Audio phonebook for the blind people

Goran Popović*, Una Pale*
* Faculty of Electrical Engineering and Computing, University of Zagreb, Zagreb, Croatia
goranpopovic@hotmail.com, una.pale@gmail.com

Summary - The technology can in many ways help visually impaired people, but problem of memorizing a large number of phone numbers for most of blind people is still not resolved. The aim of this study was to design, construct and test a device that would serve as a phone book for landline phones. The device is connected between the phone and the phone line and therefore can serve as a memory for phone numbers. It is important that it has a very simple interface and allows unobstructed use of the phone. The device was tested by visually impaired people and feedback showed that it could be used without any problem and without special training.

I. INTRODUCTION

Long distance communication has become a crucial part of life of the modern man. Without the Internet it is difficult to perform even simple personal tasks, but without phone it is almost impossible. The emergence of the SMS has brought a whole new dimension of life to the hearing impaired persons. At the first sight phones make communication of blind people easier, but only seemingly. In fact, in everyday life we use dozens, even hundreds of phone numbers. It is almost impossible to know them by heart. Today most of the people remember only a few phone numbers which they call frequently because they rely on the phonebook in their mobile phones where phone numbers are stored. Blind people do not have a possibility to write the number on the paper, nor in the mobile phones (most of them). Some people record phone numbers on audio cassettes or CDs in order to have a sort of an audio phonebook, and some, albeit rare have phone numbers written in Braille.

It is a myth that blind people, because of blindness have an excellent memory. This actually applies only to those who are systematically working to develop their mnemonics. Just like in the general population, among blind people exists a significant number of those who are not skilled with technical devices as well as those with poor memory skills. To these people it is a problem to call more than a few different phone numbers.

Based on research of Internet and scientific publications as well as consulting with blind people and their associations, it was concluded that today there is no available device that solves this problem. Also, almost all devices that are suitable for the blind (like speaking clocks, scales, blood pressure monitors, etc.) are several times more expensive [1] than the same devices for people who can see. Most of the devices are also even more expensive if the language of the device is not English.

The aim of this study was to solve this problem. The hypothesis is that this problem can be solved by constructing a device that can be connected between phone device and phone landline that would serve as an audio phonebook. It would have just about three buttons in order to be easy to operate. Buttons would enable scrolling through contacts which would be pronounced (the contact's name) and automatically dialed by pressing the "dial" button once the desired contact is found. Such device would allow blind people much easier and faster handling with the telephone device. One needs to type the phone number only once, in order to program the phonebook, which greatly facilitates the use, since there is no need to remember a lot of numbers, nor for creating any alternative phonebooks. On the other hand ordinary phones, often because of inadequate interfaces (like a lot of small buttons that are inadequately positioned) make entering the phone numbers difficult. The proposed device would reduce the use of phone keys to a minimum.

The two biggest problems that blind people have are calling the wrong number and the fact that the call is interrupted due to the long pause between entering two digits (more than eight seconds). Wrong number is entered mainly due to inadequate phone interfaces for blind people. Interruption of the call happens because people often must look for a phone number in their own phonebooks.

The second hypothesis is that such audio phonebook would eliminate wrong calls which are today present due to false memory or mistakes in operating the phone keys. The third hypothesis is that the audio phonebook could be used also by people with reduced cognitive and motor abilities.

II. EXISTING SOLUTIONS TO THE PROBLEM

Research has shown that there are two main groups of solutions to this problem: alternative phonebooks and mobile phones.

A. Alternative phonebooks

Auxiliary phonebooks that blind people use are usually CDs, audio cassettes or notes/address books in Braille which contain contact's information. Usage of any of the mentioned phonebooks is very slow and clumsy.

It is hard to learn Braille, complicated to use and digital versions are very expensive. The phones with big buttons or with Braille labels can be bought, but still the problem of remembering a phone number is not resolved because the landline phones have a small memory: 10, 20 or 30 numbers. Even if such phones would have a larger memory, the problem is remembering at which memory

location is the desired number, and there is no feedback except waiting for who will answer the call. In some countries one can call a phone assistant and ask for help, but more information about the phoned person are needed, which can be a problem for people with reduced cognitive abilities. In some countries the law requires that manufacturers of phone equipment need to produce devices that are adapted for the blind, visually impaired, deaf or people with other disabilities, the requirements that need to be fulfilled are usually minimal.

B. Mobile phone solutions

Blind people have several feasible ways to call a large number of different phone numbers, but they are adapted for people with advanced technical competences: mobile phones with talkback and mobile phones with voice recognition.

Mobile phone with talkback has a program running in the background that pronounces screen's content [2]. With that program blind user can select a phonebook, and find the desired contact. The advantage of this solution is that it uses existing, conventional models of phones ("smartphones"), phonebook size is practically unlimited, and the additional cost is only for the voice program. The disadvantage is that coping with a multitude of programs available on mobile phone, without tactile (and visual) feedback, is cognitively very demanding, and requires intense training which can be very hard to overcome for many people.

Phonebook with voice recognition [3] appeared on mobile phones even before the era of smartphones, and it is also accomplished by means of a computer program on a mobile phone. The advantages are the unlimited number of contacts, any phone can be used and the cost is only for getting certain programs. The disadvantage is that such programs do not yet have a high level of recognition, so it is necessary to use very distinguishable names of the contacts: words that do not sound similar. This means that it is necessary to remember recorded (voice print) names of individual contacts, which limits the number of possible contacts. Another problem is temporary or permanent changes of the user's voice: throat illness, teeth problems, stress as well as noisy environment.

None of the available methods is suitable for all blind people, especially the elderly people who recently got blind or people with reduced motor and cognitive abilities.

III. CONCEPT AND REQUIREMENTS FOR THE DEVICE

The basic idea is to construct a standalone device that can be installed between the landline wires and the telephone. With simple, intuitive and robust user interface the device would enable all blind people to make calls, especially the elderly and those with reduced motor and cognitive abilities.

A. Required functionalities

One of the main requirements is that the device does not limit the usage of phones and phone lines, regardless of the state of the device. This means that users can still make a phone call or answer an incoming call as if the device is not connected. Another requirement is the ability to save a large number of contacts (several hundred). Also, the user must be able to enter a new contact without anybody's help, at any time and at any position in the phonebook as he prefers. This means that moving, deleting and adding new contact anywhere in the phonebook must be possible.

The basic functionality is pronouncing the name of the contact that is selected. It is also important to be able to hear the phone number that is stored under each of the contacts. To use these options (finding the desired contact, adding a new contact, moving contact and deleting the contact) device must have voice instructions that guide the user through each function. Also, if there are a large number of contacts in the phonebook, functionality of rapid search is required and phonebook must be circularly shaped: after the last contact, comes the first, and vice versa.

B. User interface requirements

Several functions are mentioned that phonebook must have. For this reason, in order for operation to be simple, it is important that steps for each implemented functionality are logic and intuitive. Also, the physical interface must be easy to use.

The goal was to create a device with as few buttons as possible. Most important operation is „listing“, but also other operations such as calling, accepting and rejecting (e.g. just recorded name of the contact or entered phone number) and exiting (e.g. out of current option) are needed during the use of the device. All of operations can be implemented with one button, by different number of clicks on the button (one, two or three clicks). In such a way a total number of buttons can be reduced to only three buttons or even only one if encoder knob, which can be rotated and pressed, is used.

C. Flexibility requirements

Except mentioned functionalities, the goal is also that the device can be easily translated into any language. Contact names need no translation since they are entered by the user in the language he prefers. The only thing that needs to be translated into another language, are voice instructions that guide the user through the functionalities of the device. These voice instructions, as well as all the contacts, are stored on the SD memory card. Voice instructions are files in WAV format that can be recorded on any personal computer in a matter of minutes. In the same way contacts can be quickly and massively recorded, which is useful when initially storing a lot of contacts in an empty phonebook. This requires a separate program for the personal computer, for which a help of a sighted person is needed.

In addition, the goal is that the device is as cheap as possible and can be built by anyone. Therefore, the device is based on "open source" hardware so later anyone could make it, even the ones who have no engineering skills.

IV. DEVICE DEVELOPMENT

The device was built and its operation and functionality tested.

A. Hardware

General parts of the device are Arduino [5], DTMF encoder/decoder [6], speaker, microphone, memory (SD card), power supply, and the control circuit for the phone line as shown in Figure 1. The device is connected in parallel to the landline wires and the telephone. In that way device can "listen" what is happening on the line, in other words what the phone is sending, and does not disturb the line during the incoming or outgoing call when using the telephone. Device shares the line with the telephone and can send the phone number through the line instead of telephone, and then leave the rest of the call (speaking, transferring, hanging-up) to be handled by the phone. Device is electrically isolated from the landline wires and the phone through an audio transformer 1:1 with a 300Ω impedance which substituted the "existence" of the phone. Power is drawn through AC/DC adapter with voltage 7-12 V.

Figure 1 shows the circuitry of whole device.

B. Working principle

Today most telephones use DTMF [4] (Dual Tone Multiple Frequencies) standard, which defines combination of two frequencies that represent particular telephone digit/symbol. All phone devices that support DTMF dialing can generate 12 DTMF signals which represent digits/symbols: 1, 2, ..., 9, 0, '*' and '#'.

For the realization of proposed solution platform "Arduino" has been chosen, because it is "open source" and relatively cheap. The entire device is designed as a "shield" board which is just stacked on top of the Arduino board. In order to have phonebook that is easily transferable and editable, all contacts and corresponding telephone numbers are written in a single .txt (ASCII) file stored on the SD memory card. The phone numbers in the file are in the following format:

001-90981862526#########-018-002-
002-016632567##########-001-003-
003-003851676148########-002-022-
RRR-NNNNNNNNNNNNNNNNNNN-PPP-SSS-

First three digits (RRR) are the number that denotes the name of the file (.wav) where contact name audio recording is stored, but also the number of the row of number in .txt file. 20 characters (NNN…N) are reserved for the telephone number. If the number has less than 20 digits, the rest of the characters are replaced with symbol '#'. Last two three-digit numbers represent previous (PPP) and following (SSS) contact (its position in .txt file and the name of the .wav file). In such a way a linked list is created with pointers to next and previous contact.

V. DEVICE TESTING

One the device was built and its operability tested, in order to examine functionality and suitability of user interface for the visually impaired, the device was given to blind people to test it. In cooperation with the Croatian association of the blind functionality and user interface was tested by 11 blind or visually impaired users. It was planned to test the device on more people, but not all were able to participate in the available time frame. Six examiners were older than 50 years, and five were younger. Although the group of 11 examiners is relatively a small group from which statistically significant results cannot be obtained, we believe that the homogeneity of the results can confirm quality of functionality of the proposed solution. The review of similar studies with the blind [7-10] revealed that the number of the examiners was also small (under twenty examiners).

A. Testing procedure

1) Initial poll

Firstly, the initial survey was conducted, which was aimed to find out the person's profile, their habits of using the telephone, and their opinions on problems about devices adapted for blind people.

The survey consisted of three parts: personal data, issues related to the current way of using the telephone, and general issues related to the life of the blind people. In personal data, the most important data were: age of the person, whether the person is visually impaired or blind, and for how long. Also, it was important to know whether the person through their employment and life was engaged with computers and other complex technical devices, and whether they use Braille. For general questions, examiner's attitudes about the prices of devices for the blind and visually impaired, and the sensitivity of manufacturers and engineers for the blind and visually impaired people in the development of new devices were addressed.

Part of the survey, related to the current way of using telephone, comprised of first determining in which category the examiner may be put. Several categories were suggested:

- classical mobile phone with keyboard
- mobile phone with talkback
- remembers phone numbers by heart and types every number on the phone
- personal phonebook (on paper, cassette, CD, computer, etc.) but types the numbers every time
- landline phone with memory using pre-stored numbers only or predominantly

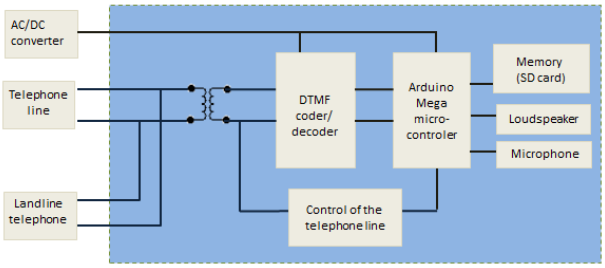

Figure 1. Basic electrical sheme of device

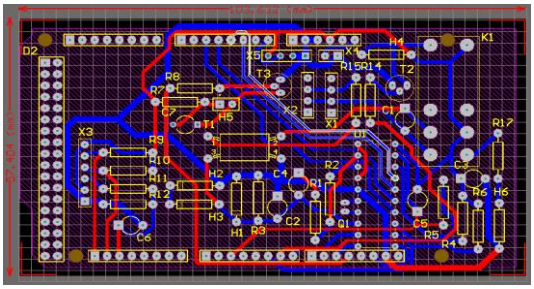

Figure 2. Electrical design of device

Important information were the number of the telephone numbers which examiners remember, number of the telephone numbers which examiners have in phonebook, average time needed to call a contact or add new contact in the phonebook, rate of calling a wrong contact, problems with current phonebook and telephone interface and autonomy they have when using the telephone. Furthermore, if they have been unsatisfied with current way of calling, problems which occur to them and their ideas for solving that problem were recorded in the poll. Also, participants were asked to evaluate if there is a need to create device that would allow blind people to call others easier, as well as what would be the acceptable price of such a device relative to prices of other devices for the visually impaired.

2) Testing the device

Testing consisted of three parts: calling the contact, entering a new contact and deleting the contact. For each of these three parts, the examiner would first call, enter and delete contact with assistance of the mentor. This was repeated until the examiner was prepared to do it without the help of the mentor. The amount of time for calling, entering and deleting the contact was measured, along with the number of questions examiner had and the number of attempts. Afterwards the time required for the examiner to find a person in the phone book and call it, to record a new contact, and to delete recorded contact was measured. Both of the interfaces were tested in order to determine which interface is better and why.

3) Closing poll

Closing poll was conducted after the testing. The aim was to evaluate examiner's satisfaction with the device, as well as the views of the examiners about offered device as a solution to problems which blind have when using the telephone. Their advices were collected for improvement of the device. They also had to decide which interface they find better, easier and more logical/intuitive.

B. Testing results

1) Initial poll results

In this section just few of the most important feedbacks are discussed. The number of contacts that people have in their phonebooks depends on the calling method.

Average number of contacts for people with smartphones is more than 80 contacts, whereas for people with ordinary mobile phones around 6. We wanted to know whether examiners need other people's help when making a call or editing the phonebook, and for which operation. 73% of examinees can do everything by themselves. Mostly senior examiners who are blind for less than five years need help of others. They need help rarely, when entering contact (e.g. contact in phonebook on mobile phones, speed dial in older mobile phone with keyboards or a landline phone). Based on the answers of the examiners, average time for creating new contact in the phonebook for mobile phones with keyboards is more than two minutes, while with smartphones average time is under one minute.

Average time to call a contact using their current calling device was 10-30 seconds. Half of the examiners dial wrong number very rarely, almost never, while the other half dials wrong number in average several times a month. A reason for mistakes is lack of audible feedback which number is pressed on older phones, and lack of saying the name of the contact selected when listing the phonebook or the name of the contact called when using the speed dial. Also, a common mistake is simultaneously pressing two buttons, or having too long pause (> 8 sec) between the two subsequent number entries during which line disconnects.

In total, 91% of examiners agreed that there is need for new solutions which would ease telephone usage among the visually impaired. However, examiners who are accustomed with smartphone stated that new solutions are needed mostly by elderly and people who are visually impaired for a relatively short time. All agreed that device manufacturers and engineers are not sufficiently sensitive to the needs of the blind. Also, all stated that the prices of the devices adapted to visually impaired are too high. Examiners estimated that the price of the audio phonebook they have tested should be in range of 200-400kn (33%), from 400- 700kn (44%), and 700-1000kn (22%).

As problems with their current way of using the phone they mentioned: the size of the keys, the smoothness of the keys, the screen contrast, the complexity of phone interface, the missing feedback that they are calling the right number, short maximum pause allowed between two numbers when dialing, a small number of contacts one can have on speed dial or in memory of a landline phone, and the complexity of creating new contacts.

2) Device testing results

The time that examiners needed to call certain contacts from the phonebook was measured (three tries).

While calling the contacts, examiners were able to ask questions. Elderly people asked questions for about 7 minutes in total, while the younger people in average 3 minutes.

Figure 4 shows that the time for calling a contact is shorter for younger people (<50 g.): Around 20 seconds. For seniors, at first test that time was higher (37s), but in three attempts the time decreased. The goal was to determine the approximate time it takes for the average person to call a desired contact. 30 contacts were stored in the memory and contacts they needed to call in two consequent attempts were equally spaced (8 contacts). Based on the results for younger and older people, that time is around 25 seconds. Slight increase in time for younger examiners is practicaly insignificant and probably attributed to fatigue, distraction and other factors. Consequently, the user interface is simple enough to call a contact very quickly, regardless of age, previous experience and skills of the user.

The time needed to erase a contact was also less for younger people. Time needed to erase a contact is longer than time needed to call the contact because it takes more steps to erase the contact than to call it. Entering a new contact lasted even longer, because in addition to entering a telephone number, user must record name of the contact which was very unusual to the examiners in the beginning. First attempts took around 90 seconds for younger examiners and about 150 seconds for senior examiners. In both cases, the time decreased in the following attempts.

The time (for calling, entering and deleting contact) tend to fall with number of repetitions, especially for the elderly. It can therefore be concluded that people can rapidly learn to use the device.

3) Closing poll

All examiners have answered that the device had fulfilled their expectations. They also said that they could use the device in their homes and that it has all the functionalities they need. Furthermore all said that the device is enough intuitive to be used. Examiners who are already using smartphones said that they do not need this device, which is understandable. As advantages over the current way of using the phone they mentioned short calling time, insurance that they are calling right contact, the ability to edit the order of the contacts by the priority, and the ease of entering a new contact.

In total 73% of the examinees opted for the interface with rotational knob, while other 27% opted for interface with three buttons.

Examiners were asked to provide as many proposals to improve the interface as they could think of. Mostly the proposals were oriented to new functionalities, such as a sound signal before recording of the contact's name starts, the option of saving an incoming number, identifying incoming calls by saying the name of the caller, etc.

VI. CONCLUSION

The blind examiners have concluded that the device with its interface and functionalities is fully adapted to their needs, and the overall impression was positive. The first hypothesis was confirmed: it is possible to make a device that would help all blind people.

The designed and developed audio phonebook for the blind people can facilitate the usage of the phone for blind. The device solves the main problems that the blind people have when making a phone call: stores a large number of contacts, completely eliminates the risk of dialing the wrong number or being interrupted because of slow dialing. This confirms the second hypothesis.

Furthermore, several advices for further improvements of the device were collected. The advices were mainly oriented to new functionalities, and not to the modification of existing functionalities or interface.

Except the feedback on the device itself, a profile of blind people was created, their needs, problems, current solutions. An overview on part of the community of blind people, to whom this device could help, was acquired. Those people are ones who did not manage to get used to the new technologies, especially on touchscreen. To those people the device would not only enable easier dialing of a phone number, but would also solve the problem of need to memorize a lot of contacts. In this research, more than half of the examined people have belonged to that category. This also indicates that the third hypothesis could be confirmed, but a carefully selected group of examiners is required in order to get scientific proof. They might now be able to delete or add new contacts, depending on severity of their cognitive impairment but calling could be obtained.

Figure 3. Final design of the device, two interface versions: buttons and rotational knob

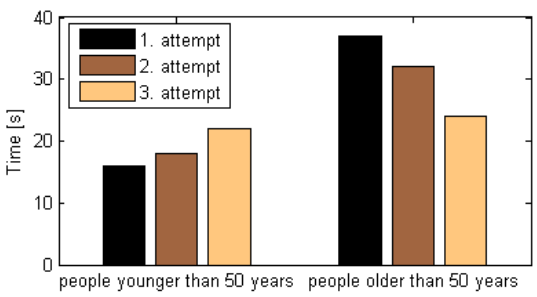

Figure 4. Calling time for two age groups

Additional feedback obtained from the examiners indicates the need for a similar user interface on other devices they use in everyday life, which represents a potential market niche at the global level.

In further work more examiners would need to be included in the research in order to get the statistically significant results.

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