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THEME

Smart stick for visually impaired people "SmartV"

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Dedication

I dedicate this work to my family, whose unwavering encouragement and support have served as my compass throughout my academic career. I have the power to overcome obstacles and pursue my dreams because you believe in me. I appreciate you being there for me constantly, having faith in my competence, and motivating me to achieve more. This achievement is equally yours and mine.

I also want to express my sincere gratitude to my professors and mentors who have helped me on this learning and development journey. Your knowledge, advice, and love of learning have shaped my academic career and motivated me to achieve success.

Thank you to my friends and classmates for the countless study sessions, jokes, and encouragement. This journey has been made memorable and enjoyable by your friendship. Together, we have overcome obstacles, and I am appreciative of the friendship we have developed.

Last but not least, I dedicate this project to everyone who has persevered despite facing similar challenges and setbacks. May this work serve as a reminder that we can achieve our goals and have a significant impact in the fields we choose if we persevere, are determined, and have a strong network of supporters.

This project is dedicated to everyone who has, directly or indirectly, contributed to my educational journey. Your confidence in me has strengthened my resolve, and I am grateful for your presence in my life. Thank you all for being an integral part of my project and for your unwavering support.

Bouchra

Dedication

I would like to express my deepest gratitude and appreciation to my family, whose constant encouragement and unwavering support have been instrumental in my academic journey. Your belief in my abilities has been a driving force behind my accomplishments. I am truly grateful for your presence in my life.

I also want to express my sincere gratitude to my professors and mentors who have helped me on this learning and development journey. Your knowledge, advice, and love of learning have shaped my academic career and motivated me to achieve success.

To my friends and classmates, thank you for the countless hours of collaboration, laughter, and support. Your friendship has made this journey memorable and enjoyable, and I am grateful for the bonds we have formed. Furthermore, I would like to dedicate this project to all those who have faced challenges and setbacks along their own paths. Your perseverance and determination serve as an inspiration to never give up on our dreams. May this project stand as a testament to our collective resilience and the impact we can make when we support one another.

Lastly, I want to express my deep appreciation to everyone who has contributed, directly or indirectly, to my educational journey. Your confidence in me has strengthened my resolve and played a significant role in the completion of this project. Thank you all for being an integral part of my journey and for your unwavering support.

Anfal

Abstract

This document presents the design and development of a smart stick specifically designed to assist visually impaired individuals in their daily lives. The stick integrates a range of advanced features, including ultrasonic sensors, a high-resolution camera, and a water sensor, all powered by a Jetson Nano and a reliable battery system. Additional components, such as a speaker and a vibrator, enhance the functionality and usability of the device.

By reviewing existing works on smart sticks for the visually impaired, this document proposes a new design that prioritizes affordability, lightweight construction, and universal accessibility. The smart stick aims to address the diverse needs of blind individuals, empowering them to navigate their surroundings safely and with increased independence.

One of the key aspects discussed in this document is the choice of Python as the primary programming language for coding the smart stick. Leveraging the versatility and simplicity of Python, the smart stick can provide accurate obstacle detection and alert the user through a combination of auditory and tactile feedback.

The integration of ultrasonic sensors enables the stick to detect obstacles within a certain range, while the camera captures real-time visual information to enhance the user's situational awareness. The water sensor ensures that the device remains functional even in adverse weather conditions, preventing damage caused by exposure to moisture.

ملخص

هذه الوثيقة تقدم تصميم و تطوير لعصا ذكية مصممة لمساعدة الاشخاص ذوي الاعاقة البصرية في حياتهم اليومية تتضمن العصا مجموعة من الميزات المتقدمة بما في ذلك حساسات فوق الصوتية , و كاميرا عالية الدقة , ومستشعر للماء , و ذلك بلاعتماد على نظام جيتسون نانو و نظام بطارية موثوق , حيث تعزز المكونات الاضافية مثل مكبر الصوت و الهزاز من وظائف و سهولة استخدام الجهاز.

من خلال مراجعة الاعمال الموجودة حول العصي الذكية للاشخاص ذوي الاعاقة البصرية ,نقدم تصميما جديدا يولي الاولوية للتكلفة المعقولة و الوزن الخفيف و الامكانية العالية للوصول .تهدف العصا الذكية الى تلبية الاحتياجات المتنوعة للمستخدم لتمكينه من التنقل بامان في محيطه و زيادة استقلاليتة.

احد الجوانب الرئيسية في الوثيقة هو استخدام بيثون كلغة برمجة رئيسية لبرمجة العصا الذكية ,من خلال استغلال مرونة و بساطة بيثون ,يمكن للعصا توفير كشف دقيق للعوائق و اعلام المستخدم من خلال مزيج من المخارج السمعية و اللمسية .

تمكن الحساسات الفوق الصوتية العصا من اكتشاف العوائق في نطاق معين ,بينما تلتقط الكاميرا معلومات بصرية في الوقت الحقيقي لتعزيز وعي المستخدم بلموقف .

Résumé

Ce document présente la conception et le développement d'une canne intelligente spécialement conçue pour aider les personnes malvoyantes dans leur vie quotidienne. La canne intègre une gamme de fonctionnalités avancées, notamment des capteurs ultrasoniques, une caméra haute résolution et un capteur d'eau, le tout alimenté par un Jetson Nano et un système de batterie fiable. Des composants supplémentaires, tels qu'un haut-parleur et un vibreur, améliorent la fonctionnalité et la convivialité de l'appareil.

En examinant les travaux existants sur les cannes intelligentes pour les personnes malvoyantes, ce document propose une nouvelle conception qui privilégie l'abordabilité, la légèreté et l'accessibilité universelle. La canne intelligente vise à répondre aux besoins diversifiés des personnes aveugles, en leur permettant de se déplacer en toute sécurité et avec une plus grande autonomie dans leur environnement.

L'un des aspects clés discutés dans ce document est le choix de Python comme langage de programmation principal pour coder la canne intelligente. En exploitant la polyvalence et la simplicité de Python, la canne intelligente peut fournir une détection précise des obstacles et alerter l'utilisateur grâce à une combinaison de rétroaction auditive et tactile.

L'intégration des capteurs ultrasoniques permet à la canne de détecter les obstacles dans une certaine plage, tandis que la caméra capture des informations visuelles en temps réel pour améliorer la conscience situationnelle de l'utilisateur. Le capteur d'eau garantit que l'appareil reste fonctionnel même dans des conditions météorologiques défavorables, en évitant les dommages causés par l'exposition à l'humidité.

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Abbreviations list

IoT Internet of Things

SMS Short Message Service

GPS Global Positioning System

GSM Global System for Mobile Communications

BVIP Blind and Visually Impaired People

mAh milliampere-hour

PIC Peripheral Interface Controller

intel galileo use the second generation

ATmega328 is a type of microcontroller chip that is used in the Arduino Uno board.

Chapter 1

Introduction

1.1 Context

The smart cane is used as an aid for the visually impaired it acts as an alternative to the ordinary white cane, whose function is to recognize the path and avoid collisions with objects during movement by moving it forward and sideways. as well as a means of drawing people's attention to the fact that the holder of this cane is blind to those who wish to volunteer to help him and to warn the drivers of the vehicles to be careful, and they are generally alloy or plastic Smart Sticks work just like regular sticks, plus a range of advanced features aimed at making life easier for the user and helping them to better and more effectively integrate with the outside world. It also aims to reduce the problems that the user may encounter when using a regular cane.

The individuals using this cane are visually impaired, meaning that a person's vision is reduced (impaired) to the point where it cannot be corrected to a normal level. As a result, a complete correction with the help of glasses, contact lenses, medication or eye surgery is not possible [1].

According to World Health Organization statistics, in 2020 it is estimated that between 40 and 45 million people worldwide are blind and 135 million are visually impaired [2].

1.2 Problem and motivation

Coping with vision loss or visual impairment presents numerous challenges for individuals in their daily lives. The traditional white cane, which has long served as a symbol of independence for the visually impaired, is no longer sufficient to address the complex requirements and solve the multitude of problems faced. As the world continues to progress, the integration of technology has become imperative in assisting individuals with visual impairments.

Among the primary challenges encountered by individuals with visual impairments are the accessibility of information, as vision is not their primary sensory organ. Furthermore, well-intentioned but overly helpful individuals, whether strangers, friends, or family members, often exhibit excessive enthusiasm in assisting visually impaired individuals. This can result in social stigma and unintended accidents arising from the disparity between a sighted world and blindness. Securing and maintaining employment also becomes challenging due to limited job opportunities. Additionally, recreational activities and accessibility remain significant obstacles for the blind or partially sighted population. Consequently, individuals with visual impairments frequently experience isolation due to these multifaceted challenges [3].

In an attempt to address these issues, various products have emerged as potential alternatives to the white cane. However, these products also present their own set of challenges. Firstly, the advanced technology incorporated into many of these products leads to a high cost, making them inaccessible for a significant portion of the visually impaired community. Additionally, most of these products fail to significantly enhance the performance of traditional canes, resulting in limited efficiency and minimal tangible benefits when compared to their costlier counterparts.

These challenges highlight the need for innovative solutions that not only overcome the limitations of traditional canes but also offer cost-effective alternatives. By leveraging advancements in technology and design, it is possible to develop products that are affordable, efficient, and truly enhance the lives of visually impaired individuals. Addressing these concerns and developing inclusive solutions can have a profound impact on empowering individuals with visual impairments, promoting social integration, and enabling them to lead fulfilling lives.

1.3 Objectifs

Our goals in developing a smart stick for people with visual impairments are concentrated on particular areas:

Enhanced Accessibility: Our main goal is to make it possible for people who are visually impaired to access and engage with the environment. Our goal is to create a smart cane that makes it easier for users to navigate their surroundings safely and effectively.

Promoting Independence: In order to empower people who are blind or visually impaired, we want to make it possible for them to go about their daily lives more easily and without the need for constant assistance. Their independence should be increased by the smart stick's functionality.

Providing Safety: We place the utmost importance on safety. In order to prevent accidents and injuries, we work to develop a smart stick with features that assist visually impaired people in avoiding hazards and obstacles.

Empowerment: Our goal is to create a smart cane that gives people who are blind or visually impaired a sense of control over their lives. It ought to offer capabilities that help users complete tasks, interact with others, and confidently navigate their surroundings.

Promoting Social Integration: We want to help visually impaired people become more integrated into society. The smart stick will make it simple to communicate with others and increase social interaction.

In conclusion, our goals in developing a smart stick for people who are blind or visually impaired are to enhance their quality of life, promote independence, and give them confidence in interacting with their environment.

1.4 Organization of the manuscript

The first chapter sheds light on the daily challenges faced by individuals with visual impairments and the limitations of using a traditional white cane. Building upon this understanding, we move on to the second chapter, where we undertake an extensive study and analysis of various works published between 2018 and 2023. Our primary aim is to delve into the existing literature, extracting essential in-

sights and findings that contribute to the advancement of knowledge in our field of study. Through a meticulous examination of scholarly publications and research papers within the specified timeframe, we have gathered valuable information, enriching the existing knowledge base.

In the third chapter, our focus shifts to the design and manufacturing process of the "SmartV" stick. Here, we delve into the intricate technical details, stages, components, and added features that distinguish our stick from previous studies. To ensure a comprehensive analysis, we carefully study and leverage the results obtained in the preceding chapters, incorporating them into the conceptualization, prototyping, testing, and refinement phases of our design process. Every component has been meticulously selected to optimize performance and durability.

What sets our SmartV stick apart is the incorporation of cutting-edge features, making it a truly innovative solution in the realm of assistive technologies for the visually impaired. By integrating advanced functionalities and technologies, we aim to address the specific needs and challenges faced by visually impaired individuals. Our stick goes beyond the limitations of traditional canes, providing enhanced capabilities and features that significantly improve their daily lives. As we continue to push the boundaries of innovation in this field, our SmartV stick emerges as a transformative tool, empowering individuals with visual impairments to navigate the world with greater confidence and independence.

Chapter 2

The state-of-the-art

2.1 Introduction

This chapter will give a thorough overview of the most recent developments in smart stick technology for those who are blind or visually impaired. The chapter will go through the solutions that have been suggested as well as the design, creation, and testing of IoT-enabled smart sticks for individuals who are blind. Different sensors included into the smart stick can identify impediments and inform the user in a variety of ways, including beeps and audio alarms. A survey of the literature on various efforts on assistive technology for the blind will also be included in this chapter. The chapter's goal is to give a summary of the most recent developments in smart stick technology and how they could aid blind people in completing activities in a world that is built for sighted people. The Kitchenham approach will be used in this chapter to provide a methodical .

2.2 taxonomy of existing works

In order to understand the current state of research and development in the field of smart sticks and canes for visually impaired individuals, a comprehensive search was conducted on popular academic platforms, namely Google Scholar and Semantic Scholar. The purpose of this search was to identify relevant literature and gather valuable insights into the existing body of work

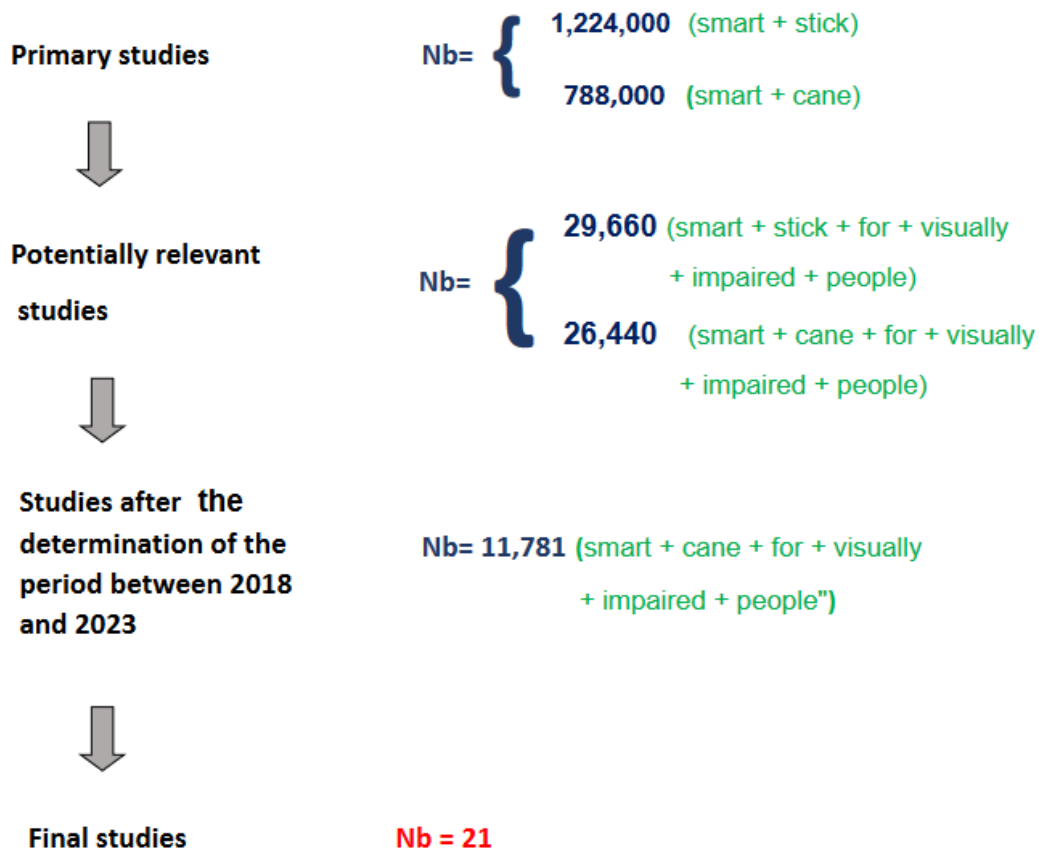


Figure 2.1: The selection procedure

figure 2.1 present an illustration of the selection process employed for the studies, wherein duplicate studies were eliminated during the stage of potentially relevant studies.

2.3 Review the existing works from 2018 to 2023

Prior to reviewing previous research on smart sticks for the blind, it is important to recognize the importance of these assistive technologies. Smart sticks have become popular as ground-breaking remedies designed to increase the independence and mobility of people with visual impairments. These tools feature cutting-edge sensors, navigational systems, and feedback mechanisms to help users avoid obstacles, move through unfamiliar environments, and gain a better overall sense of space. We can learn more about the efficacy, usability, and limitations of smart sticks as well as potential areas for future development and customization to better meet the unique needs of people who are visually impaired by reviewing the body of research and innovations that have already been made in this field.

This review aims to contribute to the ongoing efforts in creating inclusive technologies that empower and enhance the quality of life for individuals with visual impairments.

2.3.1 Smart Cane for Blind Person Assisted with Android Application and Save Our Souls Transmission (2018)

The Smart Cane is produced using ultrasonic sensors that can identify obstacles in the path of the user. The cane is interfaced with an Android application that provides voice call or SMS to a predefined number in case of an emergency. Additionally, people will get notified as Facebook status updated with emergency alert. The device also provides a flashlight feature which illuminates automatically while walking in public place during night time [4]

2.3.2 A Smart Cane to Help the Blind People Walk Confidently (2018)

The smart cane is equipped with an ultrasonic sensor that can detect obstacles or holes in front of the user. It warns the user about their presence through a buzzer beep. The system can also sense the environment for the blind person, serving as a third eye. The article does not provide detailed information on the physical design of the cane, but it emphasizes its usefulness as a tool for visually impaired

individuals to walk confidently.[5]

2.3.3 An Intelligent Walking Stick for the Visually Challenged People (2018)

the proposed walking stick is an electrical and electronics-based project interface with an Android-based application designed for visually challenged people. The walking stick is Raspberry Pi and PIC-based, with low power consumption. When the switch is turned on, it will start power supplying to Raspberry Pi, thus all the other components connected to the stick also get power. The stick has sensors like Ultrasonic and other supportive sensors along with GPS to guide visually challenged people in guiding their path as well as giving information about their location. Therefore, the smart stick is designed to help visually challenged people navigate safely and independently by providing them with real-time location information and obstacle detection capabilities.[6]

2.3.4 Smart Cane Based on IoT (2019)

The Smart Cane is designed to help blind individuals navigate their surroundings more easily. It incorporates GPS technology, ultrasonic sensors, and a buzzer to detect obstacles and provide directions. The coding used to make this IOT is C++, and it was created using a software called Arduino IDE. The Smart Cane starts construction by recycling items, making it an eco-friendly option. the project has two modules: one for distortion between barriers and sound and vibrations, and another that uses GPS with GSM to monitor the blind from harm.[7]

2.3.5 Face recognition smart cane using haar-like features and eigenfaces (2019)

The smart cane is a portable and wearable addition feature that can recognize faces and give information about the recognized face in the form of sound using a processing device Raspberry Pi. The system uses Haar-Like features and Eigenfaces for face recognition. Raspberry Pi is used as a processor to produce a portable device, and it supports portability that affects the delay and computing speed of

face recognition algorithms. The utilization of Raspi camera on the eyeglasses is for wearable purposes.[8]

2.3.6 IRJET- Smart Cane for Blind People Using IoT(2019)

The IRJET-Smart Cane for Blind People Using IoT is a project that aims to provide a safer and more convenient way for the blind to navigate their surroundings. The smart cane is designed to be a complete guide for blind people to walk with the help of a single stick without any complex hardware or software incorporated into it. The smart cane uses distance calculation to give the optimum direction (by detecting obstacles) in which the person can proceed. It is not just used to detect obstacles present in any direction and alert the person, but also provides guidance on the best path forward.[9]

2.3.7 Smart Cane for Visually Impaired with Obstacle, Water Detection and GPS (2020)

The Smart Cane for Visually Impaired individuals is designed with obstacle detection, water detection, and GPS capabilities. The cane is equipped with ultrasonic sensors and an Arduino microcontroller to detect obstacles and water puddles. The GPS location tracker allows the location of the cane to be determined via the Blynk App. This unique design provides visually impaired individuals with more information about their surroundings, making it easier for them to navigate unfamiliar areas.[10]

2.3.8 Intelligent Walking Stick for Blind People Using Arduino (2020)

The smart electronic walking stick for blind people is designed to provide a sense of vision by detecting obstacles and objects around the user. It uses an ultrasonic sensor to measure the distance between the user and any objects or obstacles in their path. When an obstacle is detected, a buzzer will alarm the user. The walking stick is light in weight and portable, providing the best travel aid for the person. The main aim of the system is to provide a safe and efficient environment

for visually impaired individuals to move independently without assistance from others.[11]

2.3.9 An Android-based Portable Smart Cane for Visually Impaired People (2021)

the smart blind stick is designed for blind people to improve navigation. It can identify multiple obstacles in the path using a water sensor, ultrasonic sensor, RF module, and GPS-GSM module installed in it. The stick then passes on this information as vibrations to notify the user about hurdles on the way.[12]

2.3.10 Development of a smart walking stick for visually impaired people (2021)

the stick is made with carbon material which reduces its weight and makes it flexible to use. The stick has been enhanced with advanced technology to help users navigate their surroundings. The technology integrated into the walking stick includes an ultrasonic sensor, a vibration motor, and a voice output system. The ultrasonic sensor detects obstacles in front of the user and sends signals to the vibration motor, which vibrates to alert the user of potential obstacles. Additionally, the voice output system can provide audio alerts to help users distinguish between different types of obstacles.[13]

2.3.11 Raspberry Pi based smart walking stick for visually impaired person (2022)

The Smart Blind Stick is designed to aid visually impaired individuals in navigating their surroundings with ease. It contains sensors and cameras that can identify obstructions and offer audio feedback to the user, helping to prevent accidents. The stick is similar in appearance to a traditional walking stick, but it offers additional features that can protect users from injury.[14]

2.3.12 'Magic Cane' for Mobility of the Blind (2022)

The design of the smart cane is divided into two parts: designing hardware in the form of electronic components and designing software using the C language Arduino IDE application. The expected feature of the tool to be designed is that the smart cane is able to automatically notify several conditions in front of the user, such as there are objects/people, there are potholes, there is fire/residual heat from burning on the road, and there is a puddle of water, through the media of human voice that informs the user.[15]

2.3.13 An IoT Machine Learning-Based Mobile Sensors Unit for Visually Impaired People (2022)

an IoT-based blind stick system designed to guide visually impaired individuals. The smart cane consists of a mobile sensor unit that can be attached to an off-the-shelf cane to collect information about the cane user and the surrounding area and deliver alarms to the cane user during navigation and to the guardian in case of emergency. The sensors used include a digital motion sensor, six-axis accelerometer/gyro, US sensors, GPS sensor, and a camera, which are all interfaced with a single-board microcomputer. A deep learning technique is used to classify captured images and inform the user through an audio output. The system also has three US sensors to detect incoming collisions and an accelerator to detect sudden changes in motion.[16]

2.3.14 The 2SEES white cane: concept and experiments (2018)

The Smart Explorer Environment Stick (SEES) is an object connected to the internet that combines mobility assistance features that are often separated in other devices. To limit the cost of the system, some tasks are performed by a smartphone, and low-cost sensors are used for data collection. The SEES prototype allowed experimentation and progress towards a more advanced concept, the "2SEES". The 2SEES is an improvement on the first SEES, with a focus on robustness. More information about the design and features of the 2SEES.[17]

2.3.15 Smart Cane: A Low Cost Assistive Device for the Visually Impaired (2023)

The smart cane is a low-cost assistive device for the visually impaired. It is designed to be affordable to individuals in all nations, developed, developing, and impoverished. The smart cane has multiple sensors that take data input and send it to the microcontroller for analysis. Based on the data, the microcontroller gives output to its user through voice output, a buzzer, and a vibration motor. The essential features of the smart cane are organized around affordability and assisting visually impaired persons in becoming more self-sufficient. The hardware elements of the smart cane are cut-rate products, making it an affordable alternative to commercial canes that can cost hundreds of dollars more.[18]

2.3.16 MEDICAL ELECTRONICS BASED SMART SHOE FOR BLIND PEOPLE (2023)

The smart shoe for blind people is designed to help them navigate their surroundings more safely and independently. The shoe contains sensors that can detect obstacles in the environment, and a vibrator that provides feedback to the wearer about the location and proximity of these obstacles. This technology can be used as both a safety device and a navigation aid, allowing visually impaired individuals to travel more confidently and with greater ease.[19]

2.3.17 Smart real-time wearable navigation support system for BVIP (2022)

The proposed system is composed of three main components: A ROS-based embedded controller, an eyeglass frame containing three ultrasonic sensors with the related vibrator modules for obstacle detection, and a similar accessory that can be worn in the hand for ramp and up-down barriers detection. The vibrator modules are used as tactile interfaces that stimulate the plantar surface with vibrations. Therefore, this work offers an affordable guidance system for the BVIP to assist them in walking in indoor and outdoor surroundings.[20]

2.3.18 Study and realization of a smart cane for people suffering from visual blindness (2019)

The smart cane proposed in this document is designed to help visually impaired individuals navigate their surroundings more easily. It is equipped with sensors that can detect obstacles in the user's path and provide haptic feedback to alert them of potential hazards. The smart cane also features Bluetooth technology, which allows it to connect to a smartphone application that provides additional information about the user's surroundings, such as nearby points of interest and directions to their destination. [21]

2.3.19 Study and realization of a smart glove for the visually impaired (2020)

The smart glove developed is designed to help visually impaired individuals navigate through unfamiliar environments by detecting and recognizing objects around them. The glove is equipped with ultrasonic sensors and a Raspberry Pi camera, which work together to detect obstacles and identify objects. The data obtained by the sensors is sent to an Android application via Bluetooth, which announces the results to the user. The glove also features a wristband that indicates its position to the wearer, making it more convenient than other gloves.[22]

2.3.20 DeepNAVI: A deep learning-based smartphone navigation assistant for people with visual impairments (2023)

DeepNAVI is a smartphone-based navigation assistant that leverages deep learning competence. It uses deep learning models for obstacle detection and scene recognition, and can provide detailed information about the various attributes of obstacles, such as distance to the user, position, and motion status (stationary or moving). DeepNAVI has onboard trained deep learning models which do not require internet connectivity to process information. What differentiates DeepNAVI is its design which gives importance to both technical and usability factors. It is designed to be portable and convenient to use without much training, providing

users with detailed information about the obstacle types that can be detected, which is essential to make informed decisions when navigating in real-time.[23]

2.3.21 Electronic Smart Canes for Visually Impaired People (2018)

The document mentions several smart canes that have been developed for visually impaired people. One of the most significant smart canes is the Smart Cane, which was originally presented by Central Michigan University's students. The Smart Cane is a portable device equipped with ultrasonic sensors, microcontroller, vibrator, buzzer, and water detector to guide visually-impaired people. Another smart cane mentioned in the document is the Ultracane, which uses ultrasound to detect obstacles and provide haptic feedback to the user. The WeWALK smart cane is also discussed in the document, which has a built-in speaker and voice assistant that can provide navigation assistance and connect to smartphones via Bluetooth. Finally, the document mentions the Laser Cane, which uses laser technology to detect obstacles and provide feedback to users through vibration or sound.[25]

2.4 Evaluation metrics

In this section, Table 2.1 presents an overview of the features of the devices/-patents available smart canes designed for individuals with visual impairments. The characteristics used for categorizing these canes are described and explained below :

h5-index: The h5-index of a journal is a measure of its quality based on articles published in the last 5 complete years. It can be calculated using data from Web of Science, Scopus, or Google Scholar. Similar to the impact factor, the journal h5-index is not influenced by varying citation practices across different fields. It is most useful for comparing journals within the same field.

Journal IF: The Impact Factor (IF) represents the IF value of the journal where the article about the device was published.

Coverage: The device can be used outdoors, indoors, or both (outdoor/indoor).

Time: The device can be used during the day, night, or both (day/night).

Range (meters): This indicates the maximum distance, in meters, at which the device can detect obstacles in front of it.

Connection Type: This field specifies the type of connection required for the device, such as Wi-Fi, Bluetooth, etc.

Cost: The cost of the device.

User Interface: This field describes how the user interacts with the device. It also includes the capability of sending messages to others through GSM technology whenever possible.

Environment Interface: This indicates how the devices or technologies used for obstacle detection interact with the environment, such as through ultrasonic or radio waves, IR spectrum, etc.

Obstacle Detection: This field specifies the devices or technologies utilized for detecting objects, including sensors, cameras, RFID, etc.

Navigation Tracking System: This describes the type of navigation and tracking system used.

Sensors: This field indicates the type of sensors employed.

Microcontroller: This field specifies the type of microcontroller embedded in the device.

Table 2.1: Characteristics of existing devices / patents

device	H5-index	Journal If	Coverage	time	Range (meters)	Connection type	cost	User interface	Environment interface	Obstacle detection	Navigation & Tracking system	sensors	microcontroller
article 1 [4]	-	-	Outdoor/indoor	day/night	N/A	Online	N/A	Vibration Speaker headphone	Ultrasonic waves	Ultrasonic Sensors	-	Ultrasonic Sensors	PIC16F877A
article 2 [5]	-	-	Outdoor	N/A	4,5m	Online	N/A	Speaker Buzzer	Ultrasonic waves	Ultrasonic Sensors Usb web camera	-	Ultrasonic Sensors	VS1003B MP3 Decode module Intel Galileo Gen2 Board
article 3 [6]	-	-	Outdoor	N/A	N/A	Offline/online	N/A	Vibration	Ultrasonic waves	Ultrasonic Sensors	GPS	Ultrasonic sensor Water Sensor	Raspberry Pi PIC18F4525
article 4[7]	-	-	Outdoor	N/A	N/A	Online	N/A	Vibrator Buzzer	Ultrasonic waves	Ultrasonic Sensors	GSM-GPS	Ultrasonic sensor	Arduino-Uno R3
article 5[8]	-	-	Outdoor	N/A	N/A	offline	N/A	earphones	-	camera	-	-	Raspberry Pi
article 6 [9]	-	-	outdoor	N/A	N/A	online	N/A	voice or audio	Ultrasonic waves	Ultrasonic Sensors	GPS	Ultrasonic Sensors with SONAR	Arduino-Uno
article 7[10]	-	-	outdoor	N/A	50cm	online	N/A	Buzzer Blynk application	Ultrasonic waves	Ultrasonic senso Water sensor	GPS	Ultrasonic senso Water sensor	ESP8266
article 8 [11]	-	-	outdoor	N/A	N/A	offline	N/A	Buzzer	Ultrasonic waves	Ultrasonic senso HC-SR04	-	Ultrasonic senso HC-SR04 LDR Sensor	Arduino-Uno

devise	H5-index	Journal lf	Coverage	time	Range (meters)	Connection type	cost	User interface	Environment interface	Obstacle detection	Navigation & Tracking system	sensors	microcontroller
article 9 [12]	-	-	outdoor	N/A	N/A	Online/ Offline	N/A	Buzzer SMS button Call Button Google Map Button Help button ANDROID APPLICA- TIO	Ultrasonic Waves	Ultrasonic senso	GPS/ GSM	Ultrasonic senso	Arduino- NANO
article 10 [13]	-	-	outdoor	N/A	50 cm	offline	N/A	Buzzer	Ultrasonic Wave	Ultrasonic sensor	-	Ultrasonic sensor	Atmega 328
article 11 [14]	-	-	N/A	day	N/A	online	high	Microphone buzzer raspberry pi cam	Microphone buzzer raspberry pi cam usb to ttl raspbian os tensor flow and keras	Ultrasonic waves	GPS - GSM	Ultrasonic infrared sensors	Raspberrry pi
article 12 [15]	-	-	outdoor	Day	N/A	offline	N/A	speaker	Ultrasonic waves infrared	Ultrasonic sensor infrared sensor tempurator	N/A	Ultrasonic infrared water moisture	Arduino nano
article 13 [16]	-	-	outdoor	Day	N/A	Online	low	MP3 buzzer vebrator	Vebration MP3 Ultrasonic waves pulse heart infrared	Ultrasonic sensor infrared sensor water sensor	GPS-GSM	Ultrasonic infrared water pulse heart moisture Rf RL	Arduino uno

devis	H5-index	Journal	Coverage	time	Range (meters)	Connection type	cost	User interface	Environment interface	Obstacle detection	Navigation & Tracking system	sensors	microcontroller
article 14 [17]	-	-	outdoor	N/A	50 cm, 100 cm, and 150 cm \pm 5 cm	online	N/A	Camera Gps Bluetooth RFCOMM.	Camera Bluetooth RFCOMM.	AS5040 magnetic encoders	Gps	Ultrasonic Infrared Laser	Arduino nano Raspberry pi 3 Atmega 328p
article 15 [18]	-	-	outdoor	N/A	N/A	offline	N/A	Buzzer Vibrator Speaker Remote controle	Buzzer Vibrator Speaker	Liquid sensor Ultrasonic sensor RF transmitter Sonar sensor	SD card	Liquid sensor Ultrasonic sensor RF transmitter Sonar sensor	Arduino UNO Wireless Remote-control
article 16 [19]	-	-	outdoor	N/A	3m	offline	N/A	buzzer Vibrator	buzzer Vibrator	IR sensor ultrasonic sensor	Gsm	Ultrasonic Pedometer water	Arduino uno
article 17 [20]	-	-	outdoor	N/A	N/A	offline	N/A	Vibrator Speech Synthesizer module	Vibrator Speech Synthesizer module	Vibrator Speech Synthesizer module	-	Ultrasonic TF-Mini Li-DAR Xsens	Raspberry pi 4 Arduino due
article 18 [21]	-	-	outdoor	N/A	N/A	online	N/A	Vibrator (buzz clip) GPS sherpa Smartphone Bluetooth	Ultrasonic Vibrator Capteur de la glycémie	Ultrasonic	GPS sherpa	Ultrasonic Color sensor TCS3200	Arduino uno
article 19 [22]	-	-	outdoor	N/A	N/A	online	N/A	Vibrator Buzzer bluetooth	Ultrasonic Vibrator Bracelet Buzzer Bluetooth camera	Ultrasonic camera	GPS bracelet	Ultrasonic	Raspberry pi
article 20 [23]	-	-	Indoor / outdoor	N/A	1 m, 3 m, 5 m	online	N/A	smartphone	smartphone	camera	Gps	-	Arduino Raspberry pi

2.5 Main findings of the Table

analyzing Table 1, we can observe some interesting patterns in the articles that have been published. The years 2018, 2019, and 2022 stand out as periods when a large number of articles were published. The use of Arduino and Raspberry Pi as microcontrollers is widespread, and ultrasonic sensors are commonly employed for data acquisition. GPS technology also plays a crucial role in enabling accurate positioning and navigation in many of these studies.

In addition to these main components, researchers have incorporated various supplementary sensors to expand the capabilities of their systems. Water and infrared sensors, among others, have been utilized to demonstrate the versatility of these technologies. Furthermore, the integration of cameras into the sensor suite has enhanced the depth and comprehensiveness of data collection.

It is worth noting that Arduino and Raspberry Pi are not limited to the articles mentioned; they are widely used in diverse research areas. The popularity of ultrasonic sensors for environmental interface, along with the integration of cameras, highlights the importance of these components in gaining a comprehensive understanding of the surrounding environment.

Analyzing the articles published in 2018 more closely, we find a diverse range of equipments being utilized. Different microcontrollers such as PIC, Intel Galileo, and Atmega 328 were explored during that year, indicating a broad technological landscape and the exploration of various options to achieve specific outcomes.

Interestingly, only a few articles specifically discuss the range of detection in their studies. For example, Shifeng Zhou (2018) focuses on a detection range of 4.5 meters, while Jean Connier et al. delve into a range of 150 cm with a permissible deviation of +5 and -5 centimeters. Other researchers, such as Nur Maisarah et al. and Bhavani et al., describe a range of 50 cm, Kingsly Jabakumar et al. present a range of 3 meters, and Bineeth Kuriakose et al. explore a range of 1-3 meters.

These varying detection ranges emphasize the flexibility and adaptability of ultrasonic sensors in different scenarios and applications. Researchers tailor their experiments to meet specific project needs and constraints, allowing for a comprehensive exploration of the capabilities and limitations of the technology.

In summary, the analysis of Table 1 reveals significant trends in the publication of articles, with Arduino, Raspberry Pi, and ultrasonic sensors playing key roles. Supplementary sensors, such as water and infrared, enhance the versatility of research systems, while the integration of cameras improves data collection. It is important to mention that the Jetson Nano was not utilized in any of the aforementioned studies. The use of different microcontrollers and the exploration of various detection ranges demonstrate the flexibility of technology in meeting specific research requirements..

2.6 conclusion

In conclusion, the development of smart sticks for visually impaired people has been an important area of research in recent years. Various works have been proposed to assist visually impaired people in detecting obstacles and dangers in front of them during walking and to identify the world around them. These smart sticks are equipped with different sensors through which they detect obstacles and alert the user with different methods, such as through beep, vibration, or voice alarms. Some smart sticks also include GPS navigation to guide the user through unfamiliar environments. The proposed solutions aim to provide a smart stick affordable and suitable for most blind people, and also it is light in weight. While there is still room for improvement in smart stick technology, the existing works represent a significant step forward in assistive technology for visually impaired people.

Chapter 3

SmartV: design and development

3.1 Introduction

In this chapter, we present a new version of the smart stick for visually impaired people. The smart stick is designed to assist visually impaired people in detecting obstacles and dangers in front of them during walking and to identify the world around them. The proposed stick is equipped with various sensors, including ultrasonic sensors, a camera, and a water sensor, and is powered by a Jetson Nano and a 3S LiPo battery. In addition to the equipment, we have added a voice alarm system to alert the user of obstacles and dangers. The stick detects obstacles and alerts the user through the speaker and vibrator, and the voice alarm system provides additional assistance.

Our new and enhanced design provides a more comprehensive solution for visually impaired people to navigate their environment safely and independently.

3.2 design of the SmartV

Before presenting our design of the SmartV, Our design strategy is centered on developing a user-centric solution that seamlessly combines cutting-edge technology and useful functionality. We have identified key features and functionalities that prioritize accessibility, ease of use, and improved user experience by carefully analyzing the requirements and gathering insights from user research.

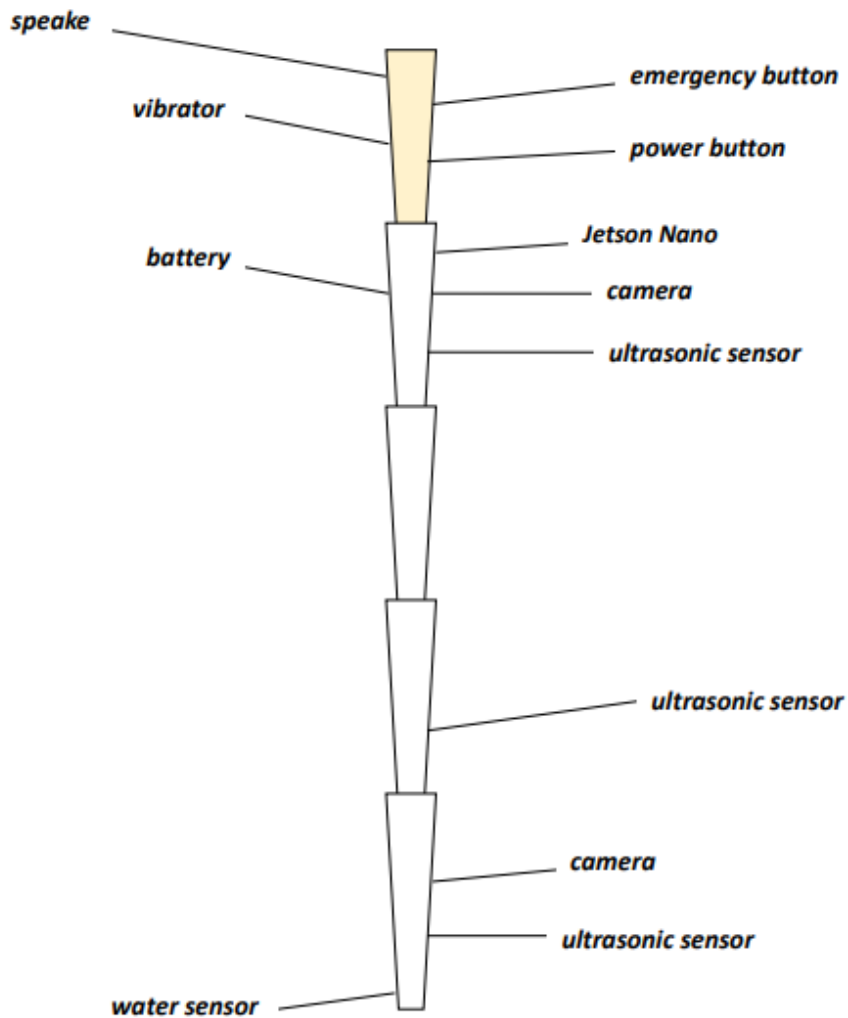


Figure 3.1: version 1.0

A detailed explanation of all the equipment used in the stick is provided below, covering each component from top to bottom. For equipment photos, please refer to the appendix.

speaker : A speaker is an electronic device component that converts electrical signals into audible sound waves, crucial for devices like smartphones, computers, and televisions. It consists of a diaphragm, voice coil, magnet, and housing enclosure. The electrical signal interacts with the magnet, causing the coil to move the diaphragm and generate sound waves. Factors like materials and design influence frequency response and sound quality. Speakers vary in size and type, from compact built-in speakers to multi-speaker setups for enhanced audio. They are essential for delivering immersive audio experiences, enriching multimedia and enhancing user satisfaction in electronic devices[24].

emergency button : An emergency button provides immediate assistance during critical situations, found in personal safety devices, phones, alarms, and public transportation. Its purpose is to quickly alert authorities or contacts in distress, triggering actions like emergency calls or alerts. Prominently placed and designed for easy access, emergency buttons enhance personal security, offering reassurance in public and private settings[25].

vibrator : A vibrator is an electronic device generating mechanical vibrations, used in massagers, mobile phones, gaming controllers, and haptic feedback systems. Its primary purpose is to provide tactile sensations and vibrations to the user. Vibrators consist of rotating masses or resonant actuators driven by electrical signals. They offer customizable intensity, frequency, and patterns for varied tactile feedback experiences. Vibrators find extensive use in haptic feedback devices, enhancing mobile communication, gaming, and discrete notifications in wearables[26].

power button : A power button is a control on electronic devices to turn them on or off, typically located on the front panel, side, or touchscreen interface. It initiates device startup or shutdown, with additional functions like sleep mode or restart. Power buttons can be physical, capacitive touch, or virtual, designed for accessible and intuitive operation[27].

Jetson Nano : The Jetson Nano by NVIDIA is a compact, low-power single-board computer designed for AI and edge computing. It belongs to the NVIDIA Jetson

family, offering high-performance capabilities. With a quad-core CPU, 128-core GPU, and 4 GB RAM, it supports various I/O interfaces for connectivity. Leveraging NVIDIA's CUDA and deep learning libraries, it accelerates AI workloads, enabling real-time inference for robotics, drones, surveillance, and embedded AI applications[28].

battery : A battery for electronic devices is a portable energy storage device powering various gadgets. It stores electrical energy chemically and converts it when needed. Common types include lithium-ion, nickel-metal hydride, and alkaline batteries. Capacity and lifespan vary based on type, power consumption, and usage. Adherence to local regulations is crucial for handling and disposal due to potential hazardous materials. Further information can be found on battery manufacturer websites, user manuals, and reputable online resources.

camera : A camera for electronic devices refers to a device that captures and records images or videos. It is an essential component found in various electronic devices, including smartphones, digital cameras, webcams, surveillance systems, and other devices with imaging capabilities.

ultrasonic sensor (HC-SR04) : The HC-SR04 ultrasonic sensor is a popular distance measuring module commonly used in robotics, automation, and other applications that require proximity sensing. It consists of an ultrasonic transmitter and receiver, which work together to emit ultrasonic waves and detect their reflection from nearby objects. The sensor measures the time it takes for the ultrasonic waves to travel to the object and back, allowing it to calculate the distance based on the speed of sound. The HC-SR04 sensor provides accurate distance measurements with high precision and a wide range of detection. It is easy to use with microcontrollers or single-board computers and can be interfaced using simple digital input/output pins. The sensor operates at a frequency of around 40 kHz and has a typical range of 2 cm to 400 cm, depending on the object's size, shape, and surface properties[29].

water sensor : A water sensor is a device that detects the presence or absence of water or liquid substances, commonly used in flood detection, plumbing, aquariums, and industrial processes. It employs various technologies like conductive, capacitive, optical, or mechanical methods. Conductive sensors measure electrical resistance, capacitive sensors detect changes in capacitance, optical sensors use light, and mechanical sensors rely on physical contact with water. These sensors

provide a digital output signal indicating water presence and may have additional features like adjustable sensitivity, alarms, or wireless connectivity. For detailed information, consult manufacturer datasheets, product specifications, or reputable online resources on sensor technology and water detection [30].

3.3 Device scenarios

The user is a visually impaired individual he has recently acquired a new smart stick that includes a range of features to improve his daily life. Here's how the smart stick could work:

Speaker: To initiate the smart stick, the user simply activates the power button on the handle. Instantly, a friendly voice prompt emanates from the speaker, warmly welcoming the user and confirming that the device is ready for use. This simple yet intuitive process ensures a hassle-free experience for our visually impaired individual.

Emergency Button: At the top of the handle, the user can easily locate the emergency button. Understanding its purpose, the user can rely on this button to swiftly call for help or summon assistance when feeling unsafe or in need of immediate support.

Vibrator: Our smart stick incorporates a built-in vibrator, capable of delivering haptic feedback to the user. By gently placing the stick near an object, the user can experience a subtle vibration, effectively indicating the presence of the object. This innovative feature enables enhanced object detection and orientation.

Jetson Nano: Facilitating artificial intelligence and machine learning capabilities, the Jetson Nano powers our smart stick. With this advanced technology, the smart stick operates in real time, recognizing objects and obstacles. It then provides the user with valuable audio feedback. For instance, when the user strolls down a bustling street, the smart stick identifies a parked car on the sidewalk and promptly alerts the user through the speaker

Camera: Equipped with a high-resolution camera, the smart stick captures images of the user's surroundings. The user can effortlessly take photos of unfamiliar buildings or street signs, and the smart stick, utilizing its analytical capabilities, promptly provides relevant information about the environment. This feature sig-

nificantly enhances the user's autonomy and awareness.

Battery: One of the standout features of our smart stick is its long-lasting battery. Users can confidently engage in their daily activities without worrying about the device running out of power. The reliable battery ensures uninterrupted assistance throughout the day.

Ultrasonic Sensor (HC-SRO4): Our smart stick incorporates three ultrasonic sensors that utilize sound waves to detect objects in the user's surroundings. These sensors play a crucial role in identifying obstacles and providing precise distance information to the user. For instance, as the user approaches a wall, they hear an audible change in feedback, indicating that the sensors have detected the obstacle.

Water Sensor: While strolling down the street, the user is promptly alerted by an alarm sound emanating from the smart stick. This alert is triggered by the water sensor, which effectively detects a puddle on the sidewalk. By promptly notifying the user of the potential hazard, the smart stick contributes to their safety and well-being.

Through the incorporation of advanced features and cutting-edge technology, our smart stick empowers visually impaired individuals to navigate their surroundings with confidence and independence. By providing audio feedback, object recognition, obstacle detection, visual analysis, and various other functionalities, this remarkable device significantly enhances the daily lives of its users.

3.4 development process :

Our commitment to improving the lives of visually impaired individuals drives the development of our smart stick. Our goal is to create a device that enhances their mobility, safety, and independence by integrating cutting-edge technologies and innovative design. we ensure that the smart stick meets the specific requirements and preferences of visually impaired individuals. The development process involves meticulous stages .

We prioritize accessibility, inclusivity, and continuous improvement to cater to the evolving needs of visually impaired individuals and provide them with a tool to enhance their quality of life.

The following use case diagram depicted below illustrates how users interact with the smart stick, showcasing its prominent features and functionalities.

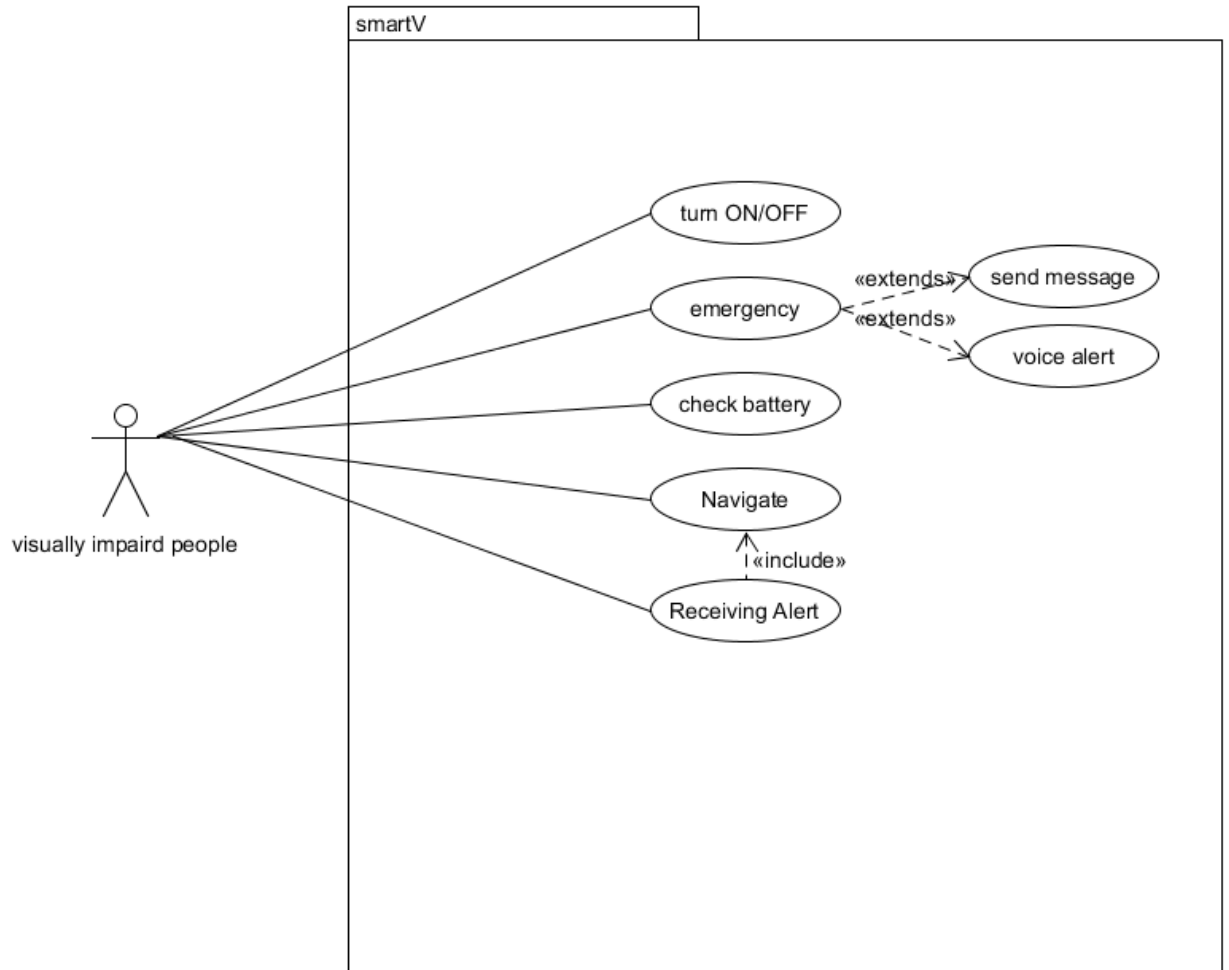


Figure 3.2: use case diagram for the SmartV

3.4.1 indoor scenarios

The user takes hold of the , smart v in the comfort of his familiar surroundings for another day of independent navigation. The cane comes to life with a gentle press of the on button, ready to assist him on his indoor journey. As he strides confidently forward, The advanced the speaker and vibrator of the stick immediately produce a harmonious blend of audio and tactile feedback. These innovative features work in tandem, scanning the surroundings and identifying any potential obstacles that may lie ahead.

the speaker guide him effortlessly through the space . They alert him to the presence of a chair, advising him to maneuver around it . The intelligent system of the stick, fine-tuned through advanced algorithms and machine learning, ensures that each alert is precise and tailored to his specific needs.

He past the chair, feeling an imperceptible vibration from the stick's integrated vibrator. The subtle but distinct sensations serve as a reminder, The stick becomes an extension of the user's perceptual abilities throughout this seamless interaction, amplifying his confidence and empowering him to walk with newfound comfort. The precision of the stick's alerts allow him to effortlessly traverse his familiar places, navigating the intricacies of his everyday environment. The stick adapts and learns in each familiar setting, whether it's his living room, kitchen, or bedroom, fine-tuning its performance to meet the user's specific needs. Its intelligent system gradually becomes acquainted with his distinct patterns, constructing a personalized map of his surroundings. With each passing day, the stick becomes a more dependable companion, attuned to the user's preferences and ready to ease his journey through the places he visits most frequently.

This elegant fusion of technology and design ensures that every step he takes is met with enhanced comfort and safety.

The following diagram provides valuable insights into the behavior of the SmartV . It showcases how this innovative device adapts its functionalities and performance to optimize indoor navigation.

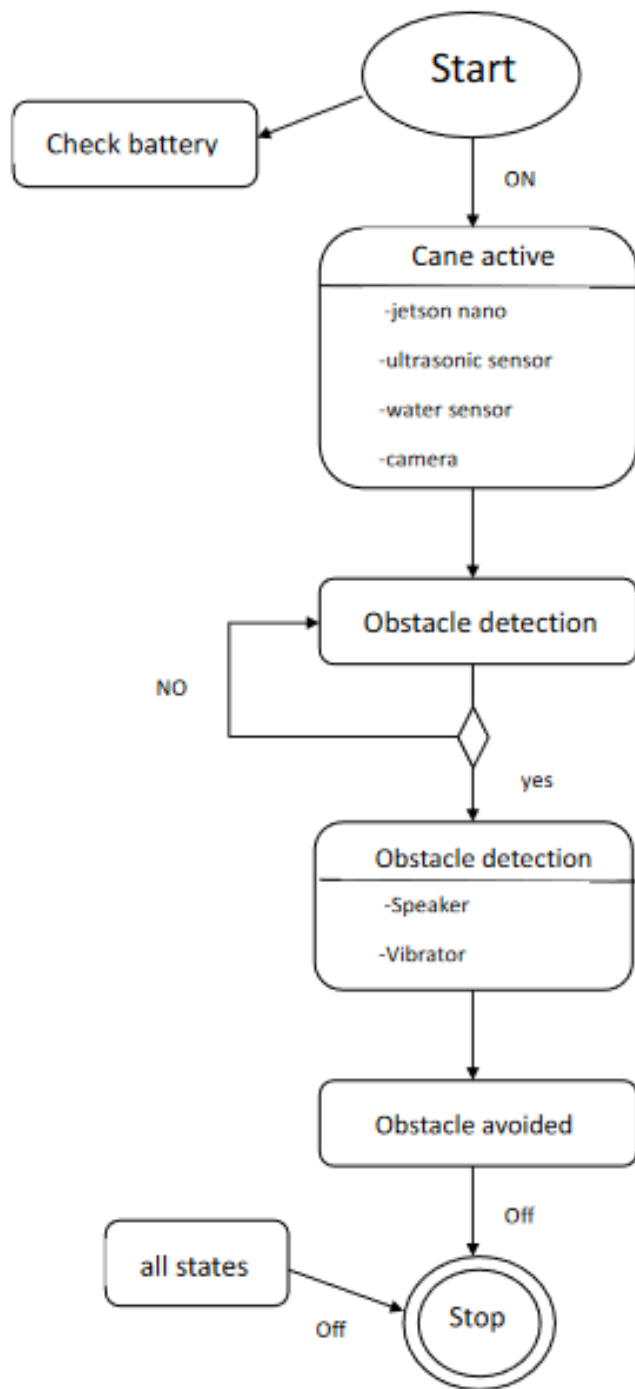


Figure 3.3: indoor scenarios diagram

3.4.2 outdoor scenarios

The user operates the stick while being outside by pressing the power button, activating its functions as they navigate through the streets. Equipped with advanced sensors and a camera, the stick continuously captures and identifies various surrounding obstacles such as cars, people, steps, animals, and more, ensuring a safe and seamless experience. The stick's performance is optimized in familiar environments where it has learned to adapt to the user's preferences and movement patterns. With extensive usage and familiarity, the stick becomes even more efficient in recognizing and navigating through known places.

In case of an emergency, the user has two options to signal for help. They can either press the emergency button continuously, triggering a loud alert from the stick that draws the attention of nearby individuals, notifying them of the user's urgent need for assistance. Alternatively, a single press of the emergency button sends an automated distress message to a designated emergency contact, such as a trusted friend, informing them of the user's specific location and requesting immediate help. To ensure uninterrupted usage, the stick incorporates intelligent battery management. When the battery level drops to 20% after extended use, the stick proactively alerts the user about the low battery status. At this point, it transitions into a safety mode, relying solely on its sensors and vibrator for operation while disabling the speaker and camera. This energy-saving mode helps conserve battery life and ensures that essential functionality remains available to the user. As the battery level reaches a critical point of 10%, the stick implements additional measures to extend its usability. The water sensor feature is temporarily deactivated, and the stick adjusts the capture distance of the ultrasonic sensor to conserve power. This smart adjustment allows the battery to last a little longer while still providing essential assistance and obstacle detection.

Finally, to power off the device, the user simply needs to press the power button twice. This intuitive action ensures a straightforward and efficient shutdown process, saving time and effort for the user.

By incorporating these enhancements and considerations, the stick offers an extended and optimized experience, prioritizing safety, usability, and convenience for the user in various scenarios and battery conditions.

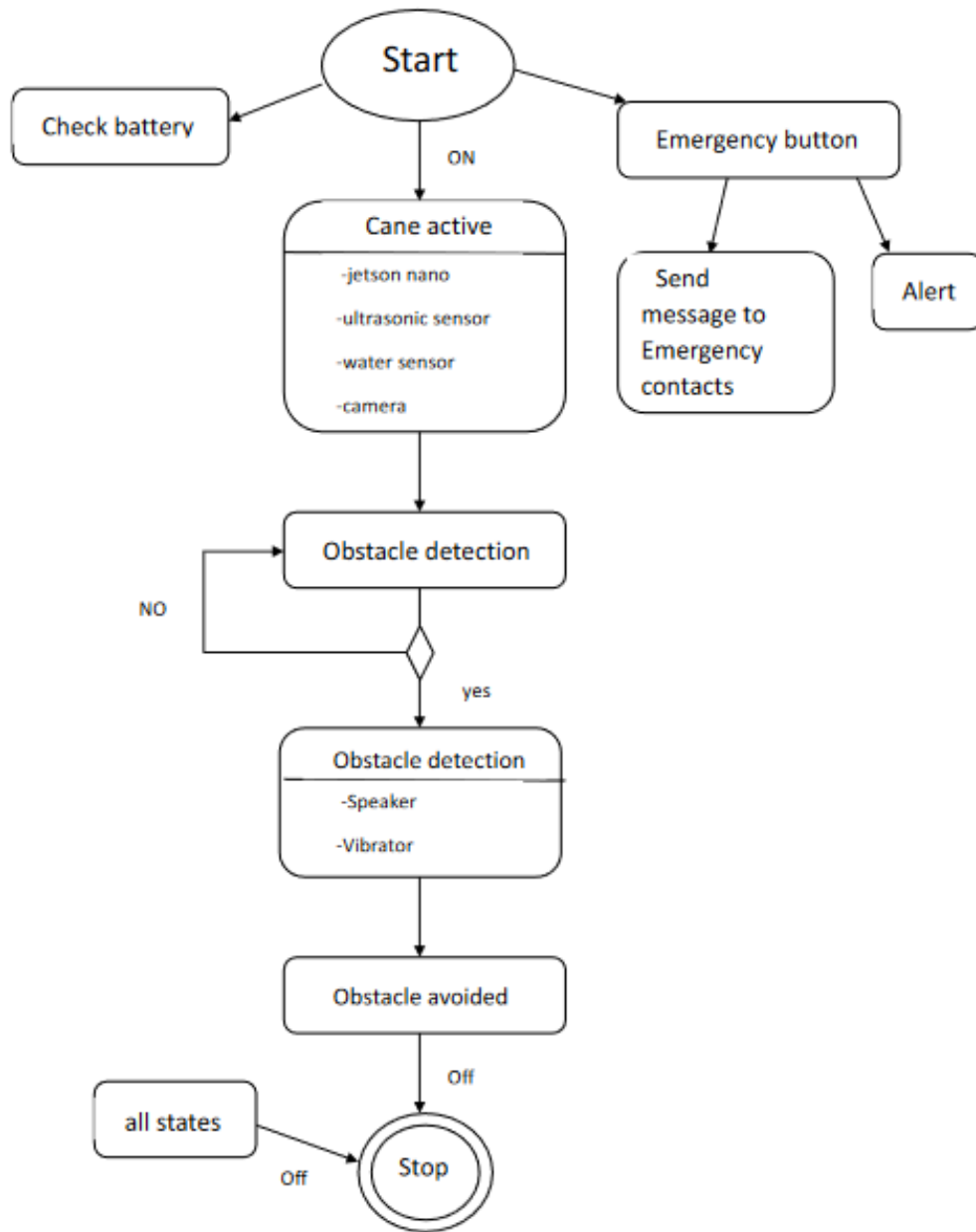


Figure 3.4: outdoor scenarios diagram

The diagram provides valuable insights into the behavior of the SmartV in outdoor environments. It showcases how this innovative device seamlessly adapts its functionalities and performance to optimize navigation in outdoor settings.

3.5 Battery Consumption and Life Period Analysis for SmartV Components

Battery consumption is a crucial aspect to consider when using smart sticks, These sticks are equipped with various components that enhance their functionality, but each component draws power from the battery, ultimately affecting the overall battery life. In this analysis, we will examine the battery consumption of the equipment used in our stick. We will compare the battery consumption for two different battery capacities: 5000mAh and 3000mAh.

The table below presents the estimated battery consumption for each device in the smart stick .

Table 3.1: Battery Usage

Device	Battery Usage (mA)
Speaker	100
Emergency Button	10
Power Button	5
Vibrator	50
Jetson Nano	1000
Camera	500
Ultrasonic Sensor	20
Water Sensor	30

3.5.1 Battery Life Period with All Devices:

To calculate the battery life period, we need to consider the total battery consumption of all devices combined. Adding up the consumption values from the table above, we have:

$$\text{Total Battery Consumption} = 100 + 10 + 5 + 50 + 1000 + (2 * 500) + (3 * 20) + 30 = 1815\text{mA}$$

Assuming a fully charged battery, the battery life period can be estimated by dividing the battery capacity by the total battery consumption.

$$\text{Battery Life Period (5000mAh)} = 5000\text{mAh} / 1815\text{mA} \approx 2.75 \text{ hours}$$

$$\text{Battery Life Period (3000mAh)} = 3000\text{mAh} / 1815\text{mA} \approx 1.65 \text{ hours}$$

3.5.2 Loss of Each Device

When losing one device at a time, the battery consumption will be reduced, potentially extending the battery life. The specific impact on battery life will depend on the lost power consumption of the device. To calculate the new battery life period after losing a device, subtract the corresponding device's battery consumption from the total battery consumption and repeat the calculation mentioned above.

Loss of Speaker:

$$\text{Total Battery Consumption without Speaker (5000mAh)} = 1715\text{mA} - 100\text{mA} = 1615\text{mA}$$

$$\text{Battery Life Period without Speaker (5000mAh)} = 5000\text{mAh} / 1615\text{mA} \approx 3.09 \text{ hours}$$

$$\text{Battery Life Period without Speaker (3000mAh)} = 3000\text{mAh} / 1615\text{mA} \approx 1.86 \text{ hours}$$

Loss of Emergency Button:

$$\text{Total Battery Consumption without Emergency Button (5000mAh)} = 1715\text{mA} - 10\text{mA} = 1705\text{mA}$$

$$\text{Battery Life Period without Emergency Button (5000mAh)} = 5000\text{mAh} / 1705\text{mA} \approx 2.93 \text{ hours}$$

$$\text{Battery Life Period without Emergency Button (3000mAh)} = 3000\text{mAh} / 1705\text{mA} \approx 1.76 \text{ hours}$$

Loss of Power Button:

$$\text{Total Battery Consumption without Power Button (5000mAh)} = 1715\text{mA} - 5\text{mA} = 1710\text{mA}$$

$$\text{Battery Life Period without Power Button (5000mAh)} = 5000\text{mAh} / 1710\text{mA} \approx 2.92 \text{ hours}$$

$$\text{Battery Life Period without Power Button (3000mAh)} = 3000\text{mAh} / 1710\text{mA} \approx$$

1.75 hours

Loss of Vibrator:

Total Battery Consumption without Vibrator (5000mAh) = 1715mA - 50mA = 1665mA

Battery Life Period without Vibrator (5000mAh) = 5000mAh / 1665mA \approx 3.00 hours

Battery Life Period without Vibrator (3000mAh) = 3000mAh / 1665mA \approx 1.80 hours

Loss of Jetson Nano:

Total Battery Consumption without Jetson Nano (5000mAh) = 1715mA - 1000mA = 715mA

Battery Life Period without Jetson Nano (5000mAh) = 5000mAh / 715mA \approx 7.00 hours

Battery Life Period without Jetson Nano (3000mAh) = 3000mAh / 715mA \approx 4.20 hours

Loss of Camera:

-one camera loss:

Total Battery Consumption without Camera (5000mAh) = 1715mA - 500mA = 1215mA

Battery Life Period without Camera (5000mAh) = 5000mAh / 1215mA \approx 4.12 hours

Battery Life Period without Camera (3000mAh) = 3000mAh / 1215mA \approx 2.47 hours

-two camera loss:

Total Battery Consumption without 2 Cameras (5000mAh) = 1715mA - (2 * 500mA) = 715mA

Battery Life Period without 2 Cameras (5000mAh) = 5000mAh / 715mA \approx 6.99 hours

Battery Life Period without 2 Cameras (3000mAh) = 3000mAh / 715mA \approx 4.20 hours

note that these calculations are based on the assumption that the power consumption of each camera is the same.

Loss of Ultrasonic Sensor:

-Loss of one sensor:

Total Battery Consumption without Ultrasonic Sensor (5000mAh) = 1715mA - 20mA = 1695mA

Battery Life Period without Ultrasonic Sensor (5000mAh) = 5000mAh / 1695mA \approx 2.95 hours

Battery Life Period without Ultrasonic Sensor (3000mAh) = 3000mAh / 1695mA \approx 1.77 hours

-Loss of two sensor:

Total Battery Consumption without 2 Ultrasonic Sensors (5000mAh) = 1715mA - (2 * 20mA) = 1675mA

Battery Life Period without 2 Ultrasonic Sensors (5000mAh) = 5000mAh / 1675mA \approx 2.99 hours

Battery Life Period without 2 Ultrasonic Sensors (3000mAh) = 3000mAh / 1675mA \approx 1.79 hours

-Loss of three sensor :

Total Battery Consumption without 3 Ultrasonic Sensors (5000mAh) = 1715mA - (3 * 20mA) = 1655mA

Battery Life Period without 3 Ultrasonic Sensors (5000mAh) = 5000mAh / 1655mA \approx 3.02 hours

Battery Life Period without 3 Ultrasonic Sensors (3000mAh) = 3000mAh / 1655mA \approx 1.81 hours

note that these calculations are based on the assumption that the power consumption of each ultrasonic sensor is the same.

Loss of Water Sensor:

Total Battery Consumption without Water Sensor (5000mAh) = 1715mA - 30mA = 1685mA

Battery Life Period without Water Sensor (5000mAh) = 5000mAh / 1685mA \approx 2.97 hours

Battery Life Period without Water Sensor (3000mAh) = 3000mAh / 1685mA \approx 1.78 hours

3.5.3 Estimating Battery Life for safety mode

the battery is $\leq 20\%$:

-For a 5000mAh battery:

Battery Capacity: 5000mAh

Camera Consumption: $500\text{mA} * 2 = 1000\text{mA}$

Speaker Consumption: 100mA

Combined Average Power Consumption of other devices: $1115\text{mA} + (20\text{mA} * 3)$
 $= 1175\text{mA}$

Remaining Battery Capacity: $5000\text{mAh} * 20\% = 1000\text{mAh}$

Reduced Power Consumption: Combined Average Power Consumption - Camera Consumption - Speaker Consumption

Reduced Power Consumption: $1175\text{mA} - 1000\text{mA} - 100\text{mA} = 75\text{mA}$

Battery Life = Remaining Battery Capacity / Reduced Power Consumption

Battery Life = $1000\text{mAh} / 75\text{mA} \approx 13.33$ hours

-For a 3000mAh battery:

Combined Average Power Consumption of other devices: $1115\text{mA} + (20\text{mA} * 3)$
 $= 1175\text{mA}$

Remaining Battery Capacity: $3000\text{mAh} * 20\% = 600\text{mAh}$

Reduced Power Consumption: Combined Average Power Consumption - Camera Consumption - Speaker Consumption

Reduced Power Consumption: $1175\text{mA} - 1000\text{mA} - 100\text{mA} = 75\text{mA}$

Battery Life = Remaining Battery Capacity / Reduced Power Consumption

Battery Life = $600\text{mAh} / 75\text{mA} \approx 8$ hours

the battery is $\leq 10\%$:

For a 5000mAh battery:

Remaining Battery Capacity: $5000\text{mAh} * 10\% = 500\text{mAh}$

Reduced Power Consumption:

Combined Average Power Consumption - (2 * Camera Consumption) - Speaker Consumption - (3 * 20% of Ultrasonic Sensor Consumption) - Water Sensor Consumption
Reduced Power Consumption:

$1115\text{mA} - (2 * 500\text{mA}) - 100\text{mA} - (3 * 0.2 * 20\text{mA}) - 30\text{mA} = 1115\text{mA} - 1000\text{mA} - 100\text{mA} - 12\text{mA} - 30\text{mA} = 973\text{mA}$

Battery Life = Remaining Battery Capacity / Reduced Power Consumption

Battery Life = $500\text{mAh} / 973\text{mA} \approx 0.51$ hours

And for a 3000mAh battery:

Remaining Battery Capacity: $3000\text{mAh} * 10\% = 300\text{mAh}$

Reduced Power Consumption: Combined Average Power Consumption - (2 * Camera Consumption) - Speaker Consumption - (3 * 20% of Ultrasonic Sensor Consumption) - Water Sensor Consumption

Reduced Power Consumption:
 $1115\text{mA} - (2 * 500\text{mA}) - 100\text{mA} - (3 * 0.2 * 20\text{mA}) - 30\text{mA} = 1115\text{mA} - 1000\text{mA} - 100\text{mA} - 12\text{mA} - 30\text{mA} = 973\text{mA}$

Battery Life = Remaining Battery Capacity / Reduced Power Consumption

Battery Life = $300\text{mAh} / 973\text{mA} \approx 0.31$ hours

When considering the estimated calculations presented in this context, it is important to keep in mind that they are approximate and depend on specific assumptions. Actual battery life can vary widely due to many factors, including but not limited to the efficiency of the device itself, the general health and condition of the battery, as well as the manner in which the device is used.

In addition, it should be noted that if the main battery runs out, the backup battery will serve as a replacement for the main battery. The same role will perform the same for all scenarios.

To ensure a smooth and uninterrupted user experience, it is highly recommended to recharge the device immediately when the battery level gets low. By following this practice, users can improve overall battery life and get a more accurate and reliable estimate of how long a battery will last in real-world scenarios.

The following diagram depicts the behavior of the smartV in relation to the remaining battery percentage. It provides insights into how the smart stick's functionalities and performance may vary as the battery level changes :

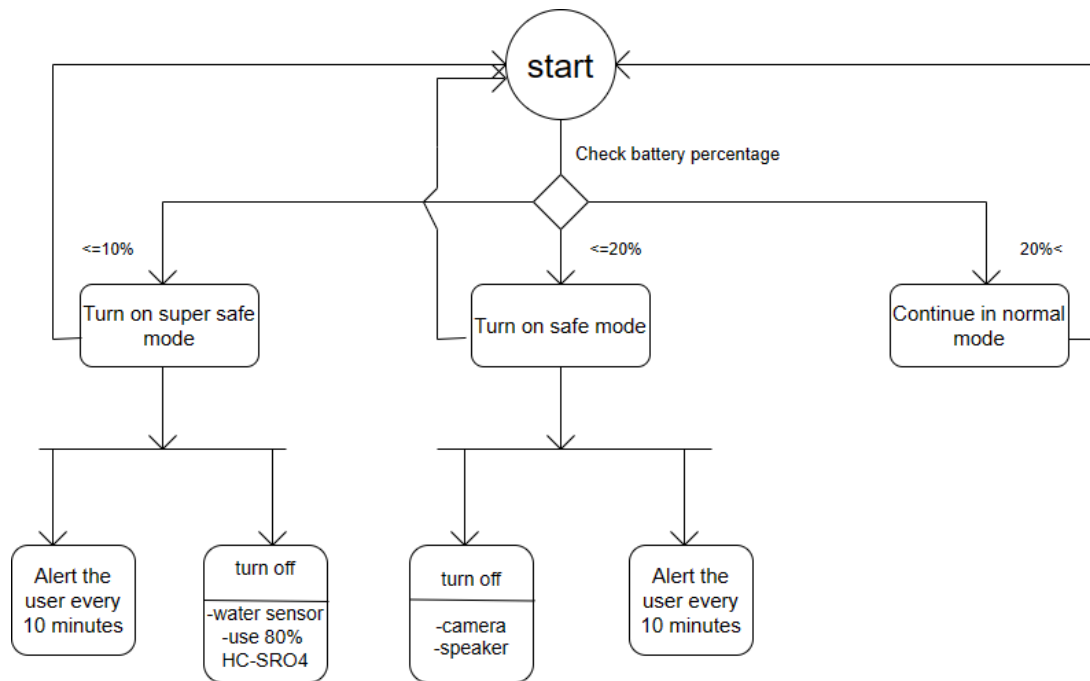


Figure 3.5: Behavior of the SmartV in Relation to Battery Percentage

3.6 SmartV Programming

In this section, we will discuss the crucial steps we followed and the programming language we employed to create a robust solution. With the aid of Python, we harnessed the power of computer vision to identify obstacles and generate real-time alerts using data from a web camera.

3.6.1 programming language

We chose Python as our programming language for its versatility and user-friendly nature. Python's simplicity, clean syntax, and extensive library support make it an ideal choice for our project. It allows us to write expressive and easy-to-understand code, reducing the learning curve for new developers and promoting collaboration.[31]

In addition, we leveraged the power of YOLO (You Only Look Once) for object detection in our project. YOLO is a popular deep learning framework that provides fast and accurate object detection capabilities. By integrating YOLO with Python, we were able to enhance our smart stick's ability to recognize and identify objects in real-time.[32]

3.6.2 code

```
1 import cvzone
2 from ultralytics import YOLO
3 import cv2
4 import math
5 import numpy as np
6 import pyttsx3
7
8 # Initialize the text-to-speech engine
9 engine = pyttsx3.init()
10
11 cap = cv2.VideoCapture(0)
12 model = YOLO("../yolov8_Project/Yolo-Weights/yolov8l.pt")
13
14 classNames = [
```

```

15     "person", "bicycle", "car", "motorbike", "aeroplane", "
        pen", "train", "truck", "boat",
16     "traffic light", "fire hydrant", "stop sign", "parking
        meter", "bench", "bird", "cat",
17     "dog", "horse", "sheep", "cow", "elephant", "bear", "
        zebra", "giraffe", "backpack", "umbrella",
18     "handbag", "tie", "suitcase", "frisbee", "skis", "
        snowboard", "sports ball", "kite", "baseball glove",
19     "skateboard", "surfboard", "tennis racket", "bottle", "
        glass", "cup",
20     "fork", "knife", "spoon", "bowl", "banana", "apple", "
        sandwich", "orange", "broccoli",
21     "carrot", "pizza", "donut", "cake", "chair", "sofa", "
        potted plant", "bed",
22     "table", "toilet", "tvmonitor", "laptop", "mouse", "
        remote", "keyboard", "cell phone",
23     "microwave", "oven", "toaster", "sink", "refrigerator", "
        book", "clock", "vase", "scissors",
24     "teddy bear", "hair dryer", "stairs"
25 ]
26
27
28 def speak(text):
29     # Convert text to speech
30     engine.say(text)
31     engine.runAndWait()
32
33 def calculate_distance(w, h):
34     # Assume a focal length and object size to estimate
        distance
35     focal_length = 1000 # Example focal length in pixels
36     object_size = 20 # Example object size in centimeters
37     image_width = 640 # Example image width in pixels
38
39     distance = (object_size * focal_length) / (w *
        image_width)

```

```

40     return distance
41
42 while True:
43     success, img = cap.read()
44     if not success:
45         break
46
47     results = model(img, stream=True)
48     for r in results:
49         boxes = r.boxes
50         for box in boxes:
51             x1, y1, x2, y2 = box.xyxy[0]
52             x1, y1, x2, y2 = int(x1), int(y1), int(x2), int(
53                 y2)
54             w, h = x2 - x1, y2 - y1
55             cvzone.cornerRect(img, (x1, y1, w, h))
56             conf = math.ceil((box.conf[0] * 100)) / 100
57             cls = int(box.cls[0])
58             object_class = classNames[cls]
59             distance = calculate_distance(w, h)
60
61             # Customize the voice output
62             text = f"Be careful, there is a {object_class} at
63                 {distance:.2f} meters."
64
65             # Speak the customized text
66             speak(text)
67
68             cvzone.putTextRect(img, text, (max(0, x1), max
69                 (35, y1)), scale=0.7, thickness=1)
70
71     cv2.imshow("Webcam", img)
72     if cv2.waitKey(1) & 0xFF == ord('q'):
73         break
74 cap.release()

```

3.6.3 code description

The provided code snippet demonstrates a Python program that utilizes various libraries and modules to implement object detection. Here's a description of the code:

The code begins by importing necessary libraries, including `cvzone`, `ultralytics`, `cv2`, `math`, `numpy`, and `pyttsx3`. These libraries provide functions and classes for image processing, machine learning, mathematical calculations, and text-to-speech capabilities. The main functionality of the code revolves around a loop that captures frames from a webcam using `cv2.VideoCapture()`. The captured frames are then passed through an instance of the YOLO object detection model from the `ultralytics` library. The model identifies objects present in the frames and returns bounding boxes and confidence scores for each detected object.

The code iterates through the detected objects and extracts relevant information such as the object's class, position, and dimensions. It then uses the `cvzone` library to draw rectangles around the detected objects on the image. Additionally, it calculates the estimated distance of each object based on its size and displays a customized text message indicating the object's class and distance.

To enhance the user experience, the code utilizes the `pyttsx3` library to convert the customized text messages into speech. This allows the system to audibly alert the user about the presence of objects and their respective distances.

The code continues to display the modified image with bounding boxes and text overlays in a separate window using `cv2.imshow()`. It listens for the 'q' key to be pressed to exit the program.

Finally, the code releases the webcam capture and closes the image display windows using `cap.release()` and `cv2.destroyAllWindows()`.

Overall, this code demonstrates the integration of object detection, image processing, and text-to-speech functionalities to create a smart stick application capable of identifying obstacles and providing audio feedback to the user.

The screenshots presented as Figure 3.5 and Figure 3.6 provide a visual representation of the results obtained from executing the code in outdoor environments. These screenshots demonstrate the successful execution and showcase the adaptability of the code in varying outdoor settings. Additionally, Figure 3.7 captures the outcome achieved in an indoor environment. This screenshot highlights the code's performance and functionality within an indoor setting. Together, these screenshots offer a comprehensive view of the code's behavior in both outdoor and indoor scenarios, providing valuable insights into its versatility and effectiveness across different environments.":



Figure 3.6: Outdoor execution vision 1



Figure 3.7: Outdoor execution vision 2



Figure 3.8: Indoor execution

3.7 conclusion

In conclusion, this chapter comprehensively addressed the design and development stages of SmartV. It encompassed the evolution from the initial model to the final programming and program components. Furthermore, the behavior and adaptations of the battery were thoroughly examined, providing valuable insights. The chapter also highlighted the equipment's characteristics and delved into various scenarios, considering both user perspectives and device functionalities. Through this exploration, a holistic understanding of SmartV's design, development, and potential applications has been achieved.

Conclusion et perspectives

In conclusion, significant strides have been made in understanding the needs of individuals with special needs, particularly those with visual impairments, and harnessing modern technology to address those needs. Smart sticks have emerged as a contemporary and innovative solution, exemplifying the progress made in assisting visually impaired individuals. However, despite the availability of various solutions, the quest for a single stick that fully satisfies all user requirements remains an ongoing challenge that requires further exploration and development.

In our endeavor to create a comprehensive smart stick, we have dedicated ourselves to integrating a range of essential features that cater to the diverse needs of users. By prioritizing obstacle detection, identification of obstacle types, and accurate measurement of distances between obstacles and the stick, we have sought to enhance the functionality and practicality of our product. Furthermore, we try to ensure that our smart stick are user-friendly and affordable, making them accessible to a wider range of individuals.

Looking towards the future, we have set specific goals that will drive the continued enhancement of our smart stick. First and foremost, we aim to adopt a user-centric approach to development, actively incorporating user feedback and insights to refine and expand the features of our product. By valuing the input of users, we can ensure that our smart sticks align closely with their needs and preferences.

Additionally, we recognize the importance of pushing the boundaries of detection capabilities. We are committed to expanding the obstacle detection range beyond the limit of 5 meters, enabling users to have greater awareness of their surround-

ings. Simultaneously, we aim to enhance the accuracy of our detection system, offering precise and reliable information to visually impaired individuals as they navigate their environment.

Furthermore, we understand that an extended battery life is crucial for an optimal user experience. By investing in research and development, we strive to extend the battery life of our smart sticks, enabling users to rely on them for longer periods without the inconvenience of frequent recharging.

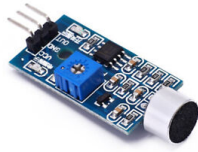
In summary, our smart stick represents a cutting-edge solution that leverages the latest technology to meet the evolving requirements of individuals with visual impairments. We are committed to staying at the forefront of technological advancements, continuously adapting our product to incorporate emerging technologies and refining its capabilities to better serve the needs of this community. Through ongoing innovation and a steadfast dedication to user-centric design, we aim to contribute to the empowerment and improved quality of life for individuals with visual impairments.

Bibliography

- [1] Adam Debrowsk. *Visual impairment: What is impaired vision?* URL: <https://www.allaboutvision.com/conditions/lowvision/visual-impairment/>.
- [2] World health organization. *Blindness and vision impairment*. URL: <https://www.who.int/news-room/fact-sheets/detail/blindness-and-visual-impairment>.
- [3] *Challenges blind people face when living life*. URL: <https://www.letsenvision.com/blog/challenges-blind-people-face-when-living-life>. (accessed: 02.03.2023).
- [4] Ms PratibhaShantaram Pawaskar, DG Chougule, and AS Mali. “Smart Stick For Blind Person Assisted with Android Application And Save Our Souls Transmission”. In: ().
- [5] Shifeng Zhou. “A Smart cane to help the blind people walk confidently”. In: *IOP Conference Series: Materials Science and Engineering*. Vol. 439. 3. IOP Publishing. 2018, p. 032121.
- [6] Yeong-Hwa Chang, Nilima Sahoo, and Hung-Wei Lin. “An intelligent walking stick for the visually challenged people”. In: *2018 IEEE International Conference on Applied System Invention (ICASI)*. IEEE. 2018, pp. 113–116.
- [7] Faiz Abdul Ghani and Asnazulfadhli Zariman. “Smart cane based on IoT”. In: *International Journal of Education, Science, Technology, and Engineering* 2.1 (2019), pp. 12–18.

- [8] Gita Indah Hapsari, Giva Andriana Mutiara, and Husein Tarigan. “Face recognition smart cane using haar-like features and eigenfaces”. In: *TELKOMNIKA (Telecommunication Computing Electronics and Control)* 17.2 (2019), pp. 973–980.
- [9] Shwetali P Talele et al. “Smart Cane for Blind People Using IoT”. In: (2019).
- [10] Nur Maisarah Ahmad Nazri et al. “Smart cane for visually impaired with obstacle, water detection and GPS”. In: *International Journal of Computing and Digital Systems* 10 (2020), pp. 2–8.
- [11] D Chiranjevulu et al. “Intelligent walking stick for blind people using Arduino”. In: *Int. J. Eng. Res. Appl* 10 (2020), pp. 42–45.
- [12] M Adil Khan et al. “An Android-based Portable Smart Cane for Visually Impaired People”. In: *2021 IEEE 15th International Conference on Application of Information and Communication Technologies (AICT)*. IEEE. 2021, pp. 1–6.
- [13] R Bhavani et al. “Development of a smart walking stick for visually impaired people”. In: *Turkish Journal of Computer and Mathematics Education (TURCOMAT)* 12.2 (2021), pp. 999–1005.
- [14] S Saranya, G Sudha, and Sankari Subbiah. “Raspberry Pi based smart walking stick for visually impaired person”. In: *AIP Conference Proceedings*. Vol. 2520. 1. AIP Publishing LLC. 2022, p. 020010.
- [15] Yuwono Imam, Damastuti Evi, et al. “The Development of a ‘Magic Cane’ for Mobility of the Blind in a Swampy Terrain”. In: (2022).
- [16] Salam Dhou et al. “An IoT machine learning-based mobile sensors unit for visually impaired people”. In: *Sensors* 22.14 (2022), p. 5202.
- [17] Jean Connier et al. “La canne blanche 2SEES: concept et expérimentations”. In: *8èmes Journées Nationales des Communications Terrestres (JNCT 2018)*. 2018.
- [18] Wohiduzzaman Kazi, Taslima Jannat Limu, and Md Rakibuzzaman. “Smart Cane: A Low Cost Assistive Device for the Visually Impaired”. In: *EAI Endorsed Transactions on Internet of Things* 8.4 (2023).
- [19] A Kingsly Jabakumar et al. “Medical electronics based smart shoe for blind people”. In: *Journal of Pharmaceutical Negative Results* (2023), pp. 1911–1917.
- [20] Yassine Boutera. “Smart real time wearable navigation support system for BVIP”. In: *Alexandria Engineering Journal* 62 (2023), pp. 223–235.

- [21] Licia Loutichene and Lysia Mahdi. “Etude et réalisation d’une canne intelligente destinée aux personnes souffrant d’une cécité visuelle”. In: 2019.
- [22] Aziza Toullahi and Lynda Zaid. “Etude et réalisation d’un gant intelligent pour les non-voyants”. PhD thesis.
- [23] Bineeth Kuriakose, Raju Shrestha, and Frode Eika Sandnes. “DeepNAVI: A deep learning based smartphone navigation assistant for people with visual impairments”. In: *Expert Systems with Applications* 212 (2023), p. 118720.
- [24] Eric W Healy et al. “Deep learning based speaker separation and dereverberation can generalize across different languages to improve intelligibility”. In: *The Journal of the Acoustical Society of America* 150.4 (2021), pp. 2526–2538.
- [25] Renee Garrett et al. “A literature review: website design and user engagement”. In: *Online journal of communication and media technologies* 6.3 (2016), p. 1.
- [26] Blake Hannaford and Allison M Okamura. “Haptics 30. Haptics”. In: ().
- [27] Zhanna Sarsenbayeva et al. “Methodological Standards in Accessibility Research-PLXBCCR-on Motor Impairments: A Survey”. In: *ACM Computing Surveys* 55.7 (2022), pp. 1–35.
- [28] *Jetson Nano Developer Kit*. URL: <https://developer.nvidia.com/embedded/jetson-nano-developer-kit>. (accessed: 02.04.2023).
- [29] <https://randomnerdtutorials.com/complete-guide-for-ultrasonic-sensor-hc-sr04/>.
- [30] <https://realpars.com/capacitive-sensor/>.
- [31] <https://www.python.org/>.
- [32] Joseph Redmon and Ali Farhadi. “Yolov3: An incremental improvement”. In: *arXiv preprint arXiv:1804.02767* (2018).



(a) speaker



(b) button



(a) vibrator



(b) jetson nano

.1 speaker, button

.2 vibrator, jetson nano

.3 battery, camera



(a) battery



(b) camera



(a)



(b) water sensor

.4 ultrasonic sensor (HC-SR04)