# CHAPTER ONE

# INTRODUCTION

## Background to the Study

People with visual impairment face enormous limitations in terms of their mobility and in today’s world there is a lack of infrastructure to make it easier. The task of moving from one place to another is a difficult challenge that involves obstacle avoidance, staying on street walks, finding doors, knowing the current location, analyzing environment characteristics like footstep sounds or echoes, and keeping on track through the memorized course until the destination is reached. A system that assists navigation and orientation in real-time would be of great benefit to achieve this demanding task.

The World Health Organization estimates that there are 285 million visually impaired people worldwide, mainly in developing countries. Of this number, 39 million are totally blind. Africa accounts for 15% (i.e. 5.9 million) of this number. Visually impaired persons are defined as those with reduced visual capacity. They can be blind or partially sighted people. These conditions often limit people’s capabilities to perform common tasks and affect their quality of life. Blind people have signiﬁcant constraints in their everyday life, mainly with regard to their mobility. Though they are often able to learn speciﬁc routes (e.g., how to get to the nearest shop or station), this ability

is far from the desirable independence in navigation. Mobility has been deﬁned by Foulke as: “*The ability to travel safely, comfortably, gracefully and independently through the environment*” (Foulke, 1997). This concept, when applied to blind travelers or the visually impaired person, implies that they must be able to detect the obstacles which are located on their walking path, to avoid them and to succeed in following their route.

All these goals could be achieved by relying on accessory devices which facilitate the navigation, known as Electronic Travel Aids (ETAs). ETAs include electronic intelligent devices whose main objective is to overcome human constraints, perceiving the surrounding environment and presenting it to the blind user through tactile, vibrations, speech or acoustic senses.

Currently, there is several visual information that helps visually enabled people to move in a right way (e.g. takes a right direction, avoid obstacles, choose the shortest path to a destination). Text information and arrow indications are frequently used; however, this information is inaccessible to visually impaired people. Often blind people are unintended withdrawn from the society with the lack of an alternative path for information. Based on this real context we focused our work on developing assisting technologies that may help blind people by bringing them back to the society.

In order to improve the quality of life for visual impaired people, in this work we focused on new technologies to help those persons in the access of public buildings (i.e. lecture halls, halls of residence, offices, etc.), roads and paths and public amenities available on campus. Therefore, this work intends to play a special role in this field by providing as much visual information as possible for visually impaired people, allowing them to take a comfortable navigation (e.g. short paths, turns, etc).

To build a prototype focused on users and their interests, we are developing this study in close partnership with the association of blind and partially sighted people on campus while focusing on ease of use and deployment.

## Statement of Problem

Visual impairment poses significant challenges to individuals in their daily lives, particularly when it comes to navigation and mobility. People with visual impairments encounter obstacles, both indoors and outdoors, that hinder their independence and safety. The existing solutions are often limited or cumbersome, necessitating innovative approaches to enhance navigation for this population.

The key challenges and limitations that were identified with existing solutions that necessitated this improvement includes but not limited to:

1. Users of those devices struggle to detect curves, steps and low-hanging branches.
2. Existing solutions may cover a broader scope and hence their accuracy and efficiency are reduced.
3. Navigating unfamiliar indoor spaces remain challenging.
4. Issues with affordability and accessibility.
5. User-friendly interfaces.

Although these previous solutions have contributed immensely to address a larger portion of the problem, however, the unsolved portion still needs to be addressed to complete the puzzle.

## Research Questions

1. What innovative approaches can enhance obstacle detection for visually impaired users?
2. What sensor fusion techniques (e.g., combining GPS, LiDAR, and inertial sensors) yield the best results?
3. How do different environmental conditions (e.g., indoor vs. outdoor) impact navigation accuracy?
4. What are the preferred interaction modalities for visually impaired users (e.g., voice commands, gestures, tactile feedback)?
5. How can we develop affordable solutions that cater to diverse socioeconomic backgrounds?
6. How can we actively engage visually impaired individuals, mobility trainers, and rehabilitation experts in the design process?
7. How can we improve the accuracy of navigation devices for visually impaired individuals?
8. What sensor fusion techniques (e.g., combining GPS, LiDAR, and inertial sensors) yield the best results?

## Objectives

1. Develop innovative navigation device by exploring novel technologies (e.g., wearable devices, smartphone apps) that enhance navigation accuracy and reliability.
2. Study user preferences and usability to design intuitive interfaces.
3. Engage visually impaired individuals, mobility trainers, and rehabilitation experts.
4. Co-create solutions that address real-world challenges.
5. Evaluate the effectiveness of voice commands, gestures, and tactile feedback.

## Purpose of the study

The successful development and implementation of Vision Aid will empower visually impaired individuals, granting them greater autonomy, safety, and confidence in their daily lives. By addressing the stated challenges, we aim to bridge the gap between existing solutions and the evolving needs of this community.

In this critical field of research, we seek to collaborate with stakeholders, perform rigorous testing of the system, center the design and implementation around the users to create a robust, cost-effective and user-friendly device to solve this global situation. One important requirement is ease deployment and usage, in other words the developed system and support application (software) must be able to be used with much ease and low-cost hardware by visual impaired persons. Generally speaking, this study is intended to contribute for the enhancement and independence of visually impaired people in society, as well as their inclusion and participation.

## Significance of the study

1. Enhancing Quality of Life: Our research aims to create practical solutions that empower visually impaired individuals, allowing them to navigate their surroundings confidently. We enhance their quality of life by addressing mobility challenges and promoting independence.
2. Ensuring Safety and Autonomy: Our navigation devices prevent accidents by detecting obstacles and providing real-time guidance. We also empower visually impaired individuals to participate actively in society, granting them greater autonomy.
3. Contributing to a Global Need: Visual impairment affects millions worldwide, especially with aging populations. Our study directly contributes to the pressing global need for accessible and effective navigation tools.
4. Driving Innovation and Technology: We explore novel technologies (e.g., wearable devices, smartphone apps) to improve navigation accuracy and reliability. Our work advances assistive technologies, benefiting the visually impaired community.
5. Advocating for Inclusivity and Awareness: By addressing the challenges faced by visually impaired individuals, we raise awareness about their needs. Our advocacy promotes accessible design and inclusive policies.

## Limitations of the study

1. While our research yields valuable insights, applying the results universally may be challenging. We considered the specific context (e.g. the university environment) when interpreting findings.
2. Technological Constraints: The effectiveness of navigation devices depends on available technology. Limitations in sensor accuracy, battery life, or connectivity may impact real-world usability.
3. Long-term Adoption: Even with successful prototypes, long-term adoption by visually impaired users remains uncertain. Factors such as cost, maintenance, and user acceptance may play a key role in its acceptance.
4. Environmental Variability: Navigation challenges differ based on the environment (indoors, outdoors, crowded spaces). Solutions may need customization for specific contexts.
5. Sample Size and Diversity: Our findings may be limited by the size and diversity of the participant pool. We need to ensure representation across various age groups, visual impairment levels, and cultural backgrounds.