"Sicha!" – The Development of a Fire Alarm App for Deaf University Attendees

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Figure 1: The University of Vienna: https://layout.univie.ac.at/fotopool/fotos-von-gebaeuden/

ABSTRACT

Approximately 10.000 people in Austria are deaf and up to one million might be suffering from a mild or severe hearing impairment. Even though a safe fire alarm option for deaf and hearing impaired students at the University of Vienna is long overdue, the university did not yet meet the demands of such a significant demographic. In this paper, we examined the current landscape of fire alarm options for hearing impaired people and constructed an app prototype that can transmit fire alarms to users' mobile phones. The app was developed and continuously improved over the span of a semester and evaluated on a small test sample. Usability tests revealed that users welcome our idea for a fire alarm app and show almost no difficulties navigating and operating it.

CCS CONCEPTS

• **Human-centered computing → Human computer interaction (HCI)**; *Accessibility*; Accessibility design and evaluation methods.

KEYWORDS

fire alarm, university, deaf, hearing impaired, app development, Human computer interaction, prototyping.

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1 INTRODUCTION

Deaf and hearing impaired people see the world through a slightly different lens than people with normal functioning hearing. When designing spaces, be it physical or digital, one needs to consider the needs of people who might not be able to fully react to auditory signals. Approximately 10.000 people in Austria are deaf and up to one million are hard of hearing or suffer from some form of hearing impairment, be it mild or severe [6]. It is therefore not a given that the typical user of any system is able to properly discern audio signals and hearing impaired people represent a user group that is not to be trifled with. When designing a system, it is therefore important to do so with accessibility in mind. In a lot of cases, this accessibility was retrofitted, as a lot of accessibility questions have only been asked in recent times.

Due to us taking the subject Human-Computer Interaction (HCI) this semester, it was our job to design an app that could function as a fire alarm system for deaf students at the University of Vienna. Our university currently does not offer a safe fire alarm alternative for hearing impaired students, neither locally nor in the form of an app. The current fire alarm system broadcasts its information solely auditory. Our project should therefore analyze how a solution to the said problem could look like. Motivational factors are hereby increased accessibility and inclusivity.

2 USER ANALYSIS

Deaf and hearing impaired people are not a homogenous group and have a broad spectrum of varying needs. Hearing impairment can range from a slight difficulty perceiving high sounds, all the way to not being able to hear any sounds at all. UI and UX designers need to take the different needs of different individuals and groups

Task	Deaf	Hard of Hearing	Minor hearing impairments
Phone vibration	+++	++	+
Phone flashlight	++	+	+
Push notification	++	+	+
Additional information (e.g. test alarm)	+++	++	++
Floorplans and escape routes	++	++	++
General fire safety guidelines	+	+	+
Local fire alarm with flashlight	+++	+	+

Table 1: Task analysis (low importance: +; medium importance: ++; high importance: +++)

of people into account when designing any product or system. For our app we derived at a total of three user groups:

- Deaf people without any hearing ability
- Hearing impaired people and those hard of hearing
- People with normal functioning hearing or only minor hearing impairments

In accordance with these groups we conducted a task-analysis to explore how important certain features would be to these groups. The analysis was based on the importance of the feature and not the expected quantity of its use, since the amount a feature is used depends on the amount of triggered fire alarms and the specific situation. We decided a life saving feature that is rarely used is therefore more important than one, that is simply used more frequently.

Making use of our user groups, task analysis and context analysis, we also formed four personas to aid us in our design process.

3 RELATED WORK

Designing whilst paying attention to inclusivity is a rather recent development, however, a lot of projects and companies have already found solutions on how to tackle the topic of fire safety for hearing impaired people.

In Austria the platform and app DEC112 [2] is available to the general public. DEC112 stands for "Deaf and Emergency Call", with the suffix 112 referring to the standard emergency number in Austria. The app allows users to make an emergency call and interact with a helpline through a text-based interface. The interface features shortcuts to speed up the conversation in order to launch a swift emergency response, if necessary. The app is also able to transmit the location of the user to speed up the process even further. The reach of the project was extended to areas of Italy and Denmark through the CELESTE project. Switzerland offers its citizens the app "DeafVoice" [1], whilst Germany is about to launch its application called "Nora" [4]

In terms of home security, there are a plethora of companies offering security options for deaf people. There are systems that in case of a fire alarm, send the alarm signal to a vibrating device, a smartwatch or a smartphone. A lot of fire alarms also send out a visual warning signal in the form of a flashing light. Those light flashes can even be set to such a high intensity that they have the ability to wake people from their sleep, increasing people's security at night, when one is most vulnerable. Most of these systems are meant for home use, however, there are some that offer their service to a wider area. The app "Nimbus Notify"[3] allows users to receive detailed information about ongoing and past fire alarms. Most Nimbus products are meant for service workers in order to maintain a fire alarm system, however, the Nimbus Notify App offers an all encompassing system of local fire alarms and ties it all together with a simple-to-use design.

A different approach to registering fire alarms is sound recognition software. By making use of large sound libraries, users can simply install an app that gives them detailed information of the sounds in their vicinity, such as for example the buzzing of a doorbell or a fire alarm. There are a variety of sound recognition services, however, in late 2020 Google released their app "Live Transcribe and Sound Notifications" for Android smartphones and smartwatches [5]. The app does not require an active internet connection and can inform the user of the occurrence of specific sounds per push notification, vibration or flashing of the display. It therefore offers a fire alarm alternative that does not require extensive infrastructure as users can carry their mobile phones wherever they go.

4 DESIGN

The App consists of four separate top-level pages that can be accessed through a navigation bar at the bottom of the screen. Its location and implementation were chosen so that it is easy to spot, easy to navigate and easy to use with one hand, which is important in any emergency situation, such as a fire alarm. The bottom navigation bar also enables faster access than a side navigation drawer due to it being not nested. The pages of the app are as follows:

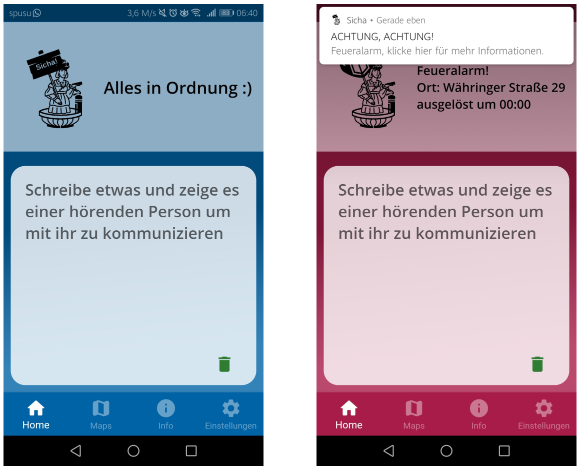
4.1 Home Screene

The Home Screen is the first thing users see when starting the app. It contains the most important information: Is a fire alarm currently in effect or not? And if yes, where is it and when was it triggered? The entire background of the app is normally colored in the shade of blue of the University of Vienna, to make the association immediately apparent, but in case of an alarm the background turns red and the logo of the app changes slightly.

The home screen also offers an empty text field that hearing impaired users may use to quickly type something and show it to somebody. That way fast communication with people of normal hearing is possible. The text field was intentionally placed on the home screen since previous user tests revealed that it was rated as very important and should therefore be easy to access.

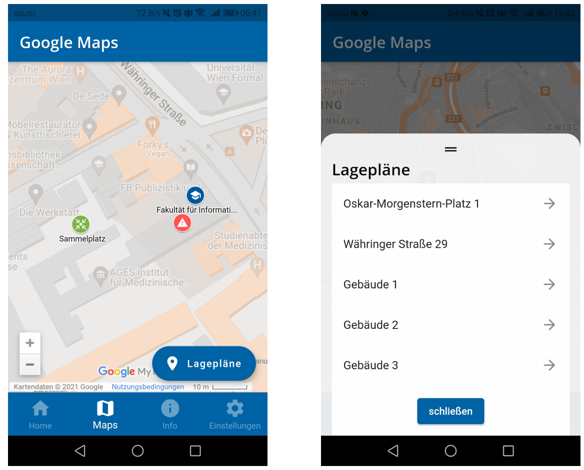
4.2 Maps Screen

Users have the option to look up the layout of buildings that are a part of the University of Vienna, as well as make use of an integrated



(a) Home without alarm (b) Home during alarm

Figure 2: Home screen



(a) Google maps screen (b) Floorplan screen

Figure 3: Maps screen

maps function with live location services. That way one can quickly find the fastest route out of a building, as well as the best route to the nearest assembly point, where in case of a fire alarm, students are supposed to wait for further instructions or an all-clear sign. The maps section of the app is still in its prototype phase. The University of Vienna consists of a plethora of buildings at various locations. The floor plans and assembly points of every building are not easily accessible and it would take a significant amount of work to make the feature compatible with every building belonging to the university. The app only features the layout of two buildings and their corresponding map location. If one were to implement a fire alarm app at the University of Vienna, however, these features should be fully implemented, since previous testing revealed that users really appreciated the integrated maps feature. Some even alluded to the fact that they might use the app for other purposes besides fire alarm warnings if it featured reliable map and building layout information.

4.3 Info Screen

The info screen is split into two tabs located at the top of the screen. One offers information on how to act in case of a fire alarm or fire. The other offers information on who to contact in case of an emergency and how to contact them.

4.4 Settings Screen

On the settings screen, users can choose how they wish to be informed of an alarm. One has the option to toggle push notifications, vibration and the camera flash on and off. Due to the fact that hearing impaired people have varying needs, it is important to offer as many options as possible so that every user can manually shape their preferred experience with the system.

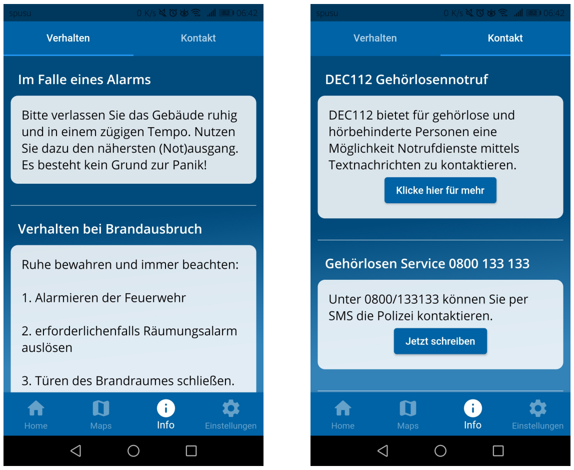
It is also possible to enable or disable the app's access to the phone's microphone and location services. The app would need access to the phone's location to offer the aforementioned map service. Access to the phone's microphone is required so that the app can use noise recognition to register any ongoing fire alarms in the user's vicinity. Normally the app would require internet access to function. In case that there is no connection the app could automatically switch over into noise recognition mode, to offer the user safety no matter where they go, since some areas of the university have less than optimal signal strength. The noise recognition, same as the location service, was only implemented prototypically as such a feature would require a lot of time, resources and support from noise recognition developers and access to their noise databases or even the formation of a new database that contains information about the sound of the local fire alarm. The settings screen also contains information on how disabling those functions could ultimately be dangerous as said functions are intended to keep people safe in emergency situations. We decided it was necessary to give users the choice if they wanted to use those features as some stated privacy concerns at the app always being able to access one's microphone and location data. Nonetheless, most users rated these features as extremely useful.

5 IMPLEMENTATION

We implemented our alarm system as an Android application using the Flutter framework and the Dart language.

One of the biggest challenges we faced was to work out how to transmit a fire alarm signal to our app. Our first approach was to use Flutter's Firebase Cloud Messaging service which would have enabled us to remotely push messages that could have functioned as a trigger to set off the alarm mode, however, this idea proved to be a lot more difficult to implement than expected. Due to our time and resource limitations we instead opted for a button in the settings page, that users themselves can tap to trigger a test alarm.

This was achieved by creating our own AlarmSettings class that contains a Boolean isAlarm which tells us if our app is currently in alarm mode or not. We let AlarmSetting inherit from Flutter's



(a) Safty guidelines screen (b) Contacts screen

Figure 4: Information screen

(a) Setting options (b) Test alarm button

Figure 5: Settings screen

ChangeNotifier and wrapped our MyApp class in a ChangeNotifier-Provider widget which allows MyApp to listen to all value changes from AlarmSettings. The test alarm button changes the isAlarm value alternatingly between true and false and its notifylistener() method is called to notify MyApp of the changes. Our App can then respond with actions such as changing the color scheme and displaying information about the ongoing fire.

This test alarm button was used for our user study and it is only for demonstration purposes. As of now, the implementation does not support remote fire alarm transmission but it is definitely something one should strive to implement in the future.

6 EVALUATION

An evaluation of the app was conducted through a series of user tests. Due to the time and resources available to us, we were not able to include any hearing impaired users in our testing, however, we did try to include a representative sample in regards to other demographic variables.

A total of four users participated in the testing. Three of the users were students at the University of Vienna, whilst one was a senior citizen. Two of the users were female and two were male.

The usability evaluations were conducted in person and could be completed in less than an hour each. The study consisted of a standardized script that explained the tests and situations to participants but left enough room for questions and assistance if required. After completing formalities and answering questions a total of two separate usability tests were conducted. Participants were asked to think aloud during the entire procedure, so their interaction with the app was easier to understand and analyze.

The first task consisted of a quick primer of the scenario with the goal of quickly familiarizing with the app and being able to navigate the system to find the quickest way to exit a particular building.

The second task utilized the communication text field of the app with participants being tasked to roleplay and find out why nobody is leaving the building, even though the app is displaying that there is a fire alarm currently in effect.

After completing the tasks participants were asked about their experience and their opinions of the app. A standardized questionnaire was developed by our group for the purpose of low-fidelity prototype testing. The questionnaire was modified and also implemented for the usability tests. Additionally, participants were encouraged to state any opinions they held and speak freely, as to offer us as much information as possible, which we would then use to improve the app.

7 RESULTS

The results of the usability evaluation revealed that most aspects of the app were functioning as intended and were used and understood correctly. Participants completed both usability tests in a swift tempo. The first task revealed that participants need some time to get used to the app and have a desire to understand all aspects of it. The task was to find the fastest exit route from a building but participants spent most of the time navigating through the app and reading the provided information on the info screen before moving on to the task. This could be seen as a problem in an emergency situation, however, we do not interpret these findings as problematic, since users would normally install the app before ever needing to use it in an emergency. If users spent a significant portion of their time coming to grips with the app and understanding its functions, we, the designers, can count on users reading the provided safety guidelines before counting on the app in emergency situations. Therefore, in terms of the task, they took rather long before focussing on the task itself but we believe that if users get used to the app beforehand they will respond even quicker in emergency situations than if they had not gotten used to it. Our app might therefore not only function as an alarm but also as a fire safety guide.

The second task revealed that users were able to utilize the text field function to communicate with other people. Participants rated their experience with the communication feature and its usefulness as positive. The goal of the test was to roleplay and communicate with a fellow student to find out that the fire alarm was only a false alarm and that there was no reason to evacuate the building. Most of the participants were able to decipher this information as intended, however, one participant interpreted the alarm on the app as more important and more true than anything a fellow student could tell them, which urged them to evacuate the building and warn as many people as possible. We therefore learned that if one were to implement such an app in real life, one needs to plan ahead for the occurrence of false alarms or test alarms and that if not properly addressed in the app design, it could lead to confusion, maybe even dangerous situations.

Having a senior citizen in the test sample proved to be an important asset. We discovered that some aspects of the app were difficult to navigate due to the participant's finger dexterity and difficult to read due to the participant's bad eyesight. Since hearing impairments often occur during later stages of life, it is important that an app such as this one meets the needs of senior students if it was to be implemented in real life.

The following changes were made to the app in response to the usability evaluation:

- A functioning map integration was added. The previous prototype only featured building layouts but users were lacking an easy way of finding out where the nearest assembly point is.
- The building layouts were reorganized in a way that is easier to access and it is now possible to zoom in on them through a button. The previous prototype allowed users to zoom by using finger movement, however, this proved difficult for our senior test user.
- The design of the app was made clearer, more consistent and more professional looking.
- Some information on the different contact options were added since users were a bit unsure when to contact whom.
- The text field was adjusted to make its purpose more clear to users.
- A large amount of minor fixes and quality of life improvements were also implemented.

8 REFLECTION

The project consisted of four milestones. Up to milestone 3 our team consisted of three people, however, our third member had to step away from the project due to health concerns, so from milestone 3 onward, our team only consisted of the two authors featured in this article: Jin-Jin Lee and Addi Wala.

During Milestone 1 we tried to form an understanding of the topic and previous design ideas and solutions. Lee analyzed existing literature, our third member looked at previous design solutions and Wala performed a context analysis, a task analysis, a user analysis and designed 4 personas that would serve as a design aid for the rest of the project.

During Milestone 2 we performed an extensive brainstorming session in which we tried to collect as many ideas as possible. Afterward, every team member designed a low-fidelity prototype that would follow different design ideas and principles. The prototypes were all designed on different platforms such as miro, invisionapp and PowerPoint.

During Milestone 3 Lee programmed the entire app and Wala offered support by assisting in design matters, such as the layout of the information screen and the logo design.

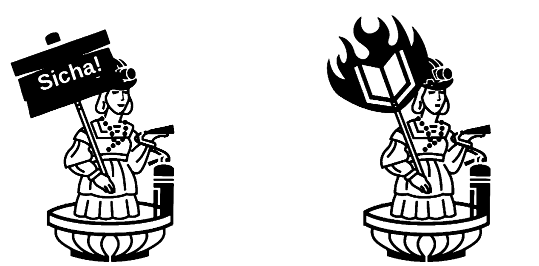
Milestone 4 is the one that led up to the writing of this paper. Lee and Wala both designed the user tests and performed them. The changes and improvements to the app were made by Lee, whilst most of the writing during the project stems from Wala.

Through our work on this project, we learned a lot about the development of apps, such as the process of prototyping, documentation, iterative design and usability testing. We also learned about the needs of hearing impaired people and how one can make design choices that lead to better accessibility, inclusivity and safety.

9 CONCLUSION AND FUTURE WORK

Our work proved that a fire alarm system for hearing impaired university attendees is an achievable goal, however, it would need a lot of time and resources to make it into a reality. We hope that future development will look towards this paper and our findings to improve and adapt their own project or to use this paper as a stepping stone that leads a step closer to a more inclusive and safer university experience for hearing impaired people and everyone alike.

We recommend that developers do not repeat mistakes that we discovered and that future projects on fire alarm apps and fire safety apps look towards the strengths of our work and try and implement features such as a clear indicator for the fire alarm, but one that is not panic inducing, an integrated map and building layout feature, information about fire safety, a way to customize the medium of the alarm and a way to communicate with hearing people if necessary.



(a) logo without active alarm **(b) logo during active alarm**

Figure 6: The logo of the Sicha App

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