Google Glass Used as Assistive Technology Its Utilization for Blind and Visually Impaired People

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Abstract. Project Google Glass represents the innovative technology developed by Google's X Lab. This smart gadget is built on human interaction with world through Android operating system. Wearable computer with the optical head-mounted display (abbreviated as OHMD) has been developing by Google. Firstly, the primary purpose of Project Google Glass was the hands-free displaying of knowledge presently obtainable to most sensible mobile phone users. Secondly, Google Glass (abbreviated as GG) was allowing interaction with the Internet and the web via basic voice or vision commands. In a basic view, Google Glasses are wearable computers that can easily power mobile devices such as Smartphones or tablets. This paper is focused on the practical utilization of Google Glass for sensually impaired people (in this case it means blind or visually impaired people). Google Glass is easily programmable and helpful technology that can significantly help people, not only the handicapped or impaired individuals, but their benefits can also make easier life for elderly people. Primary purpose of the paper is to provide and test developed application for basic navigation issues, which are usable for daily support of blind or visually impaired people. Second part of research is using Google Glass camera as a basic recognition tool for blind or visually impaired individuals. In this point of view it is possible to call GG as Assistive Technology or device, which helps blind people or people with visual impairment too. Google Glass are currently often used in various domains such as medicine, research, education.

Keywords: Google Glass · Smartphone · Assisting technology · Blindness · Visually impaired people · Voice recognition

1 Introduction

In this chapter are published the basic definitions of Google Glass, as well as its history of development, used technology and advantages. Project Google Glass represents a futuristic gadget, which can be personalized by using different Smartphone's options and Internet connection. Glass is a new first-party hardware product designed by Google. It is a head-mounted computer that sits on a human's face very similarly to a pair of glasses (resting on ears and nose). It has a camera, a display, a touchpad

M. Younas et al. (Eds.): MobiWIS 2017, LNCS 10486, pp. 70–82, 2017.
DOI: 10.1007/978-3-319-65515-4_6

(along the right arm), a speaker, and a microphone. The display is projected into a right eye using a prism, and sound is played into an eardrum from above the ear via bone conduction. While Glass looks very different from any other device, it runs an operating system that is now very common: Android. We can use this technology of your Smartphone, while not use of your hands. It is a bit like alternative device having software package and every one other options that offered in Smartphone. However, the main issue is that it is quicker, wearable and you'll be able to use it whereas doing day to day activities [1].

1.1 Google Project Glass History – The Four Generations of Google Glass

Google has declared the Project Glass in April 2012 to use the wearable technology with the optical head mounted display. Google has started selling Glass in the USA on 15th April 2013 for limited period [2]. The family of Google Glass technology consists of the four Glass Generations:

First Generation Glass

This is a pioneering version of Google Glass, which was focused mainly on using camera.

Second Generation Glass

Sometimes called as "Enterprise Edition". Second Generation was powered by an Intel Processor instead of Texas Instruments.

Third Generation Glass

This generation is working with a new functionality, which is display over both eyes, a possible hint at where the company is taking its eye-worn wearable [3].

Fourth Generation Glass

This group represents the last generation of Google Glass with many modifications. This version of GG is used in presented research.

1.2 Advantages of Google Glass

The most important advantages of Google Glass is that it communicates the requests from user to the computer and informs the conversational partner as to the wearer's use of the machine [4].

Other authors [2] have confronted the challenges and concluded that the fourth and upcoming generations of digital eye glass will prove more fruitful than other technologies as the problem of the clarification of pictures in camera, objects out from the range of laser light were also verified. Another author [5] presents the summary of seven basic advantages provided by Google Glass:

1. It is easily wearable and easy to handle.
2. It is useful technology for all kinds of people.
3. Access the documents, pictures, videos or map is very quickly.

4. There are mainly used: navigation, communication and social networks tools or applications.
5. There is natural voice command language for communication.
6. It is possible to use it with android phone through Wi-Fi.
7. It is an innovative, futuristic technology for technology lovers.

1.3 Technologies Used in Google Glass

This part of article is describing the technologies used in Google's Glass. Some of these technologies were already mentioned in this text, but without providing a precise definition from different authors.

Android Operating System
Android is a software stack for mobile devices that includes an operating system, middleware and key applications. Android is a software platform and operating system (abbr. OS) for mobile devices based on the Linux operating system and developed by Google and the Open Handset Alliance. It allows developers to write managed code in a Java. Unlike other embedded mobile environments, Android applications are all equal, for instance, an applications which come with the Smartphone are no different than those that any developer writes. The framework is supported by numerous open source libraries such as openssl, SQLite and libc. From the point of security, the framework is based on UNIX file system permissions that assure applications have only those abilities that mobile phone owner gave them at install time [6].

Bluetooth
Bluetooth is another type of short range wireless communication. This technology is based on 802.15.1, which is the standard specific for Wireless Personal Area Networks. Similar to 802.11 it works by means of radio signals in the frequency band of 2.4 GHz, but it is different due to the fact it was meant to replace wires among electronic devices. Depending on the class of the device, this technology can provide ranges of up to 100 meters (class 1) [7]. The main advantage of the Bluetooth is fact that this technology is part of every Smartphone, laptop or tablet.

EyeTap Technology
EyeTap is a device which allows, in a sense, the eye itself to function as both a display and a camera. EyeTap is at once the eye piece that displays computer information to the user and a device which allows the computer to process and possibly alter what the user sees. That which the user looks at is processed by the EyeTap. This allows the EyeTap to, under computer control, augment, diminish, or otherwise alter a user's visual perception of their environment, which creates a Computer Mediated Reality [8].

Smart Grid Technology
A smart grid is an electricity network based on digital technology that is used to supply electricity to consumers via two-way digital communication. This system allows for monitoring, analysis, control and communication within the supply chain to help improve efficiency, reduce energy consumption and cost, and maximize the transparency and

reliability of the energy supply chain. The smart grid was introduced with the aim of overcoming the weaknesses of conventional electrical grid by using smart net meters. Many government institutions around the world have been encouraging the use of smart grids for their potential to control and deal with global warming, emergency resilience and energy independence scenarios [9].

Wearable Computer

A wearable computer is a digital device that is either strapped to or carried on a user's body. It is used most often in research that focuses on behavioral modeling, health monitoring systems, IT and media development, where the person wearing the computer actually moves or is otherwise engaged with his or her surroundings. Wearable computers provide constant computer and user interaction. In extreme cases, they serve much like a prosthetic, in that device use does not require users to cease other activities Wearable computers are particularly helpful for application that need a lot of advanced process support than simply hardware coded logics [10].

Wi-Fi Technology

Wi-Fi is an abbreviation for the term Wireless Fidelity. This is popular name for IEEE 802.11 protocol for wireless local megabits per second (Mb/sec). In comparison, standard Ethernet provides maximum data speed of 10 Mb/sec via cables. Wi-Fi operates in the 2.4 Gigahertz (GHz) radio band the same frequency used by most Smartphones and microwave ovens over 11 channels [11].

1.4 Google Cloud

Google Cloud Platform is a set of public cloud computing services established by Google. This platform includes a range of hosted services for data storage, computing or application development that run on Google hardware. Google Cloud Platform services are designed primarily for software developers, cloud architects, data analysts and other IT professionals over the public Internet [12].

Vision API

Google Cloud Vision API is a part of Google Cloud Services. Google Cloud Vision API enables developers to understand the content of an image by encapsulating powerful machine learning models in as easy to use REST API. It quickly classifies images into thousands of categories (e.g., "sailboat", "lion", "Eiffel Tower"), detects individual objects and faces within images, and finds and reads printed words contained within images. You can build metadata on your image catalog, moderate offensive content, or enable new marketing scenarios through image sentiment analysis. Analyze image uploaded in the request or integrate with your image storage on Google Cloud Storage [13]. The scheme of Google Glass and Cloud Platform functionality is shown in Fig. 1.

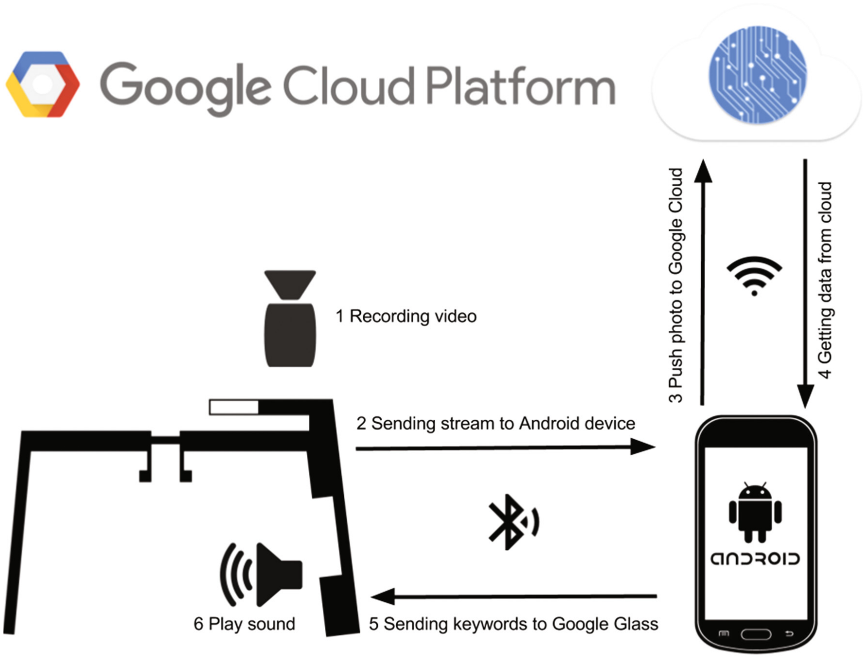

Fig. 1. Scheme of Google Glass and Cloud Platform functionality.

2 Assistive Technology and Devices Used for Blind or Visually Impaired People

Assistive technology is one of the core strategies schools and other organizations use to help with learning and attention issues. Some adaptive tools are low-tech and some are pretty high-tech. Here are some common examples of its utilization:

- Audio players and Recorders,
- Timers,
- Reading Guides,
- Seat Cushions,
- FM Listening Systems,
- Calculators,
- Writing Supports,
- Graphic Organizers.

Technological companies such as Microsoft or Google often recognize that third-party assistive technology products – such as screen readers, magnifiers, and specialty accessibility hardware – are essential for many of their customers. That's why they work closely with providers to support compatibility with Microsoft technology. The following assistive technology providers offer products used by our customers today:

- Vision,
- Learning,
- Dexterity and Mobility,
- Language and Communication [14].

2.1 For What Health Conditions Can Be Used Assistive Technology or Device?

Some disabilities are quite visible, and others are “hidden”. Most disabilities can be grouped into four major categories:

1. **Cognitive disability:** intellectual and learning disabilities/disorder, distractibility, reading disorders, inability to remember or focus on large amounts of information.
2. **Hearing disability:** hearing loss or impaired hearing.
3. **Physical disability:** paralysis, difficulties with walking or other movement, inability to use a computer mouse, slow response time, limited fine or gross motor control.
4. **Visual disability:** blindness, low vision, color blindness, visual impairment [15].

2.2 Blindness and Visual Disabilities - Worldwide Overview

More than 80% of information entering the brain is visual [16]. Other scientific studies had shown that when person’s eyes are open, our vision accounts for two-thirds of the electrical activity of the brain - a full 2 billion of the 3 billion firings per second - which was the finding of neuroanatomist R.S. Fixot in a paper published in 1957 [17]. Today, there is an estimated 180 million people worldwide who are visually disabled. Of these, between 40 and 45 million persons are blind and, by definition, cannot walk about unaided. They are usually in need of vocational and/or social support. The loss of sight causes enormous human suffering for the affected individuals and their families. It also represent a public health, social and economic problem for countries, especially the developing ones, where 9 out of 10 of the world’s blind live. In fact, around 60% of them reside in sub-Saharan African, China and India. Approximately 50% of world’s blind suffer from cataract. The majority of the remaining persons are blind from conditions that include, among others, glaucoma, trachoma, onchocerciasis (also known as river blindness) and different conditions of childhood blindness. Despite a half century of efforts, commencing with organized trachoma control activities, and the global burden of blindness is growing largely because of the population growth and ageing [18]. The global trend supported by calculated prediction of the blind people in 2020, was conducted by the World Health Organization (abbreviated WHO) and is shown in Fig. 2.

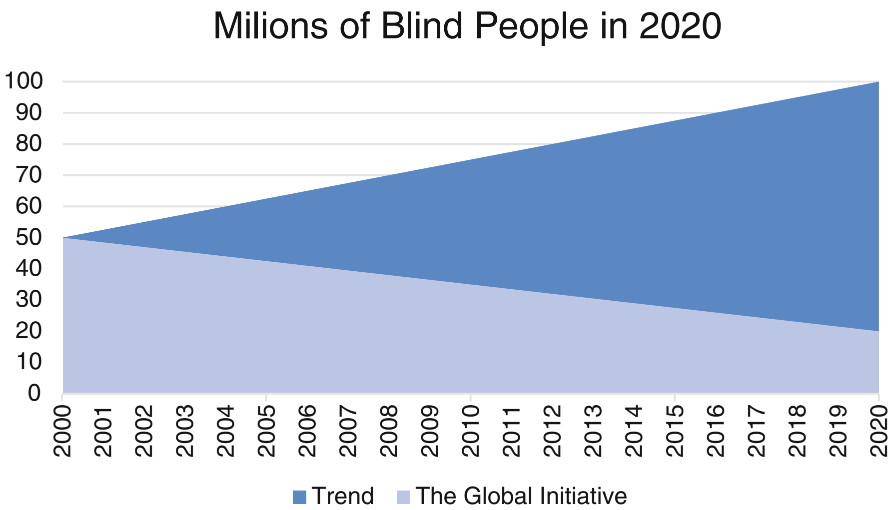

Fig. 2. Global prediction - the total number of blind people in 2020 [18].

A blind person or a person with a low vision is dealing with navigation, orientation and other recognition issues in a daily basis. These problems can be easily solved by learning or using special equipment (e.g., cane etc.), especially in a limited space area, such as in a flat or in a house. But when a blind person wants to visit a doctor, a friend, look for a job or travel few blocks, navigation and orientation in a noisy environment overwhelming with many people, cars and sometimes during night, windy or rainy weather is very demanding and sometimes impossible without a help of a social assistant. Authors of the paper have developed an assistive application, which is using a Google Glass connected via Smartphone in order to help these people and their navigation or recognition issues outdoors as well as indoor. Outdoor navigation is surely the most important problem with which are visually impaired/blind people dealing every day.

3 Methodology

Primary purpose of the paper is to provide and test developed application for basic navigation issues, which are usable for daily support of blind or visually impaired people. Second part of research is using Google Glass camera as a basic recognition tool for blind or visually impaired individuals.

Methods and methodology used in the presented research are based on case study approach. Here the focus of attention is on a particular community (e.g. blind people, visually disabled people), organization or set of documents. The attraction of this kind of research is that it stems from empirical curiosity but is at the same time practical. The whole research may be interested in a wider question but a case study enables researchers to focus on a specific example. A major challenge in case study is connection author's own primary research or re-analysis with the broader theoretical themes and empirical concerns of the existing literature.

Addressed participants were testing the functionality of developed application by using a pair of Google Glass Generation 4 and their own Smartphone with Android OS. Authors aim to provide a GG as assistive technology for visually disabled people. When the results of a presented study show that this devices and app can be successfully established as helpful assistive technology for the participants (can easily substitute social assistant and restore self-esteem/self-sufficiency of participants), it can provide a significant improve and change in their daily living.

3.1 Conducted Experiments and Testing App

Firstly, during the process of testing the app, all blind or impaired users are dealing with basic navigation issues in an open environment (e.g., town, park, hospital etc.). Each participant gets an unknown address in the town and only by using a pair of Google Glass device and developed app in Smartphone is trying to find estimated address as soon as possible. After a series of this navigation experiments the acquired results (first experiment measures time for destination point alone, second with help of social assistant and third by using GG and developed app), obstacles and comments from respondent's deep interview are analyzed as well. Second part of this experiment aims on recognition troubles indoor as well as outdoor. In this experiment, participants were approaching in a front of 30 different kinds of objects, animals and obstacles in order to use the app and GG instead of their eyes for their basic and successful recognition.

3.2 Participants

There were 15 participants participating in the presented study. All of them are dealing with visual disabilities in many varieties and 5 of them are completely blind. There are 8 women (3 of them are blind) and 7 men (2 of them blind). The average age is 45 years.

4 Results and Discussion

In this part are described two conducted experiments and measured data. First experiment is dealing with navigation issue in three different situation. First situation measured total time of participants from start to final destination on their own (without any help from an assistant or a Smartphone). Second situation measured total time from start to final destination with the assistance of social assistant. This data are shown in the table (see Table 1). Second situation provided mostly the shortest time in the first experiment, because blind/visually impaired people can walk fluently and without any troubles or obstacles in their route. They are guided by specialized assistant, who is helping them with navigation and orientation in unknown environment. There is only one disadvantage - blind/visually impaired people are trying to be as much independent

Table 1. Data and time from experiment no. 1.

Person	Alone [1]	With assist [2]	GG & SP [3]	Change [4] ([1]–[2])	Change [5] ([1]–[3])
1.	69.15	55.03	58.22	+ 14 min	+ 10 min
2.	45.01	41.12	42.50	+ 3.5 min	+ 3 min
3.	35.18	34.46	33.10	+ 1 min	+ 2 min
4.	28.33	25.54	25.14	+ 3 min	+ 3 min
5.	38.26	32.14	30.35	+ 6 min	+ 8 min
6.	56.20	51.11	50.20	+ 5 min	+ 6 min
7.	39.59	35.32	37.55	+ 4.5 min	+ 2 min
8.	35.09	33.10	32.15	+ 3 min	+ 3 min
9.	40.01	37.55	38.01	+ 2 min	+ 2 min
10.	25.59	24.17	23.20	+ 1.5 min	+ 2.5 min
11.	75.45	69.35	69.55	+ 6 min	+ 6 min
12.	61.47	59.22	62.11	+ 2 min	– 0.5 min
13.	53.35	45.13	43.02	+ 10.5 min	+ 10.5 min
14.	30.58	28.50	26.39	+ 4 min	+ 4 min
15.	36.45	31.59	32.30	+ 4.5 min	+ 4 min
AVG	**44.55**	**40.22**	**41.25**	**+ 4.5 min**	**+ 4.36 min**

as possible. Third situation provided Google Glass and connected Smartphone with App for better navigation. This situation is testing assistive technology (GG) in order to sustain people's independency without any additional support.

4.1 1st Experiment - Navigation Issue

First conducted experiment is dealing with the most crucial navigation issue among blind or visually impaired people. Blind people are often depending on social assistant's help or on other people's help in order to get to unknown address in their town. Visually impaired people are more self-sustaining, but this part of daily living is for them very stressful too. The average time to reach the final destination was about 45 min on their own. The two oldest participants were the slowest ones and got 75.45 and 69.15 min (see Table 1). Second situation changed the total time to average time, covered by 40.22 min. The variance of average time with assistant and without assistant is about 4.5–5 min. Third situation (using GG & SP) provided the average time 41.25 min, which is 3.5 min shorter than the measured time without the GG and SP. Average variance between the total time without assistance and with using a GG is 4.36 min. In this point of view we can call Google Glass and developed Smartphone app as assistive technology, because they are helping participants to get to any place faster, easier and without assistance. Developed app with utilization of Google Glass is very promising and authors are working on another testing and experiments in order to get more data for upgrading this application.

4.2 2nd Experiment - Obstacles Recognition

Second experiment deals with recognition troubles indoor as well as outdoor. In this experiment, participants are approaching in a front of 30 different kinds of objects, animals and obstacles in order to use the app and GG instead of their eyes for their basic and successful recognition. The developed application connected with GG must recognize more than 60% of tested obstacles in order to be successful. Each participant tests 15 obstacles located indoors and 15 outdoors. The most frequently mentioned obstacles by our participants are: fences, pylons, boards, billboards, uncared trees (and its long branches), bushes, cars/motorbikes/bikes parked on the pavement, dustbins, running dogs, porches, restaurant's porch railings, holes in pavement, people standing on pavement/station in queues and unmarked stairs or glass doors etc.

Tested Android application with GG recognized successfully more than three fourths of tested obstacles (covered by 75%). The downside of this experiment is fact that there were few obstacles, which could not be recognized properly by GG and App. These obstacles are: small billboards, advertising boards, restaurant's porch railings and some types of pylons or lamps. Participants were asked to mention three different obstacles or barriers, which are the most frequently present during their walk in a town. Results are illustrated in Fig. 3. The worst are pylons (99%) and trees/bushes (95%), which marked the majority of visually impaired/blind people. Next research could improve the recognition process of these obstacles in larger participants sample with focus on mentioned obstacles and their various forms.

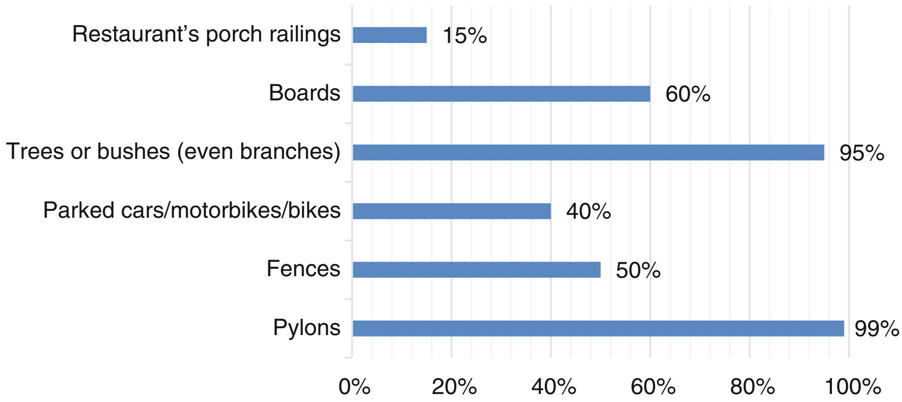

Fig. 3. The most frequently mentioned obstacles in a town

5 Conclusion

Google Glass represents a great opportunity not only for business enterprises, but also for medical organizations, education institutions and social services. Primary goal of this paper is to provide and mainly test developed application for basic navigation issues, which are usable for daily support of blind or visually impaired people.

Secondly, authors aim their attention to utilization of the app as a basic recognition tool for visually impaired people. In this point of view we can call Google Glass and developed Smartphone app as assistive technology, because they are helping participants to get to any place faster, easier and without assistance. Developed app with utilization of Google Glass is very promising and authors are working on another testing and experiments in order to get more data for upgrading this application. Conducted experiment no. 1 shows that the total time to reach destination using GG and SP is almost the same as with help of social assistant. Author's data shows that tested application is focused on two main functionalities: the first one is navigation and the second deals with recognition of 30 different objects, which are mainly addressed as obstacles for visually impaired people. Next upgraded functionality can be also a localization tool in this developed application, which will be published in a following research. Tested Android application with GG recognized successfully more than three fourths of tested obstacles (75%). The worst obstacles are pylons (99%) and trees/bushes (95%), which marked the majority of visually impaired/blind people. Next research is aimed to improve the recognition process of these obstacles in larger participants sample with focus on mentioned obstacles and their various forms.

Acknowledgement. This work and the contribution were also supported by Students Grant Agency — FIM, University of Hradec Kralove, Czech Republic (under ID: UHK-FIM-SP-2017-2108).

The Institute for Human and Machine Cognition (abbr. IHMC)
The Google's Glass used in presented research was kindly provided for free by IHMC. IHMC is a not-for-profit research institute of the Florida University System and is affiliated with several Florida universities. Researchers at IHMC pioneer technologies aimed at leveraging and extending human capabilities. Their human-centered approach often results in systems that can be regarded as cognitive, physical, or perceptual orthoses, much as eyeglasses are a king of ocular orthoses. These systems fit the human and machine components together in ways that exploit their respective strengths and mitigate their respective weaknesses. The design and fit of technological orthoses and prostheses requires a broader interdisciplinary range than is typically found in one organization, thus IHMC staff includes computer scientists, cognitive psychologist, neuroscientists, linguists, physicians, philosophers, engineers and social scientists of various stripes, as well as some people who resist all attempts to classify them. Current active research areas include: artificial intelligence, cognitive science, knowledge modeling and sharing, human interactions with autonomy, humanoid robotics, exoskeletons, advanced interfaces and displays cybersecurity, communication and collaboration, linguistics and natural language processing, computer-mediated learning systems, intelligent data understanding, software agents, expertise studies, work practice simulation, knowledge representation, big data and machine learning, as well as other related areas. IHMC faculty and staff collaborate extensively with industry and government to develop science and technology that can be enabling with respect to society's

broader goals. IHMC researchers receive funding from a wide range of government and private sources. IHMC research partners have included: DARPA, NSF, NASA, Army, Navy, Air Force NIH, IARPA, DOT, IDEO, Raytheon, IBM, Microsoft, Rockwell Collins, Boeing, Lockheed, and SAIC, among others [19]. IHMC also offers opportunity to collaborate on various projects with Faculty of Informatics and Management students. It helps students to explore real projects while studying [20].

Authors thank to IHMC in Florida and mainly to Niranjan Suri for providing Google Glass device for free, which was very important for our research. Google Glass device will be also used in next step of our research.

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