Prototype of a Smart Google Glass Solution for Deaf (and Hearing Impaired) People

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Abstract. Nowadays (in 2018), we are facing an accelerated development of smart devices. This technological boom is based on rapidly growing software and hardware requirements not only from the users, but also from producers. Statistic results show that every second person in the world will pose a smart phone (i.e., smart mobile device) in 2018. The majority of our society uses these devices for daily purposes, such as communications, work, but there are many other capabilities of these devices to be discovered. One of their best potential represents their utilization for handicapped or sensually impaired people. In this article, the authors present a specialized smart solution developed especially to help people with hearing impairment. Compared to conventional compensating aids, the developed solution connect modern technologies and originality. The aim of the solution is to digitally capture the ambient sound and based on its evaluation using neural networks, to present users needed information in a text form. To accomplish this smart solution, are used modern cloud services and a special smart device – Google Glass (abbreviated GG). These smart goggles offer sensors with the ability to compensate user's disadvantages. In the direction of facilitating the work for hearing impaired people, authors intend to further develop this technology and offer solutions in the following research to make daily life easier for people with hearing impairment.

Keywords: Smart device · Smart solution · Mobile device · Smart phone
Android · Deafness · Google Glass

1 Introduction

The first chapter describes the basic definition of the key words and terms necessary for this research. Firstly, the background and predictions for further development of the Smartphone trends and technologies such Google Glass, are presented. For the year 2017, the number of mobile phone users was forecasted to reach 4.77 billion. The number of mobile phone users in the world, is expected to pass the five billion mark by 2019. Most of the mobile market growth can be attributed to the increasing popularity of smartphones. By 2014, around 38% of all mobile users were smartphone users. By 2018, this number is expected to reach over 50% [1]. Therefore, end users are regularly shifting towards choosing a smart phone as their preferred device. The first term to explain, are

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smart devices. Smart devices are interactive electronic gadgets that understand simple commands sent by users and help in daily activities. Some of the most commonly used smart devices are Smartphones, tablets, smart watches, smart glasses and other personal electronics. While many smart devices are small, portable personal electronics, they are in fact defined by their ability to connect to a network to share and interact remotely. Many TV sets and refrigerators are also therefore considered smart devices [2].

1.1 Google Glass

Project Google Glass represents a futuristic gadget, which can be personalized by using different smartphone's' options and an Internet connection. Glass is a new first-party hardware product designed by Google. Google Glass is a head-mounted computer that sits on a human face very similar to a pair of glasses (resting on the ears and nose). It has a camera, a display, a touchpad (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 OS. 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 other option that offered in a smartphone. However, the main issue is that it is quicker, wearable and you will be able to use it whereas doing day-to-day activities [3]. Google Glass provides many useful advantages, but the most important is that the GG communicates the request from the user to the computer, then evaluate this request and give back the estimated answer or result. From the users' point of view, the advantage of wearing means that the GG is easily wearable as well as easy to handle and there is a natural voice command language for communication. This smart device also provides quick access to the documents, pictures, photos, videos or maps. The best activities to do with GG are navigation, communication and social media or application tools [4]. The operating system Android, Bluetooth and Wi-Fi technology provide wide range for further development and interconnection with Smartphone. However, to buy the Google Glass device nowadays is not possible, because the company stopped with their mass production.

Google Glass is widely used by many institutions and companies. Google Glass is currently used by: DHL, Volkswagen, GE, Opel, NSF, Penny Market, KONI, WSC, etc. These companies have found this smart device useful to meet all their recommendations and advantages. These now organize further development in practice and cooperate with other organizations unified in a platform called "GLASS" [5] Thank to this source, the authors found useful application, experience and interesting technical upgrades.

Florida Institute for Human & Machine Cognition

Thanks to the Florida Institute for Human & Machine Cognition (abbreviated IHMC, https://www.ihmc.us/ [6]), the authors have this rare opportunity to explore, evaluate and develop application for this smart device according to their research. University of Hradec Kralove is collaborating with the IHMC; their students can travel to the United States and participate in various projects. In 2015, the first author got into a project where he could use the modern or smart equipment. He got into Google Glass and IHMC offered him the chance to use this device for his own research. Because of the author's interests in helping people, they have designed a smart solution to help people with hearing impairment (especially for elderly people, who are often struggling with deafness or hearing loss). The Google's Glass used in presenting research was kindly provided for free by IHMC.

2 Deafness and Hearing Loss

Over 5% of the world's population – 360 million people – has disabling hearing loss (328 million adults and 32 million children). Disabling hearing loss refers to hearing loss greater than 40 decibels (dB) in the better hearing ear in adults and a hearing loss greater than 30 dB in the better hearing ear in children. Most people with disabling hearing loss live in low- and middle-income countries. As for elderly people, approximately one third of people over 65 years of age are affected by disabling hearing loss.

The prevalence in this age group is greatest in South Asia, Asia Pacific and sub-Saharan Africa. A person who is not able to hear as well as someone with normal hearing – hearing thresholds of 25 dB or better in both ears – is said to have hearing loss [7]. In 1980, the World Health Organization (abbreviated WHO) published a classification of degrees of hearing impairment. The hearing state is calculated as the average of the audiogram values as frequencies of 500 Hz, 1 000 Hz and 2 000 Hz on a better ear. The resulting average hearing loss is expressed in decibels (dB). The amount of hearing loss, according to the classification from WHO is:

1. Normal hearing (0–25 dB),
2. Light hearing loss (26–40 dB),
3. Moderate hearing impairment (41–60 dB),
4. Heavily damaged hearing (61–80 dB),
5. Very heavy hearing damage to deafness (81 dB and more).

It can affect one ear or both ears and leads to difficulty in hearing conversational speech or loud sounds. 'Hard of hearing' refers to people with hearing loss ranging from mild to severe. People who are hard of hearing usually communicate through spoken language and can benefit from hearing aids, cochlear implants, and other assistive devices as well as captioning. People with more significant hearing losses may benefit from cochlear implants. 'Deaf' people mostly have profound hearing loss, which implies very little or no hearing. They often use sign language for communication [8].

2.1 Impacts of Deafness and Hearing Loss

The physical and psychological impacts of deafness are quite different for every individual impaired person. Deaf people who are without hearing from birth has other problems, then the elderly who struggle with hearing loss in the last phase of their life. These elderlies have spent the whole life with normal hearing, so the loss of hearing can be much more stressful and because of it, they must change their daily living. Because of hearing impairment, impaired person is not able to fully understand the sounds of speech and to hear other sounds from his surroundings [9].

Authors' solution compensates for the complex tool of nature - the human ear. The authors only come closer to the human ear to compensate for the lack of hearing necessary for communication with other people. To further and following research, authors will try to get closer to community of deaf and hearing-impaired people. The secondary output of the research aims at informing and active work with another organization, where authors can already test developed solutions with a specific group of affected (i.e., hearing impaired or deaf) people.

3 Problem Definition

People with hearing impairment cannot live in a standard way because of their problem and communication barriers, but many daily problems must be solved in a quite different way. Hearing impairment can be compensated by various aids that help people to communicate in a great extent. Not all people want to use it, however, due to their feelings by showing their impairment to healthy around them. Elderly people do not recognize their hearing loss in the time that is why they often think that their family members (or other people surrounding them) are whispering or slandering behind their back on purpose. These people are emotionally more frustrated or stressed because they cannot recognize the hearing-loss and feel isolated from a society [10].

Because some people with hearing impairment have a hearing debris, they can use it and then to that use different compensating aids to improve their reception of sounds. Hard-of-hearing have useful hearing debris and they often use different compensating aids, such as hearing aids, to improve the reception of sounds. This group of hearing impaired people is, however, considerably inconsistent, as the amount of hearing loss may vary considerably from person to person. One hearing impaired person can understand the spoken word even in a busy environment, another one has a tiny noise in the environment and he cannot understand anything at all. Some of them often, hear the spoken word and they receive the information from a combination of tapping and reading. With hearing impaired people, it is possible to communicate without troubles in a written form. Hearing impaired people often use paper or smartphone to tape the communication flow to a hearing person [11]. In addition, communication is likely to be a particularly important issue for deaf or blind people, due to the significance of hearing for communication by non-disabled people, leading to possible barriers, exclusion, and isolation. The fact that many deaf people need support with communication, access to information, and mobility gives rise to the risk that other people may with the best of intentions act as gatekeepers and reduce the control deafblind people have over their own lives, making independence an important issue for them [12].

3.1 Current State and Solution – Simultaneous Speech Transcription of Spoken Czech

Nowadays, there are several companies that offer simultaneous speech transcription. Compared to English, the Czech language is quite demanding and hard to recognize. Simultaneous speech transcription of spoken Czech is provided with a help of trained transcriber, who is writing everything on the computer or notebook [13]. The text appears on the screen or on a board or tablet. By reading the transcribed text, a person with hearing impairment acquires needed information by sight, a sense more accessible to people than listening to spoken speech. This solution is almost immediate, it is only dependent on the speed of the transcriber and the second disadvantage is that you need a normal hearing person (i.e., transcriber). The authors' research aims on the effective use of the GG, as it is an innovative device and it is very promising for further development (thanks to the fact that is quite new, full of technology and not entirely explored).

3.2 Evaluation of Google Glass Technology

The first phase of the article is to analyze and evaluate main technical possibilities of Google Glass (such as memory, processor and operating system). This process is crucial to find all positive as well as negative characteristics of GG and work with them in author's research. The analysis can help us to find the best solution for deaf people. The second output of the evaluation is to decide about the utilization of GG or find another way (device or architecture). The results of the evaluation can be usable, not usable or usable with limits.

The second part of the analysis is based on development experience with GG device. Here is the main aim to find out more data to decide the best GG usability for deaf (or hearing impaired) people. Further development of this version GG is quite limited and very dependent on a connection with a smart phone. Controlling the whole Google Glass is based on a voice response from the user, where the main controlling word is "OK, Glass…". This short command sentence starts up next voice menu. Google Glass has also a touchpad on the side, which controls other gestures, such as: tap, swipe down (BACK), swipe right, swipe left etc. All these gestures are available for developers to use it (see Table 1). Compared to common Android development it is possible to change a lifecycle of the whole page (Activity). As for GPS module, it is necessary to have your smart phone connected with Google Glass. Otherwise, there is no module for GPS in Glass (or through the Internet) and it is the same case with API, so these are negative characteristics of GG. Internet connection is based on Wi-Fi connection with a smart phone, so this leads to questions about the battery capacity and its limitations. All capacity demanding processes and applications, such as camera control or other actions, are discharging the battery. This feature of the GG is also important for testing. Also, all sensors are working properly without any problem. On the other hand, the most important cons of GG are: noisy environment for utilization, foreign languages and pronunciation problems. Thank to these cons the Google Glass device is marked as usable with limits. Because the GG device can be easily replaced by a smart phone connected to the Internet and smart phones are quite common for most in a today's society.

Table 1. Technical specification (Hard Data conducted by Authors) of used Google Glass

Processor	OMAP 4430 SoC
Memory	1 GB RAM (682 MB available for developers)
Video modes	Mini-projector that uses a semi-transparent prism, 640 × 360 pixels (equivalent to the 25″ screen from a distance of eight feet)
External Memory	16 GB Flash total (12 GB usable memory)
Operating System	Android OS, ver. 4.0.4. (API 19)
Connectivity	Wi-Fi 802.11 b/g & Bluetooth
Sensors	3 axis gyroscopes, accelerometer & magnetometer (compass), ambient world (surrounding) shooting/camera & proximity sensor
Start of mass production	1. For developers (US): February 2013 2. For consumers: 2014

4 Developed Smart Solution

Nowadays, sound recognition offers also public services built on robust neural networks that can instantly convert a recorded audio track of different quality to the text. Therefore, it is not necessary to implement a solution that would not produce such high-quality results. The key element is to prepare a client who can capture the ambient sound, process the acquired data and make it clear to the user again in the form of specific information. Compared to conventional compensation aids, this solution works with modern technology and opens opportunities for improvement and customization. The Cloud Speech API was selected for this research from the Google Cloud Platform. The service offers up to 110 different languages to translate and offers real-time high-quality results [14].

The next figure shows the prototype of designed architecture, which is used for effective communicating between three environments. GG, mobile device as a smart mediator, and neural network server.

Authors's architecture consists of two client parts and one server part (see Fig. 1). Client's parts consist:

1. **Google Glass** device performs as little work as possible and
2. let all **Mobile computing** and complex logic work together.

Due to the low volume of scanned sound data, it is possible to capture sound on Google Glass and stream it through Bluetooth to a connected mobile device. The mobile device communicates with the cloud and receives a response in the form of JSON objects. For every short recording, we get the words that are contained in the recording and the percentage estimate of how much the neural network is certain to be true words. In Google Glass, users only see translated words that they can respond to. Mobile client development for both Google Glass and other mobile devices running Android was in Java.

In addition to new information about current events, it also opens the possibility of storing the history of individual discussions. This path would allow users with memory failures to recall the information they learned during an interview with someone else. The second benefit is data stored of all conversations and discussions. The end user can easily find in his smart phone, what he did not hear or forgot. This feature can significantly help elderly people, who must deal with memory loss in a daily basis.

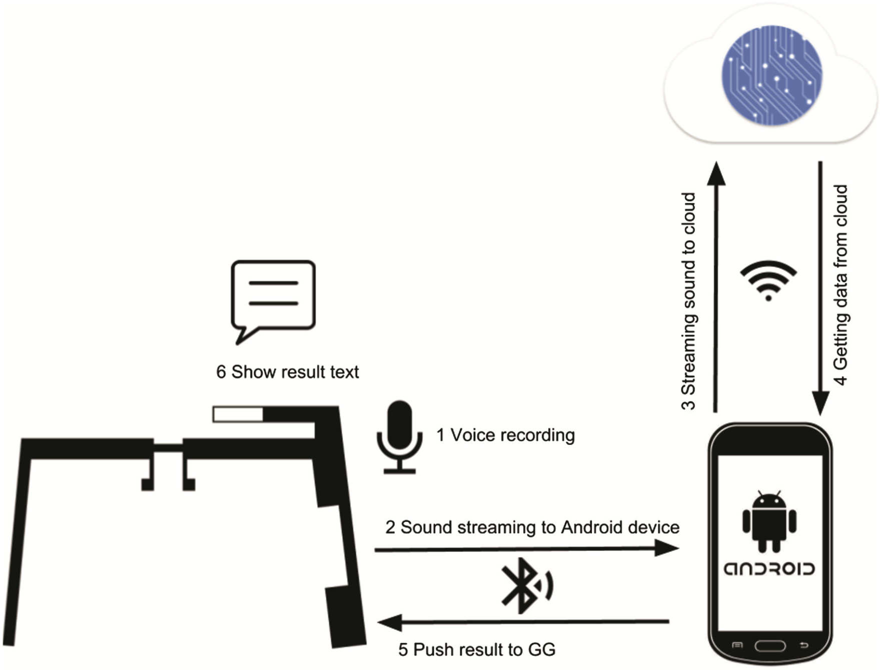

Fig. 1. The prototype architecture

5 Testing the Prototype Architecture

Firstly, authors must design the prototype architecture according to the scheme on Fig. 2. This part was fulfilled during the first pre-testing stage in a functional solution (i.e., prototype architecture is communicating with a server and the information are presented to a user in a satisfactory amount of time. After this goal, authors continued to the key (2^{nd}) phase of the research, which is another real-use testing by deaf or hearing-impaired people. Finishing 2^{nd} phase of research showed quite interesting results. These results are based on the experience, tracking and interviewing about 10 deaf (or hearing impaired) people from the Czech Republic. The majority of these people were satisfied with the results, functioning and the whole idea leading towards their higher independence in communication with a normal hearing people without needing of transcriber or assistant. Data were obtained from the interviews and practical experiment that were carried out as part of a larger research project. The first phase of testing proved that the prototype architecture designed by the authors is functional; however, there are still some aspects to be improved. The most significant pro is that authors' solution can recognize the voice (even with a different pronunciation or accent in a common, noisy environment) and with the help of neural network, this speech is converted into a text.

This transcribed text is then displayed on the GG's display. This means the communication is not interrupted by a transcriber or an assistant, the responses are faster than with a help of another person or paper, etc. Testing was conducted on a smart phone interconnected with a smart phone through Wi-Fi.

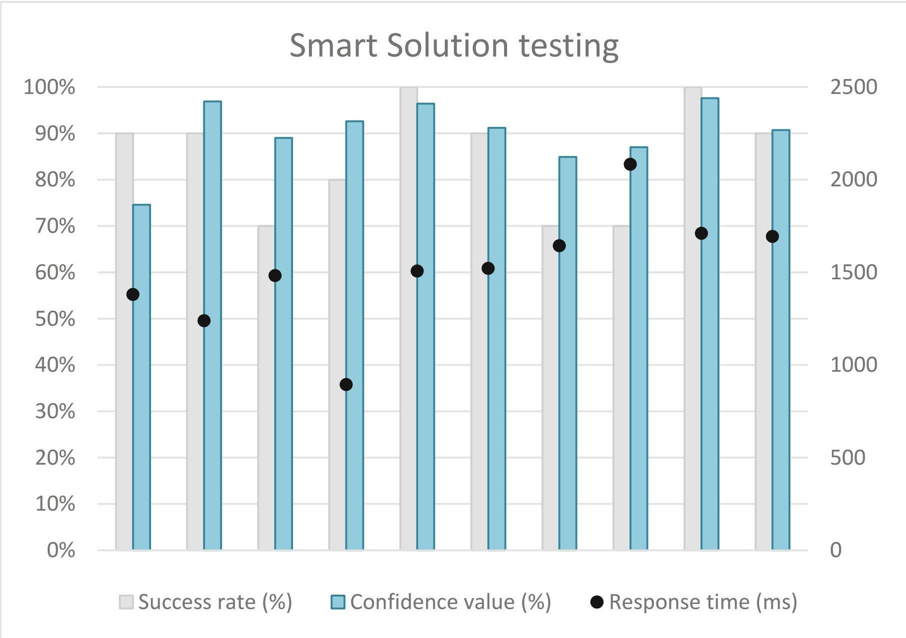

Fig. 2. Results conducted by author's testing

This testing is based on the 10 randomly selected English phrases that, can anyone use in a daily communication in English, such as: "Never mind. Don't give up. You are improving a lot. Let me check. Enjoy your stay with us. What is your key to success?, etc." These sentences were pronounced by a 10 different people with a normal level of hearing (with a different pronunciation and accents) and the correct translation as well as displaying the output of the neural network was tested. The total number of conducted tests proving the level of successful voice recognition and translation is 100 test cases. The level of successful recognition and translation is expressed in percentage terms. On the other hand, authors were also measuring a time in milliseconds (abbr. ms). This time shows the response, i.e. for how long it takes to get a result from the server. During this 100 test cases, authors were also testing a confidence value. The confidence value is an estimate between 0.0 and 1.0. A higher number indicates an estimated greater likelihood that the recognized words are correct. For example, you may use the confidence value to decide whether to show alternative results to the user or ask for confirmation from the user. If the confidence for the top value is high, it's likely correct. Whereas if the confidence in the top value is lower, there is a greater chance that one of the other alternatives is more accurate. Your code should not require the confidence field as it is not guaranteed to be accurate, or even set, in any of the results [15].

For detailed results, please see the Fig. 2. below. The most significant result is that in 85% (85 test cases) the designed solution was successful. Only 15% of cases are wrong, it means that the solution is incorrect in 15 test cases from 100. This success rate of developed solution is quite high and provides very promising results for further research (after a few small improvements). Indicator called "Confidence value" reached a mark 90% that are quite high number for this phase of testing. The average response time is 1515 ms (1st phase of testing), which is not ideal. That is why, the authors are working on improvements (how to save some time) in order to get close to real-time response. The only disadvantage the users were mentioning is a little bit longer time to get the output, so it is important to work on this part of the developed solution. Another possible disadvantage to improve by authors is:

1. Changing a way of communication with a server and,
2. decide which way is the best for passing on the output results to the user.

These two challenges are a key part of following research activities in the near future. After eliminating this and another testing phase, there will be no further obstacles to offer this solution to non-profit deaf organizations and to help deaf people communicate with the majority society of normal hearing people.

6 Conclusion

In this article, the authors present a specialized smart solution developed specially to help people with hearing impairment. Compared to conventional compensating aids, the developed solution connects modern technologies and originality. The aim of the solution is to digitally capture the ambient sound and based on its evaluation using neural networks, to present users needed information in a text form. This aim was successfully accomplished, and smartphone/GG was a well-chosen device for this purpose. However, because GG is no longer produced (and was very expensive) and there is no support for it, it will be necessary to choose another device (e.g., smart phone or other "smart glasses") or makes author's own smart glasses. Today, there are other glasses than GG, for example, Intel provides its own as well as other technological companies. The next step is to take advantage of virtual reality.

Technical evaluation also showed that the Glass technology can be excluded from the prototype architecture and it is possible to replace it with a common smart phone. Therefore, the used version of GG is out of date and works in a very energy-intensive way, has an inefficient microphone and is transferring more data than necessary. The testing success rate of developed solution is quite high and provides very promising results for further research (after a few small improvements). Indicator called "Confidence value" reached a mark 90% that are quite high number for this phase of testing. The average response time is 1515 ms.

Firstly, the next step in this research is the optimization of the developed solution. Secondly, the authors will focus on distinguishing the color of the voice, so that the user can recognize who is speaking and what (during the talk of more than two people). Unexpected utilization of the author's solution is that it can serve the deaf, but also for normal "hearing" people travelling or working abroad who do not understand the foreign language (in the future).

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