"AR HOPE TOUR"

— Earthquake Reconstruction Experience/Disaster-prevention Education Tourism using Wearable-device Glasses —

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1. Introduction

It is now six years since the Great East Japan Earthquake in 2011. Videos from the time being played repeatedly portray the raw power and menace of the tsunami that followed, overwhelming our imaginations. We all recall how we felt powerless, but even though those lessons were carved violently on our memories at the time, in these six years they will have started to fade.

To preserve the memory of the disaster in the affected areas, stories are being told and tours to promote disaster prevention are being given, but the conditions at the time are difficult to convey in words, and it is more and more difficult to experience the conditions at the time of the earthquake, as reconstruction in the region has progressed. Images and video from the time are being used to complement the experiences, but these 2D representations are limited.

We created a solution to this issue with a see-through wearable glasses device utilizing imaging devices and augmented reality (AR) technology. The solution we have developed displays photos of the tsunami damage right after the earthquake and computer graphic data over the real scenery in front of the viewer. Also in addition to providing an experience of the tsunami disaster site, our solution provides high quality advance training and can transform the journey to the site into part of the experience using various imaging devices.

This article describes this technology, demonstrations held in Miyagi Prefecture, and future prospects.

2. Development and sale of SmartEyeglass

In September 2014, Sony announced development of "SmartEyeglass," a see-through wearable glasses device, and began sales in March 2015. It also began providing a software development kit (SDK), which is currently marketed by Sony Semiconductor Solutions Corp.

The device has many sensing functions; including a CMOS image sensor, accelerometers, gyroscope, electronic compass, light sensor, and microphone, as well as smartphone connectivity for obtaining location and other data. The device uses display overlays that allow data to be checked without looking away from the object being viewed. This enables information to be added to the real world, and information can be presented based on the user's situation. The device uses a thin lens rather than a half mirror, which would obstruct the view. The lens is only 3.0 mm thick, has high transparency of 85%, and was made possible with Sony proprietary holographic optics technology. The display is monochrome rather than color to reduce power consumption, and has maximum brightness of 1,000 cd/m^2. The binocular display is able to display easy-to-read text that is highly visible in various environments. The device can exchange sensor, image and other data wirelessly with a smartphone, for use in a variety of scenarios depending on the smartphone application[1]. Sony has begun cultivating companies, developers and other creative partners who are considering solutions and businesses using SmartEyeglass.

Photo 1: SmartEyeglass "SED-E1"

3. Implementing the NATORI AR HOPE TOUR

The National High-School Sightseeing Plan Contest (also called Sightseeing Koshien) was held in August 2014, backed by MEXT and the Japan Tourism Agency. The grand prize was won by Miyagi Prefecture Agricultural High School with their concept, "Feel the Past! Experience the Present! Relate to the Future! Be Enchanted by All—A time-traveling disaster tour (or tsunami affected area tour)" which used AR[2].

While the school was developing the concept with ASA Inc. (headquartered in Sendai City), ASA made a proposal to Sony to use SmartEyeglass in the project. The following year, during the 3rd UN world Conference on Disaster Risk Reduction held in Sendai City on March 15, 2015, they held disaster experience demonstrations in collaboration with the Natori City Tourism Association, with the title, "NATORI AR HOPE TOUR." At each point along the tour, beacons (devices emitting a radio signal) sent signals which were received by smartphone apps, which would send corresponding image data to a SmartEyeglass device connected via Bluetooth. The devices would coordinate with sensor data to display AR images in front of the viewer, which would follow their line of sight. This produced a vivid display of Natori City in the past (before the earthquake), just after the earthquake, and today. Listening to the high-school student story-teller guides made the tour into an experience of hope for the youth who are rebuilding for the future rather than focusing on the tragedy.

Photo 2: Wearing SmartEyeglass at Hiyoriyama

(Left) Experiencing horizontal 360° images of the landscape right after the earthquake, with accumulated debris. The image follows as the users turn their heads.
(Right) Height of the tsunami in the viewing direction displayed with a CG bar. The height level also moves up and down as the viewer looks up and down.

Photo 3: Commemorative photos along the Teizan Canal at the end of the tour. Cherry trees were planted as a prayer for recovery, and a computer graphic AR portrayal of these "recovery cherry trees" as they will be in 10 years was displayed on a tablet for a photograph of all the participants.

4. Expanding the AR HOPE TOUR into Sendai/Tagajo

After the NATORI AR HOPE TOUR, we received many responses, from national newspapers and other media, tourism associations and educational institutions, and we decided to repeat the demonstrations in 2016, keeping creation of a tour business in mind.

There were three main advances from the previous instance: (1) Tohoku University International Research Institute of Disaster Science participated in planning, in addition to Sony and ASA Inc., supervised by Associate Professor Akihiro Shibayama from the university (Disaster Digital Archive Research); (2) Demonstrations were held in the cities of Sendai and Tagajo, incorporating features of the disaster in each location; and (3) The quality of the tour packages was improved using a format of "Prior input through lecture → On-site experience → Consideration from another's perspective." This included a lecture giving an overview of the disaster with the latest video equipment before visiting the disaster site, and sessions afterward, listening to story tellers who had actually experienced the disaster and thinking about it and workshops on topics such as evacuation and disaster mitigation.

Photo 4: AR HOPE TOUR in Sendai/Tagajo leaflet

5. AR HOPE TOUR in Sendai: March 12, 2016 (Sat) exhibit

Before experiencing the tsunami site using SmartEyeglass, an orientation was held using a 4K ultra-short-throw projector (VPL-GTZ1) provided by Sony Business Solutions Corp. The high-resolution 4K aerial photographs taken directly after the earthquake gave participants a spatial understanding of the earthquake site and threat of the tsunami and totally immersed them in the aftermath of the tsunami.

Photo 5: Participants drawn in by the 4K high-resolution video

Participants then boarded a bus for the Sendai Arahama Elementary School, which was hit by the tsunami. On the bus, they experienced the disaster site through 360° whole-sky video collected by Tohoku University over the two weeks following the earthquake and shown using Xperia Z4 tablets from Sony Mobile Communications Inc.

Photo 6: 360° video of the area surrounding the bus from the time of the earthquake, shown clearly on the Xperia Z4 tablet. Participants entered their disaster experience contrasting it with the debris cleaned up in current surroundings outside the bus.

Finally, they arrived at the disaster site, Arahama Elementary, 700 m from the sea shore. This area received the worst damage within Sendai City, and more than 180 people were lost. Arahama Elementary has been preserved in Sendai City as a reminder of the earthquake.

Photo 7:
(Left) Arahama Elementary after the disaster. People trapped in this area narrowly escaped with their lives (Photo: Sendai City)
(Right) Arahama Elementary (during tour)

During this tour, the tour guide sent images from his smartphone to apps on the participants' smartphones rather than using the beacon format as in the previous tour. This improved operation.

Wearing the SmartEyeglass in front of the Arahama Elementary school building, participants could see AR images

of the mountains of debris at that location immediately following the earthquake, overlaid on the current scenery, which provided a realistic experience of the untouched remains after the earthquake. The height of the tsunami was also shown in AR, using a bar over the school building. This gave a sense of the height that was difficult to get from the ground surface. Sighs and surprised exclamations were heard all around as the participants recognized the terror of the tsunami.

Photo 8: Wearing SmartEyeglass in front of the school building. Seeing the mountains of debris and the height of the tsunami left participants speechless.


Photo 9:
(Left) Moving to the roof of the school to see the height of the tsunami from above.
(Right) Participants experienced the onslaught of the tsunami through images of the Arahama area and testimony of survivors recorded during the tsunami, shown clearly in color on the tablets.


Later, they took a walk to the sea shore. Using AR to compare images just after the earthquake with the current scene showed how the tsunami erased a village of some 800 houses in an instant. Even five years later, it was unchanged, with only the foundations remaining.

Photo 10:
(Left) This area was the only swimming beach in Sendai and was a thriving center. The bare foundations of the houses washed away by the tsunami are all that is left.
(Right) Finally, in front of the disaster monument, all participants put their hands together in prayer for the many lost in the disaster.


Participants completed their AR experience of the tsunami site, returned to the bus and moved to the Shichigo Community Center. Lastly, they had an opportunity to hear from actual victims of the disaster in the Arahama area, who are actively telling their stories today. They had a chance to seriously reconsider for themselves, what they should do if an earthquake occurs. That concluded the tour.

Photo 11: Describing conditions and telling emotional stories of their experiences of the earthquake. Storytellers emphasized the terror of the tsunami and urged listeners to prepare for disaster prevention saying, "Decisions and behavior right after the earthquake determined life or death. We hope you will put this lesson into practice."


Photo 12: Students from Miyagi Prefecture Agricultural High School, who originally proposed the 2015 "NATORI AR HOPE TOUR", also participated. They were very impressed with the wonderful upgraded experience. They were both delighted and happy to see their original idea developed further.

6. AR HOPE TOUR in Tagajo: March 26 2016 Exhibit

A tour was also held in Tagajo City to experience the tsunami in an urban environment.

In contrast to the Sendai City experience, Tagajo was based on a "City Walk" format. The arrival of the tsunami was not visible among buildings and the complexity of the onslaught was terrifying. The experience raised participants' awareness of disaster prevention.

Participants first experienced 360° whole-sky video of Tagajo City two weeks after the earthquake in an air-dome theatre provided by Wakayama University. The air dome video simulated an experience of being in the site just after the earthquake. One city staff person said that seeing the debris along the rail lines brought tears to her eyes as the memories came back.

Photo 13: The mobile dome system from Wakayama University. Providing a simulated experience with 360° whole-sky video taken by Tohoku University using a vehicle mounted camera


Next, participants went by bus to the Sony Sendai Technology Center (Sony Sendai Tech) to begin their "City Walk."

The gyro-sensor in the SmartEyeglass enables it to know its position and orientation. Participants learned about the complex

Photo 14:
(Left) In the bus headed for Sony Sendai Tech, participants used tablet computers to learn about disaster conditions in Tagajo from video taken during the disaster and victim testimonies
(Right) Sony Sendai Tech, a familiar place to Tagajo residents. The affiliated Sony Sendai FC won the Japan Football League (JFL) Championship in 2015. It has become the hope and pride of residents after the earthquake.


characteristics of the "Urban tsunami disaster"[3], with buildings and flat geography making it impossible to see the arrival of the tsunami. Getting a sense of the relative positions of the ocean and rivers, helped to understand how the tsunami flowed directly from the Port of Sendai and also up the Sunaoshi River and over the broken levees, following the railroad tracks from two directions in complicated patterns.

Photo 15:
(Left) Associate Professor Akihiro Shibayama from Tohoku University, as the tour guide, provided all content and supervised all scenarios for the AR HOPE TOUR. It was a valuable opportunity to learn directly from a disaster prevention training professional.
(Right) Within Tagajo City. Wearing SmartEyeglass, AR images were shown in 360° panoramas at different locations and distances, including the Port of Sendai, the Sunaoshi River, and a large commercial facility. Participants considered what they would do faced with a tsunami incoming from two directions.


The end of the City Walk was at "Sue no Matsuyama". This place, famous in Tagajo City, is also featured in the Hyakunin Isshu ancient collection of Japanese poems[4]. It is high ground, so even today, the tradition is passed on that it is a good place to seek refuge from a large tsunami. In fact, the tsunami did not reach it after the Great East Japan Earthquake either, and it was a refuge for many.

Photo 16: Matsuo Basho also visited with his apprentice Kawai Sora during his "Narrow Road to the Interior" journey.

After the tour, the participants returned to the starting point and participated in a workshop on disaster reduction.

They were divided into several teams to discuss any measures, no matter how small, to mitigate the disaster, and characteristics of the "Urban tsunami" learned from their experience in the tour. They also presented their results. It was an opportunity for participants to think seriously about what they could do in the future to mitigate disaster.

Photo 17:
(Left) At the end of the program was a workshop to think about how to use the experiences and lessons from the "AR HOPE TOUR" to reduce disaster in the future.
(Right) Participants from diverse regions, age-groups, and lifestyles gathered to consider what "disaster reduction" means to them.


7. Future developments

The "AR HOPE TOUR in Sendai/Tagajo" was covered in television, newspapers and on the Web and other media and was very highly rated by the participants.

Of the ten-year reconstruction period defined in the Great East Japan Earthquake Reconstruction Basic Law, the initial five-year "Concentrated Reconstruction Period" has ended, and the subsequent five-year "Reconstruction and Revitalization Period" has begun [5].

The AR HOPE TOUR project promoted by Sony, ASA, and Tohoku University, is contributing to earthquake experience and disaster prevention education as well as reconstruction and revitalization through a series of demonstrations, and is encouraging collaboration between the tourism industry and government to build businesses in Tohoku disaster prevention education and sightseeing tourism.

The project is also advancing to the next stage, as Kinki Nippon Tourist Co. Ltd. has recently joined. Our goal for the summer of 2017 is to start an "AR HOPE TOUR" in Sendai City as an on-site package tour with these same companies.

In the future, we hope to produce even higher quality earthquake experiences and disaster prevention education through collaboration with various industries and organizations and with Sony technologies and products such as SmartEyeglass, and to contribute to reconstruction and revitalization in Tohoku and to disaster prevention and mitigation around the world.

References
[1] From a Sony Corp. press release, February 17, 2015.
[2] From the site of the National High school Sightseeing Planning Contest
[3] From the "Tagajo Kenbunoku" Web site
[4] From the Tagajo City Tourism Association Web site
[5] From "Great East Japan Earthquake Recovery Policy" (Decided by the Great East Japan Earthquake Recovery Headquarters, Aug. 11, 2011) and Great East Japan Earthquake Reconstruction Basic Policy in "Reconstruction and Revitalization Periods" (March 11 2016 Cabinet decision)