Czech Technical University in Prague
Faculty of Electrical Engineering
Department of Computer Graphic and Interaction

Audiobook player for older adults with vision impairment

Master thesis

Bc. Barbora Endrštová

Master programme: Open Informatics
Branch of study: Human computer interaction
Supervisor: Ing. Miroslav Macík, Ph.D.

Prague, January 2019

Thesis Supervisor:
Ing. Miroslav Macík, Ph.D.
Department of Computer Graphics and Interaction
Faculty of Electrical Engineering
Czech Technical University in Prague
Karlovo náměstí 13
121 35 Praha 2
Czech Republic

Declaration

I hereby declare I have written this master thesis independently and quoted all the sources of information used in accordance with methodological instructions on ethical principles for writing an academic thesis. Moreover, I state that this thesis has neither been submitted nor accepted for any other degree.

In Prague, January 2019

.....
Bc. Barbora Endrštová

ČVUT
ČESKÉ VYSOKÉ UČENÍ TECHNICKÉ V PRAZE

ZADÁNÍ DIPLOMOVÉ PRÁCE

I. OSOBNÍ A STUDIJNÍ ÚDAJE

Příjmení: **Endrštová** Jméno: **Barbora** Osobní číslo: **418979**

Fakulta/ústav: **Fakulta elektrotechnická**

Zadávající katedra/ústav: **Katedra počítačové grafiky a interakce**

Studijní program: **Otevřená informatika**

Studijní obor: **Interakce člověka s počítačem**

II. ÚDAJE K DIPLOMOVÉ PRÁCI

Název diplomové práce:

Přehrávač knih pro seniory se zrakovým postižením

Název diplomové práce anglicky:

Audiobook player for older adults with vision impairement

Pokyny pro vypracování:

Analyzujte výsledky výzkumu zaměřeného na potřeby seniorů se zrakovou vadou [1], který je v současné době prováděn na katedře DCGI. Zaměřte se na trávení volného času, přehrávání audioknih a poslech hudby. Proveďte kvalitativní uživatelský výzkum s cílovou skupinou uživatelů. Pomocí metody User Centered Desing navrhněte a realizujte sadu prototypů zařízení pro přehrávání audioknih a dalších zvukových forem. Interakční metodu přizpůsobte potřebám, preferencím a schopnostem cílové uživatelské skupiny. Jednotlivé prototypy otestujte se zástupci cílové uživatelské skupiny. Seznamte se s platformou Raspberry Pi a s rozšiřujícími moduly pro přehrávání zvuku. Tutu platformu využijte při realizaci finálního prototypu.

Seznam doporučené literatury:

[1] Macik, M., Maly, I., Balata, J., & Mikovec, Z. (2017, September). How can ICT help the visually impaired older adults in residential care institutions: The everyday needs survey. In Cognitive Infocommunications (CogInfoCom), 2017 8th IEEE International Conference on (pp. 000157-000164). IEEE.

Jméno a pracoviště vedoucí(ho) diplomové práce:

Ing. Miroslav Macík, Ph.D., Katedra počítačové grafiky a interakce

Jméno a pracoviště druhé(ho) vedoucí(ho) nebo konzultanta(ky) diplomové práce:

Datum zadání diplomové práce: **19.09.2018** Termín odevzdání diplomové práce: **08.01.2018**

Platnost zadání diplomové práce: **19.02.2020**

Ing. Miroslav Macík, Ph.D. podpis vedoucí(ho) práce	podpis vedoucí(ho) ústavu/katedry	prof. Ing. Pavel Ripka, CSc. podpis děkana(ky)

III. PŘEVZETÍ ZADÁNÍ

Diplomantka bere na vědomí, že je povinna vypracovat diplomovou práci samostatně, bez cizí pomoci, s výjimkou poskytnutých konzultací. Seznam použité literatury, jiných pramenů a jmen konzultantů je třeba uvést v diplomové práci.

11. 12. 2018
Datum převzetí zadání

Podpis studentky

Abstract

This thesis focuses on supporting reading, an important activity of visually impaired older adults. More than half of people with severe vision impairment is older than 70 years. We present the design concept of a physical device for audio content playback tailored to specific needs and preferences of this user group. The design is based on analysis and the outcomes of fundamental research conducted with visually impaired older adults living in a residential care institution. A qualitative user study (N = 9) focused specifically on audio content consumption has been conducted. We employed iterative development and formative evaluation to develop two generations of the audiobook player prototype. Implemented metaphors links control components with generally known concepts to support understandability of user interface: the shape resembles a book, the opening of the device starts playback, the closing stops it; button shapes are related to their function; the layout of available items for listening matches to the clock reference system. Four qualitative evaluation experiments have been conducted: early informal study (N = 3), low-fidelity prototype evaluation with visually impaired (N = 7, age mean = 45.6) and visually impaired older adults (N = 7, age mean = 73), high-fidelity prototype evaluation (N = 2). We conclude that the preferences of visually impaired differ. Younger and more active users listen to different genres, require easy portability and advanced features. Older and more passive users listen mostly to audiobooks, their primary requirements are simplicity, understandability, appropriate dimensions and layout of controls. The final design was marked as simple and useful by representatives of the target user audience.

Keywords: audiobook player, visually impaired older adults, visually impaired users, assistive devices, matching between user interface and the real world, User-Centered Design, Human-Computer Interaction, user research, usability evaluation, prototyping, formative evaluation

Abstrakt

Překlad titulu: Přehrávač knih pro seniory se zrakovým postižením

Tato práce se zabývá designem přehrávače knih pro seniory se zrakovým postižením. Více než polovina zrakově postižených je starší sedmdesáti let. Hlavním účelem navrhovaného zařízení je zpřístupnit slabozrakým a nevidomým seniorům důležitou volnočasovou aktivitu – čtení. Práce je zaměřena na interakci posluchače se zařízením. Design je založen na limitacích, znalostech a potřebách jedinců cílové skupiny získaných z provedené analýzy a výsledků předchozího výzkumu s nevidomými seniory žijícími v domově s pečovatelskou službou. Realizovaný kvalitativní uživatelský výzkum s nevidomými uživateli (N = 9) byl zaměřený na čtení a trávení volného času. Vývoj designu probíhal iterativně, byly vytvořeny a formativně testovány dvě generace prototypů. Pro podporu pochopitelnosti rozhraní byly implementovány metafory propojující ovládací komponenty s obecně známými koncepty: přehrávač svým tvarem působí jako kniha; otevření spustí přehrávání, zavření zastaví; tvary tlačítek souvisí s jejich funkcí; rozložení položek k poslouchání odpovídá hodinovému ciferníku. Průběžná evaluace zahrnovala 4 experimenty: neformální časnou zpětnou vazbu (N = 3), testování low-fidelity prototypu s nevidomými participanty (N = 7, věkový průměr = 45.6) a se seniory se zrakovou vadou (N = 7, věkový průměr = 73) a ověření high-fidelity prototypu seniory se zrakovým postižením (N = 2, věk = 81). Testování ukázalo, že preference nevidomých uživatelů jsou různé. Mladší a aktivnější uživatelé poslouchají různé žánry a vyžadují snadnou přenosnost a pokročilé funkce. Starší a pasivnější uživatelé poslouchají převážně audioknihy a jejich hlavní požadavky jsou jednoduchost, pochopitelnost, vhodná velikost a rozložení komponent uživatelského rozhraní. Zhotovený design byl dotazovanými participanty označen jako jednoduchý a užitečný.

Klíčová slova: přehrávač knih, senioři se zrakovým postižením, nevidomí, asistenční pomůcky, propojení uživatelského rozhraní s reálným světem, User-Centered Design, interakce člověka s počítačem, uživatelský výzkum, testování použitelnosti, prototypování, formativní testování

Acknowledgements

I would first like to thank my thesis advisor Ing. Miroslav Macík Ph.D. of the Faculty of Electrical Engineering at Czech Technical University in Prague. The door to Ing. Macik's office was always open whenever I ran into a trouble spot or had a question about my research or writing. He consistently allowed this thesis to be my own work, but steered me in the right the direction whenever he thought I needed it.

I would also like to thank the expert Lukáš Treml for his valuable remarks.

Finally, I must express my very profound gratitude to my parents for providing me with unfailing support and continuous encouragement throughout my years of study and through the process of researching and writing this thesis. This accomplishment would not have been possible without them.

This research has been supported by the project Navigation of handicapped people funded by grant no. SGS16/236/OHK3/3T/13 (FIS 161 – 1611663C000).

Thank you.

Babrora Endrštová

List of Tables

List of Figures

List of Acronyms

AD Analog-to-digital. 48

AVG Average. 31, 53

CD Compact disc. 20, 23, 27, 67, 93

CPU Central Processing Unit. 30

DAISY Digital Accessible Information System. 20

GPIO General-purpose input/output. 30, 46

GUI Graphical User Interface. xiii, 46, 62

I2C Inter-Integrated Circuit. 46

KDD Library of digital documents (e-books) in Prague. 63–65, 67, 69

KTN Library for visually impaired in Prague. 29, 32, 41, 63, 64, 67, 69

NVDA NonVisual Desktop Access. 65, 67

OCR Optical character recognition. 17

PC Personal Computer. 25, 27, 35, 63, 66, 70

PLA Polylactic Acid. 43

SD Secure digital card. 20, 24, 27

SD Standard deviation. 31, 53

SoC System on a Chip. 30

TTS Text-to-speech. 7, 17–19, 22, 32, 41, 54, 63, 64

UCD User Centered Design. xiii, xviii, 1, 5, 6, 8, 9, 33, 35, 51, 59, 61

UI User Interface. xiii, 3, 5, 6, 8, 18–26, 28, 46, 59, 62

USB Universal serial bus. 19–25, 27, 30, 46, 53, 70

WHO World Health Organization. 1, 31, 53, 55, 57

Contents

Chapter 1

Introduction

The master thesis follows the outcomes of fundamental research conducted with visually impaired older adults living in a residential care institution (described in [1]). The idea of book player similar to a book was suggested by the author of this thesis during Design studio [2] workshop[1].

The objective of the thesis is the design of book player that will improve accessibility to book content by seniors with visual impairment. The thesis focuses on the listener–player interaction. The practiced UCD methodology (suggested by [3]) should ensure usability and positive user experience of the proposed design.

In this chapter, we present a motivation, define used methodologies, basic terms, and the goals of the thesis. The Chapter 2 is dedicated to the analysis of the target audience, related work, existing devices, legislation related to book content access by visually impaired, platform for implementation, also user research. The analysis is concluded by the specification of requirements for the proposed device. In Chapter 3, we present the design and the solution of the user interface by prototypes. The next Chapter 4 describes the implementation of created prototypes. Chapter 5 captures realized formative evaluation. Finally, the Chapter 6 discusses and Chapter 7 concludes this thesis. The suggestions for future development are included in the last chapter.

1.1 Motivation

A significant fraction of society is challenged with vision impairment. The risk of visual impairment increases with age; the rising trend can be seen in the Figure 1.1. According to World Health Organization (WHO), population growth and aging will increase the risk that more people acquire vision impairment [5].

Most visually impaired are seniors, who become blind lately. The loss of vision is a life-changing event, especially in higher age. A human body with "senescence" loses

[1]The Design studio was realized at an event organized by the UX Association [3]. The purpose of the activity was to suggest ideas for improving the well-being of the visually impaired seniors living in the Palata [4].

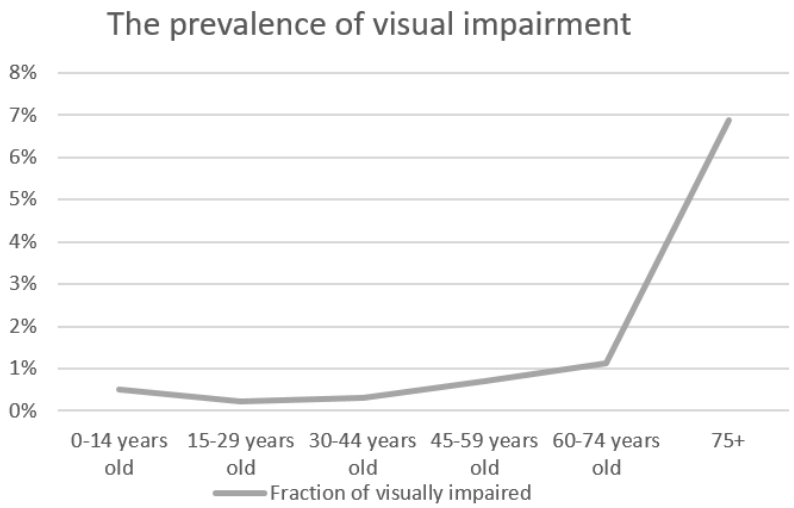


Figure 1.1: The prevalence of visual impairment in Czech Republic in 2007. The majority of people with vision impairment is over the age of 50 years, from [6].

the adaption abilities to the environment. With the loss of vision, an individual loses the independence he was used to and has to learn how to solve everyday situations in a new way. Some visually impaired decided to live in a residential care institution that provides safety and dignified living conditions, such as Home Palata in Prague [4].

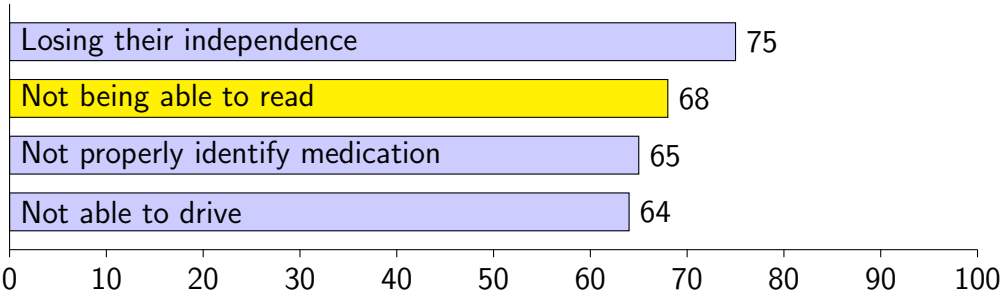


Figure 1.2: Findings of American national survey on attitudes and opinions of severe vision loss and blindness. 68% out of 1000 asked adults ages 18 and older Americans would be concerned about losing the ability to read, from [7].

This work aims to develop a design solution that will improve the well-being of visually impaired older adults. Because participation in leisure activities is associated with improved well-being, we have decided to facilitate access to one of the favorite leisure activities of many seniors, enjoying the book content. The results of American national survey point to the reading is important for many adults (Figure 1.2). The proposed design should by user-intuitive, based on knowledge, limitations, and needs of the target audience. Listening to books should not be conditioned by computer skills.

1.2 Methodology and basic terms

This section describes the basic terms and methodologies for this thesis. Well-being provides a summary of positive and negative factors influencing the subjectively perceived quality of human being. The definition of a useful device outlines what the device must meet to be useful in the real world. User-centered design [8] is the recommended methodology for developing a useful design. Sympathetic design is set of recommendations for designing devices for older adults. The last section lists access options to book content for visually impaired users.

1.2.1 Well-being

According to the Google Dictionary, the "well-being" means: *"the state of being comfortable, healthy, or happy"* [9]. In the field of psychology, the definition of the concept of well-being is more complex [10]. Carol Ryff in [11] dealt with specific dimensions and indicators contouring well-being (Table 1.1). The individual dimensions of well-being offers extensive descriptions of what it means to be in good psychological health. The dimensions have been formulated on the basis of extensive psychological theories.

Ryff operationalized the dimensions by conducting a research with 321 young, middle-aged, and older adult participants. Results point to a highly differentiated profile of psychological functioning across the adult life cycle. The findings reveal higher levels of depression (although not in the range of clinical depression) with age, concommitant with lower levels of purpose in life and personal growth. Even well-educated, healthy, economically comfortable older adults face significant challenges in their efforts to maintain a sense of purpose and self-realization in later life.[11]

From the defined points follows that well-being can be positively affected by a sense of mastery and competence in managing the environment, understanding and consciously and autonomously controlling the devices around. On the other hand, the subjective well-being can be affected negatively by: feeling bored with life, managing difficulty everyday situations, lacking a sense of control over the external world, sensing of personal stagnation.

1.2.2 Useful device

"Usefulness" can be defined as the presence of two qualities: usability and utility [12]. Utility refers to the design's functionality: "*Does the device do what users need?*". Usability, the attribute that assesses how easy UI is to use, is defined by five quality components [13]:

- **Learnability** - The system should be understandable for the target user, speak the users' language. Used concepts, words, and phrases should be familiar to the user.
- **Efficiency** - Interaction with the user should be effective for the user. Frequent actions should be allowed to tailor. The interface should take into account the

Self-acceptance	
+ possesses a positive attitude toward the self	- feels dissatisfied with self
+ acknowledges and accepts multiple aspects of self including good and bad qualities	- is disappointed with what has occurred in past life - is troubled about certain personal qualities
+ feels positive about past life	- wishes to be different than what he or she is
Positive relations with others	
	- has few close, trusting relationships with others
+ has warm, satisfying, trusting relationships	- finds it difficult to be warm, open, and concerned about others
+ is concerned about the welfare of others	
+ capable of strong empathy, affection, and intimacy	- is isolated and frustrated in interpersonal relationships
	- not willing to make compromises to sustain important ties with others
Autonomy	
	- is concerned about the expectations and evaluations of others
+ is self-determining and independent	
+ able to resist social pressures to think and act in certain ways	- relies on judgments of others to make important decisions
+ regulates behavior from within	- conforms to social pressures to think and act in certain ways
+ evaluates self by personal standards	
Environmental mastery	
+ has a sense of mastery and competence in managing the environment	- has difficulty managing everyday affairs
	- feels unable to change or improve surrounding context
+ controls complex array of external activities	
+ makes effective use of surrounding opportunities	- is unaware of surrounding opportunities
+ able to choose or create contexts suitable to personal needs and values	- lacks sense of control over external world
Purpose in life	
+ has goals in life and a sense of directedness	- lacks a sense of meaning in life
+ feels there is meaning to present and past life	- has few goals or aims, lacks sense of direction
+ holds beliefs that give life purpose	- does not see purpose of past life
+ has aims and objectives for living	- has no outlook or beliefs that give life meaning
Personal growth	
+ has a feeling of continued development	- has a sense of personal stagnation
+ sees self as growing and expanding	- lacks sense of improvement or expansion over time
+ is open to new experiences	
+ sees improvement in self and behavior over time	- feels bored and uninterested with life
+ is changing in ways that reflect more self-knowledge and effectiveness	- feels unable to develop new attitudes or behaviors

Table 1.1: The Dimensions of well-being with indicators, from [11]. These dimensions are based on: Maslow's concept of self-actualization, Rogers's view of the fully functioning person, Jung's formulation of individuation, Allport's concept of maturity, Erikson's psychosocial stags model, Buhler's basic life tendencies that work toward the fulfillment of life, Neugarten's descriptions of personality change in adulthood and old age and Jahoda's positive criteria of mental health.
"+" High scorer indicators "-" Low scorer indicators

abbreviations for experienced users.

- **Memorability** - The system should be matched with real world.
- **Errors** - The design should prevent mistakes and slips. Norman in [14] recommends that the design of different controls meanings should be perceived differently.
- **Satisfaction** - The interaction with the device should be pleasant.

1.2.3 User-Centered Design

User-Centered Design (UCD) is a development approach, which aims to design a useful UI (1.2.2) by focusing on needs, requirements, and limitations of the target user group [15]. The methodology is defined in international standard ISO 9241-210:2010 [8]. The design process phases can be seen in Figure 1.3. The process is iterative, repeated until requirements are met.

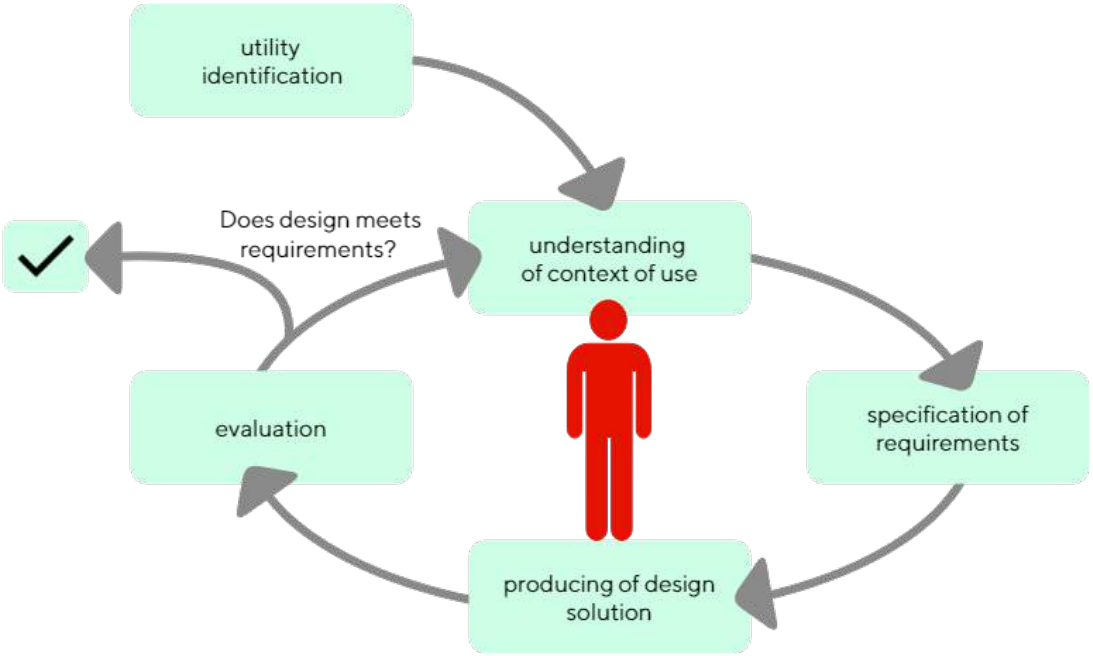


Figure 1.3: Design process diagram according to UCD, based on [16].

According to the UCD, four phases of the development process can be derived:

1. ***Analysis:*** The main purpose of the analysis is to understand the context of the use as well as the limitations, needs and knowledge of the target users. The analysis consists of studying the relevant literature, review of existing devices, familiarization with related legislation and user research.
2. ***Requirements:*** Based on the analysis, the design requirements are specified.
3. ***Design:*** According to the requirements the proposed device is designed and implemented. This phase starts with a description of the context of use using scenarios

and storyboards. Design continues with sketches. Based on sketches, prototypes of the device are created. There are some forms of prototypes:

a) **Low-fidelity prototype** — Testable design expression through fast-realizable components, in order to verify the used concepts in the early part of the development.
b) **High-fidelity prototype** — Functional design prototype, which is in many detail close to the final product.

4. ***Evaluation:*** The aim of the evaluation is to verify the usability of the proposed design. The prototype can be evaluated using expert analysis or usability study with target audience.

1.2.4 Sympathetic Design

Sympathetic design is set of recommendations for designing devices for older adults [17]. These recommendations are in line with the UCD methodology. The recommendations are:

- The functionality of the device should be simple to use, and addressing specific older adults need.
- The UI should consist of the tangible elements appropriately contextualized[2].
- Integrating older adults into the design process.
- Contextual design methodology [18]: user research, storyboarding and prototyping.
- Universal design[3] principles: simple and intuitive use, perceptible information, tolerance for error, low physical effort.

These recommendations lead to the creation of a simple physical interface that corresponds to the real world. Formative evaluation during development process with target users is recommended.

1.2.5 Reading without sight

We use the term to read also in meaning getting textual information using assistive technologies through the perceptible modality by the visually impaired user. There are three ways, how the visually impaired access to a book content:

- **Listening to Audiobooks (talking books)**, voice recordings of the book read out by a human speaker. The recording can be underlined by music and sound effects.

[2] *Contextualization* is referred as to the physical arrangement of technologies in use.
[3] Universal Design is the design and composition of an environment, which can be accessed, understood and used to the greatest extent possible by all people regardless of their age, size, ability or disability.

Some books are available even in several variants, while many books lack the audio equivalent. Widely used (in the Czech Republic) audiobooks produced in the Studio KTN[4] are divided into 20-minute tracks regardless of the internal structure of the book, each track is indexed. Audiobooks from other sources are usually divided into files based on the structure of the book (by chapters), each recording may be different in length. The usual format of an audio file is MP3.

- **Listening to book processed by Text-to-speech (TTS) software**, where voice is computer-generated from the input text. Although the developers aim to improve algorithms to the synthesized speech sounds as natural as human speech, the synthesized speech still sounds quite artificially. Modern TTS systems use machine learning and knowledge of linguistics. Some TTS systems offer the choice out of several voices.
- **Reading Braille**, a form of written language for visually impaired, in which characters are represented by patterns of raised dots that are felt with the fingertips. Ability to read Braille is conditioned by good acuity of fingertips. The acuity may be impaired due to aging, receptor degeneration (for example caused by diabetes) or trauma. Learning to read Braille depends on the good cognition. For individuals who did not learn it in childhood, there are training courses lasting several years. Reading braille brings benefits like classical reading: independence of the surrounding sounds, perceiving grammar, etc. The disadvantage is the complexity of learning and expensive devices.

Assistive technologies can increase the independence of individuals with visual impairment by enabling them to perform tasks that they were formerly unable to accomplish [20]. Choice of the variant depends on the skills, subjective preferences, and context of use.

[4] Digital internet library for the Visually Impaired in Prague [19].

1.3 Goals of the thesis

The following goals of the thesis are based on the thesis assignment and the initial analysis that offered a deeper understanding of the solved problem.

G1 **Analyze the specifics of the visually impaired older adults.** Knowledge of the target user's limitations is important for the design process according to UCD.

G2 **Analyze the current state of access to book content by visually impaired people and related legislation.** To determine the requirements for a new device, it is beneficial to know the features of the current solutions. The results from related research can be inspiring.

G3 **Get acquainted with the Raspberry Pi platform and its expansion modules.** The functional prototype of the player requires the implementation of hardware and software expressing the functionality of the proposed device. For the implementation, it is advisable to know the possibilities offered by this platform.

G4 **Employing qualitative user research, analyze the needs and requirements of potential users.** Qualitative user research brings real user experience in a given focus. The relevant topics for this project are leisure time, playing audio-books, and listening to music.

G5 **Regarding the results of the user research and analysis define requirements.** Specifying of the purpose, functional and non-functional requirements form the basis of design.

G6 **According to User-centered design methodology create prototypes of the UI.** The prototype expresses the intended design and allows usability testing, where the design issues may be detected in an early state of development.

G7 **Describe the implementation of particular prototypes.** For future work, the implementation has to be documented.

G8 **Evaluate the developed solution with the target user audience.** The usability of the used control concepts should be verified by appropriate method of evaluation.

Chapter 2

Analysis

This chapter deals with the analytical phase of the UCD design process. The first section 2.1 addresses topics related to the target audience. The next part 2.2 describes the current state of access to the book content by visually impaired users. The section 2.3 mentions the exception in the Copyright Act, which allows free access to book content in an audio or digital format for visually impaired users. The section 2.4 is dedicated to Raspberry Pi platform as the core of the final prototype. User research is described in the section 2.5. The final section 2.6 specifies the requirements for the proposed device based on the whole analysis.

2.1 Visually impaired older adults

This section describes the topics related to the visually impaired older adults. The first part is dedicated to the loss of vision that each of our target users experienced. The next part is devoted to the changes in the human body associated with aging, the possible limitations of user abilities. The third part describes the Home Palata, an example of the environment in which the proposed device would be used. The last topic is leisure activities and their importance. The key facts of the whole section are summarised at the end of the section.

2.1.1 Vision loss

Blindness can be defined as loss of useful sight. The leading causes of blindness worldwide are a cataract, uncorrected refractive error, and macular degeneration [21]. The cataract can be caused by increasing the density of the crystalline lens during adulthood [22], the macular degeneration is caused by damaged retinal tissue [23]. Other causes are for example genetic diseases, retinopathy of prematurity [24], infections, injuries, diabetes, strokes or neurological diseases etc. Cataract, uncorrected refractive error, trachoma, glaucoma, and diabetic retinopathy are avoidable vision loss due to preventable or treatable causes [21]. Therefore, it can be observed in Figure 2.1 that in the regions where

modern healthcare is available, the situation is significantly more favorable than worldwide.

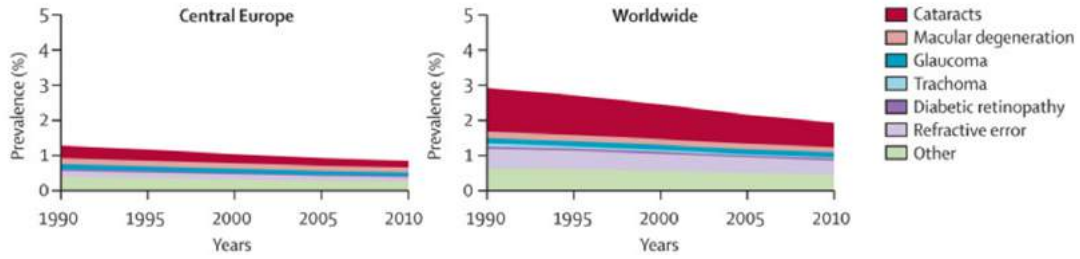


Figure 2.1: Prevalence of blindness in adults aged 50 years and older, by cause, in Central Europe and Worldwide, from 1990 to 2010, from [21].

Congenitally visually impaired (and they, who have lost vision at an early age) has different visual perceptual development [25], [26]. Congenitally impaired learn to adaptation to life without sight since their childhood, for example, in a specialized school, they learn to read Braille in place of classical reading. The study [27] showed the visual experience during development irreversibly influences the subsequent perception of tactile stimuli, blind participants outperformed sighted with the tactile acuity of the fingertip. Research [28] exposed that the blind subjects retained high acuity into old age showing no age-related decline, unlike their aging sighted peers.

Later loss of vision is a life-changing experience that is likely to have far-reaching consequences for the person affected [29], [30]. The newly visually impaired person suddenly lacks visual information about himself furthermore objects and people in his surrounding. For many situations, that he was previously able to solve quickly and efficiently himself, he needs foreign assistance or learns to use assistive devices to help resolve that particular situation now. A person who was previously independent must suddenly learn to fulfill own basic needs in a new way.

Many impaired had to stop doing daily life activities, for instance in [31] a participant expressed upset following his diagnosis because he could no longer read, something that he previously enjoyed doing. There are more serious obstacles with which the blind must deal like working, giving up on some future life plans, being a more dependent person, being more isolated from the others, being abandoned by others, and losing friends and trust in others [32].

The experience of vision loss is associated with negative feelings, for example, sadness, depression, anguish, anxiety, shock, non-acceptance of the impairment, anger, thoughts of death, activity restriction and poor self-esteem [30]–[33]. One participant in [31] described visual loss like: *"being in the black hole of Calcutta"*, what implies that he felt trapped. Another participant in [34] described his situation: *"Others told me that I wasn't the same person... I was happier... today I'm feeling sad... I isolated myself at home because I lost my interest in everything. Moreover, nobody understands me. Few people want to accept a blind person and have her as a friend. On the other hand, it's very hard to depend*

so much on others.”. The experience of vision loss is subjective and may have different meanings for different people. After vision loss, people show different kinds of adjustment courses and achieve different levels of rehabilitation outcomes [32]. For example, twelve participants (out of 38) form [32] exhibited narratives about themselves and their vision loss where they appeared to be identified with their impairment. In these cases, the impairment was addressed as being part of them, the rehabilitation and the assistive devices were appraised as being helpful and positive resources.

In the case of vision loss in higher age, the impact of visual impairment is often felt more keenly because of other problems associated with aging: declining in intellectual skills, which affects the absorption of new information [35], [36], consequences of illnesses and injuries sustained during the previous life. Fear of falling in vision Impairment affects 20 to 43% of older adults [33]. Vision impairment in later life can have profound consequences for the physical functioning, psychological well-being, and health service needs of older adults [30].

Elderly persons may find it difficult to compensate for vision loss through increased reliance on other senses. Augmentation of the quality and quantity of sensory stimuli enhances information about the environment and should facilitate adjustments to new conditions in life. For example, auditory informational input with speech synthesizers is used increasingly. Additional environmental information can be gained through the tactile senses.[25][1]

2.1.2 Changes in the human body associated with aging

Aging can be defined as an organism's change with time. Senescence, a sub-period of aging, is the deteriorative process beginning after maturity and resulting with decreased viability and increased vulnerability. An organism with senescence loses the ability to adapt to its environment. In fact, every individual ages in its own way, and these phenomena are attributed to the combination of external factors and genetic assumptions. Physical changes, changes in hearing, vision, touch, and cognition are described below.[25]

Physical changes

The changes described in this section are common to the human body. They express the natural trends of slowing down and reducing the efficiency of processes in the body. The physiological, physical changes in higher age are [25]:

- decrease the size and strength of the muscular system,
- less elastic skin,
- reduced height and limited mobility(caused by skeleton degeneration),
- decrease in vital lungs capacity,

[1]The superscript citation behind the dot is related to the entire paragraph.

- decreased acid secretion and mobility in stomach and intestines,
- changes in the reproductive system,
- the lower rate of kidneys respond,
- decreased sensitivity of pancreatic beta-cells (reduction of glucose tolerance),
- decreased adrenal androgens (as natural prevent against obesity and cancer),
- the decreased protective efficiency of the immune system,
- the increased autoimmune response of the system,
- cell loss in cerebral and cerebellar cortexes,
- loss of speed in receiving, processing and sending of the neurological signal,
- slower reflex, reaction times and sensorimotor skills.

Hearing changes

Age-related changes to the ear are pictured in Figure 2.2. Our sense of hearing is most acute at the age of 10 years and then gradually declines with age [37]. The tympanic membrane becomes less vascular and begins to thin and stiffen, hair cells degenerate, conduction and amplification of sound waves become less efficient [38]. An old ear cannot detect very high and very low pitches [39]. The level of an alarm should be at least 10 dB above the background noise. Otherwise, some older adults with age-related hearing loss will not hear it [40]. Some seniors require a slower speech speed [41].

About 50 percent of those 75 or older have trouble carrying on a conversation. Older adults are able to hear speech but understanding can be complicated due to the words become garbled. For example, the consonants s, z, t, f, and g are high-frequency sounds and can be hard to hear. The low pitched vowels a, e, i, o, and u are easier to hear. It may be hard to distinguish between words that sound alike (hair may sound like "bear" etc).[42]

There are two main kinds of non-physiological hearing impairment: conductive (a disorder in the outer or middle ear) and nerve deafness (central nerve loss). Nerve loss is a permanent consequence. Some hearing loss is hereditary, others may be caused due to repeated exposures of damaging factors, or their accumulation during lifetime. The critical factors are [42]:

- ***Noise:*** Exposure to constant or a sudden very loud noise can cause permanent hearing loss.
- ***Injuries:*** Any blow to the head or ear can cause a permanent hearing loss.
- ***Diseases:*** Common diseases such as heart disease, kidney disease, diabetes, stroke, or tumor can interfere with hearing. tumor can interfere with hearing.
- ***Ear Infections:*** In case of failure or inadequate treatment can a common infection cause hearing loss.

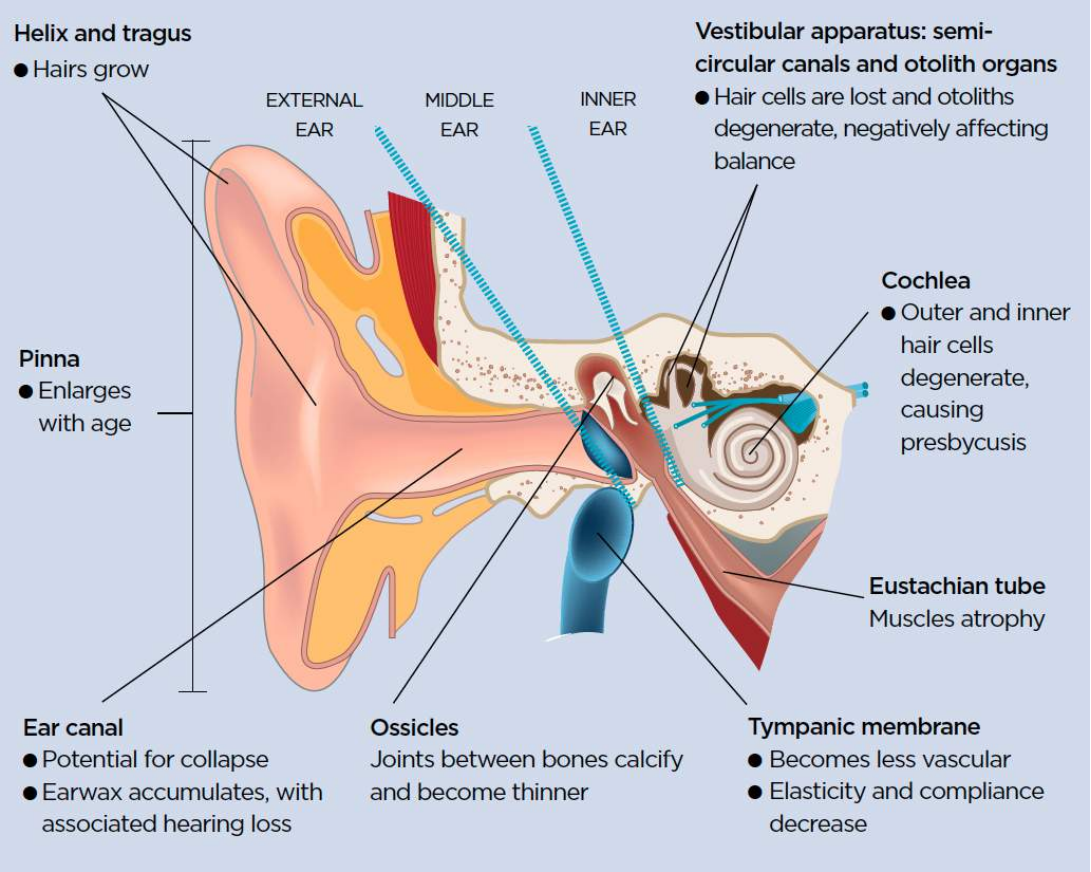


Figure 2.2: Age related changes to the ear, from [38].

Vision changes

Several age-related changes to the eye are pictured in Figure 2.3. With rising age, the cornea tends to be flattened and the corneal epithelium often degenerates, which can lead to astigmatism. Sclera becomes less elastic and turns to yellow because of the accumulation of fat. The ciliary body thickens and becomes hyalinized, what can cause obstruction in draining aqueous fluid from the eye, but a concomitant decrease in the production of aqueous fluid decrease elevation of intraocular pressure. Some loss of retinal photoreceptor cells can reduce the size of the visual field and adversely affect acuity. The accommodation (the focusing ability) for close vision is decreased and slower. To the photoreceptors gets less light, because the iris becomes more rigid and the diameter of the pupil is lessened, so older people tend to need more intense light to see as well as the once did. The opacity of the vitreous is disturbed, for example by hemorrhaging of retinal blood vessels into vitreous. Eyelids can drop or turn inward or outward, as a result of decreased elasticity and the loss of muscle tone. The decrease in the secretion of tears from the lacrimal glands causes dry eye, what is more often seen in elderly women than men. The near-vision declines, the percentage of older people who need glasses for reading raising with the age.[25], [38], [43]

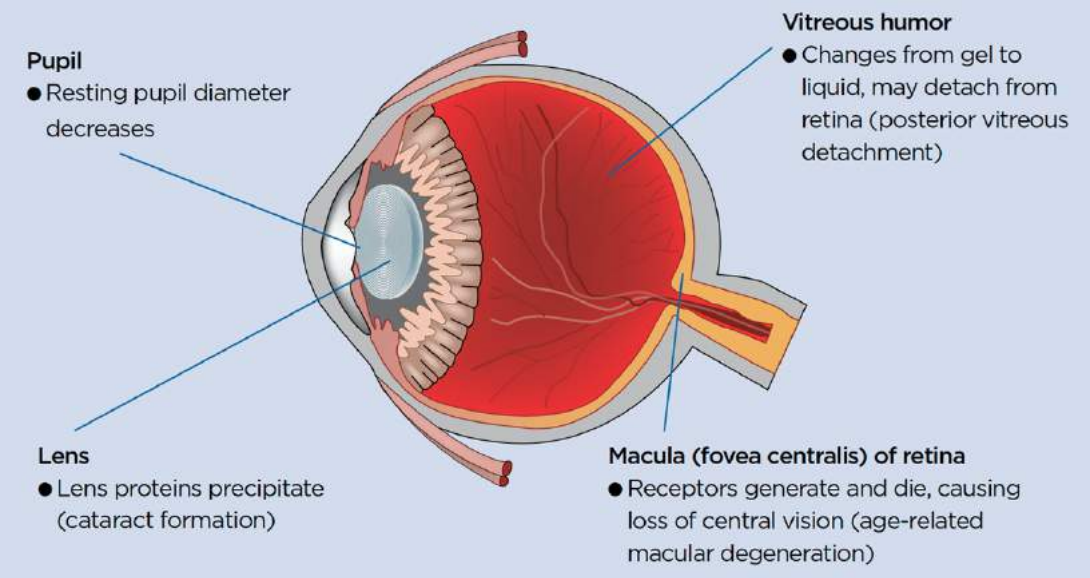


Figure 2.3: Age related changes to the eye, from [38].

Cognitive changes

With higher age declines the speed of cognitive processing, working memory, executive cognitive function and cognitive tasks that require to quickly process or transform information to make a decision. On the other hand, the cumulative knowledge and experiential skills are well maintained into advanced age.[44]

There is growing evidence the age-releated changes along with exposure to critical factors (neurotoxins like alcohol, depression, hypertension, diabetes, and obstructive sleep apnea) can cause advanced cognitive impairments severe enough to impair everyday functional abilities, dementia. Physical activity, mental stimulation and other healthy lifestyle factors are recommended as prevention.[44]

Sense of touch

Tactile thresholds increased significantly with age [45]. Sighted people, who do not practice the sensitivity of fingertips regularly as visually impaired, experience the age-related decrease in tactile acuity by roughly 1% per annum [28]. Loss of sensory acuity can impact aspects of function in the elderly, including articulation of speech, hand grip, and postural stability [46]. Touch can be pathologically affected by diagnoses like diabetes, which causes degeneration of tactile receptors.

2.1.3 Home Palata

Since fundamental research described in [1] we have cooperated with Home Palata [4]. The Home Palata is a residential care institution for visually impaired older adults. The building was built in 1892-93 on the occasion of the 40th anniversary of Emperor Franz Joseph's the first, the modern reconstruction was completed in 2008. The current capacity

of the Palata is 125 beds (45 one-bed and 40 two-bedrooms). The average age of clients is around 84 years. Internal code of ethics inspired by Böhm's method [47] defines the basic rules of employee behavior towards clients.

Figure 2.4: Home Palata: exterior, room and corridor, from [1], [4]. On the one hand side of the corridor, we can see orientation elements (haptic marks), the other side is equipped with items and furniture that support socialization, resting and psychical well-being of the clients.

The interior of the building is equipped with elements of spatial orientation. Figure 2.4 shows the appearance of a typical corridor. The environment is adapted to be maximally natural for the clients. A standard room equipment includes an electrically adjustable bed, cabinet, bedside table, chair, table, shelf, landline phone, a signaling system for calling staff, and washbasin with hot and cold water. Clients can equip their room with their personal accessories or with small furniture. The devices used by the clients are, for example, radio, television, specialized watch, telephone or mobile phone, audio players and more.[1]

Apart from regular caregiving activities, the Home Palata offers various meaningful leisure activities at any day of the week. It includes physical activities like rehabilitation as well as various social events, for example, group reading, memory training, crosswords, cooking, art activities, live music, grilling, and so on [1]. Magazine Palata is published every second month (printed and electronic magazine) and describes important and interesting events from the life in the Home. Outside the building are benches, tables, and pergolas for sitting. In the summer months, there are social events related to barbecue. The park is equipped with elements of spatial orientation and strengthening machines for seniors. On the back side of the park, there is a sheep enclosure.

2.1.4 Leisure activites

Participation in leisure activities is associated with improved well-being [48], [49]. The results of [50] suggest that maximizing activity participation is an adaptive strategy taken by older adults to compensate for social and physical deficits in later life. Leisure activities can be divided into five groups [51]:

- **Mental activity:** reading books/newspapers, memory training, studying, working crossword puzzles, drawing, painting.
- **Social activity:** attending the concerts, playing cards/games; or participating in social groups or a pension organization.
- **Productive activity:** cooking, gardening, housekeeping, doing volunteer work, knitting, sewing, weaving, or crocheting.
- **Physical activity:** walking, rehabilitation, sports.
- **Recreational activity:** listening to the radio, audiobooks, watching television.

Results of [51]–[54] suggest that frequent participation in the mental, social, or productive activity is associated with a lower risk of dementia in the elderly. The process of mental stimulation plays a role in preserving cognition. Intellectually challenging activity promotes stability or enhance cognitive performance, involves thinking and attention control processes, which might increase or maintain brain reserve even in older age.[51]

"Reading is a frequent leisure activity of many seniors. Bouchard et al. in [55] described a study with 26 visually impaired seniors experiencing severe or moderate vision loss. The aim was to clarify the role of reading for leisure and instrumental activities in daily living. About 60% of participants used talking books, and 25% used a computer for reading print. Although most older adults preserve some usable vision, age-related vision impairments mainly affect the ability to see the press. Age-related loss of vision also associates with depression, low self-esteem, and other harmful psychological reactions. The outcomes indicate that reading is essential both after vision loss and before; however, there was a significant decline in reading newspapers and magazines. Some users that lost interest in talking books reported initial difficulties in learning to use them effectively, falling asleep while reading and problems with concentration." [56]

Summarisation

The risk of vision loss increases with age. Vision loss is a life-changing event, which is in most cases subjectively associated with negative emotions. Adapting to life without sight involves learning to fulfill individual needs in other ways and depends on learning ability. Everyone deals with vision loss in own way. In higher age, the adaptation is complicated by other aging difficulties. The processes in the human body are slower and less effective when older. Sensory organs lose accuracy, cognition is getting slower.

Furthermore, abilities can be reduced by diseases (such as diabetes) or the consequences of injuries.

Elderly persons may find it difficult to compensate for vision loss through increased reliance on other senses. Augmentation of the perceptible stimuli facilitates adjustments to new conditions in life. The useful assistive devices were appraised as being helpful and resources of positive experiences.

Some institutions provide a safe home and dignified living conditions for visually impaired seniors, for instance, Home Palata in Prague. The Palata offers facilities, support services by individual needs, leisure activities and social events. Clients in Palata live in a single or double room, where they can bring their appliances or small furniture. For leisure, there are available communal indoor and outdoor spaces.

Participation in leisure activities is associated with improved well-being; boredom, on the contrary, reduces it. Independently practicable activities can help to fill the free time when no other activity is available.

2.2 State of the art

This chapter summarizes the current state of access to book content by visually impaired users. The first part is devoted to work that dealt with the related issue. In the second section the existing devices that can serve as book players are described.

2.2.1 Related work

"Massov in [57] mentioned several auditory assistive options for the visually impaired, including reading machines and talking books. Reading machines consist of a document scanner, Optical character recognition (OCR) software[2]*, and a TTS. They make text printed on flat paper accessible to the visually impaired. The machine is suitable for reading documents and is one of few ways the visually impaired can read books whose digital form does not exist. Devices for representing text available in digital form enable sophisticated browsing and search features. However, using advanced features may require more advanced user skill. In contrast, a talking book cannot support such features; its advantage is natural sound. An audio player is required for listening to talking book. The complexity of such a player vary."* [56]

"Crossland et al. in [58] evaluated two different electronic book readers as aids for individuals with low vision. They criticized the lack of extra large text option of both readers. The Amazon Kindle can read text aloud up to 200 words per minute[3]*."* [56]

"In [59] Kulkarni and Bhurchandi present a low-cost e-book reading device for blind. The device is based on two Braille characters implemented using solenoids. The work does

[2]Optical character recognition (OCR) software works with your scanner to convert printed characters into digital text.

[3]Average speed of human speech is approximately 130 words per minute.

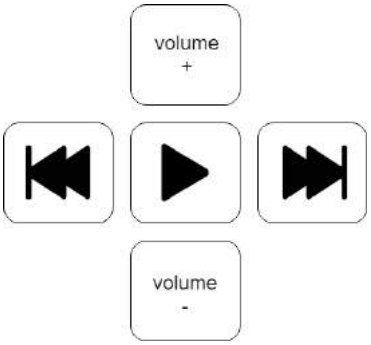


Figure 2.5: The suggested layout of audio player control buttons, from [61].

not describe any evaluation of the prototype." [56]

A technical solution of the reading-book system is described in [60]. It is a device with a built-in text-to-speech module, which supports functions: pause, stop and navigate by chapter, section, subsection or paragraph. The user interface is not visualized in the article, but there is a table of control buttons and their functions. Up and down buttons switch the level of the controlled fragment (chapter, section, subsection or paragraph); right and left buttons are used to relative navigation in the selected level (left button = previous fragment, right button = next fragment). The metaphor for relative switching the fragments with the right and left buttons is also evaluated in [61], where five out of six sketches of a drawing experiment (when each participant sketched the visual counterpart of the UI of audio player application) had the previous track button on the left and next track button on the right. The suggested layout can be seen in Figure 2.5.

"Harrison in [62] implemented real-world metaphors into user interface providing navigation within a book or document, which includes: turning to the previous/next page, and moving forward or backward in large 'chunks', relative to the beginning and end of the document. The evaluation of the prototype indicated that the interface was intuitive thanks to the metaphors. The subject of improvement to the next generation of the prototype is the addition of more manipulative elements and removal of the display from the interface." [56]

Listening to digital text using TTS enables advanced functions. Audiobooks sound natural. To implement the control of the audio player, the cross layout of the buttons has been recommended, where the right and left buttons are used for rewinding and skipping tracks. For easy understanding of the control concept, it is recommended to implement metaphors with the real world.

2.2.2 Analysis of existing devices

Many audio players can be used for listening to books. In this section nine available devices that show different approaches to the UI solution are described. The several features of presented devices are summarized in table 2.1. Individual approaches to design are discussed in the final part.

Amazon Kindle with Blind Readers Bundle

Amazon Kindle Paperwhite is an e-book[4] reader. The Kindle Audio Adapter activates VoiceView on Kindle when plugged into the micro-Universal serial bus (USB) port.

- **Dimensions:** 169 mm x 117 mm x 9 mm.
- **Weight:** 223g.
- **User interface:** touchscreen (pictured in Figure 2.6).
- **Playable content:** e-book.
- **Slots:** 1x micro USB (for adapter and charging battery).
- **Voice output:** 3.5 jack by Kindle Audio Adapter.
- **Features:** TTS with speed adjustment, Wi-Fi[5], cloud storage for all Amazon content.
- **Price:** $100.

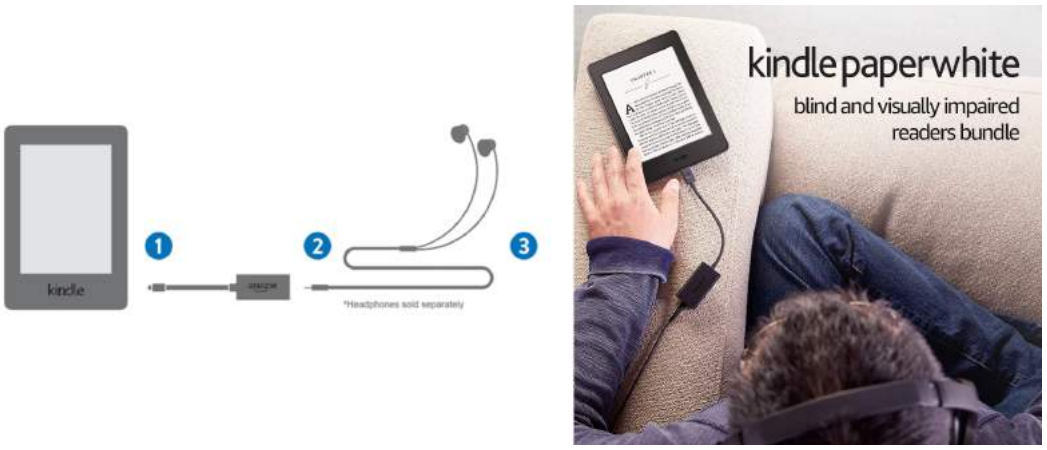


Figure 2.6: UI of *Amazon Kindle Paperwhite with Blind and Visually Impaired Readers Bundle*, from [63]. The information presented on touchscreens does not offer corresponding tactile feedback, and no positioning support mechanisms are provided [64]. The touchscreen for the blind can be effective in a specific mode where the device is controlled by gestures. Learning of gestures and gesturing requires a certain level of motor and abstraction abilities.

PlexTalk

Plextalk is an specialised book player supports reading of books (using TTS) and playing audiobooks. By the *Cross Cover* some buttons may be hidden. The UI gives spoken information about the current operation, help information (by press the Information key),

[4]E-book is book publication made available in digital form, consisting of text, images, or both, readable on the flat-panel display of computers or other electronic devices.

[5]Wi-Fi is technology for radio wireless local area networking of devices based on the IEEE 802.11 standards.

and key descriptions in Key Describer mode. The device speaks with five languages: Dutch, English, French, German, and Spanish. The manufacturer states that the device is waterproof and impact-resistant.

- **Dimensions:** 170 mm x 219 mm x 56 mm.
- **Weight:** 1.3kg.
- **User interface:** the control panel consists of 30 buttons (pictured in Figure 2.7).
- **Playable content:** e-books conforming to Digital Accessible Information System (DAISY) standards; audio files.
- **Slots:** Secure digital card (SD), USB, Compact disc (CD).
- **Voice output:** built-in speaker (impedance 4 ohm, output 2W); headphones: jack 3.5mm.
- **Features:** search function (in text input mode), volume adjustment, navigation (in audio-file mode: skipping track, album, bookmark. in the text input: Heading, Group, Page, Phrase, Bookmark), play speed adjustment, bookmarks (maximum is 10 000).
- **Price:** $500.

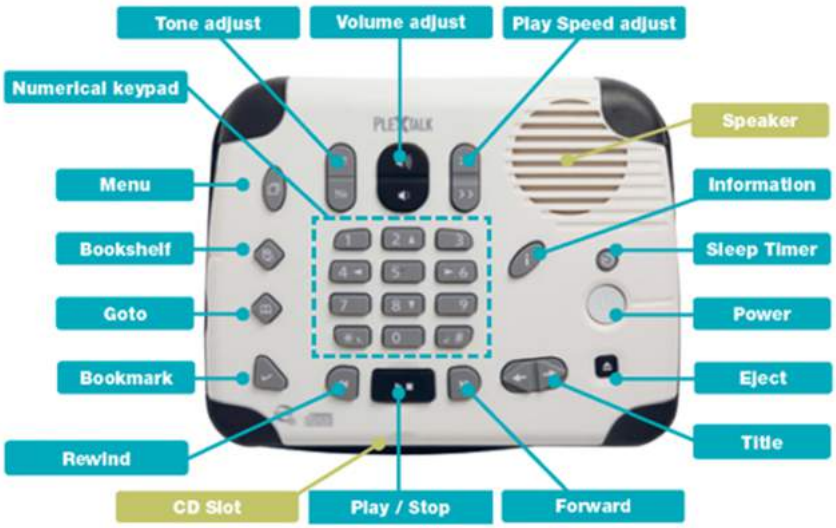


Figure 2.7: UI of PlexTalk device, from [65]. The sleep timer function turns the player automatically off at a set time.

Sovereign USB Memory Stick Player

Sovereign USB Memory Stick Player is an audio player for blind and partially sighted. The device plays audio files stored in the root folder of the plugged flash drive. An automatic bookmark, what starts the playback exactly from the position where was it stopped at the last time, is implemented.

- **Dimensions:** 116mm x 230mm x 97mm.
- **Weight:** 1.2kg.
- **User interface:** the control panel consists of 4 buttons and one potentiometer (pictured in Figure 2.8).
- **Playable content:** audio files.
- **Slot:** USB.
- **Voice output:** built-in speaker; headphones: jack 3.5mm.
- **Features:** volume adjustment, play, pause, bookmark, navigate between multiple folders, or books at the touch of a button, bookmark.
- **Price:** $40.

Figure 2.8: UI of Sovereign USB Memory Stick Player device, from [66]. The user interface consists of four buttons that have the same shape and size and one volume dial. Besides the buttons, the negative relief expresses the button function. The negative relief is hard to recognize by touch. The volume dial covers next to the volume adjustment the turning on and off.

BoomBox plus

BoomBox plus is an USB audio player with radio. If the flashdisk is plugged in the device is in audio-player mode – otherwise is in the radio mode. The automatic bookmark is implemented. The device does not support rewinding.

- **Dimensions:** 120mm x 80mm x 70mm.
- **Weight:** 400g.
- **User interface:** the control panel consists of 3 buttons (pictured in Figure 2.9), switch, and volume control dial.

- **Playable content:** audio files, e-book.
- **Slot:** USB.
- **Voice output:** built-in speaker; headphones: jack 3.5mm.
- **Features:** TTS, player, track navigation, bookmark.
- **Price:** $110.

Figure 2.9: UI of *BoomBox plus* device, from [67]. The UI consist of there buttons and main ON/OFF switch. The ON/OFF is located on the back of the device. On the top of device are there identical buttons. The middle button covers the play/pause function, the others skip track (in the radio mode skip the station).

Milestone 312

Milestone 312 is book reader/player with TTS. This device offers good portability and provides quite a lot of features. The control logic is based on several modes in which user can access to the implemented functions using five buttons.

- **Dimensions:** 90mm x 50mm x 15mm.
- **Weight:** 53g.
- **User interface:** the control panel consists of 5 buttons (pictured in Figure 2.10).
- **Playable content:** audio files.
- **Slots:** USB.
- **Voice output:** built-in speaker; headphones: jack 3.5mm.
- **Features:** audio player, TTS player, voice recorder, radio, and additional options (agenda, color reader, barcode reader).
- **Price:** $450.

Figure 2.10: UI of *Milestone 312* device, from [68]. The individual buttons are tactile recognizable. However, when we consider the many features that this facility offers, to the orientation and understanding of device modes depend on the good abstraction skills of the user.

Switch Adapted Auna Boomberry Portable Boombox

Switch Adapted Auna Boomberry Portable Boombox is portable CD, MP3, cassette, radio player which can be operated by switch function.

- **Dimensions:** 260mm x 150mm x 200mm.
- **Weight:** 1.7kg.
- **User interface:** there the control button groups, each of them controls content of different input (cassete, CD or USB) consists of 3 buttons (pictured in Figure 2.11), and volume control dial.
- **Playable content:** audio files.
- **Slot:** CD, cassette, USB.
- **Voice output:** built-in speaker, headphones: jack 3.5mm.
- **Features:** radio, audio player, track navigation (skip, rewind), pause, restart, cassette control, volume adjustment.
- **Price:** $220.

Figure 2.11: UI of *Switch Adapted Auna Boomberry Portable Boombox* device, from [69]. The controls are designed into a symmetrical layout, what subordinates their shape and position. The buttons are close together and have similar tactile features (shape, surface, material, dimensions, etc), what can lead to control mistakes, especially for inexperienced visually impaired users.

EJiasu mini digital player

EJiasu mini digital player is an audio and radio player. The user interface consists of a display and many small similar buttons. The displayed information is not accessible for visually impaired users. The device does not support voice feedback and rewind feature.

- **Dimensions:** 20mm x 70mm x 30mm.
- **Weight:** 150g.
- **User interface:** fourteen buttons (pictured in Figure 2.12), and volume control dial.
- **Playable content:** MP3 and WAV files.
- **Slots:** USB, SD card.
- **Voice output:** built-in speaker.
- **Features:** radio, audio player, skipping track, automatic channel search.
- **Price:** $15.

Figure 2.12: UI of *eJiasu mini digital player*, from [70]. In the control panel we can see the display and fourteen buttons of a similar shapes, small size, placed quite close together. The interface does not provide a voice response. These facts can cause a confusing feelings of device control for visually impaired users who do not see information on the display and labels above the buttons.

Pocket MP3 players

Pocket MP3 players are widely used devices. Small dimensions allow good portability but limit the size of control components. We can find different designs, different quality, and price categories on the market.

- **Dimensions:** from 30mm x 30mm x 10mm.
- **Weight:** from 12g.
- **User interface:** varied, the buttons in the cross layout and displays in many cases implemented (pictured in Figure 2.13).

- **Playable content:** audio files.
- **Slots:** USB (or uploading content by Personal Computer (PC)).
- **Voice output:** built-in speaker.
- **Features:** play, pause, skip track, rewind, volume adjustment, check battery state.
- **Price:** $10... $200 and even more.

Figure 2.13: UIs of pocket MP3 players, from [71]. Dimensions are especially suited to the needs of users who like to listen outside, on the go, etc., but limit the size and distance between the control components.

Smart speaker with Alexa

The Echo Dot, the *Smart speaker with Alexa*, is voice-controlled speaker that uses Alexa[6] to play music, control smart home devices, make calls, answer questions, set timers and alarms, and more. When a user wants to use Echo Dot, just says the wake word "Alexa" and Dot responds instantly. Languages supported by Alexa are English UK, English US, and Germany.

- **Dimensions:** 32 mm x 84 mm x 84 mm.
- **Weight:** 163 grams.
- **User interface:** voice UI, the device is pictured in Figure 2.14.
- **Playable content:** streamed music (Amazon Music, Spotify, and iHeartRadio ...etc).
- **Slots:** Micro-USB.
- **Voice output:** built-in speaker for voice feedback when not connected to external speakers. 3.5 mm stereo audio output for use with external speakers.
- **Features:** streaming music, audio calls, smart home devices control, ...
- **Price:** $20.

[6] Alexa is a voice-control system. It lets you speak your wishes to an Echo smart speaker and see them fulfilled, like dimming your lights or playing music tracks.

Device	**Dimensions in mm**	**Weight**	**Price**	**Playable content**	**UI**
Amazon Kindle	169 x 117 x 9	223g	$100	e-book	touchscreen headphones
PlexTalk	170 x 219 x 56	1300g	$500	e-book audiobook	30 buttons headphones speaker
Sovereign	116 x 230 x 97	1200g	$40	audiobook	4 buttons volume dial headphones speakers
Milestone 312	90 x 50 x 15	53g	$450	audiobook e-book radio	5 buttons speakers headphones
BoomBox	120 x 80 x 70	400g	$110	audiobook e-book radio	4 buttons volume dial headphones speakers
Auna	260 x 150 x 200	1700g	$220	audiobooks radio	14 buttons volume dial display headphones speakers
eJiasu	20 x 70 x 30	150g	$15	audiobook radio	14 buttons display speaker
Pocket MP3 player	from 30 x 30 x 10	from 12g	from $10	audiobook	varied (buttons, headphones, display)
Smart speaker with Alexa	32 x 84 x 84	163g	$20	streamed music	voice UI 4 buttons

Table 2.1: In the table are the key features of described book players related to this thesis summarised.

Figure 2.14: Echo Dot Smart speaker with Alexa, from [72].

Discussion

Amazon Kindle differs from other devices by touchscreen as an interactive interface. The touchscreen on Amazon Kindle does not provide any tactile feedback, unlike the physical interface composed of buttons and other components. The touchscreen can be usable for visually impaired in the special mode, where the number of objects is reduced to only the most necessary, and the simple control gestures are implemented [64]. However, the usability of the touchscreen by the visually impaired user is conditioned by a certain level of abstraction and motor skills, what can be an obstacle for elderly users.

Except for the Amazon Kindle and Smart speaker with Alexa, the described devices focus on playing content from a physical medium (USB flash drives, SD cards, or CDs). A user who wants to listen has to get the content on the right media and physically insert it into the device. This process is quite complicated in the situation when a player's user cannot work with a computer. In such case, the listening to audiobooks depends on the physical delivery of the recorded content medium from the content manager (some PC skilled user, a related person with the listener) to the player's user (book listener).

The Amazon Kindle and the Smart speaker with Alexa are unlike the others advanced in access to shared cloud storage. Remote uploading can be useful, especially when content management is realized by someone else than the user of the physical client device. Alexa offers a complete solution where users or content managers have not to be skilled in work with a computer. Everything can be done through the voice interface. Voice control may be unpleasant in some situations for older users. User by the voice control of the device may disturb the surroundings, or they would feel stupid (as is described in [73]).

The described physical user interfaces use mostly buttons and the volume control dial. Adequate size of control components is one of the desirable features of users with reduced fingertip accuracy, such as older users. This criterion is especially important for the prevention of slip errors[7]. The small and close buttons are implemented for a variety of reasons, such as small device dimensions or aesthetic reasons, as can be seen on pocket MP3 players (Figure 2.13), the eJiasu mini digital player (Figure 2.12), PlexTalk (Figure 2.7), Auna Boombery digital player (Figure 2.11).

[7]Slip means error during the realization of the right action; the user accidentally pushes a different button than he wants.

To help prevent mistakes[8], controls of various functions should be perceived differently by the user. Designs violating this rule, where similar buttons do different functions, are: PlexTalk (Figure 2.7), Sovereign USB Memory Stick Player (Figure 2.8), BoomBox plus (Figure 2.9), Auna Boomberry (Figure 2.11), eJiasu (Figure 2.12), and pocket MP3 players (Figure 2.13). In the case of a visually impaired user, it is possible to achieve different perceptions with diverse size, position, material, or sound effect of the control. The displayed information and printed labels are not useful for visually impaired. At UI Milestone 312 (Figure 2.10), the buttons are tactile differentiated and uses the cross layout, what leads to the better orientation in the UI.

The excessive complexity of the user interface can be caused by overloading one button with multiple functions, which puts requirements on either motor (rewind/skip in one button, where different ways of pushing covers diverse actions) or abstraction (Milestone 312, Figure 2.10) abilities. The PlexTalk for each feature offers its own control element. This approach is easier to understand. The problem is that for many features, the user interface has too many elements. This problem can be prevented by implementing only the features that users really need. For these reasons, it is important that the implemented functions fulfill just the right utilities. Excess or lack features can affect the usefulness of the device.

Understanding the user interface can be supported by real world metaphors. In this context, for example, the PlexTalk device has a layout based on the phones. Metaphors linked the design of player devices to the traditional reading process on described devices are not present.

[8]Mistake means the error in setting the goal of an action, for example, when the user consciously wanted to squeeze the wrong button, because he did not know the real purpose.

2.3 Related legislation

The using of copyright works, such as book and audio-books, is related to copyright law. Act No. 121/2000 on Copyright and Rights Related to Copyright implements the relevant legislation of the European Communities[9]. According to copyright law, Volume 4 Exceptions and Limitations to Copyright, Article 38: *,,Licence for Disabled, copyright is not infringed by anybody who:*

a) *exclusively for the benefit of people with disability and not for the purpose of direct or indirect economic or commercial advantage, makes a reproduction or has a reproduction made of a published work to the extent required by the specific disability; a reproduction so made may also be distributed and communicated by the same person, unless this is done for the purpose of direct or indirect economic or commercial advantage;*

b) *exclusively for the benefit of people with vision disability and not for the purpose of direct or indirect economic or commercial advantage, provides the verbal expression of the visual component and adds it to the audio component of an audiovisual recording of an audiovisual work; the audio component of the audiovisual recording of an audiovisual work may also be reproduced, distributed and communicated by the same person, unless this is done for the purpose of direct or indirect economic or commercial advantage;*

c) *if the originals or reproductions of published works are lent to meet the needs of people with disability in connection with their disability."*, from [74].

The Ministry of Culture of the Czech Republic establishes the Library for visually impaired in Prague (KTN). The KTN enables access to information and art to impaired people through audio files, Braille, embossed graphics, and digital texts. The KTN provides an online Biblio service [75] where titles in digital form are available for registered users proved by a ZTP card (severe health disability identity card).

[9]Council Directive 91/250/EEC of 14 May 1991 on the legal protection of computer programs; Council Directive 92/100/EEC of 19 November 1992 on rental right and lending right and on certain rights related to copyright in the field of intellectual property, as amended; Council Directive 93/98/EEC of 29 October 1993 harmonising the term of protection of copyright and certain related rights, as amended; Directive 2001/29/EC of the European Parliament and of the Council of 22 May 2001 on the harmonisation of certain aspects of copyright and related rights in the information society; Directive 2001/84/EC of the European Parliament and of the Council of 27 September 2001 on the resale right for the benefit of the author of an original work of art; Directive 2004/48/EC of the European Parliament and of the Council of 29 April 2004 on the enforcement of intellectual property rights.

2.4 Raspberry Pi platform

The Raspberry Pi is a series of single-board computers developed by the Raspberry Pi Foundation (United Kingdom). The Raspberry Pi platform is widely used thanks to good price-performance ratio and developer-friendliness. Raspberry PI Zero W is a computer with dimensions: 65mm x 30mm x 5mm and built-in Wi-Fi[10] module (the other key parameters can be seen in Figure 2.15). Raspbian is the official supported operating system for Raspberry Pi based on Debian[11] optimized for the Raspberry Pi hardware [76]. The operating system is still under active development.

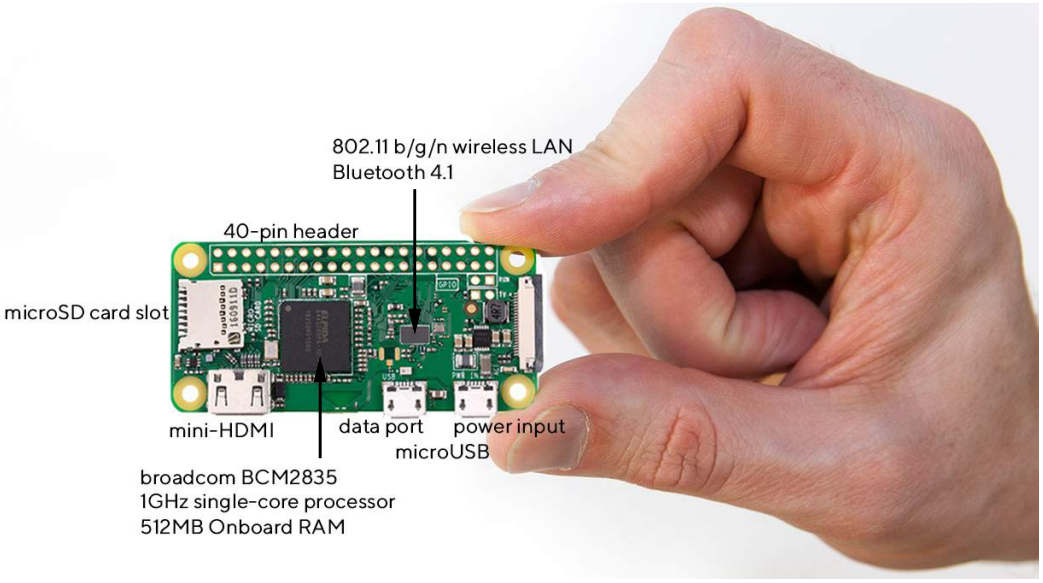


Figure 2.15: Raspberry Pi Zero W board from [77]. The Raspberry Pi is open hardware, with the exception of the primary chip, the Broadcomm System on a Chip (SoC), which runs many of the main components of the board: Central Processing Unit (CPU), graphics, memory, the USB controller, etc [78]. The General-purpose input/output (GPIO) allows to connect some hardaware components. It is possible to control GPIO pins using a number of programming languages and tools.

Raspberry Pi has been used in a wide array of digital maker projects, from music machines and parent detectors to weather stations [79].

[10]Wi-Fi is technology for radio wireless local area networking of devices based on the IEEE 802.11standards.

[11]Debian is a free operating system and includes the basic set of programs and utilities that make the computer run.

2.5 User Research

We conducted a qualitative user study with nine participants to get insight into the topic of audio-content consumption by visually impaired individuals. The discussed topics were: what they read and listen to; how do they read[12]; where they read; and which devices they use.

2.5.1 Participants

We interviewed nine participants, six female. Average age was 63,1 ($MIN = 36$; $MAX = 92$; $SD = 23,7$; Table 2.2). Four have category 4, five category 5 visual impairment [80], three were congenitally blind, six were late blind. The average duration of impairment onset for late blind participants was 19.5 years ($MIN = 5$; $MAX = 42$; $SD = 15.6$).

ID	**sex**	**age**	**degree**	**how many years is visually impaired**	**interview transcript**
P1	female	40	4	17	A.1
P2	female	41	5	41	A.2
P3	female	70	5	7	A.3
P4	female	42	4	42	A.4
P5	male	36	4	36	A.5
P6	male	68	4	13	A.6
P7	female	92	5	6	A.7
P8	female	90	5	5	A.8
P9	female	89	5	9	A.9
Average (AVG)		63,11		19,56	
Standard deviation (SD)		23,72		15,61	

Table 2.2: Participants of user study. The degree belongs to Classification of visual impairment according to WHO [80].

The sample size – nine participants was determined accordingly to the research method used - semi-structured interview. We stopped recruiting additional participants when our saturation criterion was met (no substantial new insights were gained by interviewing the last two participants). Relatively low number of participants is also determined by complicated methods to reach such a specific user group and correspondingly high costs per participant.[56]

2.5.2 Procedure

We conducted nine semi-structured interviews in an informal, quiet environment (dedicated room at the university, participant's room in a residential home facility). Each interview was recorded with the consent of the participant and took approximately 20

[12]We use the term to read also in meaning getting textual information using assistive technologies through the audio modality.

minutes. The recorded interviews were transcribed and transformed to factoids that have been grouped by topic [81]. We report information relevant to our design.[56]

2.5.3 Results

The study indicated that the most popular presentation of the content is the audio-book – a book read by a human speaker. P2: *"I prefer audio books because the voice does not sound so artificially."*. The listener is sensitive to the way an audio-book is produced: P2: *"Although the priority is the story, I postponed some books because of the speaker."*; P6: *"I follow the book, if there is music, or if the voice is pleasant."*. Only P3 prefers the TTS to audio-book: *"Those audiobooks sometimes make me angry, when the speech is too exaggerated as a theater. I prefer some more space for my interpretation."*.

Participants read primarily at home (in private). P3: *"I like to listen to and during this, I do some quiet work, such as dusting."* The bed is a specific place, where most participants prefer to read. P9 would like to listen to in her chair beside the bed, but it is blocked by too short a cable. P6, who is the client of the residential care home, likes listening to books in the smoking room. Participants prefer the use of headphones only in public areas to avoid disturbing others. Participants listen to the books mostly alone; only P1 said she sometimes listens to a book with someone else. P7 listens to radio when her roommate is not in the room to avoid disturbing her.[56]

Many clients of the residential care home use old devices, typically provided by family members — for instance, an MP3 player with small buttons, which are hardly usable for them. In contrary, some clients use new devices more specialized for seniors. However, there are still substantial issues that compromise efficient usage. Several devices do not support rewind function, P6: *"I bought a radio in which the flash drive can be inserted for playback. It remembers the place where it ended playback. It supports skipping chapters, but not rewinding. And when I fall asleep, then I have to move around the whole chapter."*. P7 would like to listen to books, but she lacks the appropriate equipment. The handling of content is quite complicated rather than based on concepts and metaphors already known by the target user audience.[56]

Participants who search for the content themselves use KTN (more in 2.3). P9 can not get the books on her own, so the books are downloaded, burned to CD and brought by her grandson into the Palata.

2.6 Requirements

This section is dedicated to the second phase of UCD process, specifies the requirements for the proposed device. Requirements are based on results of realized user study, consultation with visually impaired expert user Lukáš Treml, related work and analysis of existing solutions.

The functional requirements are:

R1: ***Playing audiobooks.***
The user research has shown that audiobooks are more popular than TTS thanks to natural sound.

R2: ***Remote content management.***
The content management process should be facilitated by remote access because the target users cannot work with a computer so the content will be managed by another person (nurse, descendant, a library officer, etc.). Therefore the player should be able to connect to the Internet. The cloud application opens up additional options for configuring the device by the specific preferences.

R3: ***The choice of book.***
The device should be able to offer several books at a time; the user could choose the book according to the current mood and situation.

R4: ***Automatic bookmark for each book.***
The user research has revealed that the bookmark is a useful feature when listening to books. Users most often use a bookmark to mark the location where they ended with reading, so they could start there next time.

R5: ***Skip track.***
The skip track is a function present on all of the analyzed devices because it is important for user control of the content.

R6: ***Rewind.***
The interviewed participants said they sometimes use rewinds, for example, when they miss a word. One of the participants said he misses the rewind function on his device.

R7: ***Volume adjustment.***
The required volume may vary in different situations. It should be possible to change the volume according to current conditions and preferences.

R8: ***Clock.***
Blind users easily lose the notion of time, even if it is day or night. Therefore, it is important that they have information about the time available.

R9: ***Speakers and headphones.***
According to user research, users prefer to listening by speakers, but in the presence of other people they use headphones to avoid disturbing them. The device should support both options.

R10: ***Battery state.***
If the device is battery-dependent, the user should be able to find out how much reading time left. In case the device is charging, the user should be able to get the remaining charging time.

The non-functional requirements are:

R11: ***Portability.***
Some participants of user research like to listen outside of their room.

R12: ***Safety.***
The device should not be dangerous for the user, not contain sharp corners etc.

R13: ***Hygiene.***
The visually impaired user can easily dirt the device due to lack of self-control over the purity of his hands. The device should be cleanable.

R14: ***Usability.***
The user interface should meet the needs, habits and limitations of visually impaired older adults. Support the understanding of the control by usage of appropriate real-world metaphors. The metaphor should link the control with generally known concepts by the target audience, such as described example in 2.2.2.

R15: ***Toughness.***
The design should take into account clumsily usage and not contain any easily damageable parts.

Chapter 3

Design

This chapter follows the design phase of the UCD process [8]. The goal of this design is to naturally blend the affordances and strengths of physically manipulatable interface with a digital audiobook content, thereby leveraging the particular strengths of each [62]. We called the device *Reprobooktor* – meaning loudspeaker plus book. In the section 3.1 the purpose of the designed device is summarised. The next section 3.2 is dedicated to the model of our user. The description of the situation context through scenarios and story-boards is presented in section 3.3, respectively in section 3.4. The next section 3.6 reports the sketches of both prototypes. Sections 3.7 and 3.8 describes prototypes of the device.

3.1 UCD Canvas of Reprobooktor

The purpose of *Reprobooktor* is summarised in Figure 3.1 by UCD canvas method [82].

3.2 Persona

We chose the target user group for the book player according to the analysis of existing book players (described in 2.2.2) and user research results (described in 2.5). As primary user group of designed book player device, we have opted visually impaired older adults who do not use a PC. We found that available devices do not meet the needs of this target group as much as they could. As a representative of the target users, we present a persona Alena in Appendix B. Persona was based on the fundamental research described in [1].

3.3 Scenarios

We present the scenarios related to the focus of this thesis, describing the interaction between an user of primary user group and the book payer device. The list was updated

User Centered Design Canvas

by The Rectangles

3. PROBLEMS

- there is no intuitive device for listening to audiobooks
- does not understand the control of music players
- can´ t perceive the feedback of devices with display
- can´ t use a computer, search for and download audiobooks, upload them to the player
- fears that the electronic device is sensible to damage
- the MP3 player control panel is small, and the buttons are too close together
- worried that by mistake, the player will accidentally start another action than he wants
- fears that the device will be disabling by unwanted action
- existing players do not support required functions

4. MOTIVES

- wants to listen to audiobooks freely and autonomously
- wants to choose a book out of several options
- wants to be able to move a little bit back, in case of interruption, missing a few words
- wants to know what time is it
- takes control of a device, know how long the battery will stay or charging
- wants to choose out of several favorite radio stations and listen to it

5. FEARS

- the device will be too complicated
- the device can be easily damaged
- book uploads will be too complicated
- the device will not be cleanable

1. BUSINESS

Reprobooktor
device for listening to audiobooks

2. USERS

Visually impared older adults, who do not use a computer

9. UNIQUE VALUE PROPOSITION

REPROBOOKTOR - uses metaphors with a real world, modern technologies and user experiences to achieve the most comfortable control of bookplayer device by the visually impaired older users.

8. COMPETITIVE ADVANTAGES

- simple and tactile-friendly UI
- metaphors with real world
- implemented required functions
- wathches
- remote content management access
- voice feedback

7. ALTERNATIVES

- Plextalk device
- EJiasu mini digital player
- Auna Boomberry Portable Boombox
- BoomBox plus
- Milestone
- Sovereign USB Memory Stick Player

6. SOLUTIONS

- intuitive UI thanks to real-world metaphors
- usage of natural mapping and appropriate controls
- UI without display
- appropriate haptic or voice feedback for each interactive element
- remote book-content management system and device configuration
- durable materials and robust construction against shocks, falls, and unskilled handling
- sufficiently large controls and far enough apart
- design distinguishing controls of different meanings
- stable controls
- no overloaded buttons with more features
- minimal volume level is set above the human ear hearing threshold
- implement the detected required user control controls from user research

Figure 3.1: UCD Canvas of Reprobooktor, based on [82].

during the iterative design process.

S1: Reading book using speakers

Alena just finished her lunch. As usual, she is going to rest with her *Reprobooktor*. She puts a *Reprobooktor* from a shelf and sits on the bed. She opens the *Reprobooktor* and places it on the table beside her bed. She comfortably lies and listens. After a while, she starts to fell sleepy. She closes the *Reprobooktor* by the left hand and falls asleep. The next day she opens the book, and the reading begins at the position where it ended yesterday.

S2: Reading book using headphones

It's a warm spring afternoon, the sun is shining. Alena decided to spend part of her afternoon on a park bench. Firstly, she checks whether the device is sufficiently charged. The *Reprobooktor* says it's up about two and half hours to discharge. She takes her charged *Reprobooktor* and headphones from the shelf and comes out of the room, calls the elevator and goes to the basement. After going out of the main exit, she goes left about twenty steps to her favorite bench. She sits down, plugs headphones and listens.

S3: Interruption of reading process

It's morning, and Alena woke up earlier than usual. After a moment of failing to fall asleep, she decided to fill the time by listening to a book. Alena opens the *Reprobooktor* player and begins to listen. After thirty minutes, nurse brings the morning medicaments. She closes the *Reprobooktor*. When she takes medication, she opens it again to find out how the story goes on. By re-opening the book player, the playback was pushed a few seconds back, but Alena rewinds a bit more to get back into the context of the story.

S4: Skipping track

Alena has finished a book and wants to start reading a new one. She agreed with her grandson to upload the new books. Alena switched to the book titled as "Hangman", she has heard nothing about this book before. Alena presses the info button to learn something about this book. She found that this book is a detective story, what is her favorite genre. She opens the *Reprobooktor*, and the playing starts. The first track is about the rules of usage that Alena has heard many times. She decided to skip the track to the next one where the narrative begins.

S5: Battery charging

Alena listens to the *Reprobooktor* on the park bench. Suddenly, the *Reprobooktor* reports that the battery is weak. Alena finishes the unfinished track and goes back to her room.

After comming back into the room, she puts the headphones on the shelf and takes the charger and connects it to the *Reprobooktor*. The device reacts by: *"the device will be fully charged in hour"*.

S6: Clock

Every Tuesday afternoon, the event so-called "Café"[1] is held. Alena likes to participate. Before this event, she usually reads or sleeps. This time, she listens to the book in her bed. She knows that to arrive in time, she has to leave the room at the latest at 15:50. She uses the clock function on the *Reprobooktor*. The time is 15:46, therefore she stops playing and leaves for the Café event.

3.4 Story-boards

In this section, we present the selected storyboards illustrating usage of the book player device. Both storyboards can be found in Appendix C.

1. Storyboard: Reading using speakers
2. Storyboard: Reading using headphones

3.5 Use Cases

In this section the use cases, the generalized scenarios are presented. The detailed description of can be found in Appendix D.

UC1: Reading book using speakers

- Corresponding scenario: S1.
- *The user picks up the book for listening and then listens to it.*

UC2: Reading book using heapdphones

- Corresponding scenario: S2.
- *The user connects the headphones, selects the book and listens to it.*

UC3: Interruption of reading process

- Corresponding scenario: S3.
- *The user is interrupted while listening.*

[1]The activity with live music in Home Palata

UC4: Skipping track

- Corresponding scenario: S4.
- *The user skips the track that he doesn't want to listen to.*

UC5: Battery charging

- Corresponding scenario: S5.
- *The user has found that the battery is weak, he connects the device to the power supply.*

UC6: Clock

- Corresponding scenario: S6.
- *The user gets to know the current time.*

3.6 Sketches

Concerning the target group and the purpose of design, we decided that the book player should resemble the look and feel of a regular book as depicted in Figures 3.2 and 3.3. The shape of the book allows using metaphors, such as: turning on reading by opening, turning off by closing. The most important functional requirements that resulted from our user study and domain analysis are: volume control, skipping chapters, rewind, bookmark, and switching between particular book titles that can be presented by the device. The content management and configuration of the device can be seen in Figure 3.5. This thesis is focused to the listener–book player interaction, the design of the cloud application is not included.

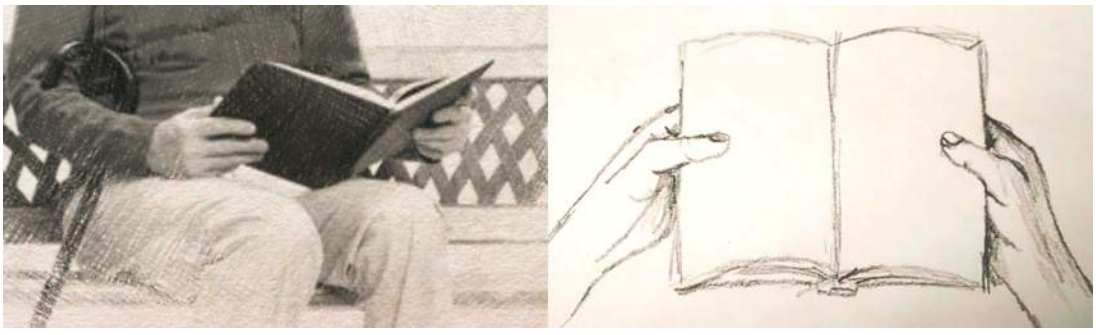


Figure 3.2: Grasping the book as inspiration for our design.

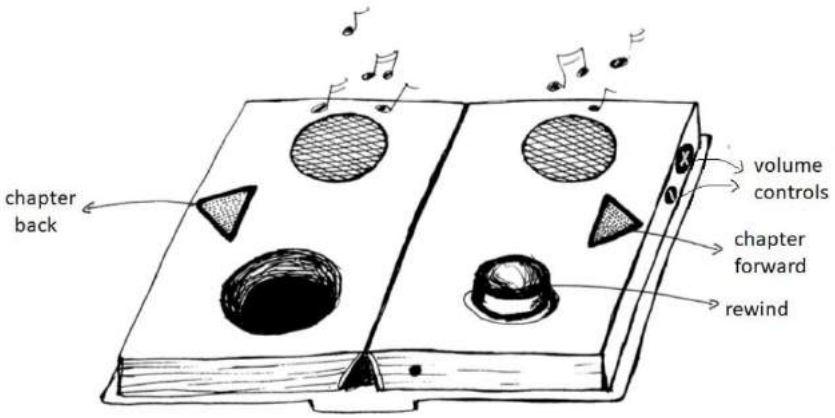


Figure 3.3: The first sketch of *Reprobooktor*. The drawing shows device resembling a regular book with tactile controls. The book is open. There are two round loudspeakers, two triangle buttons to skip chapters and a large round knob for rewind.

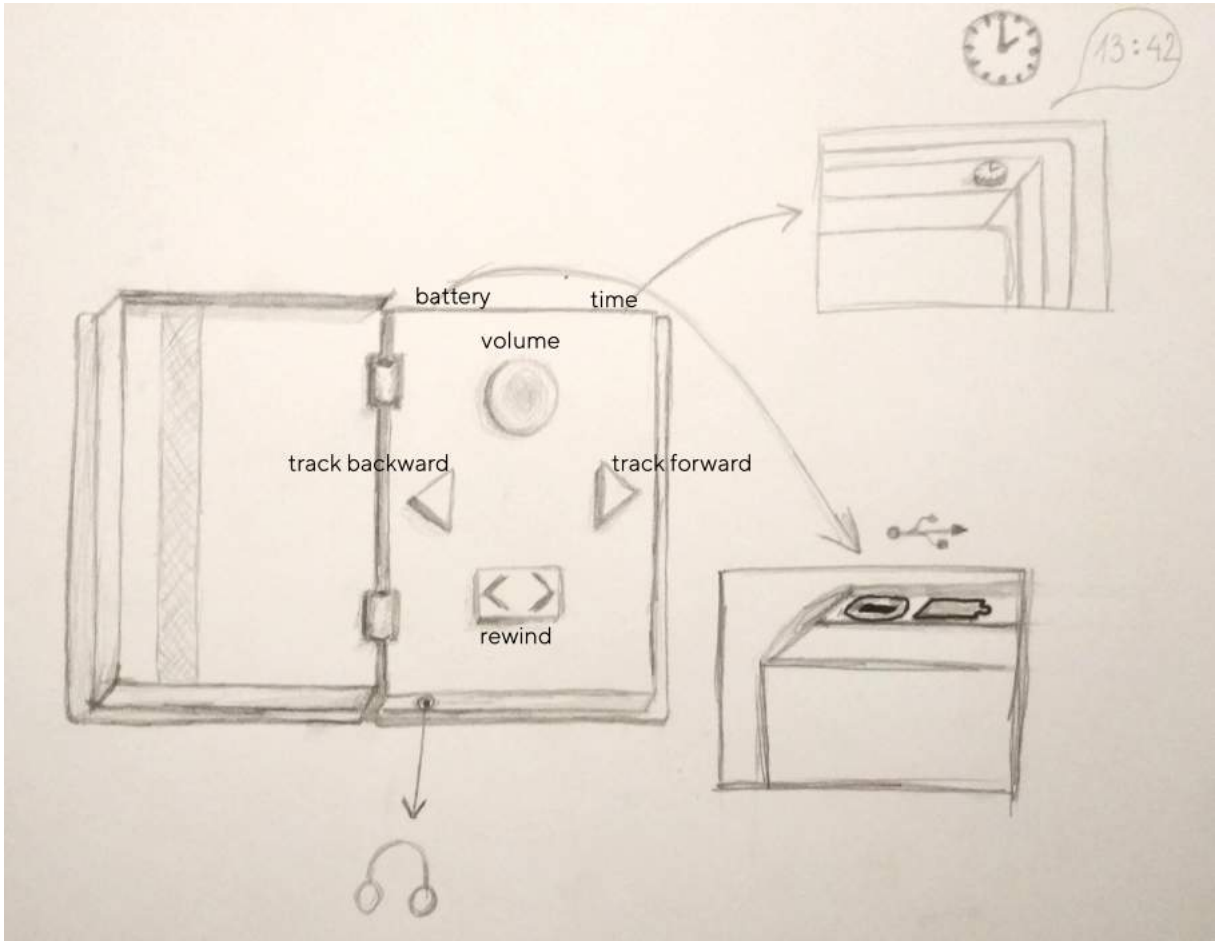


Figure 3.4: The second sketch of *Reprobooktor*. The drawing shows new component layout and added buttons.

Figure 3.5: This figure shows the intended way to manage the contents and configuration of the Reprobooktor. A cloud application can facilitate book uploading thanks to remote access. Also, it offers the link to existing services, such as KTN's Biblio service [75]. The cloud application can pre-process the uploaded content, for example, process the text from a magazine using TTS. The application can provide the advanced configuration of the device according to the specific preferences: adjust the report messages, speed, and so on.

3.7 Low-fidelity prototype

According to sketches we made the first prototype, figure 3.6 shows the implementation. The production of the physical prototype is documented in the Appendix G.

A user can use a handle on the front side of the book to select one of six book titles. Each title is represented by a rectangular element, which, due to the aspect ratio, reminds the thumbnail of the book. The placement of this component corresponds to the arrangement of the book title on the regular book. The particular book title (a pre-processed text by TTS into audio file) are played back as the handle is moved to a corresponding position. Book playback starts as the book is opened. There is an automatic bookmark function. The player begins reading at the same position as it stopped the last time. In case of a more extended idle period (more than few minutes), it plays a part of the content again to support reminiscence. The rewind function is supported by round handle (rotary encoder). When selecting the placement of buttons for switching chapters, we came out of the grip of the book in the Figure 3.2. For skipping chapters, we choose buttons with a triangular shape with vertices gradually raised. One reason was to highlight the corner towards the end/beginning of the book; the second reason was to make the comfortable shape to accommodate a thumb.[56]

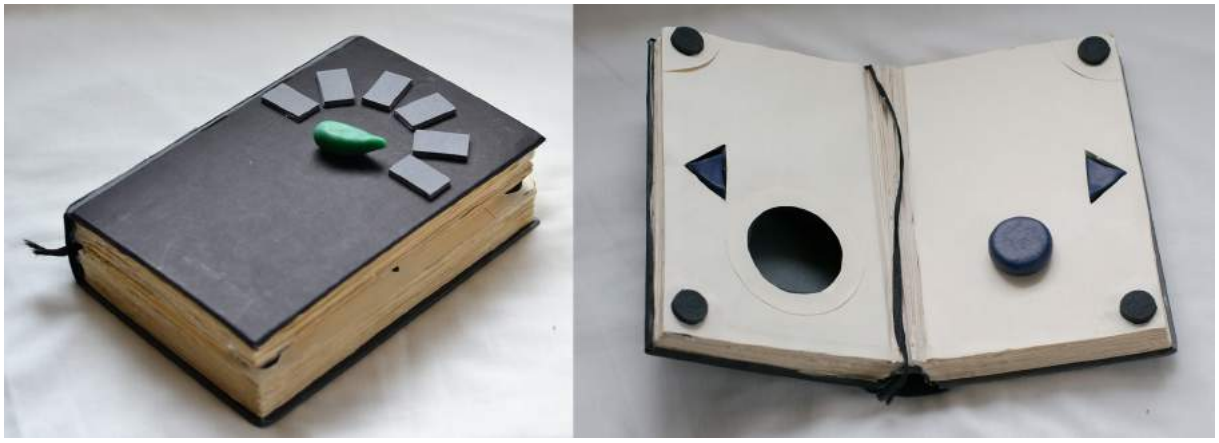


Figure 3.6: A physical prototype of *Reprobooktor* with tactile control elements. Two photos show the book closed (left) and opened (right). In the closed state, there is a handle that allows switching between particular book titles. While opened, there are tactile controls that correspond to the description in Figure 3.3 above.

3.8 High-fidelity prototype

In this section, we present design of 3D-printed high-fidelity prototype showed in Figure 3.8 and Figure 3.9. The main design concept is similar to Low-fidelity prototype. Based on the test result, we decided to implement several changes. The dimensions of the entire device are smaller, but the size of the controls is preserved. All internal controls was placed on the right panel of the book. The sliding potentiometer (volume control) was replaced with a rotary knob. The rotary encoder for rewinding has been replaced by a button component. The power input was added to the prototype accompanied with a battery status button, designed into the battery shape. A watch button shaped like a miniature watch was placed on the device. Battery and watch button were placed so that they were accessible both in the closed and open condition. For the switch on the front side (pictured in Figure 3.8), we decided to implement the *clock reference system* [83]: twelve switch positions correspond to the number layout on the watch. By using a familiar concept, we want to support component orientation and facilitate communication between the content manager and the book listener. The items: 3, 6, 9, and 12, are marked by a substantial sign for better orientation in the layout. In each position is the yellow circle info button, after which pushing the additional information for the book title will be reported: the first click starts the message, the second stops.

The book panels were connected with a hinge that allows the device to hold open and closed. The device is more suited to listening while placed on a flat surface such as on a bedside table, shelf, table. Rubber legs are placed on the underside. The built-in speaker in the left panel is more powerful to enable louder playback.

The development of this prototype lasted for quite a long time (approximately five months). Fusion 360 [84] was chosen as the modeling tool. The modeled parts of the prototype can be seen in Appendix H. Individual parts were printed by a 3D printer. The

printing of the left inner side is depicted in the Figure 3.7.

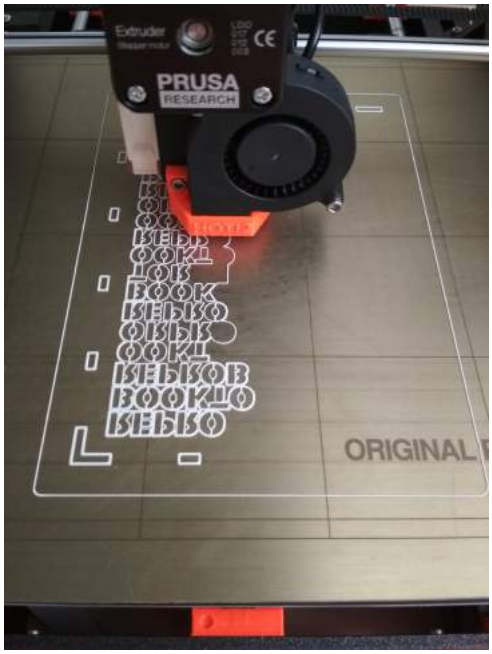


Figure 3.7: 3D printing of high-fidelity prototype. All components were printed on Prusa MK3 [85]. Polylactic Acid (PLA) was selected as the material.

The components were iteratively improved to meet the design requirements, the interaction of particular components can be seen in Appendix I. The interim results of the user interface design were consulted with the visually impaired expert[2].

Figure 3.8: A 3D-printed prototype of Reprobooktor with tactile control elements. Two photos show the book closed (left) and opened (right). In the closed state, there is a handle that allows switching between particular book titles. The yellow circular buttons provide information about the book title. While opened, there are tactile controls that correspond to the description in Figure 3.4 above.

[2]The orientation system expert, a librarian and former employee of a residential care home for visually impaired older adults.

Figure 3.9: The left image shows the added battery status button, watch button, and power connector on the high-fidelity prototype. The right image shows the rubber leg.

Chapter 4

Implementation

This chapter describes the implementation of low-fidelity prototype (specified in Section 3.7) as well as high-fidelity prototype (specified in Section 3.8). The implemented applications provide the music player functionality for which was used the Music module of Pygame [86]. Both prototypes use the common classes written in Python 3 [87]. The state diagram of application can be seen in Figure 4.1, class diagram can be found in Appendix M. Individual applications differ from each other in event listening.

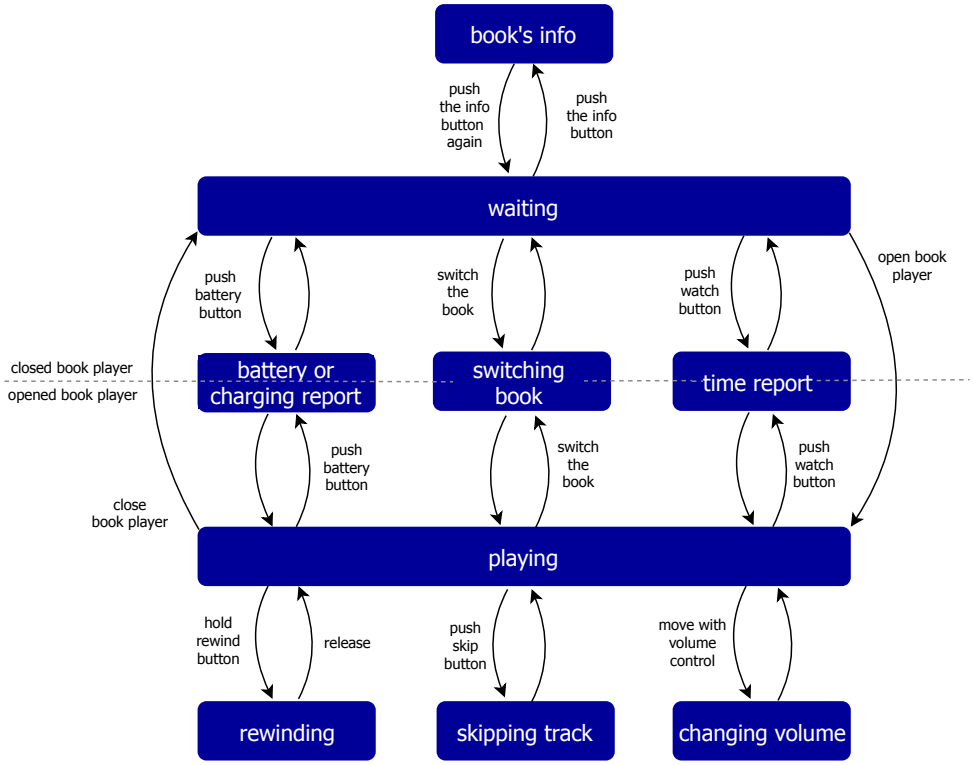


Figure 4.1: In the diagram are possible states and their transitions of *Reprobooktor* pictured.

4.1 Low-fidelity prototype

In this section, we present the implementation of an application that simulates *Reprobooktor's* function in experiments described in 5.2 and 5.3. The GUI of application provides buttons for each action that a user can do with the physical prototype (the GUI can be seen in Figure 4.2). The the GUI application was written in Python 3 [87] and based on Tkinter module [88], the standard Python interface to the Tk GUI toolkit. The individual buttons are mapped to the audio player methods mentioned in the introduction of this chapter. After the first experiment, keyboard shortcuts were implemented to ease the simulation.[56]

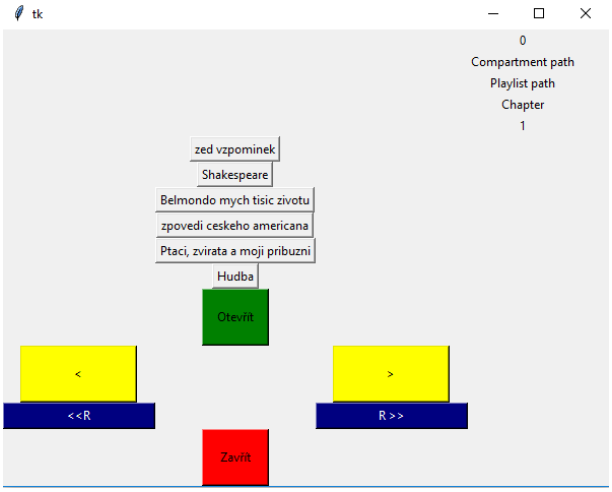


Figure 4.2: GUI of python application for the simulation of *Reprobooktor* functions.

4.2 High-fidelity prototype

As the core of high-fidelity prototype, the Raspberry Pi Zero W was used. The control components of UI were connected via the microcontroller Arduino Pro Micro [89]. The description of implemented hardware and software follows.

Hardware

The wiring is illustrated in Figure 4.3. Raspberry Pi Zero includes digital connection points GPIO, no analog inputs. We solved the connection of the analog components through micro-controller Arduino Pro Micro [89]. In addition, the connected Arduino Pro Micro can handle also digital inputs. Arduino sends information about the state of each input to Raspberry via USB[1].

The expansion module Adafruit Speaker bonnet [90] provides the audio output. The bonnet includes a 3W stereo amplifier and communicates with the Raspberry Pi by Inter-

[1]USB is an industry standard that establishes specifications for cables, connectors and protocols for connection, communication and power supply.

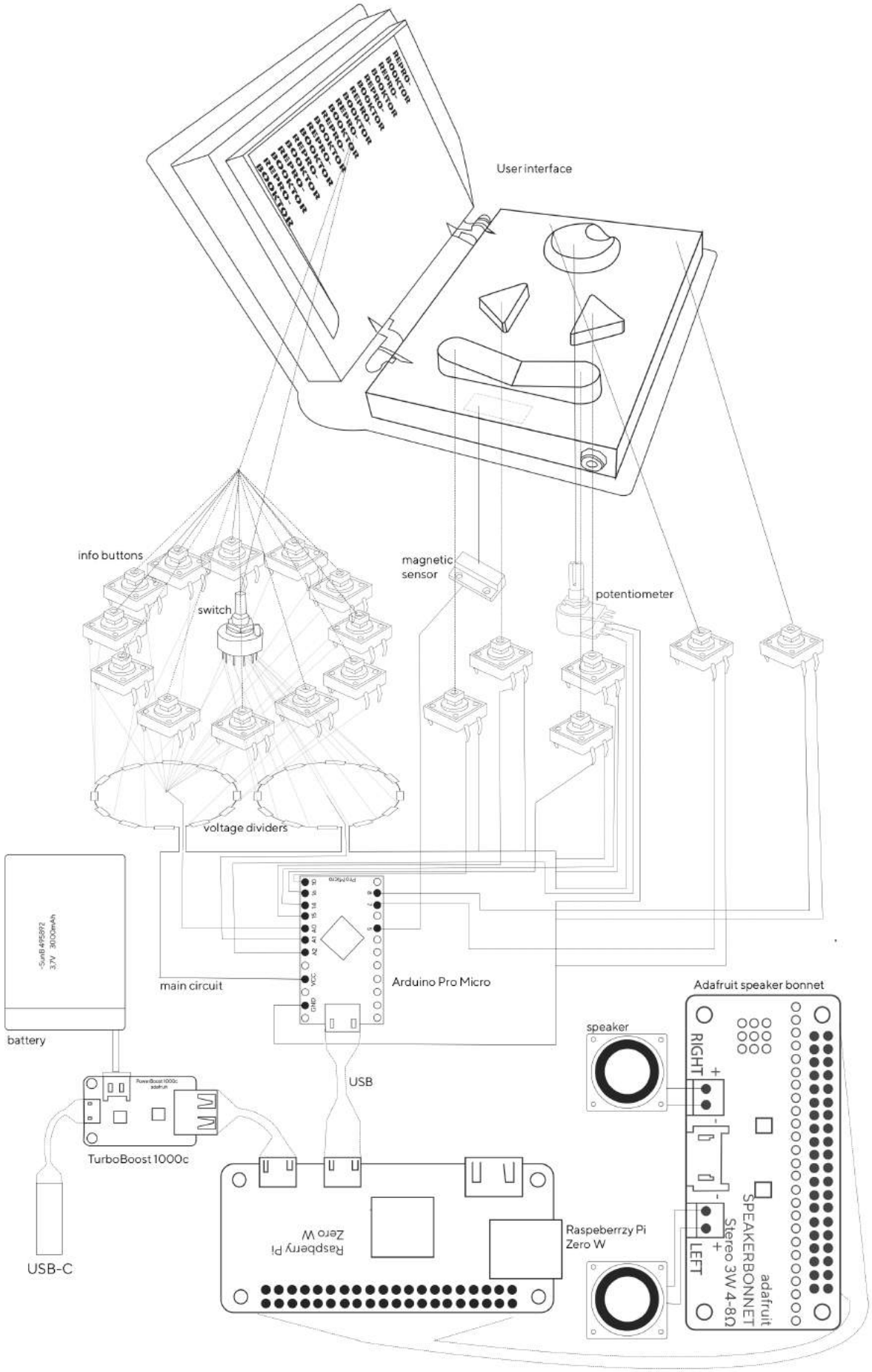


Figure 4.3: Connection of hardware components of the *Reprobooktor* device.

Integrated Circuit (I2C)[2]. Power supply module PowerBoost [91] deals with the connection between the battery, motherboard, and charger.

The user interface of *Reprobooktor* consists of eighteen buttons[3], one switch[4] and one potentiometer[5]. The switch and info buttons are connected to Arduino's analogue pins via a voltage divider to reduce the required number of input pins. A potentiometer for volume control is connected to the third analogue pin. Other components use digital pins.

UI element	**hardware**	**pin**	**arduino input[6] data range**	**arduino output data range**	**parsed string position**
Switch	switch and rezistors [92]	A0	15-1023	1-12	0
Info buttons	buttons and rezistors [93]	A1	0-1023	0-12	1
Volume	potentiometer [94]	A2	0-1023	0-100	2
Opened or closed	magnetic sensor [95]	5	0 or 1	0 or 1	3
Battery	button [93]	7	0 or 1	0 or 1	4
Clock	button [93]	8	0 or 1	0 or 1	5
Rewind backward	button [93]	10	0 or 1	0 or 1	6
Rewind forward	button [93]	16	0 or 1	0 or 1	7
Skip track right	button [93]	14	0 or 1	0 or 1	8
Skip track left	button [93]	15	0 or 1	0 or 1	9

Table 4.1: The table describes data transfer from user interface elements to the application core. The "pin" column refers to Arduino. "A" marks an analog pin.

Software

The software of high-fidelity prototype consists of two main parts: Arduino script (reading of inputs) and application on Raspberry (player functions, the common part with the Low-fidelity prototype). The Arduino script was based on a code example described in [96]. The script presents the state of the user interface elements wired to the pins (specified in the Table 4.1).

The structure of the *Reprobooktor* file system used in Raspberry Pi is described in Appendix P. The Raspberry application is started by script (main.py), which is in the operating system set as a service[7]. *"Reprobooktor"* service is set to start after booting and restart in case of failure. *"Reprobooktor.py"* listens the data through the PySerial module [98] in the infinity loop. When the status change is recognized, the corresponding event is triggered. The *"Compartment"* class provides the player functions, loading files, position storage, etc. The Response to the status of the user interface elements is

[2]I2C (Inter-Integrated Circuit) is synchronous, serial computer bus.
[3]18 buttons require 18 digital inputs or through a voltage divider to connect to an analogue pin.
[4]12-contact switch requires 12 digital pins or an analogue pin.
[5]Potentiometer requires an analog pin.
[6]Arduino input means the output of the integrated Analog-to-digital (AD) converter.
[7]Services on Raspberry Pi are managed by [97].

provided by the reprobooktor.py script, which includes following event handlers (detailed in Appendix F):

- ***Opening:*** The opening sound effect is played. The playback starts from the stored bookmark position minus 5 seconds.
- ***Closing:*** The closing sound effect is played. The playback stops. The current position is stored into the bookmark json[8] file.
- ***Book switching:*** The switching sound effect is played. The compartment is loaded, and the book title message is played.
- ***Info:*** If the position of pressed info button corresponds to selected compartment position, the sound effect followed by info message is played. If the button is pressed for the second time, the info message is stopped.
- ***Forward skip:*** The playback stops. The sound effect is played, and the lexicographically following song starts. In case of the last track, the "End" message is played.
- ***Backward skip:*** The playback stops. The sound effect is played, and the lexicographically antecedent song starts. In case of the first track, the "beginning" message is played, the first track follows.
- ***Forward rewind:*** The time of pressed button is measured. The rewinding sound effect is playing until the button is released. The measured time is recalculated according to the quadratic function and added to the playback position, playback starts.
- ***Backward rewind:*** Implemented similarly as *Forward rewinding*.
- ***Clock:*** The pushed button sound effect followed by the time message is played. In the case of active playback, the additional tones are added to separate the time message form readings. When resuming playback, the position is automatically rewound by five seconds. The last phrase is repeated to make the return to the story easier.
- ***Battery:*** The pushed button sound effect followed by the battery status message is played (resp. charging status). The resuming is implemented similarly as in *Clock* button.
- ***End of track:*** When the end of track is detected, the event *Forward skip* is triggered.

[8]JSON: JavaScript Object Notation, a syntax for storing and exchanging data.

Chapter 5

Evaluation

This chapter describes formative qualitative evaluation performed during the *Reprobooktor* development, the fourth phase of UCD process. The primary aim of the evaluation was to assess the usability of the *Reprobooktor* device with representatives of the target user audience. We conducted four experiments. The first informal experiment (described in 5.1.4) with a mixed audience (sighted older adults and visually impaired expert) to gain early feedback and to reveal possible pressing design issues. The next two experiments have a form of a usability study. Their purpose was to assess the usability of *Reprobooktor* device from the perspective of the visually impaired in general (described in 5.2), respectively form the perspective of visually impaired older adults (described in 5.3) in the case of the final study. The purpose of the fourth experiment was to verify whether the final changes did not disturb the usability of the design (described in 5.4).[56]

5.1 Early feedback

"*Aiming at early feedback from the users, we conducted an informal experiment with three participants, two older adults without significant vision impairment and one visually impaired individual. By this test, we aimed to reveal serious design issues of the prototype before conducting complex experiments. The older adults helped with investigating whether the concept is understandable for the elderly, while the visually impaired participant focused primarily on the usability of the tactile interface components.*" [56] The transcripts can be seen in Appendix J.

5.1.1 Participants

"There were two older adults – 77 years old female and 82 years old male. The visually impaired was 42 years old a male – orientation system expert, a librarian and former employee of a residential care home for visually impaired older adults. The small sample size reflects the need to gain rapid feedback on the design to mitigate serious design issues before evaluating the product with harder to reach user audience." [56]

5.1.2 Procedure

"The experiment was conducted with the older adults in their home environment. They picked up the device and explored it. During the experiment, they were given assignments and were asked to follow the think-aloud protocol to describe their solution. The test with the visually impaired user took place in one quiet office at the university; the procedure was similar. In the post-test discussion, the evaluation with the visually impaired expert adopted a form of participatory design as he was asked to suggest improvements." [56]

5.1.3 Results

"The test indicated that magnets at the corners of the device and unusual shape of the buttons to switch chapters are disturbing the interaction. The visually impaired participant perceived raised edges as separate objects, not as a single triangular button. The evaluation also pointed out the need to add a volume control component. The third finding was the shape of the elements representing the titles. The user associated their shape with button, not the thumbnail of a book. The individual elements were too close to each other and had too much area." [56]

Figure 5.1: *Reprobooktor* prototype with implemented changes based on the first informal study results.

5.1.4 Design changes

"After this test, we decided to change the shape of the title elements from rectangular to simple lines. We also removed magnets and added a linear potentiometer for volume control. We placed it on the right side of the device to be manageable even when the book is closed. The control follows a metaphor where the volume increases when one moves it up (to the top edge of the book) and decreases in the opposite direction. The surface of the buttons for switching chapters has been redesigned to be flat. Finally, we added a headphone jack input with haptically recognizable border. The updated prototype is in the Figure 5.1." [56]

5.2 General acceptance of Low-fidelity prototype with visually impaired

An advanced prototype of *Reprobooktor* was evaluated through a usability study with representatives of the user group of visually impaired individuals. In this study, we recruited participants without restricting their age to assess general acceptance of the prototype by visually impaired. Experiment guide can be found in Appendix K, transcripts in L.

5.2.1 Participants

"The prototype was evaluated with seven users (P1 – P7), four male representing the user group of visually impaired. Their age ranged from 33 to 70 (mean = 45.6, $SD = 12.9$). All participants have category 4 of category 5 [80] vision impairment. Four of the participants are congenitally blind; the others become blind lately. All participants have the experience of reading books. They read by a computer, a mobile phone, an MP3 player, a radio player with a USB input (similar to the device in Figure 2.12) or a dictaphone. The sample size was determined accordingly to the evaluation method used - usability test / first impression test. Participants were selected to represent the visually impaired in the Czech Republic according to demographic distribution (age, gender, impairment onset) [99]. The number of participants is typical for this type of experiment [100]." [56]

ID	**sex**	**age**	**degree**	**vision loss (how long)**	**transcript**
P1	male	41	5	lately blind (10)	L.1
P2	male	33	4	congenitally blind	L.2
P3	female	42	4	lately blind (19)	L.3
P4	male	53	5	congenitally blind	L.4
P5	male	47	5	congenitally blind	L.5
P6	female	70	4	lately blind(7)	L.6
P7	female	33	4	congenitally blind	L.7
AVG		45.6			
SD		12.9			

Table 5.1: Participants of low-fidelity prototype experiment: general acceptance by visually impaired. The degree belongs to Classification of visual impairment according to WHO [80].

5.2.2 Procedure

"The usability study was conducted in laboratory settings, and it took maximally half an hour. Participants were using a prototype of Reprobooktor*, and its function was simulated using a computer application by employing the Wizard of Oz method [101]. A computer reproduced the sound. The participants were acquainted with the fact that the*

prototype is in the early stage of development. They were asked to think aloud that any that any of their comments would be useful for the further development." [56]

"The task of the first part of the test was to get acquainted with the device. The participants were told that the subject of the test is a book listening device. The participants then tried controls and thought aloud about their purpose. They were asked to describe the purpose and function of each particular control element. In the second part, participants were asked to comment on individual elements. The last part focused on the device as a whole. Participants answered the open-ended questions: What do they mean as the advantages/disadvantages of the Reprobooktor*; if they want to use* Reprobooktor *in their life and if so, then in which situation."* [56]

5.2.3 Results

"*The evaluation showed that the evaluated prototype is in general as understandable for the visually impaired. All participants recognized a similarity with the regular book. As the main disadvantage, five of seven participants reported that the device is too large. Four participants had a problem with a finding of the left switch chapter button. They expected all the controls to be placed on one panel. P2 felt the skip-track-buttons as over-sensitive. The available capacity (six books) is for two of participant too small, for the rest is sufficient. The automatic playback by opening is intuitive for all of the participants, but P3 and P6 would like to listen to the* Reprobooktor *in the closed state, to enable the listening during walking. Three of the participants expected the volume to be controlled by spinning. P6 and P7 are afraid they will accidentally break the volume control component because it protrudes from the device. P1 and P5 desire more advanced features such as paragraph skip and search.*" [56]

"*Everyone appreciated the automatic bookmark function, but P1, P4, and P5 would like multiple bookmarks in one title when listening to the expert literature. Six out of seven participants identified the convenience of simplicity of control, P6 authenticity. Five participants would use the device in practical life, for example, P2 in the kitchen where he does not want to use a computer; P3 in the bed before sleeping; P6 at home and also out of the home. P1 and P5 would not use* Reprobooktor *because they have more advanced devices to meet their needs better. Other interesting findings include: P3 would like to know how much time remains to the end of the book, P3 would like to speed of rewind was accelerated, P6 would like to vote a voice for TTS.*" [56]

5.3 Low-fidelity prototype with visually impaired older adults

The third experiment was conducted with representatives of the target user audience – visually impaired older adults living in a residential care home. The purpose of the test

was to determine whether the user interface is usable by the target group audience.

5.3.1 Participants

"The prototype was evaluated with seven users (P1 – P7, Table 5.2), three female representing the user group of visually impaired older adults. Their age ranged from 51 to 94 (mean = 73, SD = 15.7). One participant is congenitally blind; the others become blind lately. Participants have category 3 (P6), 4 (P5 and P7) or 5 of visual impairment according to WHO [80]. P3 and P7 are challenged with minor haptic impairment, P6 is challenged with dementia, P5 has a hearing disability. The sample size was determined accordingly to the evaluation method used - usability test / first impression test. Participants were selected to represent the visually impaired older adults living in residential care institutions. The number of participants is typical for this type of experiment [100]." [56]

id	**sex**	**age**	**degree**		**transcript**
P1	male	68	5	congenitally blind	M.1
P2	male	59	5	lately blind	M.2
P3	male	51	5	lately blind	M.3
P4	female	81	5	lately blind	M.4
P5	female	94	4	lately blind	M.5
P6	female	89	3	lately blind	M.6
P7	male	69	4	lately blind	M.7
AVG		73			
SD		15.7			

Table 5.2: Participants of low-fidelity prototype experiment: visually impaired older adults. The degree belongs to Classification of visual impairment according to WHO [80].

5.3.2 Procedure

"The usability study was conducted in a quite dedicated room in the residential care facility, and it took maximally half an hour. The procedure was similar to the previous test. The Wizard of Oz user interface for simulating Reprobooktor *functions has been optimized by adding keyboard shortcuts. In some cases, it was necessary to adapt the program of the test to the participant's capabilities and abilities, for instance, some part of the test was repeated and in one case omitted."*

5.3.3 Results

"This evaluation has shown that the simplicity and intuitiveness of the user interface is the determining usability criterion for the target group. The features: play, stop, automatic bookmark and book switch were understood by all users except P5. For P5, the reproduced sound was not perceptible, so the procedure was terminated at the beginning.

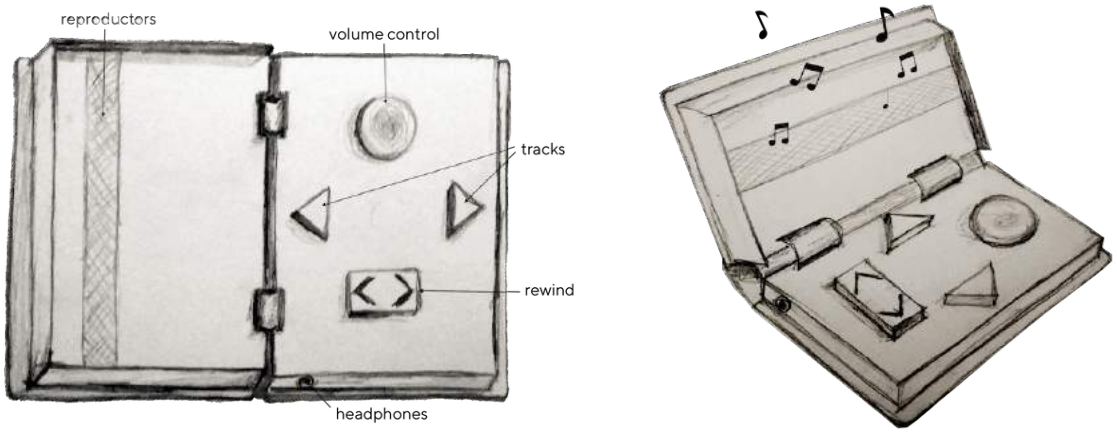


Figure 5.2: Sketch of the next generation of *Reprobooktor* prototype.

Five participants assigned the volume control function to the rotary encoder. P4 did not understand the function of switching tracks because she did not understand the concept of tracks, but she understood other functions. P1, P3, and P7 mentioned as a disadvantage the excessive size of the device. P3 would like to know more than title about available books. P7 mentioned the advantage of a rewinding function that his current player does not support." [56]

5.3.4 Design changes

"The layout of the next generation of the prototype is in Figure 5.2. The dimensions of the entire device will be smaller, but the size of the controls should be preserved. The built-in speaker in the left panel will be more powerful to enable louder playback. All internal controls will be placed on the right panel of the book. The power input will be added to the prototype accompanied with a battery status button. For each switch position an info button will be added." [56]

5.4 High-fidelity prototype

The test aimed to verify whether the changes made to the low-fidelity prototype did not interfere with the usability of the device.

5.4.1 Participants

Because the main concept of control has been tested already (described in the previous sections 5.1.4, 5.2, and 5.3) and changes of control concept are not considered as substantial, we have decided to recruit just two participants (P1–P2, Table 5.3), both female and 81 years old. Both have lost their sight at an older age, and the degree of their

disability is four[1]. P1 has lived in the residential care home Palata for eight years, P2 only for two months. Both participants currently do not listen to books because they do not have the appropriate equipment available.

id	sex	age	how long is imapired	degree	how long lives in Palata	transcript
P1	female	81	13	4	8 years	O.1
P2	female	81	5	4	2 months	O.2

Table 5.3: Participants table of high-fidelity prototype evaluation. The degree belongs to Classification of visual impairment according to WHO [80].

5.4.2 Procedure

The usability study was conducted in the participant's room in the residential care facility, and it took maximally half an hour. The experiment guide can be seen in Appendix O. The subject of the test was the prototype described in Sections 4.2 and 3.8. The experiment consisted of parts: informed consent, icebreaking, pre-test questionnaire, first impression test, six test tasks and post-test questionnaire. The tasks were based on use-cases described in the section 3.5.

5.4.3 Results

The overall impression of the device was positive in both cases. Some minor implementation deficiencies have been revealed. P1 pressed the info button too long, causing the triggered message to be turned off after a short time, which confused the participant. The sensitivity of the button must be corrected in such a way as to prevent a similar case. P2 squeezed the middle part of the rewind component to which the prototype was not ready, the center of this control has to be anchored. Both participants did not know the concept of dividing the audiobook into the tracks. After an explanation, they quickly acquired the individual controls.

Turning on the playback by opening was not recognized immediately. However, after a short exploration, revealed the function themselves. To summarised the experiment, both participants have been able to use all the controls of the device successfully. Except for the skip track button, they were able to reveal the function of individual control elements.

[1]Classification of visual impairment according to [80].

Chapter 6

Discussion

Based on analysis and user research, a prototype of a book player for visually impaired seniors was created. The formative evaluation was realized during the development process according to UCD.

The analysis of the topics related to the target group showed that in the older age the efficiency of the processes in the human body decreases: the reactions are slower, the accuracy of the receptors decreases, the motor skills deteriorate, the cognition slows down. For older users, it becomes more challenging to learn new concepts. That's why we suggest a simple user interface for this target audience. Too small devices or complicated features may be counterproductive in their case. In addition to vision impairment, other age-related limitations that can make the interaction more complicated are frequent. Small buttons close to each other are hard to recognize, especially for those with a tactile disability. Complicated interfaces providing many complex functions may be hard to learn especially for individuals that are challenged with cognitive impairment. Designers should avoid unknown or abstract features that may be difficult to understand.

On the other hand, cumulative knowledge and experiential skills are well maintained in advanced age [44]. We agree with Harrison [62] that the understandability of UI can be support by using concepts that people already know from an earlier life, such as PlexTalk (Figure 2.7), where the layout of the buttons was similar to the phone. We decided to use metaphors such as: opening a book to start playing and closing to stop, a bookmark as an automatically realized function when book is closing, the skip and rewind button on the right side of the control panel move playback toward the end of the book, left to the beginning, *clock reference system* [83] for info buttons layout, the shapes of buttons related to their functions (battery and watch). Evaluation has shown that the implemented concept is simple and easy to understand.

The low-fidelity prototype evaluation revealed some problems to be addressed by the high-fidelity prototype generation. These include the form of volume control, rewind control, and the position of the switch-chapter buttons. It also showed that requirements for the device vary across the visually impaired population. Younger and more active users require more advanced features and portability. They read in numerous places, different

genres including educational literature. Older and more passive users listen mostly to audiobooks or radio. In design, we preferred to optimize simplicity and understandability to portability.

Although the starting playback by opening did not seemed practical to younger and more active users, we decided to keep this concept. This concept simplifies control by its naturalness and by physically separating logic groups of controls. According to the Hick's Law [102], minimizing the number of available options making a choice easier.

The implemented concept was tested only qualitatively. In the next phases, we plan to test the device on a long-term basis through a diary study. For these purposes, more robust prototypes of the device must be made. The data will be collected through logging (directly from the player) and ongoing conversations. Comparative studies of this device with a voice assistant also come into consideration.

Chapter 7

Conclusion

The goal of this thesis was to design an audiobook player for visually impaired older adults. The development of Reprobooktor consisted of several steps that correspond to the goals defined in Section 1.3. These goals together with the description of their realization are described below.

G1 **Analyze the specifics of the visually impaired older adults.** The topics related to older adults with vision impairment was analyzed in Section 2. The section described the loss of vision, the impact of aging on the human body, residential care institution Home Palata, and the influence of leisure activities. Almost one-half ($47,3\%$) of visually impaired individuals is older than 75 years [99]; they require specific interaction methods to reflect other age-related limitations apart from the vision loss [56].

G2 **Analyze the current state of access to book content by visually impaired people and related legislation.** The Section 1.2.5 described three ways of accessing book content by a visually impaired user. The Section 2.2 dealt with the analysis of the current state of the access; the first part addressed related work, the second described and discussed the existing devices. The Section 2.3 covered the related legislation, described the Licence for Disabled.

G3 **Get acquainted with the Raspberry Pi platform and its expansion modules.** The Raspberry Pi platform was described in Section 2.4, used expansion modules in 4.2.

G4 **Employing qualitative user research, analyze the needs and requirements of potential users.** Conducted user research was described in Section 2.5. A qualitative user study (N = 9) focused specifically on audio content consumption has been conducted. The purpose of the design was expressed in Section 3.1 through the UCD Canvas.

G5 **Regarding the results of the user research and analysis define requirements.** Functional and non-functional requirements were summarized in Section 2.6.

The created design complies with the defined requirements, except for *R2: Remote content management*, which was due to its complexity and variability postponed to the future works.

G6 **According to User-centered design methodology create prototypes of the UI.** The prototype design process was presented in Chapter 3. The design process was focused on listener – Reprobooktor interaction. Design began with a description of the context of use through scenarios and storyboards that were generalized to use cases. Subsequent sketches have been created according to which testable prototypes were assembled. Formative evaluation was realized during the development.

G7 **Describe the implementation of particular prototypes.** Implementation of prototypes was described in Chapter 4. The functionality of the low-fidelity prototype was simulated by GUI application. The Raspberry Pi formed the core of high-fidelity prototype, to which the hardware components were connected via the microcontroller Arduino Pro Micro. Both applications used Python classes to play audio files.

G8 **Evaluate the developed solution with the target user audience.** The formative evaluation was described in the Chapter 5. Four qualitative evaluation experiments have been conducted: early informal study (N = 3), low-fidelity prototype evaluation with visually impaired (N = 7, age mean = 45.6) and visually impaired older adults (N = 7, age mean= 73), high-fidelity prototype evaluation (N = 2).

7.1 Future work

In the future, the system for content management should be designed, implemented and evaluated until the requirements will be met. Appropriate technologies or their combinations should be selected. Today's technology offers many options: uploading through a cloud application, direct connection of the device with a computer, using a voice assistant, mobile application, and more. The solution should comply with the requirements described in section 2.6.

Because the individuals of the target group in many cases also use other content than audiobooks, additional use cases should be considered, for example, *Reprobooktor* could also be used as a radio or RSS[1] reader thanks to the future cloud application.

After finishing the implementation, the system should be evaluated quantitatively. We propose a diary study or a comparative study of the *Reprobooktor* versus the voice assistant device. For a qualitative test, the proposed device should be further improved to provide better durability and reliability.

[1]Rich Site Summary is a type of web feed which allows users and applications to access updates to online content in a standardized, computer-readable format.

Appendix A

Transcripts: User research

A.1 P1

Participantka ráda čte. Ve volných chvílích se věnuje převodu knih do zvukových stop, což obnáší naskenovat knihu stránku po stránce a pak celý text postupně upravit. Knihy poslouchá doma, na chatě i v práci, protože to její zaměstnání umožňuje. Z TTS hlasů má nejraději hlas Eliška. Nejraději poslouchá audioknihy. Občas poslouchá s někým. Zařízení, která pro poslech používá jsou PC, notebook nebo diktafon.

- **Co děláte ve svém volném čase?**
  "Ve volném čase sbírám autogramy, čtu a skenuji knihy. Právě tento víkend jsem převedla jednu knihu, která mi chyběla." [F101]
- **Můžete popsat celý proces převodu knihy do audio podoby?**
  "Půjčím si knihu z knihovny, vezmu ji do domu, naskenuju ji stránku po stránce, což zdaleka ještě není to nejhorší, následně ji nechám namluvit v programu Balabolka, kde mohu nastavit i rychlost finální MP3 [F112], a pak ji upravuji tak, aby se jednalo o dobře zpracovaný text, opravím chyby, přiřadím kapitoly, hlavičku a tak dále." Převod knihy do audio nahrávky je časově náročný proces. [F103]
- **Která syntéza je vaše oblíbená?**
  "Mám ráda hlas Eliška. Ve svém notebooku mám hlas Zuzana, ale Eliška je pro mě příjemnější." Hlas Eliška participantce přijde příjemější než hlas Zuzana. [F102]
- **Čtete i namluvené audioknihy?**
  "Samozřejmě, ty mám nejraději." - usmívá se [F104]. *"Máme knihovnu KTN, kde jsou tyto namluvené knihy, ale nejsou tam všechny, takže nejdříve se podívám, jestli knihu mají v KTN, když je tam, tak ji stahuji přednostně. Pokud tam není, podívám se na Library of digital documents (e-books) in Prague (KDD)*[1] *nebo Matildy*[2]*. Tam jsou ve formě textu, který mohu přeložit pomocí Balabolky."* [F111]

[1] KDD je Knihovna Digitálních Dokumentů pro nevidomé.
[2] Online služba poskytující elektronické knihy.

Audioknihy získává z KTN. [F105]
Digitální dokumenty získává z knihovny KDD. [F106]
Syntetizuje pomocí programu Balabolka. [F107]

- **Jaká zařízení používáte k poslechu knih?**
  "Doma, velký počítač, v práci notebook, na chatě diktafon." [F108]
- **Jak často používáte sluchátka?**
  "Spíše ne. Dnes jsem v práci poslouchala polovinu přes sluchátka a polovinu bez sluchátek. Ale většinou poslouchám bez nich."
  Spíše poslouchá bez sluchátek. [F109]
- **Posloucháte někdy knihy s někým jiným?**
  "Ano, někdy ano, ale tady je problém najít čas." [F110]

A.2 P2

Rozhovor probíhal v budově FEL v odpoledních hodinách, jako součást rozhovoru podobného uživatelského výzkumu. Participantka poslouchá knihy jak doma, tak i na cestách, na MP3 přehrávači. Preferuje mluvené slovo před syntézou. Ocení, když předčítatel "umí text prodat". Z TTS má nejraději hlas Eliška.

- **Čtete knihy?**
  "Ano." [F200]
- **Upřednostňujete hlasovou syntézu nebo mluvené slovo?**
  Spíš mám ráda, když ten hlas není úplně strojový [F201]. Ono strašně záleží také, kdo to načítá. I když je priorita děj, tak některé knihy jsem odložila z části kvůli načitatelce, protože to neuměla podat... [F202]
- **Kde čtete nejraději?**
  "Já čtu doma, nebo si to vezmu s sebou do autobusu, do metra, že si to dám na sluchátka. Takže v podstatě mi je to jedno."
  Čte doma i na cestách. [F203]
  Když čte na cestách, používá sluchátka. [F203]
- **Jaká používáte sluchátka?** *"Mám ráda pecky, protože jsou skladné. I třeba ty přes hlavu nejsou špatné, ale ty už nejsou tolik skladné."* [F204]
- **Jaká je vaše oblíbená audiosyntéza?**
  "Já se to zítra budu teprve učit, jak převádět text do mp3. Ale můj oblíbený hlas je Eliška, ten mám na mobilu. Ta mluví dobře, třeba jak klesá hlasem [F205]. Spíš mám raději ženskou syntézu." [F206]
- **Z jakých zařízení knihy posloucháte?**
  "MP3 přehrávač nebo z počítače [F207]. A potom taky můžu číst naskenované knihy

na Braileském řádku, ale to už není audio-kniha. Protože je zase potřeba, aby člověk vnímal tu gramatiku [F208]. Protože někdy jak ti nevidomí píšou, to je utrpení."

A.3 P3

Participantka velmi ráda poslouchá knihy. Upřednostňuje syntetizovanou knihu před namluvenou, u které jí občas rozčiluje příliš výrazný přednes, který dle ní nedává volný průchod fantazii a představivosti. Pomocí jejího oblíbeného hlasu Jakub přečetla řadu rozsáhlých děl jako Milenium. Další výhodu, kterou na syntéze vidí je možnost regulace rychlosti předčítání. Knihy pro ženy čte rychleji, oproti naučné literatuře, u které kvůli většímu toku informací volí pomalejší tempo. Ráda poslouchá doma přes svůj notebook s repráčky, protože u toho může dělat i některé tiché domácí práce, jako je například utírání prachu. Pro poslech knih v dopravních prostředcích má mp3 přehrávač se sluchátky. Když tu a tam něco přeslechne, nahrávku přetočí o kousek zpět.

- **Čtete knihy?**
  "Ano." [F300]
- **Jaké knihy ráda čtete?**
  "Já čtu buď audioknihy, nebo ty zdigikitalizované knihy, které nám čte umělý hlas na počítači. Ten hlasový software, který nám pomáhá v navigaci na počítači, například NVDA[3], Supernova a podobně [F314]. Je to prostě umělý hlas, který plynule čte ten text. Nevadí mi to, to ucho si na to zvykne, je to takový trošku polorobot [F301], anebo čtu Audioknihy. Ale v brailu moc nečtu, ale trochu taky." [F302]
- **Máte nějaký oblíbený hlas?**
  "Mám, Jakub [F303] z WinTalkerVoice, který má tři hlasy, Mirek, Markéta a Jakub, přičemž Jakub je střední hlas, Markéta je vyšší hlas a Mirek je hlubší hlas. A já jsem si zvykla po řadu let na toho Jakuba. S tím jsem přečetla třeba Milénium[4]. S tím Jakubem čtu rozsáhlé knihy [F304]. Protože všechny knihy nejsou v audio podobě. A mě to fakt vůbec nevadí ten hlas takovej... "
- **Jak postupujete, když si chcete přečíst knihu, která není namluvená?**
  "Tak kouknu se doKDD, Knihovny digitálních dokumentů, kde mají texty, jako třeba to Milénuim. Ty audioknihy mě někdy i rozčilují, protože ty umělci to hrajou jako [F306]. Klesají hlasem, nebo předváděj nějakou slečnu a zase pána. A já mám ráda když mi to čte, čte a tu rychlost si stanovím sama a tu představivost si nechám sama na sobě [F307]. Já nepotřebuji, aby mi to hráli, jako ty jednotlivé postavy."
  Používá KDD. [F305]

[3]NonVisual Desktop Access (NVDA) je screen-reader s českou hlasovou syntézou určený pro platformu Microsoft Windows.

[4]Literární dílo, které má přes 2000 stran.

- **Z jakého důvodu?**
  "Protože se mi líbí, že si můžu nechat volný průchod fantazií. Představovat si to, ty lidi, jací jsou. Je to krásné potom."
- **Jakou rychlost poslouchání máte nejraději?**
  "No takovou, abych to dokázala vnímat, ten sled. To si vždycky můžu zvolit, jakou rychlostí to chci. Třeba když je to něco naučného, tak si to dávám pomaleji a když je to třeba taková nějaká kniha pro ženy, například nějaký takový ten odpočinek, tak to si to pustím fofrem." [F308]
- **Jak dlouho trvá, než přečtete dlouhou knihu?**
  "To nedovedu říct ....Taky pořád nemáte na to čas, děláte jiné věci. To je stejné jako někteří lidé mají na nočním stolku dlouho knížku, tak to my máme úplně stejně. Taky pak třeba záleží, jak je to napínavé, tak se pak nemůžu dočkat, abych honem honem mohla zase sedět a číst si."
- **Z jakého zařízení čtete?**
  "Z notebooku, dala jsem si tam repráčky, aby mi to hezky hrálo a abych si u toho mohla v místnosti i něco dělat [F309]. Jakože udělám dvě věci najednou. Něco hezkýho čtu a třeba si ještě utřu prach. Něco, co je takové tiché, co můžu u toho dělat."
- **Používáte při čtení sluchátka?**
  "Nemám je moc ráda. Ale samozřejmě, když jedu vlakem, tak si nečtu na celé coupé, ale dám si sluchátka. Ale doma ne, doma nečtu se sluchátky." [F310]
- **Takže čtete i ve vlaku...**
  "Určitě, všude... Mám MP3 přehrávač, tak si to pustím. To je jinak škoda času." [F311]
- **Jak se vám ten MP3 přehrávač ovládá?**
  "Dobře, tak já mám takový nejjednodušší. Mám i jeden s repráčkem. Je tam typický kurzorový kříž, uprostřed je repráček, nahoru dolu hlasitost, doleva, doprava o kousek přetáčím." [F312]
- **Jak často přetáčíte?**
  "Spíš ojediněle. Ale jsem za to ráda, že tam ta možnost je." [F313]

A.4 P4

Participantka nežli knihy, čte raději články z internetu, například z wikipedie o jejích oblíbených hudebních interpretech a podobně. Čtení knih není jejím koníčkem. Raději se věnuje poslechu hudby či filmů. Jako hlasovou syntézu ve svém PC nejraději používá WindowEyes - mužský hlubší hlas Mirek. Sice má doma scanner, ale nepoužívá ho. Když

potřebuje přečíst dokumenty, obrací se na své známé, kteří ji ho buď přečtou, nebo pošlou nascannované.

- **Čtete knihy?**
  "Moc ne, upřednostňuji film před knihou. Ale pokud jde o text, tak si ráda přečtu třeba něco o mých oblíbených interpretech. Třeba na Wikipedii." [F401]
- **Z jakého zařízení čtete?**
  Z počítače. V brailu toho moc nemám. Pár časopisů. Ale spíše čtu už jenom přes ten počítač [F402]. Do nedávna jsem měla magneťák s CDčkem, ale ten jsem dala pryč.
- **Když si potřebujete přečíst dokumen, například smlouvu, jak postupujete?**
  "S někým se domluvím [F404]. Mám sice scanner, ale nenaučila jsem se ho používat."
- **Jaký hlas máte nejraději?**
  "Hlas Mirek z WindowEyes [F403]. NVDA je na mě moc podrobné."
- **Kde čtete?**
  "Doma."

A.5 P5

Participant upřednostňuje mluvené slovo před syntézou. Pro poslech knih používá počítač a mobilní telefon. Knihy rád čte doma v posteli a ve vaně. Text na zvukovou nahrávku nejraději syntetizuje hlasem SpeechTech Stanislav. Funkce, které při poslouchání používá jsou: záložka, pauza, přetáčení a přeskakování kapitol. Rychlost jeho čtení je rychlejší než běžné mluvené slovo. Knihy získává od přátel nebo si je sám stáhne z internetu (KTN Biblio [75], KDD).

- **Čtete knihy?**
  "Občas." [F501]
- **Kdy jste četl naposledy?**
  "Předvčírem."
- **Co jste četl?**
  "Boss Babiš." (smích)
- **Jakým zařízením jste ji četl?**
  "Na počítači." [F502]
- **Kým byla načtená?**
  "Nějaký chlap, hezky to četl, ale nepamatuji si jméno. Nějaký herec asi. Poslouchal namluvenou audioknihu." [F503]

- **Čtete i knihy namluvené audiosyntézou?**
  "Ano, čtu. Já jsem takový čtenář na baterky. Pracuji hodně na počítači, takže mi syntéza vůbec nevadí." [F504]
- **Jakou hlasovou syntézu máte nejraději?**
  "WinTalkerVoice a nebo SpeechTech Stanislav." [F505]
- **Když porovnáme syntézu a mluvené slovo, co vám vyhovuje více?**
  "Je mi to asi jedno... Jsem zvyklý na obojí. Tak samozřejmě je příjemnější, když to čte někdo, ale nějak je mi to asi fuk."
  Mluvené slovo je příjemnější, ale syntéza mu nevadí. [F506]
- **Už se vám někdy stalo, že jste poslouchal mluvené slovo a štval vás způsob, jakým to bylo namluvené?**
  "To se mi nestalo. Ale samozřejmě se to stát může. Ale ještě se mi to nestalo."
  Nestalo se, že by někdy poslouchal knihu, která pro něj byla nepříjemně namluvená. [F507]
- **Dovedl by jste říct nějaké výhody vaší oblíbené syntézy SpeechTech?**
  "Je to hlas moderní, dobře intonuje, příjemný hlas... A nebo pak ještě mám rád hlas Eliška [F508], Alcapela, to jeden z nejlepších hlasů. A hodně se mi teď líbí teď ten hlas Google. Ale s tím nejde moc dobře pracovat při převádění, nejde tam například regulovat rychlost. "
  Cítí potřebu u syntézy konfigurovat rychlost. [F509]
- **Když mluvíte o nastavování rychlosti, jakou rychlost máte pro poslouchání syntetizovaných textů nejraději?**
  "Já osobně preferuji rychlost jako když se normálně mluví. Někteří lidé rádi poslouchají rychle, mají to pak takové naspeedované, tak to já úplně nemusím." Participant pustil nahrávku, která byla rychlejší, než defalutní rychlost syntetizérů. Pustil jízdní řád z mobilního telefonu.
  Syntetizuje rychleji, než je defalutní rychlost hlasové syntézy. [F510]
- **Co všechno čtete touto rychlostí?**
  "Vesměs všechno, texty, internet..."
- **Říkal jste, že čtete z počítače. Z jakých dalších zařízeních čtete?**
  "Z mobilu... a to je vesměs všechno." [F511]
- **Jaké funkce při čtení obvykle používáte?**
  "Akorát pauzu. Nebo záložku."
  Používá záložku(pauzu). [F512]
- **Přetáčení někdy používáte? Dopředu, dozadu?**
  "Tak určitě. Třeba když se nějak přerušim. No jasně, používám."
  Používá přetáčení když se přeruší. [F513]

- **Jak daleko přetáčíte, když se takto přerušíte?**
  "To záleží...podle toho, kolik mi toho uteče. Ocenil bych funkci skok na čas."
- **Jak si konkrétně představujete funkci skok na čas?**
  "Poslouchám a pak potřebuji přestat. Tak si zapamatuji, kde jsem skončil a až se k tomu později vrátím, tak to zapnu a skočím na tu minutu. Ale samozřejmě na toto fungují ty záložky, takže asi není potřeba skákat na čas.... To spíš používám ve filmu, protože tam žádná záložka není."
- **A při čtení audioknihy záložky používáte?**
  "Tak v audioknihách, v těch namluvených, tam záložku také nepoužívám, protože to nejde, ale když čtu syntetizovaný text, tak tam si ji mohu udělat. Audioknihy se dělí na několik souborů, třeba po dvaceti minutách, tak tam si většinou pamatuji, v jakém souboru jsem skončil a pak už to jednoduše dohledám."
  Listuje mezi kapitolami, když se vrací k poslouchání a pamatuje si, kde minule skončil se čtením. [F514]
- **Kde nejraději posloucháte?**
  "Ve vaně, nebo v posteli. Ale spíš si pouštím nějaké filmy." [F515]
- **Čtete i mimo domov?**
  "To ani ne, já jsem spíš na hudbu. Ale když knížky, tak většinou doma."
  Mimo domov spíše poslouchá muziku. [F516]
- **Používáte při čtení sluchátka?**
  "Při čtení ne, při muzice ano. Protože nečtu venku. Kdybych četl venku, tak je používám. Kdybych třeba četl v autobuse, tak samozřejmě jo."
  Pro čtení nepoužívá sluchátka, pro poslech hudby ano. [F518]
- **Posloucháte knihy sám, nebo někdy i s někým?**
  "To spíše sám."
- **Odkud čerpáte audioknihy?**
  "To je úplně různé. Většinou od kámošů. Knihy získává od přátel." [F519]
- **Jaké knihovny používáte?**
  "Z internetové knihovny Biblio."[5] *"Pak existuje knihovna Krakovski, která načítá knihy(pozn. herci je zde namlouvají), pak tam jsou v mp3, tam si taky stahuju. A pak samozřejmě nějaká ulož-ta, a podobně... A nebo je knihovna textových souborů, která se jmenuje KDD, a tam je spousta textů, který si stáhnete a pak si je čtete, nebo je převedete do syntetizovaných mp3 a ty si potom čtete v čemkoliv, v telefonu, magneťáku, v čem chcete..."*
  Jako zdroj digitálních dokumentů užívá KDD. [F519]
  Audio knihy získává z Krakovski, KTN a jiných úložišť. [F520]

[5]KTN Biblio [75]

A.6 P6

Klient z domu Palata. Rád čte. Žije v Palatě. Ztrátou zraku trpí přes 10 let. V domě Palata nenavštěvuje společenské akce, protože to vždy končí pomlouváním. Čas raději tráví sám. Stará se o ovce. Další část svého volného času tráví na PC. Čte nejraději po obědě v kuřárně se sluchátky a šálkem kávy, nebo v posteli ve svém pokoji, kde u poslouchání občas i usne. K poslouchání nejčastěji používá rádio, které umí přehrávat USB flash disk s MP3. Na tomto zařízení mu nejvíce vadí to, že nejde přetáčet o trochu dozadu. V případech, když něco nepochopí či přeslechne, musí přeskakovat celou kapitolu a poslouchat znovu, což je frustrující. Co se týká zvukové syntézy, příliš mu nevadí v případě, že poslouchá hlas Zuzana, naopak hlas Antonín mu je nepříjemný.

- **Čtete knihy?** *"Ano."* [F600]
- **Kdy jste poslouchal audioknihu naposledy?**
  "Včera odpoledne. Protože po obědě mám vždycky dvě hodiny, protože to se dlouho nedá, pak člověk začne usínat. Záleží jak je dobře udělaná."
  U čtení usíná. [F601]
- **Podle čeho hodnotíte, že je kniha dobře udělaná?**
  "To já moc nesleduji, já spíš sleduji tu knížku, jestli je tam hudba, nebo jestli je ten hlas příjemnej." [F602]
- **Byl vám někdy nějaký hlas z audioknihy nepříjemný?**
  "Zatím co jsem četl, tak nebyl. Můj vlastně je mi nepříjemnej, když slyším [F603]. Když jsem namlouval něco na počítač a pak jsem si to pustil. To je šílený. Ale to má tady každý, že nesnáší vlastní hlas."
  Zatím nenarazil na nepříjemné namluvení audioknihy. [F604]
- **Jakou formu namluvení máte nejraději? Spíše divadelní hry nebo jen přečtený text?**
  "To záleží. Někdy to v rámci umění přeženou." [F605]
- **V jakém smyslu to přeženou?**
  "Třeba tam dají zvuky houslí, když se tam nehodí. Ale to je můj názor, někomu se to může líbit."
- **Jaké máte pocity z namluveného textu počítačem?** *"Mně to nevadí, já jsem si našel dobrý hlas a celkem to jde. Člověk si na to musí zvyknout [F606]. Všechny slova nemůžou být v té paměti počítače, takže cizí slova to hláskuje."*
- **O jaký hlas se konkrétně jedná?**
  "Protože jsem chodil na dědinu, tak jsme vybrali Zuzana. Nejhorší je ten mužskej Kuba. Ten je nepříjemnej dost takovej." [F608]
  Oblíbený hlas Zuzana. [F607]

- **Dovedl by jste říct, proč je nepříjemný?**
  "To je asi jen můj pocit, protože spousta lidí na té dědině ho používá."
- **Kde čtete nejraději?**
  "V kuřárně, s kafem." [F609]
- **Z jakého zařízení čtete?**
  "Koupil jsem si takové radio, do kterého jde zasunout flashka a přehrává to[F610]. To vaše by mělo být lepší, protože tohle nepřetáčí. To si pamatuje místo, kde to skončí. A pak se dají jen přeskakovat kapitoly." [F610]
- **Takže vám tam chybí funkce přetáčení...**
  "No, protože občas něco nepochopíte a chcete se vrátit a musíte se vrátit o kapitolu." [F611]
- **Jaké funkce tento přehrávač ještě má?** *"Já ho jinak nepoužívám, jen takhle. Chtěl bych mít takhle méně věcí. Třeba více v jednom."* [F612]
- **Jaká zařízení ještě používáte?**
  "Hodinky, počítač, radio s MP3, flash disk, vysílačku pro nevidomé." [F615]
- **Používáte sluchátka?** *"Ano tady leží na stole."*[6] [F613]
- **Posloucháte někdy s někým?**
  "Ne, poslouchám sám." [F614]

A.7 P7

- **Čtete knihy?**
  "Chodím na skupinové čtení, ale nevím, jak bych mohla číst sama..." [F701]
- **Jak ráda trávíte volný čas?**
  "Ráda poslouchám rádio, chodím na akce tady v Palatě, ty si utéct nenechám....Chodím na kavárnu, skupinové čtení..." [F702]
- **Jakou stanici posloucháte nejraději?**
  "Dvojku(pozn. Český rozhlas 2).. Ikdyž se mi teď někam zatoulala. Nějak ji nemůžu naladit, ale ona se zase někdy objeví...." [F703]
- **Jakým způsobem ladíte stanice?**
  Participantka podá obdélníkové rádio(cca 20x15x3cm), které leží za ní na druhém kraji postele, u zdi. Ukazuje jednotlivé ovládací prvky:
  "Tady tu anténu mi nějaký nešťastník urazil."
  "Stanice ladím kolečkem, občas tam něco najdu... teď tam mám jednu stanici, kde dávají rozhovory, třeba s vědcema nebo tak."
  "Tady tím kolečkem na boku ladím hlasitost."

[6] Pozn. na stole leží klasická malá sluchátka.

- **V jakých situacích používáte sluchátka?**
  "Moc je nepoužívám, spíše si poslouchaním krátím chvíle, kdy tu není moje spolubydlící. Někdy posloucháme rádio spolu." [F704]

A.8 P8

- **Čtete knihy?**
  "Já jdu radeji navštívit sousedy, já se nerada válím" [F801]
- **Jak ráda trávíte volný čas?**
  "Ráda chodím na zdejší akce a pletu." [F802]
- **Jaká zařízení používáte?**
  "Mám tadyty mluvící hodiny, když zmáčknu, tak mi řeknou, kolik je hodin." [F803]
  Zmáčkla tlačítko a zařízení řeklo: *"patnáct dvacet dva"*. [F804]
- **Jak poznáte, že se Vám vybila baterie?**
  "Řekne mi to slabá baterie, tak řeknu ošetřovatelce, aby mi ji vyměnila." [F805]

A.9 P9

- **Čtete knihy?**
  "Ano, čtu, moc ráda." [F901]
- **Jak je posloucháte?**
  "Mám tady takové rádo, do kterého dávám cédéčka, které mi vnuk připravil. Mám je tady, v komínku." [F902]
- **Kde je posloucháte?**
  "V posteli. Používám sluchátka, abych nerušila spolubydlící...Ráda bych posluchala i vedle na židli, ale nemám na to tak dlouhý kabel." [F904]
- **Podle čeho jednotlivá CD rozpoznáváte?**
  "No, víte, můj vnuk ví, co ráda posclouchám, připraví mi to a donese. Včera mi zrovna volal. Jak je mám v komínku, vezmu CD zezhora a dám ho do rádia, a když se mi nelíbí, tak ho vyndám, dám ho dospaodu, a pustím si, co jsem měla další na řadě." [F903]
- **Jaké funkce na tomto rádiu používáte?**
  "Hlasitost, občas přetáčení a občas rádio." [F905]

Appendix B

Persona Alena

The Persona Alena is based on fundamental research described in [1].

- 85 years old
- Sight problems since 69
- Almost fully blind since 78

Alena was born in Hradec Kralove and she spent most of life in this city. She worked as a lawyer for almost 40 years. She liked reading in her spare time. Not long after her retirement, she became to experience problems with her sight. *"I could not read those small letters in the books, even with the best glasses."* she described. Her husband passed away ten years ago. At that time, her sight problems rapidly worsened. Since then, she can see only shadows. She realized that it is not safe for her to live alone in her flat. Fortunately, her daughter has found Home Plata - residential care institution for visually impaired seniors.

At the beginning, she had problems with adaptation to the new environment. She had problems with the orientation, but over the time she managed to go to places in Palata alone. *"I am here for seven years already, so I navigate through Palata. But only to places I know. I learned it step-by-step. Firstly, I was barely able to go out of my room, and then, slowly, you know, during those years you will learn even if you don't want to. But if I came to a new environment that I do not familiar with, I can not even make a step"*. Alena also uses high contrast navigation bars on the corridors. *"On corridors, there is a bright bar and right next to it black one. I can go along."*.

She liked the regularity in the course of each day. Typically, a nurse wakes her up as she brings the morning medicaments. Then she goes to the day room at the department C, where they sever the breakfast. Her roommate has problems with her legs, especially in the morning, so she has breakfast in the room.

After the breakfast, typically she attends some morning activity. They broadcast activities available for each day as well as meals that will be served. *"Morning program? They always broadcast in which room and when it is."*. Alena likes memory training the most. However, she gladly attends other activities like music listening, concerts, newspaper reading or event crafts. *"I really like memory training. An activation worker organizes it. They always announce it by the broadcast in the morning. I can go there by myself. I like it, it's great. We not only learn new things but also entertain ourselves."*

Then she goes to the big dining room for lunch. Sometimes she meets her ex-roommate from the department B. She mostly likes the food, however, she misses the times when she could have to cook. *"The food is quite good, but therefore I cooked well, I sometimes think I could wave done it better. There is an opportunity to cook, but I can not even peel an onion."*

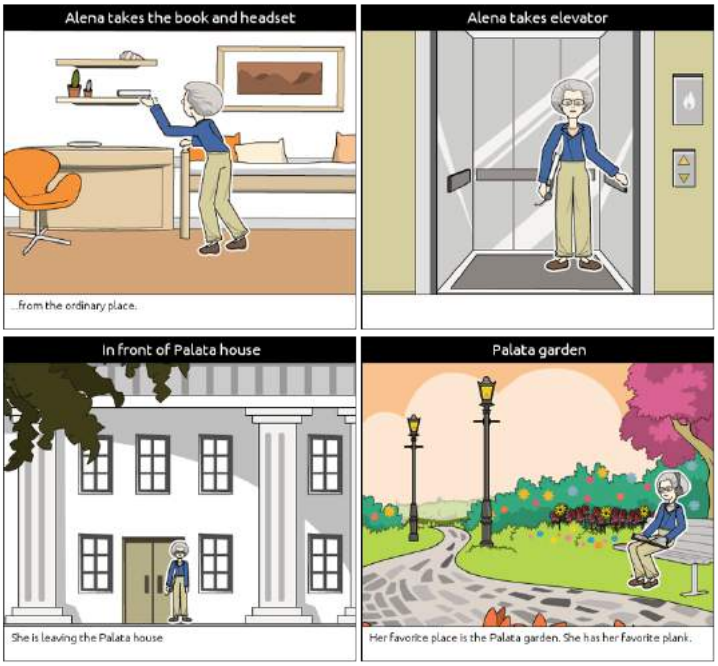
Alena takes a rest after the lunch. She mentions that she deserves some calm in her age. She starts her rest in bed by reading her favorite book, sometimes she falls asleep. Then there are various afternoon activities. Alena likes the café the most. *"Each Tuesday, we have so-called café. And there, for instance, Mrs. Mikes sings, and Mr. Portos plays the piano. Or Mr. Macha plays keyboard piano. Or there was that band . . . Pohodari, they are guitarists."*

After dinner, she listens to her radio with her roommate. *"We have a favorite radio station - number two. But we listen only to it. I rather don't touch the radio not to put it out of tune."* Sometimes she makes a call to somebody from her big family. *My daughter set it up for me, to numbers .. one, two ... it is up to nine. When I need to call, I use my glasses, but it is very difficult for me to find the right number. On number two, I have one of my daughters; on number five the other one...*, continues with listing all numbers.

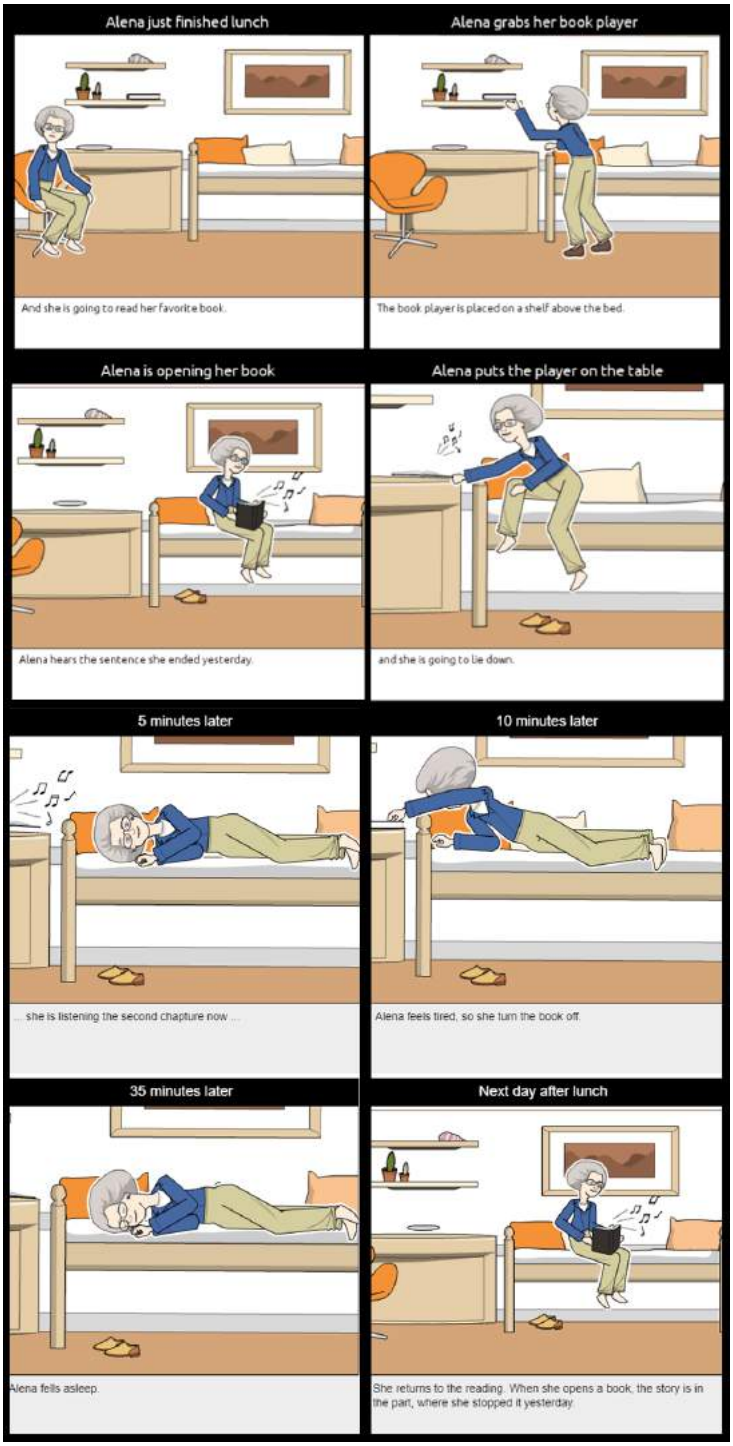
Appendix C

Story-boards

Storyboard: Reading using headphones



Storyboard: Reading using speakers



Appendix D

Use Cases

UC1: Reading book using speakers

- **Precondition:**
  The battery of book player is charged or the device is plugged into the power supply.
- **Flow:**

  1. User sets the book for reading.
  2. User opens the *Reprobooktor*; the player starts to play the selected book from the bookmark position minus five seconds.
  3. User listens to a story. When a track is finished, the next one in playlist starts automatically.
  4. When user wants to stop, closes the *Reprobooktor*.
  5. The current position is saved into the bookmark related to a book. The playback is stopped.

UC2: Reading book using heapdphones

- **Precondition:**
  The battery of book player is sufficiently charged.
- **Flow:**

  1. User plugs headphones in.
  2. User chooses a book.
  3. User opens the *Reprobooktor*.
  4. User listens to the story. When the track is finished, the next one in playlist starts automatically.
  5. When user wants to stop, closes the *Reprobooktor*.

6. The current position is saved into the bookmark related to a book. The playback is stopped.

UC3: Interruption of reading process

- **Precondition:**
  The battery of *Reprobooktor* player is charged or the device is plugged into the power supply. The *Reprobooktor* is playback.
- **Basic flow:**

  1. User detects an interrupting event.
  2. User closes the *Reprobooktor*.
  3. User solves sudden situation.
  4. User opens the *Reprobooktor*; the player starts to play the selected book a few seconds before the bookmark position.
  5. User listens again.

- **Alternate flow:**

  5a When a user does not orient in the story, he uses rewind, until he feels returned into the context of the story.

- **Post-conditions:**
  User continues with listening to *Reprobooktor*.

UC4: Skipping track

- **Precondition:**
  The battery of *Reprobooktor* player is charged or the device is plugged into the power supply. The *Reprobooktor* is playback.
- **Flow:**

  1. User sets the book for reading.
  2. User opens the *Reprobooktor*.
  3. User skips the track.

- **Post-conditions:**
  The user listens to required track.

UC5: Battery charging

- **Precondition:**
  The device says the battery is weak.
- **Flow:**
  1. User recognized a low battery report.
  2. User connects the device to the power supply.
  3. The device announces the expected time until it is fully charged.
- **Post-conditions:**
  The battery of the device is charging.

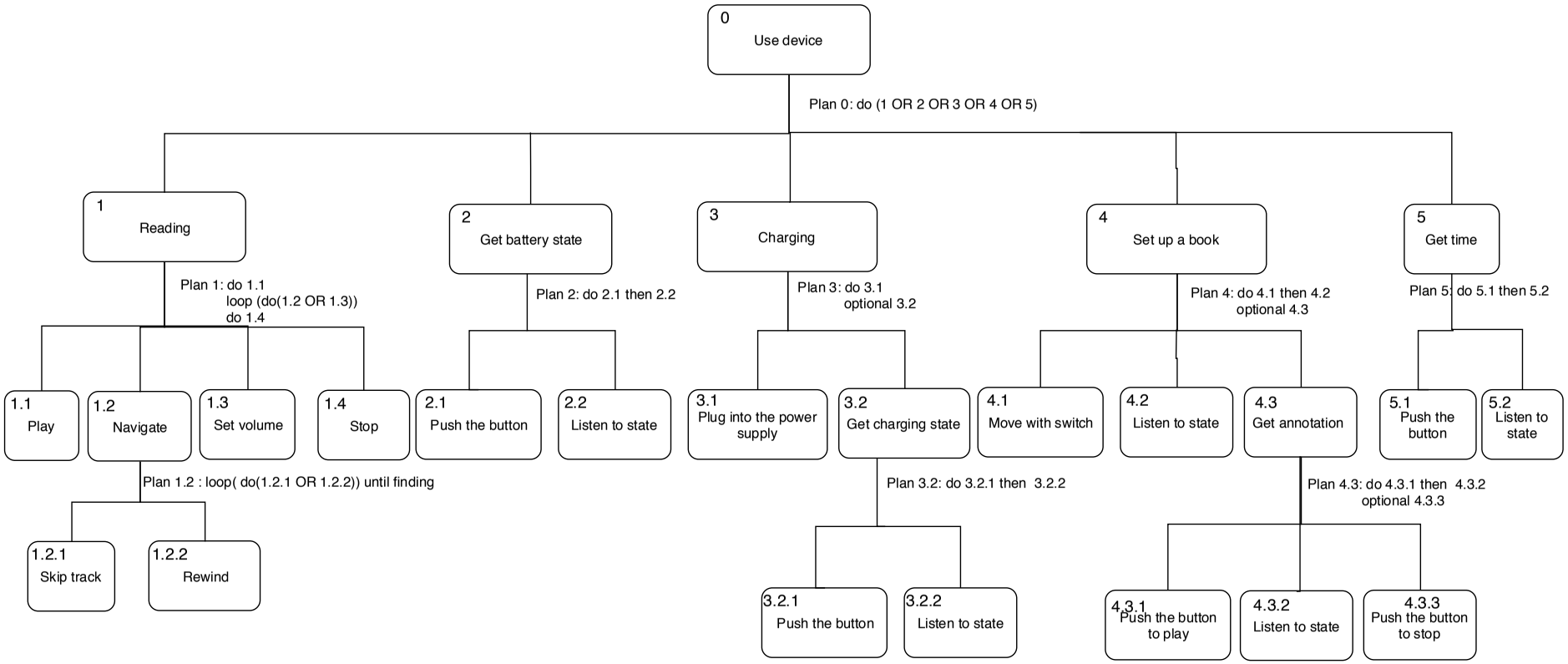
UC6: Clock

- **Precondition:**
  The battery of *Reprobooktor* player is charged or the device is plugged into the power supply.
- **Basic flow:**
  1. User presses the clock button.
  2. The device reacts by quick sound effect feedback.
  3. Device tells the time.
  4. The device returns to the state before the request.
- **Alternate flow:**
  3a When the *Reprobooktor* is in the opened state, the time message is wrapped in an initial and a return tone to divide the time report from the playback of the book. Playback automatically returns a few seconds, to make it easier to get back into the context.
- **Post-conditions:** The user knows the current time.

Appendix E

HTA with plans

The figure with the HTA and plans can be seen in the next page.


0
Use device
Plan 0: do (1 OR 2 OR 3 OR 4 OR 5)
1
Reading
2
Get battery state
3
Charging
4
Set up a book
5
Get time
Plan 1: do 1.1
loop (do(1.2 OR 1.3))
do 1.4
Plan 2: do 2.1 then 2.2
Plan 3: do 3.1
optional 3.2
Plan 4: do 4.1 then 4.2
optional 4.3
Plan 5: do 5.1 then 5.2
1.1
Play
1.2
Navigate
1.3
Set volume
1.4
Stop
2.1
Push the button
2.2
Listen to state
3.1
Plug into the power supply
3.2
Get charging state
4.1
Move with switch
4.2
Listen to state
4.3
Get annotation
5.1
Push the button
5.2
Listen to state
Plan 1.2 : loop(do(1.2.1 OR 1.2.2)) until finding
Plan 3.2: do 3.2.1 then 3.2.2
Plan 4.3: do 4.3.1 then 4.3.2
optional 4.3.3
1.2.1
Skip track
1.2.2
Rewind
3.2.1
Push the button
3.2.2
Listen to state
4.3.1
Push the button to play
4.3.2
Listen to state
4.3.3
Push the button to stop

Appendix F

Event handlers

The implemented event handlers are:

- **Opening:**
  1. The opening sound effect is played back.
  2. The track is loaded according to bookmark.
  3. The position is set to bookmark position minus 5 seconds.
  4. The playback starts.
- **Closing:**
  1. The playback is stopped.
  2. The closing sound effect is played back.
  3. The bookmark is stored.
- **Book switched:**
  - If the *Reprobooktor* is closed:
    1. The switch sound is played back.
    2. The selected compartment is loaded.
    3. The title of compartment is played back.
  - If the *Reprobooktor* is opened:
    1. The playback stops by the closing event.
    2. The switch sound is played back.
    3. The selected compartment is loaded.
    4. The title of the compartment is played back.
    5. The playback starts according to the opening event.
- **Info button pressed:**
  - If the *Reprobooktor* is closed and the id of info button belongs to the selected book:

1. The sound effect of the info button is played back.
2. The message starts.
    * If the button is pressed for the second time while the message is playing, the message stops and the sound effect of info button is played back.

- **Rewind:**

1. The position of playback is stored.
2. The playback is stopped.
3. The time measurement starts.
4. The rewind sound effect is playing back until the rewind button is released.
5. The time measurement is stopped.
6. The rewind distance is computed and added to the stored position.
7. The new position is set.
8. The playing starts.

- **Skipping track:**

  - The right button is pressed.
    1. The sound effect is played back.
    2. The track is set to the next one (next lexicographically).
    3. The next track is loaded and started.
  - The left button is pressed.
  - The sound effect is played back.
  - The track is restarted.
    * If the playback started less than 5 seconds ago, the previous track is loaded and played back.

- **Watch button:**

  - If the *Reprobooktor* is opened
    1. The sound effect of a pushed button is played back.
    2. The position of playback is stored.
    3. The playback is stopped.
    4. The introduction tone is played back.
    5. The time message is played back.
    6. The returning sound effect is played back.
    7. The playback started from stored position minus 5 seconds.
  - If the *Reprobooktor* is closed:
    1. The sound effect of a pushed button is played back.

2. The time message is reported.

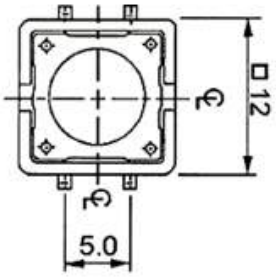
- **Battery button:**
  - If the *Reprobooktor* is opened
    1. The sound effect of the pushed button is played back.
    2. The position of playback is stored.
    3. The playback is stopped.
    4. The introduction tone sound effect is played back.
    5. The battery status message is played back (in case of power supply is played back the remaining time to fully charged state).
    6. The returning tone sound effect is played back.
    7. The playback started from stored position minus 5 seconds.
  - If the *Reprobooktor* is closed:
    1. The sound effect of a pushed button is played back.
    2. The battery status message is played back(in case of power supply is played back the remaining time to fully charged state).

Appendix G

Production of low-fidelity prototype

Book switch

Chapter button



Rewind dial

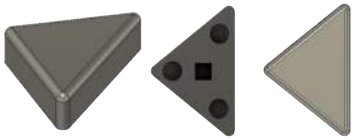
Book case

Appendix H

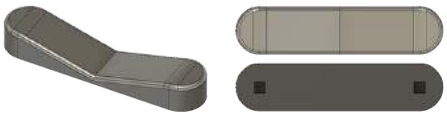
3D modeling

Fusion 360 [84] was used as a 3D modeling tool. Components have been designed to areas requiring a smooth surface were printed as a base.

(a) Book switch

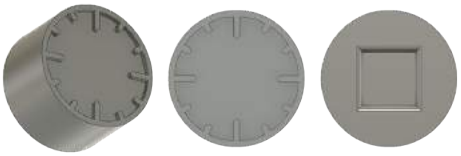


(b) Chapter button fingerboard



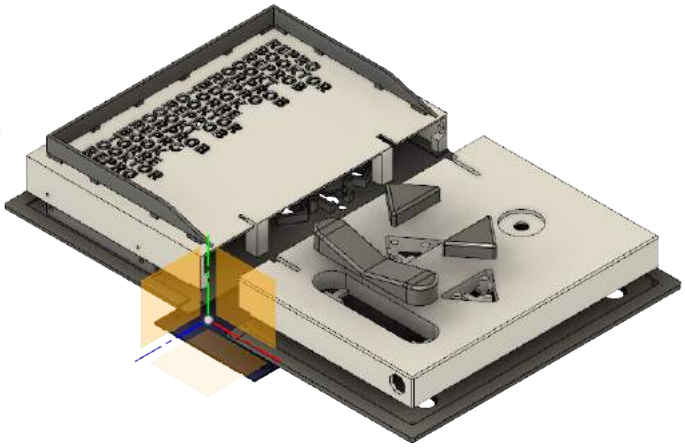
(c) Rewind button fingerboard

(d) Volume dial

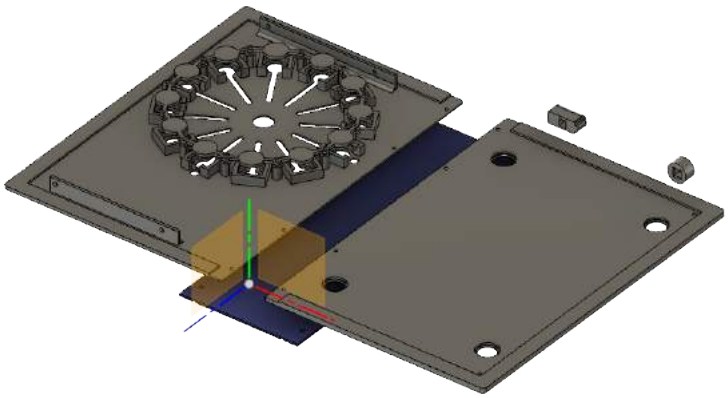


(e) Watch button fingerboard

(f) Battery button fingerboard



(a)



(b)

Appendix I

Prototyping of controls

Figure I.1: Book switch iterations.

Figure I.2: Rewind buttons iterations.

Figure I.3: Volume dial iterations.

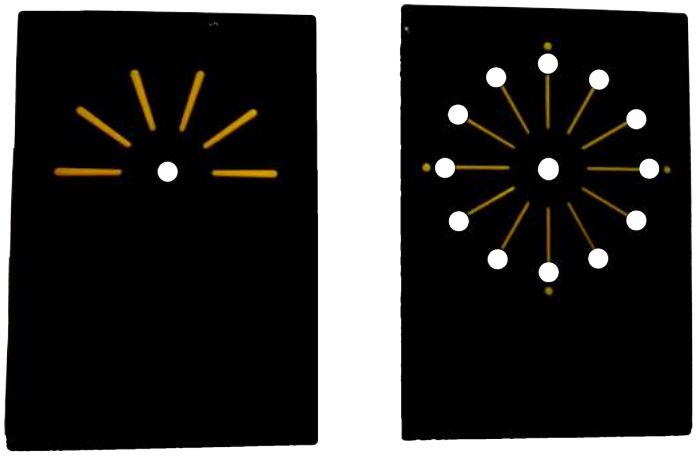


Figure I.4: Front side layout iterations.

Figure I.5: Left book side iterations.

Appendix J

Transcripts: Early feedback

Visually impaired user

- Prvním zajímavým zjištěním bylo, když vzal přehrávač do ruky, poznal knihu, ale myslel, že mezera v zavřené knize je vstup pro CD.
- **Konektor na sluchátka** by očekával na boční spodní straně knihy (strana zařízení situovaná směrem k participantovi). S tím, že hledání konektoru by se nevidomým zjednodušilo hladkým povrchem boků zařízení: *"Hrubé pro nevidomé znamená nepřehledné."*. V současnosti jsou 3 boky zařízení tvořené slepenými stránkami, aby model maximálně připomínal knihu. *"Vstup na sluchátka by měl mít alespoň trochu vystouplý okraj, oproti desce, aby ho nevidomý pohodlně a rychle našel."*, dodal.
- **Výběr knihy:** *"Ta tlačítka nejsou dobře rozlišitelná. Měla by mít jiný tvar, ne obdélníkový. Jsou moc blízko u sebe (pozn. myslel tím vzájemnou vzdálenost jednotlivých elementů) a špatně se rozlišují. A taky by měly být blíž k tomu kormidlu."*. Hloubka je dle jeho názoru dobrá. Zajímavé je, že obdélníky reprezentující knihy automaticky považoval za tlačítka. Co se týče povrchu, nepovažuje za předmětné jednotlivé volby hapticky rozlišovat. Dále měl připomínku k vyčnívajícímu přepínači na přední straně: *"Přepínač má hákovitý tvar, to není dobré, když tam stále ční, mohl by se někde zachytit."*.
- **Zapnutí čtení:** Participant neodhalil možnost otevření knihy. Četní chtěl zahájit stisknutím nějaké z ovládacích komponent. Mohlo to být způsobeno, že vlivem magnetů držela kniha dobře zavřená, oproti klasické knize a také díky mnoha zkušenostem participanta s moderními zařízeními, která jsou často zapínána právě pomocí tlačítka.
- Po tom, co se dozvěděl o způsobu zapnutí otevření dodal, že by bylo dobré, kdyby desky knihy přesahovaly přes boky o trochu více. Přítomnost mezery nijak výrazně v tomto ohledu otevírání nepomáhá, spíše ruší design.

- Dále vznesl zajímavý nápad, že kdyby kniha měla ovládání řešené podobně jako notebook, bylo by možné položit zařízení na stůl a nasměrovat reproduktory správným směrem.
- Po otevření jeho pozornost přitáhl rotační enkodér, který považoval za ovládání hlasitosti. Líbila se mu jeho velikost i hladký tvar. Skutečnost, že tato komponenta slouží k přetáčení se mu nepozdávala. Tuto funkcionalitu by řešil pomocí přetížení tlačítek pro přetáčení kapitol.
- **Magnety v rozích** stránek na nevidomého participanta působili rušivým dojmem. Považoval je za ovládací prvky.
- **Otvor umístěný naproti od enkodéru** uživatele mátl. Raději by jednu část opatřil rantlem a okraje druhé poloviny knihy nechal hladké. Na levé polovině v otevřené knize by byla "ohrádka" a uvnitř reproduktory, na pravé polovině by se nacházely ovládací prvky pro hlasitost, přepínání kapitol a přetáčení.
- **Přeskakování kapitol:** Nestandartní tvar tlačítek (vyvýšené rohy trojúhelníku) zapuštěných do desky byl pro participanta matoucí. Hroty považoval za samostatné komponenty. Od tlačítka očekává rovný tvar, vystouplý oproti okolní desce.
- **Reproduktory:** Dle participantových zkušeností z Palaty by z hygienických důvodů reproduktory a ovládání měli být odděleny, aby nedošlo při ovládání nečistýma rukama k zanešení reproduktorů.
- **Záložka:** Funkci záložky označil jako jednu z nejdůležitějších funkcí přehrávače. Zamýšlený záměr způsobu implementace se participantovi líbil.

Seniors

ID	pohlaví	ročník	věk
T1	žena	1941	77
T2	muž	1936	82

- **Výběr knihy:**
  Oba participanti začali prozkoumávat od levé krajní položky, postupovali postupně doprava. Informace o názvu knihy dle nich byla dostatčná, T1 dodala: *"Záleží, jestli jsem si to tam vybrala sama, nebo mi to takhle někdo dal. Asi než začnu číst, bych chtěla vědět o čem ta knížka je."*. T2 k designu měl jednu připomínku ohledně komponenty na čelní straně, že mu nevyhovuje, jak ční.
- **Spuštění přehrávání**
  Oba participanti otevřeli knihu. T2 se zde zeptal, jak zjistí, kolik mu chybí do konce.
- **Přeskočení tracku:**
  Oba participanti identifikovali tlačítka.

- **Přetáčení zpět:**
  T1 nejprve chtěla zmáčknout tlačítko o kapitolu zpět, ale pak se zarazila a řekla: *"No to nechci o celou kapitolu."*. Zde chvilku trvalo, než zjistili, že kolečkem na pravé straně knihy se dá otáčet. Jakmile na to přišli, ihned zodpověděli, že otočí o kousek doleva.
- **Pozastavení:**
  T1: *"Já bych zmáčkla to kolečko, jakože to má zůstat, tam kde to je."*.
- **Automatická záložka**
  Tato funkce se oboum dvoum participantům zdála přirozená.

Appendix K

Experiment guide: Low-fidelity evaluation

Informovaný souhlas

Katedra počítačové grafiky a interakce, Fakulty Elektrotechnické ČVUT v Praze vyvíjí zařízení pro čtení knih, primárně určeného pro zrakově znevýhodněné seniory. Součástí projektu jsou konzultace a rozhovory s lidmi, kteří mají odpovídající zkušenost a mohou poskytnout relevantní informace související s tímto tématem.

- Nyní jsme ve fázi návrhu designu, máme zde první prototyp a testujeme, zda je použitelný.
- Účast je dobrovolná a může být ukončena v jakýkoliv okamžik.
- Získané údaje budou zpracovávány anonymně a nebudou spojovány s osobou účastníka výzkumu.
- Za výzkum zodpovídá Barbora Endrštová
- Souhlasíte se svou účastí v testování použitelnosti zařízení pro čtení knih primárně určeného zrakově znevýhodněným seniorům? - čekání na odpověď
- Souhlasíte, že může být provedena video-nahrávka, zachycující interakci se zařízením?
- Tato nahrávka bude použita pouze pro potřeby vývoje a výzkumu a nebude poskytnuta třetím osobám.
- Potvrzujete, že Vám osoba zastupující Katedru počítačové grafiky a interakce (KPGI) fakulty elektrotechnické ČVUT v Praze, odpověděla na otázky týkající se výzkumu?

Úvod

Testujeme zařízení pro poslech knih, primárně určené pro zrakově znevýhodněné seniory. Máme zde první prototyp. Dali jsme mu název Reprobooktor.
Není zatím zcela funkční samo o sobě, protože otázky o konečném provedení jsou stále otevřené. Tímto testováním chceme odhalit chyby, abychom se jich vyvarovali při zhotovení finálního zařízení.

- Nicméně, zařízení je připojené k počítači a jeho funkčnosti v tomto testování nasimulujeme.
- Začněte ji poslouchat.V rámci tohoto sezení bychom chtěli zjistit, jak toto zařízení vnímáte, zda je ovládání pochopitelné, chceme odhalit případné nejasnosti a chyby. Zvyšte hlasitost.
- Proto vás poprosím, aby jste v průběhu testování přemýšlel/a nahlas, popisoval/a, co si myslíte, že daná komponenta dělá, k čemu slouží, jak chápete jednotlivé ovládací prvky i zařízení jako celek.
- Každý poznatek bude bezesporu užitečný pro další vývoj, ať už jako potvrzení, že je jsme danou komponentu navrhli správně a je pochopitelná, nebo bychom měli komponentu předělat.
- V průběhu testování se Vás budu ptát na otázky a budu si dělat poznámky.
- Máte nějaké otázky?

Seznámení se zařízením

Nejprve Vám zařízení půjčím do ruky o poprosím Vás o komentář. –

- Co vám zařízení připomíná?
- Můžete zkusit komponenty použít ...
- Jak chápete slova, která zazněla?
- Jak začnete poslouchat vybranou knihu?

V následujících částech mám několik konkrétních úkolů. Opět prosím komentujte celý svůj postup a své uvažování nahlas.

1. Vyberte si ke čtení knihu “Belmondo - Mých tisíc životů”.
2. Začněte ji poslouchat.
3. Zvyšte hlasitost.
4. Snižte hlasitost.
5. Přeslechl jste slovo, posuňte přetáčení o kousek zpět.

6. Posuňte se o dvě kapitoly vpřed.
7. Posuňte se o jednu kapitolu zpět.
8. Představte si situaci, že někdo zazvonil na zvonek a Vy chcete přerušit přehrávání. Jak budete postupovat?
9. A teď si představte, že chceme začít číst rozečtenou knihu Saturnin. Když ji vyberete, kde očekáváte, že po otevření začne číst?
10. Kniha obsahuje otvor na sluchátka. Zkuste identifikovat tento vstup.

Hodnocení komponent

Nyní si projdeme jednotlivé komponenty, u každé za čtyř komponent se vás budu ptát, zda vám toto řešení připadá:
Určitě ne – spíše ne – nevím – spíše ano – ano
Nechám Vám v ruce vypnuté zařízení, aby jste si mohl jednotlivé komponenty připomenout.

1. Zapnutí čtení prostřednictvím "otevření knihy" je vhodné a intuitivní.
   Jaké máte k tomuto ovládacímu prvku připomínky?
2. Přepnutí kapitoly prostřednictvím trojúhelníkových tlačítek při levém a pravém okraji zařízení je vhodné a intuitivní.
   Jaké máte k tomuto ovládacímu prvku připomínky?
3. Přetáčení prostřednictvím enkodéru je vhodné a intuitivní.
   Jaké máte k tomuto ovládacímu prvku připomínky?
4. Nastavení hlasitosti je vhodné a intuitivní.
   Jaké máte k tomuto ovládacímu prvku připomínky?
5. Výběr knihy na přední straně je vhodný a intuitivní.
   Jaké máte k tomuto ovládacímu prvku připomínky?
6. Automatická záložka pomocí zavření knihy je vhodná a intuitivní.
   Jaké máte k tomuto ovládacímu prvku připomínky?

Hodnocení zařízení jako celku

- Co považujete za nevýhody tohoto zařízení?
- Co považujete za výhody tohoto zařízení?
- V jaké situaci by jste používal by jste toto zařízení?
- Jaké máte otázky k tomuto zařízení?

Post-test

Q1 Jaký byl pro Vás test?

Q2 Máte k průběhu testování nějaký komentář?

Q3 Máte pro mě nějaký námět na vylepšení?

Q4 Proběhlo zde něco, co se Vám nezdálo relevantní?

Q5 Máte otázky?

Appendix L

Transcripts: General acceptance with visually impaired

L.1 P1

První dojmy

"To je obrovský. . . . To je pseudokniha." [F100] [F111]. Participant prozkoumával zařízení od přepínače knih. Správně odhalil jeho funkci. Kapacita se mu zdála být příliš malá. Posuvník pro nastavení hlasitosti považoval za záložku. Vstup na sluchátka správně identifikoval ihned po tom, co ho našel [F112]. V otevřeném zařízení se objevil problém s nalezením levé šipky pro přepnutí na předchozí track [F102]. Během testování nemohl najít šipku pro přeskočení kapitoly zpět. Hledá ji na stejné desce, kde je tlačítko pro přeskočení kapitoly vpřed. Nejdříve myslel, že tato tlačítka slouží k přepínání mezi stránkami, když je na každé stránce jedno tlačítko [F102]. Když narazil na tuto komponentu: "Když je to plynulé, tak to bude asi hlasitost, ale čekal jsem tu záložku, na boku" [F105].

Hodnocení komponent

- Zapnutí čtení prostřednictvím otevření knihy je vhodné a intuitivní: **rozhodně ano**.

Pzn.: *"Je to pochopitelné a každý to zná."*.

- Přepnutí kapitoly prostřednictvím trojúhelníkových tlačítek při levém a pravém okraji zařízení je vhodné a intuitivní: **spíše ano**.

Pzn.: *"Přivítal bych další jemnější variantu přetáčení. Mezi kapitolou a jemným přetáčením může být velká propast, například přidat přepínání podle stránkování."*. [F103]

- Přetáčení prostřednictvím enkodéru je vhodné a intuitivní: **spíše ano**.

Pzn.: *"Čím déle a čím rychleji otáčím, tím by měla růst i rychlost přetáčení."*. [F104]

- Nastavení hlasitosti je vhodné a intuitivní: **spíše ano**.

Pzn.: *"Nenapadá mě vhodnější varianta."*.

- Výběr knihy na přední straně je vhodný a intuitivní: **spíše ano**.

Pzn.: *"Je omezený pouze na 6 knih."*. [F106]

- Automatická záložka je vhodná a intuitivní: **spíše ano**

Pzn.: *"Uvítal bych více záložek."*,
V jakých situacích používáte více záložek?,
"Když listuji knihou, například učebnicí.". [F107]

Hodnocenní zařízení jako celku

- Co považujete za nevýhody tohoto zařízení? *"Není to PC, neumí vyhledávat, obsah, přidávat více záložek, nevyužívá možností audio-formátů knih, tak jak by mohlo."* [F110]
- Co považujete za výhody tohoto zařízení? *"Jednoduchost, blbuvzdornost, odolnost."* [F109]
- Používal by jste toto zařízení? *"Ne, protože pro tyto účely používám PC."* [F108]
- Jaké máte otázky k tomuto zařízení?
  - *"Jaká bude cena zařízení?"*
  - *"Zařízení by mělo být víc chytré, využívat možnosti moderních datových formátů knih."*
  - *"Co například poznámky pod čarou? Znám knihy, které jsou určené široké veřejnosti a poznámek pod čarou je tam mnoho."*
  - *"Obsah... Normální člověk, když otevře knihu, tak na začátku má obsah, na konci bude mít index. Obsah pomáhá jak v orientaci, tak k přeskakování, protože některé věci číst nechci."*

L.2 P2

První dojmy

"Je to velká tlustá kniha, působí na mě masivně." [F200]. Nejprve našel otvor na sluchátka, odhadl správně jeho účel. [F209]. Následně se zaměřil na přepínač, správně identifikoval jeho funkci. Design se mu líbil. Potenciometr pro nastavení hlasitosti nejprve odhadoval jako záložku nebo aretaci. Po dalším prozkoumávání dodal: "Pokud je kniha zavřená, je to aretace, pokud je otevřená, je to ovládání hlasitosti." Po otevření rychle prozkoumal celou

plochu otevřené knihy a zaměřil se na šipky na okrajích zařízení. Vyzkoušel funkčnost a po několika přepnutí oznámil, že šipky slouží k posunu po kapitolách. Následně zkusil šipku podržet a předpokládal, že tím dojde k přetáčení v rámci stopy. [F203] K tomu ale nedošlo a proto tuto funkci přiřadil k rotačnímu enkodéru. Správně odhadl, že jeden krok je vázaný na určitý počet sekund. Po stisknutí enkodéru řekl, že zde by si představoval pozastavení přehrávání. [F204]

Hodnocení komponent

- Zapnutí čtení prostřednictvím otevření knihy je vhodné a intuitivní: **rozhodně ano**

Pzn.: *"Já bych uvítal, kdyby kniha mluvila, i když je zavřená. Protože, když je otevřená, tak je dvakrát větší a zranitelnější, jako to je u mobilů, ať přehrávají i když jsou zhaslé."*. [F201]

- Přepnutí kapitoly prostřednictvím trojúhelníkových tlačítek při levém a pravém okraji zařízení je vhodné a intuitivní: **rozhodně ano**.

Pzn.: *"Tento prvek je poměrně citlivý, řekl bych že až moc."*. [F202]

- Přetáčení prostřednictvím enkodéru je vhodné a intuitivní: **spíše ano**.

Pzn.: *"Jsem zvyklý přetáčet podržením tlačítek na přepínání stop. "*. [F203]

- Nastavení hlasitosti je vhodné a intuitivní: **rozhodně ano**.

Pzn.: *"Když to dám na minimum, nedojde k úplnému ztišení?*
Tím jak je ovládání na horním okraji, tak když takto leží na stole, tak to nemohu ovládat jednou rukou, ale musím to vždy druhou rukou alespoň přidržovat.".

- Výběr knihy na přední straně je vhodný a intuitivní: **rozhodně ano**.

Pzn.: *"Kapacitu bych navýšil klidně na 10"*. [F204]

- Automatická záložka je vhodná a intuitivní: **rozhodně ano**.

Pzn.: *"Více záložek v jedné knize by bylo zapotřebí, pokud chce člověk knihu spíše studovat než číst."*. [F205]

Hodnocenní zařízení jako celku

- Co považujete za nevýhody tohoto zařízení? *"Velikost, že nelze poslouchat ze zavřené knihy, příliš vysoká citlivost tlačítek (a jejich nestabilita)"* [F206]
- Co považujete za výhody tohoto zařízení? *"Jednoduchost ovládání, hezký design, vypadá to jako knížka"* [F207]
- V jaké situaci by jste používal toto zařízení? *"Ano, dovedu si to představit, třeba v kuchyni, tam nechci tahat počítač."* [F208]
- Jaké máte otázky k tomuto zařízení?

– *"Jak se bude nabíjet?"*

L.3 P3

První dojmy

"No to vypadá jako knížka." [F300]

S hmatníkem hlasitosti chtěla participantka nejprve otáčet. Pak zkusila posunout: *"Aha, nejdřív jsem to chtěla otočit, ale to posunutí se mi zdá lepší."* [F301]. Komponentu přetáčení vyzkoušela hned jako první a pochopila jeho funkčnost: *"Tak to bude pravděpodobně přetáčení v textu, asi se to posunuje po úsecích."*. Participantka našla a správně identifikovala vstup pro sluchátka [F308]. O kapitolu dopředu se participantka dokázala dostat bez problémů, správnou komponentou. Levou šipku nemohla najít. Hledala ji na stejné straně knihy. Nejprve zkoušela různé varianty zmačknutí šipky doprava, dvojklik a podržet. Když řekla že neví, prozradila jsem ji, že se na zařízení nachází ještě jedna šipka: *"Aha, předpokládala jsem, že to bude všechno na jedné straně, když je tam kolečko i šipka."* [F302]

Kniha jde otevřít pouze na 160°, zadní desky leží na stole, kdežto druhá, levá, strana je nad stolem. Participantka má tendenci ovládat pouze stranu, která leží na stole.

Hodnocení komponent

- Zapnutí čtení prostřednictvím otevření knihy je vhodné a intuitivní: **spíše ano**.

Pzn.: *"Pro seniory to je intuitivní, ale já bych si představovala, kdyby se to dalo zapnout nějakým tlačítkem, protože jsem na to tak zvyklá z jiných zařízeních, třeba z MP3 přehrávače, kde přehrávání jedním tlačítkem zapnu a pak třeba pozastavím."*. [F303]

- Přepnutí kapitoly prostřednictvím trojúhelníkových tlačítek při levém a pravém okraji zařízení je vhodné a intuitivní: **rozhodně ano**.
- Přetáčení prostřednictvím enkodéru je vhodné a intuitivní: **spíše ano**.

Pzn.: *"To je sympatické a praktické, tohle kolečko."*.

- Nastavení hlasitosti je vhodné a intuitivní: **rozhodně ano**.

Pzn.: *"Posouvátko je dobré, zdá se mi jen, že by zařízení mělo hrát víc nahlas."*. [F304]

- Výběr knihy na přední straně je vhodný a intuitivní: **rozhodně ano**.

Pzn.: *"kapacita mi přijde dostatečná. Já mám ve zvyku číst jednu knihu a až pak začít s další."*. [F305]

- Automatická záložka je vhodná a intuitivní: **rozhodně ano**.

Pzn.: *"Když čtu knihu nyní, tak se snažím přestat číst na konci kapitoly, abych při dalším čtení dané místo rychle našla. Automatickou záložku u každé knihy bych uvítala."*.

Hodnocenní zařízení jako celku

- Co považujete za nevýhody tohoto zařízení? *"Nevím jaké to má nevýhody . . . zdá se mi rozměry a designem optimální. Mohu si to zabalit do zavazadla a vzít na chatu."*
- Co považujete za výhody tohoto zařízení? *"Vypadá to jako knížka, to provedení se mi moc líbí, další velkou výhodou je automatická záložka."* [F307]
- V jaké situaci by jste používal toto zařízení? *"Ano, používala bych ho třeba před spaním. Ve chvíli, kdy už nechci zapínat notebook. To je takové zdlouhavé."* [F306]
- Jaké máte otázky k tomuto zařízení?
  - *"Kdy se začne vyrábět?"*
  - *"Jak se bude nabíjet? Bude na kabel nebo na baterky "*

L.4 P4

První dojmy

"No to vypadá jako knížka, je to poměrně velké a silné" [F400]. Komponentu přetáčení vyzkoušel hned jako první a po vyzkoušení pochopil jeho funkčnost. Funkci záložky zmínil a předpověděl sám. Participant měl problém s nalezením levého tlačítka pro přepnutí stopy zpět [F401]. Vstup na sluchátka participant po seznámení se zařízením prakticky hned. [F402]

Hodnocení komponent

- Zapnutí čtení prostřednictvím otevření knihy je vhodné a intuitivní: **spíše ano**.

Pzn.: *"Z počátku mě to nenapadlo, ale dobrý je to, zajímavý přístup."*. [F403]

- Přepnutí kapitoly prostřednictvím trojúhelníkových tlačítek při levém a pravém okraji zařízení je vhodné a intuitivní: **spíše ano**.

Pzn.: *"Je to v pořádku, jednou si to člověk osahá a je to dobré."*.

- Přetáčení prostřednictvím enkodéru je vhodné a intuitivní: **spíše ano**.

Pzn.: *"Kroky přetáčení se mi zdají moc malé."*. [F404]

- Nastavení hlasitosti je vhodné a intuitivní: **rozhodně ano**.
- Výběr knihy na přední straně je vhodný a intuitivní: **rozhodně ano**.
- Výběr knihy na přední straně je vhodný a intuitivní: **rozhodně ano**.

Pzn.: *"Při používání složitějších textů někdy používám více záložek."*. [F405]

Hodnocenní zařízení jako celku

- Co považujete za nevýhody tohoto zařízení? *"Mohlo by to být celkově menší, aby se to lépe dalo přenášet."* [F406]
- Co považujete za výhody tohoto zařízení? *"Jednoduchost."* [F406]
- V jaké situaci by jste používal toto zařízení? *"Četl bych s ním asi hlavně beletrii."* [F307]
- Jaké máte otázky k tomuto zařízení?
  - *"Jak zjistím, kolik mi zbývá do konce stopy, knihy? "* [F308]

Tento participant čte syntetizované knihy i audioknihy. *"U syntetizovaných je výhoda, že můžete hledat v textu. Ale používám obojí a u každého vidím výhodu, u mluvených je to to, že nám to čte příjemný hlas, u syntetizovaných můžeme s textem lépe pracovat."*

"Čtu z iPhone, kde je na to aplikace. Mohu vyhledávat a tak. U MP3 to nejde a tam se hodí záložky."

L.5 P5

První dojmy

Participanta jako první upoutal ovladač hlastitosti: *"Tady je nějaký posuv, to bude asi hlasitost". "Vzdáleně mi to připomíná knížku."* [F500]. Objevil se zde problém s nalezením levého tlačítka pro přepnutí stopy zpět [F501]. Vstup na sluchátka participant nalezl a správně identifikoval. [F502]

Hodnocení komponent

- Zapnutí čtení prostřednictvím otevření knihy je vhodné a intuitivní: **spíše ano**.
- Přepnutí kapitoly prostřednictvím trojúhelníkových tlačítek při levém a pravém okraji zařízení je vhodné a intuitivní: **rozhodně ano**.

Pzn.: *"Když to bude jasně daná jednotka, která vím, jak je dlouhá, tak je to jasné. Pokud je neznámé, jak dlouhá, tak to tak dobré nebude. Třeba když to bude 20 stránek."*.

- Přetáčení prostřednictvím enkodéru je vhodné a intuitivní: **nevím**.

Pzn.: *"Tento krok se mi zdá malý."*. [F503]

- Nastavení hlasitosti je vhodné a intuitivní: **spíše ano**.
- Výběr knihy na přední straně je vhodný a intuitivní: **spíše ano**.
- Automatická záložka je vhodná a intuitivní: **rozhodně ano**.

Hodnocenní zařízení jako celku

- Co považujete za nevýhody tohoto zařízení? *"Chybí mi mezikrok v přetáčení, něco mezi kapitolou a enkodérem."* [F504]
- Co považujete za výhody tohoto zařízení? *"Jednoduchost, dobrý rozměr, mohlo by to být menší."* [F505]
- V jaké situaci by jste používal toto zařízení? *"Asi nepoužíval, já čtu z mobilu. Dneska jsou pro mě zajímavější aplikace, třeba v iPhone. "* [F506]
- Jaké máte otázky k tomuto zařízení?
  - *"Kde vzniknul nápad?"*

L.6 P6

První dojmy

"No to vypadá jako kniha." [F600]. *"Tady nahoře jsou paprskovitě rozmístěné značky, v půlkruhu. A je tam hrot, který směřuje nahoru"*. Zkusí pootočit přepínačem: *"Aha, tak to je menu, kde si vyberu, jakou knihu si chci poslechnout."* [F601]. Participantka chtěla začít knihu číst zmáčknutím přepínače: *"Když chci začít číst, tak to tady zmáčknu, jako potvrzení, jako enter."*. Po připomenutí, že je zařézení podobné knize participantka přehrávač zkusila otevřít: *"Aha, takže to otevřu, jako klasickou knížku."*. Po otevření objevovala další ovládací komponenty. Nejprve objevila tlačítka na přepínání kapitol: *"Takže by tohleto bylo pro přepnutí dopředu, a tohle(pozn. levé) dozadu."*. Následně prozkoumávala rotační enkodér. Nejprve jeho funkčnost odhadla na ovládání hlasitosti. Po vyzkoušení správně identifikovala, že se jedná o přetáčení. Otáčela nejprve doprava, správně uvedla, že se stopa pohybuje dopředu: *"Tak toto kolečko mi taky pomáhá posouvat se dopředu."*. Následně zkusila kolečkem otáčet dozadu. V tomto momentě zjistila, jak enkodér funguje: *"Tak tímto kolečkem se posouvám po menších úsecích a šipkami po větších úsecích."*. Participantka nemohla najít ovládání hlasitosti. Uvedla, že čekala, že ovládání hlasitosti bude uvnitř knihy, jako šipky a kolečko. [F603]

Představte si situaci, že uplynul den a vy se chcete vrátit k poslouchání knihy "Belmondo, mých tisíc životů". Jak budete postupovat? *Tak nejprve knihu nastavim v tom menu a pak by tam mělo být nějaké zařízeníčko, které si zapamatuje to místo, kde jsem včera skončila a od toho to pustí.* Vstup na sluchátka identifikovala ihned. [F602]

Hodnocení komponent

- Zapnutí čtení prostřednictvím otevření knihy je vhodné a intuitivní: **rozhodně ano**.

Pzn.: *"Jak jsem zblblá z těch přehrávačů tak jsem zvyklá mačkat tlačítka a nenapadla mě tak triviální věc, otevřít knihu."*. [F601]

- Přepnutí kapitoly prostřednictvím trojúhelníkových tlačítek při levém a pravém okraji zařízení je vhodné a intuitivní: **rozhodně ano**.

Pzn.: *"To je perfektní, bylo mi to hned jasný, když tam jsou šipky."*.

- Přetáčení prostřednictvím enkodéru je vhodné a intuitivní: **rozhodně ano**.

Pzn.: *"Je to logický, první jsem myslela hlasitost, protože je to kolečko, ale když jsem s tím otočila, tak mi to bylo hned jasný, doprava dopředu, doleva dozadu."*. [F603]

- Nastavení hlasitosti je vhodné a intuitivní: **rozhodně ano**.

Pzn.: *"Bála bych se, aby se to neulomilo."*. [F604]

- Výběr knihy na přední straně je vhodný a intuitivní: **rozhodně ano**.

Pzn.: *"Je to tak krásně jednoduchý, že jsem to nečekala."*.

- Automatická záložka je vhodná a intuitivní: **rozhodně ano**.

Pzn.: *"Úžasná, i že funguje k pozastavení."*.

Hodnocení zařízení jako celku

- Co považujete za nevýhody tohoto zařízení? *"Mohlo by to být trochu menší, kvůli přenosnosti. Čím menší, tím lepší."* [F605]
- Co považujete za výhody tohoto zařízení? *"Jednoduchost ovládání, kdyby to bylo menší, tak bych si to taky pořídila."* [F606]
- V jaké situaci by jste toto zařízení používal?
  "Ano, doma, v dopravě, v čekárně. . . .všude." [F607]
- Jaké máte otázky k tomuto zařízení?
  - *"Kdyby tam byla možná změna hlasu. Já bych chtěla, aby tam byl můj oblíbenější hlas Kuba?"*

L.7 P7

První dojmy

"No to vypadá to jako kniha, super!" [F700]. Participantka začala prozkoumávat knihu od přepínače, identifikovala šest paprsků a když zkusila otočit s přepínačem zjistila, že přepínač lze nastavit k jednotlivým paprskům. Podle zvukového výstupu rozpoznala, že se jedná o názvy knih. Participantka zařízení vnímala, jako knihu, hned ji napadlo, že čtení aktivuje pomocí otevření. Nejprve nalezla participantka levou šipku a zkusila ji použít. Rozpoznala, že se jedná o šipku. Po překliknutí se dostala na začátek knihy. Chvíli

poslouchala úvod a pak se rozhodla, že by ho přeskočila. V ten moment našla na opačném, pravém okraji zařízení, druhou šipku. Řekla že úvod přeskočí, zkusila zmáčknout pravou šipku a tím přeskočila úvodní stopu. Následně se zaměřila na enkodér. Nejprve myslela, že se jedná o hlasitost, po vyzkoušení odhalila, že jde o přetáčení. Pozastavení přehrávání chtěla participantka realizovat pomocí stisknutí enkodéru. [F701] Při tom, když hledala, jak lze přehrávání pozastavit, objevila ovládání hlasitosti, kterému přiřadila funkci na základě interakce. Hledala dále, zkusila dlouze podržet šipku pro přepnutí kapitoly, to ji ale posunulo o několik stop dále. Pak ji napadlo knihu zavřít. Zavřela ji a přehrávání se vypnulo: *"To bych nečekala. Teď když to otevřu, začne to hrát tam, kde jsem skončila? Ano, začalo."*. *"Očekávala jsem, že tu bude zastavovací tlačítko. Že bych to nejprve zastavila a pak až zavřela."* *"Teda ale jinak je to krásný, dělá to na mě dojem opravdický knížky, což je skvělý."* Vstup pro sluchátka identifikovala. [F703]

Hodnocení komponent

- Zapnutí čtení prostřednictvím otevření knihy je vhodné a intuitivní: **rozhodně ano**.
- Přepnutí kapitoly prostřednictvím trojúhelníkových tlačítek při levém a pravém okraji zařízení je vhodné a intuitivní: **rozhodně ano**.

Pzn.: *"Líbí se mi, jak jsou hmatné a příjemné."*.

- Přetáčení prostřednictvím enkodéru je vhodné a intuitivní: **spíše ano**.

Pzn.: *"Je dobré, jak to cvaká, že to není volné. Musela bych si to ale trochu vychytat, o jaké kroky se to posouvá."*.

- Nastavení hlasitosti je vhodné a intuitivní: **nevím**.

Pzn.: *"Já bych se bála, že to ulomím... raději bych to měla někde schované. Příliš to vyčnívá."*. [F702]

- Výběr knihy na přední straně je vhodný a intuitivní: **rozhodně ano**.

Pzn.: *"No to je krásné, moc se mi to líbí"*.

- Automatická záložka je vhodná a intuitivní: **rozhodně ano**.

Hodnocenní zařízení jako celku

- Co považujete za nevýhody tohoto zařízení? *"Hlasitost, ta se mi nezdá, jinak mě tu nic neruší."*
- Co považujete za výhody tohoto zařízení? *"To, že je to knížka a je to tak jednoduché"* [F704]
- V jakých situacích by jste používal by jste toto zařízení? *"Ano, doma...všude."*
- Jaké máte otázky k tomuto zařízení?

– *"Bude tam nějaké centrální zapínání?"*

Appendix M

Transcripts: Low-fidelity prototype evaluation with impaired older adults

M.1 P1

Sociodemografické údaje: Muž, 68 let, stupeň zrakového postižení 5.

Průběh testování:

Participant poznal, že se jedná o zařízení ve tvaru knihy [F100]. Odhalil, jak funguje nastavení knihy k poslouchání, zapnutí a vypnutí přehrávání [F101]. Objevil se zde problém s nalezením levé šipky pro přepnutí zvukové stopy zpět [F102].Participant předpokládal, že všechny ovládací prvky jsou na jednom panelu [F103]. Rotačnímu enkodéru nejprve participant přiřadil funkci nastavení hlasitosti [F104].

M.2 P2

Sociodemografické údaje: Muž, 59 let, stupeň zrakového postižení 5.

Průběh testování:

Participant poznal, že se jedná o zařízení ve tvaru knihy [F200]. Odhalil, jak funguje nastavení knihy k poslouchání, zapnutí a vypnutí přehrávání. Objevil se zde problém s nalezením levé šipky pro přepnutí zvukové stopy zpět [F201]. Participant předpokládal, že všechny ovládací prvky jsou na jednom panelu [F202]. Rotačnímu enkodéru nejprve participant přiřadil funkci nastavení hlasitosti, ale potom co objevil tahový potenciometr, zhodnotil tento způsob nastavení hlasitost dobře [F203].

M.3 P3

Sociodemografické údaje: Muž, 51 let, stupeň zrakového postižení 5, problémy s hmatem kvůli diabetu.

Průběh testování:

Participant poznal, že se jedná o zařízení ve tvaru knihy [F300]. Odhalil, jak funguje nastavení knihy k poslouchání, zapnutí a vypnutí přehrávání. Objevil se zde problém s nalezením levé šipky pro přepnutí zvukové stopy zpět [F301]. Participant předpokládal, že všechny ovládací prvky jsou na jednom panelu [F302]. Rotačnímu enkodéru nejprve participant přiřadil funkci nastavení hlasitosti [F303]. Jako nevýhodu zařízení uvedl velké rozměry zařízení a taky [F304]. Projevil také obavu, že se mu uvnitř zařízení bude usazovat prach [F305].

M.4 P4

Sociodemografické údaje: Žena, 81 let, stupeň zrakového postižení 5, o zrak přišla v pozdějším věku.

Průběh testování:

Participantka poznala, že se jedná o zařízení ve tvaru knihy [F401]. Odhalila, jak funguje nastavení knihy k poslouchání, zapnutí a vypnutí přehrávání. Objevil se zde problém v použitelnosti, kdy participantka nepochopila koncept zvukových stop (fakt, že nahrávka knihy je rozdělena na zvukové stopy, tracky) a tím pádem nepochopila ani tlačítka pro jejich přepínání [F402]. Ostatním funkcím porozuměla, což bylo prokázáno úspěšným splněním zadaných úkolů (výběr knihy, nastavení hlasitosti, přetáčení), rotačnímu enkodéru přiřadila prvním dojmem funkci nastavení hlasitosti [F403].

M.5 P5

Sociodemografické údaje: Žena, 94 let, stupeň zrakového postižení 4, sluchové znevýhodnění.

Průběh testování:

Kvůli problémům se sluchem musel být experiment ukončen hned na začátku. Participantka nerozuměla zvuku z reproduktoru počítače, a proto nemělo cenu v testu pokračovat [F500].

M.6 P6

Sociodemografické údaje: Žena, 89 let, stupeň zrakového postižení 3, trpí demencí.

Průběh testování:

Participantka poznala, že se jedná o zařízení ve tvaru knihy [F601]. Odhalila, jak funguje nastavení knižního titulu k poslouchání, zapnutí a vypnutí přehrávání. Objevil se zde problém v použitelnosti, kdy participantka rotačnímu enkodérů přiřadila funkci hlasitosti [F602], ačkoliv ji několikrát během testování bylo vysvětleno, že se jedná o komponentu pro přetáčení. Také se zde objevil se zde problém s nalezením levé šipky pro přepnutí zvukové stopy zpět [F603].

M.7 P7

Sociodemografické údaje: Muž, 69 let, stupeň zrakového postižení 4, zhoršená hmatová citlivost následkem popálení.

Průběh testování:

Participant poznal, že se jedná o zařízení ve tvaru knihy [F701]. Odhalil, jak funguje nastavení knižního titulu k poslouchání, zapnutí i vypnutí přehrávání, přepínání zvukových stop, nastavení hlasitosti. Objevil se zde problém s nalezením levé šipky pro přepnutí zvukové stopy zpět [F702]. Participant předpokládal, že všechny ovládací prvky jsou na jednom panelu [F703]. Líbila se mu možnost přetáčení, která mu u jeho současného zařízení chybí [F704].

Appendix N

Experiment guide: High-fidelity prototype evaluation

Informovaný souhlas

Katedra počítačové grafiky a interakce, Fakulty Elektrotechnické ČVUT v Praze vyvíjí zařízení pro čtení knih, které je určené hlavně pro zrakově znevýhodněné seniory. Nyní jsme ve fázi návrhu designu, máme zde prototyp a testujeme, zda je použitelný. Účast je dobrovolná a může být ukončena v jakýkoliv okamžik. Získané údaje budou zpracovávány anonymně a nebudou spojovány s osobou účastníka výzkumu. Za výzkum zodpovídají: Barbora Endrštová, Miroslav Macík.

- Souhlasíte se svou účastí v testování použitelnosti zařízení pro čtení knih primárně určeného zrakově znevýhodněným seniorům? - čekání na odp.
- Souhlasíte, že může být provedena video-nahrávka, zachycující interakci se zařízením?

Tato nahrávka bude použita pouze pro potřeby vývoje a výzkumu a nebude poskytnuta třetím osobám.

Icebreaking

Jak se máte? Atd... Čtete audioknihy? Jaké zařízení používáte? Vyhovuje vám? Krom knih, co rád/a posloucháte? Radio, televizi, hudbu, časopisy (jaké?), něco jiného?

Pre-test dotazník

- Kolik Vám je let?
- Jak dlouho nevidíte?
- Jaký je stupeň vašeho zrakového potižení?
- Jak dlouho žijete v Palatě?

Testování

Jak jsme řekli, dnes budeme testovat přehrávač knih určený pro seniory.

Vývoj tohoto přehrávače probíhá tak, že vytvoříme prototyp zařízení, a pak ho konzultujeme s lidmi, kteří mají odpovídající zkušenost a mohou poskytnout relevantní informace související s tímto tématem.

Design zařízení není finální, ale je otevřený k úpravám.

Proto budeme rádi za každý váš poznatek, když budete přemýšlet nahlas. Každý váš poznatek nám pomůže. Ať už jako podnět ke změně, nebo jako ujištění, že jsme danou věc řešili dobře.

Nyní vám dám zařízení do ruky a popište mi, jak na Vás působí.

Jaké prvky cítíte a k čemu předopkládáte, že slouží.

TASK 1: Chcete si poslechnout knihu o Belmodovi. Zkuste k tomu použít toto zařízení. Zkuste nahlas popisovat, co Vás napadá, když zařízení používáte.

TASK 2: Když Vás teď někdo během poslouchání přeruší, jako například já, nebo sestra, která vám přinesla léky a vy kvůli tomu přeslechnete kousek vyprávění,jak budete postupovat?

TASK 3: Chcete začít poslouchat knihu "Zpovědi českého američana". Ale nechcete poslouchat první stopu s informacemi. Jak budete postupovat?

TASK 4: Chtěla byste poslouchat v křesle, které je daleko od zásuvky. Jak budete postupovat? Jak zjistíte, kolik zbývá baterie?

TASK 5: Ve dvě se chystáte jít na Kavárnu., do té doby si chcete číst. Jak pomocí tohoto zařízení zjistíte, kolik je hodin?

TASK 6: Když chcete poslouchat na pokoji, ale je tam i vaše spolubydlící, kterou nechcete rušit a máte tady k dispozici sluchátka. Jak budete postupovat?

Post-test dotazník

Q0: Jaké máte k přehrávači otázky?

Q1: Jaká část pro vás byla nejtěžší? ... a proč?

Q2: Co se vám na tomto zařízení nejvíce nelíbilo? ....a proč? Jaké další věci se vám nelíbily?

Q3: Jáká funkce na tomto zařízení se vám líbila nejvíce?

Q4: Jak hodnotíte tento test?

Appendix O

Transcripts: High-fidelity prototype evaluation

O.1 P1

Icebreaking

Posloucháte knihy? *"No, víte, já nevím, jak bych je poslouchala."*
Co posloucháte, rádio, televizi či něco jiného? *"Poslouchám rádio."*

První dojem

Jak na Vás zařízení působí? *"Působí na mě jako hezká krabička, taková sympatická."* [F101]

"Tady je nějakej čudlik a stím se asi nějak hne....Jo tam je jiná kniha.....Takže když to budu mačkat, takto dokola, tak pokaždý tam bude jiná kniha." Participantka přepíná dokola. Naráží zarážku 12 a 1, proto přepíná zpět, aby prozkoumala všechny dostupné tituly. U každé položky se zastaví, poslechne název titulu a pak přepne dál.

"Moc hezky se s tím točí.", kladně reaguje na přepínač. U jedné z položek zkusí zmáčknout info button. Protože participantka stiskla info button dlouze, sice se zpráva s anotací spustila, ale po pár sekundách se ukončila, což je pro participantku matoucí. [F102]

Testování

Task 1: Poslouchání knihy.

1. Participantka hledá knihu o Belmodovi mezi tituly.
2. Participantka neví, jak má přehrávání spustit: *"Tady musí být nějaké tlačítko."*. Nejdříve přemýšlí nad spuštěním pomocí info buttonu. Po chvíli tápání ji směruji ke konceptu knihy. Po tom co zmíním, že se zařízení chová jako klasická kniha, tak participantku napadne Reprobooktor otevřít. Komentuje to slovy: *"Ono to je tak jednoduchý, že mě to nenapadlo"*. Otevírá zařízení, jde ji to více ztuha, než očekávala: *"Jo to je těžký"*, nakonec se ji zařízení povede otevřít. Přehrávač začne hrát.
3. Participantka popisuje, co cítí: *"Tady je kolečko, to bude na hlasitost... Chtělo by to, aby to hrálo ještě víc nahlas."*... zkoučí točit doprava, ale to už nejde.
4. Po chvíli zavírá přehrávač.

Task 2: Přetočení zpět.

1. Participantka má otevřenou knihu.
2. Participantka prozkoumává otevřený přehrávač. Komentuje další komponenty: *"Šipky, ty nevím k čemu jsou, ale mohly by trochu přetočit, tak to zkusíme."*– šipka přepla na začátku tracku. Problémem je, že participantka nezná koncept rozdělení audioknihy do tracků [F103]. Popisuju ji, jak to funguje. Na základě popisu participantka pochopila, že přesunutí na začátek tracku není přesně to, co potřebovala. Prozkoumává zařízení dál.
3. Mačká tlačítko pro přepnutí zpět. Stopa se přepne o pár sekund zpět. Participantka rozpoznává, že toto je přesně, co hledala. Rekapituluje veškeré komponenty v otevřeném Reprobooktoru.

Task 3: Přeskočení zvukové stopy.

1. Participantka nastavuje knihu Zpovědi českého američana.
2. Otevírá přehrávač.
3. Mačká pravou šipku.

Task 4: Zjištění stavu baterie.

1. Participantka prozkoumává zařízení. Nejprve zeshora, následně z boků.
2. Nejprve prozkoumá kolik tlačítek se na zařízení nachází, pak je zkouší mačkat.
3. Podle jednoho z hlášení říká, že do vybití zbývají dvě hodiny a půl.

Task 5: Hodinky.

1. Participantka mačká hodinkové tlačítko.

2. Poslouchá, kolik je hodin

Task 6: Sluchátka.

1. Uživatelka prozkoumala zařízení, našla vstup pro sluchátka.
2. Vzala do ruky kabel od sluchátek a našla konektor.

Post-test dotazník

Q0 : –

Q1 : *"Nejtěžší bylo najít tlačítko na baterku."*

Q2 : *"Mně se moc líbí."*

Q3 : *"Líbí se mi, to přepínátko. S tím se moc hezky točí. Celé se mi to líbí. Jak je to jednoduché."*

Q4 : *"Test mě bavil."*

O.2 P2

Icebreaking

Posloucháte knihy? *"Poslouchám, ale tady v Palatě jsem si zatím nenechala přivést rádio, protože je moc veké a nevešlo by se mi na noční stolek, podívejte, jak je malý....nemohla bych si tam pak dávat jiné věci."* [F201]
Co ještě posloucháte, rádio, televizi či něco jiného? *"Poslouchám rádio a televizi."*

První dojem

Jak na Vás zařízení působí? *"No je to hezky malé, o mnoho menší než to moje velké rádio."* [F202]

"Tady něco cítím, jo, s tím se točí ... a co mi to říká? Jo to budou názvy knížek asi."
Participantka přepíná po směru hodinových ručiček.

Testování

Task 1: Poslouchání knihy.

1. Participantka hledá knihu o Belmodovi mezi tituly.
2. Participantka neví, jak má přehrávání spustit. Nejdříve zkouší zmáčknout info button. Reprobooktor říká anotaci knihy., která po schvíli skončí. Participantka reaguje: "Jo to asi jsou informace o knize.... ale jak to spustit, to nevím". [F203] Napovím, že se zařízení chová podobně jako kniha. Participantka otevře reprobooktor: "Jo ono to je takhle jednoduchý!".
3. Přehrávání začne hrát.

Task 2: Přetočení zpět.
"Tak když přijde sestra, tak to asi budu chtít v první řadě pozastavit. Ale nevím, jak to udělám.... no, možná to zkusím zavřít."

1. Participantka zavírá zařízení.
2. Participantka otevírá přehrávač. Dodávám otázku, jak by přetočila o kousek zpět, kdyby přeci jen ještě potřebovala trochu přetočit, protože nestihla knihu zavřít včas. *"Tak to asi bude tady nějaké tlačítko. Ale nevím které.... "* zkusí levé trojúhelníkové. To ji posunulo na začátek tracku. Nezná koncept tracků, tak ji ho vysvětluji. Konceptu tracků porozumí jakmile track přirovnám ke kapitole. "No, tak bud budu poslouchat kus znovu, nebo kousek přetočím tím spodním."
3. Přetáčí. Zkouší dopředu i dozadu.

Task 3: Přeskočení zvukové stopy.

1. Participantka nastavuje knihu Zpovědi českého američana.
2. Otevírá přehrávač.
3. Mačká pravou šipku.

Task 4: Zjištění stavu baterie.

1. Participantka prozkoumává zařízení.
2. Prstem jede po boku zařízení směrem od hřbetu. Nalézá válcovité tlačítko a mačká ho.
3. Dodává: *"Tak ještě zbává přes dvě hodiny."*.

Task 5: Hodinky.

1. Participantka prozkoumává zařízení. Nalézá konektor pro napájení, protože nejde zmáčknout, tak jede dál. Nalézá malé kulaté tlačítko a mačká ho.
2. Poslouchá, kolik je hodin. Zprávu pustí ještě podruhé a sdělí mi správný čas.

Task 6: Sluchátka.

1. Uživatelka prozkoumává přehrávač, našla vstup pro sluchátka.
2. Zapojuje sluchátka.

Post-test dotazník

Q0 : –

Q1 : *"Nejtěžší bylo asi to přetáčení a přepínání, než jsem pochopila, jak to funguje."*

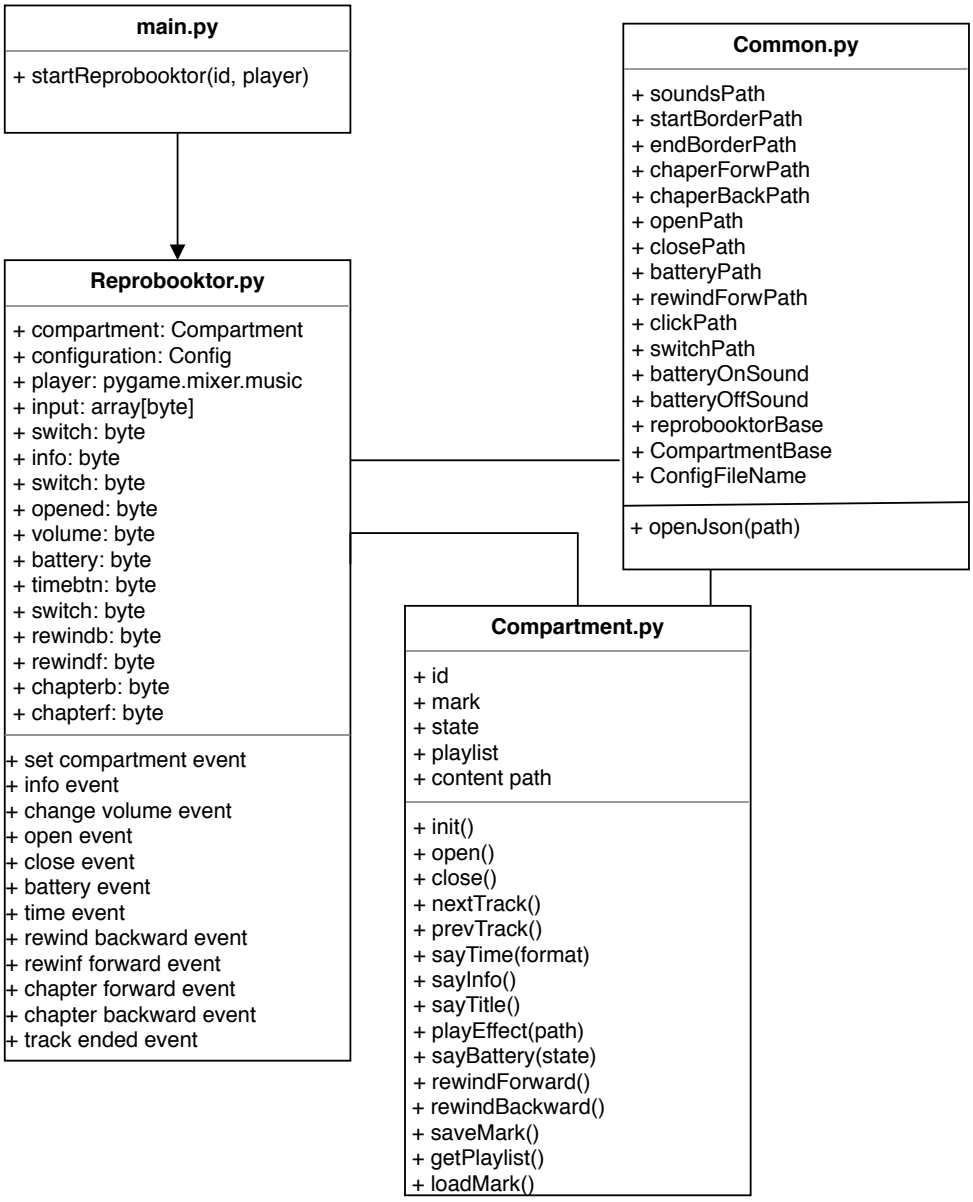
Q2 : –

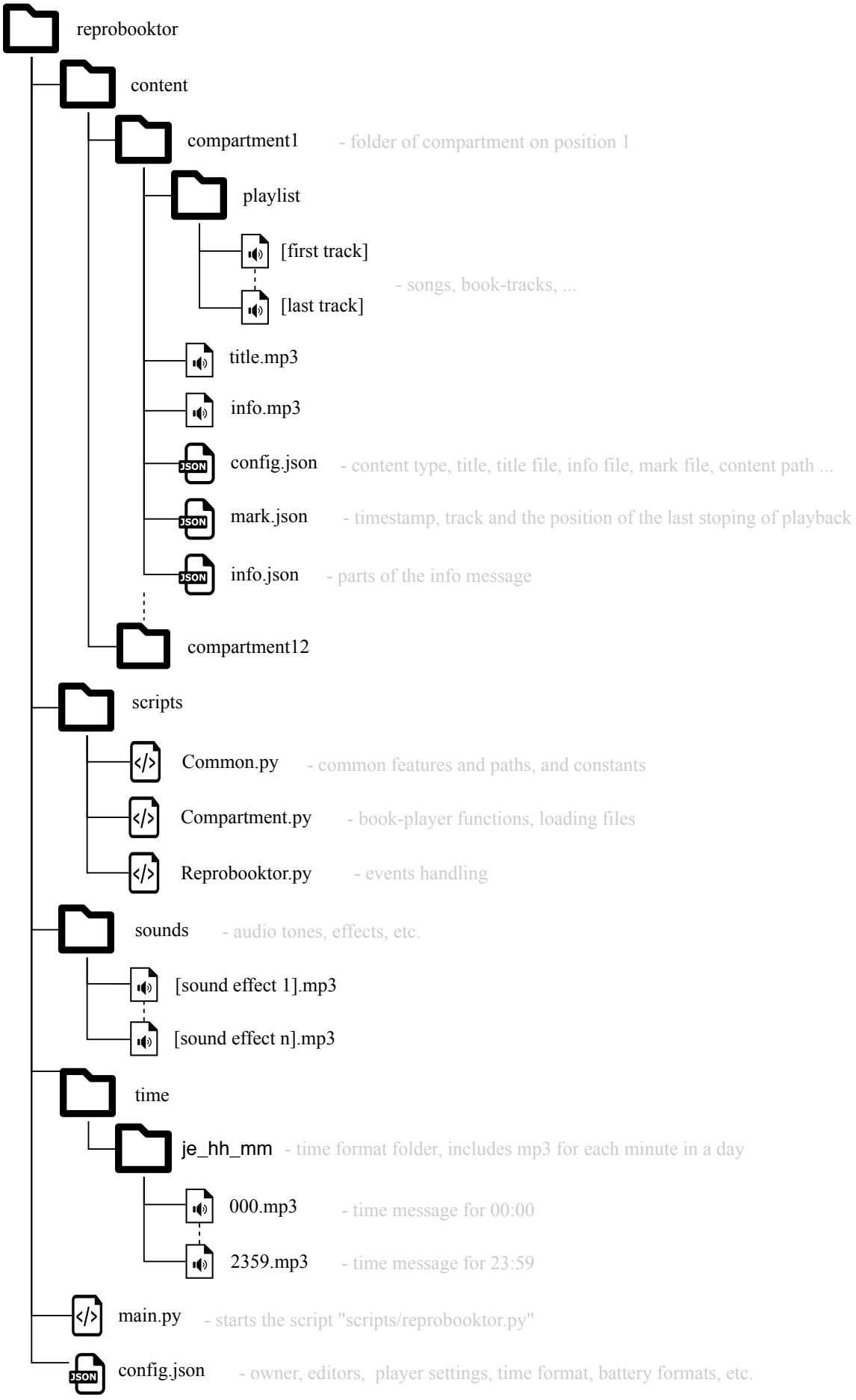
Q3 : *"Je to tak akorát velké a hezky jednoduché."*

Q4 : *"V pořádku. Až budete mít zařízní hotové, tak bych si jedno zamluvila."*

Appendix P

Structure of the application




reprobooktor
content
compartment1 - folder of compartment on position 1
playlist
[first track]
- songs, book-tracks, ...
[last track]
title.mp3
info.mp3
config.json - content type, title, title file, info file, mark file, content path ...
mark.json - timestamp, track and the position of the last stoping of playback
info.json - parts of the info message
compartment12
scripts
Common.py - common features and paths, and constants
Compartment.py - book-player functions, loading files
Reprobooktor.py - events handling
sounds - audio tones, effects, etc.
[sound effect 1].mp3
[sound effect n].mp3
time
je_hh_mm - time format folder, includes mp3 for each minute in a day
000.mp3 - time message for 00:00
2359.mp3 - time message for 23:59
main.py - starts the script "scripts/reprobooktor.py"
config.json - owner, editors, player settings, time format, battery formats, etc.

Bibliography

[1] M. Macik, I. Maly, J. Balata, and Z. Mikovec, "How can ict help the visually impaired older adults in residential care institutions: The everyday needs survey", in *Cognitive Infocommunications (CogInfoCom), 2017 8th IEEE International Conference on*, IEEE, 2017, pp. 000 157–000 164.

[2] *Design studio, Facilitating an effective workshop*, Prague. [Online]. Available: `https://www.nngroup.com/articles/facilitating-design-studio-workshop/`.

[3] *Asociace ux*, Prague. [Online]. Available: `http://www.asociaceux.cz/`.

[4] *Home palata, About home palata*, Prague. [Online]. Available: `https://palata.cz/o-palate/`.

[5] *Blindness and vision impairment*. [Online]. Available: `http://www.who.int/news-room/fact-sheets/detail/blindness-and-visual-impairment`.

[6] *Výsledky šetření o zdravotně postižených osobách v české republice za rok 2007, Tabulka č. 7: Typ zdravotního postižení podle pohlaví a věku*, Praha, 2008. [Online]. Available: `http://www.nrzp.cz/dokumenty/Vybrane_statisticke_udaje_OZP_2007.pdf`.

[7] *American foundation for the blind, Key findings: National poll on severe vision loss/blindness*, Washington, 2007. [Online]. Available: `http://www.afb.org/info/programs-and-services/public-policy-center/policy-research/national-poll-findings-3376/1235`.

[8] *Ergonomics of human-system interaction, Part 210: Human-centred design for interactive systems*, 1st ed., Geneva, Switzerland: International Organization for Standardization, 2010.

[9] *Google translator, Definition of term well-being*. [Online]. Available: `https://translate.google.cz/?hl=cs\#en/cs/well-being`.

[10] J. Mareš, "Problémy s pojetím pojmu kvalita života as jeho definováním", *Kvalita života u detí a dospievajúcich I*, pp. 11–28, 2006.

[11] C. D. Ryff, "Happiness is everything, or is it? explorations on the meaning of psychological well-being.", *Journal of personality and social psychology*, vol. 57, no. 6, p. 1069, 1989.

[12] J. Nielsen, *Usability 101: Introduction to usability, Definition of usability*, 2012. [Online]. Available: `https://www.nngroup.com/articles/usability-101-introduction-to-usability/`.

[13] J. Nielsen, *Usability engineering*. Elsevier, 1994.

[14] D. A. Norman, *The design of everyday things, Human error? no, bad design*, Revised and expanded edition. New York, New York: Basic Books, [2013], ISBN: 978-0-465-00394-5.

[15] D. Norman and S. Draper, *User centered system design: New perspectives on human-computer interaction*, ser. New Perspectives on Human-Computer Interaction Series. Lawrence Erlbaum Associates, 1986. [Online]. Available: `https://books.google.cz/books?id=IR9FAAAAYAAJ`.

[16] *Human–centred design processes for interactive systems*, Geneva: International Standards Organisation, 1999.

[17] C. B. Rebola and B. Jones, "Sympathetic devices: Designing technologies for older adults", in *Proceedings of the 31st ACM international conference on Design of communication*, ACM, 2013, pp. 151–156.

[18] H. Beyer and K. Holtzblatt, *Contextual design: Defining customer-centered systems*. Elsevier, 1997.

[19] *Knihovna a tiskárna pro nevidomé, Digitální internetová knihovna*, Praha. [Online]. Available: `https://www.ktn.cz`.

[20] L. Izsó, "The significance of cognitive infocommunications in developing assistive technologies for people with non-standard cognitive characteristics: Coginfocom for people with non-standard cognitive characteristics", in *Cognitive Infocommunications (CogInfoCom), 2015 6th IEEE International Conference on*, IEEE, 2015, pp. 77–82.

[21] R. R. Bourne, G. A. Stevens, R. A. White, J. L. Smith, S. R. Flaxman, H. Price, J. B. Jonas, J. Keeffe, J. Leasher, K. Naidoo, *et al.*, "Causes of vision loss worldwide, 1990–2010: A systematic analysis", *The lancet global health*, vol. 1, no. 6, e339–e349, 2013.

[22] J. Xu, J. Pokorny, and V. C. Smith, "Optical density of the human lens", *JOSA A*, vol. 14, no. 5, pp. 953–960, 1997.

[23] T. Vinding, "Occurrence of drusen, pigmentary changes and exudative changes in the macula with reference to age-related macular degeneration an epidemiological study of 1000 aged individuals", *Acta ophthalmologica*, vol. 68, no. 4, pp. 410–414, 1990.

[24] J. Chen and L. E. Smith, "Retinopathy of prematurity", *Angiogenesis*, vol. 10, no. 2, pp. 133–140, 2007.

[25] A. L. Orr, *Vision and aging: Crossroads for service delivery*. American Foundation for the Blind, 1992.

[26] M. Macik, "Cognitive aspects of spatial orientation", English, vol. 15, no. 5, 2018. DOI: `10.12700/APH.15.5.2018.5.9`. [Online]. Available: `http://uni-obuda.hu/journal/Macik_84.pdf`.

[27] B. Röder, F. Rösler, and C. Spence, "Early vision impairs tactile perception in the blind", *Current Biology*, vol. 14, no. 2, pp. 121–124, 2004.

[28] G. E. Legge, C. Madison, B. N. Vaughn, A. M. Cheong, and J. C. Miller, "Retention of high tactile acuity throughout the life span in blindness", *Perception & psychophysics*, vol. 70, no. 8, pp. 1471–1488, 2008.

[29] S. A. Stevelink, E. M. Malcolm, and N. T. Fear, "Visual impairment, coping strategies and impact on daily life: A qualitative study among working-age uk ex-service personnel", *BMC public health*, vol. 15, no. 1, p. 1118, 2015.

[30] A. Horowitz, "The prevalence and consequences of vision impairment in later life", *Topics in Geriatric Rehabilitation*, vol. 20, no. 3, pp. 185–195, 2004.

[31] C. Rooney, K. Hadjri, K. Mcallister, M. Rooney, V. Faith, and C. Craig, "Experiencing visual impairment in a lifetime home: An interpretative phenomenological inquiry", *Journal of Housing and the Built Environment*, vol. 33, no. 1, pp. 45–67, 2018.

[32] H. Senra, R. A. Oliveira, and I. Leal, "From self-awareness to self-identification with visual impairment: A qualitative study with working age adults at a rehabilitation setting", *Clinical rehabilitation*, vol. 25, no. 12, pp. 1140–1151, 2011.

[33] U. E. White, A. A. Black, J. M. Wood, and K. Delbaere, "Fear of falling in vision impairment", *Optometry and vision science*, vol. 92, no. 6, pp. 730–735, 2015.

[34] R. Z. Hayeems, G Geller, D Finkelstein, and R. Faden, "How patients experience progressive loss of visual function: A model of adjustment using qualitative methods", *British Journal of Ophthalmology*, vol. 89, no. 5, pp. 615–620, 2005.

[35] I. Stuart-Hamilton, "Intellectual changes in late life.", 1996.

[36] M. Zajicek, "Interface design for older adults", in *Proceedings of the 2001 EC/NSF workshop on Universal accessibility of ubiquitous computing: Providing for the elderly*, ACM, 2001, pp. 60–65.

[37] T. Huang, "Age-related hearing loss.", *Minnesota medicine*, vol. 90, no. 10, pp. 48–50, 2007.

[38] J. Knight, C. Wigham, and Y. Nigam, "Anatomy and physiology of ageing 6: The eyes and ears", *Nursing Times*, vol. 113, no. 7, pp. 39–42, 2017.

[39] J. Berkowitz and S. Casali, "Influence of age on the ability to hear telephone ringers of different spectral content", in *Proceedings of the Human Factors Society Annual Meeting*, SAGE Publications Sage CA: Los Angeles, CA, vol. 34, 1990, pp. 132–136.

[40] E. Skovenborg and S. H. Nielsen, "Evaluation of different loudness models with music and speech material", in *Audio Engineering Society Convention 117*, Audio Engineering Society, 2004.

[41] B. A. Schneider, M. Daneman, and D. R. Murphy, "Speech comprehension difficulties in older adults: Cognitive slowing or age-related changes in hearing?", *Psychology and aging*, vol. 20, no. 2, p. 261, 2005.

[42] J. S. Youmasu, "Understanding the effects of aging on the sensory system", [Online]. Available: `http://pods.dasnr.okstate.edu/docushare/dsweb/Get/Document-2418/T-2140web.pdf`.

[43] *Age-related vision loss, Data from survey of income and program participation, 2008*. [Online]. Available: `http://www.afb.org/info/for-employers/visual-impairment-and-your-current-workforce/age-related-vision-loss/345`.

[44] D. L. Murman, "The impact of age on cognition", in *Seminars in hearing*, Thieme Medical Publishers, vol. 36, 2015, p. 111.

[45] J. M. Thornbury and C. M. Mistretta, "Tactile sensitivity as a function of age1", *Journal of Gerontology*, vol. 36, no. 1, pp. 34–39, 1981. DOI: 10.1093/geronj/36.1.34. eprint: /oup/backfile/content_public/journal/geronj/36/1/10.1093/geronj/36.1.34/2/36-1-34.pdf. [Online]. Available: http://dx.doi.org/10.1093/geronj/36.1.34.

[46] M. Wickremaratchi and J. G. Llewelyn, "Effects of ageing on touch", *Postgraduate medical journal*, vol. 82, no. 967, pp. 301–304, 2006.

[47] E. Böhm, "Psychobiographisches pflegemodell nach böhm", 1999.

[48] K. B. Adams, S. Leibbrandt, and H. Moon, "A critical review of the literature on social and leisure activity and wellbeing in later life", *Ageing & Society*, vol. 31, no. 4, pp. 683–712, 2011.

[49] W. J. Brown, G. Mishra, C. Lee, and A. Bauman, "Leisure time physical activity in australian women: Relationship with well being and symptoms", *Research quarterly for exercise and sport*, vol. 71, no. 3, pp. 206–216, 2000.

[50] A. Karp, S. Paillard-Borg, H.-X. Wang, M. Silverstein, B. Winblad, and L. Fratiglioni, "Mental, physical and social components in leisure activities equally contribute to decrease dementia risk", *Dementia and geriatric cognitive disorders*, vol. 21, no. 2, pp. 65–73, 2006.

[51] H.-X. Wang, A. Karp, B. Winblad, and L. Fratiglioni, "Late-life engagement in social and leisure activities is associated with a decreased risk of dementia: A longitudinal study from the kungsholmen project", *American journal of epidemiology*, vol. 155, no. 12, pp. 1081–1087, 2002.

[52] J. Verghese, R. B. Lipton, M. J. Katz, C. B. Hall, C. A. Derby, G. Kuslansky, A. F. Ambrose, M. Sliwinski, and H. Buschke, "Leisure activities and the risk of dementia in the elderly", *New England Journal of Medicine*, vol. 348, no. 25, pp. 2508–2516, 2003.

[53] J. Verghese, A. LeValley, C. Derby, G. Kuslansky, M. Katz, C. Hall, H. Buschke, and R. B. Lipton, "Leisure activities and the risk of amnestic mild cognitive impairment in the elderly", *Neurology*, vol. 66, no. 6, pp. 821–827, 2006, ISSN: 0028-3878. DOI: 10.1212/01.wnl.0000202520.68987.48. eprint: http://n.neurology.org/content/66/6/821.full.pdf. [Online]. Available: http://n.neurology.org/content/66/6/821.

[54] M. Silverstein and M. G. Parker, "Leisure activities and quality of life among the oldest old in sweden", *Research on aging*, vol. 24, no. 5, pp. 528–547, 2002.

[55] E. Bouchard Ryan, A. P. Anas, M. Beamer, and S. Bajorek, "Coping with age-related vision loss in everyday reading activities", *Educational Gerontology*, vol. 29, no. 1, pp. 37–54, 2003.

[56] B. Endrstova, M. Macik, and L. Treml, "Reprobooktor: A concept of audiobook player for visually impaired older adults", Aug. 2018.

[57] R. W. Massof, "Auditory assistive devices for the blind", Georgia Institute of Technology, 2003.

[58] M. Crossland, A. F. Macedo, and G. Rubin, "Electronic books as low vision aids", *British Journal of Ophthalmology*, vol. 94, no. 8, pp. 1109–1109, 2010.

[59] A. Kulkarni and K. Bhurchandi, "Low cost e-book reading device for blind people", in *Computing Communication Control and Automation (ICCUBEA), 2015 International Conference on*, IEEE, 2015, pp. 516–520.

[60] A. Nazemi, C. Ortega-Sanchez, and I. Murray, "Digital talking book player for the visually impaired using fpgas", in *Reconfigurable Computing and FPGAs (ReConFig), 2011 International Conference on*, IEEE, 2011, pp. 493–496.

[61] A. Pirhonen, S. Brewster, and C. Holguin, "Gestural and audio metaphors as a means of control for mobile devices", in *Proceedings of the SIGCHI conference on Human factors in computing systems*, ACM, 2002, pp. 291–298.

[62] B. L. Harrison, K. P. Fishkin, A. Gujar, C. Mochon, and R. Want, "Squeeze me, hold me, tilt me! an exploration of manipulative user interfaces", in *Proceedings of the SIGCHI conference on Human factors in computing systems*, ACM Press/Addison-Wesley Publishing Co., 1998, pp. 17–24.

[63] *Kindle paperwhite blind and visually impaired readers bundle*. [Online]. Available: https://www.amazon.com/Kindle-Paperwhite-Visually-Impaired-Readers/dp/B01AS6HK7G.

[64] H. Huang, "Blind users' expectations of touch interfaces: Factors affecting interface accessibility of touchscreen-based smartphones for people with moderate visual impairment", *Universal Access in the Information Society*, vol. 17, no. 2, pp. 291–304, 2018.

[65] *Plextalk, Ptn2 cross*. [Online]. Available: http://www.plextalk.eu/en/top/products/ptn2/specifications/.

[66] *Products, Sovereign usb memory stick player*. [Online]. Available: https://shop.rnib.org.uk/sovereign-usb-memory-stick-player-2.html.

[67] *Boombox plus*. [Online]. Available: https://www.amazon.co.uk/BoomBox-memory-stick-player-radio/dp/B007NIBN7G.

[68] *Amazon, Milestone 312*. [Online]. Available: https://www.amazon.com/Milestone-312-Text-to-Speech-Book-Reader-Player/dp/B008OVGREU.

[69] *Switch adapted auna boomberry portable boombox*. [Online]. Available: https://www.livingmadeeasy.org.uk/product.php?product_id=0113290\&groupid=3671.

[70] *Portable fm radio, ejiasu rechargeable mini digital radio speaker mp3 music player support tf card / usb disk with led screen display and emergency flashlight function(black)*. [Online]. Available: https://www.amazon.co.uk/Portable-eJiasu-Rechargeable-Emergency-Flashlight-Black/dp/B01AHODEKG/ref=mp_s_a_1_7/260-3295360-8670610?ie=UTF8\&qid=1543597584\&sr=1-7\&refinements=p_n_feature_keywords_two_browse-bin\%3A2712727031\&pi=AC_SX236_SY340_FMwebp_QL65\&dpPl=1\&dpID=41jmFrAvR6L\&ref=plSrch.

[71] *Amazon*. [Online]. Available: https://www.amazon.com/.

[72] *Echo dot - smart speaker with alexa - black, 2nd generation*. [Online]. Available: https://www.amazon.com/gp/product/B01DFKC2SO/ref=s9_acsd_al_bw_c_x_3_w?pf_rd_m=ATVPDKIKX0DER\&pf_rd_s=merchandised-search-4\&pf_rd_r=7VRS55VH9VYJVC53A7AN\&pf_rd_r=7VRS55VH9VYJVC53A7AN\&pf_rd_t=101\&pf_rd_p=9389011f-3294-4071-bbd4-6f22760c1ef1\&pf_rd_p=9389011f-3294-4071-bbd4-6f22760c1ef1\&pf_rd_i=9818047011.

[73] F. Portet, M. Vacher, C. Golanski, C. Roux, and B. Meillon, "Design and evaluation of a smart home voice interface for the elderly: Acceptability and objection aspects", *Personal and Ubiquitous Computing*, vol. 17, no. 1, pp. 127–144, 2013.

[74] *Copyright act, Consolidated version of act no. 121/2000 on copyright and rights related to copyright and on amtendment to certain acts (the copyright act), as amended by act no. 81/2005, act no. 61/2006 and act no. 216/2006.* Prague, 2000.

[75] *Biblio, Katalog.* [Online]. Available: `https://biblio.oui.technology/biblio/catalog`.

[76] *Raspberry pi, Raspbian*, Cambridge, UK, 2017. [Online]. Available: `https://www.raspberrypi.org/downloads/raspbian/`.

[77] *Raspberry pi, Zero w*, Cambridge, UK, 2017. [Online]. Available: `https://www.raspberrypi.org/products/raspberry-pi-zero-w/`.

[78] *What is raspberry pi?, Is the raspberry pi open hardware?* [Online]. Available: `https://opensource.com/resources/raspberry-pi`.

[79] *Raspberry pi.* [Online]. Available: `https://www.raspberrypi.org/about/`.

[80] World Health Organization and others, "International statistical classification of diseases and health related problems, 10th revision. icd-10 version: 2016. 2010", *Apps. who. int/classifications/icd10/browse/2016/en*, 2016.

[81] D. R. Thomas, "A general inductive approach for analyzing qualitative evaluation data", *American journal of evaluation*, vol. 27, no. 2, pp. 237–246, 2006.

[82] *Ucd canvas.* [Online]. Available: `https://ucdc.therectangles.com/\#how`.

[83] *Hints for easier eating and pouring.* [Online]. Available: `http://www.visionaware.org/info/essential-skills-2/eating-techniques/hints-for-easier-eating-and-pouring/235`.

[84] *Fusion 360, Fusion 360 free 3d cad/cam design software for students, educators, and academic institutions.* [Online]. Available: `https://www.autodesk.com/products/fusion-360/students-teachers-educators`.

[85] *Mk3, 3d tiskárna original prusa i3.* [Online]. Available: `https://www.prusa3d.cz/original-prusa-i3-mk3/`.

[86] *Pygame documentation, Pygame.mixer.music.* [Online]. Available: `https://www.pygame.org/docs/ref/music.html`.

[87] *Python, Download*, 2001-2018. [Online]. Available: `https://www.python.org/downloads/`.

[88] *The python standard library, 24.1. tkinter.* [Online]. Available: `https://docs.python.org/2/library/tkinter.html`.

[89] *Adruino boards, Pro micro 5v*, Niwot. [Online]. Available: `https://www.sparkfun.com/products/12640`.

[90] *Adafruit, Adafruit i2s 3w stereo speaker bonnet for raspberry pi*, NYC. [Online]. Available: `https://www.adafruit.com/product/3346`.

[91] *Adafruit, Powerboost 1000 charger*, NYC. [Online]. Available: `https://www.adafruit.com/product/2465`.

[92] *Otočné spínače do panelu, P-ds1*, Praha. [Online]. Available: https://www.gme.cz/p-ds1.

[93] *Mikrotlačítka, Dts 24n2*, Prague. [Online]. Available: https://www.ges.cz/cz/dts-24n2-GES06503880.html.

[94] *Rotační logaritmický potenciometr, P4s-log 1,0k*, Prague. [Online]. Available: https://www.ges.cz/cz/p4s-log-1-0k-GES05303169.html.

[95] *Magnetický jazýčkový kontakt ls-311-b38*, České Budějovice. [Online]. Available: http://rpishop.cz/soucastky/215-magneticke-kontakty.html.

[96] *Built-in examples, Analog read serial*. [Online]. Available: https://www.arduino.cc/en/Tutorial/AnalogReadSerial.

[97] *Sytemmd, Systemd system and service manager*. [Online]. Available: https://freedesktop.org/wiki/Software/systemd/.

[98] C. Liechti, *Pyserial, Pyserial api*, 2001-2018. [Online]. Available: https://pythonhosted.org/pyserial/.

[99] Czech Statistical Office, "Výběrové šetření osob se zdravotním postižením VŠPO 13, in czech, available from: https://www.czso.cz/documents/10180/20543019/k3_260006-14_1.pdf/4384f318-fcae-4a20-941c-33f10d5a6324?version=1.0, accessed 2018-07-10", 2013.

[100] K. Caine, "Local standards for sample size at chi", in *Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems*, ACM, 2016, pp. 981–992.

[101] S. Dow, B. MacIntyre, J. Lee, C. Oezbek, J. D. Bolter, and M. Gandy, "Wizard of oz support throughout an iterative design process", *IEEE Pervasive Computing*, vol. 4, no. 4, pp. 18–26, 2005.

[102] *Hick's law, Making the choice easier for users*. [Online]. Available: https://www.interaction-design.org/literature/article/hick-s-law-making-the-choice-easier-for-users.