3-16-2021

Design for Hiking Safety & Fun

Tianyou Wu
tw9208@rit.edu

R·I·T

Design for Hiking Safety & Fun

by

Tianyou Wu

A Thesis Submitted in Partial Fulfillment of the Requirements for the Degree of Master of Fine Art in Industrial Design

Department of Design

College of Imaging Arts and Sciences

Rochester Institute of Technology

Rochester, NY

March 16, 2021

RIT | College of Art and Design

Thesis Approval

Design for Hiking Safety & Fun

Thesis Title

Tianyou Wu

Thesis Author

Submitted in partial fulfillment of the requirements for the degree of Master of Fine Arts

The School of Design | Industrial Design

Rochester Institute of Technology | Rochester, New York

Alex Lobos — Graduate Director

Name — Title

Alex Lobos — Digitally signed by Alex Lobos Date: 2021.05.10 16:16:35 -04'00'

Electronic Signature: Use Adobe Acrobat

Lorraine Justice — Chief Thesis Advisor

Name — Title

Lorraine Justice — Digitally signed by Lorraine Justice Date: 2021.05.10 19:48:12 -04'00'

Electronic Signature: Use Adobe Acrobat

--- select a Title ---

Name (Optional for some programs) — Title (Optional for some programs)

Electronic Signature: Use Adobe Acrobat (Optional for some programs)

--- select a Title ---

Name (Optional for some programs) — Title (Optional for some programs)

Electronic Signature: Use Adobe Acrobat (Optional for some programs)

Abstract

With the urbanization of the world's population, more and more people have begun to choose outdoor hiking to get close to nature and get exercise. But outdoor hiking can be dangerous, and lack of relevant knowledge not only makes hikers have a poor or stressful time, but it can also be fatal. Losing your way in the wilderness encountering wild beasts, an unfamiliar poisonous plant, lack of physical strength, extreme weather, and other accidents will put many travelers into crisis every year. A safe and comfortable outdoor travel experience could not only increase the safety and fun of travel but also attract more people to join in outdoor hiking. With the rapid development of the information age, many high-tech products have entered people's lives. However, In the current outdoor travel field, these high-tech products are not much used. In this article, the author will explore a method to integrate many new technologies such as Differential Global Positioning System (DGPS), Augmented Reality (AR), Big data, and Artificial Intelligence (AI) into one system to create a future outdoor hiking system that greatly improves the safety and provides comfort and fun to travelers.

Keywords： Differential Global Positioning System, Augmented Reality, Internet of things, Big data analysis， Rare creature detecting, Smart device.

Introduction:

Studies have shown that the biggest cause of outdoor accidents is getting lost. [1]Many unprofessional outdoor hikers lack professional navigation knowledge. At the same time, the existing navigation equipment will deviate due to various reasons, and they also lack knowledge of outdoor rare animals and plants and being unfamiliar with the environment leads to missing or not finding a suitable viewing spot. This proposed project is to design a system to ensure the safety and fun of outdoor travelers. This design hopes to provide ordinary outdoor hikers with easy-to-understand outdoor safety guidelines and navigation through AR technology and big data analysis and use DGPS (Differential GPS) to achieve outdoor accurate navigation. At the same time, augmented reality (AR) and big data are used to personally customize the most suitable tour route for tourists. Through the wild animal recognition system, it provides hikers with rare wild animal discovery tips and dangerous wild animal tips, so as to improve their pleasure in discovering rare things and protect them from danger.

Initial Research and Insights:

Safety issue:

Compared with other sports such as skiing, parachuting, diving, outdoor hiking only requires walking, and the difficulty is extremely low. Many ordinary people can hike without professional training.

Although hiking seems easy, it is quite easy to get lost in the wild environment. In addition, there are fewer people in proximity to help, and it is impossible to get rescued in times of crisis. Hikers need their own outdoor hiking knowledge.

Fig 1 Hoh Xil, missing college student

[1] CHINESE MOUNTAINEERING ASSOCIATION. *Mountaineering and Outdoor Accident Report in Mainland China*. Beijing, 2016; 2012;.

In Mountaineering and Outdoor Accident Report in Mainland China, we can clearly see that being lost accounts for almost half. In fact, there are many reasons for getting lost. Misjudgment by the guide, malfunction of GPS, offset of the map, change of terrain, loss of landmarks. For non-professional hikers, they will be at a loss if these guiding methods fail.

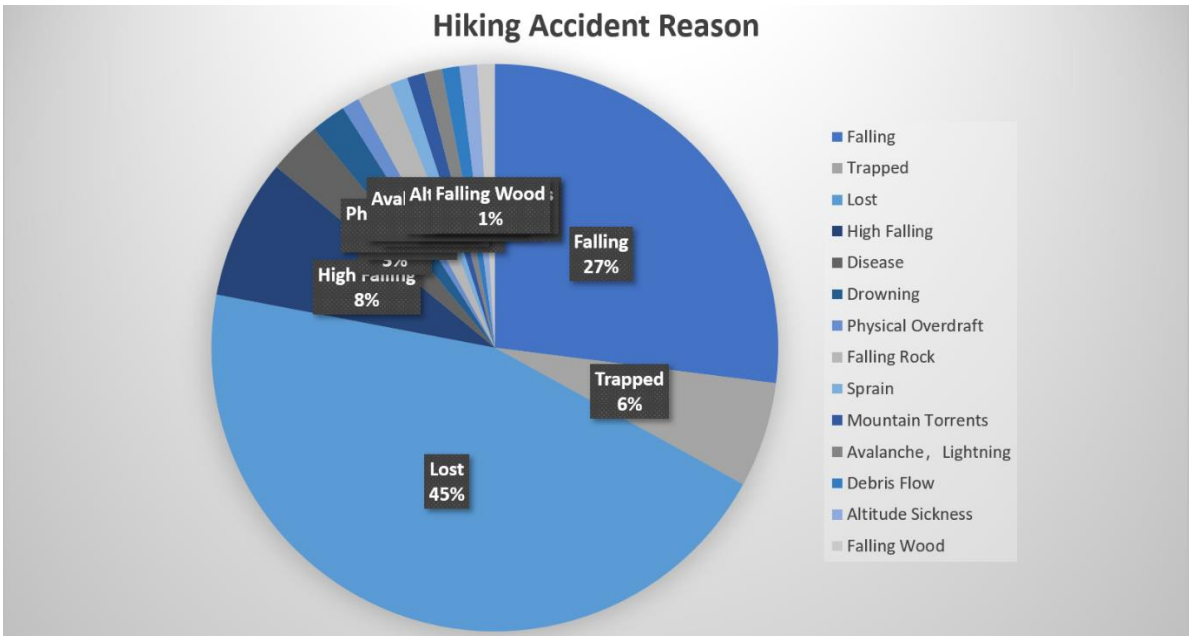


Fig 2 Type of China's mountaineering Outdoor Sport Accident in 2016[2]

Time Factor

According to the research on the time factor in the report, the researchers found that the afternoon has the highest incidence of accidents. The reason is that people are often energetic in the morning, and the probability of making mistakes is very low, but in the afternoon, because they have been hiking for a long time, they have often gone deep into the wild, coupled with physical exertion, which is very easy to cause accidents.

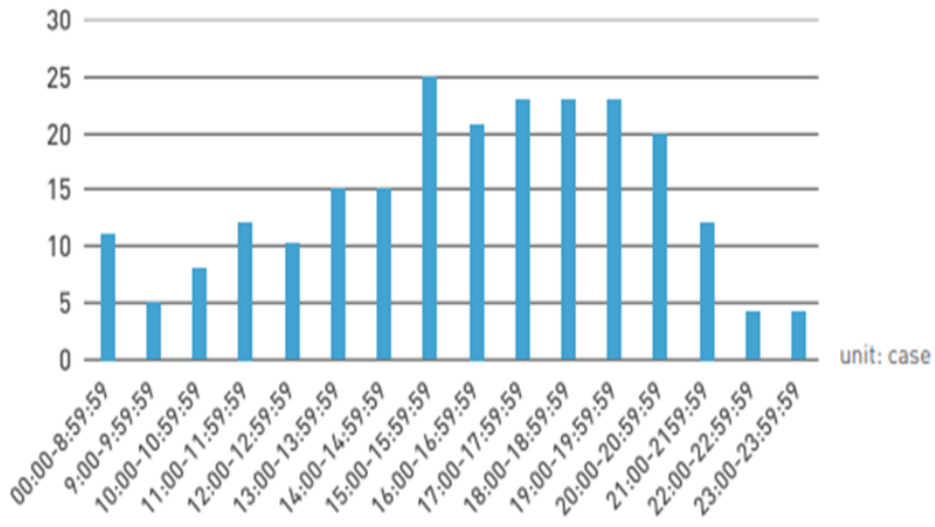


Fig 3: Relationship Between the Occurrence of the Accident and the Time[3]

[2] CHINESE MOUNTAINEERING ASSOCIATION. *Mountaineering and Outdoor Accident Report in Mainland China*. Beijing, 2016; 2012;.

[3] CHINESE MOUNTAINEERING ASSOCIATION. *Mountaineering and Outdoor Accident Report in Mainland China*. Beijing, 2016; 2012;.

Weather Factor

According to data research, the weather will basically not affect the occurrence of accidents. The main reason is that when bad weather comes, outdoor travelers often suspend their operations and wait for the weather to improve, so accidents generally happen on sunny days.

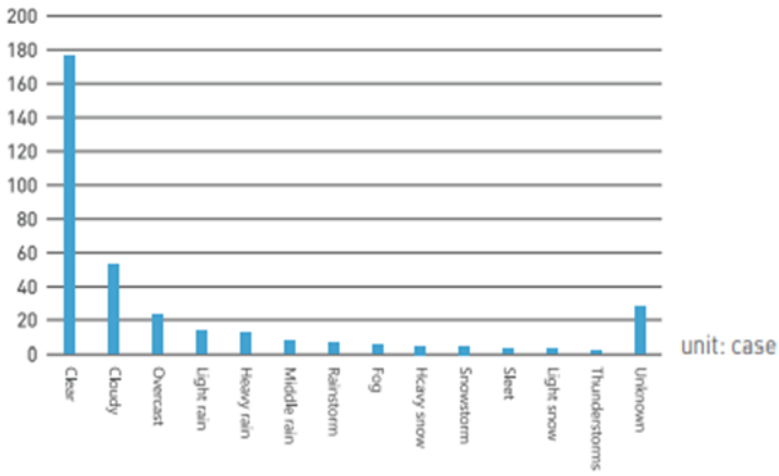


Fig 4: Relationship Between the Accident and The Weather[4]

User Needs: SAFE & FUN

Safe and comfortable travel experience. Fun in nature. Most outdoor hikers are not professionals. Most of them just want to enjoy the fresh air in nature and exercise. Due to a lack of professional knowledge, they are often unable to properly handle the various difficulties encountered in the wild. Even if it is a very safe and smooth journey, they will miss a lot of fun due to a lack of knowledge about wild animals and plants.

Fig 4: Hiking

[4] CHINESE MOUNTAINEERING ASSOCIATION. *Mountaineering and Outdoor Accident Report in Mainland China*. Beijing, 2016; 2012;.

Solution

Studies have shown that the biggest cause of outdoor accidents is getting lost. Hikers also lack knowledge of outdoor rare animals and plants and being unfamiliar with the environment leads to missing or not finding a suitable viewing spot. This proposed project is to design a system to ensure the safety and fun of outdoor travelers. This design hopes to provide ordinary outdoor hikers with easy-to-understand outdoor safety guidelines and navigation through AR technology and big data analysis and use DGPS (Differential GPS) to achieve outdoor accurate navigation. At the same time, augmented reality (AR) and big data are used to personally customize the most suitable tour route for tourists. Through the wild animal recognition system, it provides hikers with rare wild animal discovery tips and dangerous wild animal tips, so as to improve their pleasure in discovering rare things and protect them from danger.

Keywords：DGPS (Differential GPS), AR (Augmented Reality), Big Data

System Overview:

Early Concepts for the System

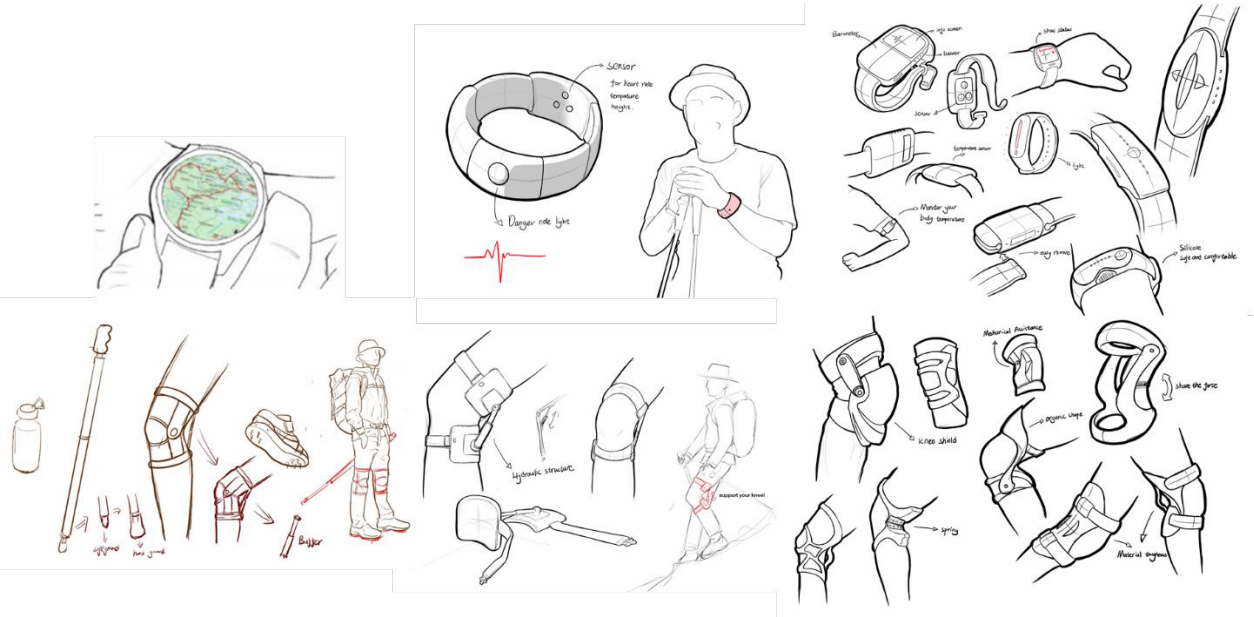


Fig 5: Early Concept Sketch

Early concepts focused on the personal equipment of hikers. For the safety of hikers, a lot of body detection wearable devices were designed in the early concept. These devices can monitor the hiker's physical condition in real-time, analyze the hiker's condition in time, and give reasonable travel advice. Avoid hikers in danger due to their physical condition. The early concept also designed some power-assisted knee pads to make hikers more energy-saving.

But after studying and analyzing outdoor hiking accidents, I found that the biggest cause of accidents is getting lost. So, I started to adjust the design thinking, putting the safety center on how to avoid the hikers getting lost.

Final Concept

In the final concept, in order to achieve more accurate outdoor navigation, DGPS (Differential Global Position System) technology was introduced into the design. Since DGPS requires a reference signal, it is necessary to set up a beacon tower in the field. At the same time, these beacon towers can also be used as nodes for big data processing and can interact with users' AR and other smart devices. So, the final design became an outdoor hiking system with the beacon tower as the core.

Fig 6: Beacon System Concept

DGPS Technologies

The global positioning system (GPS) allows properly equipped users to determine their position based on the measured pseudoranges to at least four satellites. Differential GPS operation (DGPS) uses a reference station at a known location to calculate and broadcast pseudorange corrections to local users, resulting in improved user position accuracy. DGPS accuracy is limited by the ability of the reference station to remove the effects of receiver measurement noise and multipath errors from the broadcast corrections.[5]

[5] Farrell, J. and T. Givargis. "Differential GPS Reference Station Algorithm-Design and Analysis." *IEEE Transactions on Control Systems Technology* 8, no. 3 (2000): 519-531.

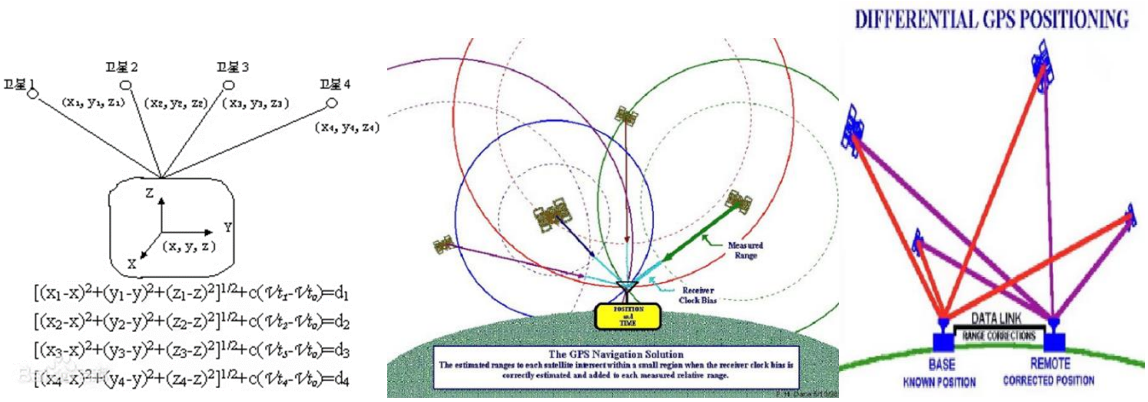


Fig 7: Differential GPS Concept

Using DGPS technology can make people's navigation outdoors more precise and will hardly be interfered. To use this technology, we need to set up many reference stations in the field. I call it beacon towers. According to the latest technology, a beacon tower can provide DGPS within a maximum range of 600km. [6] But considering the cost and the actual needs of outdoor travel, we don't need such a large range. Studies have shown that the walking speed of a normal person is 3.39-5.16km/h.[7] People will feel tired after walking for two hours. In order to provide people with a more comfortable hiking experience, the beacon tower is best to provide people with a place to rest. Therefore, the distance between each beacon is preferably about 10km. Of course, the best separation distance of beacon towers should be adjusted according to the different terrain in the field.

Placement of the Beacon Tower

In summary, in the future Hiking System using DGPS, we will need to set up a beacon tower every ten kilometers along the regular hiking route. At the same time, a few beacon towers are also arranged in inaccessible places. One beacon tower can provide accurate navigation of 600 square kilometers. We only need to arrange a small number of beacon towers to cover the entire field environment.

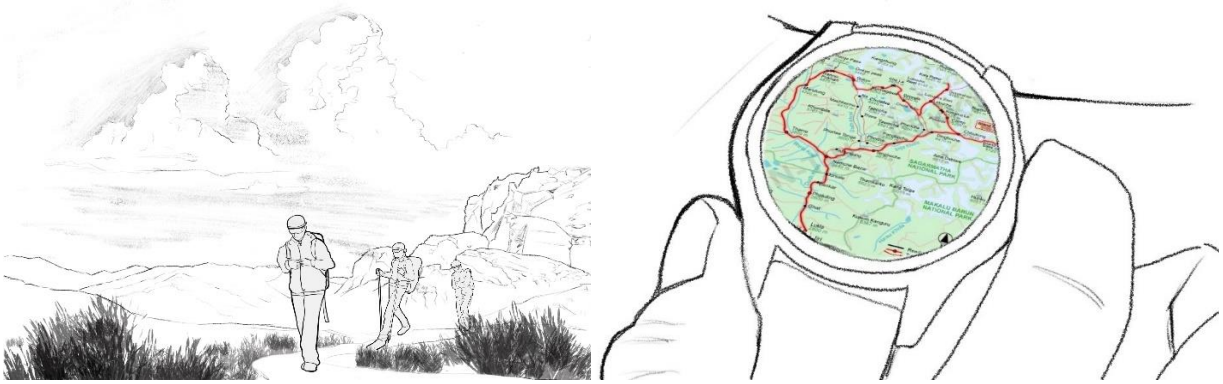


Fig 8: Beacon Navigation

[6] Mohino, Elsa, Mauricio Gende, and Claudio Brunini. "Improving Long Baseline (100–300 km) Differential GPS Positioning Applying Ionospheric Corrections Derived from Multiple Reference Stations." Journal of Surveying Engineering 133, no. 1 (2007): 1-5.

[7] Bohannon, Richard W. and A. Williams Andrews. "Normal Walking Speed: A Descriptive Meta-Analysis." *Physiotherapy* 97, no. 3 (2011): 182-189.

Functions of the Beacon tower

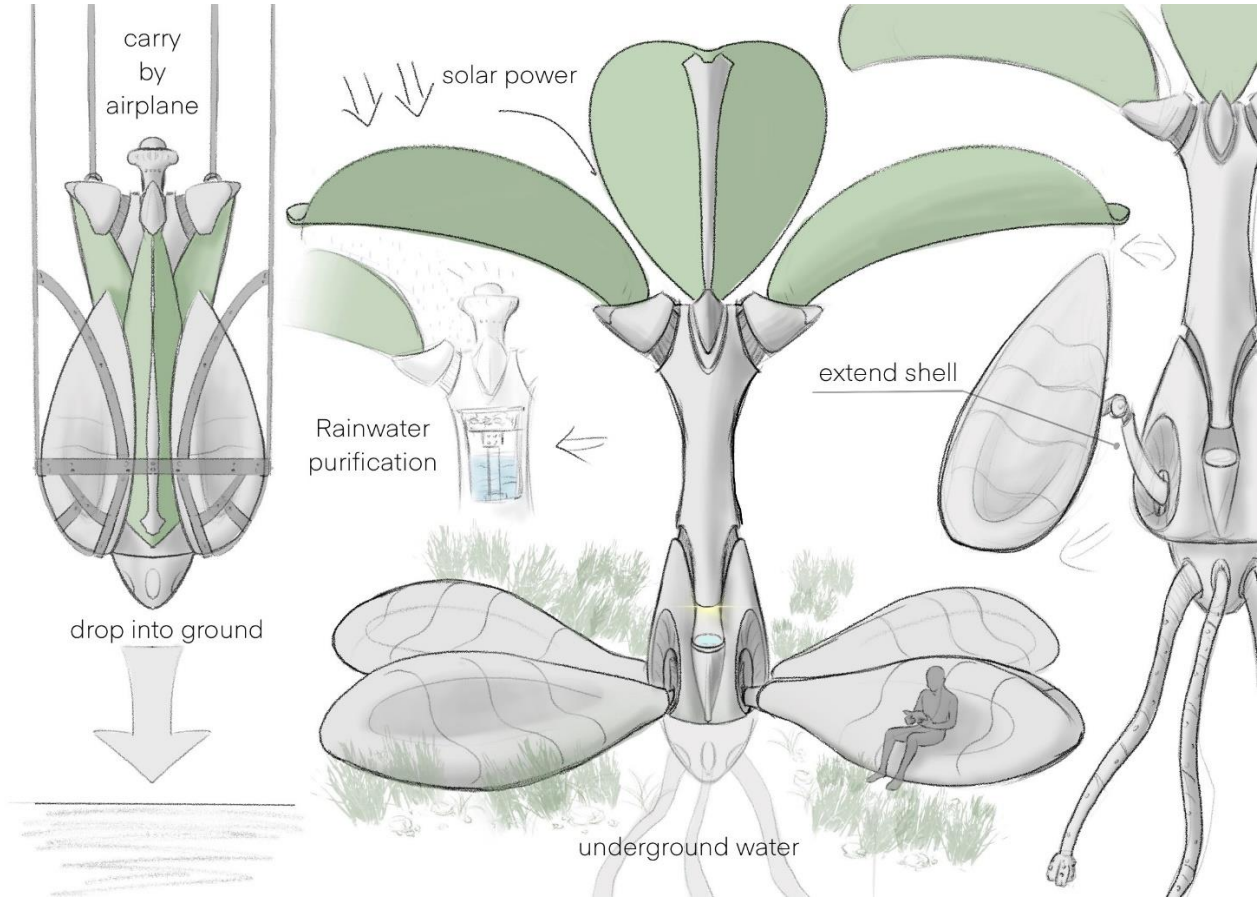


Fig 9: Beacon Tower Concept Sketch

1. Provide a place to rest

Keywords: Seat, network signal, cell phone signal

The outer shell of the beacon tower can protect the beacon tower during transportation and installation to prevent internal equipment from being damaged.

When the beacon tower is placed, the shell will unfold and become a stable support for the beacon tower.

When the shell becomes a support, the uniquely designed shape makes it a bench that can provide people with a rest.

When the hikers pass by the beacon tower, the beacon tower will provide the hikers with mobile phone signals and network signals so that the hikers can communicate with the outside world here. Or stop here and share the photos they took during their journey on social media.

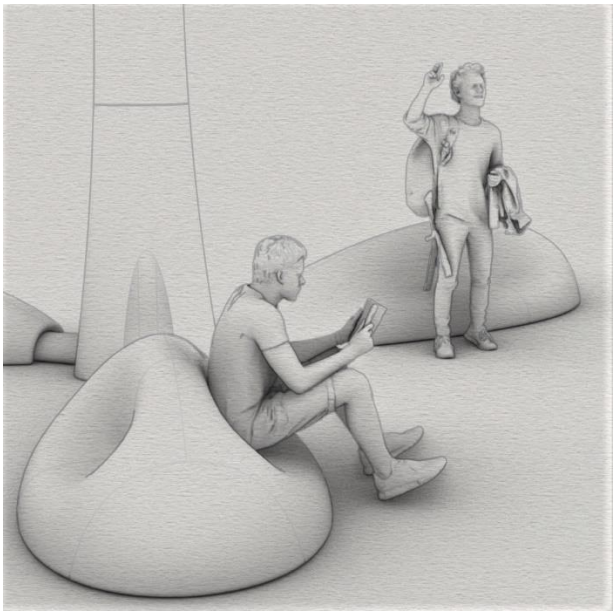


Fig 10: Shell seat

2. Provide Clean Water

Keywords: Rainwater purification and storage

The solar panels on the top of the beacon tower have a certain angle, like the leaves of plants, which can guide rainwater into the top of the beacon tower. The water purification device on the beacon tower can continuously purify rainwater and store it. When hikers reach the beacon tower, they can get clean drinking water here.

Lack of water during hiking is a dangerous thing. Many water resources in the wild are not safe. Even if some water looks clean, there will be parasites and harmful bacteria invisible to the human eye. A beacon tower provides clean and sanitary drinking water for hikers to ensure their health and safety.

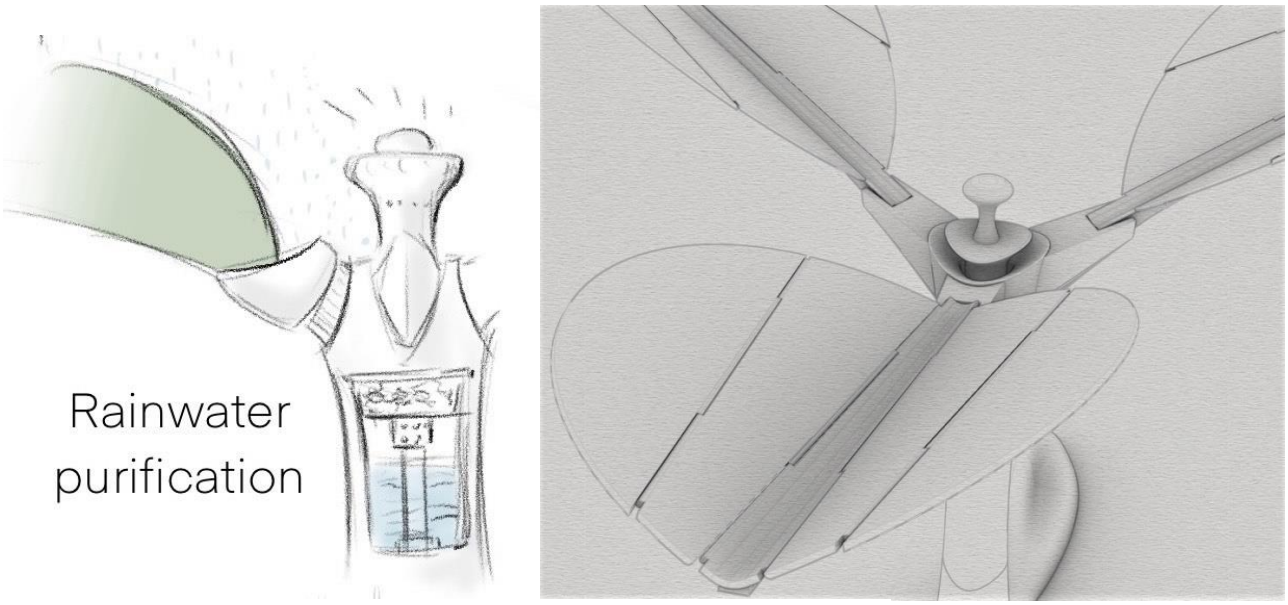


Fig 11: Rainwater collecting.

3. Provide Energy

Keywords： Device charging

The solar panels of the beacon tower provide electricity. Hikers can also charge their devices at the beacon tower. In the future, if wireless charging technology becomes more mature, hikers only need to approach the beacon to charge their devices, which will make the journey more convenient.

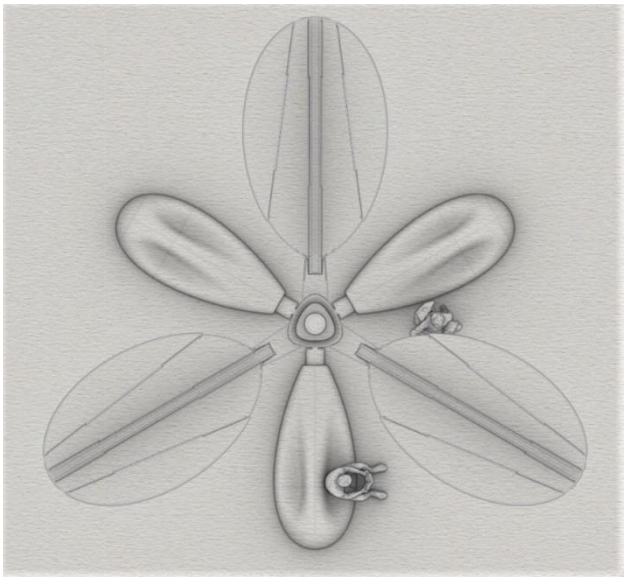


Fig 12： Solar Panels

4. AR Interaction & Intranet

Keywords：Team information sharing, AR navigation

When users use smart devices to connect to the system, they can use the powerful virtual interactive functions of the system. The best experience can be obtained when wearing an AR device.

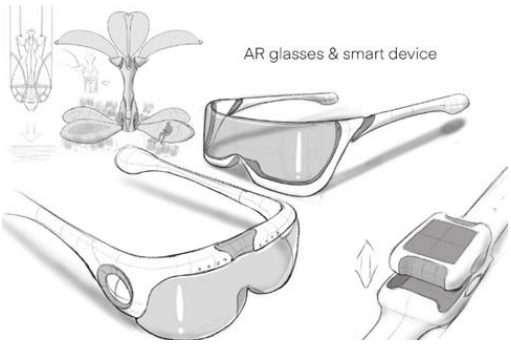


Fig 13：AR Connection Concept Sketch

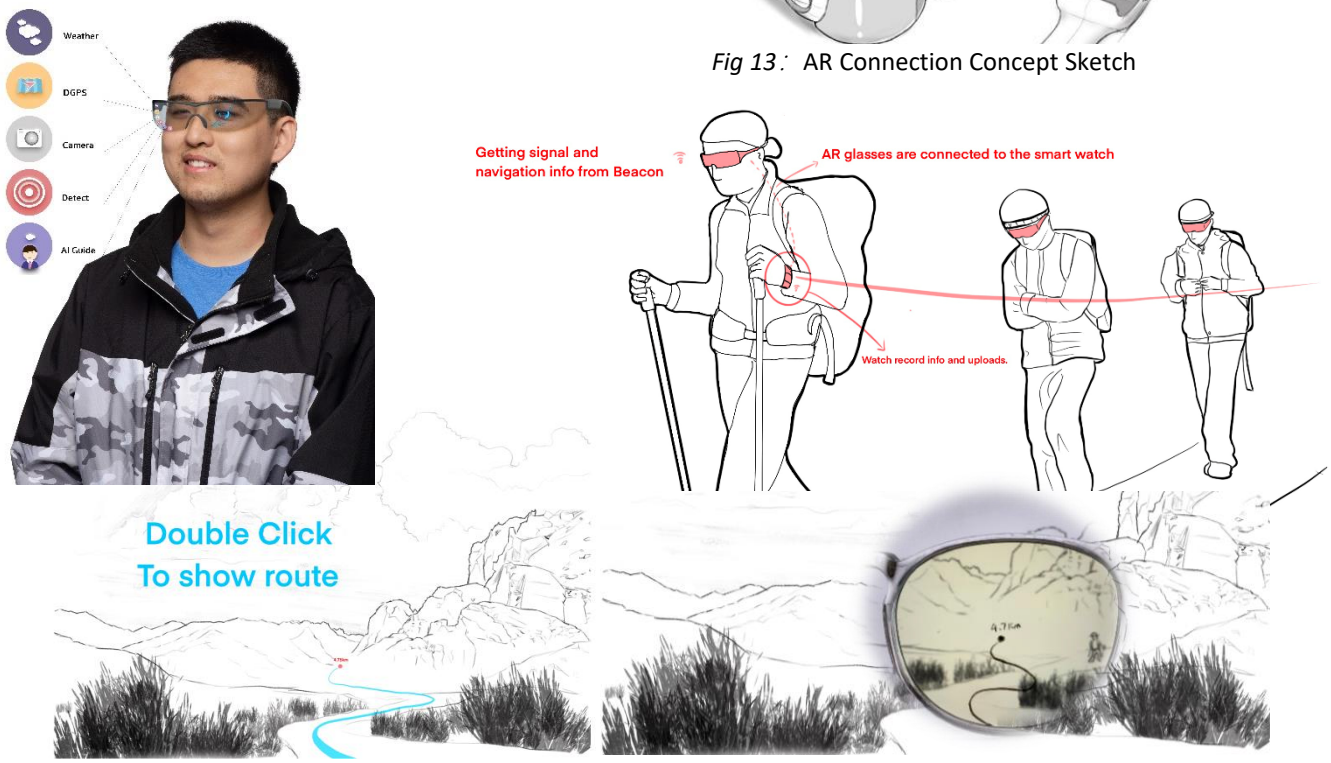


Fig 14: AR Navigation Concept Sketch

The navigation is more precise: everyone is a route mapper.

After the use of DGPS technology, the accuracy of navigation will be greatly improved. In the past, GPS navigation maps were all 2D maps, with only direction information but no altitude information. In this system, if the user uses AR glasses or the AR app in the mobile phone, a 3D path can be seen in the field of view, which is AR navigation. The three-dimensional route includes three-axis coordinates to make navigation more precise. Even non-professional hikers can follow the route. It is like drawing a line in the real space, extending to the target point. People just need to walk along this line and never get lost.

The location information of the hikers will also be continuously uploaded to the beacon tower and will be shared with the team members. When the team members disappear from the field of view, they will become light spots and appear in your AR field of view. You can also choose to display their trajectory, which will make it easier for you to find your teammates or follow them.

Constantly updated map

As the hikers in the system travel every day, their trajectories will be recorded to help the system continuously update the navigation route. If the terrain changes in some areas, as long as a hiker finds the problem, his change

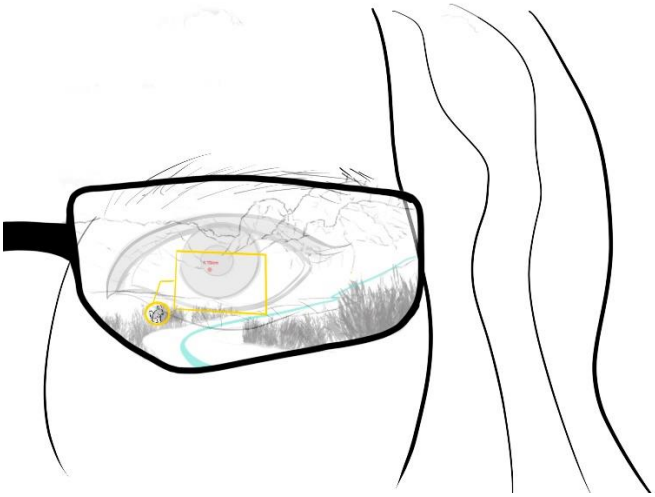
track will be recorded, and the system can notify the professional hikers to investigate and plan a new route based on this abnormal change.

Safety

This kind of accurate location record can also ensure the safety of hikers. For example, if the system finds that the hiker's height has changed rapidly, it is very likely that the hiker has fallen from a certain cliff. Based on its own judgment, the system will immediately verify the situation with the hiker. If there is an accident or no response is received, the system will contact the nearest hiker through the beacon tower for help and contact a professional search and rescue team for rescue.

5. Wildlife detection system

Most non-professional hikers cannot identify wild animals in the wild, so they cannot get the joy of discovering rare wild animals. With the help of this system, hikers can discover more rare animals. It will also help hikers identify possible dangers.



In the system, the sight of the hiker through the AR glasses will also be shared in the beacon tower, which will analyze what the hiker sees and identify rare wild animals and plants. The basic information will only have the rarity of this species and whether it is dangerous. If hikers are interested, the system will also explain them in detail so that hikers can learn more about the stories of these species. In this way, even hikers without relevant knowledge can enjoy the fun of discovering rare plants and animals.

Fig 15: Wildlife Detection Concept

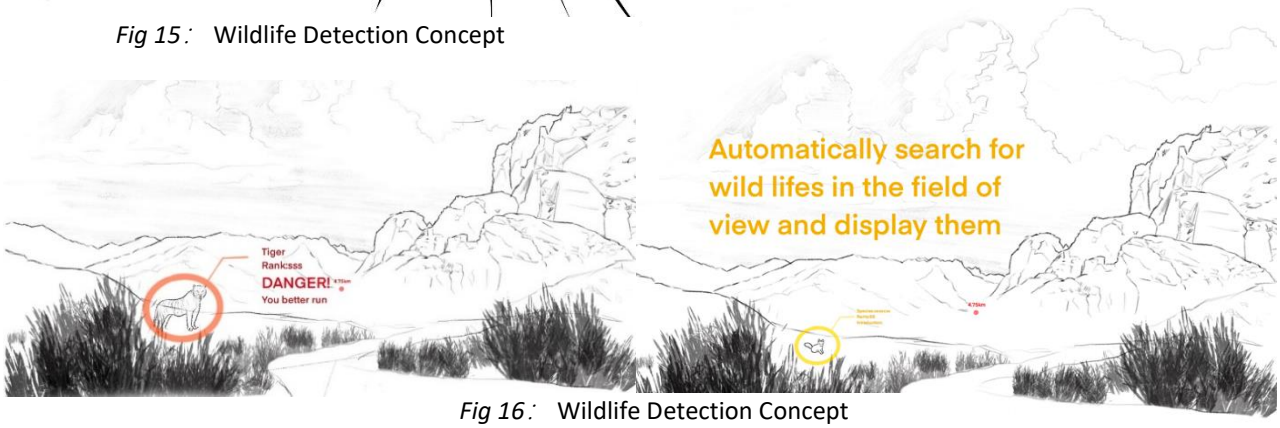


Fig 16: Wildlife Detection Concept

Similarly, if a hiker has witnessed dangerous wild animals. The system will also immediately remind hikers to stay away from danger, and at the same time notify other hikers in the area to avoid approaching dangerous wild animals.

6. Big Data Analysis and Artificial Intelligence Tour Guide

There are computing modules in each beacon. They are like information processing nodes. When they are combined, it is like a supercomputer in this area. With the accumulation of user data, by analyzing these data, the system can provide users with more accurate and excellent hiking recommendations. The beacon towers scattered in various places record the climate and weather information in real time. What the hikers saw during their journey and their trajectory will be recorded. In addition, the system users' feedback and the evaluation of the scenery will also be incorporated into the system for reference. The system can evaluate a lot of useful information by analyzing these big data.

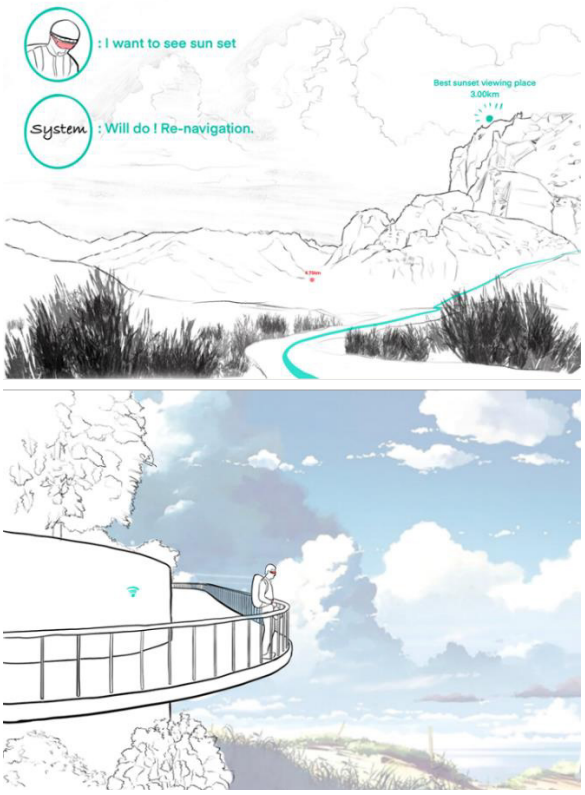


Fig 17: Big Data Analysis

For example, it can summarize the distribution of different wild animals by analyzing the sighting data of wild animals, so that if there are hikers who want to see wild animals, the system can tell them what to do and where to find.

Through the real-time weather information collected by the beacon tower and the scenery seen by hikers in the current area, the system can also analyze which area currently has the best scenery and which area has bad scenery.

Based on the above various data analysis, combined with the user's own preferences, the system can tailor the best hiking plan for the user.

And this plan is not static. The system will make correction suggestions to hikers based on real-time changes in the situation. To ensure that hikers get the best tour experience.

Transport and installation of beacon towers

The terrain in the wild environment is complex and there is no infrastructure. How to set up these beacon towers in the wild is also a problem that needs to be considered.

Therefore, in the design of the beacon tower, it is designed to be foldable. The upper solar panel can be stored here, and the lower shell can also be folded away. These beacon towers can be transported by helicopter and placed on the ground by hanging them. A part of the beacon tower will be inserted into the ground and extend a stable structure similar to the roots of a tree. At the same time, the shell can be expanded, so that a beacon tower can be installed very quickly.

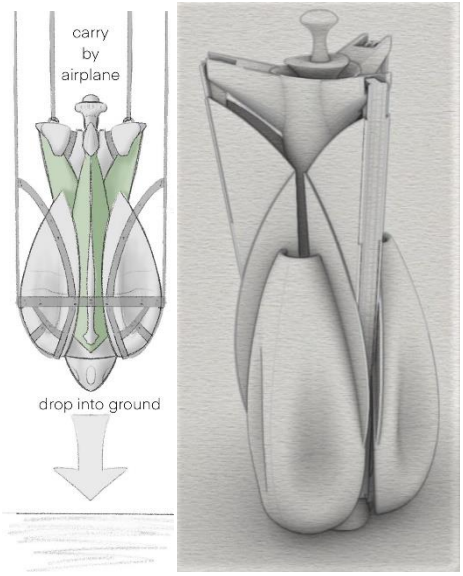


Fig 18: Beacon tower in collapsed state

User Testing:

frame

Choose representatives from potential user groups and describe the functions of the system to them. Explain the changes that the system can bring, focusing on describing the security that DGPS brings to outdoor travel safety and the outdoor travel virtual AI suggestion system based on big data analysis.

Use the prototype of simulated AR to show people the direct visual experience of the suggestion system based on big data analysis and the three-dimensional navigation system.

There are a total of seven people participating in the user test, all of whom have hiked.

Fig 19: Beacon Tower Model

Before starting the user test, I first investigated your opinions on the existing hiking modes and GPS navigation systems.

Their answer is that some people have encountered the problem of inaccurate GPS navigation, and one of them has bypassed the road in the wild because of inaccurate GPS navigation. Some people also said that in some national parks with good guidelines, the hiking trails are very mature and will not encounter problems. But they all said that the safety issue is important, and the existing safety conditions need to be strengthened. None of them have professional outdoor knowledge, and they have never encountered rare wild animals, and they have all encountered situations where they missed many beautiful sceneries due to the weather.

Will the beacon tower affect the appreciation of nature?

It is generally believed that the shape of the beacon tower is similar to a natural creation, and it is not dense, which will not affect the hikers' appreciation of nature.

Will places with this system be more attractive?

People generally think that the way this system integrates science and technology into nature is interesting. In the future, people will rely more on smart devices, and parks with this system will be more attractive.

Fig 20: Beacon Tower Model

Can the shell seats of the beacon tower provide people with a comfortable rest?

People observe the character model and the shell model, and then feel this shape with their hands.

They generally feel that this shape is very clever. It feels very comfortable to the touch, and it should be comfortable to do. Some people also raised concerns that the chair is a bit small, but they also understand that this is because there are other structures inside, which is acceptable.

Fig 21: Seating Model

Future Opportunities:

Fig 22: Beacon Concept

With the development of artificial intelligence, people will increasingly use smart devices in the future. Even now, based on big data algorithms, some software can also analyze our preferences. For example, some music apps can recommend songs that people might like based on people's listening habits. In the future, when these are combined with artificial intelligence, algorithms will become more aware of you.

People wear smart devices to enter the future trekking system. As people hike for many times, the beacon tower can also analyze people's preferences. Furthermore, perhaps when people are still specifying travel plans, people's smart devices can judge what kind of scenery people want to see and what kind of travel they want through the information users search on the Internet. After the device is connected to the system, the system will create a personalized travel plan for travelers based on this information.

Over time, perhaps the system will understand your preferences better than you.

System Overview:

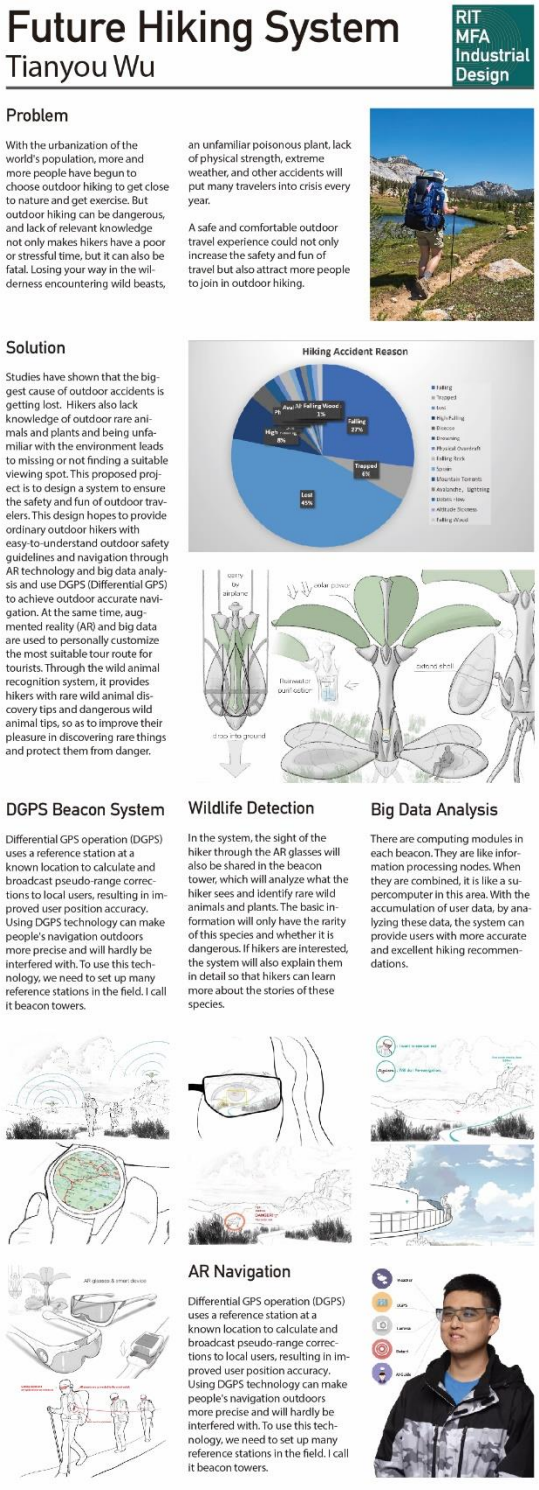


Figure 23: Poster

Conclusion:

If modern science and technology are applied to outdoor hiking, it will greatly increase safety and fun. However, there are still some constraints such as environment and energy. How to bring modern advanced science and technology into the field of hiking has become my thinking. I hope these new technologies can bring people a safer and more interesting hiking experience.

In fact, Differential GPS technology is not a new technology, DGPS has been widely used in surveying and mapping. It may be cost and maintenance issues, and no one thought of using it to serve people on hiking trips. But with the advancement of technology and the attention of the government and park managers, if these systems are built, people will also be willing to pay a certain fee in exchange for a better experience. In the future, these beacon towers may be built like infrastructure. In addition to the development of electronic money in the future, the management party will charge a certain service fee based on the number of times people connect to the beacon tower to meet the cost of construction and maintenance. This makes these systems possible.

In the future, AR technology will become popular. People will get used to the combination of virtual and reality. AR glasses will become a good medium to use this Hiking system. The beacon sends signals to provide positioning information for AR devices. AR devices and other wearable devices share the user's body information and what they see and hear to the beacon tower. The beacon tower guarantees the safety of pedestrians by analyzing and monitoring this information.

The application of new technology can undoubtedly bring a safer and more interesting hiking experience to hikers. Even if the current technology may not achieve the best experience, soon, these ideas are very likely to become realistic.

References:

Schamel, Johannes and Hubert Job. "National Parks and Demographic Change – Modelling the Effects of Ageing Hikers on Mountain Landscape Intra-Area Accessibility." *Landscape and Urban Planning* 163, (2017): 32-43.

Farrell, J. and T. Givargis. "Differential GPS Reference Station Algorithm-Design and Analysis." *IEEE Transactions on Control Systems Technology* 8, no. 3 (2000): 519-531.

CHINESE MOUNTAINEERING ASSOCIATION. Mountaineering and Outdoor Accident Report in Mainland China. Beijing, 2016; 2012;.

Mohino, Elsa, Mauricio Gende, and Claudio Brunini. "Improving Long Baseline (100–300 km) Differential GPS Positioning Applying Ionospheric Corrections Derived from Multiple Reference Stations." Journal of Surveying Engineering 133, no. 1 (2007): 1-5.

Bohannon, Richard W. and A. Williams Andrews. "Normal Walking Speed: A Descriptive Meta-Analysis." *Physiotherapy* 97, no. 3 (2011): 182-189.

"Development and Equipment of Hiking Trails [Tender Documents : T445721310]." *MENA Report* (2019).

JUNWEI, ZHANG, ZHANG SONGSONG, ZHANG BAORONG, and XU WENFEI. *Wild Hiking Radio Communication Equipment Carrying Device* 2018.

Zürcher, Severin, Christian Jackowski, and Corinna A. Schön. "Circumstances and Causes of Death of Hikers at Different Altitudes: A Retrospective Analysis of Hiking Fatalities from 2003–2018." *Forensic Science International* 310, (2020): 110252-110252.

Martínez-Graña, A. M., A. M. Martínez-Graña, P. Legoinha, P. Legoinha, J. A. González-Delgado, J. A. González-Delgado, C. J. Dabrio, et al. "Augmented Reality in a Hiking Tour of the Miocene Geoheritage of the Central Algarve Cliffs (Portugal)." *Geoheritage* 9, no. 1 (2017): 121-131.

Luley, Patrick, Roland Perko, Johannes Weinzerl, Lucas Paletta, and Alexander Almer. "Mobile Augmented Reality for Tourists – MARFT." In , 21-36. Berlin, Heidelberg: Springer Berlin Heidelberg.

Mayer-Schönberger, Viktor and Kenneth Cukier. *Big Data: A Revolution that Will Transform how we Live, Work, and Think*. Boston: Houghton Mifflin Harcourt, 2013.

Andrade, Thiago, Brais Cancela, and João Gama. "From Mobility Data to Habits and Common Pathways." *Expert Systems* 37, no. 6 (2020): n/a.

Mason, Ryan C., BA, Suner, Selim, MD, MS, and Kenneth A. Williams MD. "An Analysis of Hiker Preparedness: A Survey of Hiker Habits in New Hampshire." *Wilderness & Environmental Medicine* 24, no. 3 (2013): 221-227.

Gasser, Benedikt Andreas and Robin Schaub. "Accidents with Animals while Hiking in the Swiss Alps." *Praxis (Bern. 1994)* 110, no. 3 (2021): 151.

Gomez Villa, Alexander, Augusto Salazar, and Francisco Vargas. "Towards Automatic Wild Animal Monitoring: Identification of Animal Species in Camera-Trap Images using very Deep Convolutional Neural Networks." *Ecological Informatics* 41, (2017): 24-32.

Yu, X., J. Wang, R. Kays, P. A. Jansen, T. Wang, and T. Huang. "Automated Identification of Animal Species in Camera Trap Images." *EURASIP Journal on Image and Video Processing* 2013, no. 1 (2013): 1-10.