	10--0	80--80
M-->X		THUMB	INDEX	MIDDLE	RING	LITTLE	M-->Y		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-10)-(-20)	0--0	0--0	0--0	0--0		JOINT 1	(-10)--0	0--0	0--0	0--0	0--0
	JOINT 2	45--30	75--0	75--85	75--85	85--85		JOINT 2	45--0	75--85	75--85	75--85	85--0
	JOINT 3	85--45	75--45	75--85	75--85	85--85		JOINT 3	85--0	75--85	75--85	75--85	85--0
	JOINT 4	10--0	10--45	10--80	10--80	80--80		JOINT 4	10--0	10--80	10--80	10--80	80--0
M-->Z		THUMB	INDEX	MIDDLE	RING	LITTLE							
	JOINT 1	(-10)-(-20)	0--0	0--0	0--0	0--0							
	JOINT 2	45--30	75--0	75--85	75--85	85--85							
	JOINT 3	85--45	75--0	75--85	75--85	85--85							
	JOINT 4	10--0	10--0	10--80	10--80	80--80							

Angle transition values for Letter N

N-->B		THUMB	INDEX	MIDDLE	RING	LITTLE	N-->C		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-10)--0	0--0	0--0	0--0	0--0		JOINT 1	(-10)-(-30)	0--0	0--0	0--0	0--0
	JOINT 2	30--20	75--0	75--0	85--0	85--0		JOINT 2	30--25	75--45	75--45	85--45	85--45
	JOINT 3	60--25	75--0	75--0	85--0	85--0		JOINT 3	60--30	75--45	75--45	85--45	85--45
	JOINT 4	10--0	10--0	10--0	80--0	80--0		JOINT 4	10--10	70--10	70--10	80--10	80--10
N-->D		THUMB	INDEX	MIDDLE	RING	LITTLE	N-->E		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-10)-(-30)	0--0	0--0	0--0	0--0		JOINT 1	(-10)--0	0--0	0--0	0--0	0--0
	JOINT 2	30--25	75--0	75--45	85--45	85--45		JOINT 2	30--35	75--45	75--45	85--45	85--45
	JOINT 3	60--45	75--0	75--45	85--45	85--45		JOINT 3	60--85	75--85	75--85	85--85	85--85
	JOINT 4	10--15	10--0	70--10	80--10	80--10		JOINT 4	10--20	10--80	10--80	80--80	80--80
N-->F		THUMB	INDEX	MIDDLE	RING	LITTLE	N-->G		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-10)-(-20)	0--0	0--0	0--0	0--0		JOINT 1	(-10)-(-30)	0--0	0--0	0--0	0--0
	JOINT 2	30--25	75--45	75--0	85--0	85--0		JOINT 2	30--20	75--85	75--85	85--85	85--85
	JOINT 3	60--60	75--45	75--0	85--0	85--0		JOINT 3	60--0	75--0	75--85	85--85	85--85
	JOINT 4	10--10	70--10	10--0	80--0	80--0		JOINT 4	10--0	10--0	10--80	80--80	80--80
N-->H		THUMB	INDEX	MIDDLE	RING	LITTLE	N-->I		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-10)-(-20)	0--0	0--0	0--0	0--0		JOINT 1	(-10)-(-20)	0--0	0--0	0--0	0--0
	JOINT 2	30--45	75--0	75--0	85--85	85--85		JOINT 2	30--10	75--85	75--85	85--85	85--0
	JOINT 3	60--85	75--0	75--0	85--85	85--85		JOINT 3	60--80	75--85	75--85	85--85	85--0
	JOINT 4	10--0	10--0	10--0	80--80	80--80		JOINT 4	10--0	10--80	10--80	80--80	80--0
N-->J		THUMB	INDEX	MIDDLE	RING	LITTLE	N-->K		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-10)-(-20)	0--0	0--0	0--0	0--0		JOINT 1	(-10)-(-10)	0--0	0--0	0--0	0--0
	JOINT 2	30--10	75--85	75--85	85--85	85--0		JOINT 2	30--10	75--0	75--45	85--85	85--85
	JOINT 3	60--80	75--85	75--85	85--85	85--0		JOINT 3	60--45	75--0	75--0	85--85	85--85
	JOINT 4	10--0	10--80	10--80	80--80	80--0		JOINT 4	10--0	10--0	10--0	80--80	80--80
N-->L		THUMB	INDEX	MIDDLE	RING	LITTLE	N-->M		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-10)--0	0--0	0--0	0--0	0--0		JOINT 1	(-10)-(-10)	0--0	0--0	0--0	0--0
	JOINT 2	30--0	75--0	75--85	85--85	85--85		JOINT 2	30--45	75--75	75--75	85--75	85--85
	JOINT 3	60--0	75--0	75--85	85--85	85--85		JOINT 3	60--85	75--75	75--75	85--75	85--85
	JOINT 4	10--0	10--0	10--80	80--80	80--80		JOINT 4	10--10	10--10	10--10	80--10	80--80
N-->A		THUMB	INDEX	MIDDLE	RING	LITTLE	N-->O		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-10)--0	0--0	0--0	0--0	0--0		JOINT 1	(-10)-(-30)	0--0	0--0	0--0	0--0
	JOINT 2	30--20	75--85	75--85	85--85	85--85		JOINT 2	30--25	75--60	75--60	85--60	85--60
	JOINT 3	60--25	75--85	75--85	85--85	85--85		JOINT 3	60--45	75--45	75--45	85--45	85--45
	JOINT 4	10--0	10--80	10--80	80--80	80--80		JOINT 4	10--45	10--10	10--10	80--10	80--10
N-->P		THUMB	INDEX	MIDDLE	RING	LITTLE	N-->Q		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-10)-(-10)	0--0	0--0	0--0	0--0		JOINT 1	(-10)-(-30)	0--0	0--0	0--0	0--0
	JOINT 2	45--10	75--0	75--45	85--85	85--85		JOINT 2	45--20	75--85	75--85	85--85	85--85
	JOINT 3	85--45	75--0	75--0	85--85	85--85		JOINT 3	85--0	75--0	75--85	85--85	85--85
	JOINT 4	10--0	10--0	10--0	85--80	85--80		JOINT 4	10--0	10--0	10--80	80--80	80--80

N-->R		THUMB	INDEX	MIDDLE	RING	LITTLE	N-->S		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-10)-(-20)	0--15	0--(-5)	0--0	0--0		JOINT 1	(-10)-(-20)	0--0	0--0	0--0	0--0
	JOINT 2	30--45	75--20	75--0	85--85	85--85		JOINT 2	30--30	75--85	75--85	85--85	85--85
	JOINT 3	60--45	75--0	75--0	85--85	85--85		JOINT 3	60--45	75--85	75--85	85--85	85--85
	JOINT 4	10--0	10--0	10--0	80--80	80--80		JOINT 4	10--45	10--80	10--80	80--80	80--80
N-->T		THUMB	INDEX	MIDDLE	RING	LITTLE	N-->U		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-10)--0	0--(-10)	0--0	0--0	0--0		JOINT 1	(-10)-(-20)	0--0	0--0	0--0	0--0
	JOINT 2	30--20	75--60	75--85	85--85	85--85		JOINT 2	30--45	75--0	75--0	85--85	85--85
	JOINT 3	60--25	75--80	75--85	85--85	85--85		JOINT 3	60--45	75--0	75--0	85--85	85--85
	JOINT 4	10--0	10--45	10--80	80--80	80--80		JOINT 4	10--0	10--0	10--0	80--80	80--80
N-->V		THUMB	INDEX	MIDDLE	RING	LITTLE	N-->W		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-10)-(-20)	0--(-10)	0--10	0--0	0--0		JOINT 1	(-10)-(-10)	0--(-10)	0--0	0--10	0--0
	JOINT 2	30--45	75--0	75--0	85--85	85--85		JOINT 2	30--45	75--0	75--0	85--0	85--85
	JOINT 3	60--45	75--0	75--0	85--85	85--85		JOINT 3	60--45	75--0	75--0	85--0	85--85
	JOINT 4	10--0	10--0	10--0	80--80	80--80		JOINT 4	10--0	10--0	10--0	80--0	80--80
N-->X		THUMB	INDEX	MIDDLE	RING	LITTLE	N-->Y		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-10)-(-20)	0--0	0--0	0--0	0--0		JOINT 1	(-10)--0	0--0	0--0	0--0	0--0
	JOINT 2	30--30	75--0	75--85	85--85	85--85		JOINT 2	30--0	75--85	75--85	85--85	85--0
	JOINT 3	60--45	75--45	75--85	85--85	85--85		JOINT 3	60--0	75--85	75--85	85--85	85--0
	JOINT 4	10--0	10--45	10--80	80--80	80--80		JOINT 4	10--0	10--80	10--80	80--80	80--0
N-->Z		THUMB	INDEX	MIDDLE	RING	LITTLE							
	JOINT 1	(-10)-(-20)	0--0	0--0	0--0	0--0							
	JOINT 2	30--30	75--0	75--85	85--85	85--85							
	JOINT 3	60--45	75--0	75--85	85--85	85--85							
	JOINT 4	10--0	10--0	10--80	80--80	80--80							

Angle transition values for Letter O

O-->B		THUMB	INDEX	MIDDLE	RING	LITTLE	O-->C		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-30)--0	0--0	0--0	0--0	0--0		JOINT 1	(-30)-(-30)	0--0	0--0	0--0	0--0
	JOINT 2	25--20	60--0	60--0	60--0	60--0		JOINT 2	25--25	60--45	60--45	60--45	60--45
	JOINT 3	45--25	45--0	45--0	45--0	45--0		JOINT 3	45--30	45--45	45--45	45--45	45--45
	JOINT 4	45--0	10--0	10--0	10--0	10--0		JOINT 4	45--10	10--10	10--10	10--10	10--10
O-->D		THUMB	INDEX	MIDDLE	RING	LITTLE	O-->E		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-30)-(-30)	0--0	0--0	0--0	0--0		JOINT 1	(-30)--0	0--0	0--0	0--0	0--0
	JOINT 2	25--25	60--0	60--45	60--45	60--45		JOINT 2	25--35	60--45	60--45	60--45	60--45
	JOINT 3	45--45	45--0	45--45	45--45	45--45		JOINT 3	45--85	45--85	45--85	45--85	45--85
	JOINT 4	45--15	10--0	10--10	10--10	10--10		JOINT 4	45--20	10--80	10--80	10--80	10--80
O-->F		THUMB	INDEX	MIDDLE	RING	LITTLE	O-->G		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-30)-(-20)	0--0	0--0	0--0	0--0		JOINT 1	(-30)-(-30)	0--0	0--0	0--0	0--0
	JOINT 2	25--25	60--45	60--0	60--0	60--0		JOINT 2	25--20	60--85	60--85	60--85	60--85
	JOINT 3	45--60	45--45	45--0	45--0	45--0		JOINT 3	45--0	45--0	45--85	45--85	45--85
	JOINT 4	45--10	10--10	10--0	10--0	10--0		JOINT 4	45--0	10--0	10--80	10--80	10--80
O-->H		THUMB	INDEX	MIDDLE	RING	LITTLE	O-->I		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-30)-(-20)	0--0	0--0	0--0	0--0		JOINT 1	(-30)-(-20)	0--0	0--0	0--0	0--0
	JOINT 2	25--45	60--0	60--0	60--85	60--85		JOINT 2	25--10	60--85	60--85	60--85	60--0
	JOINT 3	45--85	45--0	45--0	45--85	45--85		JOINT 3	45--80	45--85	45--85	45--85	45--0
	JOINT 4	45--0	10--0	10--0	10--80	10--80		JOINT 4	45--0	10--80	10--80	10--80	10--0
O-->J		THUMB	INDEX	MIDDLE	RING	LITTLE	O-->K		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-30)-(-20)	0--0	0--0	0--0	0--0		JOINT 1	(-30)-(-10)	0--0	0--0	0--0	0--0
	JOINT 2	25--10	60--85	60--85	60--85	60--0		JOINT 2	25--10	60--0	60--45	60--85	60--85
	JOINT 3	45--80	45--85	45--85	45--85	45--0		JOINT 3	45--45	45--0	45--0	45--85	45--85
	JOINT 4	45--0	10--80	10--80	10--80	10--0		JOINT 4	45--0	10--0	10--0	10--80	10--80
O-->L		THUMB	INDEX	MIDDLE	RING	LITTLE	O-->M		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-30)--0	0--0	0--0	0--0	0--0		JOINT 1	(-30)-(-10)	0--0	0--0	0--0	0--0
	JOINT 2	25--0	60--0	60--85	60--85	60--85		JOINT 2	25--45	60--75	60--75	60--75	60--85
	JOINT 3	45--0	45--0	45--85	45--85	45--85		JOINT 3	45--85	45--75	45--75	45--75	45--85
	JOINT 4	45--0	10--0	10--80	10--80	10--80		JOINT 4	45--10	10--10	10--10	10--10	10--80
O-->N		THUMB	INDEX	MIDDLE	RING	LITTLE	O-->A		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-30)-(-10)	0--0	0--0	0--0	0--0		JOINT 1	(-30)--0	0--0	0--0	0--0	0--0
	JOINT 2	25--30	60--75	60--75	60--85	60--85		JOINT 2	25--20	60--85	60--85	60--85	60--85
	JOINT 3	45--60	45--75	45--75	45--85	45--85		JOINT 3	45--25	45--85	45--85	45--85	45--85
	JOINT 4	45--10	10--10	10--10	10--80	10--80		JOINT 4	45--0	10--80	10--80	10--80	10--80
O-->P		THUMB	INDEX	MIDDLE	RING	LITTLE	O-->Q		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-30)-(-10)	0--0	0--0	0--0	0--0		JOINT 1	(-30)-(-30)	0--0	0--0	0--0	0--0
	JOINT 2	25--10	60--0	60--45	60--85	60--85		JOINT 2	25--20	60--85	60--85	60--85	60--85
	JOINT 3	45--45	45--0	45--0	45--85	45--85		JOINT 3	45--0	45--0	45--85	45--85	45--85
	JOINT 4	45--0	10--0	10--0	10--80	10--80		JOINT 4	45--0	10--0	10--80	10--80	10--80

O-->R		THUMB	INDEX	MIDDLE	RING	LITTLE	O-->S		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-30)-(-20)	0--15	0--(-5)	0--0	0--0		JOINT 1	(-30)-(-20)	0--0	0--0	0--0	0--0
	JOINT 2	25--45	60--20	60--0	60--85	60--85		JOINT 2	25--30	60--85	60--85	60--85	60--85
	JOINT 3	45--45	45--0	45--0	45--85	45--85		JOINT 3	45--45	45--85	45--85	45--85	45--85
	JOINT 4	45--0	10--0	10--0	10--80	10--80		JOINT 4	45--45	10--80	10--80	10--80	10--80
O-->T		THUMB	INDEX	MIDDLE	RING	LITTLE	O-->U		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-30)--0	0--(-10)	0--0	0--0	0--0		JOINT 1	(-30)-(-20)	0--0	0--0	0--0	0--0
	JOINT 2	25--20	60--60	60--85	60--85	60--85		JOINT 2	25--45	60--0	60--0	60--85	60--85
	JOINT 3	45--25	45--80	45--85	45--85	45--85		JOINT 3	45--85	45--0	45--0	45--85	45--85
	JOINT 4	45--0	10--45	10--80	10--80	10--80		JOINT 4	45--0	10--0	10--0	10--80	10--80
O-->V		THUMB	INDEX	MIDDLE	RING	LITTLE	O-->W		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-30)-(-20)	0--(-10)	0--10	0--0	0--0		JOINT 1	(-30)-(-10)	0--(-10)	0--0	0--10	0--0
	JOINT 2	25--45	60--0	60--0	60--85	60--85		JOINT 2	25--45	60--0	60--0	60--0	60--85
	JOINT 3	45--45	45--0	45--0	45--85	45--85		JOINT 3	45--45	45--0	45--0	45--0	45--85
	JOINT 4	45--0	10--0	10--0	10--80	10--80		JOINT 4	45--0	10--0	10--0	10--0	10--80
O-->X		THUMB	INDEX	MIDDLE	RING	LITTLE	O-->Y		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-30)-(-20)	0--0	0--0	0--0	0--0		JOINT 1	(-30)--0	0--0	0--0	0--0	0--0
	JOINT 2	25--30	60--0	60--85	60--85	60--85		JOINT 2	25--0	60--85	60--85	60--85	60--0
	JOINT 3	45--45	45--45	45--85	45--85	45--85		JOINT 3	45--0	45--85	45--85	45--85	45--0
	JOINT 4	45--0	10--45	10--80	10--80	10--80		JOINT 4	45--0	10--80	10--80	10--80	10--0
O-->Z		THUMB	INDEX	MIDDLE	RING	LITTLE							
	JOINT 1	(-30)-(-20)	0--0	0--0	0--0	0--0							
	JOINT 2	25--30	60--0	60--85	60--85	60--85							
	JOINT 3	45--45	45--0	45--85	45--85	45--85							
	JOINT 4	45--0	10--0	10--80	10--80	10--80							

Angle transition values for Letter P

P-->B		THUMB	INDEX	MIDDLE	RING	LITTLE	P-->C		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-10)--0	0--0	0--0	0--0	0--0		JOINT 1	(-20)-(-30)	0--0	0--0	0--0	0--0
	JOINT 2	10--20	0--0	45--0	85--0	85--0		JOINT 2	10--25	0--45	45--45	85--45	85--45
	JOINT 3	45--25	0--0	0--0	85--0	85--0		JOINT 3	45--30	0--45	0--45	85--45	85--45
	JOINT 4	0--0	0--0	0--0	80--0	80--0		JOINT 4	0--10	0--10	0--10	80--10	80--10
P-->D		THUMB	INDEX	MIDDLE	RING	LITTLE	P-->E		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-10)-(-30)	0--0	0--0	0--0	0--0		JOINT 1	(-10)--0	0--0	0--0	0--0	0--0
	JOINT 2	10--25	0--0	45--45	85--45	85--45		JOINT 2	10--35	0--45	45--45	85--45	85--45
	JOINT 3	45--45	0--0	0--45	85--45	85--45		JOINT 3	45--85	0--85	0--85	85--85	85--85
	JOINT 4	0--15	0--0	0--10	80--10	80--10		JOINT 4	0--20	0--80	0--80	80--80	80--80
P-->F		THUMB	INDEX	MIDDLE	RING	LITTLE	P-->G		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-10)-(-20)	0--0	0--0	0--0	0--0		JOINT 1	(-10)-(-30)	0--0	0--0	0--0	0--0
	JOINT 2	10--25	0--45	45--0	85--0	85--0		JOINT 2	10--20	0--85	45--85	85--85	85--85
	JOINT 3	45--60	0--45	0--0	85--0	85--0		JOINT 3	45--0	0--0	0--85	85--85	85--85
	JOINT 4	0--10	0--10	0--0	80--0	80--0		JOINT 4	0--0	0--0	0--80	80--80	80--80
P-->H		THUMB	INDEX	MIDDLE	RING	LITTLE	P-->I		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-10)-(-20)	0--0	0--0	0--0	0--0		JOINT 1	(-10)-(-20)	0--0	0--0	0--0	0--0
	JOINT 2	10--45	0--0	85--0	85--85	85--85		JOINT 2	10--10	0--85	45--85	85--85	85--0
	JOINT 3	45--85	0--0	85--0	85--85	85--85		JOINT 3	45--80	0--85	0--85	85--85	85--0
	JOINT 4	0--0	0--0	80--0	80--80	80--80		JOINT 4	0--0	0--80	0--80	80--80	80--0
P-->J		THUMB	INDEX	MIDDLE	RING	LITTLE	P-->K		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-10)-(-20)	0--0	0--0	0--0	0--0		JOINT 1	(-10)-(-10)	0--0	0--0	0--0	0--0
	JOINT 2	10--10	0--85	45--85	85--85	85--0		JOINT 2	10--10	0--0	45--45	85--85	85--85
	JOINT 3	45--80	0--85	0--85	85--85	85--0		JOINT 3	45--45	0--0	0--0	85--85	85--85
	JOINT 4	0--0	0--80	0--80	80--80	80--0		JOINT 4	0--0	0--0	0--0	85--80	85--80
P-->L		THUMB	INDEX	MIDDLE	RING	LITTLE	P-->M		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-10)--0	0--0	0--0	0--0	0--0		JOINT 1	(-10)-(-10)	0--0	0--0	0--0	0--0
	JOINT 2	10--0	0--0	45--85	85--85	85--85		JOINT 2	10--45	0--75	45--75	85--75	85--85
	JOINT 3	45--0	0--0	0--85	85--85	85--85		JOINT 3	45--85	0--75	0--75	85--75	85--85
	JOINT 4	0--0	0--0	0--80	80--80	80--80		JOINT 4	0--10	0--10	0--10	80--10	80--80
P-->N		THUMB	INDEX	MIDDLE	RING	LITTLE	P-->O		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-10)-(-10)	0--0	0--0	0--0	0--0		JOINT 1	(-10)-(-30)	0--0	0--0	0--0	0--0
	JOINT 2	10--30	0--75	45--75	85--85	85--85		JOINT 2	10--25	0--60	45--60	85--60	85--60
	JOINT 3	45--60	0--75	0--75	85--85	85--85		JOINT 3	45--45	0--45	0--45	85--45	85--45
	JOINT 4	0--10	0--10	0--10	80--80	80--80		JOINT 4	0--45	0--10	0--10	80--10	80--10
P-->A		THUMB	INDEX	MIDDLE	RING	LITTLE	P-->Q		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-10)--0	0--0	0--0	0--0	0--0		JOINT 1	(-10)-(-30)	0--0	0--0	0--0	0--0
	JOINT 2	10--20	0--85	45--85	85--85	85--85		JOINT 2	10--20	0--85	45--85	85--85	85--85
	JOINT 3	45--25	0--85	0--85	85--85	85--85		JOINT 3	45--0	0--0	0--85	85--85	85--85
	JOINT 4	0--0	0--80	0--80	80--80	80--80		JOINT 4	0--0	0--0	0--80	80--80	80--80

P-->R		THUMB	INDEX	MIDDLE	RING	LITTLE	P-->S		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-10)-(-20)	0--15	0--(-5)	0--0	0--0		JOINT 1	(-10)-(-20)	0--0	0--0	0--0	0--0
	JOINT 2	10--45	0--20	45--0	85--85	85--85		JOINT 2	10--30	0--85	45--85	85--85	85--85
	JOINT 3	45--45	0--0	0--0	85--85	85--85		JOINT 3	45--45	0--85	0--85	85--85	85--85
	JOINT 4	0--0	0--0	0--0	80--80	80--80		JOINT 4	0--45	0--80	0--80	80--80	80--80
P-->T		THUMB	INDEX	MIDDLE	RING	LITTLE	P-->U		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-10)--0	0--(-10)	0--0	0--0	0--0		JOINT 1	(-10)-(-20)	0--0	0--0	0--0	0--0
	JOINT 2	10--20	0--60	45--85	85--85	85--85		JOINT 2	10--45	0--0	45--0	85--85	85--85
	JOINT 3	45--25	0--80	0--85	85--85	85--85		JOINT 3	45--85	0--0	0--0	85--85	85--85
	JOINT 4	0--0	0--45	0--80	80--80	80--80		JOINT 4	0--0	0--0	0--0	80--80	80—80
P-->V		THUMB	INDEX	MIDDLE	RING	LITTLE	P-->W		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-10)-(-20)	0--(-10)	0--10	0--0	0--0		JOINT 1	(-10)-(-10)	0--(-10)	0--0	0--10	0--0
	JOINT 2	10--45	0--0	45--0	85--85	85--85		JOINT 2	10--45	0--0	45--0	85--0	85--85
	JOINT 3	45--45	0--0	0--0	85--85	85--85		JOINT 3	45--45	0--0	0--0	85--0	85--85
	JOINT 4	0--0	0--0	0--0	80--80	80--80		JOINT 4	0--0	0--0	0--0	80--0	80--80
P-->X		THUMB	INDEX	MIDDLE	RING	LITTLE	P-->Y		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-10)-(-20)	0--0	0--0	0--0	0--0		JOINT 1	(-10)--0	0--0	0--0	0--0	0--0
	JOINT 2	10--30	0--0	45--85	85--85	85--85		JOINT 2	10--0	0--85	45--85	85--85	85--0
	JOINT 3	45--45	0--45	0--85	85--85	85--85		JOINT 3	45--0	0--85	0--85	85--85	85--0
	JOINT 4	0--0	0--45	0--80	80--80	80--80		JOINT 4	0--0	0--80	0--80	80--80	80--0
P-->Z		THUMB	INDEX	MIDDLE	RING	LITTLE							
	JOINT 1	(-10)-(-20)	0--0	0--0	0--0	0--0							
	JOINT 2	10--30	0--0	45--85	85--85	85--85							
	JOINT 3	45--45	0--0	0--85	85--85	85--85							
	JOINT 4	0--0	0--0	0--80	80--80	80--80							

Angle transition values for Letter Q

Q-->B		THUMB	INDEX	MIDDLE	RING	LITTLE	Q-->C		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(30)-0	0--0	0--0	0--0	0--0		JOINT 1	(-30)-(-30)	0--0	0--0	0--0	0--0
	JOINT 2	20--20	85--0	85--0	85--0	85--0		JOINT 2	20--25	85--45	85--45	85--45	85--45
	JOINT 3	0--25	0--0	85--0	85--0	85--0		JOINT 3	0--10	0--45	85--45	85--45	85--45
	JOINT 4	0--0	0--0	80--0	80--0	80--0		JOINT 4	0--10	0--10	80--10	80--10	80--10
Q-->D		THUMB	INDEX	MIDDLE	RING	LITTLE	Q-->E		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-30)-(-30)	0--0	0--0	0--0	0--0		JOINT 1	(-30)--0	0--0	0--0	0--0	0--0
	JOINT 2	20--25	85--0	85--45	85--45	85--45		JOINT 2	20--35	85--45	85--45	85--45	85--45
	JOINT 3	0--45	0--0	85--45	85--45	85--45		JOINT 3	0--85	0--85	85--85	85--85	85--85
	JOINT 4	0--15	0--0	80--10	80--10	80--10		JOINT 4	0--20	0--80	80--80	80--80	80--80
Q-->F		THUMB	INDEX	MIDDLE	RING	LITTLE	Q-->G		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-30)-(-20)	0--0	0--0	0--0	0--0		JOINT 1	(-30)-(-30)	0--0	0--0	0--0	0--0
	JOINT 2	20--25	85--45	85--0	85--0	85--0		JOINT 2	20--20	85--85	85--85	85--85	85--85
	JOINT 3	0--60	0--45	85--0	85--0	85--0		JOINT 3	0--0	0--0	85--85	85--85	85--85
	JOINT 4	0--10	0--10	80--0	80--0	80--0		JOINT 4	0--0	0--0	80--80	80--80	80--80
Q-->H		THUMB	INDEX	MIDDLE	RING	LITTLE	Q-->I		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-30)-(-20)	0--0	0--0	0--0	0--0		JOINT 1	(-30)-(-20)	0--0	0--0	0--0	0--0
	JOINT 2	20--45	85--0	85--0	85--85	85--85		JOINT 2	20--10	85--85	85--85	85--85	85--0
	JOINT 3	0--85	0--0	85--0	85--85	85--85		JOINT 3	0--80	0--85	85--85	85--85	85--0
	JOINT 4	0--0	0--0	80--0	80--80	80--80		JOINT 4	0--0	0--80	80--80	80--80	80--0
Q-->J		THUMB	INDEX	MIDDLE	RING	LITTLE	Q-->K		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-30)-(-20)	0--0	0--0	0--0	0--0		JOINT 1	(-30)-(-10)	0--0	0--0	0--0	0--0
	JOINT 2	20--10	85--85	85--85	85--85	85--0		JOINT 2	20--10	85--0	85--45	85--85	85--85
	JOINT 3	0--80	0--85	85--85	85--85	85--0		JOINT 3	0--45	0--0	85--0	85--85	85--85
	JOINT 4	0--0	0--80	80--80	80--80	80--0		JOINT 4	0--0	0--0	80--0	80--80	80--80
Q-->L		THUMB	INDEX	MIDDLE	RING	LITTLE	Q-->M		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-30)--0	0--0	0--0	0--0	0--0		JOINT 1	(-30)-(-10)	0--0	0--0	0--0	0--0
	JOINT 2	20--0	85--0	85--85	85--85	85--85		JOINT 2	20--45	85--75	85--75	85--75	85--85
	JOINT 3	0--0	0--0	85--85	85--85	85--85		JOINT 3	0--85	0--75	85--75	85--75	85--85
	JOINT 4	0--0	0--0	80--80	80--80	80--80		JOINT 4	0--10	0--10	80--10	80--10	80--80
Q-->N		THUMB	INDEX	MIDDLE	RING	LITTLE	Q-->O		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-30)-(-10)	0--0	0--0	0--0	0--0		JOINT 1	(-30)-(-30)	0--0	0--0	0--0	0--0
	JOINT 2	20--30	85--75	85--75	85--85	85--85		JOINT 2	20--25	85--60	85--60	85--60	85--60
	JOINT 3	0--60	0--75	85--75	85--85	85--85		JOINT 3	0--45	0--45	85--45	85--45	85--45
	JOINT 4	0--10	0--10	80--10	80--80	80--80		JOINT 4	0--45	0--10	80--10	80--10	80--10
Q-->P		THUMB	INDEX	MIDDLE	RING	LITTLE	Q-->A		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-30)-(-10)	0--0	0--0	0--0	0--0		JOINT 1	(-30)--0	0--0	0--0	0--0	0--0
	JOINT 2	20--10	85--0	85--45	85--85	85--85		JOINT 2	20--20	85--85	85--85	85--85	85--85
	JOINT 3	0--45	0--0	85--0	85--85	85--85		JOINT 3	0--25	0--85	85--85	85--85	85--85
	JOINT 4	0--0	0--0	80--0	80--80	80--80		JOINT 4	0--0	0--80	80--80	80--80	80--80

Q-->R		THUMB	INDEX	MIDDLE	RING	LITTLE	Q-->S		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-30)-(-20)	0--15	0--(-5)	0--0	0--0		JOINT 1	(-30)-(-20)	0--0	0--0	0--0	0--0
	JOINT 2	20--45	85--20	85--0	85--85	85--85		JOINT 2	20--30	85--85	85--85	85--85	85--85
	JOINT 3	0--45	0--0	85--0	85--85	85--85		JOINT 3	0--45	0--85	85--85	85--85	85--85
	JOINT 4	0--0	0--0	80--0	80--80	80--80		JOINT 4	0--45	0--80	80--80	80--80	80--80
Q-->T		THUMB	INDEX	MIDDLE	RING	LITTLE	Q-->U		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-30)-0	0--(-10)	0--0	0--0	0--0		JOINT 1	(-30)-(-20)	0--0	0--0	0--0	0--0
	JOINT 2	20--20	85--60	85--85	85--85	85--85		JOINT 2	20--45	85--0	85--0	85--85	85--85
	JOINT 3	0--25	0--80	85--85	85--85	85--85		JOINT 3	0--85	0--0	85--0	85--85	85--85
	JOINT 4	0--0	0--45	80--80	80--80	80--80		JOINT 4	0--0	0--0	80--0	80--80	80--80
Q-->V		THUMB	INDEX	MIDDLE	RING	LITTLE	Q-->W		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-30)-(-20)	0--(-10)	0--10	0--0	0--0		JOINT 1	(-30)-(-10)	0--(-10)	0--0	0--10	0--0
	JOINT 2	20--45	85--0	85--0	85--85	85--85		JOINT 2	20--45	85--0	85--0	85--0	85--85
	JOINT 3	0--45	0--0	85--0	85--85	85--85		JOINT 3	0--45	0--0	85--0	85--0	85--85
	JOINT 4	0--0	0--0	80--0	80--80	80--80		JOINT 4	0--0	0--0	80--0	80--0	80--80
Q-->X		THUMB	INDEX	MIDDLE	RING	LITTLE	Q-->Y		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-30)-(-20)	0--0	0--0	0--0	0--0		JOINT 1	(-30)--0	0--0	0--0	0--0	0--0
	JOINT 2	20--30	85--0	85--85	85--85	85--85		JOINT 2	20--0	85--85	85--85	85--85	85--0
	JOINT 3	0--45	0--45	85--85	85--85	85--85		JOINT 3	0--0	0--85	85--85	85--85	85--0
	JOINT 4	0--0	0--45	80--80	80--80	80--80		JOINT 4	0--0	0--80	80--80	80--80	80--0
Q-->Z		THUMB	INDEX	MIDDLE	RING	LITTLE							
	JOINT 1	(-30)-(-20)	0--0	0--0	0--0	0--0							
	JOINT 2	20--30	85--0	85--85	85--85	85--85							
	JOINT 3	0--45	0--0	85--85	85--85	85--85							
	JOINT 4	0--0	0--0	80--80	80--80	80--80							

Angle transition values for Letter R

R-->B		THUMB	INDEX	MIDDLE	RING	LITTLE	R-->C		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-20)--0	15--0	(-5)--0	0--0	0--0		JOINT 1	(-20)-(-30)	15--0	(-5)--0	0--0	0--0
	JOINT 2	45--20	20--0	0--0	85--0	85--0		JOINT 2	45--25	20--45	0--45	85--45	85--45
	JOINT 3	45--25	0--0	0--0	85--0	85--0		JOINT 3	45--30	0--45	0--45	85--45	85--45
	JOINT 4	0--0	0--0	0--0	80--0	80--0		JOINT 4	0--10	0--10	0--10	80--10	80--10
R-->D		THUMB	INDEX	MIDDLE	RING	LITTLE	R-->E		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-20)-(-30)	15--0	(-5)--0	0--0	0--0		JOINT 1	(-20)--0	15--0	(-5)--0	0--0	0--0
	JOINT 2	45--25	20--0	0--45	85--45	85--45		JOINT 2	45--35	20--45	0--45	85--45	85--45
	JOINT 3	45--45	0--0	0--45	85--45	85--45		JOINT 3	45--85	0--85	0--85	85--85	85--85
	JOINT 4	0--15	0--0	0--10	80--10	80--10		JOINT 4	0--20	0--80	0--80	80--80	80--80
R-->F		THUMB	INDEX	MIDDLE	RING	LITTLE	R-->G		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-20)-(-20)	15--0	(-5)--0	0--0	0--0		JOINT 1	(-20)-(-30)	15--0	(-5)--0	0--0	0--0
	JOINT 2	45--25	20--45	0--0	85--0	85--0		JOINT 2	45--20	20--85	0--85	85--85	85--85
	JOINT 3	45--60	0--45	0--0	85--0	85--0		JOINT 3	45--0	0--0	0--85	85--85	85--85
	JOINT 4	0--10	0--10	0--0	80--0	80--0		JOINT 4	0--0	0--0	0--80	80--80	80--80
R-->H		THUMB	INDEX	MIDDLE	RING	LITTLE	R-->I		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-20)-(-20)	15--0	(-5)--0	0--0	0--0		JOINT 1	(-20)-(-20)	15--0	(-5)--0	0--0	0--0
	JOINT 2	45--45	20--0	0--0	85--85	85--85		JOINT 2	45--10	20--85	0--85	85--85	85--0
	JOINT 3	45--85	0--0	0--0	85--85	85--85		JOINT 3	45--80	0--85	0--85	85--85	85--0
	JOINT 4	0--0	0--0	0--0	80--80	80--80		JOINT 4	0--0	0--85	0--80	80--80	80--0
R-->J		THUMB	INDEX	MIDDLE	RING	LITTLE	R-->K		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-20)-(-20)	15--0	(-5)--0	0--0	0--0		JOINT 1	(-20)-(-10)	15--0	(-5)--0	0--0	0--0
	JOINT 2	45--10	20--85	0--85	85--85	85--0		JOINT 2	45--10	20--0	0--45	85--85	85--85
	JOINT 3	45--80	0--85	0--85	85--85	85--0		JOINT 3	45--45	0--0	0--0	85--85	85--85
	JOINT 4	0--0	0--85	0--80	80--80	80--0		JOINT 4	0--0	0--0	0--0	80--80	80--80
R-->L		THUMB	INDEX	MIDDLE	RING	LITTLE	R-->M		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-20)--0	15--0	(-5)--0	0--0	0--0		JOINT 1	(-20)-(-10)	15--0	(-5)--0	0--0	0--0
	JOINT 2	45--0	20--0	0--85	85--85	85--85		JOINT 2	45--45	20--75	0--75	85--75	85--85
	JOINT 3	45--0	0--0	0--85	85--85	85--85		JOINT 3	45--85	0--75	0--75	85--75	85--85
	JOINT 4	0--0	0--0	0--80	80--80	80--80		JOINT 4	0--10	0--10	0--10	80--10	80--80
R-->N		THUMB	INDEX	MIDDLE	RING	LITTLE	R-->O		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-20)-(-10)	15--0	(-5)--0	0--0	0--0		JOINT 1	(-20)-(-30)	15--0	(-5)--0	0--0	0--0
	JOINT 2	45--30	20--75	0--75	85--85	85--85		JOINT 2	45--25	20--60	0--60	85--60	85--60
	JOINT 3	45--60	0--75	0--75	85--85	85--85		JOINT 3	45--45	0--45	0--45	85--45	85--45
	JOINT 4	0--10	0--10	0--10	80--80	80--80		JOINT 4	0--45	0--10	0--10	80--10	80--10
R-->P		THUMB	INDEX	MIDDLE	RING	LITTLE	R-->Q		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-20)-(-10)	15--0	(-5)--0	0--0	0--0		JOINT 1	(-20)-(-30)	15--0	(-5)--0	0--0	0--0
	JOINT 2	45--10	20--0	0--45	85--85	85--85		JOINT 2	45--20	20--85	0--85	85--85	85--85
	JOINT 3	45--45	0--0	0--0	85--85	85--85		JOINT 3	45--0	0--0	0--85	85--85	85--85
	JOINT 4	0--0	0--0	0--0	85--80	85--80		JOINT 4	0--0	0--0	0--80	80--80	80--80

R-->A		THUMB	INDEX	MIDDLE	RING	LITTLE	R-->S		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-20)--0	15--0	(-5)--0	0--0	0--0		JOINT 1	(-20)-(-20)	15--0	(-5)--0	0--0	0--0
	JOINT 2	45--20	20--85	0--85	85--85	85--85		JOINT 2	45--30	20--85	0--85	85--85	85--85
	JOINT 3	45--25	0--85	0--85	85--85	85--85		JOINT 3	45--45	0--85	0--85	85--85	85--85
	JOINT 4	0--0	0--85	0--80	80--80	80--80		JOINT 4	0--45	0--85	0--80	80--80	80--80
R-->T		THUMB	INDEX	MIDDLE	RING	LITTLE	R-->U		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-20)--0	15--(-10)	(-5)--0	0--0	0--0		JOINT 1	(-20)-(-20)	15--0	(-5)--0	0--0	0--0
	JOINT 2	45--20	20--60	0--85	85--85	85--85		JOINT 2	45--45	20--0	0--0	85--85	85--85
	JOINT 3	45--25	0--80	0--85	85--85	85--85		JOINT 3	45--85	0--0	0--0	85--85	85--85
	JOINT 4	0--0	0--45	0--80	80--80	80--80		JOINT 4	0--0	0--0	0--0	80--80	80--80
R-->V		THUMB	INDEX	MIDDLE	RING	LITTLE	R-->W		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-20)-(-20)	15--(-10)	(-5)--10	0--0	0--0		JOINT 1	(-20)-(-10)	15--(-10)	(-5)--0	0--10	0--0
	JOINT 2	45--45	20--0	0--0	85--85	85--85		JOINT 2	45--45	20--0	0--0	85--0	85--85
	JOINT 3	45--45	0--0	0--0	85--85	85--85		JOINT 3	45--45	0--0	0--0	85--0	85--85
	JOINT 4	0--0	0--0	0--0	80--80	80--80		JOINT 4	0--0	0--0	0--0	80--0	80--80
R-->X		THUMB	INDEX	MIDDLE	RING	LITTLE	R-->Y		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-20)-(-20)	15--0	(-5)--0	0--0	0--0		JOINT 1	(-20)--0	15--0	(-5)--0	0--0	0--0
	JOINT 2	45--30	20--0	0--85	85--85	85--85		JOINT 2	45--0	20--85	0--85	85--85	85--0
	JOINT 3	45--45	0--45	0--85	85--85	85--85		JOINT 3	45--0	0--85	0--85	85--85	85--0
	JOINT 4	0--0	0--45	0--80	80--80	80--80		JOINT 4	0--0	0--85	0--80	80--80	80--0
R-->Z		THUMB	INDEX	MIDDLE	RING	LITTLE							
	JOINT 1	(-20)-(-20)	15--0	(-5)--0	0--0	0--0							
	JOINT 2	45--30	20--0	0--85	85--85	85--85							
	JOINT 3	45--45	0--0	0--85	85--85	85--85							
	JOINT 4	0--0	0--0	0--80	80--80	80--80							

Angle transition values for Letter S

S-->B		THUMB	INDEX	MIDDLE	RING	LITTLE	S-->C		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-20)--0	0--0	0--0	0--0	0--0		JOINT 1	(-20)-(-30)	0--0	0--0	0--0	0--0
	JOINT 2	30--20	85--0	85--0	85--0	85--0		JOINT 2	30--25	85--45	85--45	85--45	85--45
	JOINT 3	45--25	85--0	85--0	85--0	85--0		JOINT 3	45--10	85--45	85--45	85--45	85--45
	JOINT 4	45--0	80--0	80--0	80--0	80--0		JOINT 4	45--10	80--10	80--10	80--10	80--10
S-->D		THUMB	INDEX	MIDDLE	RING	LITTLE	S-->E		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-20)-(-30)	0--0	0--0	0--0	0--0		JOINT 1	(-20)--0	0--0	0--0	0--0	0--0
	JOINT 2	30--25	85--0	85--45	85--45	85--45		JOINT 2	30--35	85--45	85--45	85--45	85--45
	JOINT 3	45--45	85--0	85--45	85--45	85--45		JOINT 3	45--85	85--85	85--85	85--85	85--85
	JOINT 4	45--15	80--0	80--10	80--10	80--10		JOINT 4	45--20	80--80	80--80	80--80	80--80
S-->F		THUMB	INDEX	MIDDLE	RING	LITTLE	S-->G		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-20)-(-20)	0--0	0--0	0--0	0--0		JOINT 1	(-20)-(-30)	0--0	0--0	0--0	0--0
	JOINT 2	30--25	85--45	85--0	85--0	85--0		JOINT 2	30--20	85--85	85--85	85--85	85--85
	JOINT 3	45--60	85--45	85--0	85--0	85--0		JOINT 3	45--0	85--0	85--85	85--85	85--85
	JOINT 4	45--10	80--10	80--0	80--0	80--0		JOINT 4	45--0	80--0	80--80	80--80	80--80
S-->H		THUMB	INDEX	MIDDLE	RING	LITTLE	S-->I		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-20)-(-20)	0--0	0--0	0--0	0--0		JOINT 1	(-20)-(-20)	0--0	0--0	0--0	0--0
	JOINT 2	30--45	85--0	85--0	85--85	85--85		JOINT 2	30--10	85--85	85--85	85--85	85--0
	JOINT 3	45--85	85--0	85--0	85--85	85--85		JOINT 3	45--80	85--85	85--85	85--85	85--0
	JOINT 4	45--0	80--0	80--0	80--80	80--80		JOINT 4	45--0	80--80	80--80	80--80	80--0
S-->J		THUMB	INDEX	MIDDLE	RING	LITTLE	S-->K		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-20)-(-20)	0--0	0--0	0--0	0--0		JOINT 1	(-20)-(-10)	0--0	0--0	0--0	0--0
	JOINT 2	30--10	85--85	85--85	85--85	85--0		JOINT 2	30--10	85--0	85--45	85--85	85--85
	JOINT 3	45--80	85--85	85--85	85--85	85--0		JOINT 3	45--45	85--0	85--0	85--85	85--85
	JOINT 4	45--0	80--80	80--80	80--80	80--0		JOINT 4	45--0	80--0	80--0	80--80	80--80
S-->L		THUMB	INDEX	MIDDLE	RING	LITTLE	S-->M		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-20)-0	0--0	0--0	0--0	0--0		JOINT 1	(-20)-(-10)	0--0	0--0	0--0	0--0
	JOINT 2	30--0	85--0	85--85	85--85	85--85		JOINT 2	30--45	85--75	85--75	85--75	85--85
	JOINT 3	45--0	85--0	85--85	85--85	85--85		JOINT 3	45--85	85--75	85--75	85--75	85--85
	JOINT 4	45--0	80--0	80--80	80--80	80--80		JOINT 4	45--10	80--10	80--10	80--10	80--80
S-->N		THUMB	INDEX	MIDDLE	RING	LITTLE	S-->O		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-20)-(-10)	0--0	0--0	0--0	0--0		JOINT 1	(-20)-(-30)	0--0	0--0	0--0	0--0
	JOINT 2	30--30	85--75	85--75	85--85	85--85		JOINT 2	30--25	85--60	85--60	85--60	85--60
	JOINT 3	45--60	85--75	85--75	85--85	85--85		JOINT 3	45--45	85--45	85--45	85--45	85--45
	JOINT 4	45--10	80--10	80--10	80--80	80--80		JOINT 4	45--45	80--10	80--10	80--10	80--10
S-->P		THUMB	INDEX	MIDDLE	RING	LITTLE	S-->Q		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-20)-(-10)	0--0	0--0	0--0	0--0		JOINT 1	(-20)-(-30)	0--0	0--0	0--0	0--0
	JOINT 2	30--10	85--0	85--45	85--85	85--85		JOINT 2	30--20	85--85	85--85	85--85	85--85
	JOINT 3	45--45	85--0	85--0	85--85	85--85		JOINT 3	45--0	85--0	85--85	85--85	85--85
	JOINT 4	45--0	80--0	80--0	85--80	85--80		JOINT 4	45--0	80--0	80--80	80--80	80--80

S-->R		THUMB	INDEX	MIDDLE	RING	LITTLE	S-->A		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-20)-(-20)	0--15	0--(-5)	0--0	0--0		JOINT 1	(-20)-(-20)	0--0	0--0	0--0	0--0
	JOINT 2	30--45	85--20	85--0	85--85	85--85		JOINT 2	30--30	85--85	85--85	85--85	85--85
	JOINT 3	45--45	85--0	85--0	85--85	85--85		JOINT 3	45--45	85--85	85--85	85--85	85--85
	JOINT 4	45--0	80--0	80--0	80--80	80--80		JOINT 4	45--45	80--80	80--80	80--80	80--80
S-->T		THUMB	INDEX	MIDDLE	RING	LITTLE	S-->U		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-20)--0	0--(-10)	0--0	0--0	0--0		JOINT 1	(-20)-(-20)	0--0	0--0	0--0	0--0
	JOINT 2	30--20	85--60	85--85	85--85	85--85		JOINT 2	30--45	85--0	85--0	85--85	85--85
	JOINT 3	45--25	85--80	85--85	85--85	85--85		JOINT 3	45--85	85--0	85--0	85--85	85--85
	JOINT 4	45--0	80--45	80--80	80--80	80--80		JOINT 4	45--0	80--0	80--0	80--80	80--80
S-->V		THUMB	INDEX	MIDDLE	RING	LITTLE	S-->W		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-20)-(-20)	0--(-10)	0--10	0--0	0--0		JOINT 1	(-20)-(-10)	0--(-10)	0--0	0--10	0--0
	JOINT 2	30--45	85--0	85--0	85--85	85--85		JOINT 2	30--45	85--0	85--0	85--0	85--85
	JOINT 3	45--45	85--0	85--0	85--85	85--85		JOINT 3	45--45	85--0	85--0	85--0	85--85
	JOINT 4	45--0	80--0	80--0	80--80	80--80		JOINT 4	45--0	80--0	80--0	80--0	80--80
S-->X		THUMB	INDEX	MIDDLE	RING	LITTLE	S-->Y		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-20)-(-20)	0--0	0--0	0--0	0--0		JOINT 1	(-20)--0	0--0	0--0	0--0	0--0
	JOINT 2	30--30	85--0	85--85	85--85	85--85		JOINT 2	30--0	85--85	85--85	85--85	85--0
	JOINT 3	45--45	85--45	85--85	85--85	85--85		JOINT 3	45--0	85--85	85--85	85--85	85--0
	JOINT 4	45--0	80--45	80--80	80--80	80--80		JOINT 4	45--0	80--80	80--80	80--80	80--0
S-->Z		THUMB	INDEX	MIDDLE	RING	LITTLE							
	JOINT 1	(-20)-(-20)	0--0	0--0	0--0	0--0							
	JOINT 2	30--30	85--0	85--85	85--85	85--85							
	JOINT 3	45--45	85--0	85--85	85--85	85--85							
	JOINT 4	45--0	80--0	80--80	80--80	80--80							

Angle transition values for Letter T

T-->B		THUMB	INDEX	MIDDLE	RING	LITTLE	T-->C		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	0--0	(-10)--0	0--0	0--0	0--0		JOINT 1	0--(-30)	(-10)--0	0--0	0--0	0--0
	JOINT 2	20--20	60--0	85--0	85--0	85--0		JOINT 2	20--25	60--45	85--45	85--45	85--45
	JOINT 3	25--25	80--0	85--0	85--0	85--0		JOINT 3	25--30	80--45	85--45	85--45	85--45
	JOINT 4	0--0	45--0	80--0	80--0	80--0		JOINT 4	0--10	45--10	80--10	80--10	80--10
T-->D		THUMB	INDEX	MIDDLE	RING	LITTLE	T-->E		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	0--(-30)	(-10)--0	0--0	0--0	0--0		JOINT 1	0--0	(-10)--0	0--0	0--0	0--0
	JOINT 2	20--25	60--0	85--45	85--45	85--45		JOINT 2	20--35	60--45	85--45	85--45	85--45
	JOINT 3	25--45	80--0	85--45	85--45	85--45		JOINT 3	25--85	80--85	85--85	85--85	85--85
	JOINT 4	0--15	45--0	80--10	80--10	80--10		JOINT 4	0--20	45--80	80--80	80--80	80--80
T-->F		THUMB	INDEX	MIDDLE	RING	LITTLE	T-->G		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	0--(-20)	(-10)--0	0--0	0--0	0--0		JOINT 1	0--(-30)	(-10)--0	0--0	0--0	0--0
	JOINT 2	20--25	60--45	85--0	85--0	85--0		JOINT 2	20--20	60--85	85--85	85--85	85--85
	JOINT 3	25--60	80--45	85--0	85--0	85--0		JOINT 3	25--0	80--0	85--85	85--85	85--85
	JOINT 4	0--10	45--10	80--0	80--0	80--0		JOINT 4	0--0	45--0	80--80	80--80	80--80
T-->H		THUMB	INDEX	MIDDLE	RING	LITTLE	T-->I		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	0--(-20)	(-10)--0	0--0	0--0	0--0		JOINT 1	0--(-20)	(-10)--0	0--0	0--0	0--0
	JOINT 2	20--45	60--0	85--0	85--85	85--85		JOINT 2	20--10	60--85	85--85	85--85	85--0
	JOINT 3	25--85	80--0	85--0	85--85	85--85		JOINT 3	25--80	80--85	85--85	85--85	85--0
	JOINT 4	0--0	45--0	80--0	80--80	80--80		JOINT 4	0--0	45--80	80--80	80--80	80--0
T-->J		THUMB	INDEX	MIDDLE	RING	LITTLE	T-->K		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	0--(-20)	(-10)--0	0--0	0--0	0--0		JOINT 1	0--(-10)	(-10)--0	0--0	0--0	0--0
	JOINT 2	20--10	60--85	85--85	85--85	85--0		JOINT 2	20--10	60--0	85--45	85--85	85--85
	JOINT 3	25--80	80--85	85--85	85--85	85--0		JOINT 3	25--45	80--0	85--0	85--85	85--85
	JOINT 4	0--0	45--80	80--80	80--80	80--0		JOINT 4	0--0	45--0	80--0	80--80	80--80
T-->L		THUMB	INDEX	MIDDLE	RING	LITTLE	T-->M		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	0--0	(-10)--0	0--0	0--0	0--0		JOINT 1	0--(-10)	(-10)--0	0--0	0--0	0--0
	JOINT 2	20--0	60--0	85--85	85--85	85--85		JOINT 2	20--45	60--75	85--75	85--75	85--85
	JOINT 3	25--0	80--0	85--85	85--85	85--85		JOINT 3	25--85	80--75	85--75	85--75	85--85
	JOINT 4	0--0	45--0	80--80	80--80	80--80		JOINT 4	0--10	45--10	80--10	80--10	80--80
T-->N		THUMB	INDEX	MIDDLE	RING	LITTLE	T-->O		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	0--(-10)	(-10)--0	0--0	0--0	0--0		JOINT 1	0--(-30)	(-10)--0	0--0	0--0	0--0
	JOINT 2	20--30	60--75	85--75	85--85	85--85		JOINT 2	20--25	60--60	85--60	85--60	85--60
	JOINT 3	25--60	80--75	85--75	85--85	85--85		JOINT 3	25--45	80--45	85--45	85--45	85--45
	JOINT 4	0--10	45--10	80--10	80--80	80--80		JOINT 4	0--45	45--10	80--10	80--10	80--10
T-->P		THUMB	INDEX	MIDDLE	RING	LITTLE	T-->Q		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	0--(-10)	(-10)--0	0--0	0--0	0--0		JOINT 1	0--(-30)	(-10)--0	0--0	0--0	0--0
	JOINT 2	20--10	60--0	85--45	85--85	85--85		JOINT 2	20--20	60--85	85--85	85--85	85--85
	JOINT 3	25--45	80--0	85--0	85--85	85--85		JOINT 3	25--0	80--0	85--85	85--85	85--85
	JOINT 4	0--0	45--0	80--0	85--80	85--80		JOINT 4	0--0	45--0	80--80	80--80	80--80

T-->R		THUMB	INDEX	MIDDLE	RING	LITTLE	T-->S		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	0--(-20)	0--15	0--(-5)	0--0	0--0		JOINT 1	0--(-20)	(-10)--0	0--0	0--0	0--0
	JOINT 2	20--45	60--20	85--0	85--85	85--85		JOINT 2	20--30	60--85	85--85	85--85	85--85
	JOINT 3	25--45	80--0	85--0	85--85	85--85		JOINT 3	25--45	80--85	85--85	85--85	85--85
	JOINT 4	0--0	45--0	80--0	80--80	80--80		JOINT 4	0--45	45--80	80--80	80--80	80--80
T-->A		THUMB	INDEX	MIDDLE	RING	LITTLE	T-->U		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	0--0	(-10)--0	0--0	0--0	0--0		JOINT 1	0--(-20)	(-10)--0	0--0	0--0	0--0
	JOINT 2	20--20	60--85	85--85	85--85	85--85		JOINT 2	20--45	60--0	85--0	85--85	85--85
	JOINT 3	25--25	80--85	85--85	85--85	85--85		JOINT 3	25--85	80--0	85--0	85--85	85--85
	JOINT 4	0--0	45--80	80--80	80--80	80--80		JOINT 4	0--0	45--0	80--0	80--80	80--80
T-->V		THUMB	INDEX	MIDDLE	RING	LITTLE	T-->W		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	0--(-20)	0--(-10)	0--10	0--0	0--0		JOINT 1	0--(-10)	0--(-10)	0--0	0--10	0--0
	JOINT 2	20--45	60--0	85--0	85--85	85--85		JOINT 2	20--45	60--0	85--0	85--0	85--85
	JOINT 3	25--45	80--0	85--0	85--85	85--85		JOINT 3	25--45	80--0	85--0	85--0	85--85
	JOINT 4	0--0	45--0	80--0	80--80	80--80		JOINT 4	0--0	45--0	80--0	80--0	80--80
T-->X		THUMB	INDEX	MIDDLE	RING	LITTLE	T-->Y		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	0--(-20)	(-10)--0	0--0	0--0	0--0		JOINT 1	0--0	(-10)--0	0--0	0--0	0--0
	JOINT 2	20--30	60--0	85--85	85--85	85--85		JOINT 2	20--0	60--85	85--85	85--85	85--0
	JOINT 3	25--45	80--45	85--85	85--85	85--85		JOINT 3	25--0	80--85	85--85	85--85	85--0
	JOINT 4	0--0	45--45	80--80	80--80	80--80		JOINT 4	0--0	45--80	80--80	80--80	80--0
T-->Z		THUMB	INDEX	MIDDLE	RING	LITTLE							
	JOINT 1	0--(-20)	(-10)--0	0--0	0--0	0--0							
	JOINT 2	20--30	60--0	85--85	85--85	85--85							
	JOINT 3	25--45	80--0	85--85	85--85	85--85							
	JOINT 4	0--0	45--0	80--80	80--80	80--80							

Angle transition values for Letter U

U-->B		THUMB	INDEX	MIDDLE	RING	LITTLE	U-->C		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-20)--0	0--0	0--0	0--0	0--0		JOINT 1	(-20)-(-30)	0--0	0--0	0--0	0--0
	JOINT 2	45--20	0--0	0--0	85--0	85--0		JOINT 2	45--25	0--45	0--45	85--45	85--45
	JOINT 3	85--25	0--0	0--0	85--0	85--0		JOINT 3	85--10	0--45	0--45	85--45	85--45
	JOINT 4	0--0	0--0	0--0	80--0	80--0		JOINT 4	0--10	0--10	0--10	80--10	80--10
U-->D		THUMB	INDEX	MIDDLE	RING	LITTLE	U-->E		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-20)-(-30)	0--0	0--0	0--0	0--0		JOINT 1	(-20)--0	0--0	0--0	0--0	0--0
	JOINT 2	45--25	0--0	0--45	85--45	85--45		JOINT 2	45--35	0--45	0--45	85--45	85--45
	JOINT 3	85--45	0--0	0--45	85--45	85--45		JOINT 3	85--85	0--85	0--85	85--85	85--85
	JOINT 4	0--15	0--0	0--10	80--10	80--10		JOINT 4	0--20	0--80	0--80	80--80	80--80
U-->F		THUMB	INDEX	MIDDLE	RING	LITTLE	U-->G		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-20)-(-20)	0--0	0--0	0--0	0--0		JOINT 1	(-20)-(-30)	0--0	0--0	0--0	0--0
	JOINT 2	45--25	0--45	0--0	85--0	85--0		JOINT 2	45--20	0--85	0--85	85--85	85--85
	JOINT 3	85--60	0--45	0--0	85--0	85--0		JOINT 3	85--0	0--0	0--85	85--85	85--85
	JOINT 4	0--10	0--10	0--0	80--0	80--0		JOINT 4	0--0	0--0	0--80	80--80	80--80
U-->H		THUMB	INDEX	MIDDLE	RING	LITTLE	U-->I		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-20)-(-20)	0--0	0--0	0--0	0--0		JOINT 1	(-20)-(-20)	0--0	0--0	0--0	0--0
	JOINT 2	45--45	0--0	0--0	85--85	85--85		JOINT 2	45--10	0--85	0--85	85--85	85--0
	JOINT 3	85--85	0--0	0--0	85--85	85--85		JOINT 3	85--80	0--85	0--85	85--85	85--0
	JOINT 4	0--0	0--0	0--0	80--80	80--80		JOINT 4	0--0	0--80	0--80	80--80	80--0
U-->J		THUMB	INDEX	MIDDLE	RING	LITTLE	U-->K		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-20)-(-20)	0--0	0--0	0--0	0--0		JOINT 1	(-20)-(-10)	0--0	0--0	0--0	0--0
	JOINT 2	45--10	0--85	0--85	85--85	85--0		JOINT 2	45--10	0--0	0--45	85--85	85--85
	JOINT 3	85--80	0--85	0--85	85--85	85--0		JOINT 3	85--45	0--0	0--0	85--85	85--85
	JOINT 4	0--0	0--80	0--80	80--80	80--0		JOINT 4	0--0	0--0	0--0	80--80	80--80
U-->L		THUMB	INDEX	MIDDLE	RING	LITTLE	U-->M		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-20)--0	0--0	0--0	0--0	0--0		JOINT 1	(-20)-(-10)	0--0	0--0	0--0	0--0
	JOINT 2	45--0	0--0	0--85	85--85	85--85		JOINT 2	45--45	0--75	0--75	85--75	85--85
	JOINT 3	85--0	0--0	0--85	85--85	85--85		JOINT 3	85--85	0--75	0--75	85--75	85--85
	JOINT 4	0--0	0--0	0--80	80--80	80--80		JOINT 4	0--10	0--10	0--10	80--10	80--80
U-->N		THUMB	INDEX	MIDDLE	RING	LITTLE	U-->O		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-20)-(-10)	0--0	0--0	0--0	0--0		JOINT 1	(-20)-(-30)	0--0	0--0	0--0	0--0
	JOINT 2	45--30	0--75	0--75	85--85	85--85		JOINT 2	45--25	0--60	0--60	85--60	85--60
	JOINT 3	85--60	0--75	0--75	85--85	85--85		JOINT 3	85--45	0--45	0--45	85--45	85--45
	JOINT 4	0--10	0--10	0--10	80--80	80--80		JOINT 4	0--45	0--10	0--10	80--10	80--10
U-->P		THUMB	INDEX	MIDDLE	RING	LITTLE	U-->Q		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-20)-(-10)	0--0	0--0	0--0	0--0		JOINT 1	(-20)-(-30)	0--0	0--0	0--0	0--0
	JOINT 2	45--10	0--0	0--45	85--85	85--85		JOINT 2	45--20	0--85	0--85	85--85	85--85
	JOINT 3	85--45	0--0	0--0	85--85	85--85		JOINT 3	85--0	0--0	0--85	85--85	85--85
	JOINT 4	0--0	0--0	0--0	80--80	80--80		JOINT 4	0--0	0--0	0--80	80--80	80--80

U-->R		THUMB	INDEX	MIDDLE	RING	LITTLE	U-->S		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-20)-(-20)	0--15	0--(-5)	0--0	0--0		JOINT 1	(-20)-(-20)	0--0	0--0	0--0	0--0
	JOINT 2	45--45	0--20	0--0	85--85	85--85		JOINT 2	45--30	0--85	0--85	85--85	85--85
	JOINT 3	85--45	0--0	0--0	85--85	85--85		JOINT 3	85--45	0--85	0--85	85--85	85--85
	JOINT 4	0--0	0--0	0--0	80--80	80--80		JOINT 4	0--45	0--80	0--80	80--80	80--80
U-->T		THUMB	INDEX	MIDDLE	RING	LITTLE	U-->A		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-20)--0	0--(-10)	0--0	0--0	0--0		JOINT 1	(-20)--0	0--0	0--0	0--0	0--0
	JOINT 2	45--20	0--60	0--85	85--85	85--85		JOINT 2	45--20	0--85	0--85	85--85	85--85
	JOINT 3	85--25	0--80	0--85	85--85	85--85		JOINT 3	85--25	0--85	0--85	85--85	85--85
	JOINT 4	0--0	0--45	0--80	80--80	80--80		JOINT 4	0--0	0--80	0--80	80--80	80--80
U-->V		THUMB	INDEX	MIDDLE	RING	LITTLE	U-->W		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-20)-(-20)	0--(-10)	0--10	0--0	0--0		JOINT 1	(-20)--(-10)	0--(-10)	0--0	0--10	0--0
	JOINT 2	45--45	0--0	0--0	85--85	85--85		JOINT 2	45--45	0--0	0--0	85--0	85--85
	JOINT 3	85--45	0--0	0--0	85--85	85--85		JOINT 3	85--45	0--0	0--0	85--0	85--85
	JOINT 4	0--0	0--0	0--0	80--80	80--80		JOINT 4	0--0	0--0	0--0	80--0	80--80
U-->X		THUMB	INDEX	MIDDLE	RING	LITTLE	U-->Y		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-20)-(-20)	0--0	0--0	0--0	0--0		JOINT 1	(-20)--0	0--0	0--0	0--0	0--0
	JOINT 2	45--30	0--0	0--85	85--85	85--85		JOINT 2	45--0	0--85	0--85	85--85	85--0
	JOINT 3	85--45	0--45	0--85	85--85	85--85		JOINT 3	85--0	0--85	0--85	85--85	85--0
	JOINT 4	0--0	0--45	0--80	80--80	80--80		JOINT 4	0--0	0--80	0--80	80--80	80--0
U-->Z		THUMB	INDEX	MIDDLE	RING	LITTLE							
	JOINT 1	(-20)-(-20)	0--0	0--0	0--0	0--0							
	JOINT 2	45--30	0--0	0--85	85--85	85--85							
	JOINT 3	85--45	0--0	0--85	85--85	85--85							
	JOINT 4	0--0	0--0	0--80	80--80	80--80							

Angle transition values for Letter V

V-->B		THUMB	INDEX	MIDDLE	RING	LITTLE	V-->C		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-20)--0	(-10)--0	10--0	0--0	0--0		JOINT 1	(-20)-(-30)	(-10)--0	10--0	0--0	0--0
	JOINT 2	45--20	0--0	0--0	85--0	85--0		JOINT 2	45--25	0--45	0--45	85--45	85--45
	JOINT 3	85--25	0--0	0--0	85--0	85--0		JOINT 3	85--10	0--45	0--45	85--45	85--45
	JOINT 4	0--0	0--0	0--0	80--0	80--0		JOINT 4	0--10	0--10	0--10	80--10	80--10
V-->D		THUMB	INDEX	MIDDLE	RING	LITTLE	V-->E		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-20)-(-30)	(-10)--0	10--0	0--0	0--0		JOINT 1	(-20)--0	(-10)--0	10--0	0--0	0--0
	JOINT 2	45--25	0--0	0--45	85--45	85--45		JOINT 2	45--35	0--45	0--45	85--45	85--45
	JOINT 3	85--45	0--0	0--45	85--45	85--45		JOINT 3	85--85	0--85	0--85	85--85	85--85
	JOINT 4	0--15	0--0	0--10	80--10	80--10		JOINT 4	0--20	0--80	0--80	80--80	80--80
V-->F		THUMB	INDEX	MIDDLE	RING	LITTLE	V-->G		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-20)-(-20)	(-10)--0	10--0	0--0	0--0		JOINT 1	(-20)-(-30)	(-10)--0	10--0	0--0	0--0
	JOINT 2	45--25	0--45	0--0	85--0	85--0		JOINT 2	45--20	0--85	0--85	85--85	85--85
	JOINT 3	85--60	0--45	0--0	85--0	85--0		JOINT 3	85--0	0--0	0--85	85--85	85--85
	JOINT 4	0--10	0--10	0--0	80--0	80--0		JOINT 4	0--0	0--0	0--80	80--80	80--80
V-->H		THUMB	INDEX	MIDDLE	RING	LITTLE	V-->I		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-20)-(-20)	(-10)--0	10--0	0--0	0--0		JOINT 1	(-20)-(-20)	(-10)--0	10--0	0--0	0--0
	JOINT 2	45--45	0--0	0--0	85--85	85--85		JOINT 2	45--10	0--85	0--85	85--85	85--0
	JOINT 3	85--45	0--0	0--0	85--85	85--85		JOINT 3	85--80	0--85	0--85	85--85	85--0
	JOINT 4	0--0	0--0	0--0	80--80	80--80		JOINT 4	0--0	0--80	0--80	80--80	80--0
V-->J		THUMB	INDEX	MIDDLE	RING	LITTLE	V-->K		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-20)-(-20)	(-10)--0	10--0	0--0	0--0		JOINT 1	(-20)-(-10)	(-10)--0	10--0	0--0	0--0
	JOINT 2	45--10	0--85	0--85	85--85	85--0		JOINT 2	45--10	0--0	0--45	85--85	85--85
	JOINT 3	85--80	0--85	0--85	85--85	85--0		JOINT 3	85--45	0--0	0--0	85--85	85--85
	JOINT 4	0--0	0--80	0--80	80--80	80--0		JOINT 4	0--0	0--0	0--0	80--80	80--80
V-->L		THUMB	INDEX	MIDDLE	RING	LITTLE	V-->M		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-20)--0	(-10)--0	10--0	0--0	0--0		JOINT 1	(-20)-(-10)	(-10)--0	10--0	0--0	0--0
	JOINT 2	45--0	0--0	0--85	85--85	85--85		JOINT 2	45--45	0--75	0--75	85--75	85--85
	JOINT 3	85--0	0--0	0--85	85--85	85--85		JOINT 3	85--85	0--75	0--75	85--75	85--85
	JOINT 4	0--0	0--0	0--80	80--80	80--80		JOINT 4	0--10	0--10	0--10	80--10	80--80
V-->N		THUMB	INDEX	MIDDLE	RING	LITTLE	V-->O		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-20)-(-10)	(-10)--0	10--0	0--0	0--0		JOINT 1	(-20)-(-30)	(-10)--0	10--0	0--0	0--0
	JOINT 2	45--30	0--75	0--75	85--85	85--85		JOINT 2	45--25	0--60	0--60	85--60	85--60
	JOINT 3	85--60	0--75	0--75	85--85	85--85		JOINT 3	85--45	0--45	0--45	85--45	85--45
	JOINT 4	0--10	0--10	0--10	80--80	80--80		JOINT 4	0--45	0--10	0--10	80--10	80--10
V-->P		THUMB	INDEX	MIDDLE	RING	LITTLE	V-->Q		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-20)-(-10)	(-10)--0	10--0	0--0	0--0		JOINT 1	(-20)-(-30)	(-10)--0	10--0	0--0	0--0
	JOINT 2	45--10	0--0	0--45	85--85	85--85		JOINT 2	45--20	0--85	0--85	85--85	85--85
	JOINT 3	85--45	0--0	0--0	85--85	85--85		JOINT 3	85--0	0--0	0--85	85--85	85--85
	JOINT 4	0--0	0--0	0--0	80--80	80--80		JOINT 4	0--0	0--0	0--80	80--80	80--80

V-->R		THUMB	INDEX	MIDDLE	RING	LITTLE	V-->S		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-20)-(-20)	(-10)--15	10--(-5)	0--0	0--0		JOINT 1	(-20)-(-20)	(-10)--0	10--0	0--0	0--0
	JOINT 2	45--45	0--20	0--0	85--85	85--85		JOINT 2	45--30	0--85	0--85	85--85	85--85
	JOINT 3	85--45	0--0	0--0	85--85	85--85		JOINT 3	85--45	0--85	0--85	85--85	85--85
	JOINT 4	0--0	0--0	0--0	80--80	80--80		JOINT 4	0--45	0--80	0--80	80--80	80--80
V-->T		THUMB	INDEX	MIDDLE	RING	LITTLE	V-->U		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-20)--0	(-10)-(-10)	10--0	0--0	0--0		JOINT 1	(-20)-(-20)	(-10)--0	10--0	0--0	0--0
	JOINT 2	45--20	0--60	0--85	85--85	85--85		JOINT 2	45--45	0--0	0--0	85--85	85--85
	JOINT 3	85--25	0--80	0--85	85--85	85--85		JOINT 3	85--85	0--0	0--0	85--85	85--85
	JOINT 4	0--0	0--45	0--80	80--80	80--80		JOINT 4	0--0	0--0	0--0	80--80	80--80
V-->A		THUMB	INDEX	MIDDLE	RING	LITTLE	V-->W		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-20)--0	(-10)--0	10--0	0--0	0--0		JOINT 1	(-20)-(-10)	(-10)-(-10)	10--0	0--10	0--0
	JOINT 2	45--20	0--85	0--85	85--85	85--85		JOINT 2	45--45	0--0	0--0	85--0	85--85
	JOINT 3	85--25	0--85	0--85	85--85	85--85		JOINT 3	85--45	0--0	0--0	85--0	85--85
	JOINT 4	0--0	0--80	0--80	80--80	80--80		JOINT 4	0--0	0--0	0--0	80--0	80--80
V-->X		THUMB	INDEX	MIDDLE	RING	LITTLE	V-->Y		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-20)-(-20)	(-10)--0	10--0	0--0	0--0		JOINT 1	(-20)--0	(-10)--0	10--0	0--0	0--0
	JOINT 2	45--30	0--0	0--85	85--85	85--85		JOINT 2	45--0	0--85	0--85	85--85	85--0
	JOINT 3	85--45	0--45	0--85	85--85	85--85		JOINT 3	85--0	0--85	0--85	85--85	85--0
	JOINT 4	0--0	0--45	0--80	80--80	80--80		JOINT 4	0--0	0--80	0--80	80--80	80--0
V-->Z		THUMB	INDEX	MIDDLE	RING	LITTLE							
	JOINT 1	(-20)-(-20)	(-10)--0	10--0	0--0	0--0							
	JOINT 2	45--30	0--0	0--85	85--85	85--85							
	JOINT 3	85--45	0--0	0--85	85--85	85--85							
	JOINT 4	0--0	0--0	0--80	80--80	80--80							

Angle transition values for Letter W

W-->B		THUMB	INDEX	MIDDLE	RING	LITTLE	W-->C		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-10)--0	(-10)--0	0--0	10--0	0--0		JOINT 1	(-10)-(-30)	(-10)--0	0--0	10--0	0--0
	JOINT 2	45--20	0--0	0--0	0--0	85--0		JOINT 2	45--25	0--45	0--45	0--45	85--45
	JOINT 3	45--25	0--0	0--0	0--0	85--0		JOINT 3	45--10	0--45	0--45	0--45	85--45
	JOINT 4	0--0	0--0	0--0	0--0	80--0		JOINT 4	0--10	0--10	0--10	0--10	80--10
W-->D		THUMB	INDEX	MIDDLE	RING	LITTLE	W-->E		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-10)-(-30)	(-10)--0	0--0	10--0	0--0		JOINT 1	(-10)--0	(-10)--0	0--0	10--0	0--0
	JOINT 2	45--25	0--0	0--45	0--45	85--45		JOINT 2	45--35	0--45	0--45	0--45	85--45
	JOINT 3	45--45	0--0	0--45	0--45	85--45		JOINT 3	45--85	0--85	0--85	0--85	85--85
	JOINT 4	0--15	0--0	0--10	0--10	80--10		JOINT 4	0--20	0--80	0--80	0--80	80--80
W-->F		THUMB	INDEX	MIDDLE	RING	LITTLE	W-->G		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-10)-(-20)	(-10)--0	0--0	10--0	0--0		JOINT 1	(-10)-(-30)	(-10)--0	0--0	10--0	0--0
	JOINT 2	45--25	0--45	0--0	0--0	85--0		JOINT 2	45--20	0--85	0--85	0--85	85--85
	JOINT 3	45--60	0--45	0--0	0--0	85--0		JOINT 3	45--0	0--0	0--85	0--85	85--85
	JOINT 4	0--10	0--10	0--0	0--0	80--0		JOINT 4	0--0	0--0	0--80	0--80	80--80
W-->H		THUMB	INDEX	MIDDLE	RING	LITTLE	W-->I		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-10)-(-20)	(-10)--0	0--0	10--0	0--0		JOINT 1	(-10)-(-20)	(-10)--0	0--0	10--0	0--0
	JOINT 2	45--45	0--0	0--0	0--85	85--85		JOINT 2	45--10	0--85	0--85	0--85	85--0
	JOINT 3	45--45	0--0	0--0	0--85	85--85		JOINT 3	45--80	0--85	0--85	0--85	85--0
	JOINT 4	0--0	0--0	0--0	0--80	80--80		JOINT 4	0--0	0--80	0--80	0--80	80--0
W-->J		THUMB	INDEX	MIDDLE	RING	LITTLE	W-->K		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-10)-(-20)	(-10)--0	0--0	10--0	0--0		JOINT 1	(-10)-(-10)	(-10)--0	0--0	10--0	0--0
	JOINT 2	45--10	0--85	0--85	0--85	85--0		JOINT 2	45--10	0--0	0--45	0--85	85--85
	JOINT 3	45--80	0--85	0--85	0--85	85--0		JOINT 3	45--45	0--0	0--0	0--85	85--85
	JOINT 4	0--0	0--80	0--80	0--80	80--0		JOINT 4	0--0	0--0	0--0	0--80	80--80
W-->L		THUMB	INDEX	MIDDLE	RING	LITTLE	W-->M		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-10)--0	(-10)--0	0--0	10--0	0--0		JOINT 1	(-10)-(-10)	(-10)--0	0--0	10--0	0--0
	JOINT 2	45--0	0--0	0--85	0--85	85--85		JOINT 2	45--45	0--75	0--75	0--75	85--85
	JOINT 3	45--0	0--0	0--85	0--85	85--85		JOINT 3	45--85	0--75	0--75	0--75	85--85
	JOINT 4	0--0	0--0	0--80	0--80	80--80		JOINT 4	0--10	0--10	0--10	0--10	80--80
W-->N		THUMB	INDEX	MIDDLE	RING	LITTLE	W-->O		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-10)-(-10)	(-10)--0	0--0	10--0	0--0		JOINT 1	(-10)-(-30)	(-10)--0	0--0	10--0	0--0
	JOINT 2	45--30	0--75	0--75	0--85	85--85		JOINT 2	45--25	0--60	0--60	0--60	85--60
	JOINT 3	45--60	0--75	0--75	0--85	85--85		JOINT 3	45--45	0--45	0--45	0--45	85--45
	JOINT 4	0--10	0--10	0--10	0--80	80--80		JOINT 4	0--45	0--10	0--10	0--10	80--10
W-->P		THUMB	INDEX	MIDDLE	RING	LITTLE	W-->Q		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-10)-(-10)	(-10)--0	0--0	10--0	0--0		JOINT 1	(-10)-(-30)	(-10)--0	0--0	10--0	0--0
	JOINT 2	45--10	0--0	0--45	0--85	85--85		JOINT 2	45--20	0--85	0--85	0--85	85--85
	JOINT 3	45--45	0--0	0--0	0--85	85--85		JOINT 3	45--0	0--0	0--85	0--85	85--85
	JOINT 4	0--0	0--0	0--0	0--80	80--80		JOINT 4	0--0	0--0	0--80	0--80	80--80

W-->R		THUMB	INDEX	MIDDLE	RING	LITTLE	W-->S		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-10)-(-20)	(-10)--15	0--(-5)	10--0	0--0		JOINT 1	(-10)-(-20)	(-10)--0	0--0	10--0	0--0
	JOINT 2	45--45	0--20	0--0	0--85	85--85		JOINT 2	45--30	0--85	0--85	0--85	85--85
	JOINT 3	45--45	0--0	0--0	0--85	85--85		JOINT 3	45--45	0--85	0--85	0--85	85--85
	JOINT 4	0--0	0--0	0--0	0--80	80--80		JOINT 4	0--45	0--80	0--80	0--80	80--80
W-->T		THUMB	INDEX	MIDDLE	RING	LITTLE	W-->U		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-10)--0	(-10)-(-10)	0--0	10--0	0--0		JOINT 1	(-10)-(-20)	(-10)--0	0--0	10--0	0--0
	JOINT 2	45--20	0--60	0--85	0--85	85--85		JOINT 2	45--45	0--0	0--0	0--85	85--85
	JOINT 3	45--25	0--80	0--85	0--85	85--85		JOINT 3	45--85	0--0	0--0	0--85	85--85
	JOINT 4	0--0	0--45	0--80	0--80	80--80		JOINT 4	0--0	0--0	0--0	0--80	80--80
W-->V		THUMB	INDEX	MIDDLE	RING	LITTLE	W-->A		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-10)-(-20)	(-10)-(-10)	0--10	10--0	0--0		JOINT 1	(-10)--0	(-10)--0	0--0	10--0	0--0
	JOINT 2	45--45	0--0	0--0	0--85	85--85		JOINT 2	45--20	0--85	0--85	0--85	85--85
	JOINT 3	45--85	0--0	0--0	0--85	85--85		JOINT 3	45--25	0--85	0--85	0--85	85--85
	JOINT 4	0--0	0--0	0--0	0--80	80--80		JOINT 4	0--0	0--80	0--80	0--80	80--80
W-->X		THUMB	INDEX	MIDDLE	RING	LITTLE	W-->Y		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-10)-(-20)	(-10)--0	0--0	10--0	0--0		JOINT 1	(-10)--0	(-10)--0	0--0	10--0	0--0
	JOINT 2	45--30	0--0	0--85	0--85	85--85		JOINT 2	45--0	0--85	0--85	0--85	85--0
	JOINT 3	45--45	0--45	0--85	0--85	85--85		JOINT 3	45--0	0--85	0--85	0--85	85--0
	JOINT 4	0--0	0--45	0--80	0--80	80--80		JOINT 4	0--0	0--80	0--80	0--80	80--0
W-->Z		THUMB	INDEX	MIDDLE	RING	LITTLE							
	JOINT 1	(-10)-(-20)	(-10)--0	0--0	10--0	0--0							
	JOINT 2	45--30	0--0	0--85	0--85	85--85							
	JOINT 3	45--45	0--0	0--85	0--85	85--85							
	JOINT 4	0--0	0--0	0--80	0--80	80--80							

Angle transition values for Letter X

X-->B		THUMB	INDEX	MIDDLE	RING	LITTLE	X-->C		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-20)--0	0--0	0--0	0--0	0--0		JOINT 1	(-20)-(-30)	0--0	0--0	0--0	0--0
	JOINT 2	30--20	0--0	85--0	85--0	85--0		JOINT 2	30--25	0--45	85--45	85--45	85--45
	JOINT 3	45--25	45--0	85--0	85--0	85--0		JOINT 3	45--30	45--45	85--45	85--45	85--45
	JOINT 4	0--0	45--0	80--0	80--0	80--0		JOINT 4	0--10	45--10	80--10	80--10	80--10
X-->D		THUMB	INDEX	MIDDLE	RING	LITTLE	X-->E		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-20)-(-30)	0--0	0--0	0--0	0--0		JOINT 1	(-20)--0	0--0	0--0	0--0	0--0
	JOINT 2	30--25	0--0	85--45	85--45	85--45		JOINT 2	30--35	0--45	85--45	85--45	85--45
	JOINT 3	45--45	45--0	85--45	85--45	85--45		JOINT 3	45--85	45--85	85--85	85--85	85--85
	JOINT 4	0--15	45--0	80--10	80--10	80--10		JOINT 4	0--20	45--80	80--80	80--80	80--80
X-->F		THUMB	INDEX	MIDDLE	RING	LITTLE	X-->G		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-20)-(-20)	0--0	0--0	0--0	0--0		JOINT 1	(-20)-(-30)	0--0	0--0	0--0	0--0
	JOINT 2	30--25	0--45	85--0	85--0	85--0		JOINT 2	30--20	0--85	85--85	85--85	85--85
	JOINT 3	45--60	45--45	85--0	85--0	85--0		JOINT 3	45--0	45--0	85--85	85--85	85--85
	JOINT 4	0--10	45--10	80--0	80--0	80--0		JOINT 4	0--0	45--0	80--80	80--80	80--80
X-->H		THUMB	INDEX	MIDDLE	RING	LITTLE	X-->I		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-20)-(-20)	0--0	0--0	0--0	0--0		JOINT 1	(-20)-(-20)	0--0	0--0	0--0	0--0
	JOINT 2	30--45	0--0	85--0	85--85	85--85		JOINT 2	30--10	0--85	85--85	85--85	85--0
	JOINT 3	45--85	45--0	85--0	85--85	85--85		JOINT 3	45--80	45--85	85--85	85--85	85--0
	JOINT 4	0--0	45--0	80--0	80--80	80--80		JOINT 4	0--0	45--80	80--80	80--80	80--0
X-->J		THUMB	INDEX	MIDDLE	RING	LITTLE	X-->K		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-20)-(-20)	0--0	0--0	0--0	0--0		JOINT 1	(-20)-(-10)	0--0	0--0	0--0	0--0
	JOINT 2	30--10	0--85	85--85	85--85	85--0		JOINT 2	30--10	0--0	85--45	85--85	85--85
	JOINT 3	45--80	45--85	85--85	85--85	85--0		JOINT 3	45--45	45--0	85--0	85--85	85--85
	JOINT 4	0--0	45--80	80--80	80--80	80--0		JOINT 4	0--0	45--0	80--0	80--80	80--80
X-->L		THUMB	INDEX	MIDDLE	RING	LITTLE	X-->M		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-20)--0	0--0	0--0	0--0	0--0		JOINT 1	(-20)-(-10)	0--0	0--0	0--0	0--0
	JOINT 2	30--0	0--0	85--85	85--85	85--85		JOINT 2	30--45	0--75	85--75	85--75	85--85
	JOINT 3	45--0	45--0	85--85	85--85	85--85		JOINT 3	45--85	45--75	85--75	85--75	85--85
	JOINT 4	0--0	45--0	80--80	80--80	80--80		JOINT 4	0--10	45--10	80--10	80--10	80--80
X-->N		THUMB	INDEX	MIDDLE	RING	LITTLE	X-->O		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-20)-(-10)	0--0	0--0	0--0	0--0		JOINT 1	(-20)-(-30)	0--0	0--0	0--0	0--0
	JOINT 2	30--30	0--75	85--75	85--85	85--85		JOINT 2	30--25	0--60	85--60	85--60	85--60
	JOINT 3	45--60	45--75	85--75	85--85	85--85		JOINT 3	45--45	45--45	85--45	85--45	85--45
	JOINT 4	0--10	45--10	80--10	80--80	80--80		JOINT 4	0--45	45--10	80--10	80--10	80--10
X-->P		THUMB	INDEX	MIDDLE	RING	LITTLE	X-->Q		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-20)-(-10)	0--0	0--0	0--0	0--0		JOINT 1	(-20)-(-30)	0--0	0--0	0--0	0--0
	JOINT 2	30--10	0--0	85--45	85--85	85--85		JOINT 2	30--20	0--85	85--85	85--85	85--85
	JOINT 3	45--45	45--0	85--0	85--85	85--85		JOINT 3	45--0	45--0	85--85	85--85	85--85
	JOINT 4	0--0	45--0	80--0	85--80	85--80		JOINT 4	0--0	45--0	80--80	80--80	80--80

X-->R		THUMB	INDEX	MIDDLE	RING	LITTLE	X-->S		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-20)-(-20)	0--15	0--(-5)	0--0	0--0		JOINT 1	(-20)-(-20)	0--0	0--0	0--0	0--0
	JOINT 2	30--45	0--20	85--0	85--85	85--85		JOINT 2	30--30	0--85	85--85	85--85	85--85
	JOINT 3	45--45	45--0	85--0	85--85	85--85		JOINT 3	45--45	45--85	85--85	85--85	85--85
	JOINT 4	0--0	45--0	80--0	80--80	80--80		JOINT 4	0--45	45--80	80--80	80--80	80--80
X-->T		THUMB	INDEX	MIDDLE	RING	LITTLE	X-->U		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-20)--0	0--(-10)	0--0	0--0	0--0		JOINT 1	(-20)-(-20)	0--0	0--0	0--0	0--0
	JOINT 2	30--20	0--60	85--85	85--85	85--85		JOINT 2	30--45	0--0	85--0	85--85	85--85
	JOINT 3	45--25	45--80	85--85	85--85	85--85		JOINT 3	45--85	45--0	85--0	85--85	85--85
	JOINT 4	0--0	45--45	80--80	80--80	80--80		JOINT 4	0--0	45--0	80--0	80--80	80--80
X-->V		THUMB	INDEX	MIDDLE	RING	LITTLE	X-->W		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-20)-(-20)	0--(-10)	0--10	0--0	0--0		JOINT 1	(-20)-(-10)	0--(-10)	0--0	0--10	0--0
	JOINT 2	30--45	0--0	85--0	85--85	85--85		JOINT 2	30--45	0--0	85--0	85--0	85--85
	JOINT 3	45--45	45--0	85--0	85--85	85--85		JOINT 3	45--45	45--0	85--0	85--0	85--85
	JOINT 4	0--0	45--0	80--0	80--80	80--80		JOINT 4	0--0	45--0	80--0	80--0	80--80
X-->A		THUMB	INDEX	MIDDLE	RING	LITTLE	X-->Y		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-20)--0	0--0	0--0	0--0	0--0		JOINT 1	(-20)--0	0--0	0--0	0--0	0--0
	JOINT 2	30--20	0--85	85--85	85--85	85--85		JOINT 2	30--0	0--85	85--85	85--85	85--0
	JOINT 3	45--25	45--85	85--85	85--85	85--85		JOINT 3	45--0	45--85	85--85	85--85	85--0
	JOINT 4	0--0	45--80	80--80	80--80	80--80		JOINT 4	0--0	45--80	80--80	80--80	80--0
X-->Z		THUMB	INDEX	MIDDLE	RING	LITTLE							
	JOINT 1	(-20)-(-20)	0--0	0--0	0--0	0--0							
	JOINT 2	30--30	0--0	85--85	85--85	85--85							
	JOINT 3	45--45	45--0	85--85	85--85	85--85							
	JOINT 4	0--0	45--0	80--80	80--80	80--80							

Angle transition values for Letter Y

Y-->B		THUMB	INDEX	MIDDLE	RING	LITTLE	Y-->C		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	0--0	0--0	0--0	0--0	0--0		JOINT 1	0--(-30)	0--0	0--0	0--0	0--0
	JOINT 2	0--20	85--0	85--0	85--0	0--0		JOINT 2	0--25	85--45	85--45	85--45	0--45
	JOINT 3	0--25	85--0	85--0	85--0	0--0		JOINT 3	0--30	85--45	85--45	85--45	0--45
	JOINT 4	0--0	80--0	80--0	80--0	0--0		JOINT 4	0--10	80--10	80--10	80--10	0--10
Y-->D		THUMB	INDEX	MIDDLE	RING	LITTLE	Y-->E		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	0--(-30)	0--0	0--0	0--0	0--0		JOINT 1	0--0	0--0	0--0	0--0	0--0
	JOINT 2	0--25	85--0	85--45	85--45	0--45		JOINT 2	0--35	85--45	85--45	85--45	0--45
	JOINT 3	0--45	85--0	85--45	85--45	0--45		JOINT 3	0--85	85--85	85--85	85--85	0--85
	JOINT 4	0--15	80--0	80--10	80--10	0--10		JOINT 4	0--20	80--80	80--80	80--80	0--80
Y-->F		THUMB	INDEX	MIDDLE	RING	LITTLE	Y-->G		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	0--(-20)	0--0	0--0	0--0	0--0		JOINT 1	0--(-30)	0--0	0--0	0--0	0--0
	JOINT 2	0--25	85--45	85--0	85--0	0--0		JOINT 2	0--20	85--85	85--85	85--85	0--85
	JOINT 3	0--60	85--45	85--0	85--0	0--0		JOINT 3	0--0	85--0	85--85	85--85	0--85
	JOINT 4	0--10	80--10	80--0	80--0	0--0		JOINT 4	0--0	80--0	80--80	80--80	0--80
Y-->H		THUMB	INDEX	MIDDLE	RING	LITTLE	Y-->I		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	0--(-20)	0--0	0--0	0--0	0--0		JOINT 1	0--(-20)	0--0	0--0	0--0	0--0
	JOINT 2	0--45	85--0	85--0	85--85	0--85		JOINT 2	0--10	85--85	85--85	85--85	0--0
	JOINT 3	0--85	85--0	85--0	85--85	0--85		JOINT 3	0--80	85--85	85--85	85--85	0--0
	JOINT 4	0--0	80--0	80--0	80--80	0--80		JOINT 4	0--0	80--80	80--80	80--80	0--0
Y-->J		THUMB	INDEX	MIDDLE	RING	LITTLE	Y-->K		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	0--(-20)	0--0	0--0	0--0	0--0		JOINT 1	0--(-10)	0--0	0--0	0--0	0--0
	JOINT 2	0--10	85--85	85--85	85--85	0--0		JOINT 2	0--10	85--0	85--45	85--85	0--85
	JOINT 3	0--80	85--85	85--85	85--85	0--0		JOINT 3	0--45	85--0	85--0	85--85	0--85
	JOINT 4	0--0	80--80	80--80	80--80	0--0		JOINT 4	0--0	80--0	80--0	80--80	0--80
Y-->L		THUMB	INDEX	MIDDLE	RING	LITTLE	Y-->M		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	0--0	0--0	0--0	0--0	0--0		JOINT 1	0--(-10)	0--0	0--0	0--0	0--0
	JOINT 2	0--0	85--0	85--85	85--85	0--85		JOINT 2	0--45	85--75	85--75	85--75	0--85
	JOINT 3	0--0	85--0	85--85	85--85	0--85		JOINT 3	0--85	85--75	85--75	85--75	0--85
	JOINT 4	0--0	80--0	80--80	80--80	0--80		JOINT 4	0--10	80--10	80--10	80--10	0--80
Y-->N		THUMB	INDEX	MIDDLE	RING	LITTLE	Y-->O		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	0--(-10)	0--0	0--0	0--0	0--0		JOINT 1	0--(-30)	0--0	0--0	0--0	0--0
	JOINT 2	0--30	85--75	85--75	85--85	0--85		JOINT 2	0--25	85--60	85--60	85--60	0--60
	JOINT 3	0--60	85--75	85--75	85--85	0--85		JOINT 3	0--45	85--45	85--45	85--45	0--45
	JOINT 4	0--10	80--10	80--10	80--80	0--80		JOINT 4	0--45	80--10	80--10	80--10	0--10
Y-->P		THUMB	INDEX	MIDDLE	RING	LITTLE	Y-->Q		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	0--(-10)	0--0	0--0	0--0	0--0		JOINT 1	0--(-30)	0--0	0--0	0--0	0--0
	JOINT 2	0--10	85--0	85--45	85--85	0--85		JOINT 2	0--20	85--85	85--85	85--85	0--85
	JOINT 3	0--45	85--0	85--0	85--85	0--85		JOINT 3	0--0	85--0	85--85	85--85	0--85
	JOINT 4	0--0	80--0	80--0	85--80	0--80		JOINT 4	0--0	80--0	80--80	80--80	0--80

Y-->R		THUMB	INDEX	MIDDLE	RING	LITTLE	Y-->S		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	0--(-20)	0--15	0--(-5)	0--0	0--0		JOINT 1	0--(-20)	0--0	0--0	0--0	0--0
	JOINT 2	0--45	85--20	85--0	85--85	0--85		JOINT 2	0--30	85--85	85--85	85--85	0--85
	JOINT 3	0--45	85--0	85--0	85--85	0--85		JOINT 3	0--45	85--85	85--85	85--85	0--85
	JOINT 4	0--0	80--0	80--0	80--80	0--80		JOINT 4	0--45	80--80	80--80	80--80	0--80
Y-->T		THUMB	INDEX	MIDDLE	RING	LITTLE	Y-->U		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	0--0	0--(-10)	0--0	0--0	0--0		JOINT 1	0--(-20)	0--0	0--0	0--0	0--0
	JOINT 2	0--20	85--60	85--85	85--85	0--85		JOINT 2	0--45	85--0	85--0	85--85	0--85
	JOINT 3	0--25	85--80	85--85	85--85	0--85		JOINT 3	0--85	85--0	85--0	85--85	0--85
	JOINT 4	0--0	80--45	80--80	80--80	0--80		JOINT 4	0--0	80--0	80--0	80--80	0--80
Y-->V		THUMB	INDEX	MIDDLE	RING	LITTLE	Y-->W		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	0--(-20)	0--(-10)	0--10	0--0	0--0		JOINT 1	0--(-10)	0--(-10)	0--0	0--10	0--0
	JOINT 2	0--45	85--0	85--0	85--85	0--85		JOINT 2	0--45	85--0	85--0	85--0	0--85
	JOINT 3	0--45	85--0	85--0	85--85	0--85		JOINT 3	0--45	85--0	85--0	85--0	0--85
	JOINT 4	0--0	80--0	80--0	80--80	0--80		JOINT 4	0--0	80--0	80--0	80--0	0--80
Y-->X		THUMB	INDEX	MIDDLE	RING	LITTLE	Y-->A		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	0--(-20)	0--0	0--0	0--0	0--0		JOINT 1	0--0	0--0	0--0	0--0	0--0
	JOINT 2	0--30	85--0	85--85	85--85	0--85		JOINT 2	0--20	85--85	85--85	85--85	0--85
	JOINT 3	0--45	85--45	85--85	85--85	0--85		JOINT 3	0--25	85--85	85--85	85--85	0--85
	JOINT 4	0--0	80--45	80--80	80--80	0--80		JOINT 4	0--0	80--80	80--80	80--80	0--80
Y-->Z		THUMB	INDEX	MIDDLE	RING	LITTLE							
	JOINT 1	0--(-20)	0--0	0--0	0--0	0--0							
	JOINT 2	0--30	85--0	85--85	85--85	0--85							
	JOINT 3	0--45	85--0	85--85	85--85	0--85							
	JOINT 4	0--0	80--0	80--80	80--80	0--80							

Angle transition values for Letter Z

Z-->B		THUMB	INDEX	MIDDLE	RING	LITTLE	Z-->C		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-20)--0	0--0	0--0	0--0	0--0		JOINT 1	(-20)-(-30)	0--0	0--0	0--0	0--0
	JOINT 2	30--20	0--0	85--0	85--0	85--0		JOINT 2	30--25	0--45	85--45	85--45	85--45
	JOINT 3	45--25	0--0	85--0	85--0	85--0		JOINT 3	45--30	0--45	85--45	85--45	85--45
	JOINT 4	0--0	0--0	80--0	80--0	80--0		JOINT 4	0--10	0--10	80--10	80--10	80--10
Z-->D		THUMB	INDEX	MIDDLE	RING	LITTLE	Z-->E		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-20)-(-30)	0--0	0--0	0--0	0--0		JOINT 1	(-20)--0	0--0	0--0	0--0	0--0
	JOINT 2	30--25	0--0	85--45	85--45	85--45		JOINT 2	30--35	0--45	85--45	85--45	85--45
	JOINT 3	45--30	0--0	85--45	85--45	85--45		JOINT 3	45--85	0--85	85--85	85--85	85--85
	JOINT 4	0--15	0--0	80--10	80--10	80--10		JOINT 4	0--20	0--80	80--80	80--80	80--80
Z-->F		THUMB	INDEX	MIDDLE	RING	LITTLE	Z-->G		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-20)-(-20)	0--0	0--0	0--0	0--0		JOINT 1	(-20)-(-30)	0--0	0--0	0--0	0--0
	JOINT 2	30--25	0--45	85--0	85--0	85--0		JOINT 2	30--20	0--85	85--85	85--85	85--85
	JOINT 3	45--60	0--45	85--0	85--0	85--0		JOINT 3	45--0	0--0	85--85	85--85	85--85
	JOINT 4	0--10	0--10	80--0	80--0	80--0		JOINT 4	0--0	0--0	80--80	80--80	80--80
Z-->H		THUMB	INDEX	MIDDLE	RING	LITTLE	Z-->I		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-20)-(-20)	0--0	0--0	0--0	0--0		JOINT 1	(-20)-(-20)	0--0	0--0	0--0	0--0
	JOINT 2	30--45	0--0	85--0	85--85	85--85		JOINT 2	30--10	0--85	85--85	85--85	85--0
	JOINT 3	45--85	0--0	85--0	85--85	85--85		JOINT 3	45--80	0--85	85--85	85--85	85--0
	JOINT 4	0--0	0--0	80--0	80--80	80--80		JOINT 4	0--0	0--80	80--80	80--80	80--0
Z-->J		THUMB	INDEX	MIDDLE	RING	LITTLE	Z-->K		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-20)-(-20)	0--0	0--0	0--0	0--0		JOINT 1	(-20)-(-10)	0--0	0--0	0--0	0--0
	JOINT 2	30--10	0--85	85--85	85--85	85--0		JOINT 2	30--10	0--0	85--45	85--85	85--85
	JOINT 3	45--80	0--85	85--85	85--85	85--0		JOINT 3	45--45	0--0	85--0	85--85	85--85
	JOINT 4	0--0	0--80	80--80	80--80	80--0		JOINT 4	0--0	0--0	80--0	80--80	80--80
Z-->L		THUMB	INDEX	MIDDLE	RING	LITTLE	Z-->M		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-20)--0	0--0	0--0	0--0	0--0		JOINT 1	(-20)-(-10)	0--0	0--0	0--0	0--0
	JOINT 2	30--0	0--0	85--85	85--85	85--85		JOINT 2	30--45	0--75	85--75	85--75	85--85
	JOINT 3	45--0	0--0	85--85	85--85	85--85		JOINT 3	45--85	0--75	85--75	85--75	85--85
	JOINT 4	0--0	0--0	80--80	80--80	80--80		JOINT 4	0--10	0--10	80--10	80--10	80--80
Z-->N		THUMB	INDEX	MIDDLE	RING	LITTLE	Z-->O		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-20)-(-10)	0--0	0--0	0--0	0--0		JOINT 1	(-20)-(-30)	0--0	0--0	0--0	0--0
	JOINT 2	30--30	0--75	85--75	85--85	85--85		JOINT 2	30--25	0--60	85--60	85--60	85--60
	JOINT 3	45--60	0--75	85--75	85--85	85--85		JOINT 3	45--45	0--45	85--45	85--45	85--45
	JOINT 4	0--10	0--10	80--10	80--80	80--80		JOINT 4	0--45	0--10	80--10	80--10	80--10
Z-->P		THUMB	INDEX	MIDDLE	RING	LITTLE	Z-->Q		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-20)-(-10)	0--0	0--0	0--0	0--0		JOINT 1	(-20)-(-30)	0--0	0--0	0--0	0--0
	JOINT 2	30--10	0--0	85--45	85--85	85--85		JOINT 2	30--20	0--85	85--85	85--85	85--85
	JOINT 3	45--45	0--0	85--0	85--85	85--85		JOINT 3	45--0	0--0	85--85	85--85	85--85
	JOINT 4	0--0	0--0	80--0	85--80	85--80		JOINT 4	0--0	0--0	80--80	80--80	80--80

Z-->R		THUMB	INDEX	MIDDLE	RING	LITTLE	Z-->S		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-20)-(-20)	0--15	0--(-5)	0--0	0--0		JOINT 1	(-20)-(-20)	0--0	0--0	0--0	0--0
	JOINT 2	30--45	0--20	85--0	85--85	85--85		JOINT 2	30--30	0--85	85--85	85--85	85--85
	JOINT 3	45--45	0--0	85--0	85--85	85--85		JOINT 3	45--45	0--85	85--85	85--85	85--85
	JOINT 4	0--0	0--0	80--0	80--80	80--80		JOINT 4	0--45	0--80	80--80	80--80	80--80
Z-->T		THUMB	INDEX	MIDDLE	RING	LITTLE	Z-->U		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-20)--0	0--(-10)	0--0	0--0	0--0		JOINT 1	(-20)-(-20)	0--0	0--0	0--0	0--0
	JOINT 2	30--20	0--60	85--85	85--85	85--85		JOINT 2	30--45	0--0	85--0	85--85	85--85
	JOINT 3	45--25	0--80	85--85	85--85	85--85		JOINT 3	45--85	0--0	85--0	85--85	85--85
	JOINT 4	0--0	0--45	80--80	80--80	80--80		JOINT 4	0--0	0--0	80--0	80--80	80--80
Z-->V		THUMB	INDEX	MIDDLE	RING	LITTLE	Z-->W		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-20)-(-20)	0--(-10)	0--10	0--0	0--0		JOINT 1	(-20)-(-10)	0--(-10)	0--0	0--10	0--0
	JOINT 2	30--45	0--0	85--0	85--85	85--85		JOINT 2	30--45	0--0	85--0	85--0	85--85
	JOINT 3	45--45	0--0	85--0	85--85	85--85		JOINT 3	45--45	0--0	85--0	85--0	85--85
	JOINT 4	0--0	0--0	80--0	80--80	80--80		JOINT 4	0--0	0--0	80--0	80--0	80--80
Z-->X		THUMB	INDEX	MIDDLE	RING	LITTLE	Z-->Y		THUMB	INDEX	MIDDLE	RING	LITTLE
	JOINT 1	(-20)-(-20)	0--0	0--0	0--0	0--0		JOINT 1	(-20)--0	0--0	0--0	0--0	0--0
	JOINT 2	30--30	0--0	85--85	85--85	85--85		JOINT 2	30--0	0--85	85--85	85--85	85--0
	JOINT 3	45--45	0--45	85--85	85--85	85--85		JOINT 3	45--0	0--85	85--85	85--85	85--0
	JOINT 4	0--0	0--45	80--80	80--80	80--80		JOINT 4	0--0	0--80	80--80	80--80	80--0
Z-->A		THUMB	INDEX	MIDDLE	RING	LITTLE							
	JOINT 1	(-20)-(-20)	0--0	0--0	0--0	0--0							
	JOINT 2	30--30	0--85	85--85	85--85	85--85							
	JOINT 3	45--45	0--85	85--85	85--85	85--85							
	JOINT 4	0--0	0--80	80--80	80--80	80--80							