

**STUDY OF INDEPENDENT TRAVEL NEEDS
OF PERSONS WITH BLINDNESS AND
ASSISTIVE TECHNOLOGY SOLUTIONS**

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OF PERSONS WITH BLINDNESS AND
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by

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Certificate

This is to certify that the thesis titled **Study of Independent Travel Needs of Persons with Blindness and Assistive Technology Solutions** being submitted by **PIYUSH CHANANA** for the award of **Doctor of Philosophy** in Amar Nath and Shashi Khosla School of Information Technology is a record of bonafide work carried out by him under our guidance and supervision at the Amar Nath and Shashi Khosla School of Information Technology. The work presented in this thesis has not been submitted elsewhere either in part or full, for the award of any other degree or diploma.

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Abstract

According to an estimate, there are 36 Million people with blindness globally, of which an estimated 5 Million people live in India. Among the persons with disability in India, nearly 1 in 5 has visual disability and nearly half of the population with blindness in India are uneducated. Lack of accessible infrastructure restricts their travel that in turn affects the education and employment prospects ultimately hampering the quality of life and often results in social exclusion and economic burden.

Assistive Technologies (ATs) for aiding independent travel have huge potential and can play a pivotal role in significantly improving the quality of life for persons with visual disabilities. Despite of significant research and development efforts to realize assistive devices, more than 90% of visually disabled population in India and in many parts of the world do not have access to appropriate AT solutions.

One of the reasons of limited success in adoption of assistive technologies is that many of these have come from developed countries and are designed keeping structured environments which exist in those countries. They often do not work in unstructured environments that exist in countries such as India. Affordability and access to these devices for people in India is another major reason for lack of their success. Another reason for abandonment of these devices is tendency to design and develop such aids on technical aspects with very limited or no focus on human dimension.

The present research is a first comprehensive attempt to study independent travel needs of persons with blindness in unstructured environments and is carried with an objective to identify assistive technology requirements to address these unmet needs. In the first part of the thesis, two major studies have been undertaken to understand present status of mobility and navigation characteristics of people with blindness as well as to capture their future requirements for independent mobility. The first part of the study focused on understanding the travel patterns of persons with blindness, challenges faced during travel and the strategies undertaken by them to overcome such challenges. The second part of the study concentrated on understanding their current use of assistive technology products and solutions, their preferences and their expectations from the future AT products and solutions.

White cane is the most widely used mobility aid in developing countries. However, a normal white cane can detect obstacles from ground to knee height and fails to detect obstacles from knee to head height. Negotiating obstacles from knee to head height may not be a major requirement for visually challenged people residing in structured environments but it certainly is a primary requirement for people residing in countries such as India. One of the mobility devices, which have been designed keeping these requirements of visually challenged people, is SmartCane. It is an electronic travel aid designed for negotiating obstacles and for path finding, which is also affordable. SmartCane is one of the first affordable devices that have some penetration in developing countries such as India. Two studies involving 30 users and 150 users were conducted to evaluate the efficacy of SmartCane device. Efficacy of this device in meeting user needs, expectations and aspirations has been studied as a part of the present research. The results show that SmartCane has been largely successful in meeting all user requirements.

Outdoor mobility not only demands negotiating obstacles along travel paths but also overcoming navigation challenges. Navigations applications such as Google maps etc. are used by sighted people but the same is not designed keeping all the navigation requirements of people with blindness. In this case, people require different landmarks than those used by sighted people and different interfaces than the ones that rely heavily on vision. Keeping this in mind a Navigation System for Persons with Blindness (NAVI) has been proposed.

In the subsequent part of the thesis, NAVI system has been built and implemented. User interface of NAVI is made completely accessible with TalkBack. Comparative study of NAVI with Google maps in terms of performance and overall user satisfaction is conducted. Results revealed that average time to complete the journey with Google maps was 20% more as compared to NAVI. Task success rate with NAVI was 78% and with Google maps, it was only 54%.

This research work carried out as a part of this thesis show that SmartCane effectively ensures detection and avoidance of obstacles and NAVI enables independent navigation to the desired destination. Their combination can address the travel related challenges for people with blindness residing in unstructured environments.

सारांश

एक अनुमान के अनुसार, विश्व स्तर पर 36 मिलियन लोग दृष्टि बाधित हैं, जिनमें से अनुमानित 5 मिलियन लोग भारत में रहते हैं। भारत में विकलांग व्यक्तियों में से 5 में से लगभग 1 में दृश्य विकलांगता है और भारत में दृष्टि बाधित लोगों की लगभग आधी आबादी अशिक्षित है। सुलभ बुनियादी ढांचे की कमी उनकी यात्रा को प्रतिबंधित करती है कि बदले में शिक्षा और रोजगार की संभावनाओं को अंततः जीवन की गुणवत्ता में बाधा आती है और अकसर जिसका परिणाम सामाजिक बहिष्कार और आर्थिक बोझ होता है।

स्वतंत्र यात्रा में सहायक असिस्टिव टेक्नॉलजी (सहायक प्रौद्योगिकियों) में अपार संभावनाएं हैं और यह दृष्टि बाधित व्यक्तियों के लिए जीवन की गुणवत्ता में काफी सुधार करने में महत्वपूर्ण भूमिका निभा सकती है। सहायक उपकरणों को साकार करने के लिए महत्वपूर्ण अनुसंधान और विकास प्रयासों के बावजूद, भारत और दुनिया के कई हिस्सों में 90% से अधिक नेत्रहीन आबादी के पास उपयुक्त असिस्टिव टेक्नॉलजी समाधान तक पहुंच नहीं है।

भारत में लोगों के लिए इन उपकरणों को अपनाने में सीमित सफलता और पहुँच का एक कारण यह है कि ज्यादातर टेक्नॉलजी विकसित देशों में बनी है और इन देशों में मौजूद संरचित वातावरण को ध्यान में रखते हुए डिजाइन की गई है। ये अकसर असंरचित वातावरण में काम नहीं करते हैं जो भारत जैसे देशों में मौजूद हैं। इन उपकरणों के परित्याग का एक और कारण मानव आयाम पर बहुत सीमित या कोई ध्यान नहीं देने के साथ तकनीकी पहलुओं पर इस तरह के उपकरणों को डिजाइन और विकसित करने की प्रवृत्ति है।

वर्तमान अनुसंधान असंरचित वातावरण में दृष्टि बाधित व्यक्तियों की स्वतंत्र यात्रा आवश्यकताओं का अध्ययन करने का पहला व्यापक प्रयास है और इन अपूर्ण आवश्यकताओं को पूरा करने के लिए सहायक प्रौद्योगिकी आवश्यकताओं की पहचान करने के उद्देश्य से किया गया है। थीसिस के पहले भाग में, दृष्टि बाधित लोगों की मोबिलिटी और नेवीगेशन की वर्तमान स्थिति को समझने के साथ-साथ स्वतंत्र गतिशीलता के लिए उनकी भविष्य की आवश्यकताओं को समझने के लिए दो प्रमुख अध्ययन किए गए हैं। अध्ययन का पहला भाग दृष्टि बाधित व्यक्तियों के यात्रा पैटर्न, यात्रा के दौरान आने वाली चुनौतियों और ऐसी चुनौतियों से उबरने के लिए उनके द्वारा शुरू की गई रणनीतियों को समझने पर केंद्रित था। अध्ययन के दूसरे भाग में सहायक प्रौद्योगिकी उत्पादों और समाधानों, उनकी प्राथमिकताओं और भविष्य में उत्पादों और समाधानों से उनकी अपेक्षाओं के अपने वर्तमान उपयोग को समझने पर ध्यान केंद्रित किया गया।

विकासशील देशों में दृष्टि बाधित लोगों के द्वारा मोबिलिटी उपकरण के तौर पर सफेद छड़ी का उपयोग सबसे अधिक किया जाता है। हालांकि, एक सामान्य सफेद छड़ी जमीन से घुटने की ऊंचाई तक की बाधाओं का

पता लगा सकता है परंतु यह घुटने से सिर की ऊंचाई तक बाधाओं का पता लगाने में नहीं होती। घुटने से सिर की ऊंचाई तक बाधाओं का पता ना चल पाना संरचित वातावरण में रहने वाले नेत्रहीन लोगों के लिए एक बड़ी आवश्यकता नहीं हो सकती है लेकिन यह निश्चित रूप से भारत जैसे देशों में रहने वाले लोगों के लिए एक प्राथमिक आवश्यकता है। स्मार्टकेन एक मोबिलिटी उपकरण है जिसे नेत्रहीन लोगों की इन आवश्यकताओं को ध्यान में रखते हुए डिजाइन किया गया है। यह एक किफायती इलेक्ट्रॉनिक मोबिलिटी उपकरण है जो रास्ते में आने वाली बाधाओं से बचाव और पथ खोजने के लिए डिज़ाइन की गई है। स्मार्टकेन पहले किफायती उपकरणों में से एक है जिसकी भारत जैसे विकासशील देशों में इस्तेमाल की जा रही है। स्मार्टकेन डिवाइस की प्रभावकारिता का मूल्यांकन करने के लिए 30 उपयोगकर्ताओं और 150 उपयोगकर्ताओं से जुड़े दो अध्ययन किए गए। वर्तमान शोध के एक भाग के रूप में उपयोगकर्ता की जरूरतों, अपेक्षाओं और आकांक्षाओं को पूरा करने में इस डिवाइस की प्रभावकारिता का अध्ययन किया गया है। परिणाम बताते हैं कि स्मार्टकेन सभी उपयोगकर्ता आवश्यकताओं को पूरा करने में काफी हद तक सफल रहा है।

आउटडोर मोबिलिटी में रास्ते में आने वाली बाधाओं से बचाव के साथ नेविगेशन की चुनौतियों पर पार पाना जरूरी होता है। गूगल मैप्स जैसी नेविगेशन ऐप्लिकेशन का ज्यादातर लोग उपयोग करते हैं, परंतु इसका निर्माण दृष्टि बाधित लोगों की आवश्यकताओं को ध्यान में रखकर नहीं किया गया है। दृष्टि बाधित लोग अलग तरह के स्थल चिन्ह और ऐप्लिकेशन इंटरफेस का इस्तेमाल करते हैं।

इसे ध्यान में रखते हुए दृष्टि बाधित व्यक्तियों के लिए एक नेविगेशन ऐप्लिकेशन का निर्माण किया गया है। थीसिस के बाद के हिस्से में नेविगेशन ऐप्लिकेशन का डिजाइन और परीक्षण किया गया है। इसका यूजर इंटरफेस टॉकबैक के साथ पूरी तरह से सुलभ बनाया गया है। नेविगेशन ऐप्लिकेशन के प्रदर्शन और यूजर संतुष्टि के लिए गूगल मैप्स के साथ तुलनात्मक अध्ययन किया है। नतीजों से पता चलता है कि गूगल मैप्स के साथ यात्रा पूरी करने का औसत समय नेविगेशन ऐप्लिकेशन (नवी) की तुलना में 20% अधिक था। नवी के साथ टास्क सक्सेस रेट 78% था और गूगल मैप्स के साथ यह सिर्फ 54% था।

इस थीसिस के एक हिस्से के रूप में किए गए इस शोध कार्य से पता चलता है कि स्मार्टकेन प्रभावी रूप से बाधाओं का पता लगाने और परिहार सुनिश्चित करता है और नवी वांछित गंतव्य के लिए स्वतंत्र नेविगेशन को सक्षम बनाता है। उनका संयोजन असंरचित वातावरण में रहने वाले अंधापन वाले लोगों के लिए यात्रा से संबंधित चुनौतियों का समाधान कर सकता है।

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Abbreviations

AT	Assistive Technology
ETA	Electronic Travel Aids
OSM	Open Street Maps
GPS	Global Positioning System
GIS	Global Information System
NAVI	Navigation System
NASA TLX	NASA Task Load Index
ASQ	After Scenario Questionnaire
PSSUQ	Post Session System Usability Questionnaire