Some Studies on Accessible Mobile Interfaces for Visually Challenged

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JULY 2025

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Submitted

In fulfilment of the requirement for the degree of Doctor of Philosophy

To the

INDIAN INSTITUTE OF TECHNOLOGY DELHI

HAUZ KHAS, NEW DELHI - 110016

JULY 2025

Dedicated to

My Family

CERTIFICATE

This is to certify that the thesis entitled - Some Studies on Accessible Mobile Interfaces for Visually Challenged, being submitted by Mr. Sachin Tanwar for the award of the Degree of Doctor of Philosophy to the Department of Design, Indian Institute of Technology Delhi, is a record of bonafide work by him under my supervision and guidance. The matter embodied in this thesis has not been submitted to any other University or Institute for the award of any degree or diploma.

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ACKNOWLEDGMENT

I would like to express my great appreciation to my supervisor, **Prof. PVM Rao** who guided me with patience and inspired me all this time. With his excellent knowledge and passion for the design of accessible products, he closely verified and reviewed my work giving the important directions and insightful ideas in the research period and writing this thesis. Beyond the professional collaboration, I would like to thank him for the moral support and the encouragement he gave me to complete my doctoral research.

I would like to thank my student research committee members - *Prof. Deepti Gupta* (Chairperson), *Prof. Tapan Gandhi* (External expert), and *Prof. Jyoti Kumar* (Internal expert), and other faculty members from Department of Design who have provided their valuable inputs and feedback throughout my research journey. I am thankful to the Indian Institute of Technology Delhi for providing me with a scholarship to pursue doctoral research and the necessary funding for this research work. I want to express my gratitude to the Assistech Lab, & Department of Design, IIT Delhi, for all the help they provided with the infrastructure, exposure to assistive technology products, users, and knowledgeable experts, for helping and supporting me through my research studies.

Finally, I would like to express my deep sense of gratitude to my father, Mr. Brahm Prakash, my mother, Mrs. Brijesh, and my brother, Lalit Tanwar, for the immense support and motivation and making me what I am today. My wife, Dr. Kanika Jolly & daughter Teshika Tanwar, have been at my side during this incredible and arduous journey. I would like to thank them and express my sincere gratitude for inspiring and supporting me to navigate this research work towards completion.

Also, I would like to thank my colleagues from IIT Delhi, Ganesh S, Anchal Sharma, Swagatam, Gulshan Kumar, Gauri, Dr. Piyush Chanana and all my other friends from the Department of Design for their moral support and companionship during my PhD journey.

Sachin Tanwar
2016 DDZ 8478

ABSTRACT

Globally, over 43 million people are visually challenged (VC), and an estimated 295 million live with moderate to severe visual impairment, according to the World Health Organization. In India alone, there are more than 9 million VC individuals—the highest for any country. Despite growing smartphone penetration and advancements in assistive technologies like screen readers, visually challenged users continue to face significant usability challenges. Mobile apps are still largely designed for sighted users, often overlooking non-visual interaction needs. This research addresses that critical gap, aiming to promote digital equity through more inclusive, experience-driven design.

Despite advancements in digital accessibility standards, many mobile applications still struggle to provide equitable user experiences for visually challenged (VC) individuals. While compliance with accessibility guidelines such as WCAG 2.1 has improved, these standards often overlook the deeper usability challenges faced by non-visual users who rely on screen readers. This thesis addresses these gaps through a comprehensive series of studies involving over 100 participants. The research highlights significant disparities in usability between VC and sighted users, revealing that while apps may meet basic accessibility criteria, their interaction models often prioritize visual aesthetics and efficiency over accessibility for VC users. Ethnographic research and NASA TLX assessments provide deeper insights into the cognitive demands and usability challenges experienced by VC users, particularly in tasks like form filling and error management.

Based on these findings, the SEE (Sensory-Equitable Experience) Framework is developed—a co-design approach aimed at improving VC user comfort, confidence, and usability perception. Prototype testing validates the framework's effectiveness in enhancing the overall user experience for VC individuals. This thesis proposes a shift in perspective from mere technical compliance to a more inclusive and user-centred design approach. It advocates for mobile UX practices that consider diverse user needs and experiences, aiming to set new standards in digital accessibility and usability.

सारांश

विश्व स्वास्थ्य संगठन के अनुसार, दुनियाभर में 4.3 करोड़ लोग पूरी तरह नेत्रहीन हैं, और लगभग 29.5 करोड़ लोग मध्यम से गंभीर दृष्टिबाधा से ग्रस्त हैं। अकेले भारत में, 90 लाख से अधिक लोग नेत्रहीन हैं – जो किसी भी देश में सबसे अधिक है। हालांकि स्मार्टफोन की पहुंच और स्क्रीन रीडर जैसी सहायक तकनीकों में काफी प्रगति हुई है, फिर भी दृष्टिबाधित उपयोगकर्ताओं को उपयोगिता से जुड़ी गंभीर चुनौतियों का सामना करना पड़ता है। अधिकांश मोबाइल ऐप अब भी दृष्टिशाली उपयोगकर्ताओं को ध्यान में रखकर बनाए जाते हैं, जिससे नॉन-विज़ुअल इंटरफेस की ज़रूरतें अक्सर नज़रअंदाज़ हो जाती हैं। यह शोध इसी महत्वपूर्ण अंतर को संबोधित करता है, ताकि अधिक समावेशी और अनुभव-केंद्रित डिज़ाइन के ज़रिए डिजिटल समानता को बढ़ावा दिया जा सके।

हालांकि डिजिटल एक्सेसिबिलिटी के मानकों में काफी प्रगति हुई है, फिर भी कई मोबाइल एप्लिकेशन दृष्टिबाधित (VC) उपयोगकर्ताओं को समान अनुभव प्रदान करने में विफल रहते हैं। WCAG 2.1 जैसे एक्सेसिबिलिटी दिशानिर्देशों का पालन बढ़ा है, लेकिन ये मानक अक्सर उन गहरी उपयोगिता समस्याओं को नज़रअंदाज़ कर देते हैं जिनका सामना नॉन-विज़ुअल यूज़र्स–जो स्क्रीन रीडर पर निर्भर करते हैं–करते हैं।यह शोध श्रृंखलाबद्ध अध्ययनों के माध्यम से इन समस्याओं को उजागर करता है, जिसमें 100 से अधिक प्रतिभागियों को शामिल किया गया। अध्ययन से यह स्पष्ट हुआ कि जबकि कई ऐप्स तकनीकी रूप से एक्सेसिबल माने जा सकते हैं, उनकी डिज़ाइन प्राथमिकताएँ अक्सर विज़ुअल उपयोगकर्ताओं की कुशलता को केंद्र में रखती हैं और दृष्टिबाधित उपयोगकर्ताओं की जरूरतों की उपेक्षा करती हैं। एथ्नोग्राफिक अनुसंधान और NASA TLX मूल्यांकन के माध्यम से यह शोध उन कार्यों की पहचान करता है जिनमें VC उपयोगकर्ताओं को अत्यधिक मानसिक प्रयास, भ्रम और असुविधा होती है–जैसे कि फॉर्म भरना या त्रुटियों को पहचानना और उन्हें सुधारना।

इन निष्कर्षों के आधार पर SEE (Sensory-Equitable Experience) फ्रेमवर्क विकसित किया गया है, जो एक सह-डिज़ाइन दृष्टिकोण है जिसका उद्देश्य VC उपयोगकर्ताओं के अनुभव को बेहतर बनाना है। इस फ्रेमवर्क को प्रोटोटाइप परीक्षण के माध्यम से मान्य किया गया, जिसने इसके प्रभावी होने को साबित किया। यह शोध तकनीकी अनुपालन से आगे बढ़कर एक समावेशी और उपयोगकर्ता-केंद्रित डिज़ाइन पद्धति की ओर बदलाव का प्रस्ताव करता है। यह मोबाइल UX डिज़ाइन में विविध उपयोगकर्ताओं की जरूरतों को ध्यान में रखने की वकालत करता है और डिजिटल एक्सेसिबिलिटी और यूज़ेबिलिटी के क्षेत्र में नए मानक स्थापित करने का लक्ष्य रखता है।

Table of Contents

Page No.

Chapter 3

Chapter 5

Chapter 6

Chapter 7

Chapter 8

List of Figures

B. List of Tables

C. Key Words

To support non-specialist readers and ensure clarity, the following terms are defined:

- **ARIA** (Accessible Rich Internet Applications): A WAI specification that enhances accessibility of dynamic content by adding semantic information to HTML elements.

- **OCR** (Optical Character Recognition): Technology used to convert printed or handwritten text into machine-readable text. Useful in reading physical documents via screen readers.

- **NVDA** (NonVisual Desktop Access): A popular free screen reader for Windows (PC).

- **JAWS** (Job Access With Speech): A widely used commercial screen reader for Windows (PC).

- **TalkBack**: Android's built-in screen reader.

- **VoiceOver**: iOS screen reader for Apple devices.

- **Touch Target Size**: Minimum tappable area (typically 48dp by 48dp) ensuring accessibility for all users, including those with motor or vision impairments.

- **CSS pixel**: A relative unit of screen measurement in web design used to define dimensions and layouts.