Prototype Design of Alert Device for Hearing Impaired Users

Priyank Kularia, Ganesh Bhutkar, Sumit Jadhav
and Dhiraj Jadhav

Center of Excellence in HCI, Vishwakarma Institute of Technology,
Pune, India
ganesh.bhutkar@vit.edu

Abstract

Sounds are essential pressure waves which keep humans informed about the events around them. Users with hearing impairment have difficulties in recognition of the sounds that are vital in their day-to-day life. This research paper discusses a paper prototype design of Alert Device for hearing impaired users within their work environment at home. This prototype of Alert Device is designed based on a detailed literature survey as well as peer Android application review. The device design focuses on recognition of sounds in the home environment such as detection of the doorbell, crying of a baby, fire alarm, motion detection alarm and phone ringing at home. It also includes features such as self-training of sound, Panic/SOS button and sound log. The proposed proto-type will reduce the dependency of hearing impaired users on other family members around them within the work environment at home and will improve their daily life activities through Information and Communication Technology (ICT).

Keywords

Alert Device · Hearing Impairment Users · Deaf · Non-Speech Sounds · Hearing Disability · Hearing Loss

1 Introduction

The world human population has reached to about 7.7 billion by February 2019. According to WHO, around 466 million people worldwide have a hearing disability, of which 131 million are from South Asia [10]. It is estimated that over 900 million people all around the world will have a hearing disability by 2050, and South Asia will have a significant effect of this with an increment of about 2% making upto 267 million hearing disabled people [13].

A study by Gudyanga shows that the inability to detect any sounds in the surroundings leads to social, emotional and behavioural problems [4]. Also, hearing impaired user rely on sign language or lip-reading to understand speech sound. But, in the case of non-speech sounds, the users with hearing disability face numerous troubles in a home environment [3]. The major problems include **difficulty in communication with friends/family, lack of awareness about surrounding work environment, inability to handle dangers and emergencies, and behavioural issues like loneliness or depression**.

Hearing disability is based on the grade of impairment [12] which is summarized in Table 1. There are different kinds of devices available for hearing impaired users such as Assistive Devices, Augmentative Devices and Alert Devices [8]. The study of these devices reveals that there are only a few costly Alert Devices that are available as compared to Assistive and Augmentative devices. Due to this, the hearing impaired user always needs an interpreter to know about the events happing around him/her even in home environment. Thus, to make hearing impaired user self-sufficient regarding detection of Non-Speech Sound related events around; there is a need of a Universal Alert Device. This device should be portable and should detect all the desired Non-Speech Sounds for hearing impaired users.

Table 1: Grades of hearing impairment (dBHL: decibels Hearing Level)[12].

Grade of Impairment	Audiometric ISO value
No impairment	25 dBHL or less
Slight Impairment	26–40 dBHL
Moderate impairment	41–60 dBHL
Severe impairment	61–80 dBHL
Profound impairment	81 dBHL or greater

This research paper provides an overview of the investigation process and a related paper prototype design of the Alert Device for hearing impaired users within their work environment at home. The next section discusses an extensive literature review which tends to focus first on Alert Devices and then on Non-Speech Sounds.

2 Literature Review

A literature review on the Alert Devices and related Non-Speech Sounds has been comprehensive. This section discusses a few research articles which mainly focus on Alert Devices and related Non-Speech Sounds, which have helped in the initial process of prototype designing. These articles mainly include conference papers, journal papers and a patent published from 2004 till 2018. Most of these articles involve studies with a prototype design, real-world products, and mobile applications. The following sub-section discusses articles on Alert Devices first, and then about articles related to Non-Speech Sounds.

2.1 Articles on Alert Devices

Table 2 depicts details of different features and aspects present in the Alert Devices discussed in related research articles [1–2, 5–7]. The abbreviation NA in Table 2 stands for data Not Available. Major features are selected after the rigorous study of these research articles, which are -use of display unit (other than smartphone), use of vibrations, self-training of sound, Panic/SOS button and sound log. The important observations from data in Table 2 are provided as follows:

- **The smartphone is the most preferred device** for primary display.
- **Home and Work are the most preferred work environments** for deaf users.
- **100% (5 out 5) of the Alert Devices use vibrations** as an alert medium.
- **60% (3 out of 5) of the Alert Devices store sound log** and use display unit other than a smartphone.
- 40% (2 out of 5) of the Alert Devices have the ability of self-training of sound.
- **Only 20% (1 out of 5) of the Alert Devices provide Panic/SOS button.**
- The most common range of participant users is about 15 or fewer users.

2.2 Literature Review on Non-Speech Sounds

The different sounds which Alert Devices of different research studies are able to detect include **door knock, landline/phone, doorbell, loud noise, fire/smoke alarm, intruder alarm, motion detection alarm, baby cry and**

Table 2: Summary of features in Alert Devices of research studies.

Features and Aspects	Research Articles				
	Matthews et al. 2005	Ander et al. 2017	Obe et al. 2018	Mielke et al. 2016	Bragg et al. 2016
Primary Display	Smartphone	Smartphone, TV, Tablet	Smartphone	Smartwatch	Smartphone
Environment(s)	Office	Home, Office &Hotel	Home	Controlled room	Home, Office& Mobile
Display unit (other than smartphone)	No	Yes	Yes	Yes	No
Use of vibrations	Yes	Yes	Yes	Yes	Yes
Self-training of sound	No	Yes	No	NA	Yes
SOS/Panic button	No	Yes	No	No	No
Sound log	Yes	Yes	NA	NA	Yes
No. of participants in the user survey	12 Users (3 deaf, 3 mostly deaf & 6 hard of hearing)	NA	NA	6 Users (3 deaf, 2 mostly deaf & 1 hard of hearing)	87 Users (50 deaf & 37 hard of hearing)

opening/closing of the door [1–2, 5–7]. As per data researched, 80% (4 out of 5) of the Alert Devices are able to detect door knock. 60% (3 out of 5) of the Alert Devices are able to identify sound of landline/phone, doorbell, loud noise, fire/smoke alarm, intruder alarm and motion detection alarm, less than 50% of the Alert Devices are able to detect baby sound and door opening/ closing.

3 Android Application Review

A systematic review has been conducted for currently available leading Android apps related to alerts and sound detection used mainly by hearing impaired users. Applications reviewed include **Baby Monitor 3G, Flash Alert Call & SMS, Sentechtor, Sound Detector and Visualfy** [9, 11, 14–16].

Different features and details observed in these selected apps which are used mainly by hearing impaired users include a visual information, flash, alert

from different mobile apps, vibration, sounds log, self-training of sound and Panic/SOS button. Important observations of these apps are provided below:

- **Most of the apps (4 out of 5) provide alert using mobile display and also store sounds log** which makes it is easy to understand the alert generated.
- **Most of the apps (3 out of 5) have provided a vibration feature** for better focus on alert **and Panic/SOS button** for making emergency contacts.
- **Only two apps give alert from different applications and also provide self-training of sound.**
- Flash feature is provided in only one app and it is an essential feature for deaf.

4 Paper Prototype Design for Alert Device

The prototype will be developed with the consideration of the home environment as a work environment for the hearing impaired users. These users can benefit from this device immensely by detecting everyday essential sounds as well as certain very important non-speech sounds like opening/closing of the door, fire alarm, intruder alarm and movement detection that are crucial for safety and security at home.

The proposed prototype of Alert Device consists of four main blocks which are **Sensors, Sound Detection Unit, Communication Unit and Output Unit**, designed to be utilized within work environment at home. The hardware components/design will be completed at later stage. Apart from the prototype design of Alert Device, design of Smartphone Application is also proposed which consists of **Alert Detection, Training of Sound and Sound Log**. In Alert Detection, user can have live detection of the sounds with options of doorbell, crying of baby, fire alarm, phone ringing, motion-detection alarm and sound log. User can also customize the pattern and intensity of vibration for individual sound.

5 Conclusion

A paper prototype for this Alert Device is designed based on allied literature review as well as Android app review. The prototype design includes a few functionalities which can support users from slightly to profound impairment within work environment at home. It has features such as detection of various sounds, self-training of sound, Panic/SOS button, and sound log. Thus, the proposed Alert Device is designed with the primary intention of helping hearing impaired users to detect sounds occurring at home environment. The development of the proposed Alert Device will reduce the dependency of hearing impaired users on other family members at home and will improve their work engagement through Information and Communication Technology (ICT). In the future, the proposed Alert Device will be developed with an initial focus to make a Universal Alert Device, which will be portable and able to recognize all the desired Non-Speech Sounds.

References

1. Ander, B., Ander, S., Kushar, A.: Alarm Monitoring System. United States Patent. (2017)
2. Bragg, D., Huynh, N., E. Lander, R.: A Personalizable Mobile Sound Detector App Design for Deaf and Hard-of-Hearing Users. 18th International ACM SIGACCESS Conference on Computers and Accessibility – ASSETS 2016, Reno, NV, USA, pp. 3–13. (2016)
3. Dobie, R., Hemel, S. (edts): Hearing Loss Determining Eligibility for Social Security Benefits, Chapter 6, National Academies Press, USA. (2005)
4. Gudyanga, E., Wadesango, N., Eliphanos, H., Gudyana, A.: Challenges Faced by Students with Hearing Impairment in Bulawayo Urban Regular Schools. Mediterranean Journal of Social Sciences, 5(9), pp. 445–451. (2014)
5. Matthews, T., Fong, J., Mankoff, J.: Visualizing Non-Speech Sounds for the Deaf. 7th International ACM SIGACCESS Conference on Computers and Accessibility – ASSETS 2005, Baltimore, Maryland, USA. (2005)
6. Mielke, M., Brück, R.: AUDIS Wear: A Smartwatch based Assistive Device for Ubiquitous Awareness of Environmental Sounds. Annual International Conference – IEEE Engineering in Medicine and Biology Society, Orlando, FL, USA, pp. 5343–5347. (2016)
7. Obe, O., Abe, S., Boyinbode, O.: Development of Wireless Home Automation System for The Disabled (Deaf, Dumb And Alzheimer) People. International Journal of Scientific & Engineering Research, 9(10), pp. 1–6. (2018)
8. Assistive Devices for People with Hearing, Voice, Speech, or Language Disorders, https://www.nidcd.nih.gov/health/assistive-devices-people-hearing-voice-speech-orlanguage-disorders, last accessed on 15th Jan 2019
9. Baby monitor 3G, https://play.google.com/store/apps/details?id=com.tappytaps.android.babymonitor3g.trial&hl=en_US, last accessed on 9th Feb 2019
10. Deafness and hearing loss, https://www.who.int/news-room/fact-sheets/detail/deafness-and-hearing-loss, last accessed on 7th Jan 2019
11. Flash Alert Call &amp SMS, https://play.google.com/store/apps/details?id=call.sms.flash.alert&hl=en, last accessed on 9th Feb 2019
12. Global burden of hearing loss in the year 2000, https://www.who.int/healthinfo/statistics/bod_hearingloss.pdf, last accessed on 10th Jan 2019
13. Global estimates on prevalence of hearing loss, https://www.who.int/deafness/Global-estimates-on-prevalence-of-hearing-loss-for-website.pptx?ua=1, last accessed on 10th Jan 2019
14. Sentechtor, https://apkpure.com/sentector/com.mobisys.android.sentector, last accessed on 9th Feb 2019
15. Sound detector, https://apkpure.com/sound-detector/dk.mvainformatics.android.sounddeector, last accessed on 9th Feb 2019
16. Visualfy, https://play.google.com/store/apps/details?id=com.fusiodarts.visalfy.lite&hl=en_IN, last accessed on 9th Feb 2019