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VIRTUAL EYE: A NEW APPROACH IN ASSISTIVE TECHNOLOGY FOR VISUALLY IMPAIRED PEOPLE

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ABSTRACT

In this paper, we propose a novel approach in assistive devices for visually impaired people, named Virtual Eye. The idea is to allow the blind person to feel the world around him in a form of a 3D textured map in a handheld device, and move/react accordingly. To realize this idea, three technologies are to be integrated, Project Tango by Google, E-sense by Senseg, and RFID. We envision that Virtual Eye will get the world in the hands of the blind people, and hence, improve the quality of their life.

Keywords: assistive technology, RFID, 3D environment, depth perception, motion detection.

INTRODUCTION

According to the World Health Organization (WHO) [1], an estimate of 285 million people is visually impaired worldwide: 39 million are blind and 246 have low vision. The incidents and demographics of vision impairment differ substantially in different countries around the world. In most developed countries, approximately 0.4% of the population is blind, whereas in developing countries it goes up to 1%. WHO estimated that 90% of the world's visually impaired live in developing countries?

Of all sensations perceived through our senses, those received through sight have by far the highest influence on perception. Sight, coupled with other senses, enables us to get a world perception and to take actions upon it. For the visually impaired, the shortage of sight is a main obstacle in daily living, comprises information access, mobility, and interaction with the environment and with other people, among others, are challenging issues.

In fact, school and working-age blind have very high analphabetic and unemployment rates [2]. For instance, in the USA, the blind unemployment rate is around 70% while only 10% of blind children receive education in Braille [2]. In spite of efforts put by the organizations and individuals, the bitter truth is that most schools and employers are not properly equipped to accommodate blind people.

The issue of providing quality of life for the visually impaired people has become a pressuring issue in terms of health and social security. Costly nursing home care and welfare expenses on unemployment and health services have to be covered by the state. This resulted in a state focusing more on enabling the blind/visually impaired to live independent and productive lives. This is to be achieved by teaching them new ways to accomplish routine daily tasks. Varity of specialties is incorporated, i.e. special education teachers, Braille teachers, psychologists, orientations and mobility specialists, vision rehabilitation therapists, to name a few [3]. Also, the usage of assistive devices has a major contribution in enabling the blind people to live independently and, hence, improve the quality of their life.

The simplest and most widely used assistive device used by all blinds is the white cane. It has been providing blind people with a better way to reach destination and detect obstacles on ground. However, it cannot give them a high guarantee to protect themselves and being away from all level of obstacles. Advances of technology and knowledge in human psycho-physiological 3D world perception and processing have enabled the design and development of powerful and fast interfaces assisting humans with disabilities. For the visually impaired, research on supportive systems has focused on two main areas: information transmission and mobility assistance [3]. The focus of the paper will be on mobility assistance in terms of investigating current technology-enabled solutions and proposing a new assistive device to enhance the interaction of visually impaired person through incorporating the latest technologies in Internet of Things and 3D environment.

Internet of Things (IoT) is changing the way we interact with our environment. From smart homes to smart cars, our devices communicate to us, giving us information beyond what our five senses can perceive. Information beyond sight can revolutionize the way persons with blindness interact with their environment.

Assistive Technology devices can sense information, like distance from an obstacle or the colour of a pair of socks. However, sending this information to a user is a challenging and a critical part. Most devices have auditory readouts, some have vibrators and a rare few have Braille displays. As a result, compared to the sensing medium, the output medium is a larger and more expensive component in every device.

We propose Virtual Eye, which is a handheld device that displays a 3D textured map of the environment surrounding the visually impaired person so that he/she can sense it with his/her figures and get a virtual image of his/her surroundings and move accordingly. The device will integrate connect assistive technology, i.e. Project

Tango [21] form motion tracking and depth perception, and E-Sense [22] for 3D textual display, as corresponding to the data received by smart IoT objects in the environment.

The rest of the paper is organized as follows. Section 2 surveys and critically analyzes the literature in the assistive technologies for visually impaired people. Section 3 presents our proposed solution, Virtual Eye. Section 4 discusses the pilot experiment of the proposed solution. Finally, Section 5 presents the conclusion and future work.

RELATED WORK

Issues related to mobility assistance are challenging as they involve spatial information of the closest environment, orientation and obstacle avoidance. They all share the same operation principle: they all scan the environment, using various technologies, and represent the gathered information to an alternative sense, mainly hearing and touch.

Assistive devices can be mainly grouped into two categories: wearable and portable devices. There is a minor difference between both: Wearable devices are distinctive from portable devices by permitting hands-free interaction, or at least minimizing the use of hands when using the device. This is achieved by devices that are actually worn on the body such as head-mounted devices, wristbands, vests, belts, shoes, etc. Portable devices are usually small in size, lightweight, they can be easily carried (but not worn) by the user and require continuous hand interaction. For example: tactile displays, electronic canes, mobile phones, laptop computers, etc. [3].

The area of portable and wearable devices is currently a hot research topic in assisting people with disabilities such as the blind. This section will review the existing solutions of assistive portable and wearable devices for the blind and pave the way to introduce our proposed solution in the next section.

Portable assistive devices

A number of systems to aid the mobility of the visually impaired people have already been developed. The author in [4] proposed RFID based system to support the blind in grocery shopping. The system relies on the RFID tags that are placed at various locations in the store and provides the aids only inside the store. A system proposed in [5] uses information of GPS location with building maps and relevant spatial information to provide directions to locations within a campus environment. A smart wheel-chair system equipped with sensors for similar purposes was proposed in [6]. This system employs differential GPS location information to allow the user to navigate in an open area. The usage of GPS technologies has become popular with blind's mobility assistive devices. An example of such a system is the Sendero [7]. It is software that works with any Braille note product. This system is in a shape of a mini computer and be worn easily on the individual. Another system is called a 'Street Talk' [8], which is a GPS-based solution allowing the user to create a route in order to get from one location to another. A smart cane is a similar system that uses on board sensors for obstacle avoidance [9]. The system utilizes on an ultrasonic sensor that detects obstacles and commands the two-wheeled steering axle. The blind feels the steering command through the handle and follow the stick easily without any conscious effort. The author in [10] proposed an intelligent guide stick that consists of an ultrasound displacement sensor, two DC motors, and a microcontroller.

Wearable assistive devices

Head-mounted devices (HMDs) such as headsets and headbands are the most widely used types of wearable assistive devices. Recently, a number of HMDs have been developed to assist blinds in travelling. In the past, the most sophisticated device that first became commercially available for this purpose was the Binaural Sonic Aid (SonicGuide) [11]. The Sonic Guide consisted of ultrasonic wide-beam equipment mounted on spectacle lenses. Signals reflected back from the 3D world were presented to the user as audio indicating the existence of an obstacle and its approximate distance to the user. Over the years, the Sonic Guide has undergone continuous improvements and its latest version is the system called KASPA [12]. KASPA is worn as a headband and creates an auditory representation of the objects ahead of the user. With sufficient training, it allows users to distinguish different objects and even different surfaces in the environment.

Touch involving assistive devices for the blind have recently attracted the researches. These devices exploiting touch as the substitution sense are tactile displays for the fingertips and palms. Typical tactile displays involve set of vibrators or upward/downward moveable pins as skin indentation mechanisms. Many tactile devices have been developed using a wide range of technologies. Approaches range from traditional actuation technologies such as servomotors, electromagnetic coils, piezoelectric ceramics and pneumatics [13-16] to the new ones: shape memory alloys (SMAs), electro-active polymers (EAPs), electro rheological (ER) fluids and airborne ultrasound [17-20].

VIRTULA EYE ARCHITECTURE

System description

Our solution proposes paradigm shift in how the assistive devices for the blind work. Instead of reaching out and searching for the surrounding data and interpret it in a form of a guidance to the visually impaired person, we propose that our handheld device will capture the data transmitted by the smart objects in the surrounding environment and interpret it by creating touchable 3D map which can be sensed by visual impaired people. We

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envision that the surrounding environment will be Smart city with smart objects, i.e. Internet of Things that can send information about themselves, as depicted in Figure-1.

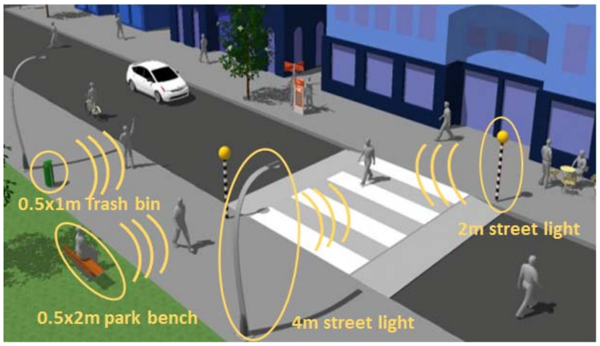

Figure-1. Smart city.

Enabling technologies

To realize the idea mentioned above, we aim at utilize latest technologies in tagging, depth sensing and depth perception as following.

- **Tagging technologies (RFID)**

RFID technology enables a user to understand what the object is so they can act on it.

- **Depth sensing technology**

It contains customized hardware and software designed to track full 3-dimensional motion, while simultaneously capturing geometry of the environment.

- **Depth perception technology**

The user can feel the depth by touching the 3D screen.

Handheld product idea

Virtual Eye will combine both Google's Project Tango [21], for motion tracking and depth perception, and Senseg's E-sense [22] for 3D textured touchscreen technology. By integrating these technologies, the visually impaired person will be able to 'touch' and 'feel' the environment he/she is moving in. Following is further details on the above mentioned technologies.

a) Google's "Project Tango"

Project Tango technology gives a mobile device the ability to navigate the physical world similar to how we do as humans. Project Tango brings a new kind of spatial perception to the mobile device platform by adding advanced computer vision, image processing, and special vision sensors [21], as shown in Figure-2. Project Tango consists of the following components.

- **Motion tracking camera**

Motion tracking allows a device to comprehend positions and orientation using Project Tango's custom sensors. This gives real-time information about the 3D motion of a device.

- **Integrated depth sensing**

Depth sensors can inform us of the shape of the world around us. Understanding depth lets our virtual world interact with the real world in new ways.

- **Computer vision processors**

Project Tango devices can use visual cues to help recognize the word around them. They can self-correct errors in motion tracking and re-localize in areas they have seen before.

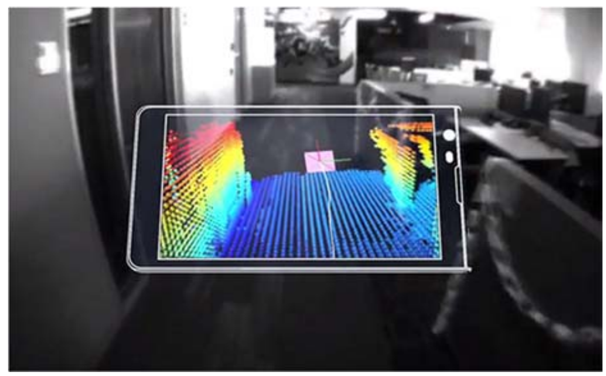

Figure 2. Project tango.

b) Senseg's E-sense

E-Sense is a technology developed by Senseg Company [22], which gives texture to a touchscreen. By using "tixels" generated by electric fields from elements embedded around the screen, it can make areas of the screen feel rough, ridged or rounded, as shown in Figure-3, and change those just as the screen pixels can change.

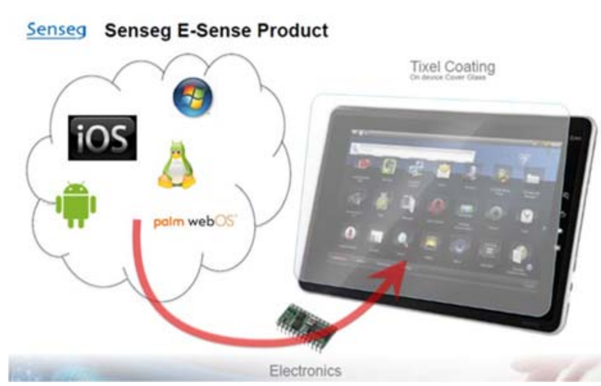

Figure-3. E-sense.

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Figure-4 shows Virtual Eye architecture, which depicts the integration between the above mentioned enabling technologies to achieve the required service.

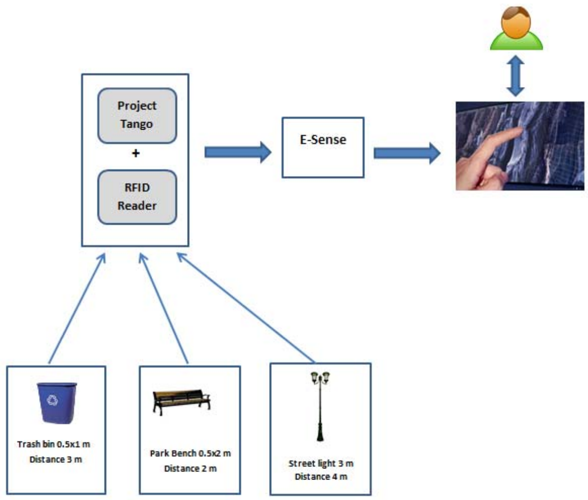

Figure-4. Virtual eye architecture.

PLANNING PILOT EXPERIMENT

In order to put our idea into reality and measure its effectiveness, a pilot experiment is needed to carry out the following tasks.

- Choose a small area on campus and tag its main objects.
- Use the depth sensing technology in order to draw a map for the area.
- Use the depth perception technology to view the map with different depths that can be felt and touched.
- Conduct a pilot test on a sample of vision impaired people and get there feedback.

CONCLUSIONS

In this paper, we have proposed a new assistive system for guiding individuals who are blind or partially sighted by integrating state-of-art technologies in motion tracking, depth perception, and 3D rendering. We have also described how the system can be used to enable those people to move with the same ease and confidence as a sighted people.

As future work, we are planning to build the propose system and conduct the pilot experiment mentioned in Section 4 to evaluate and enhance the system.

REFERENCES

[1] World Health Organization.2014. 'Visual impairment and blindness. Fact SheetN°282. http://www.who.int/mediacentre/factsheets/fs282/en/, accessed online in 28/4/2015.

[2] National Federation of the Blind, 2012. 'Blindness Statistics - Statistical Facts about Blindness in the United States. https://nfb.org/blindness-statistics, accessed online in 24/4/2015.

[3] R. Velazques. 2010. Wearable Assistive Devices for the Blind. Chapter 17 in A. Lay-Ekuakille and S.C. Mukhopadhyay (Eds.), Wearable and Autonomous Biomedical Devices and Systems for Smart Environment: Issues and Characterization, LNEE 75, Springer. pp. 331-349.

[4] V. Kulyukin, C. Gharpure, and J. Nicholson. RoboCart: Toward Robot-Assisted Navigation of Grocery Stores by the Visually Impaired. IEEE/RSJ International Conference on Intelligent Robots and Systems, Edmonton, CA.

[5] A. Helal, S. E. Moore, and B. Ramachandran. 2001. Drishti: An Integrated Navigation System for the Visually Impaired and Disabled. International Symposium on Wearable Computers, Zurich, Switzerland. pp. 149-156.

[6] H. Mori and S. Kotani. 1998. Robotic Travel Aid for the Blind: HARUNOBU-6. European Conference on Disability, Virtual Reality, and Assistive Technology, Sovde, Sweden.

[7] Sendero Group. http://www.senderogroup.com/, accessed online in 28/4/2015.

[8] StreetTalk. http://www.afb.org/prodProfile.asp?ProdID=984, accessed online in 28/4/2015.

[9] B. Johann and U. Iwan. 1997. The Guide Cane - A Computerized Travel Aid for the Active Guidance of Blind Pedestrians. Proceedings of the IEEE International Conference on Robotics and Automation, Albuquerque, NM. pp. 1283-1288.

[10] S. J. Kang, Y. H. Kim, and I. H. Moon. 2001. Development of an Intelligent Guide- Stick for the Blind. Proceedings of the 2001 IEEE International Conference on Robotics and Automation, Seoul, Korea, May 21-26.

[11] L. Kay. 1975. A sonar aid to enhance spatial perception of the blind: engineering design and evaluation. Radio and Electronic Engineer. 44(11): 605-627.

ARPN Journal of Engineering and Applied Sciences

[12] Sonic Vision. Updated information available at www.sonicvision.co.nz.

[13] C. Wagner, S. Lederman and R Howe. 2002. Design and performance of a tactile shape display using RC servomotors. Proceedings of 10th Symposium on Haptic Interfaces for Virtual Environment and Teleoperator Systems, Orlando, Fl, USA. pp. 354-355.

[14] H. Fischer, B. Neisius and R. Trapp. 1995. Tactile feedback for endoscopic surgery. Satava R, Morgan K, Sieburg H, Mattheus R, and Christensen J (Eds.), Interactive technology and the new paradigm for healthcare, IOS Press. pp. 114-117.

[15] I. Summers and C. Chanter. 2002. A broadband tactile array on the fingertip. Journal of the Acoustical Society of America. 112: 2118-2126.

[16] F. Vidal M. Madueño and R. Navas. 2005. Thermo-pneumatic actuator for tactile displays and smart actuation circuitry. Proceedings of SPIE International Symposium on Micro technologies for the New Millenium, Sevilla, Spain. pp. 484-492.

[17] R. Velazquez, E. Pissaloux, M. Hafez, and J. Szewczyk. 2008. Tactile rendering with shape memory alloy pin-matrix. IEEE Transactions on Instrumentation and Measurement. 57(5): 1051-1057.

[18] M. Konyo, S Tadokoro, and T. Takamori. 2000. Artificial tactile feel display using soft gel actuators. Proceedings of IEEE International Conference on Robotics and Automation, San Francisco, CA, USA. pp. 3416-3421.

[19] P. Taylor, D. Pollet, A. Hosseini, and C. Varley. 1998. Advances in an electrorheological fluid based tactile array. Displays. 18: 135-141.

[20] T. Hoshi, T. Iwamoto and H. Shinoda. 2009. Non-contact tactile sensation synthesized by ultrasound transducers. Proceedings of 3rd Joint Eurohaptics Conference and Symposium on Haptic Interfaces for Virtual Environment and Tele-operator Systems, Salt Lake City, UT, USA. pp. 256-260.

[21] Project Tango, Google. https://www.google.com/atap/project-tango/about-project-tango/, accessed in 6/19/2015.

[22] E-Sense, Senseg, http://senseg.com/, accessed in 6/19/2015.