4-13-2006

When the Artistic Meets the Scientific: A New Method of Digital Processing for Audio, Video, and Images

Chance M. Glenn Sr
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When the Artistic Meets the Scientific

A New Method of Digital Processing for Audio, Video, and Images

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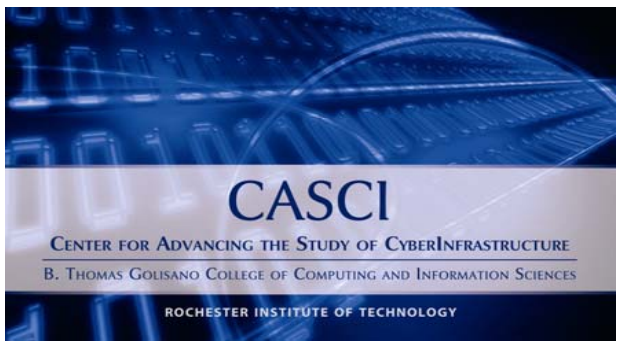
Affiliation

The Laboratory for Advanced Communications Technology
LACT

DYNAMAC
Digital Media Research Group

ECTET Electrical, Computer, & Telecommunications Engineering Technology



CAST
SCHOLARLY WORKS
DISCOVERY • INTEGRATION • APPLICATION • TEACHING

A Moment to Recognize…

•Wiley McKenzie – Dean of CAST

•Carol Richardson – Vice Dean (former Department Chair)

•Mike Eastman – Department Chair (research colleague)

•**Students:**
past and present graduate and undergraduate students who have played a part in the success of this work

Marsha Glenn – my wife and greatest supporter

My Background

•Born in New Jersey and grew up in the rural South (Alabama, I admit it) as the youngest of eight children.

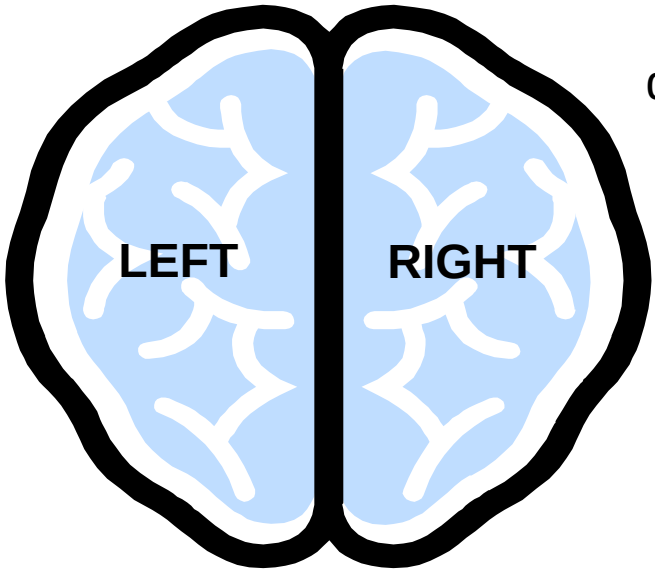
•Raised by my grandmother, who stressed education and church (not necessarily in that order).

•Was always interested in electronics (tore everything apart), but also interested art and singing.

•Was always trying to make things.

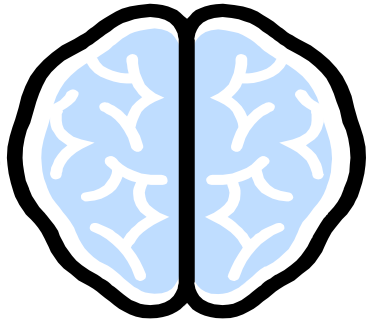
Left Brain/Right Brain

analytical thought, abstractions, structure, discipline, rules, time sequences, mathematics, categorizing, logic, rationality, deductive reasoning ,details, knowledge, definitions, planning, goals, words, productivity, efficiency, science, technology, stability, extraversion, physical activity, and the right side of the body.



intuition, feelings, sensitivity, emotions, daydreaming, visualizing, creativity, color, spatial awareness, and first impressions, rhythm, spontaneity, impulsiveness, the physical senses, risk-taking, flexibility and variety, learning by experience, relationships, mysticism, play and sports, introversion, humor, motor skills, recognize patterns

Left Brain/Right Brain Test



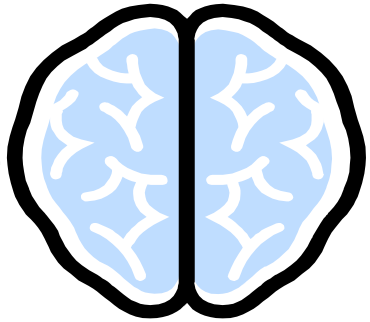
1. I constantly look at a clock or wear a watch
2. I find it hard to follow directions precisely
3. To find a lost item, I try to picture it in my head where I last saw it
4. I learn math with ease
5. People tell me I am always late getting places
6. When somebody asks me a question, I turn my head to the left
7. If someone asks me a question, I turn my head to the right
8. I believe there are two ways to look at almost everything
9. In a debate, I am objective and look at he facts before forming an opinion
10. I've considered becoming a poet, a politician, an architect, or a dancer.

1. L
2. R
3. L
4. L
5. R
6. R
7. L
8. R
9. L
10. R

I took a test at www.testcafe.com and scored:
31% LEFT 28% RIGHT

(*I don't know where the rest of the my brain went*)

Left Brain/Right Brain Test



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10. R

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31% LEFT 28% RIGHT

Left Brain/Right Brain Test

You are more left-brained than right-brained.

Your left brain controls the right side of your body. In addition to being known as left-brained, you are also known as a critical thinker who uses logic and sense to collect information. You are able to retain this information through the use of numbers, words, and symbols. You usually only see parts of the "whole" picture, but this is what guides you step-by-step in a logical manner to your conclusion. Concise words, numerical and written formulas and technological systems are often forms of expression for you.

Some occupations usually held by a left-brained person include a **lab scientist**, banker, judge, lawyer, **mathematician**, librarian, and **skating judge**.

My Musical Journey

- Established an independent record label in 1999
- Produced 5 gospel music albums
- Recorded 2 albums
- Ran nationally syndicated radio show
- Album nominated for Grammy in Gospel music genre in 2000.
- Began writing songs.
- Currently distributing music through publishing company.

My Musical Journey

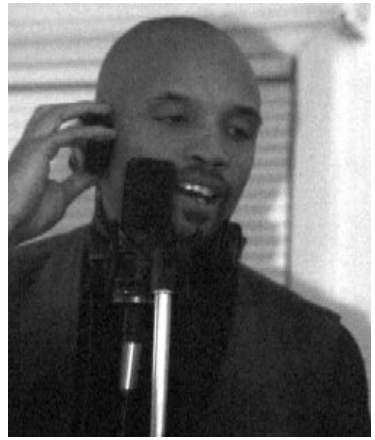
Grammy nominated - 2000
Dove Award nominated - 2000
AFIM Nominated – 2001
#1 Gospel song on MP3.com – 2001
National and international radio airplay
Performed regionally, nationally and internationally

Still available all over the Internet

My Musical Journey

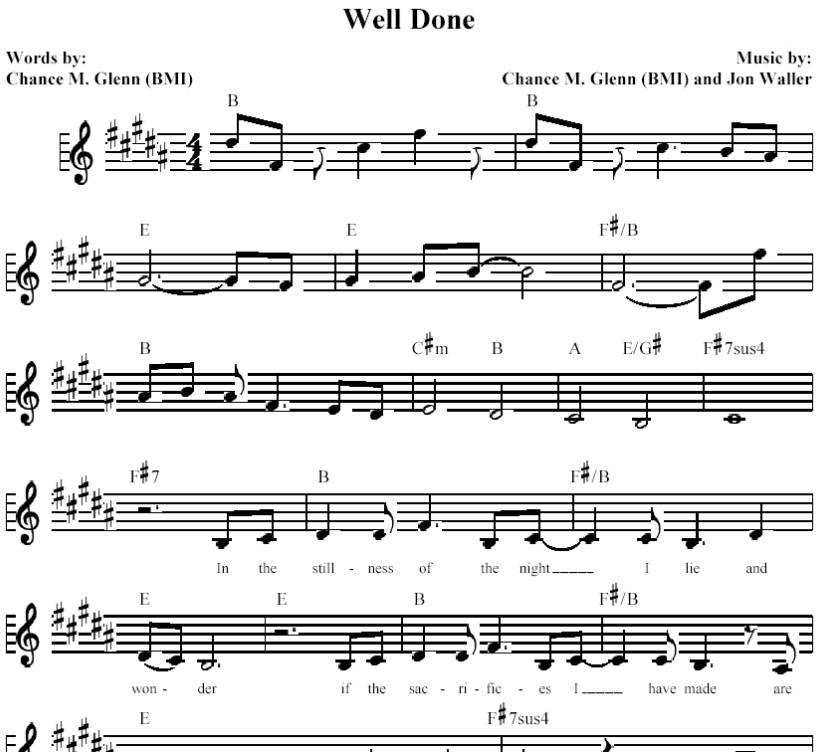
Performances

Recording



Production

The Connection



- In October of 2001, our home church, Bridgeway Community Church, recorded an album, Bridge of Hope: Songs of Faith to raise money for the September 11, relief fund.

- I wrote the song “Well Done” to honor those who gave their lives to save others that day.

PLAY CLIP (note waveform)

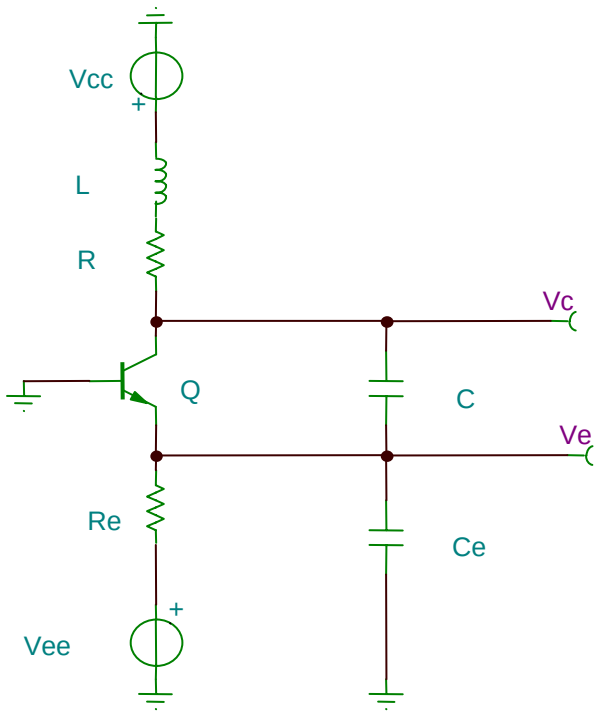
Nonlinear Dynamics

- At the same time, I was completing my Ph.D. in electrical engineering at Johns Hopkins University
- My dissertation was on the implementation of nonlinear dynamical systems theory to power amplification in radio frequency systems (or something like that).
- I came to study the diversity and variation of chaotic oscillations as they were produced by various types of systems:

- Mathematical
- Electrical
- Fluid dynamics
- Pendulums
- Chemical

Nonlinear Dynamics

- A typical chaotic oscillator is the Colpitts system.
- The Colpitts circuit is a typical circuit topology used in the engineering design of oscillators.



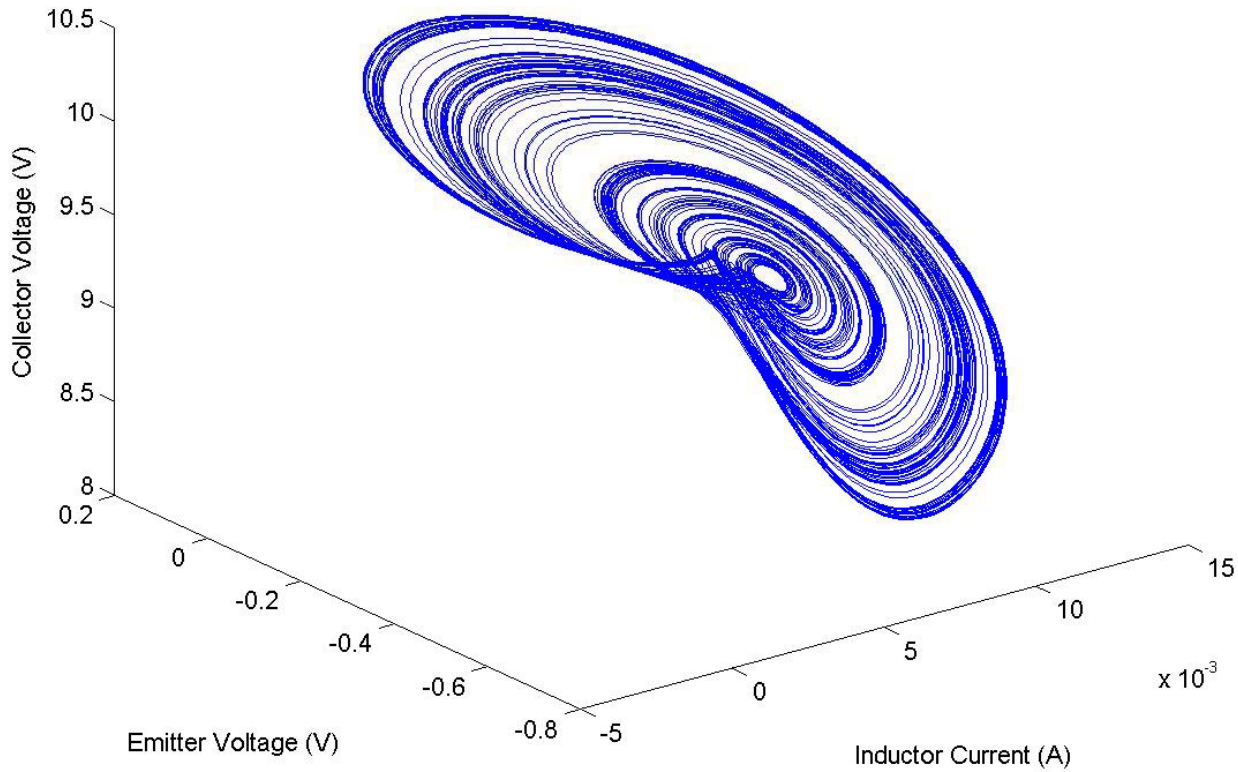
$$L\frac{di_L}{dt} = V_{CC} - v_c - (R + R_L)i_L$$

$$C_e\frac{dv_e}{dt} = i_L - \frac{v_e - V_{EE}}{R_e}$$

$$C\frac{dv_c}{dt} = C\frac{dv_e}{dt} + i_L - i_c$$

where $$i_c = \gamma\left(e^{-\alpha v_e} - 1\right)$$

Nonlinear Dynamics



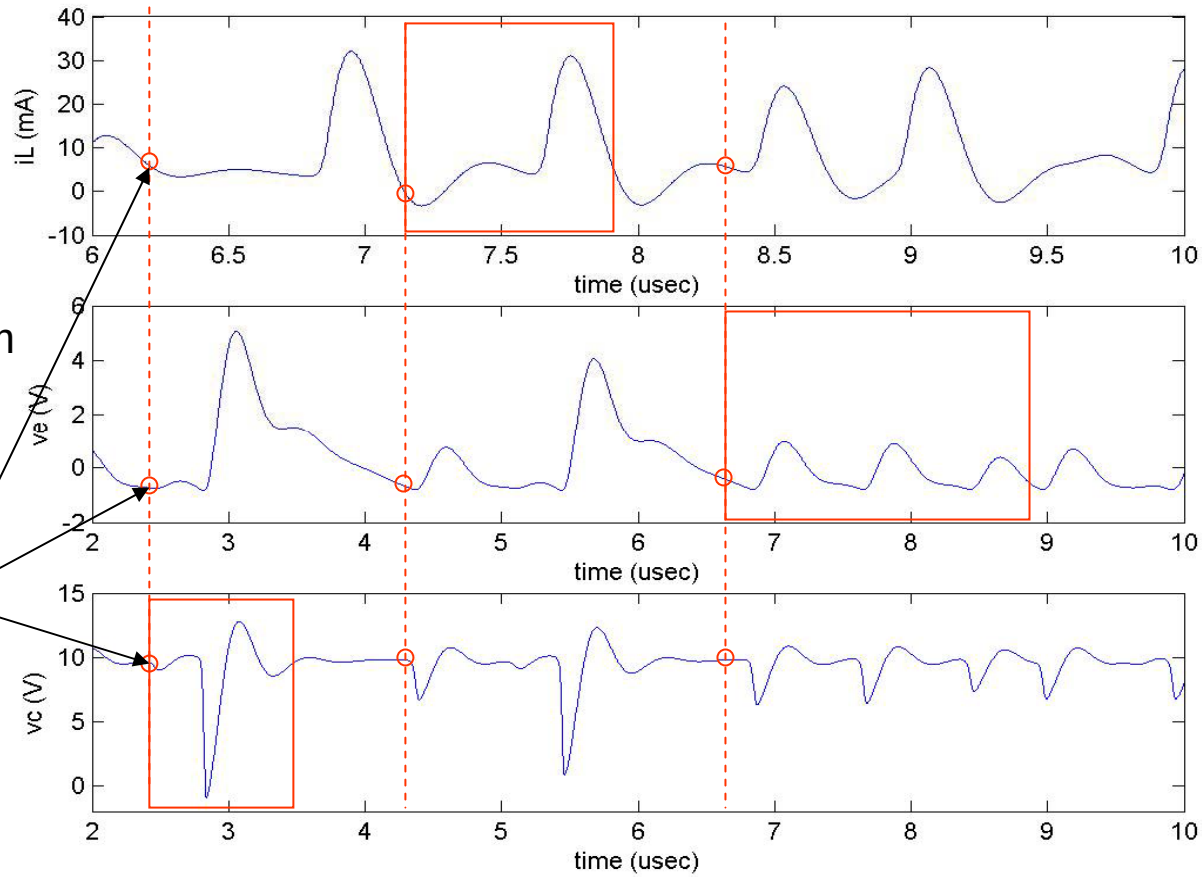
Nonlinear Dynamics

Time-dependent waveforms

Note the waveform variation in these segments

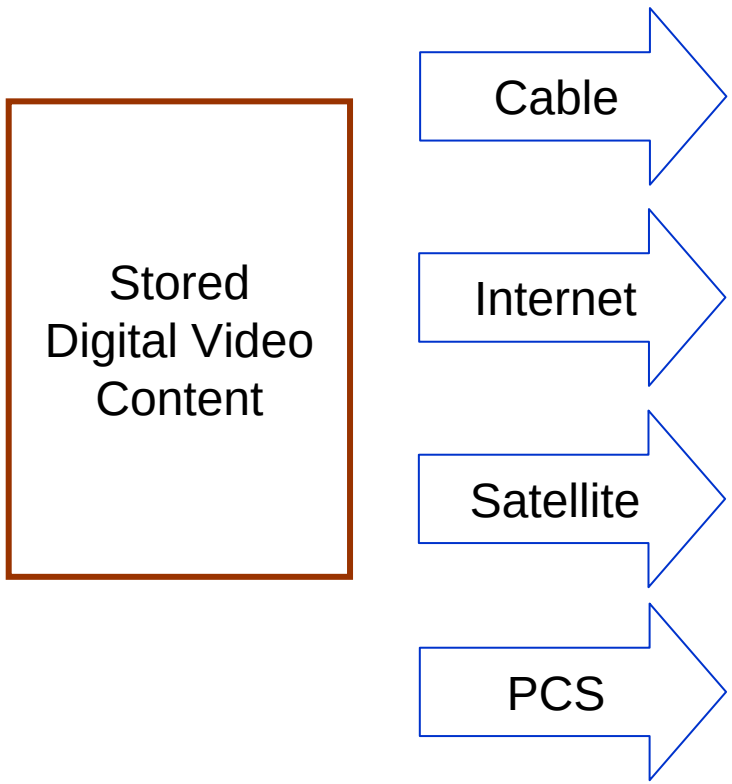
Initial conditions

•*We've expanded upon this method*



What's the Point?

C. Video On Demand

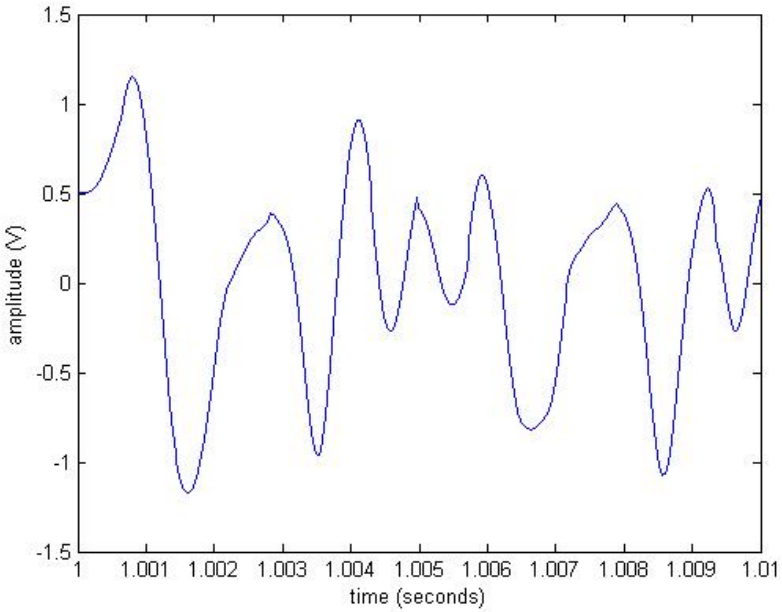


	Bandwidth	Availability
Cable	*high*	*high*
Internet	*medium (fiber?)*	*average*
Satellite	*high*	*low*
PCS	*low*	*high*

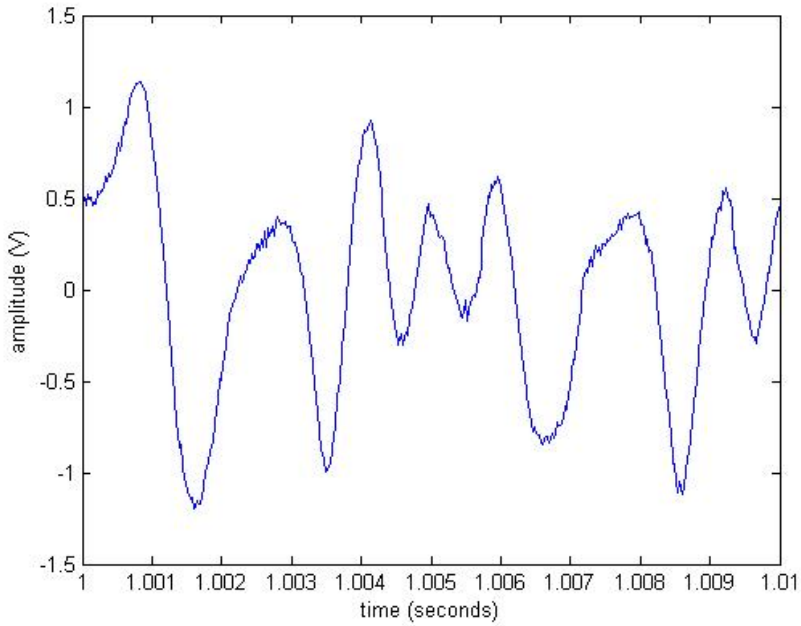
Who wins?

Sound and Noise

A. Why Digital?



Part of an analog audio waveform…



20-dB signal-to-noise ratio

Digital Waveforms

B. Sampling (Audio)

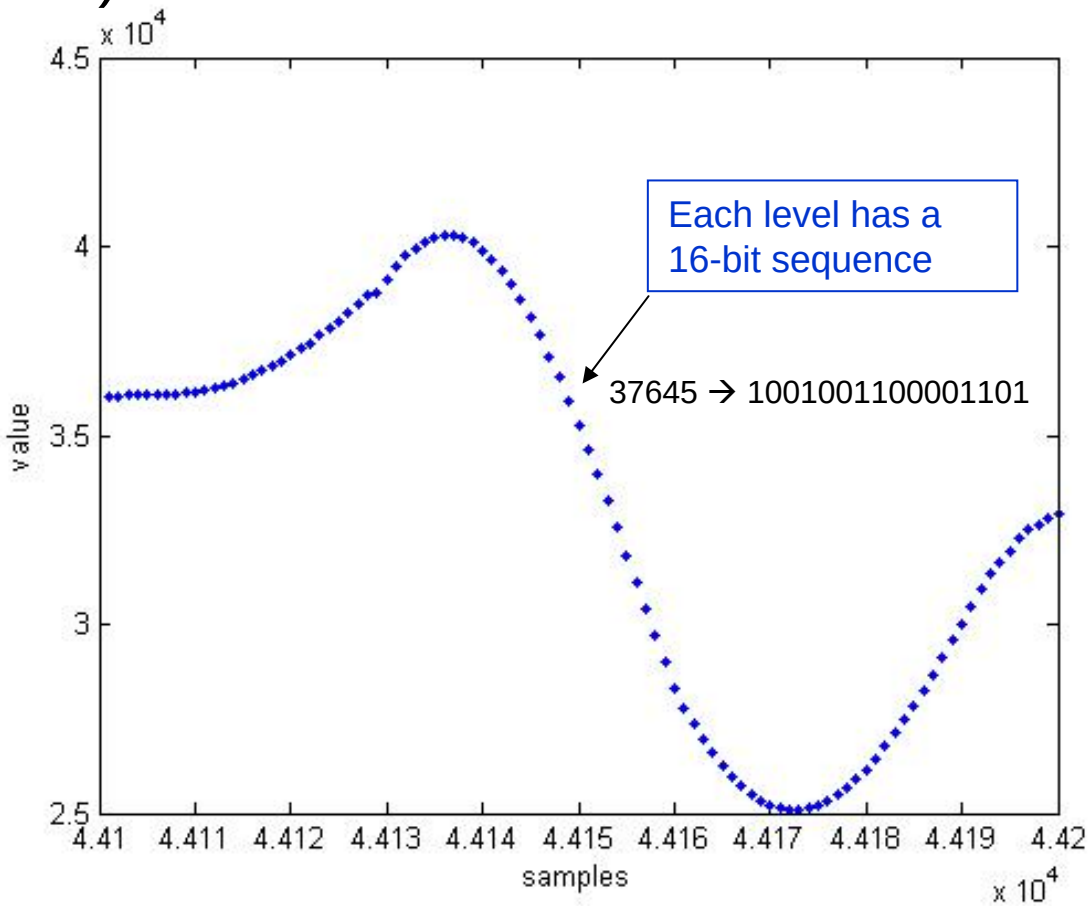
CD Quality Audio

Sample rate
44100 sps

Sample resolution
16-bit

2 channels

1.4112 Mbps



II. Digital Fundamentals

B. Sampling (Video)

Standard Digital TV

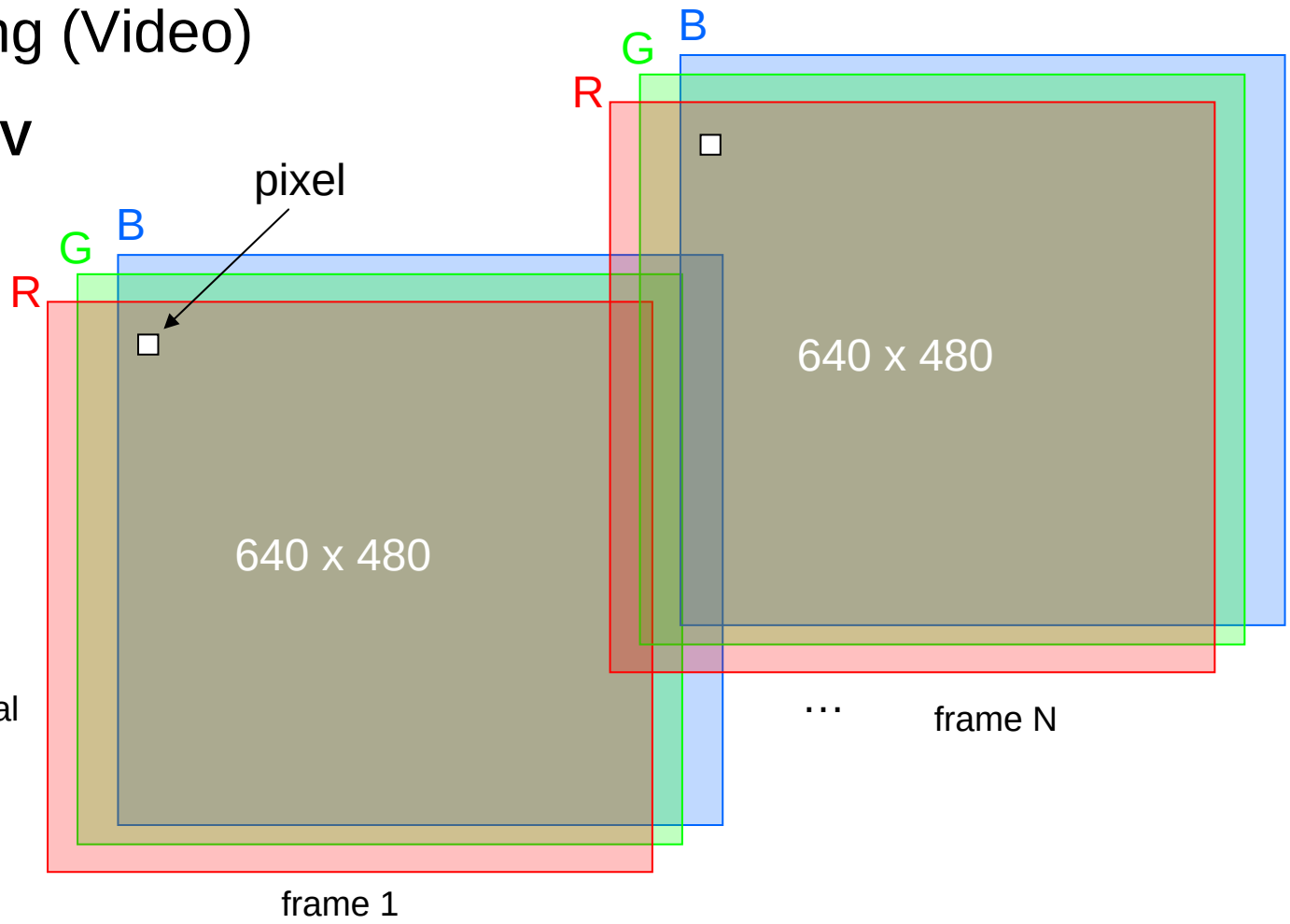
Frame rate
30 fps

Sample resolution
8-bit

Channels
3 (R,G,B)

Size
640 vertical x 480 horizontal

221.184 Mbps



D. DYNAMAC

DYNAMAC (DY-na-mac) stands for dynamics-based algorithmic compression. The basic foundation of the process lies in the realizations that (a) chaotic oscillators are dynamical systems that can be governed by mathematical expressions, and (b) chaotic oscillators are capable of producing diverse waveform shapes.

Further, if we improve the chaotic oscillator's ability to produce diverse waveform shapes, we increase the probability of matching arbitrary digital sequence segments.

Under Development by the DYNAMAC Media Research Group at the Rochester Institute of Technology

The D-Transform

Symbolically, we can describe the D-transform operator as

$$\bar{d} = \mathcal{D}\left(\bar{x}, \mathbf{C}, \bar{k}\right)$$, where

$\bar{x}$ is the original digital sequence,

$\mathbf{C}$ is the combined chaotic oscillation matrix (static), and

$\bar{k}$ is the matrix ordering sequence.

[9]

if $l\left(\bar{d}\right) < l\left(\bar{x}\right)$ where $l(.)$ is the length function

then compression occurs. We reproduce the digital sequence by $\bar{x}' = \mathcal{D}^{-1}\left(\bar{d}, \mathbf{C}, \bar{k}\right)$

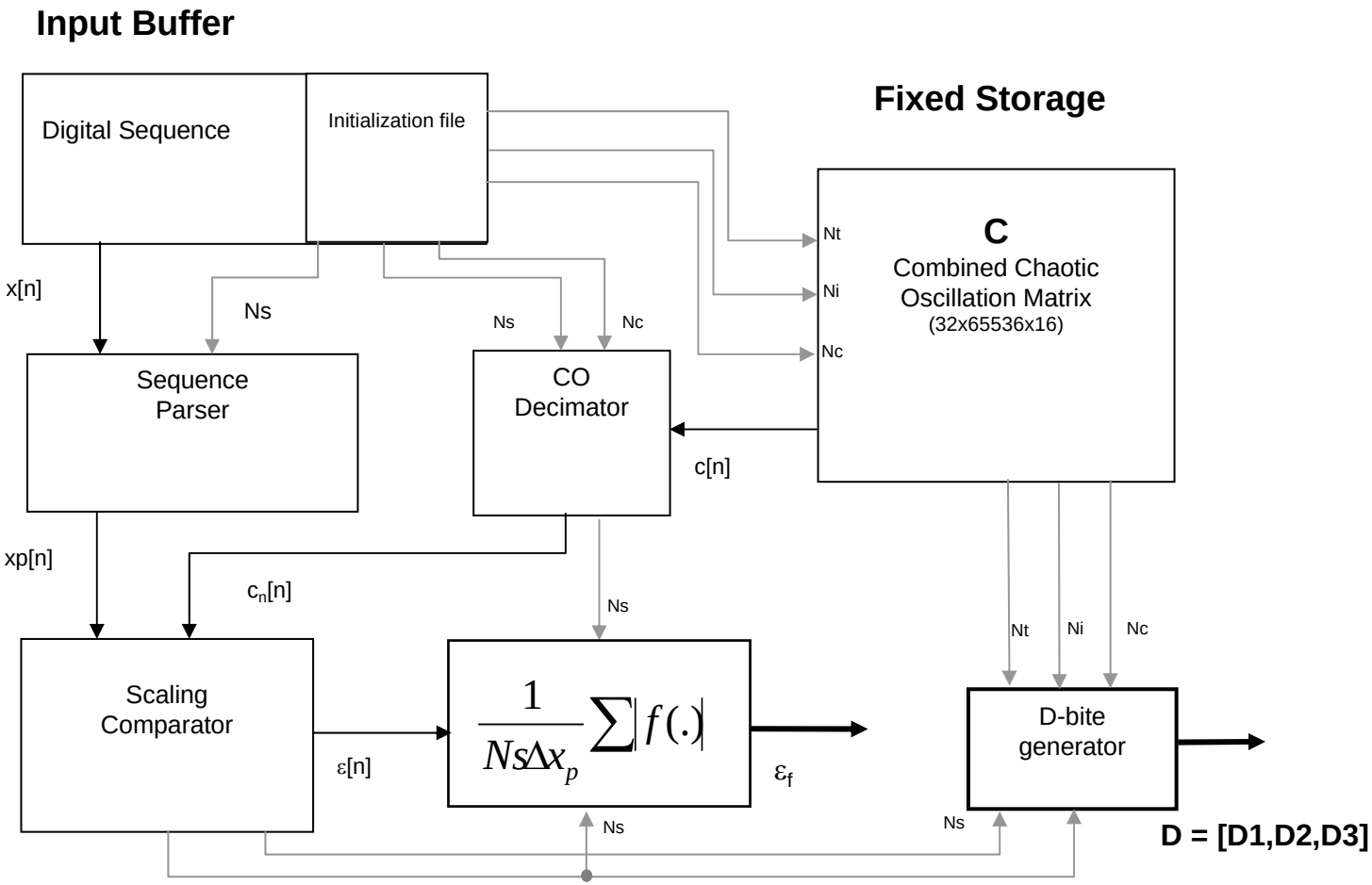
The point-wise error between the original and reconstructed sequence is $\bar{\varepsilon} = \bar{x} - \bar{x}'$

$\mathrm{E} = \sum_{Ns} \left|\bar{\varepsilon}\right|$ is the total error between the sequences. $\mathrm{E} = 0$ mean lossless compression.

The DYNAMAC Algorithm

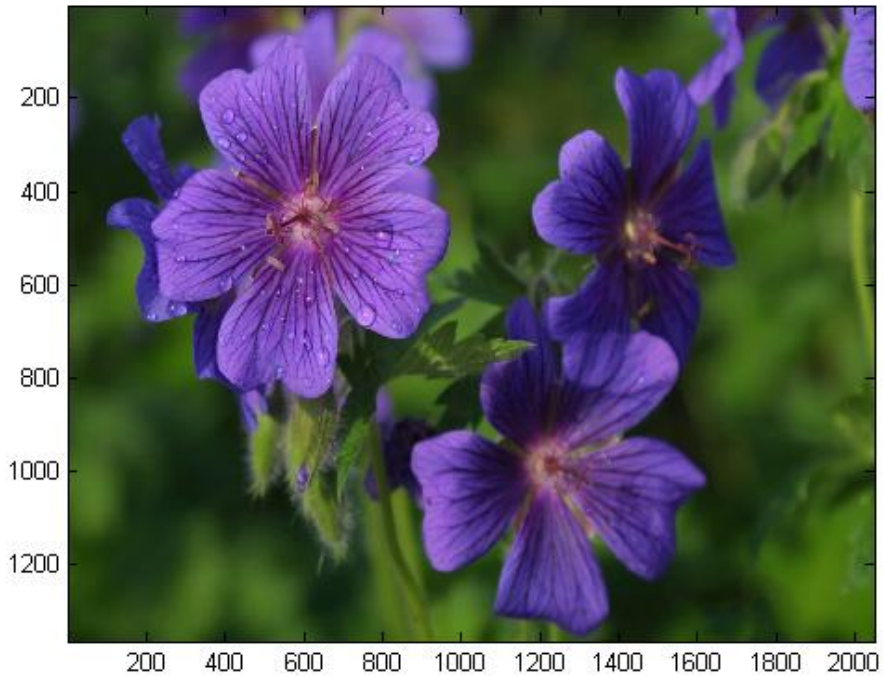
BLOCK DIAGRAM

(EXAMPLE)

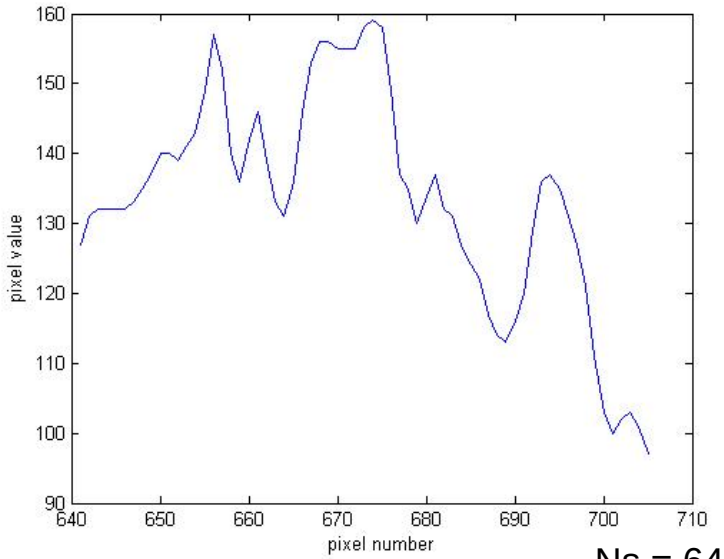


V. DYNAMAC and HDTV

original image

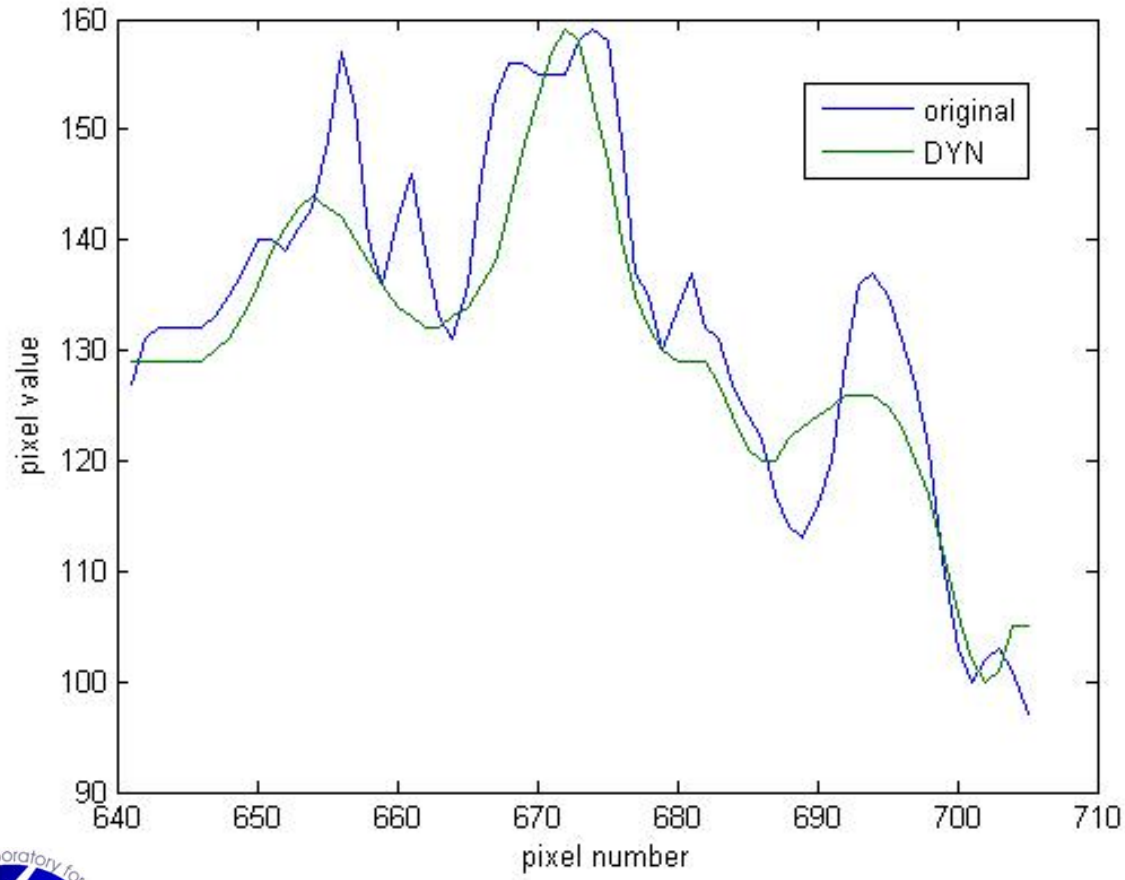


from row 400 – 64 pixels (green)



Ns = 64

The DYNAMAC Algorithm



compression ratio

$$c = N_s N_b / N_D$$

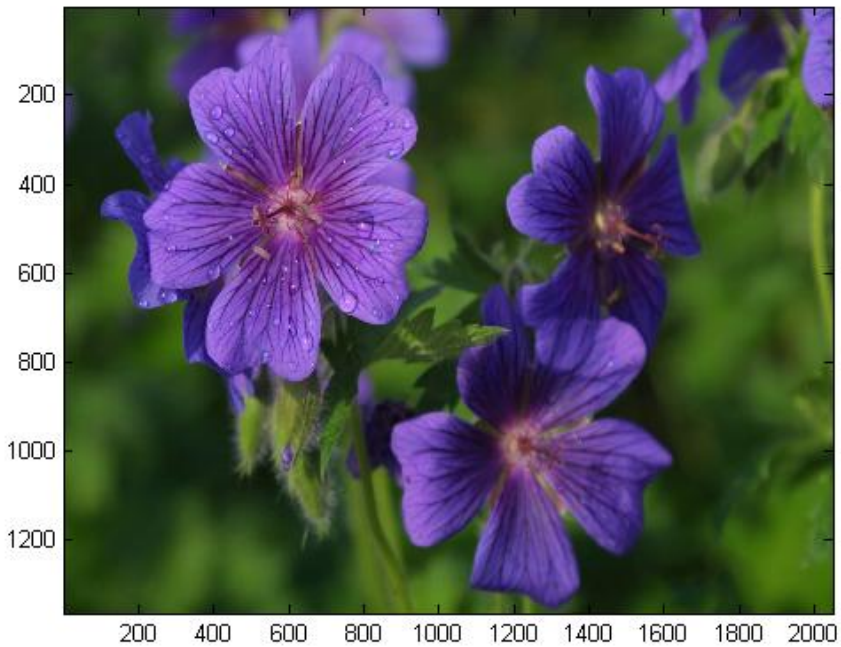
where,

N_s – length of data segment
N_b – bit resolution per channel
N_D – number of bits to represent d-bite

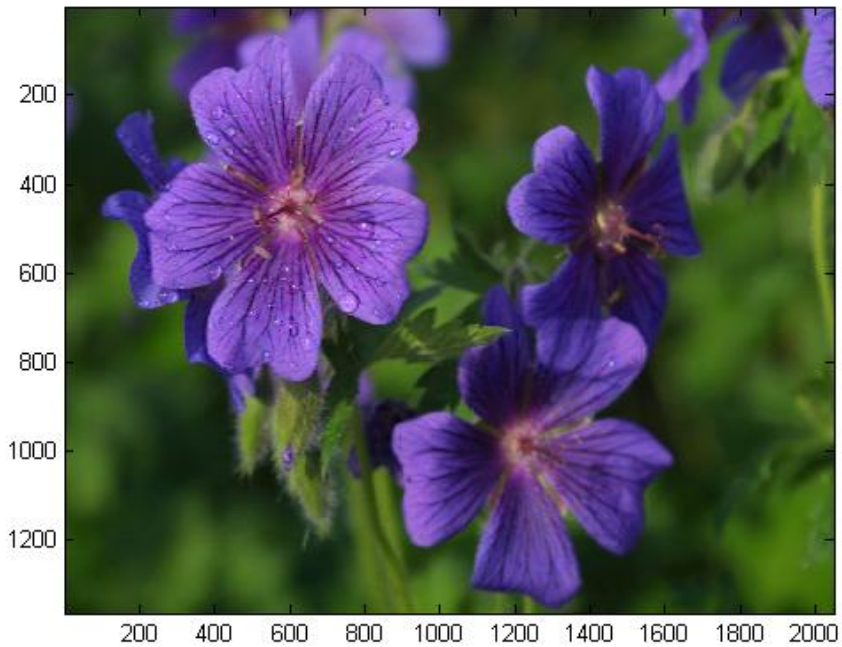
ex.
$N_s = 64$, $N_b = 8$, $N_D = 40$

c = 12.8:1

The DYNAMAC Algorithm



Original BMP image

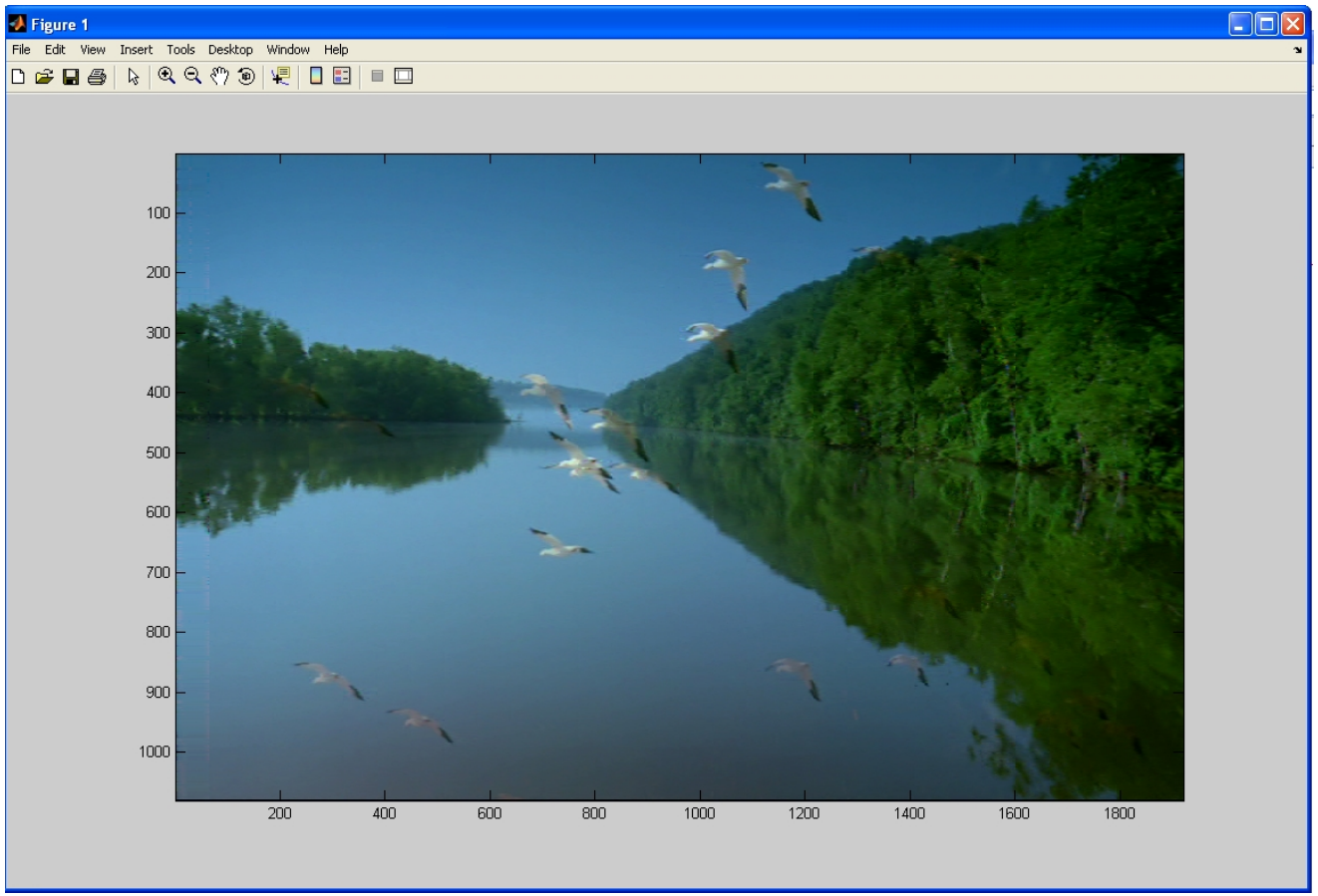


Decompressed DYN image

The DYNAMAC Algorithm

Digital Rights Management

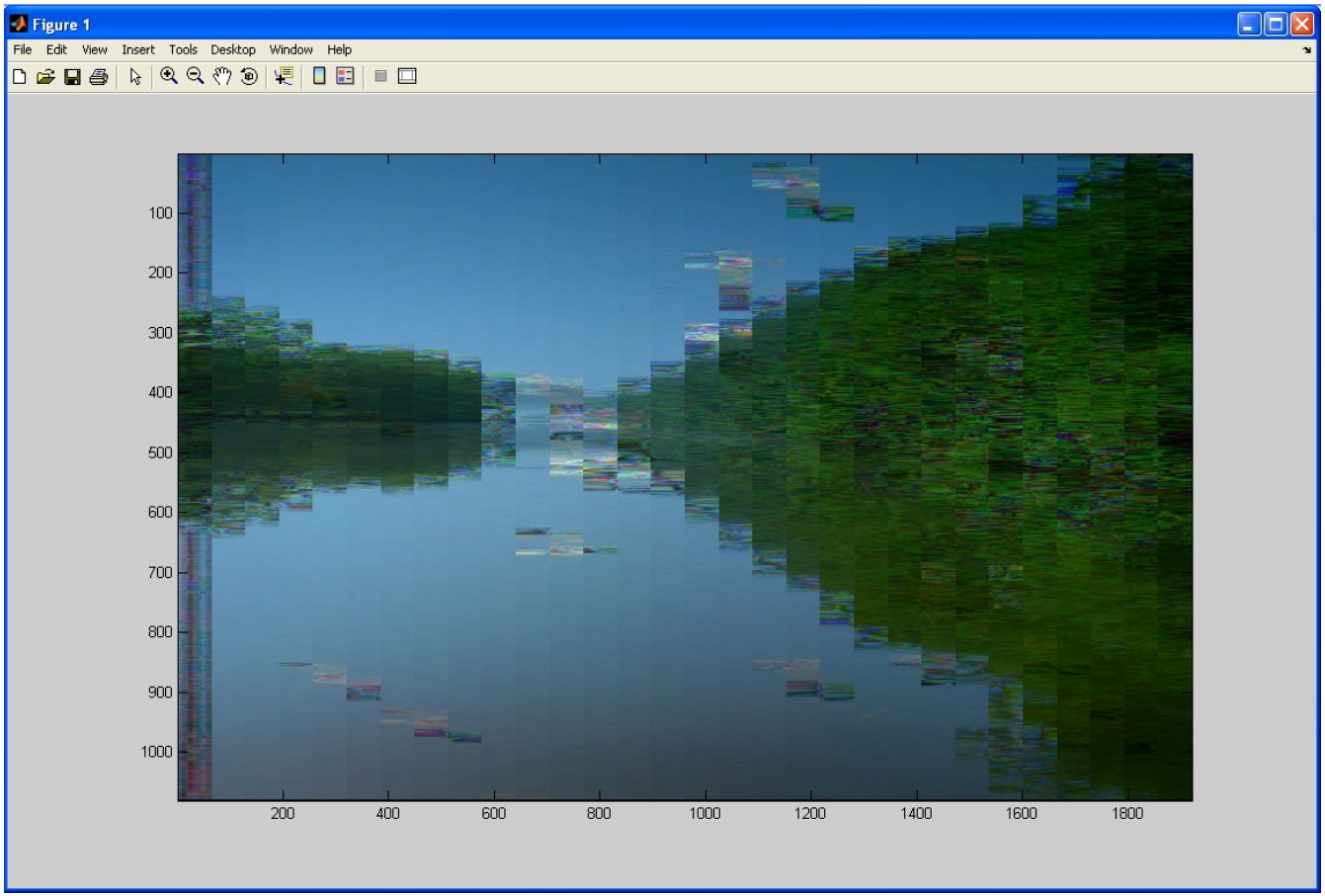
Proper 160-bit key



The DYNAMAC Algorithm

Digital Rights Management

Improper 160-bit key



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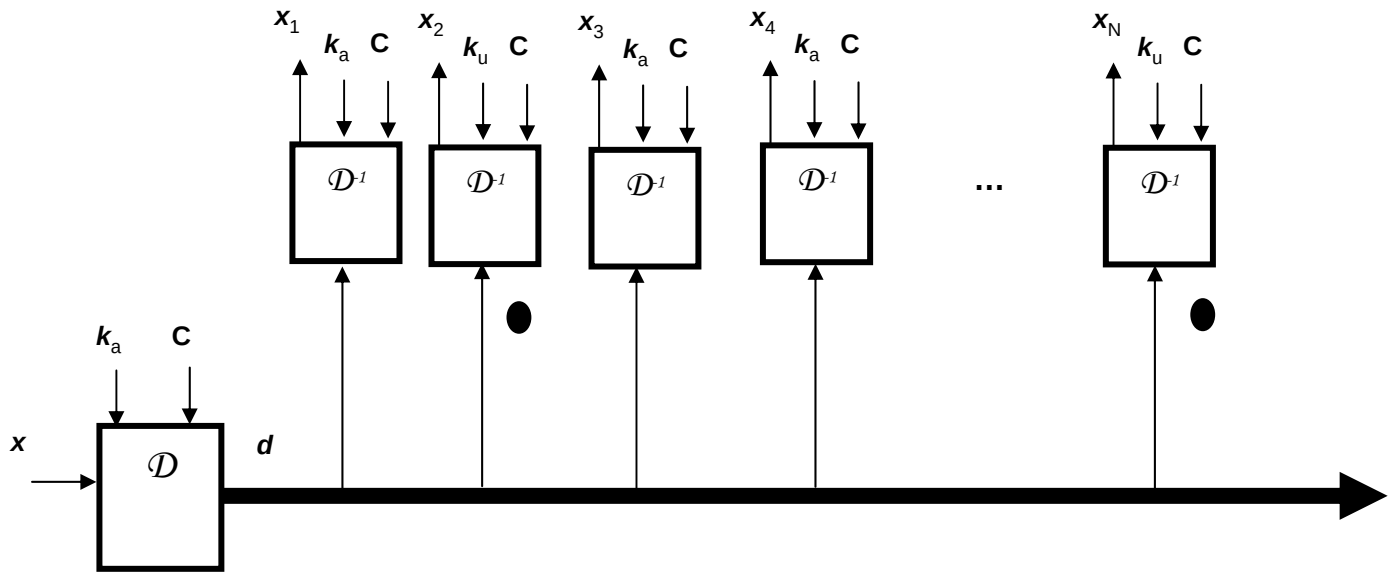

Simultaneous streaming of content to users on a network. Unauthorized users, signified with dots, will not receive quality content.

Examples:

1. Audio
2. Image
3. Video

QUESTIONS?