An AI text summarization tool to improve visually impaired individual's skimming reading

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Abstract

With the continuous development of society and technology, accessibility for minority groups, particularly visually impaired persons (VIPs), is gaining more attention. This paper explores ways to enhance VIP reading efficiency and experience through the design of a tailored automatic text summarization tool, contributing to the European Accessibility Act's objective to improve accessible products and services. In collaboration between Delft University of Technology and Koninklijke Bibliotheek, this project addresses the specific challenges VIPs face when accessing information in both physical and digital library environments.

This research highlights the gap between sighted readers and VIPs in skimming reading strategies, a critical aspect of information retrieval. Skimming, defined as quickly identifying the main ideas of a text, is typically a faster process for sighted readers who can use spatial cues. For VIPs, reading is linear and auditory, increasing their cognitive load and reducing comprehension. Through a detailed analysis of VIP needs and existing skim-reading tools, such as Skimmer, this paper narrows its design scope to address the identified gaps, particularly in two-dimensional navigation.

The primary goal of this research is to develop an AI-driven summarization tool that enhances the skim-reading experience for VIPs by supporting non-visual implementations of macro-structures and enabling non-linear exploration. By tailoring summaries to VIP preferences, the tool allows users to quickly access relevant sections of text, improving both reading speed and overall comprehension. The design employs inclusive, iterative, and user-centered methods, ensuring the final product meets the specific needs of VIPs. User testing and feedback are integral to the development process, refining the tool to enhance usability and accessibility.

The project also contributes to the theoretical understanding of VIPs' cognitive processes during skim reading. It reveals the importance of designing summaries that are intuitive and customizable to meet diverse needs. By integrating generative AI tools, the tool can produce personalized summaries, progressively refining them to align with user interests. The final deliverable is a web-based application that provides VIPs with efficient and satisfying reading experiences, closing the gap between sighted and visually impaired readers.

This research advances assistive technology by addressing the lack of suitable reading tools for VIPs, particularly in non-academic, everyday reading contexts. The project fills market gaps by offering an accessible solution for digital reading materials that can cater to the unique challenges faced by VIPs. Ultimately, the tool

enhances VIPs' cognitive abilities, reduces their cognitive burden, and fosters a more engaging reading experience, contributing to increased reading efficiency and self-efficacy.

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1. Introduction

1.1 Project Description:

With the development of society and technology, the interests of minority groups should receive more attention. The European Accessibility Act, which is currently being implemented, ‘aims to improve the functioning of the internal market for accessible products and services’ (European Accessibility Act, n.d.).

This project, undertaken in this context, is a research and innovation collaboration between Delft University of Technology and the Koninklijke Bibliotheek. It focuses on visually impaired or low vision individuals and aims to improve their reading ability and enhance their reading experience.

Currently, individuals with visual impairments (VIP) face multifaceted challenges in accessing information from libraries, both online and offline. In addition to the insufficient variety and quantity of materials in alternative formats, the information access experience for VIP warrants attention.

In Bodaghi et al.'s (2016) research, in the offline library environment, VIPs expressed being afraid to ask for help from librarians, being disappointed, confused, uncomfortable, and not being understood due to a lack of librarians' sense of empathy.’

As for online reading environment, Martiniello et al. (2019) compared the experiences of VIP using traditional assistive devices and mainstream devices in experiments , Result shows that VIP are more sensitive to the devices and external behaviors they use. The reason lies in their reluctance to be treated differently and their heightened sensitivity to others' reactions.

Therefore, there remains significant unmet demand in enhancing the reading experience for VIPs, their emotional needs, self-esteem, and sense of efficacy have long been overlooked.

Today, the library is no longer just a place to store paper or electronic documents; rather, it tends to be more proactive in offering and tailoring information for individuals and communities and in supporting community efforts to capture, structure, and share knowledge (Omisore & Samuel, 2014). Libraries have significant potential to focus on visually impaired individuals and utilize their resources to explore better designs that enhance the reading experience for VIPs.

This paper explores the design from the perspective of skimming. According to Grellet’s (1981) definition, ‘Skimming is used to quickly identify the main ideas of a text’ . ‘You're probably not reading it word-by-word; instead, you're skimming the text. Skimming is done at a speed three to four times faster than normal reading.’

By discussing the daily reading needs of VIPs and the role of skimming within that, as well as examining the differences and gaps in skimming strategies between sighted individuals and those with visual impairments, this paper identifies the skimming challenges the design seeks to address and responds to them by exploring automatic text summarization methods.

In all, This paper aims to conduct in-depth theoretical research tailored to the needs of visually impaired individuals. The goal is to explore how designing an automatic summary tool can enhance the cognitive abilities of VIP, thereby narrowing the reading gap between them and normal sighted people.

1.2 Research Goal:

The aim of this project is to comprehensively review skim reading strategies and gaps among visually impaired persons, investigate how summaries can be integrated to enhance skim reading, and understand visually impaired individuals' needs and expectations regarding summaries.

Leveraging the affordances of generative text AI using large language models offered by commercial services, the project seeks to develop new knowledge on an automatic summarization system for visually impaired persons. The deliverable of this project will be a web interface designed to communicate visually impaired persons' personalized requirements and their preferred **interaction** mode for this system.

1.3 Design method

The design employs a multifaceted approach to ensure both functionality and accessibility. The process integrates the following methods：

a. **Inclusive approach**：By including the target group as much as possible to gain insights and gather feedback, and considering diverse user needs from the outset, the design process aims to eliminate barriers and promote usability for VIPs.

b. **Iterative design**： Each iteration involves creating a prototype, conducting user tests, gathering feedback, and making necessary adjustments. This cyclical process helps identify and resolve issues early, leading to a more robust and VIP-friendly final product.

c. **User-Centered Design**: Central to the development process is the user-centered design methodology, which involves active collaboration with visually impaired users. This approach emphasizes understanding their specific needs, preferences, and challenges through interviews, surveys, and usability testing. Feedback from these sessions directly informs design decisions, ensuring that the system is tailored to the actual requirements of the end-users.

2. Background

This chapter offers a comprehensive overview of the nature of visual impairment (VI):

- Provide precise definition and classification of VI.

- Introduce the global and regional statistics of visual impairment, focusing on the situation in the Netherlands.

-Discuss multifaceted impact of VI, examining its physical, cognitive, psychological, and social consequences, particularly among older adults.

Through various studies and frameworks, this chapter aims to provide a detailed understanding of how visual impairment affects individuals' lives, considering these factors could help in the design and development of supportive interventions for VIPs.

2.1 Introduction of visually impaired people

2.1.1 Definition

Visual impairment (VI) is a condition of reduced visual performance that cannot be remedied by refractive correction (spectacles or contact lenses), surgery, or medical methods (Noncommunicable Diseases, Rehabilitation and Disability (NCD), 2019c).

2.1.2 Classifications of visual impairment under consideration

a. From visual acuity perspective:

Visual acuity classification typically follows guidelines from the World Health Organization (WHO) and is based on presenting visual acuity:

Table-2.1 Classifications of visual impairment from visual acuity perspective:

** Visual acuity is calculated by using two numbers. The first number indicates the distance between the chart and the person reading the chart. The second number is the distance that someone with normal vision is able to read at 20ft. distance from the chart. People with normal vision can read the 20 ft line at 20 ft., a 20/20 visual acuity.*

Category	**Visual acuity in the better eye**	
	Worse than:	**Equal to or better than:**
Mild vision impairment	6/12	6/18
Moderate vision impairment	6/18	6/60
Severe vision impairment	6/60	3/60

Blindness	3/60	
Near vision impairment	N6 or M 0.8 at 40cm	

b. From type：

- Refractive Errors: Conditions like myopia, hyperopia, and astigmatism which can often be corrected with glasses or contact lenses.

- Cataracts: Clouding of the lens, which is a major cause of blindness.

- Glaucoma: A group of eye conditions that damage the optic nerve, often associated with increased intraocular pressure.

- Diabetic Retinopathy: Damage to the blood vessels in the retina due to diabetes.

- Age-Related Macular Degeneration (AMD): Deterioration of the central portion of the retina, affecting central vision.

- Congenital Conditions: Such as congenital cataract and retinopathy of prematurity, particularly significant in children in low-income regions (World Health Organization (WHO)) (Wikipedia).

These classifications help in understanding and addressing the specific needs and treatment options for individuals with visual impairments. When observing users with reading disabilities, we should first recognize the multitude of differences. Therefore, grouping users into clusters aids in design management. However, it should be noted that within each cluster, differences remain significant, and there may be overlap between clusters. Thus, the purpose of understanding these classifications is to help me empathize with the lives of VIPs and facilitate design management in subsequent stages. To ensure diversity, participants were selected with consideration of the different types of visual disabilities, this allowed me to account for these differences during the analysis phase, ensuring that the design solutions I propose are inclusive and address a broad spectrum of needs.

2.1.3 VIP statistics globally and in the Netherlands

Globally, there are approximately 2.2 billion people with vision impairment. Specifically, about 285 million people are visually impaired, with 39 million of them being blind and 246 million having low vision (World Health Organization (WHO)) (ICEVI).

In the Netherlands, this situation is further classified (Limburg & Keunen, 2009):

- In 2008 an estimated 311,000 people are visually impaired in The Netherlands: 77,000 are blind and 234,000 have low vision. With the current intervention the number may increase by 18% to 367,000 in 2020.

- Visual impairment is most prevalent among residents of nursing homes and care institutions for the elderly, intellectually disabled persons and people aged 50+ living independently.

- Of all people with visual impairment 31% is male (97,000) and 69% female (214,000).

2.1.4 Visual impairment Impact

Despite measures such as corrective eyewear, assistive devices, and medical treatment, VIPs still face significant disparities compared to those with normal vision.

In education, "School-age children with vision impairment can also experience lower levels of educational achievement." In social employment, adults similarly "experience lower rates of employment and higher rates of depression and anxiety" (World Health Organization: WHO, 2023).

Swenor et al.'s framework

Swenor et al. (2019) proposed a conceptual framework, shown in figure 2.1，systematically describing the impact of vision impairment on the functioning of older adults and subsequently on health outcomes. He pointed out that 'This model is applicable to all forms of VI and does not distinguish by VI type.'

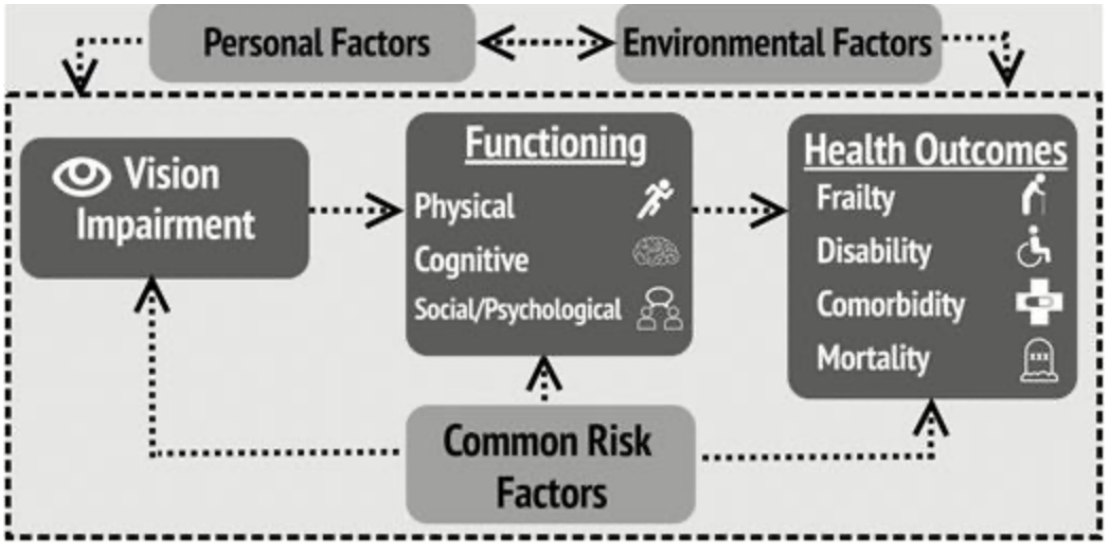


Figure-2.1 conceptual framework of the impact of vision impairment on older adults

A. Physical impact:

VI is an important contributor to mobility disability — particularly walking difficulty — among older adults. VIPs face "more mobility difficulty and have slower walking speeds" (Swenor, Muñoz, & West, 2013a, 2013b), physical activity restrictions in people with VIP (Van Landingham, Willis, Vitale, & Ramulu, 2012; Willis, Jefferys, Vitale, & Ramulu, 2012).

B. Cognitive impact

Longitudinal analyses indicate that impaired vision predicts cognitive decline (Swenor et al., 2018; Zheng et al., 2018) and the risk of dementia (Rogers & Langa, 2010).

C. Psychological and social impact

The likelihood of depression and anxiety in older adults with low vision is about twice that of older adults with normal vision. Approximately 54% of older adults with VI report feeling lonely, while lonely individuals have more difficulty adapting to vision loss and receive less social support than those not lonely (Verstraten, Brinkmann, Stevens, & Schouten, 2005). Among nursing home residents, worse VI is associated with lower social engagement (Resnick, Fries, & Verbrugge, 1997).

Insight of This Section

- The challenges faced by VIPs are multifaceted and complex. In the design process, besides researching basic needs, the psychological and social impacts should also be considered.

- Swenor et al.'s conceptual framework provides a solid theoretical foundation for the design research and user empathy of this project – understanding and supporting VIPs from a systematic perspective of physical, cognitive, social/psychological.

- Due to the physical impact, VIPs have limited mobility, and reading is likely to play a more significant role in their recreational activities. At the same time, due to the "mobility difficulty and slower walking speeds" caused by visual impairment, VIPs may experience more frustration and fear of challenges in daily life than those with normal vision.

2.2 What is skim-reading

2.2.1Definition

The Cambridge dictionary defines 'skim' as 'to read or look at something quickly without looking at the details' ("Cambridge Dictionaries Online," 2007)

By its definition, the skimming reading strategy is a technique that involves a quick scan of a text with the purpose of identifying the main ideas, important elements of its structure, key points, and relevant concepts in a short period of time and without reading every single word.

2.2.2 why people use skim-reading?

a. Skim reading is becoming more important

With the development of mobile internet, we have entered the era of information overload, which brings new changes to people's reading habits and skills. On one hand, our reading habits are shifting from paper to screen reading, more than 80% of participants in a survey described their screen-based reading behavior as being characterized mainly by browsing and scanning, as well as non-linear reading (Liu, 2005). On the other hand, and the amount of available reading material has greatly

increased, Therefore, "the ability to read selectively, or to skim-read, is becoming an important skill (Machulla et al., 2018)."

b. skim reading can significantly improve reading speed and efficiency.

In early experiment, Just and Carpenter explored skim reading and they found that skim readers were about two and a half times faster than normal readers (Just & Carpenter, 1986). Furthermore, research by Hyönä et al. (2002b) suggests that effective skimming techniques can help readers identify potentially more relevant information, leading to better memory retention of important details and the ability to produce more accurate text summaries.

Skim reading, as a technique, could assist readers in several ways:

- It allows individuals to determine in a shorter amount of time whether a text is relevant to their specific needs and whether it warrants investing time and effort into reading it in its entirety.

- It aids in evaluating the content and structure of reading materials, enabling readers to understand their place and importance within the overall context. This, in turn, facilitates faster, easier, and more effective comprehension and retention of the material.

- It enables readers to swiftly locate the sections containing the information they require, facilitating selective and focused reading.

2.3 Explorative Interview

2.3.1 Aim of Interview

While existing literature provides general information about the reading behaviors of VIPs, it lacks in-depth empathy towards their reading experiences and a systematic explanation of their overall reading behavior patterns, including the role of skim reading.

Therefore, interviews can reveal unique challenges and preferences that are not extensively covered in existing studies, helping to create a more comprehensive and empathetic understanding of the target users. Additionally, interviews can

more accurately depict the user journey, highlighting critical touchpoints and pain points that might be overlooked in broader research.

2.3.2 Research Questions

My interview questions mainly focus on the following areas: Background and Reading Habits, Book Selection and Exploration Challenges, Navigating and Understanding Content, How to Skim Read, Psychological Factors and Experience, Unmet Needs, etc.

2.3.3 Method: Online Interview

In this section, I used a snowball sampling method to reach out to five visually impaired individuals. The five interviewees are between the ages of 40 and 55, with vision conditions ranging from blindness to partial vision impairment. Through semi-structured interviews, I aimed to understand their reading habits and behavior, resulting in the creation of user journey maps and persona.

2.3.4 Key Findings

VIP's basic reading situation：

A. Book type: Daily reading/Casual reading

Books commonly read by VIPs include, but are not limited to: Mystery Novels, Self-Help Books, Educational Textbooks, Magazines, Science Fiction and Fantasy, Historical Fiction, Romance Novels, Poetry Collections, Health and Wellness Guides, Travel Guides, Classic Literature, etc. Overall, they tend to prefer casual reading over academic reading.

B. Two main Purpose: For interests/For specific goals

The purposes and needs for reading vary greatly, such as for interest and entertainment/for knowledge enhancement, or to say, for browsing/or seeking specific information. These vary according to personal preferences, scenarios, and stages in time.

C. Need of Summary when they want to skim

VIP have indicated that book summaries are crucial in helping them decide whether to read a book or which parts of a book to focus on. However, since most books only offer a summary of the entire book, they often rely on reading the table of contents and skimming the first few pages to achieve this. This approach results in a significant amount of wasted time and effort. Currently, they have not found a better method to address this issue.

2.3.5 Analysis：Persona and Journey mapping

Personas represent fictional characters that embody specific user characteristics, needs, and goals, which could help researchers understand the diverse experiences and challenges of their target audience.

By creating personas and journey maps based on survey responses and interviews, the thesis project can derive meaningful insights, identify common patterns and themes.

The following two types of personas and their journey maps represent reading under two different purposes. I divided their reading into three stages: before reading, during reading, and after reading, and summarized their behaviors at each stage. The height of the yellow dots below represents the reader's mood and feelings, with higher dots indicating better experiences. The yellow areas highlight the stages where readers felt negative emotions, and these were the focus of further interviews. From this, I identified common challenges.

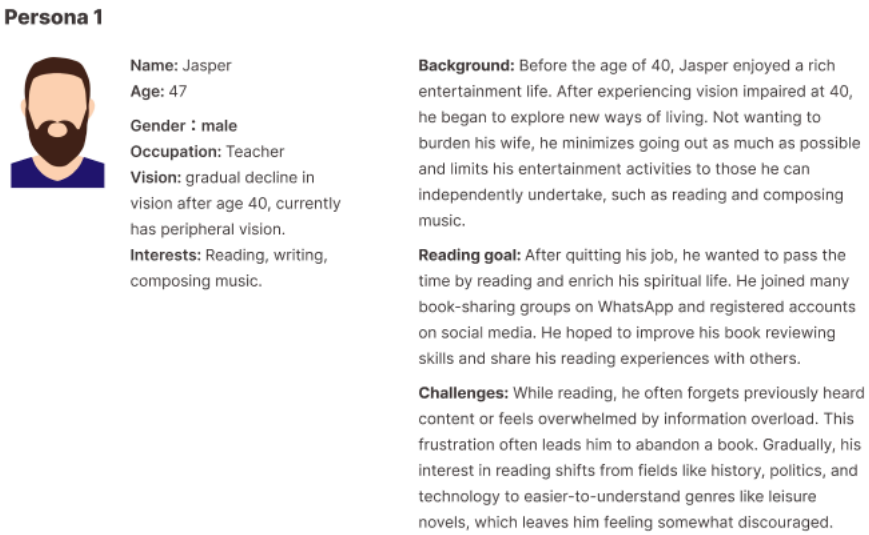


Figure-2.1: Persona 1 (reading goal: for interests)

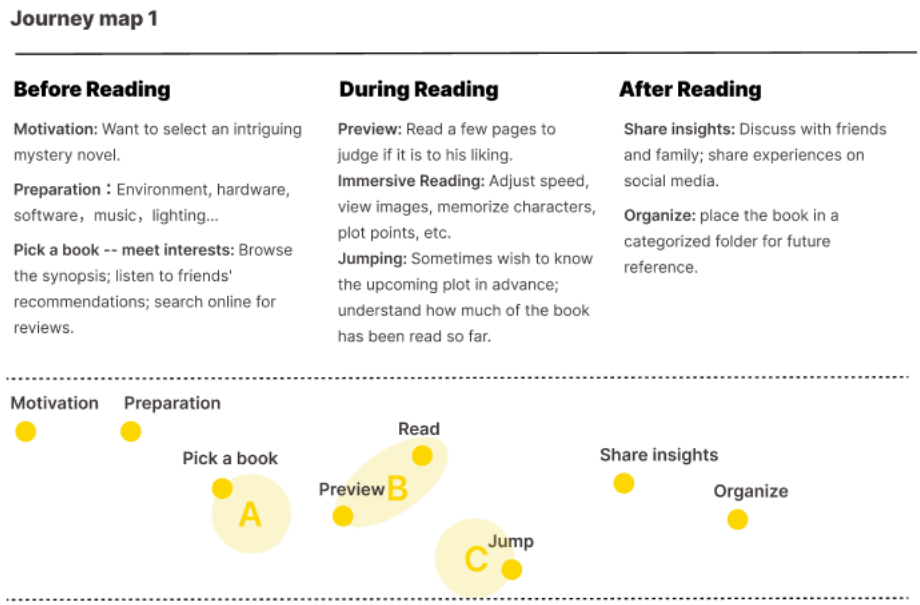


Figure-2.3: Journey map 1 (reading goal: for interests)

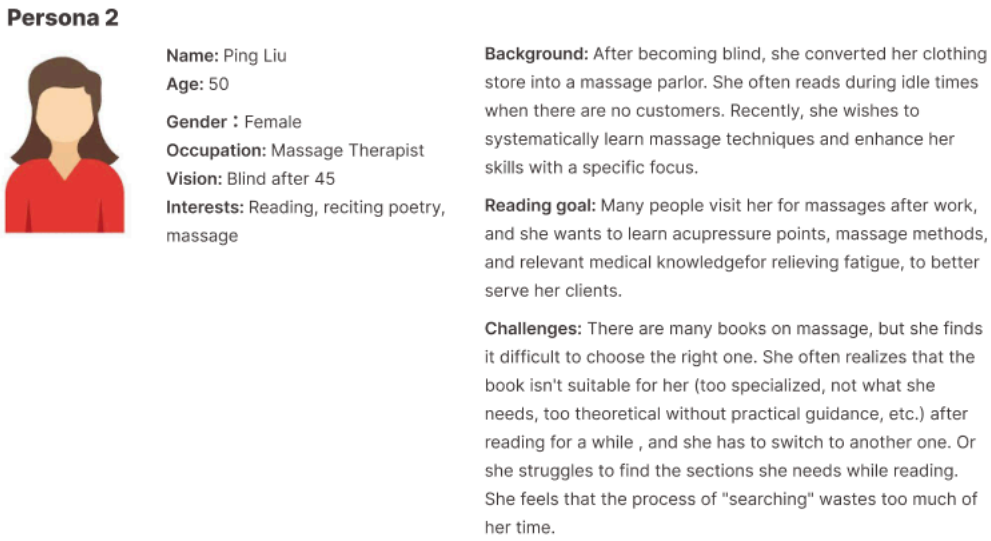


Figure-2.4: Persona 2 (reading goal: for specific goals)

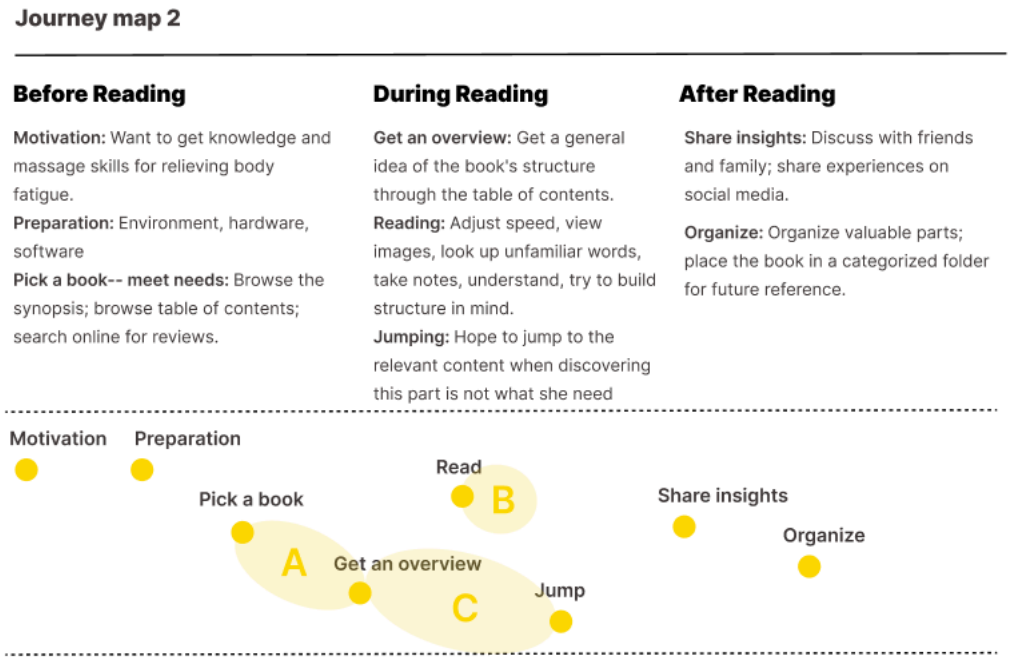


Figure-2.5: Journey map 2 (reading goal: for specific goals)

Insight of common difficulty during reading process:

A. Pick a book

Based on my own experience and that of people around me， Normal-sighted readers typically judge their interest in a book by browsing the synopsis, contents, and quickly flipping through the pages. However, all five of the participants struggled to grasp the essence of a book solely by listening to the table of contents.

B. Context Disconnection:

Since audio books can only be read word by word and cannot convey the context, visually impaired individuals find it difficult to grasp the logical structure of books, leading to potential understanding difficulties and challenges in memorization. This obstacle often causes frustration among readers and even discourages them from reading.

C. Non-linear exploration

They expressed that the difficulty in skimming forces them to "follow the audio sequentially" and makes it "challenging to read selectively and with varying levels of detail as they could when their vision was normal."

2. Psychological challenges

1. Need of Independence: "don’t want to trouble others" is a common psychological sentiment among visually impaired individuals. They hope to independently complete every step of the reading process without seeking help from others.

2. Frustration: "Frustration" are common feelings among visually impaired individuals after their vision loss. During the reading process, complex software operations or interactions that conflict with natural methods often reduce the reading experience.

3 Sense of Achievement: Reduced social work capacity due to vision loss has led to a widespread feeling of unfulfilled achievement (more pronounced in males). Many visually impaired individuals write during their spare time and post their writings on social media platforms, where likes, followers, and comments become a source of achievement for them.

4. Hope to be treated as normal sighted people

3. Skim-reading

This chapter:

- Analyze the strategies employed by both visually impaired persons (VIPs) and normally sighted individuals based on Machulla et al.’ s (2018) study. It delves into the advantages that sighted readers have due to their ability to utilize spatially-coded information, the challenges VIPs face as losing access to these spatial cues.

- Discuss design implications based on VIP and normal sighted reader’s differenct skim-reading patterns, which serve as a theoretical framework for analysis and design.

- Analyze existing product in this field:Skimmer and examines its contribution in aiding VIPs with skim-reading, identifying its strengths and limitations in this context, which helps narrow my design scope.

3. 1 Strategies for VIPs and normal sighted people

3.1.1 For normal sighted people

In fact, sighted users have advantages when quickly browsing through written text, as skim-reading is readily supported by visual reading material. The study conducted by Machulla et al(2018) showed the sighted participants used spatially-coded information to help them skim, see table 3.1.

Strategies based on spatially-coded information could be grouped into three broad categories: use of macro- and micro-structures of the document, and non-linear skimming. The macro and micro structures serve as cues to guide reader attention and establish structures, facilitating personalized nonlinear reading, all of which are visually based.

Table-3.1 Skimming strategies for normal sighted people from Machulla et al.'s study

Strategy	Definition	Explanation
macro-structures	any feature of the document that is at least the size of a paragraph,figure, or table. 'The semantic content and the logical structure of the reading material is typically reflected in the visual layout of the document.'	Participants use macro-structures to quickly navigate through the document. The most frequently used macro-structures at the beginning of the interaction with the document were figures
micro-structures	certain information "caught their eye" because it was printed in bold, italicised, or colored words, lists, and bullet points.	- draw the attention of the sighted reader by 'popping out' of the sur-rounding text passage

		- particularly useful in emphasizing keywords or main ideas
non-linear skimming	skipping sentences, sections, and entire pages, as well as return referrals to locations that are chronologically earlier in the reading order.	- its distribution across space allows exploring non-linearly, like jumping from a section to another - control for selective reading, 'where the users can quickly go through the text, and slow down when the text seems important.'

For sighted individuals, reading is perceived as a visual spatial search task where the goal is to identify structure and locate areas of highest information content or interest. In addition to filtering functions, spatial layout allows readers to quickly scan documents, including larger, targeted jumps across sections and pages, enabling the extraction of desired information in a non-sequential manner.

3.2.2 For VIPs

As 'Some of the features of the document that support efficient skim-reading in sighted readers are lost in the transformation for visually-impaired individual '，the two-dimensional nature of the text is linearized into one dimension. Therefore, VIP readers faces greater challenges in skim reading. Machulla et al. 's experiment discusses some of the skim-reading strategies they adopt to adapt to speech reading:

Table-3.2 Skimming strategies for VIP from Machulla et al.'s study

Strategy		**Explanation**	**Problem**
Use of four features	table-of-contents (TOC)	Vips attempt to understand the structure and distribution through TOC,	- it did not provide links to the different sections of the document

		linking to sections or pages.	- the information provided in the TOC is very limited
	pages and page numbers	use them to remember the location of specific information for later searches	- hard to remember - can't take signals
	section headers	used as targets for skimming jumps, as were paragraphs "Reading would befaster if I could go to each section and read a bit of each."	- Do not support jumping between section/paragraph - Not reflected in TOC - User can only know the content by reading word by word
	paragraphs.	Similar as section headers	
Non-linear document exploration		Always reading the first few sentences of each section/paragraph before moving on.	- perceives his approach to be linear compared to visual reading, less flexible with regards to the order in which information is taken up.
Increasing the rate of information uptake and cognitive information filtering		When readers has little possibility to identify and target regions with high information content, he or she	- it requires increased focused and sustained attention on the side of the participant

	chooses to listen to everything. high reading speed increases the rate at which information is taken up.	- word comprehension can be diminished by higher narration rates

During the process of reading through a screen reader (relying on auditory input), spatially-coded information in the form of macro-and micro-structures is mostly lost，the skimming strategy is challenging to execute.

As Machulla et al.’s (2018) experiment shows, the current situation for VIP is as follows: although the needs for skimming exist, most of VIPs tend not to employ skimming in their daily readings. In the rare cases where skimming is used, they typically choose to read the entire text word by word, supplemented with light non-linear exploration through TOC or section headers in the initial or later reading stage.

The compensatory approach adopted by VIP is to increase reading speed, which improves the efficiency of information retrieval at a one-dimensional linear reading level. However, it fails to provide structures or overviews at a two-dimensional level, thus hindering comprehension and memory while increasing cognitive load.

Overall, the absence of skimming among VIP reduces efficiency and comprehension. When reading materials are particularly challenging, this could lead to feelings of frustration, which may potentially cause readers to abandon the reading document. This aligns with the conclusion I drew from my recent interview，as one participant say: *"I read less and less now because whenever the reading material becomes even slightly challenging, I easily lose focus or lose track of where I am, which makes me feel very frustrated.* (Interview, March 23, 2024)"

3.1.2 Implication

Based on the study result, Machulla et al. proposes several design implications to improve the skimming experience for visually impaired individuals, see table 3.2:

The points in the table will serve as the theoretical framework for my analysis and design. First, I use it to identify the design shortcomings of existing products(skim

reading tool that could be used by VIP) in the market. Then, I use it to develop and evaluate designs proposals.

Table-3.3 Skim reading gap and implication from Machulla et al.'s study

Skim reading gap	**Implication**
Loss of spatially-coded information	1. Support non-visual implementations of macro-structures Better utilize the table of contents and sections (as mentioned earlier, the most commonly used macro-structure information includes figures and sections, but VIPs find it difficult to use figure information) to help navigate through the document
	2. Support non-visual implementations of macro-structures - For auditory text presentation, that could be a change in pitch or the presentation of additional auditory or tactile stimuli for-emphasis, such as peep tones or tactile vibrations
Non-linear document exploration	3. Clear connection between logical document structures and structures for navigation
	4. Allow for non-linear exploration - Macro-structures connected to the logical structure of the document should be easy to locate and target during navigation - Allow large jumps through the linear structure of the text to regions of high interest.

Cognition overload	5. Allow for flexible information uptake rate - Allow users to seamlessly switch between the original text and a summary of the text, effectively compressing and decompressing information density. - Implement fast interaction techniques for adjusting the rate of information uptake

3.2 Analysis of Skim Reading App

Machulla et al.'s research demonstrated the gap in skim reading between VIPs and normal sighted people. Building on this foundation, I further investigated the only one existing design solutions in this field（skim reading tool that could be used by VIP） — skimmer.

Based on Machulla et al.'s theory, I will analyze Skimmer to understand its contributions in helping VIP bridge the skimming gap, identify its shortcomings, and further explore my design positioning based on its progress.

3.2.1 Eye-reduced design

Eye-reduced design is created for situational impairment. ‘Situational disability refers to a temporary impairment in a person’s ability to interact with technology due to their situation, context, or environment (Bikkani & Bikkani, 2023)’. For instance, people may prefer not to look at screens while walking or in public transportation to avoid motion sickness.

In this context, the team at the University of British Columbia embarked on addressing the "design problem of translating the visual interactions in skim-reading into a mode of interactions that depend less on visual attention" (Khan et al., 2020), proposed design guidelines and developed an app: Skimmer.

3.3.2 Analysis：skimmer

Skimmer, while initially conceived as a reading app based on situational impairment, aiding individuals in practicing skim reading under conditions of reduced vision, has expanded its design exploration to encompass eye-free skim reading.

The table below combines Skimmer's functionalities, interactions based on Khan et al.'s (2020) research, and the skim reading gaps they aim to address based on Machulla et al.'s(2018) research. Furthermore, I analyze the effectiveness of these solutions, which helps me focus the design scope.

Function	Interaction	Problem Solving
Basic navigation for eyes-reduced skimming	**skip sentences:**eyes-free tap gesture on the right or left side; **Paragraph navigation:** up or down vertical flicking gestures	**Non-linear document exploration** O Clear connection between logical structures, navigation and Macro-structures O Allow for large jumps
Discourse marker navigation	supports selective jumps between various discourse markers.	
Overview to support understanding document structure	a table- of-content style Overview page apart from the main document view, which is accessible eyes-free	**(Also cognition overload)**
Easy-to-understand audio narration	written text and structural information are narrated in two different voices to help distinguish meta-information from verbatim content.	**lost of spatially-coded information** O Emphasis of micro-structures O Help establishment of macro-structures
Haptic cues to support visual opt-in	informs the user with haptic feed- back when encounting figure or table (opt-in)	
Auditory cues to signify critical skimming moments	a limited set of distinctive earcons to provide subtle auditory feedback in key operations (eg, switching between sentences, paragraphs, and discourse markers, and navigating to the Overview page)	
Accommodating individual differences in listening rates	dynamically adjust the speech rate through an eyes-free tap gesture	**Cognition overload** O Allow for flexible information uptake rate

Figure-3.1 Skimmer's function, interaction and the corresponding skim problem it aim to solve

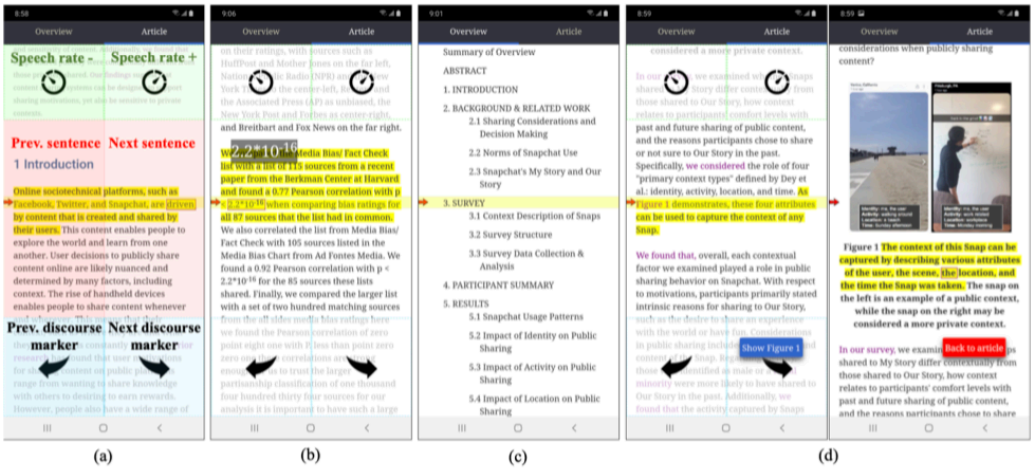


Figure-3.2 Skimmer's interface

The comparative analysis of functionalities and their corresponding problem-solving capabilities reveals that 'Skimmer' contributes to addressing issues in three aspects: loss of spatially-coded information, non-linear document exploration, and cognitive overload.

Skimmer emphasizes enhancement in the 'one-dimensional aspect,' enriching micro information through voice and tactile prompts, akin to the effects of 'italics' and 'bold,' which is commented 'Auditory feedback and haptic feedback help to re-focus.'

Additionally, it offers a more flexible and intuitive speed adjustment interaction scheme, proven to be effective and enhance user experience.

Among these features, 'Users appreciate Overview the most'. 'They use this feature 'to jump between sections, look at the screen in the Results section, skip by paragraphs, often stopping for a brief moment to find interesting results quickly.' Participants noted, 'it was really easy with this application.'

It also enables small-scale non-linear exploration. Participants 'jumped from the Conclusion to the last sentence of the Abstract by using a combination of section, paragraph, and sentence jumps'.

Overall, although 'the goal for this research was to design an interface that would allow people to skim documents in an eyes-reduced way', the experimental results show that 'participants did in fact not use their eyes while using Skimmer.' Further, participants were positive about the overall design concept of Skimmer and expressed willingness to continue using it in the future. This proves that Skimmer's feature design can aid VIPs in skim reading.

However, Skimmer also has its limitations. On one hand, Skimmer ‘focused on structured, academic/professional documents’, which differs greatly from the daily reading range of visually impaired individuals.

On the other hand, comparing the skimming needs of visually impaired individuals (Table 3.2), it can be found that, skimmer's contribution is relatively limited in the 'two-dimensional aspect.' In terms of micro structure, it provides an eye-free accessible table of contents and allows flexible and seamless mode switching (overview and article), aiding readers in judging the relative position of the section within the entire book. Still, the limited information in the table of contents makes it challenging for readers to build an understanding of the overall book. In non-linear exploration, Skimmer allows 'small jumps' such as sentence skip and paragraph navigation, as well as 'big jumps' by returning to the table of contents and selecting chapters/sections. However, due to the limitations of the table of contents, readers find it difficult to locate the desired content accurately and efficiently.

Insight:

- Skimmer provides partial solutions for VIP's skim reading: On the one-dimensional level, such as micro structures, speed adjustment, and 'small jump,' Skimmer offers comprehensive and effective solutions. However, due to the limited information in the book's introduction and table of contents, the enhancement of two-dimensional functionality has not been effectively applied.

- Focusing the design scope: Based on Skimmer's design foundation, I aim to focus on enhancing the two-dimensional aspect of skim reading, namely aiding in constructing an understanding of the book's general idea and overall structure. Based on this, 'big jumps' could be implemented to promote non-linear exploration. And explore skimming assistance tools that are suitable for the characteristics of everyday reading materials for VIPs.

Conclusion of this chapter:

- **Disparity in VIP and normal sighted readers' experiences:**

While sighted readers benefit from visual cues and could easily achieve navigating and skimming through documents, VIPs face significant challenges due to the linearization of text in auditory formats. Although compensatory strategies, such as increased reading speed, offer some relief, they do not fully address the loss of two-dimensional spatial cues, leading to a higher cognitive load and reduced comprehension.

- **Existing solutions in this field：skimmer**

The design gap and implacation proposed by Machulla et al. (2018) is used as the standard for evaluating. Skimmer reveals its potential in supporting one-dimensional skim-reading for VIPs through features like micro-structures (implication 2), speed adjustments(implication 5), and roughly achieve 'small jumps'(jump through paragraphs)(part of implication 4). However, it also identified areas where the app falls short, particularly in addressing the need for two-dimensional navigation.

- **Focus on design scope:**

Analysis of Skimmer helps narrowing my design scope and inform the design direction in subsequent chapters: focusing on enhancing the two-dimensional skim-reading experience for VIPs to better support their everyday reading needs, including 'support non-visual implementations of macro-structures' (implication 1) and 'Allow for non-linear exploration' (implication 4), especially of the part of 'Allow large jumps through the linear structure of the text to regions of high interest'.

4. Summarization

The previous chapter focused on the design scope: enhancing VIP's skim reading abilities and overall reading experience through "supporting non-visual implementations of macro-structures" and "allowing for non-linear exploration." This chapter will discuss why and how summarization can achieve this, including:

- The significance of summarization in aiding skim reading, especially for visually impaired individuals

- Summary Composition: Various dimensions of effective summarization

- Criteria for a Good Summary: Including its intrinsic and extrinsic criteria

- Methods for Generating Summaries: With a focus on the capabilities of AI tools

- Concludes with insights into organizing and presenting summaries to enhance user experience

This chapter provides the theoretical foundation and evaluation criteria for the subsequent design.

4.1 Why summarization could help skim reading?

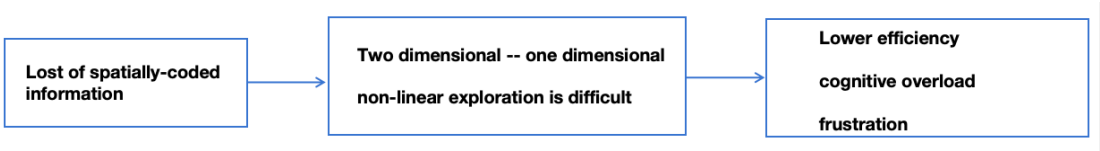


Figure-4.1 Consequences and impacts of lost of spatially-coded information

As discussed in section 3.1.1, the loss of visual spatially coded information results in a degradation from two-dimensional to one-dimensional information. This impedes readers' overall understanding of the book's two-dimensional structure and their ability to explore it nonlinearly, posing sustained challenges that contribute to lower reading efficiency and higher cognitive load for visually impaired individuals. Consequently, this persistent difficulty can lead to a heightened sense of inefficiency over the long term.

From Khan et al.' s (2020) research, ' Users appreciate Overview (table of contents) the most, In interviews, interviewee emphasized 'that book summaries and tables of contents are crucial indicators for deciding whether to read a book and which parts to focus on'. Summaries provide an overview of the book's content, while a table of contents outlines its structure. The combination of both aids basic scanning needs for readers. However, Accessible books currently available in the library often provide overly simplistic summaries and contents. As a result, these tools fail to meet the deeper, broader, and more personalized needs of visually impaired readers. Therefore, exploring more flexible and tailored summary tools that better suit the needs of VIPs holds profound significance in enhancing their scanning abilities.

4.2 What makes a summarization?

Document summarization is rather complex. Firstly, documents typically consist of multiple themes, which are "elaborated on and supported through the text" (Stewart, 2009b), so a summary involves identifying and presenting these themes. Additionally, "there is much variation in writing styles, document genres, lexical items, syntactic constructions, etc' (Stewart, 2009b), all of which can influence the form, style, content, etc., of the summary.

4.2.1 Aim and relevance:

This section elaborates on the dimensions that affect summarization, mainly according to Stewarts study. This contributes to what factors we could control and in which way, in order to achieve a good summary.

4.2.2 Dimensions of summary

a. Summary Purpose:

According to the different purposes readers have for reading summaries, summarization can be divided into two main types: generic or overview summary, which "gives an overall sense of the document's content," such as the summaries we see in novel books; and goal-focused summary, which "provides information related to a particular objective, such as plot or opinion," similar to the summaries we encounter when browsing the web.

For example, a generic summary of ‘The Great Gatsby’ might describe the book as a story about the mysterious Jay Gatsby and his unrequited love for Daisy Buchanan set in the opulent world of 1920s Long Island. In contrast, a goal-focused summary might focus specifically on the themes of the American Dream and social stratification, emphasizing how Gatsby's lavish lifestyle and ultimate downfall critique the myth of the self-made man (Keswani, 2024).

a. Summary Role:

Summaries can be indicative or informative. Indicative summaries provide "an overview of the content of a document," whereas informative summaries "allow the user to gain knowledge about a particular topic or answer one or more questions."

b. Set for Summarization:

A single document summary provides an overview of one document, whereas a multi-document summary provides this functionality for many.

c. Genre:

The information contained in a document’s genre can provide linguistic and structural information useful for summary creation. Genre maps to people's focus points for summaries and is an important influencing factor in summary

generation outcomes. According to the Library of Congress, genres include categories such as autobiography, biography, children’s literature, fairy tales, fiction romance, saga, thriller, and many more (*Subject Headings and Genre/Form Terms (Cataloging and Acquisitions at the Library of Congress)*, n.d.).

d. Modality:

Traditional summaries focus on pure text summarization, but there is also emerging exploration into multi-modal and multi-media summary formats. For example, Multi-Modal Medical Summaries, which integrate various data modalities such as text, audio, and images to generate a comprehensive summary of medical consultations; And multi-Modal News Summaries, which can include text, images, and videos to provide a richer summary of events (Jangra et al., 2020).

e. User Goal:

Roy and Dutta‘s (2022) study on recommender systems shows that user behaviors are often divided into exploratory browsing and targeted searching. Exploratory browsing involves users looking for items of potential interest without a specific goal, while targeted searching involves users seeking specific information or items.

This aligns with the results from interviews with visually impaired individuals, where their reading purposes can generally be categorized as exploratory browsing for interest and targeted searching, with specific goals such as self-improvement, information seeking, etc. The summary needs to reflect the user task. The user goal and summary content, as well as other factors, have a certain mapping relationship, such as "When browsing, people may prefer indicative summaries from which they can choose to explore."

g. Summary Length:

‘The length of the summary may be a fixed length or a percentage of the size of the original document(s).’ From an algorithmic perspective, "The best summary length is a function of the genre, the document length, the content redundancy present in the document(s), and naturally the reader's information-seeking goals." Generally, novel summaries are between 150-250 words. Newswire articles are usually in 3-5 sentences. Scientific articles are often around 150 words.

h. Summary presentation/format:

The presentation form of summaries can be keywords, phrases, sentences, or paragraphs. In experiments investigating skim reading strategies of VIP readers,

VIPs indicated that "text with hyperlink references to the original text(s)" was more helpful.

4.2.3 Focusing points of summary

The book 'Five elements of fiction: plot, setting, character, point of view, theme' gives 5 elements that construct a story. When readers access a summary, they often choose to focus on one or a few key points from these elements. Understanding these elements helps in knowing what a good summary should provide.

a. plot： How the author arranges events to develop the basic idea; it is the sequence of events in a story or play. The plot is a planned, logical series of events having a beginning, middle, and end.

b. Character：

1) People in a work of fiction can be a(n):

• Protagonist - Clear center of story; all major events are important to this character.

• Antagonist - Opposition or "enemy" of main character.

2) Characteristics of a character can be revealed through:

c. scene/setting： Time and location that a story takes place. Multiple aspects a setting could have: Place, time, weather conditions, social conditions, mood or atmosphere.

d. Theme: Central message, "moral of the story," and underlying meaning of a fictional piece; may be the author's thoughts on the topic or view of human nature.

e. Point of view： The angle from which the story is told, it could be first Person, second Person,or third Person

4.3 What is a good summarization?

An ideal text summary includes the relevant information for which the user is looking and excludes extraneous and redundant information, while providing background to suit the user's profile (Goldstein et al., 1999).

Mani (2001) proposes two criteria for evaluating summaries: extrinsic evaluation, namely the Information-seeking perspective, for real-world applications; and intrinsic evaluation, namely the System generation perspective, for having a good internal composition. Here we will discuss what aspects should be considered for a good summary from these two perspectives.

4.3.1 Extrinsic Perspective

From previous research, it is evident that users have diverse reading preferences and purposes, leading to different reading focuses and points of interest. Even for the same user, their reading emphasis may change with each reading scenario， the reading purpose and summary they expect would change accordingly. It can be said that for users, an ideal summary should be personalized.

Thus here, we proposed a concept: goal focused summary.

Goal-focused summary:

A. Levels of user goals

User reading purposes are highly diverse and constantly evolving. Xie's (2019) study provides a theoretical framework, categorizing user goals into four levels: long-term goal, leading search goal, current search goal, and interactive intention. The higher-level goals guide and influence the lower ones. Although this framework is based on web search reading, it is also applicable to our topic.

Level	Type of User Goals	Definition	Examples
1	Long-term Goal	Personal Goal	Professional achievements, personal interests
2	Leading Search Goal	Task-related goal that leads to a search	Writing a paper, preparing a project
3	Current Search Goal	Specific Search Results a user intends to obtain	Looking for a model, a book, answers to questions
4	Interactive Intention	Subgoals a user must achieve to accomplish "current Search Goal"	Identify, Learn, Find, Access, Locate, Evaluate, Record, Obtain

Figure-4.2 Xie's Levels of User Goals

This theoretical model aligns well with the observations I made during the earlier research on interviewee's reading behavior (see section xxx). One interviewee mentioned that when she wants to understand feminist knowledge (long-term

goal), she need to quickly view summaries of multiple books to quickly locate which books align with her interests. After accumulating some knowledge, she may want to delve deeper into a specific topic of feminism (leading search goal), where she needs to understand what each chapter of a book covers, finding relevant sections or paragraphs (current search goal), for focused reading. Throughout this process, she may use various methods such as table of contents, navigation, and quick scanning.

The **design implications** brought by this model are:

1. Recognizing users' long-term goals is beneficial for understanding lower-level reading purposes.

2. For VIPs, every reading purpose can be enhanced with summaries. Identifying which level of goal the user is currently at is beneficial for providing targeted summaries.

3. Viewing summaries needs to be interspersed with multiple interactive behaviors, and the system needs to allow for natural switching.

B. Summary Type

Based on the level of detail or coverage scope of the content, summary could come in different forms to address readers' varying needs.

1. Coarse Summary:

These methodologies provide an overview of users' information-seeking goals at a broad level:

1) Generic: a survey of the information.

2) Adhoc or query relevant: addressing the information in the query.

3) Topic relevant: addressing the information presented in a topic query.

2. Summary Facets or Facet Summaries:

Facets represent specific summarization goals that can be applied across various genres.

For example, when a reader is reading a romance novel, they may want to see a focused description of the plot in the summary while ignoring other factors. In this example, plot summaries would be one such facet summary.

Implications:

1. Systems are best equipped to provide appropriate forms (Facet Summary/Coarse Summary) based on readers' needs.

2. At certain situations, it may be required to address specific information-seeking goals. For instance, after browsing the initial summary, users may need to continue receiving a facet summary corresponding to a particular need, taking care to avoid substantial repetition of previously covered content.

3. Systems should be able to adapt to readers' reading patterns, progressively evolving from coarse summaries to more refined form.

4.3.2 Intrinsic perspective

From the perspective of text generation, Stewart (2009) put forward several factors to consider when generating a summary, such as length and genre, along with some standards for measuring the quality of the text itself.

a. Genre

Literature is categorized into genres based on various standards, such as literary technique (purpose and form), tone (purpose), and subject matter (content). Therefore, genre is considered to include the communicative purpose and form of the document (Goldstein et al., 2007). Roussinov and colleagues found that genre was one of the clues used in assessing relevance, value, quality, and usefulness (Roussinov et. al., 1991).

Therefore, summaries can be tailored based on the genre. This can help identify key points in the summary, such as viewpoints or facts, plots or ideas.

b. Length

Summaries also must be an appropriate length to fit the user's information seeking goals - as some people want to read a brief synopsis, others require more details

c. Text quality criteria

Summary is also a kind of text, so it should first fulfill the basic requirements of a good text. Beaugrande (1984) proposes some text quality criteria:

- **Cohesion and coherence**

- **Acceptability**

The same person differs according to the current role, for instance in willingness to absorb more or less input. Luhn (1958) thought that, Summaries must adapt to their readers with their current aims and roles in a specific environment.

- **Intentionality：** the author explains, informs, justifies, persuades, contradicts etc.

- **Situationality**

system should adapt to the local communication situation and the way the addressee perceives it. If the user is in a hurry, messages should be as brief as possible.

- **Informativity**

comparing the summary information with the addressee's prior knowledge, or with the knowledge represented in earlier texts, spare users much repetition of already known news or results.internal composition

DUC 2005 also proposed some other standards from a textual perspective, such as accuracy of grammar, Non-redundancy, Referential Clarity, with Focus, with Structure and Coherence, etc. Since this part is related to the summary generation algorithm, which is not within our design scope. so here won’t go into details.

4.4 How to make a summary

The generation of summaries typically stems from two sources. Firstly, there are manual summarizers. Manual summarizers engage in the process of 'selecting, evaluating, ordering, and aggregating items of information according to their relevance to a particular subject and purpose.' Sometimes, factors such as the interests of the target audience and marketing considerations also need to be taken into account.

Secondly, there are automatic text summarization methods. Prior to the emergence of AI models like ChatGPT, there existed various domain-specific automatic summarization tools. Subsequently, with the introduction of AI tools such as ChatGPT and Claude, or text summarization tools that utilize the ChatGPT interface, automatic text summarization has been more widely applied.

4.4.1 Automatic Summary System (ATS)

a. The main objective of an ATS is to produce a summary that includes the main ideas in the input document in less space (Radev, Hovy, & McKeown, 2002) and to keep repetition to a minimum (Moratanch & Chitrakala, 2017).

b. ATS classification

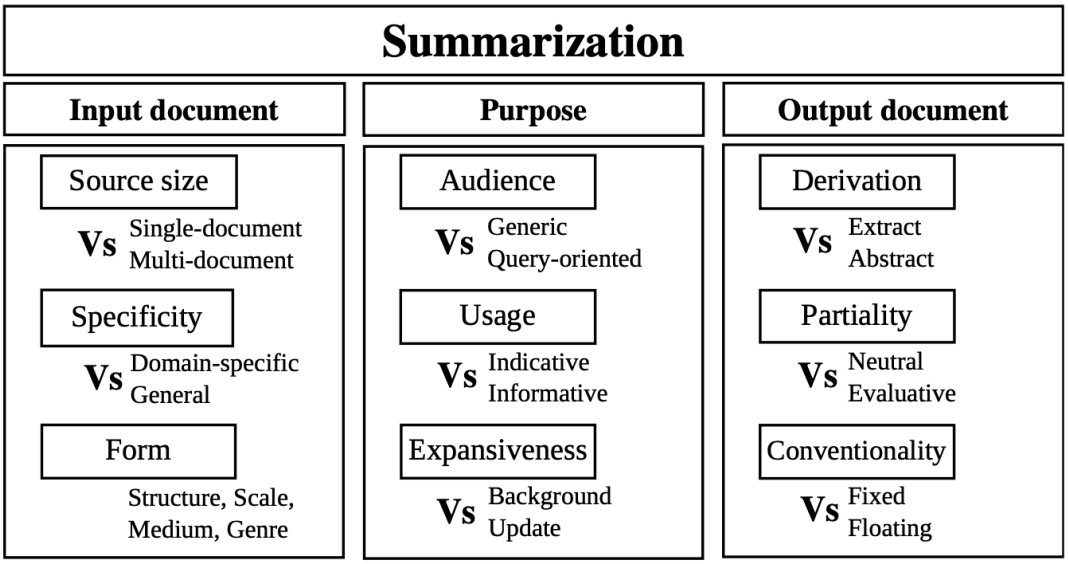


Figure-4.3 Automatic Summary System Classification

4.4.2 AI summary tool

A. Experiment

To understand the capabilities of existing AI summarization tools and select an appropriate one to support the testing and output of this project, I conducted small experiments on commonly available AI summarization tools.

Experiment Method:

Upload text and ask questions about the content of the article.

Evaluation Criteria:

These criteria are derived from the earlier section on 'what makes a good summary'. I chose the criteria that are more closely related to the text itself and can be evaluated through experiments：

Accuracy: The degree to which the answers align with the original text.

Richness: The extent to which the answers can extract and summarize key points.

Source Referencing: Whether the answers can match and reference the original text.

Multi-turn Questioning: The ability to respond to questions by connecting to the context of previous interactions.

Table-4.1 Evaluation of capabilities of existing AI summarization tools

Product	Whether free	Accuracy	Richness	Source Referencing	Multi-turn Questioning:
ChatDOC (https://chatdoc.com/)	✅	+++++	++++	✅ Locate to	✅ Thread functionali

Product	Whether free	Accuracy	Richness	Source Referencing	Multi-turn Questioning:
				paragraph	ty: Supports follow-up questions or direct questioning in the dialogue box, with default context retention.
ChatPDF (https://chatgpt.com/g/g-lijo49FhM-chatpdf)	✅	++	++	❌	✅No thread functionality, but has context memory.
Humata (https://www.humata.ai/)	✅	+	++++	✅Locate to page	✅No thread functionality, but has context memory

Product	Whether free	Accuracy	Richness	Source Referencing	Multi-turn Questioning:
PandaGPT (https://www.pandagpt.io/)	✅	+	++++	✅Locate to page	❌No clear context memory

Insights:

- **Selecting AI Tools:**

  Based on the five criteria from the above experiment, I chose Chatdoc as the AI underlying tool for this project. Chatdoc accepts prompts and generates summaries, which will be integrated with my designed interface for readers to use.

- **Issues and Adjustments in AI Summarization:**

AI-generated summaries generally achieve accuracy, adhere to the original text, and meet my personalized requirements. However, there are some common issues that affect the quality of summaries and user experience, such as overuse of clichés, boring and conventional language, lack of specific details, and generating inaccurate or false information, also known as "hallucinations" (Kryscinski et al., 2021) . These challenges can significantly impact the overall quality and utility of AI-generated summaries.

However, significant improvements can be achieved through prompt adjustment. For example, clarifying the specific goals and context of the reading within the prompt can mitigate these issues. For instance, prompts can be tailored to specify, ''I'm writing about xx and would like insights from this book regarding that perspective', or 'Use language closer to the original text', and 'Provide a specific example rather than generic statements.'

The manipulation of prompts will be explored in more detail in subsequent experiments.

B. Performance

As mentioned earlier, generating a good summary not only needs to meet reader demands, genre characteristics, appropriate length, etc., but also needs to meet textual standards. A comprehensive analysis by (Zhang et al., 2023d) focused on large language models for news summarization revealed that the quality of generated summaries is already on par with those created by humans. In some tasks, GPT4 even 'shows a higher correlation with humans in the summarization task compared to previous reference-based methods' (Liu et al., 2023).

4.5 How to organize and present a summary

A. Progressive:

Adapting AI Interaction features, the summary generation method can be designed progressively: from a general summary to a personalized one. This approach aligns with users' exploratory needs for everyday reading materials.

Generic Summary: ‘including the creation of generic summaries that aim to capture the most critical points of the text (Mani, 2001)’.

Personalized Summary: In many cases, users seek specific information beyond what is included in the general summary, highlighting the need for query-relevant summaries (Goldstein et al., 1999b).

B. Layered summary:

Earlier, several summary factors were mentioned. Here, these factors are categorized into four major groups, serving as a reference for designing personalized summary adjustments.

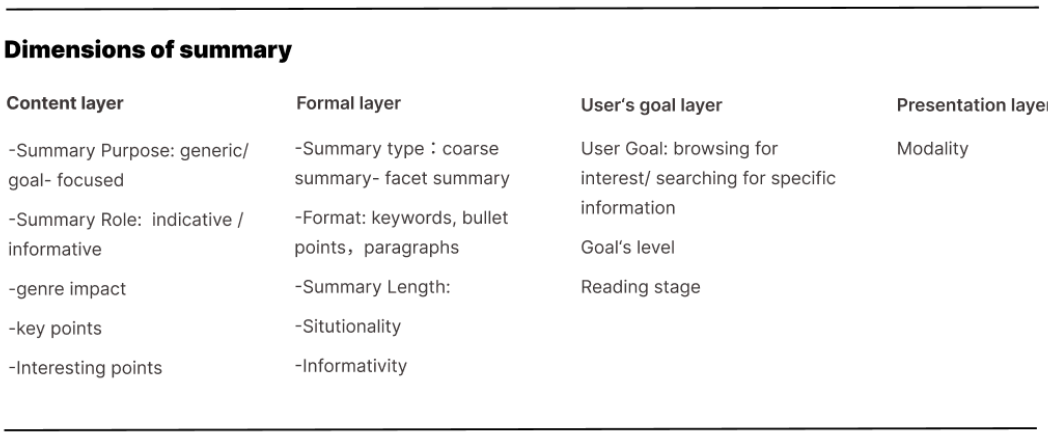


Figure-4.4 Dimensions of Summary

C. Responding to User Goals:

Xie's (2019) research provides insight into how systems can meet user goals. He suggests that an ideal system can achieve this in two ways: either by inferring the user's goal(s) through observation and/or analysis of the user and data, or by allowing the user to select specific parameters to tailor the system output to address their goals.

In other words, the system adjusts summary factors to meet personalized needs, with control over these factors stemming from two sources: the system's understanding of demand cues and user adjustments (facilitated through the interface). This is an effective approach to achieve personalized user control while reducing user burden.

Control Method	Default	System inference	User control
-Summary Purpose:	✅		✅
-Summary Role:		✅	
-genre impact		✅	
-key points		✅	
-Interesting points		✅	✅
-Summary type：	✅		✅
-Format:	✅		✅
-Summary Length:	✅	✅	✅
-Situationality			✅
-Informativity		✅	
-User goal		✅	✅
-Goal's level		✅	✅
-reading stage		✅	

Figure-4.5 Envisioned control methods of Summary generation

D. Providing guidance to ChatGPT:

A helpful way to guide ChatGPT in generating summaries is by incorporating instructions into the prompt. For example, prompting ChatGPT with "Please consider the genre of this book and provide a summary based on the genre" can significantly enhance the quality of the summary it generates.

Conclusion of this chapter:

Effective summarization plays a crucial role in improving reading efficiency, particularly for visually impaired users.

By breaking down summarization into its core dimensions, including purpose, role, genre, user goals… it highlights the necessity for tailored, flexible summaries that cater to diverse needs.

Furthermore, it evaluates various methods of summary generation, emphasizing the growing potential of AI tools in producing accurate and user-specific summaries.

These insights gathered provide a comprehensive framework for designing effective summary tools, aimed at improving VIPs' reading efficiency and overall experience.

4. Design goal

The second chapter explored the challenges and psychological experiences VIPs face during reading, particularly skim reading. The third chapter identified gaps between VIPs and sighted readers in skim reading and evaluated existing solutions, leading to the design scope for this project. The fourth chapter established AI text summarization as a viable solution and provided a theoretical foundation for effective summary generation. This chapter consolidates these findings to outline the design direction for subsequent experiments and design phases, ensuring a focused approach to enhancing VIPs' reading experiences.

This chapter synthesizes the insights gathered from the previous sections, focusing on the design goals, scope, opportunities, and requirements for improving skim reading for VIPs.

5.1 Design goal

Approaching from the perspective of skim reading, the aim is to explore how to enhance the cognitive dimension of visually impaired individuals through the design of an automatic summary tool. This is intended to enhance reading efficiency and reduce difficulties in retention and understanding, thereby narrowing the reading gap between visually impaired individuals and normal sighted people. Ultimately aims to increase willingness to read and enrich spiritual life in the long term.

5.2 Design scope

In Scope：

a. target people: All visually impaired people

b. book types: Daily reading materials (in digital forms)

c. Form: audio reading through screen reader

d. Hardware: Mobile phone

e． Scope： AI Text summarization tool in reading app

out of scope：

- Design functions unrelated to summarization, such as skim functionalities when reading (e.g., jump to next paragraph). Skimmer has already provided a fairly comprehensive solution in this regard. I will directly build upon Skimmer's design achievements and integrate them with the summarization tool.

- Features specific to screen readers, including options for auditory feedback, voiceovers, and haptic feedback designs.

5.3 Design opportunity

a. Interactive summarization

By presenting the summarization t in an interactive form, users can actively decide what and how the summary is presented

b. Progressive summarization

c. personalizable summarization

With goal-fucused summary method, users can get summary that fits their own goal and scenario

d. Summarization tailored for VIPs

Current summary tools are primarily designed for sighted users, featuring visual layouts and interactions that may not accommodate tactile or voice-based navigation. These tools often rely on keyboard input commands, which can be challenging for visually impaired users. This project aims to explore more accessible forms of interaction suitable for visually impaired individuals.

d. Summarization tailored for Daily Reading Materials:

Existing summary tools are predominantly tailored for academic materials, focusing on scenarios like presentations, group meetings, and paper writing, often dependent on typed commands. However, the need for summaries in everyday reading materials is often exploratory rather than goal-specific. Thus, exploring and adapting summaries for everyday reading materials is a key objective of this

project.

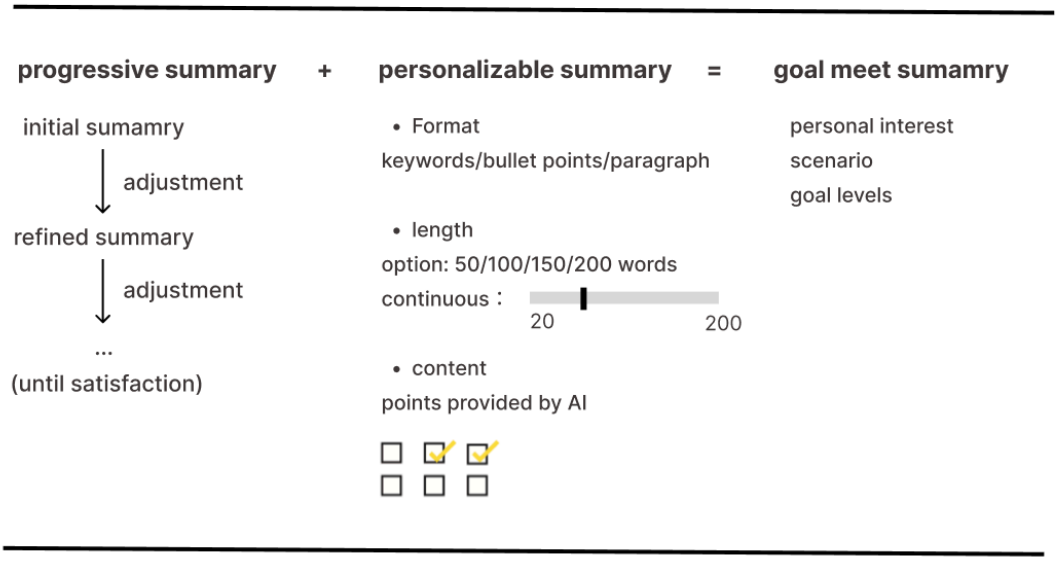


Figure-5.1 Envisioned framework for an automatic summarization tool5.4 Design Requirements

a. Navigation

- Implement intuitive, voice-guided navigation to facilitate easy exploration of content for VIPs.

- allow for seamless switching between skim-reading and normal reading at any time（see section 3.3.2）.

b. Personalization

- users can easily choose the scope and adjust the summary content as they want, the system should cater to users' goal and needs efficiently (see section 4.3.1).

c. Accessibility

- Provide intuitive and smooth interaction without big burdens like overloading choices or efforts-taking actions.

d. Usability

- Design an interface with simple, consistent layouts and clear, tactile feedback to enhance ease of use and reduce cognitive load for visually impaired users.

e. Experience

- **Self-Efficacy:** VIP should be able to use the solution independently, without needing assistance from others.

- **Normalization:** The method and process used by VIPs should not be perceived by others as ‘strange,’ ‘different,’ or ‘disabled.’ The solution should leverage mainstream devices to ensure it blends seamlessly into everyday use.

6. Design Through Test

The previous chapter clearly outlined what constitutes an ideal summary in theory, including how to classify and control the elements of summaries. This chapter will approach the topic from the perspective of users (VIPs), aiming to understand through testing what type of summaries they actually require.

The primary objectives of this test are：

1. To understand the needs of VIP users regarding text summarization during their reading process, and how text summaries can help them achieve their reading goals and tasks.

2. To gather VIP users' feedback on the generated summaries and explore how prompts can influence the AI-generated outcomes.

6.1 Design of test procedure

6.1.1 Two Stages of reading and its reading behavior

Due to the complexity of the scenarios requiring summaries, different users may form different reading goals at different stages of reading, leading to varying summary needs. Therefore, here I mainly outline two primary reading stages for visually impaired people in daily life, exploring users' reading goals, needs, and their evaluation of the quality of the generated summaries.

Stage 1: Pre-reading - Decide on which book to read

Based on previous interview research(see section 2.2.2), this stage involves readers wanting to start reading a book during their leisure time without a specific goal in mind. They may open multiple books to browse casually and determine if they match their interests. For visually impaired people, in this stage, AI-generated full-book summaries will be used as material to help them decide whether they would begin to read this book.

Stage 2: Mid-reading - Non-linear exploration

In this stage, the reader has already started reading a book and may have a need for non-linear exploration during the reading process, such as wanting to understand the relative position of the section they are reading compared to the

entire book, or jump to other sections. In this scenario, visually impaired people can freely select summaries of chapters/sections according to table of contents.

6.1.2. Test steps and methods

To understand how visually impaired persons (VIP) perceive the utility of summaries provided by AI, I conducted a series of tests involving specific reading activities. These tests aimed to evaluate their satisfaction with summaries, their preferences for summary length and format, and their overall reading experience.

Participants：

This study involved 7 participants with varying levels of visual impairment. The participants were recruited to represent a range of visual disabilities and preferences in book genres. Below is a summary table of the participants:

Table-6.1 Basic information of the participants

Number	**Age**	**Vision Condition**	**Book Genre**
1	34	Partial vision impairment	Science Fiction
2	45	Significant vision loss	Historical Fiction
3	39	Blind	Mystery
4	52	Partial vision impairment	Romance
5	38	Blind	Non-Fiction
6	41	Significant vision loss	Fantasy

7	50	Partial vision impairment	Massage textbook

Participants were recruited through a snowballing approach, with the first participant being my personal contact, and the other five participants were recruited through the first participant's introduction.

Interviews were conducted via telephone or video conferencing platforms, chosen based on participants' preferences and accessibility needs. Each interview lasted around 30 minutes.

Informed consent was obtained from all participants prior to the interviews. Participants were provided with detailed information about the study ' s objectives and their potential risks. Consent was obtained verbally due to VIP's difficulty on reading and signing.

Test steps:

In the test, participants were introduced to the background and procedures, with verbal consent obtained for recording. In Stage 1 (Pre-reading), they provided basic information, listened to book titles, selected and listened to summaries, and assessed satisfaction. They could adjust summary length (50/100/150/200 words) and format (keywords/bullet points/paragraph) based on preferences, repeating the process until satisfied. In Stage 2 (Mid-reading), participants selected chapters/sections for summarization during non-linear exploration, listened to summaries, and provided feedback. They could adjust summary details similarly to Stage 1, refining until satisfaction. Assessments included Likert scales and interviews to understand user preferences and needs.（See appendix for detailed test steps）

Test methods:

1. Thinking out loud

Participants were instructed to verbalize their thoughts, feelings, and reactions while interacting with the prototype, expressing their immediate impressions, confusions, satisfactions, and difficulties, which is useful for understanding the user's perspective and identifying areas for improvement.

2. Observing

3. Interview

Before and after each step, participants were reviewed to reflect on their goal of each step, and their satisfaction level of each summary, to understand their cognitive process.

After completing all the tasks, participants were interviewed to gather in-depth feedback.

6.2 Analysis

To analyze the data, I categorized it based on two dimensions: reading purpose (interest or specific goals) and reading stage (pre-reading or mid-reading), creating four distinct scenarios.

All of the recorded audios were reviewed for qualitative analysis, to gain deeper insights into users' needs in skim reading and how they perceive AI generated summary. Insightful quotes and observations are recorded from transcripts and clustered to acquire universal knowledge.

Also, I performed quantitative analysis to assesse the effectiveness of personalizable summaries by evaluating improvements in user satisfaction before and after modifications.

This approach allowed for comprehensive understanding of users' summary needs and guided recommendations for designing more effective summary systems.

6.2.1 Understand Users – Identifying Reading Scenarios

Through user research, I discovered that users' needs for summaries are influenced by two main dimensions: reading purpose (for interest/for specific goal) and reading stage (Stage 1: Pre-reading/Stage 2: Mid-reading). These dimensions create four distinct reading scenarios.

This section aims to:

- Explain how each dimension affects readers' summary needs.

- Describe readers' summary needs in scenarios combining these dimensions.

And the dimensions of user needs serve as the basis for design development.

A. Impact of Reading Purpose

1. Content Impact

Consistent with earlier research findings, readers' behaviors and purposes can be broadly categorized into two types: casual reading for fun and leisure, and purposeful reading for learning, information acquisition, and self-improvement.

For Interest: Summaries serve as a 'hook' to capture readers' potential interests, focusing on presenting engaging content rather than the book's overall takeaways and meanings (which may sometimes be counterproductive).

For Specific Goals: Readers' main concerning points are about the book's basic information and takeaways, including scope, significance, target audience, implications, , etc.

2. Information Presentation Order Impact

For Interest: Readers prefer to first learn about the book's most distinctive and captivating points, then delve into the content further. Some readers do not want the book's meaning included in the summary (to avoid interference with their own interpretations), so this part is placed at the end for easy skipping.

For Specific Goals: Readers seek a brief content overview upfront, including the summary's scope, target audience, and potential takeaways, to quickly decide whether to continue with the book or chapter. If it aligns with their interests, they explore more detailed summaries.

- **Impact of Reading Stage**

Readers go through different stages from selecting a book to completing it, each stage forming different goal levels. According to Xie's (2019) theoretical framework, user goals are divided into four levels. For this project, reading purposes are roughly divided into two stages:

Stage 1: Pre-reading: Readers have broad and vague reading purposes (long-term goals) like 'learning more about feminist theories', needing a general impression of a book.

Stage 2: Mid-reading: Readers have accumulated some knowledge and understanding of the book, developing specific search preferences (main search

goals) and judging the importance of different book contents, needing to assess if the summarized text matches their needs.

The combination of these two dimensions creates 'reading scenarios'. To more accurately identify and address readers' needs, I have distinguished their summary requirements from a scenario-based perspective:

Table-6.2 Context and User's reading needs during Stage 1(Pre-reading)

	For interests	For specific goals
Context	The reader values the immediate impression conveyed by the work and expects an immersive reading experience that allows them to be deeply absorbed in the world of the book. They are unable to articulate specific criteria for judgment; instead, they rely on an intuitive, emotional sense to determine whether a book aligns with their interests.	Readers have a specific goal in mind; their aim is not to seek an immersive and enjoyable reading experience, but rather to acquire knowledge, skills, or factual information.
needs	Through whole book summary, they compare the book to their interests based on specific points they care about, such as style, language, or storyline.	Through partial summary, they want to understand what the book offers and compare it to see if it meets their reading goals and suits their situation (e.g., beginner/professional reader), in a more rational and logical state.

Table-6.2 Context and User's reading needs during Stage 2(Mid-reading)

		For interests	For specific goals
Situation 1: Small jump	Context	Loss of Interest: Readers might become impatient or uninterested in the current reading part. (Participant 1 feeling bored by a chapter in a book due to extensive descriptions of Paris scenery unrelated to the main plot, he wanted to skip that part.）	Skipping Irrelevant Parts (paragraphs): Within chapters/sections, some content might not be needed by the reader, they may want to quickly skip through it. （ participant 6: when reading a theoretical text, the book might provide an application example that spans several pages, but I wishes to skip the example and focus on the theory）
	Needs	By getting summaries of the chapters/sections, readers can understand what this chapter/section generally covers to decide how much content to skip strategically.	
Situation 2: Big jump	Context	Interested in Specific Parts: Readers might only be interested in specific sections or characters, particularly when rereading a book. (Participant 2 mentioned she wanted to only revisit the romantic storyline	Finding Relevant Sections (chapters/sections): Readers may already have a clear reading goal in mind, or their goal might not be clear yet but they can judge which parts they don't need based on the content. In such cases, the most efficient reading method is

		For interests	For specific goals
		between two protagonists in "Dream of the Red Chamber" and not the historical context of the declining family fortunes.) And some readers (participant 3) prefer to know the outcome in advance and then read the story in order.	not to start from the first page but to quickly identify and locate the part they need to read.
	Needs	Readers want to understand summaries of each chapter/section, and determine where to prioritize their reading.	
Situation 3: Build a structure	Context	Understanding the Storyline: For novels with complex plots/timelines, readers may want a clear overview of the storyline and its correspondence with chapters/sections, allowing them to repeatedly jump back and forth to deepen their understanding.	Building a Knowledge Framework: Readers sometimes wish to construct a mental framework of the entire book to better absorb knowledge, to better grab the importance of the current reading part, and understand its relative position within the whole book.
	Needs	The reader wants to understand how the book is divided into parts (generally based on the book's chapters/sections) and what each part is roughly about	

		For interests	For specific goals
		to build a framework in their mind, aiding comprehension. This framework helps in focused reading and incorporating specific content into their mental structure.	

This table shows users' expected summary from a scenario-based perspective (combination of reading goal and stage)

I categorized users' needs for summaries into common needs (expressed by more than 4 out of 6 people) and personalized needs. Common needs will be emphasized in the design process and may be set as default options, while personalized needs may be addressed by allowing users to adjust settings according to their preferences.

Table-6.3 Users' expected summary from a scenario-based perspective

		For interests	**For specific goals**
Stage 1: Pre-reading	Common needs	Capture the core essence of the original book, avoiding minor details that deviate from the main storyline. Provide an overview of the basic background and setting, including key information about the main characters, plot, and major events. Highlight at least one major attraction of the book. For example, if the most praised aspect is	The overall theme, scope, and positioning of the book. Identification of the target audience (e.g., suitable for beginners or more experienced individuals/interested in a particular aspect). The main content of the book.

		For interests	For specific goals
		its storytelling technique, emphasize this to effectively engage the book's target audience.	The most important takeaways after reading the book. .
	Personalized needs	The reading value of the book (3 times): such as author introduction, recommendations from famous people, sales, rankings, historical status, and its significance/influence at the time or now. A more detailed introduction to a certain aspect/key point of the original book (6 times): historical background (related historical events), characters (identity, age, personality, etc.), artistic techniques, core discussions, significance, plot, etc. A more detailed introduction to a specific plot in the original book based on the initial summary (4 times)	Outline the basic knowledge structure. Show how the book logically presents its content. Provide examples to explain certain specialized concepts. Include keywords related to the main content of the book.

		For interests	For specific goals
		An excerpt of a brilliant original text (3 times): which can serve the purpose of a movie trailer, helping readers immerse themselves in the atmosphere of the book. For highly summarized plots ("this book contains 'subtle descriptions of life's changes'"), a more detailed explanation is preferred (e.g., "the challenges of health issues and the feeling of loneliness") (7 times).	
Stage 2:Mid-reading	Common needs	Provide more detailed summaries, focus on conveying specific characters, plot details, and concrete content rather than abstract themes and meanings. Quickly provide the gist of each chapter to compare and choose. Avoid overly formal or vague language. Capture the core elements and the most	Summarize specific points of interest (eg, the explanation of a particular theory). Quickly provide the gist of each chapter to compare and choose.

		For interests	For specific goals
		engaging aspects, summarizing in a way that aligns closely with the original style.	
	Personalized needs	Summarize specific points of interest, such as the development of a particular plot or character. Know what the next few pages or a section (based on content division) are about when the current content is not engaging.	Highlight connections between the current chapter and previous ones. Use examples in the summaries to help explain a concept, making it easier to understand. Know what the next few pages or a section (based on content division) are about （ when not needing detailed information.

6.2.2 Cognitive process

Overall, readers' cognitive process towards summaries is a non-linear exploration, where they seek overlaps between summary content and their latent interests or needs. They are motivated by clues provided by the system to explore broader potential overlaps. When readers perceive the content sufficiently meets their internal standards, they feel satisfied and make judgments.

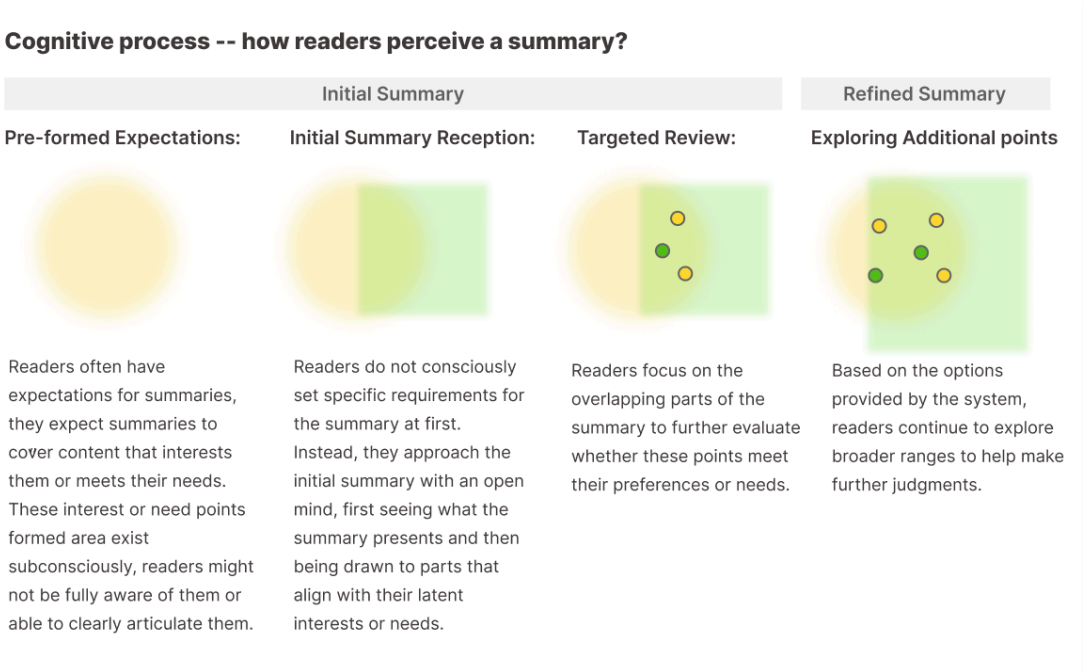


Figure-6.1 User's Cognitive process of a summary

a. **Individualized Expectations**: Readers have latent expectations that are highly personalized, potentially influenced by factors such as personality, upbringing, and educational or professional background. Building a user profile could help the system make more accurate assessments.

b. **"Laziness"**: Several participants noted a "laziness" when adjusting summaries. Instead of consciously thinking about the type of summary they need, they prefer the system to provide potential options to help guide their exploration. This preference may stem from the challenges visually impaired users face with typing or voice input, such as difficulty in verifying input and correcting homophones, making option selection more appealing.

c. **Exploration**: Reviewing summaries is a nonlinear exploration process for readers. Initially, they might not know what kind of summary they need and approach it with an open mind. They receive an initial summary and then use the options provided by the system to explore directions that interest them or meet their needs. This refined summary exploration offers positive reinforcement as they discover content that aligns with their interests and requirements.

6.2.3 The effect of personalizable summary

In the test, users receive an initial summary immediately after selecting the summary scope and then provide adjustment suggestions based on their needs. They are asked to rate their satisfaction with each summary on a scale of 1 to 5, reflecting their level of contentment with the generated summaries.

The figure below illustrates the distribution of user satisfaction ratings and average scores for both initial summaries and refined summaries (summaries modified by users).

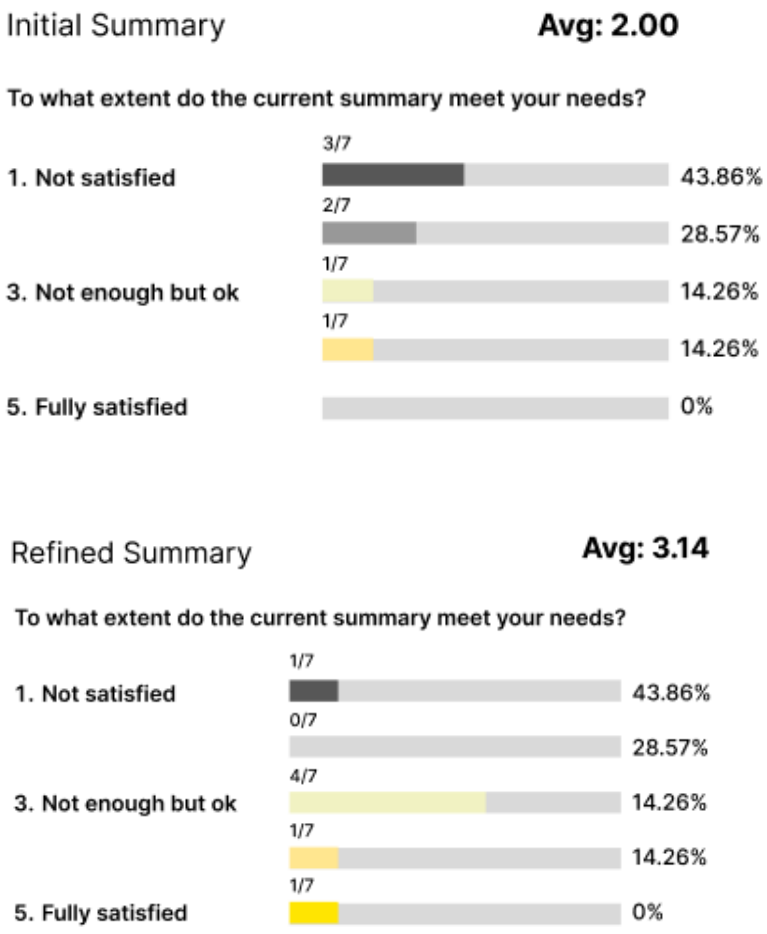


Figure-6.2 the distribution of user satisfaction ratings and average scores for both initial summaries and refined summaries

It was observed that user satisfaction improved through requirement collections (Including modifications to the format, length, and focus points, as well as some

open-ended requests (through input). Both average scores and score distributions showed marked increases.

6.3 Transformation into design decisions

To address the readers' needs and expectations for summaries, this section will explore how the system can progressively provide summaries that align with individual preferences and adapt to different reading scenarios.

Given the numerous factors that influence summaries, allowing readers to control all aspects would be overwhelming. Therefore, I propose a dual approach to summary generation:

7. **Backend automation**: Utilizing pre-set prompts and default settings to guide the initial summary generation.

- **Frontend Interaction**: Allowing readers to refine and adjust the summary through interactive controls.

6.3.1 Backend Automation-- Summaries Adapted to Reading Scenario and Book Genre

a.Prompts

The prompt is divided into two sections:

1. Identity Positioning: This part helps the AI understand its role, responsibilities, and guidelines. It provides context on how the AI should position itself and interact with users.

2. Scenario-Based Prompts: Since a single set of prompts is not sufficient to address all needs, prompts are categorized based on different scenarios. This approach ensures that the AI can effectively respond to various contexts by tailoring its responses to specific situations.

Table-6.4 Identity Positioning Prompt

Identity Positioning:	**Capabilities:** Efficiently read and understand book content. Extract the core ideas and main highlights from the provided text. Integrate information from various reviews and sources to offer a more comprehensive perspective in the summary, while citing the sources. **Desired Tasks or Goals:** Provide accurate and truthful text summaries. Capture the core highlights of the given content to engage readers' interest. Avoid lengthy and unnecessary details, keeping the summary concise and clear. **Function:** Help readers quickly grasp the essence of the given text content. Showcase the uniqueness and appeal of the given text through the summary, stimulating readers' interest. **Identity** **Role:** As a text summarization tool, it plays the role of an intelligent assistant focused on extracting and summarizing book content. **Interaction with Users:** Accepts the entire book or selected excerpts provided by the user for summarization.

	Can receive user feedback and requests to adjust the content and style of the summary. Behaviors to Avoid: Avoid inaccuracies or hallucinations that do not align with the book's content. Avoid clichés and meaningless language. Avoid significant deviations in language style from the original book. Avoid repetition, ensuring each summary is unique and fresh. Avoid excessive use of technical jargon, maintaining a language that is relatable and easy to understand. **Tool Behavior** Behavioral Characteristics: Rigorous: Focus on the accuracy and truthfulness of the content. Concise: Capture the core points of the book, avoiding lengthy and unnecessary details. Diverse: Able to incorporate online reviews and resources to provide multi-angle commentary. Adaptive: Flexible in adjusting summary content and style based on user feedback and requirements. **Personality:** Professional yet approachable: Capable of summarizing in a friendly and accessible manner. Meticulous: Paying attention to the unique highlights of the book, avoiding vague generalities.

	Innovative and flexible: Integrating external resources and reviews to add novelty to the summary.

Table-6.5 Scenario-based prompts:

	Casual Reading	**Purposal Reading**
Stage 1: Pre-reading	Please summarize the book [Book Title]. The summary should: Focus on the core content of the book, avoiding minor details that deviate from the main storyline. Maintain a language style consistent with the original book (e.g., serious and rational/light and lively). Analyze the book's genre and ensure that the key content, summary style, and language style (indicative/informative) align with the genre. The summary should be a coarse summary. The content of the summary can be based on your judgment. Additionally, highlight at least one major attraction of the book. This can be the most praised feature of the book, to engage readers who value the book's atmosphere, style, and narrative.	Please summarize the book [Book Title]. The summary should: Focus on the core content of the book. The summary content can be based on your judgment. Consider including aspects such as the overall theme, scope, and positioning of the book, as well as identifying the target readers. Explain the significance of the book or why it is worth reading, including reviews, its impact at the time of publication, and its relevance today. Maintain a language style consistent with the original book (e.g., serious and rational/light and lively). Analyze the genre of the original book and ensure that the key content, summary style, and language style (indicative/informative) align with the genre. The summary should be a coarse summary.

	You can consider this summary as a book trailer to attract readers and help them understand the main content.	
Stage 2: Mid-reading	Please summarize the book [Book Title]. The summary should: Focus on providing the core content of the text. The content of the summary can be based on your judgment. Emphasize the content of this chapter related to the main storyline or highlights of the entire book, with secondary content briefly mentioned. Provide keywords from multiple perspectives for further search. Maintain a language style consistent with the original book (e.g., serious and rational/light and lively). Analyze the genre of the original book, and ensure that the key content, summary style, and language style (indicative/informative) align with the genre.	Please summarize the book [Book Title]. The summary should: Focus on providing the core content of the text. The content of the summary can be based on your judgment. Emphasize the content of this chapter related to the main storyline or highlights of the entire book, with secondary content briefly mentioned. Provide keywords from multiple perspectives for further search. Maintain a language style consistent with the original book (e.g., serious and rational/light and lively). Analyze the genre of the original book, and ensure that the key content, summary style, and language style (indicative/informative) align with the genre.

b.Default setting

Based on the test results, although participants displayed different preferences, a length of around 100 words in paragraph format was acceptable to all six participants and was the first choice for five of them, so this will be set as the default setting.

According to XX's theory, the type and language style of a summary have a strong correlation with the book's genre. Therefore, the AI tool will be set to default to determining the summary based on the genre. During the experiment, participants did not express dissatisfaction or request modifications regarding these two aspects.

Length: About 100 words

Format: paragraph

Summary type: based on genre

Language style: based on genre

Reading stage: based on summary scope (book or chapter/section)

6.3.2 Frontstage control -- Interface Adapting to Reader's Cognitive Process and Needs

A. Summary Functions Structure

Based on the "expected summary" from last section, I categorized and integrated the needs into a hierarchical structure of summary functions.

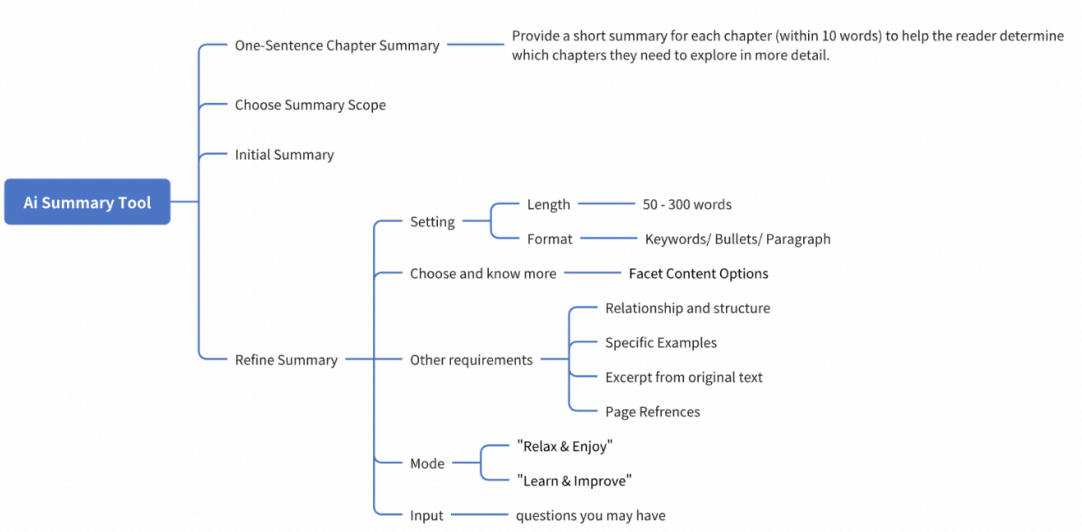


Figure-6.3 hierarchical structure of summary functions

B. Interfaces for VIPs

Learn from google talkback

Since the design scope set mobile phones as the hardware, research on the Google talkback system is conducted to learn:

Table-6.6 Basic operations of Google talkback

Drag finger	Navigation	As long as the finger hovering over a component, the content/ metadata belonged to this item will be read through spoken words
One finger swipe	Navigation	select the previous and next space by swiping right or left
Two-finger swipe	Scroll	scroll to browse more content
Touch	choose	Choose one item
Double tap	Activate	double-click anywhere on the screen to activate the object
Vibration	Switch	When navigating between different items, switching items will provide a vibration alert
Sound	Feedback	Read out the name and attributes of the current item (button)

Create MVP interface

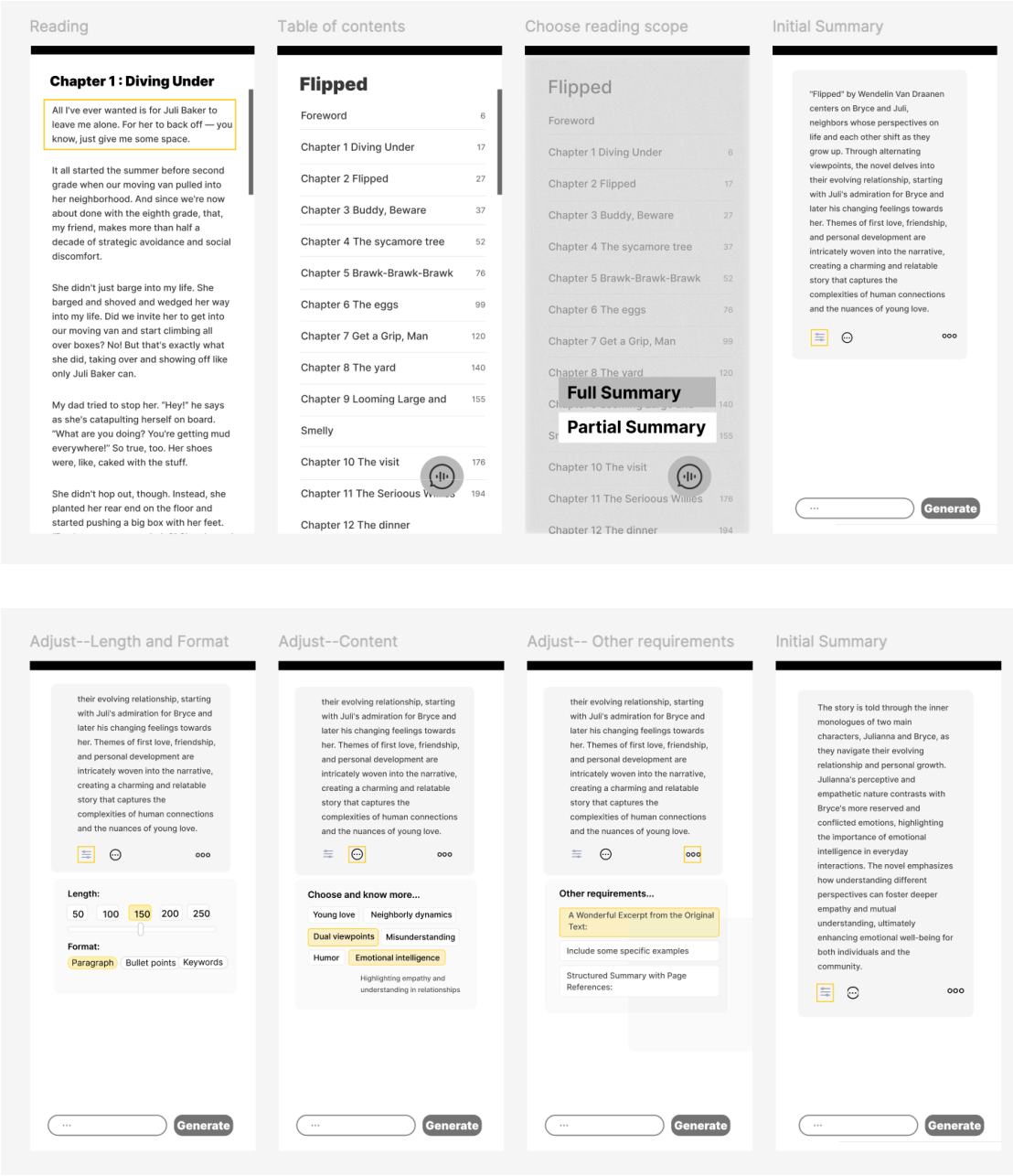


Figure-6.4 MVP interfaces

The initial interface design achieves the goal of personalized summarization theoretically through structured user control over summary elements, a progressive summary generation approach, and coordinated adjustments between the front-end and back-end systems.

The following image explains how the tool operates from a system perspective: how the backend integrates with the frontend interface, progressively gathering

reader feedback and iteratively generating summaries that better meet the reader's needs：

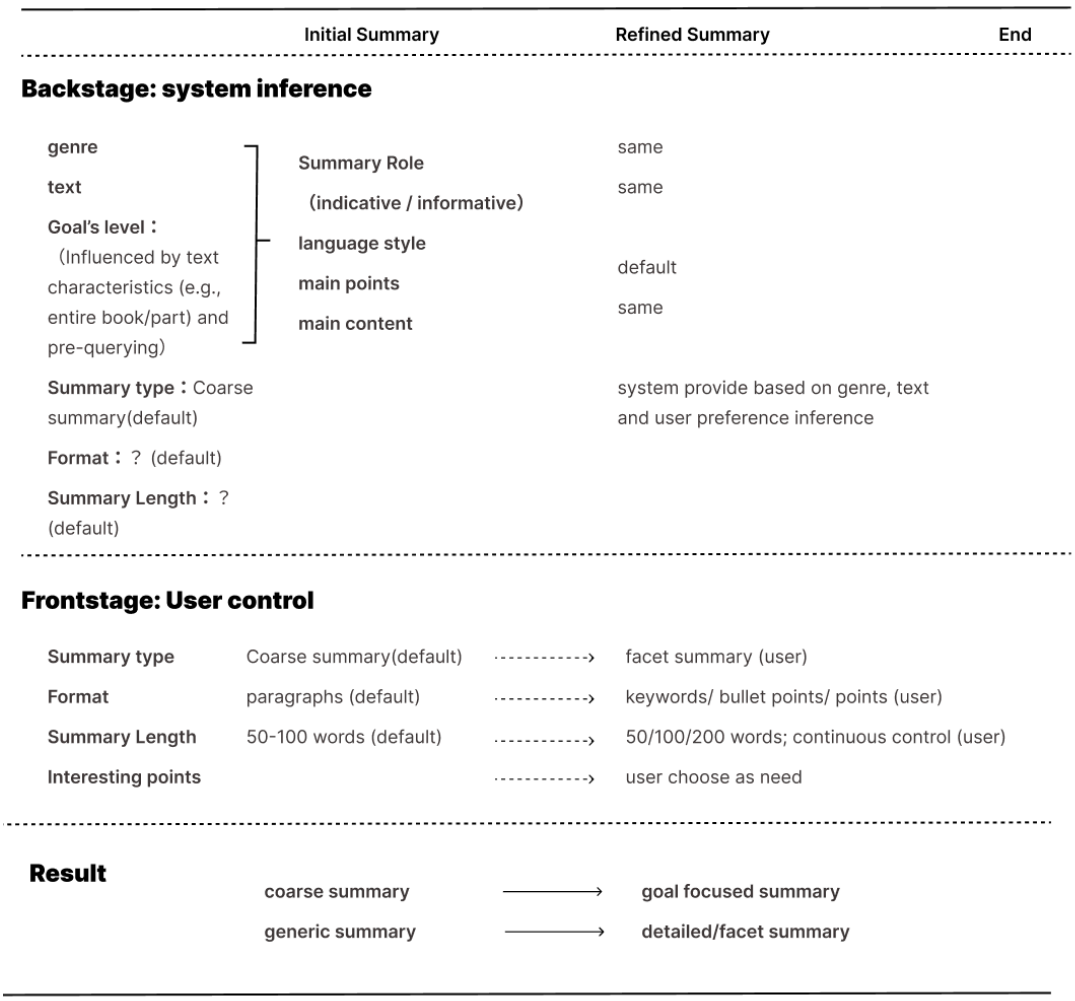


Figure-6.5 How the tool operates from a system perspective

7. Evaluation

7.1 Usability test

The goal of the usability test was to find out whether the participants could understand all the functions of the prototype, and interact with it fluently. The following research questions should be answered through this usability test:

8. How do participants experience navigating through the tool in general?

9. Is feedback provided to the participants understandable and useful?

10. Are all the functions and interactions in the interfaces accessbile and understandable?

11. How does the tool fit VIP users' reading needs and goals?

7.1.1 Tasks

This test followed the same two stages as the first test, which are:

Stage 1: Pre-reading - Deciding on which book to read

Stage 2: Mid-reading - Non-linear exploration

Participants were informed that this AI summary tool is designed to summarize selected text content to assist with reading. They were instructed to complete the reading tasks for both stages in succession according to their reading habits and explore the tool as needed.

7.1.2. Methods

Thinking out loud

Observing

the wrong attempts made by each participant for each task were recorded. This data helped in assessing the usability of the prototype, highlighting specific tasks or features that were problematic.

Interview

After completing all the tasks, participants were interviewed to gather in-depth feedback.

Questionnaire

The questionnaire is divided into three sections, each aiming to test the usability of this tool and its effectiveness in achieving the design objectives (enhancing reading efficiency, reducing cognitive burden, and improving reading experience).The questionnaire uses a five-point scale, where 1 means strongly disagree and 5 means strongly agree.

Table-7.1 Questionnaire

The system usability scale	I think that I would like to use this system.
	I found the system unnecessarily complex.
	I thought the system was easy to use.
	I think that I would need the support of a technical person to be able to use this system.
	I found the various functions in the system were well integrated.
	I thought there was too much inconsistency in this system.
	I would imagine that most people would learn to use this system very quickly.

	I found the system very cumbersome to use.
	I felt very confident using the system.
	I needed to learn a lot of things before I could get going with this system.
Improve reading efficiency	The tool helped me read the content faster than usual.
	I was able to quickly find the information I needed using this tool.
	The tool allowed me to cover more material in a shorter amount of time.
	Using the tool made my reading more enjoyable and efficient.
Cognitive overload	The tool reduced the mental effort required to enjoy and understand the reading material.
	I felt less overwhelmed when using this tool to read
	The tool helped me easily organize and process the reading material.

	I found it easier to concentrate on my leisure reading when using the tool.
Overall experience	The tool made my overall reading experience more enjoyable.
	The tool enhanced the accessibility and convenience of my reading experience.
	The tool provided an intuitive and user-friendly reading experience.
	I felt more engaged and immersed in my reading when using the tool.

Wizard of oz

To observe participants‘ interactions with the system, they are asked to interact with the prototype on their phone screens. Meanwhile, on another device, I played pre-recorded button audio content to simulate screen reader, and operated ChatDoc to generate summary text, simulating the automated functionalities of the AI through human intervention.

7.1.3 Participants

Participants remained the same as in the previous test with varying levels of visual impairment. Participants were provided with detailed information about the study’ s objectives and their potential risks. Verbally consent was obtained from all participants prior to the interviews.

7.1.4 Analysis

A. Quantitative Analysis

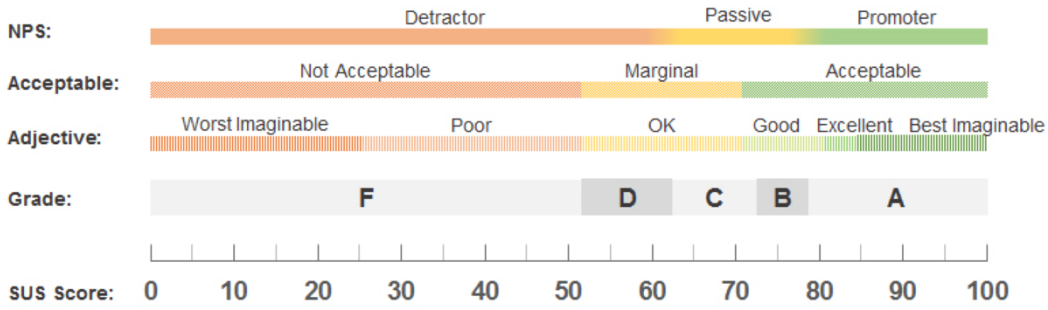


Figure-7.1 User experience metrics and overall system usability scores (SUS).

Usability:

The SUS score for this project is 64， which falls just below the average SUS benchmark score of 68,with a rating of C, there is room for improvement in the usability of the system.

While this score suggests that users found the system somewhat usable and acceptable, certain aspects likely caused frustration or confusion

Reading Efficiency Improvement：

Avg score: 3.1

Cognitive Burden Reduction:

Avg Score： 4.1

Overall experience

Avg Score： 3.5

Participants believe this tool can obviously improve reading efficiency and significantly reduce cognitive load. They feel that the summaries and adjustment options effectively cater to different stages and purposes of their reading process,

helping them build a comprehensive mental image of the book, gather information selectively, and engage in targeted skimming.

To meet personalized reading needs, designers need to balance between feature richness and usability. Currently, participants report it requires some learning effort. They initially found certain features and their impact on summaries confusing, but could quickly adapt after exploration. Six participants felt that the learning effort were comparable to other reading apps they frequently use, thus finding it acceptable and expressing willingness for long-term use.

There is still significant room for improvement, especially in enhancing reading efficiency. For now, design focus should be placed on resolving usability issues, providing clearer guidance and feedback, and ensuring an intuitive and consistent user interface. Addressing these aspects will help make the tool more effective, enjoyable, and interactive for visually impaired users engaged in their daily reading.

B. Qualitative Analysis

To analyze the feedback on the AI summary interface, I first categorized responses based on function: opening the interface, selecting summary scopes, obtaining summaries, and adjusting settings. During the tests, I observed and recorded participants' errors and confusion with each function.

Afterward, I conducted interviews to gain insights into their cognitive processes and experiences using these features. This approach allowed me to identify common issues and refine the interface based on users' practical interactions and feedback.

Table-7.2 Users' feedback on Prototype Interface

Function		**Feedback**
Open Summary Assistant interface	Double-click on the Summary Assistant logo in the bottom right corner	Often press incorrectly; sometimes want to compare the summary with the original text, and the 'Reading Assistant' finds it difficult to achieve this.

Function		Feedback
Select summary scope		All participants were able to understand and select correctly.
	Select 'Book Summary'	-
	Select 'Chapter Summary'	After selecting 'Chapter Summary', the reader needs to continue selecting specific chapters to summarize, instead of immediately getting a summary; 2 participants showed confusion.
Obtain summary		Want to know roughly how long the summary is; Hope to interrupt at any time.
Adjust summary		Confused by options like 'length' and 'format', mistakenly thinking they adjust the existing summary（3 participants）.
	Length	Sliding to adjust is more flexible than using buttons, but immediate voice feedback is needed
	Format	The first use didn't clearly understand the format(2 participants), but could immediately understand after trying.

Function		Feedback
	Choose and know more	Participants showed confusion about what effect the selected words would have on the subsequent summary(2 participants); Participants could not determine if they had reached the last keyword when sliding left and right to listen, so they continued to slide, entering the next voice input function (4 participants); Since options appear after the summary, their position changes with the summary length, requiring readers to search every time (6 participants).
	Command Input	Participants indicated they were 'lazy', preferring to use the system's provided options for adjustment rather than inputting their own questions (5 participants).
	Other requirements	Confused by the classification standards, finding it difficult to predict what the requirements refer to and their relationship with other adjustment options(3 participants).
Switch summary mode		Misunderstood the names of the modes（2 participants）; Confused about why the "mode" setting is not grouped together with other adjustment options, and how the mode impacts summary.

Function		Feedback
Adjust speed		Participants indicated the need to flexibly and frequently adjust speed during reading, but in this test's skimming mode, all 7 participants stated there was no need to adjust speed frequently; they only needed to adjust once at the beginning.

7.2 Transformation Into Design

The following transformation outlines a series of design iterations developed in response to user testing insights for the text summary interface.

The primary insights from the testing revealed several areas for improvement: like Control and Feedback: Users reported difficulties with the control bar's variable position; Summary Access and Adjustment: Uses were unclear about how different adjustments affected the summary output. The existing interface lacked intuitive guidance for these processes, etc.

In response to these insights, the design transformations include:

1. Transform "Click on the bottom right to summon the text summary assistant" to "Skimming mode," placing it at the same level as reading mode for seamless switching between the two modes.

2. Rearrange "book summary" and "chapter summary" options, placing them within the skimming mode interface for easy access and adjustment.

3. After selecting "Chapter Summary," voice guidance states, "Below, you can select the summary scope and obtain a more detailed summary."

4. Before reading the summary aloud, voice guidance announces the total word count of the entire summary.

5. After clicking "Adjust Summary," provide voice feedback saying, "Adjust the options below and generate a new summary."

6. Adjust information hierarchy:

   Place mode adjustment and other adjustment options at the same level for better understanding and control.

7. Rename them to "Relax and Joy" and "Learn and Improve" for clarity.

8. Merge "other requirements" under modes because of their strong association with modes and their ability to explain changes brought by modes, enhancing control.

9. Adjust control bar position:

10. Previously located below the generated summary bubble, which varied with summary length and posed difficulties for visually impaired users.Now fixed consistently at the bottom for accessibility and consistency.

11. Implement word count adjustment by sliding left and right:

12. During sliding, trigger voice feedback upon reaching set points (50, 100, 150, 200, 250, and above).

13. Enhance "choose and know more" function:

    Upon reaching the last keyword while sliding, provide vibration feedback and stop further sliding.

14. When users click on an input box, suggest "Questions You May Want to Ask," leveraging AI to suggest relevant questions based on text content and user data, continuously improving question quality.

15. Optimize "Return to Previous Menu" button placement:

    Fix it consistently in the top left corner for easier navigation.

These transformations were proposed to enhance user understanding, streamline navigation, and improve the overall efficiency of the text summary tool, ultimately leading to a more intuitive and accessible user experience.

7.3 Interface Design

This section presents the redesigned interface based on test insights, focusing on functionality. It illustrates how readers can explore the text by obtaining and adjusting summaries, with arrows indicating the modifications made.

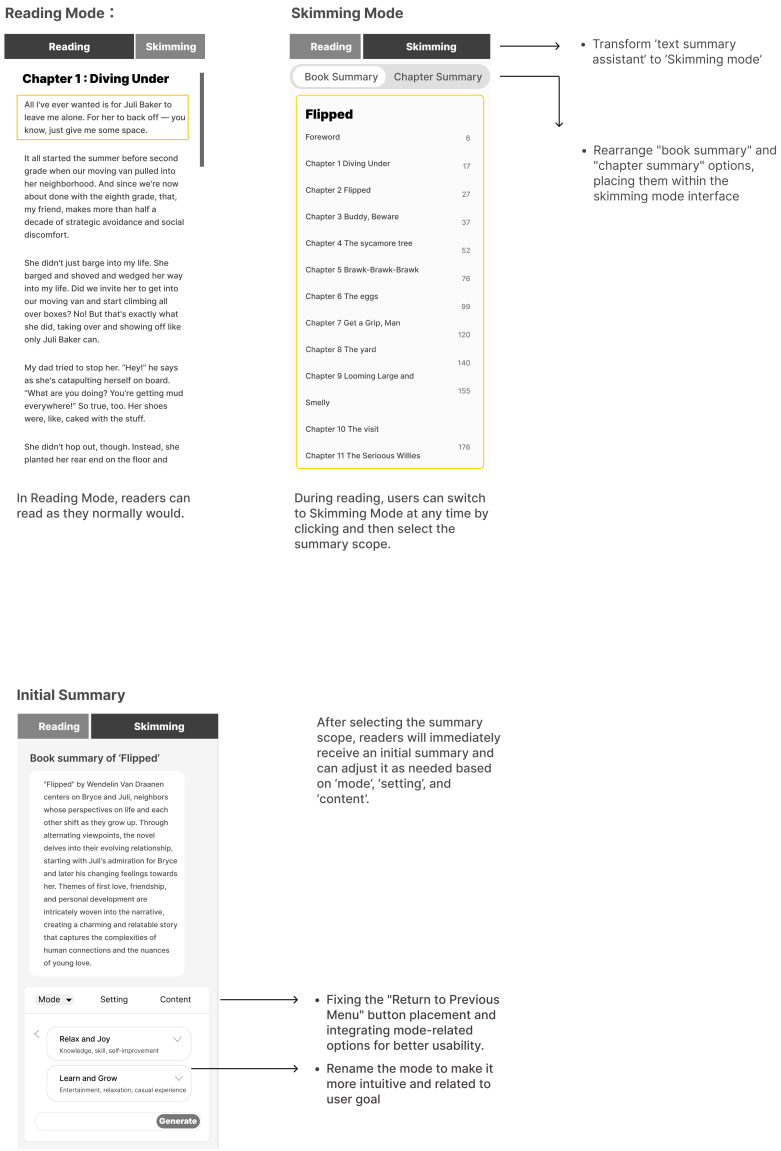
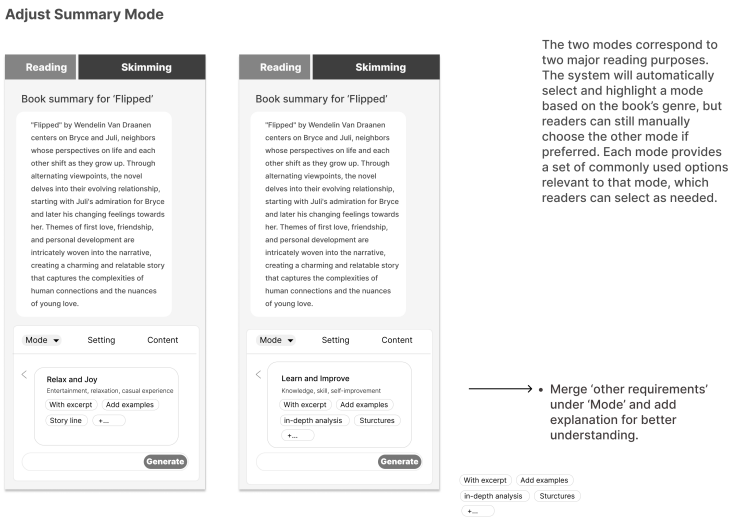


Figure-7.2 Interface Design-1



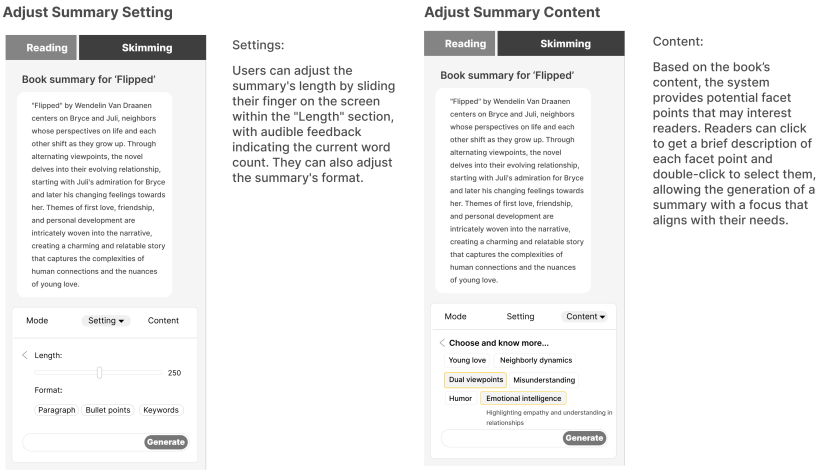


Figure-7.3 Interface Design-2

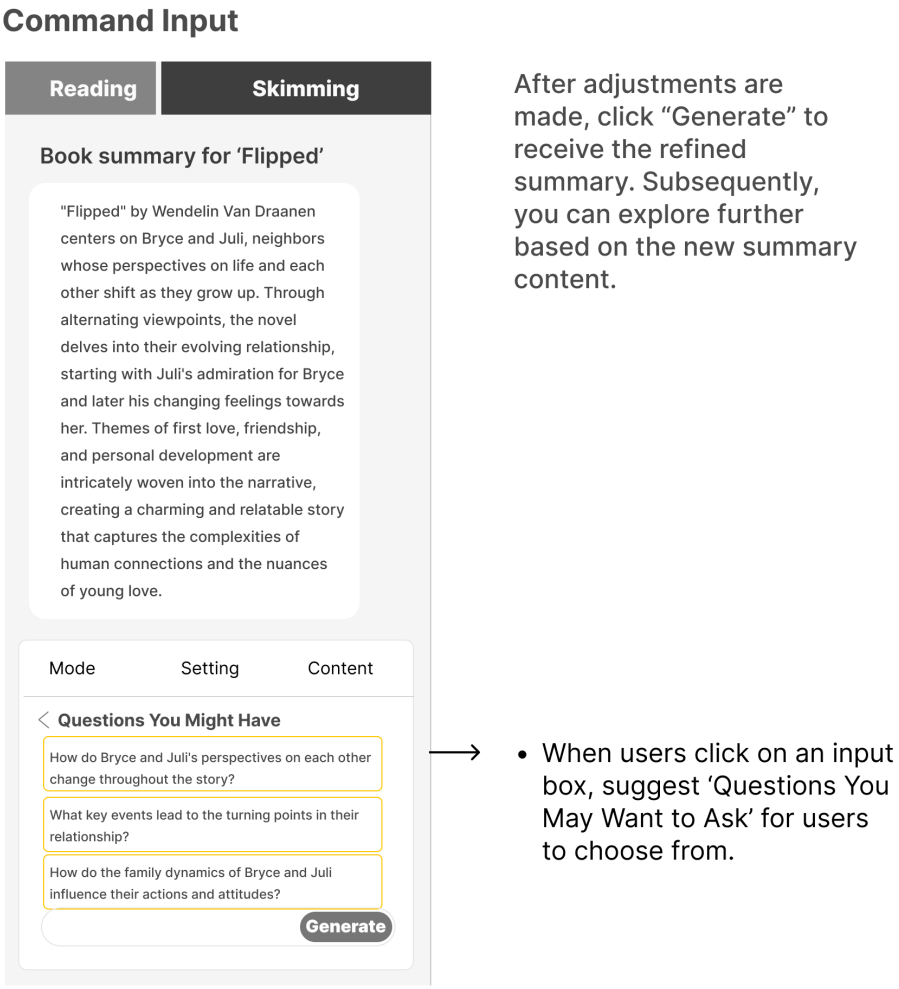


Figure-7.4 Interface Design-3

8. Final Design

8.1 Expert review

8.1.1 Aim of Interview

The aim of the interview was to assess the usability and effectiveness of the newly designed text summary interface. Gathering feedback from experts of VIP reading, could help identify potential areas for improvements that may be neglected from test as the limitation of participants.

8.1.2 Research method: Online Interview

To obtain expert insights, Ted van der Togt was invited to the interview.

Ted works at the Research department of Koninklijke Bibliotheek (KB). He is involved in the technology behind e-books and audiobooks. Together with publishers, for example, he investigates how these can be made as accessible as possible. Ted provided feedback on usability, feature effectiveness, and overall design.

8.1.3 Key Findings

- Confirmation of Functionality and Coverage Scenarios: Ted believes that the tool's features can flexibly cover a wide range of reading scenarios. He acknowledges that the four key scenarios analyzed in this project are indeed high-frequency reading situations for visually impaired individuals (and also for non-visually impaired individuals). The interaction methods and logic are more aligned with the special needs of visually impaired users.

- Button Size: Ted suggests adjusting the button sizes in the interface based on existing apps for visually impaired users. Currently, there might be issues with buttons being too small, leading to accidental touches or unclear information hierarchy.

- Clarity of Functional Hierarchy: Ted repeatedly mentioned whether the current functions can be quickly accepted by visually impaired users. The designer needs to balance personalized needs and usability. The summary adjustment

section currently has three primary functions, each containing 2-3 levels. Ted suggests reconsidering if the current setup is optimal.

- User Profile: Ted proposed considering the establishment of a user profile to better identify user purposes and needs. Due to concerns about user data privacy and AI ethics, this idea was initially abandoned. However, Ted pointed out that collecting user preferences, despite being a gray area with no perfect rules or definitions yet, could greatly enhance the response to readers' personalized needs in the future. This can be considered for future work.

- Other Functions: Ted believes that the summary tool can be well integrated with a marking function. Visually impaired users often need to mark or take notes during reading, which is also an important method to help them build their own two-dimensional structure (whereas the table of contents is a two-dimensional structure created by the author).

8.2 Final Design

To address the issue raised by Ted regarding the small button sizes and the potential overload from having too many page elements, I have implemented Ted's suggestion by learning from the layout of the ‘Easy Reader’ app—a widely used reading application for visually impaired users. By placing specific adjustment functions on a secondary level of the page, this approach makes the interface and information hierarchy clearer. This method aligns better with the conventions used in other reading apps for visually impaired individuals, thus enhancing usability and reducing cognitive overload.

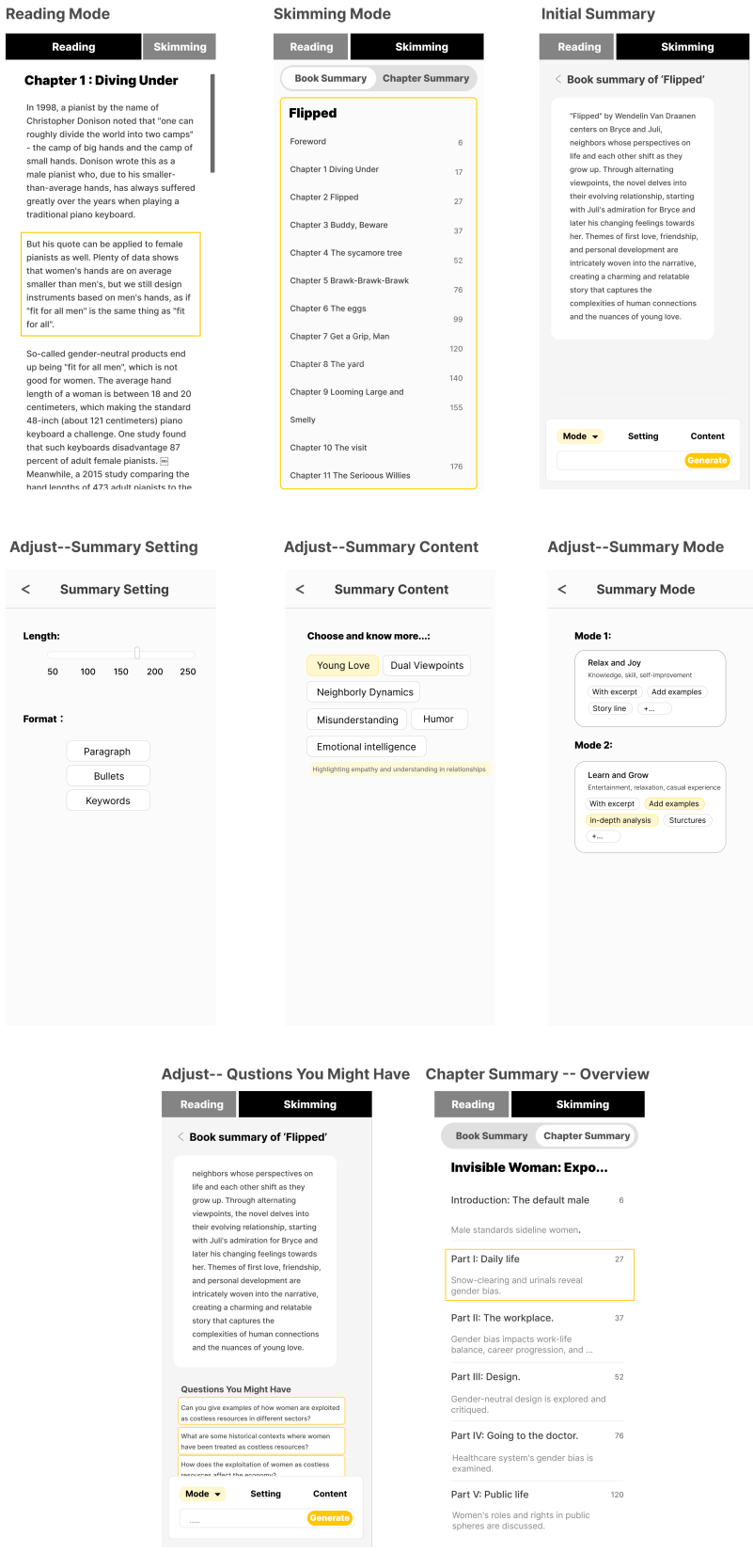


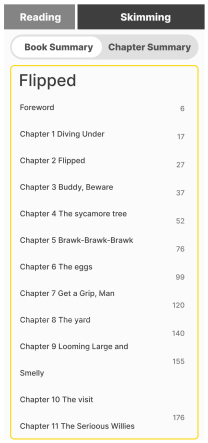
Figure-8.1 Final Interface Design

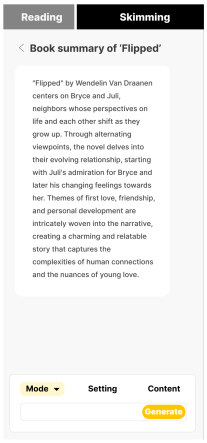
8.3 Demonstration of Using Scenario

Story 1: Casual reading for interests

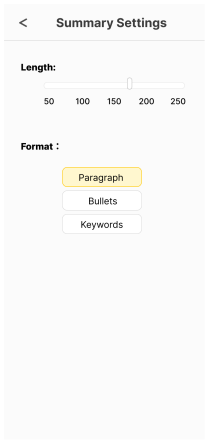
Lihua enjoys a leisurely reading time every afternoon. After reconnecting with a middle school friend yesterday, she decided to read a novel with a youth theme. Browsing through the app, she randomly clicked on 'Flipped.'

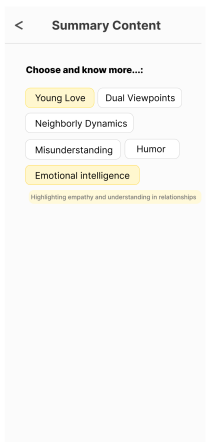
Scenario 1: Before Reading

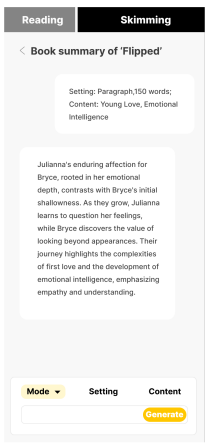




Unsure if she would like the book, she chose the 'book summary' option. Instantly, she received a summary highlighting themes such as 'first love,' 'friendship,' and 'personal development.' These words piqued her curiosity.





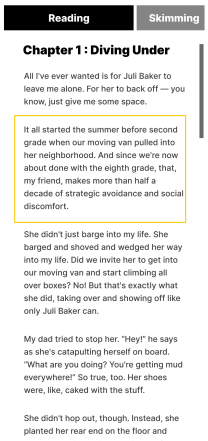


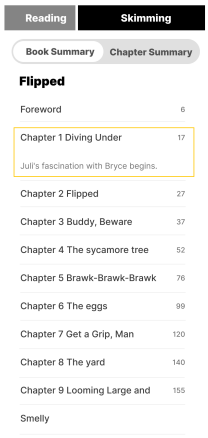
To quickly learn more about how the book explores these emotions and personal growth, she navigated to the 'content' section and looked at the focus points. She selected 'young love' and 'emotional intelligence,' which interested her the most.

The refined summary phrases like 'contrasts with Bryce's initial shallowness' and 'Julianna learns to question her feelings' moved her. She found these elements dramatic and indicative of deeper philosophical reflections on people and emotions. Convinced, she decided to start reading the book.

Figure-8.2 demonstration of using scenario-1

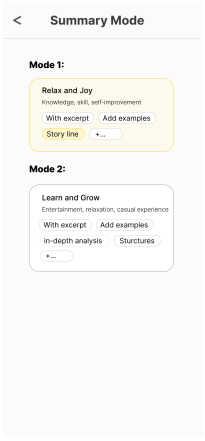
Scenario 2: Small Jump

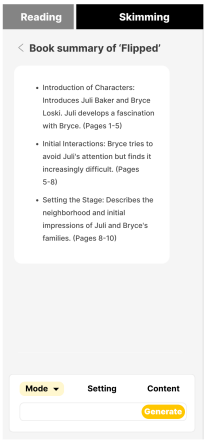


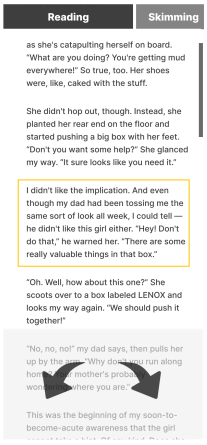


When reading the first chapter of "Flipped," she felt impatient because she was not interested in the childhood stories of the protagonists. She was more eager to learn about their teenage years and psychological development.

At this point, she switched to skimming mode, selected the first chapter.







She chose the mode "relax and joy" along with the option "storyline."

After getting an overview of the first chapter and the distribution of pages, she decided she wasn't interested in the first and second parts. Therefore, she directly jumped to page 8. By using paragraph jumps (listening to the first few sentences of each paragraph), she quickly found the section she wanted to read about: "the interactions between the two characters and the conflict between their family values."

Figure-8.3 Demonstration of using scenario-2

Story 2: Purposal Reading

Peter, after becoming visually impaired, has turned into a blogger. He frequently posts book notes and opinions on social media. He enjoys self-improvement through reading and likes to read current affairs news and sociology books. Recently, he has developed a strong interest in feminism.
By using the 'book summary' feature, he discovered that the book "Invisible Women" explores the reasons behind the neglect of women's rights from the perspectives of data and social structures. The book is also suitable for beginners. This immediately convinced him to read the book.

Scenario 3: Big Jump

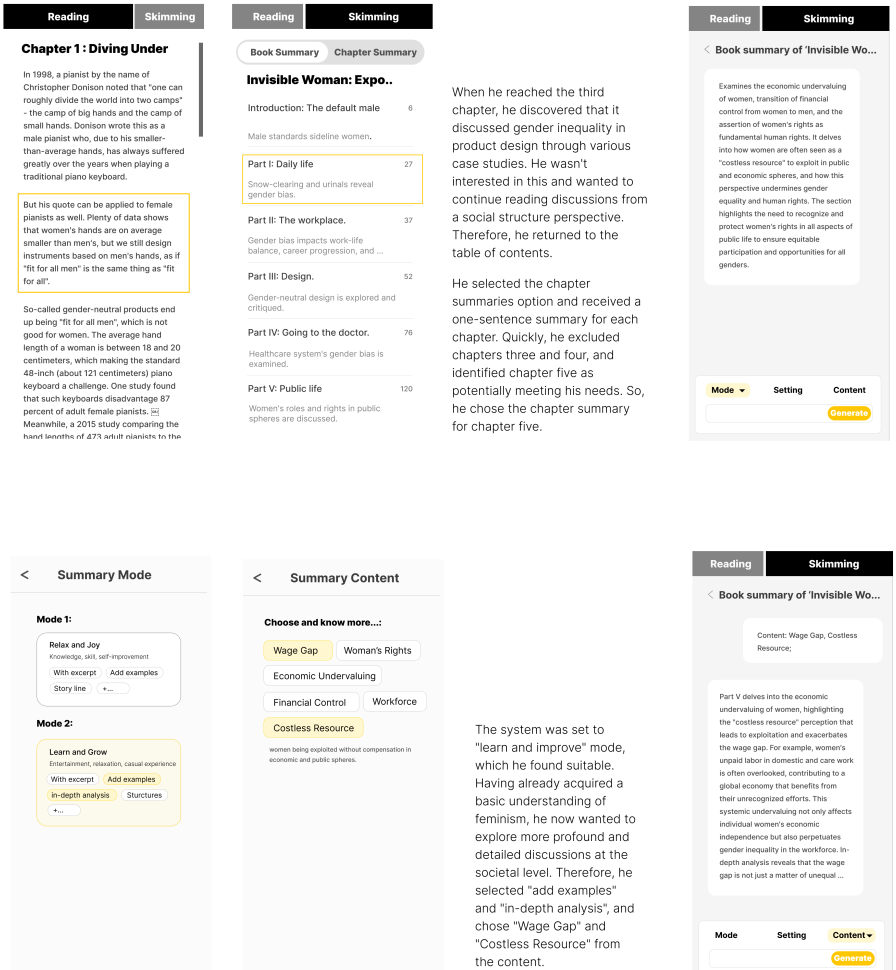


Figure-8.4 Demonstration of using scenario-3

9. Conclusion， Contribution and Limitation

9.1 Conclusion:

This project approaches the challenge of enhancing reading abilities and experiences for visually impaired people (VIPs) from the perspective of skim reading. It aims to address the multi-dimensional challenges faced by VIPs, which include not only physical limitations but also cognitive and psychological impacts. The design objectives are multi-faceted: improving reading efficiency, reducing cognitive load, and enhancing the overall reading experience for VIPs, including reducing frustration and increasing self-efficacy.

The primary goal of the project was to design an AI-driven summarization tool focused on digital formats of everyday reading materials, accessible to all VIPs through audio reading on mobile phones. This tool integrates AI text summarization within a reading application to provide a solution tailored for VIPs.

The tool addresses the gap in skim reading between VIPs and sighted readers by enhancing the two-dimensional skim-reading experience. This includes supporting non-visual implementations of macro-structures and allowing for non-linear exploration of the text. By providing summaries of selected text ranges, users can gain an overall understanding and freely explore content based on their interests. This enables non-linear exploration, allowing users to make large jumps within the text to areas of high interest, thereby meeting the reading needs of VIPs.

The implementation of these design goals has resulted in a tool that significantly improves the reading experience for VIPs. User feedback and testing indicate that this interactive, progressive, and personalized approach to summarization has notably increased satisfaction. The System Usability Scale (SUS) score for this project is 64, suggesting that while there is room for improvement, the tool is generally considered usable and acceptable. Ratings for Reading Efficiency Improvement, Cognitive Burden Reduction, and Overall Experience are 3.1, 4.1, and 3.5 respectively, reflecting positive user evaluations for these aspects.

9.2 Contribution：

The contributions of this research can be broadly categorized into four key areas: defining reading scenarios, understanding the cognitive process of VIPs, providing interactive and personalized summary tools, and addressing market gaps with a tailored solution.

1. Defining Reading Scenarios and Systematic Exploration of Reading Needs

A major contribution of this project is the development of a comprehensive framework for understanding reading scenarios and their impact on summarization needs. By categorizing reading purposes into ‘for interests’ and ‘for specific goal’, reading stages into Pre-reading and Mid-reading, the project offers a perspective on how VIPs interact with texts at different stages. This framework enables the system to tailor summaries to align with users' evolving needs, thus providing a more effective and contextually relevant reading experience.

The systematic exploration of reading needs based on these scenarios has laid a solid foundation for designing tools that can adapt to varying user goals and preferences. This approach not only enriches the theoretical understanding of reading processes for VIPs but also translates into practical design decisions that cater to real-world needs.

2. Understanding the Cognitive Process of VIP

The project contributes to a deeper understanding of how VIPs engage with summaries and process information non-linearly. The cognitive process identified in this research highlights the exploratory nature of summary interactions, where users seek to align summary content with their latent interests and needs.

The insights into individualized expectations and user behavior, such as the preference for system-provided options over manual adjustments, have informed the design of a more user-friendly summarization tool. The concept of "laziness" reveals a critical aspect of user interaction, emphasizing the importance of providing intuitive, easy-to-navigate options that cater to the unique challenges faced by VIPs, such as difficulties with typing or voice input.

3. **Interactive, Personalized, and Progressive Summary Tools**

A significant contribution of this project is the implementation of an interactive, progressive, and personalized summarization approach. By designing the

summarization tool to evolve from generic summaries to personalized ones, the project aligns with users' exploratory needs and preferences for everyday reading materials. The incorporation of layered summaries and the ability to adjust summary factors based on user goals enhance the flexibility and effectiveness of the tool.

The progressive summarization method, which transitions from general to specific content, and the layered summary design, which organizes summary factors into major groups, offer a robust mechanism for meeting diverse user needs. This approach not only improves the efficiency of information retrieval but also facilitates a more engaging and user-centered reading experience.

4. Addressing Market Gaps

The project addresses a market gap by focusing on summarization tools specifically designed for VIPs and everyday reading materials. Current summarization tools primarily cater to sighted users and academic contexts, often relying on visual layouts and keyboard inputs. In contrast, this project explores alternative interaction methods suitable for VIPs, such as voice-guided navigation, provide more options for users to choose from, with functionality and options designed around the characteristics of everyday reading materials.

In summary, the contributions of this project extend the boundaries of assistive technology by providing an understanding of reading scenarios, advancing the cognitive process of VIPs, offering interactive and personalized summary tools, and addressing critical market gaps. These advancements collectively enhance the reading efficiency, reduce cognitive burden, and improve the overall reading experience for visually impaired individuals.

9.3 Limitations:

1. **Limited Sample Size:** The study involved only seven participants, due to the complexity of vision impairment conditions among VIP, this is a relatively small sample size for drawing comprehensive conclusions about the tool's effectiveness.

2. **Scope of Application:** The tool was primarily tested with general reading materials. Its effectiveness for more specialized texts, such as academic papers or technical textbooks, may be limited. These materials often have unique

structural and informational requirements that might not be fully addressed by the current design.

3. **Testing Constraints:** The testing phase used a "Wizard of Oz" methodology,instead of a fully interactive application. This approach introduced a 1-2 second delay in user feedback and did not support real-time adjustments of text reading speed. These limitations could affect the perceived responsiveness and accuracy of the tool.

4. **User Training and Familiarity:** The study did not account for participants' prior experience with similar tools or their level of training. Variations in familiarity with technology or summarization tools could influence how effectively users interact with the system and their overall feedback.

5. **Inconsistent AI Generation:** The AI's summarization results can be unstable and random, leading to fluctuations in the quality of the generated summaries. This inconsistency can result in varying user feedback, as users may experience differences in the usefulness and accuracy of summaries with each generation.

9.4 Recommendations

1. Enhanced Note-Taking and Annotation

Incorporating note-taking and annotation features can further aid visually impaired users in their reading and summarization process. These features allow users to mark important sections, add personal notes, and create a structured outline based on their reading. Given that visually impaired users often rely on tactile or audio-based methods for note-taking, providing a flexible and intuitive system for creating and managing annotations can be highly beneficial. This approach helps users build a personalized two-dimensional structure of the text, complementing the AI-generated summaries with their own insights and observations.

2. Improved Personalization and Customization

Future iterations of the summarization tool should focus on advanced personalization and customization options. Developing a user profile system, while sensitive to privacy concerns, can offer tailored summaries based on individual preferences and reading goals. Although the implementation of user profiles requires careful consideration of data privacy and ethical implications, allowing users to adjust summary settings according to their needs can improve

the overall effectiveness of the tool. Personalized summaries, based on historical reading patterns and user-defined preferences, can provide a more relevant and engaging reading experience.

3. Regular Feedback and Iterative Improvements

Establishing a mechanism for regular user feedback and iterative improvements is crucial for the ongoing development of the summarization tool. Collecting feedback from a diverse user base and incorporating it into subsequent updates can help address emerging issues and refine the tool's features. Conducting user testing with different demographics and reading scenarios can provide valuable insights into the tool's performance and areas for enhancement. This iterative approach ensures that the tool remains responsive to user needs and evolves in line with technological advancements and user expectations.

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