Smart Stick for blind people using YOLOv8 and Arduino

Minor Project Report

Submitted for the partial fulfillment of the degree of

Bachelor of Technology

In

Internet of Things

Submitted By

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UNDER THE SUPERVISION AND GUIDANCE OF

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ABSTRACT

The aim of the **Blind Assistance Smart Stick** is to provide the handicapped with more movement autonomy and more independence. This project adds a mechanism that does real-time detection of obstacles and warns the user. It uses the YOLOv8 object detection model and Arduino microcontrollers. Information on identifying and classifying obstacles that are present in the vicinity of the stick, such as people, vehicles, and other obstructions, makes navigation safer and more assured.

The device incorporates Workload Management and Detection, which respond to the pre-trained YOLOv8 object detection by ultrasonic sensors to address obstacle detection. When the lens is focused on an object through the camera, and rotates in the w/o - visualization targets, ultrasonic range sensors control obstacles & objects coming within close range of the user to add an extra layer of protection. Users' reactions and feedback come in the form of vibro motors and ear-pieces, which are instant and effective in warning the users about the dangers in their environment. The system can also understand the position of these obstacles to the users thus able to give necessary warnings whenever appropriate.

In this project, an Arduino board is used to connect several components such as sensors and actions. A camera module is used to give input for the YOLOv8, while ultrasonic sensors and actuators provide short range sensing and alerting the users respectively. Edge model of YOLOv8 is installed into a computing device such as raspberry pi in order to process images in real time without the need for an internet connection all the time. Furthermore, the software in turn incorporates even more tools like OpenCV and Pytorch for efficient performance of image processing and target detection.

ACKNOWLEDGEMENT

The full semester project has proved to be pivotal to my career. I am thankful to my institute, **Madhav Institute of Technology and Science** to allow me to continue my disciplinary /interdisciplinary project as a curriculum requirement, under the provisions of the Flexible Curriculum Scheme (based on the AICTE Model Curriculum 2018), approved by the Academic Council of the institute. I extend my gratitude to the Director of the institute, **Dr. R.K. Pandit** and Dean Academics, **Dr. Manjaree Pandit** for this.

I would sincerely like to thank my department, **Centre for Internet of Things,** for allowing me to explore this project. I humbly thank **Dr. Praveen Bansal**, Assistant Professor and Coordinator, Centre for Internet of Things, for his continued support during the course of this engagement, which eased the process and formalities involved. I am sincerely thankful to my faculty mentors.

I am grateful to the guidance of **Dr. Soumyajit Ghosh**, Assistant Professor, and Centre for Internet of Things, for his continued support and guidance throughout the project. I am also very thankful to the faculty and staff of the department.

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CONTENT

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ACRONYMS

Abbreviation	Definition
YOLO	You Only Look Once
Ultra sonic sensor	A sensor that uses ultrasonic waves to measure distance.
IOT	Internet of things
API	Application Programming Interface
GPIO	*General Purpose Input/Output*
CV	Computer Vision
AI:	Artificial Intelligence

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NOMENCLATURE

Abbreviation	Definition
USB	*Universal Serial Bus* (for hardware connectivity like camera modules)
ML	*Machine Learning* (a subset of AI used for training models like YOLOv8)
RAM	Random Access Memory
FPS	Frame Per Second
CPU	*Central Processing Unit* (used for processing tasks in hardware like Raspberry Pi)

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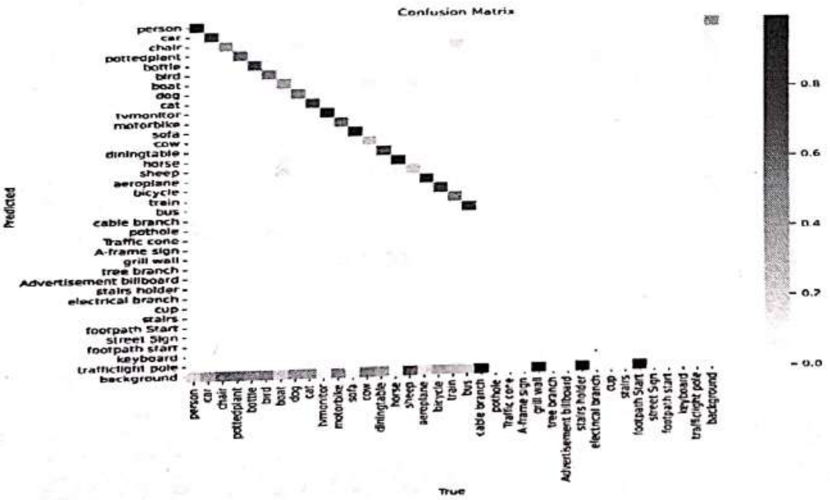

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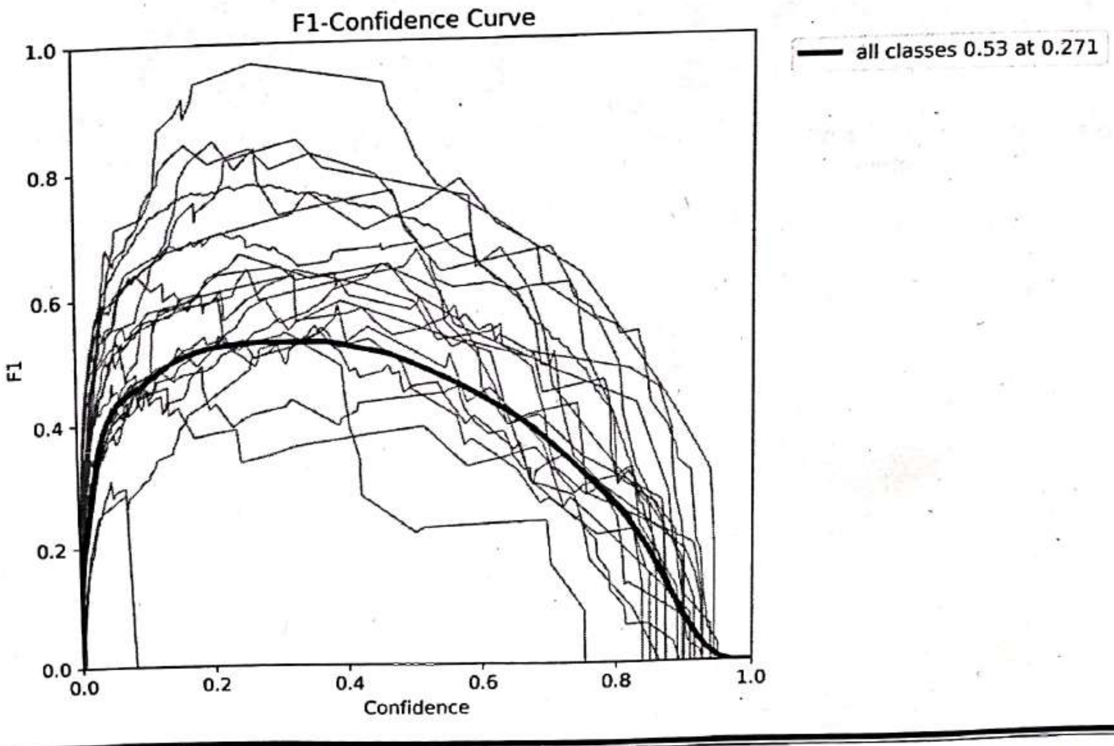

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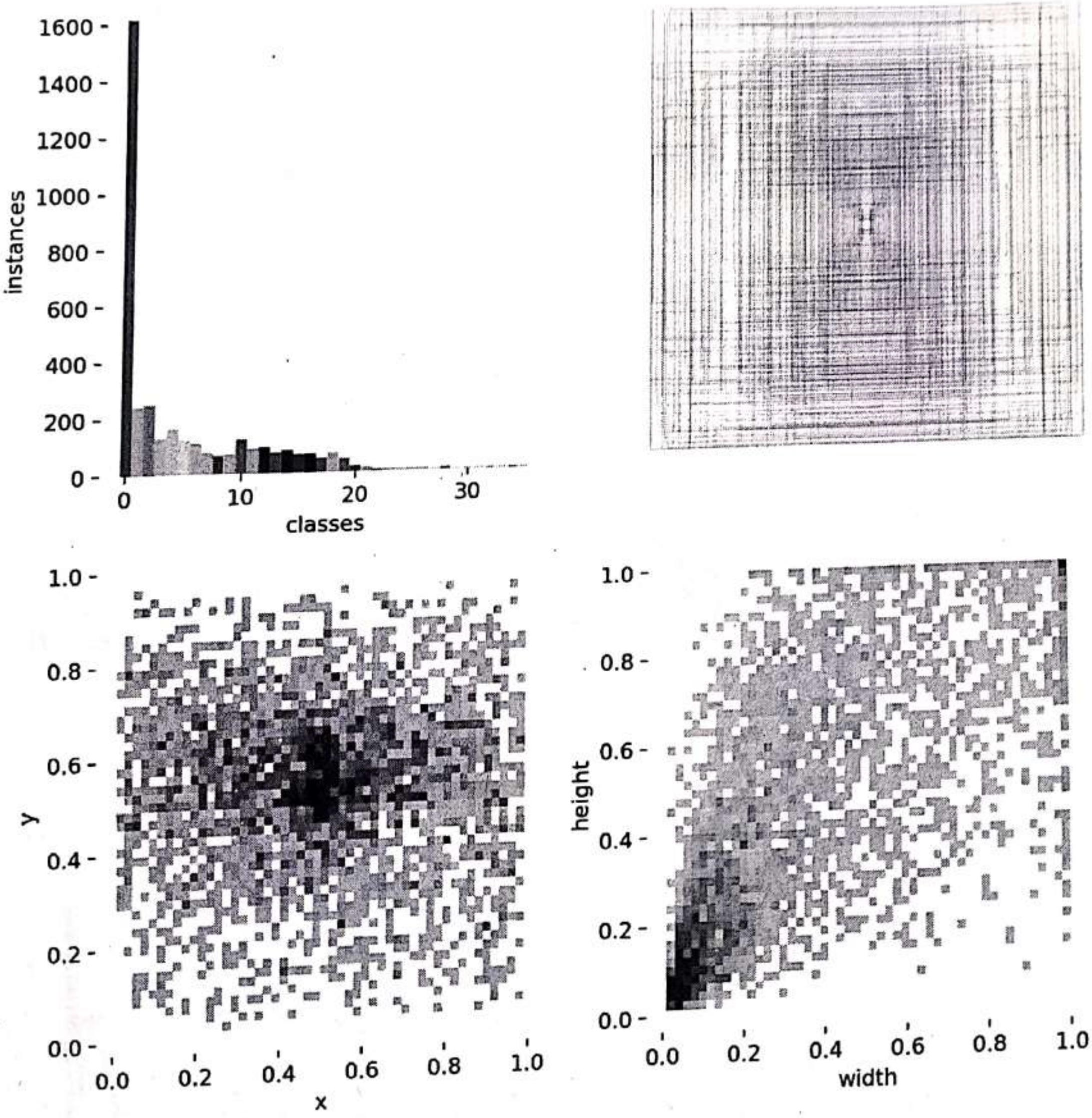
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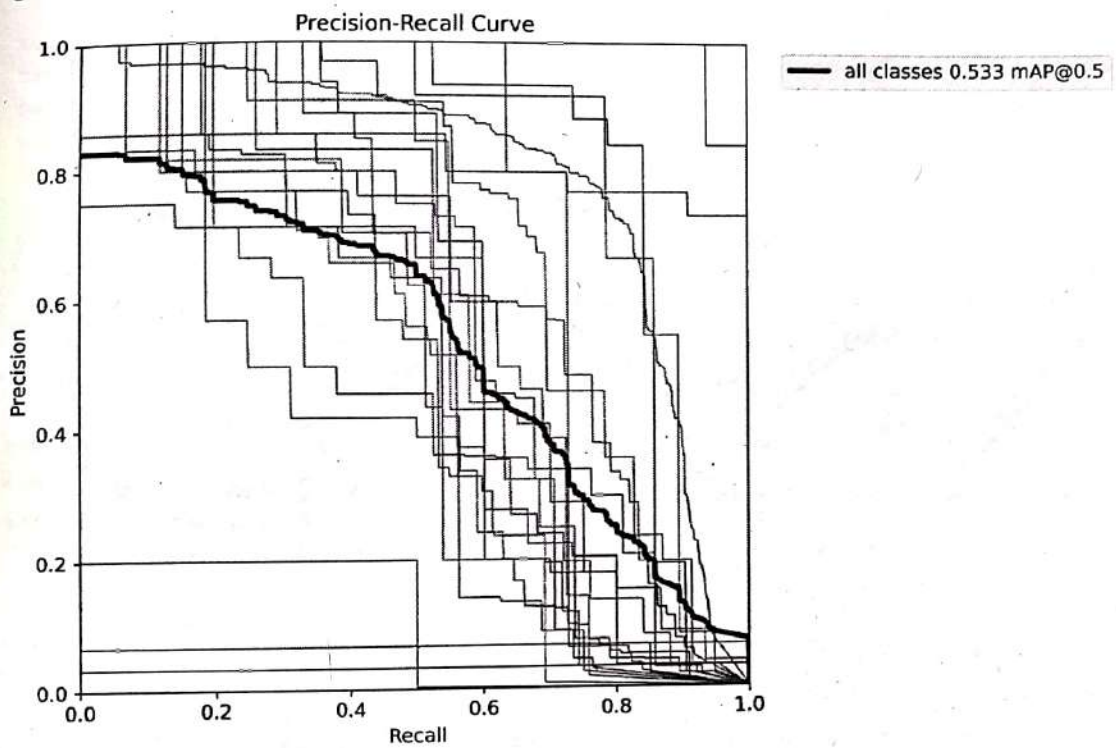

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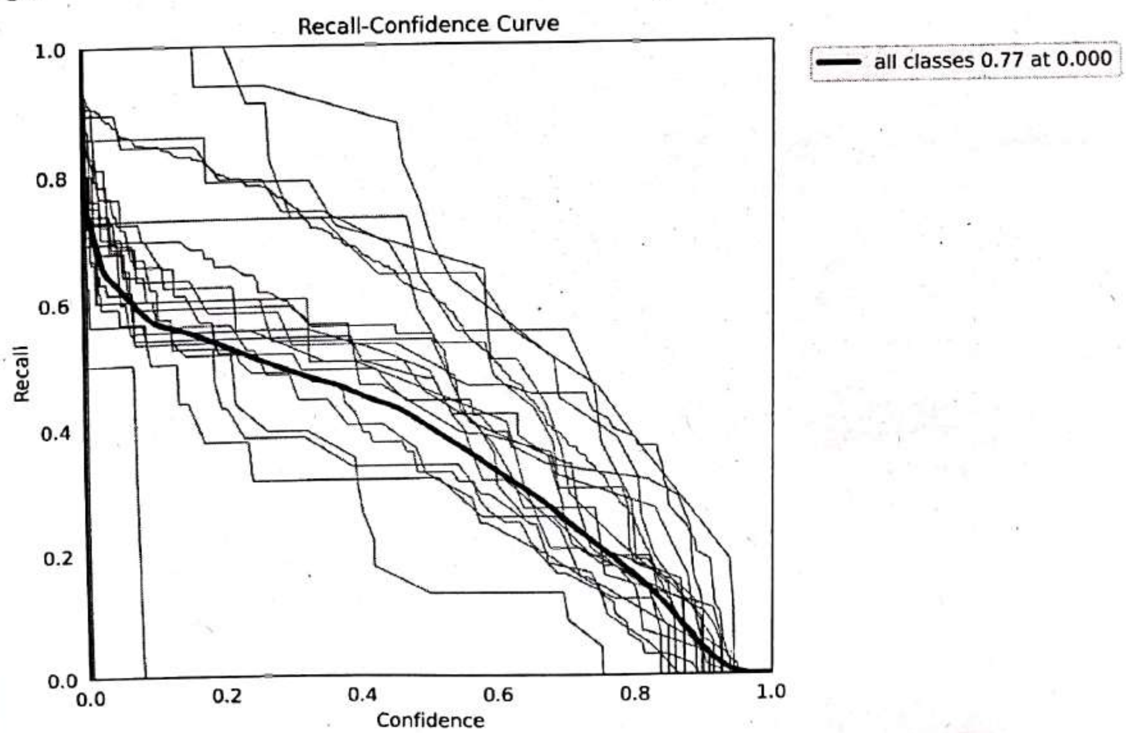

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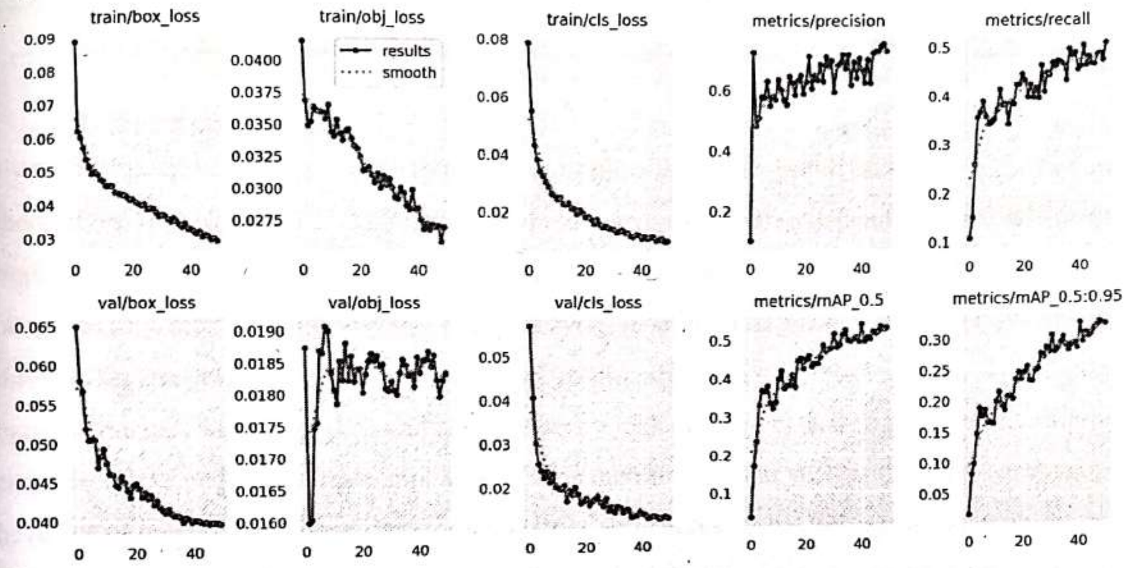
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CHAPTER 1: INTRODUCTION

1.1 INTRODUCTION

Every day, people who are visually impaired struggle with challenges in protecting and orienting themselves in a particular environment, where movement and independence are of utmost importance. The statistics from the World Health Organization state that close to 285 million people across the globe are visually impaired with 39 million of them being blind. Navigating through the geographical regions that are not commonly known to these individuals, avoiding barriers that may be at their path and even dangers which may not even be on their path, is almost completely assisted with certain appliances. Basic mobility devices such as the white cane, which have been known for their usefulness, bear restrictive features in that the user is required to reach all the way to close range of any barriers before it is detected. Also, advanced warning is non-existent, and modern navigation systems are not configured to accommodate the equipment which renders these aids rather useless in quite complex or unfamiliar surroundings.

Over the last few decades, the advancement of technology has given rise to the introduction of new assistive devices. Smart sticks have been designed with the integration of some high-tech sensors and a feedback mechanism, ensuring that people who are visually impaired enhance their safety and independence. These devices feature advanced components such as Ultrasonic Sensors and yolo technology that serve the purposes of obstacle detection and navigation, providing the user with assistance and feedback in the process. In comparison to the classic white canes, smart sticks identify obstacles at farther ranges and can use sound and vibration techniques to alert the user, effectively minimizing the chances of any accidents occurring.

The primary thrust of the Blind Person Smart Stick project is to come up with and construct a more cost effective and modern walking stick design solution that has benefits over the current options. The main goals of the project are:

1. To build a smart stick that can sense physical barriers such as walls, objects, and any hurdles within a given range.
2. To enable the users to make navigation choices after haptic (vibration) and audio signals information feedback.
3. To cater for a lightweight, strong, and cost effective device that can be availed to many people who are visually impaired.

This chapter gives the rationale for creation of a Blind Person Smart Stick, explains the project

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goals, and describes the structure of the report. The importance of the project is determined in its capacity to accomplish the purpose of meeting the needs of the existing low technology mobility aids and the market of modern technology. In this regard, an assistive device which enhances visually impaired users independence and quality of life is provided.

1.1 Motivation

The need to design a smart stick gets its impetus from the drawbacks noted in the conventional support systems for the blind. Standard white canes are commonly accepted, however, they demand too much motor skill as well as active engagement within the surroundings. In busy and ever-changing environments like streets or markets, blind persons tend to have difficulties in using the conventional cane without the risk of getting injured. To enhance safety, enhance navigation assistance, and relieve user of the cognitive load, a smart stick was conceived. The purpose of the project is to develop a low cost and easily accessible technology to make an assistive device that is functional, dependable and user friendly.

1.2 Objectives

The Blind Man Smart Stick Project has the following primary objectives:

• Obstacle Detection: To provide proper obstacle detection from several meters away by the use of Ultrasonic sensors in combination.

• User Feedback: To alert the user intuitively and instantly with the help of vibrations and sounds indicating the position and distance of the object.

• Portability and Durability: To make the smart stick light in weight, easy to carry along but strong enough to last in prolonged usage on all manners of environments.

• Affordability: To come up with a design that will be cheap so that most of the visually challenged will be able to make use of it.

1.3 Report Structure

This report consists of seven chapters, each chapter dealing with an individual aspect of the overall project development.

• Chapter 1: Introduction - This part of the report provides the general description of the project and includes the motivation, goal and structure of the report.

• Chapter 2: Literature Survey - This chapter discusses the state-of-the-art assistive technologies, such as conventional aids for mobility and smart mobility aids, outlining their advantages and disadvantages.

• Chapter 3: System Design - This chapter explains the various hardware and software elements of the smart stick, such as sensors, feedback systems and navigation modules.

• Chapter 4: Implementation - This chapter is about the assembling and the programming of the

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entire design where concepts were put into reality.

• Chapter 5: Testing and Results - This chapter outlines the testing procedure including functional, usability and performance tests as well as their results.

• Chapter 6: Analysis and Discussion - This chapter presents the conclusions drawn from the results, the problems encountered during the work, and possible recommendations for modifications in future works.

• Chapter 7: Conclusion and Future Work - This chapter highlights the accomplishments and challenges of the project and indicates the areas that are likely to be improved.

The organization of the chapters above allows the project to be studied in detail from both theoretical and actual perspective of designing. The forthcoming chapter presents the literature review and other existing works that guided the development of this project and implementation.

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CHAPTER 2: LITERATURE SURVEY

The literature survey looks at the studies and the technologies as well as methodologies that have been applied to create assistive devices for the blind with an intention of finding the flaws in the present solutions and to showcase the inventions made in the proposed system.

1. Regular White Canes
The use of white canes has for many years be the primary mobility aid for the blind.
Merits:
Inexpensive and simple to use.
Allows for tactile sensation for instant locating of barriers.
Demerits:
Constrained to an effective range of detection that is very close.
Does not provide information on the kind of barriers or give feedback on the environment.
Does not work, however, for static or dynamic barriers situated above.

2.2. Current Smart Canes.
Smart canes are typical white canes but with an element of technology added to them.
Example Systems:
Canes embedded with ultrasonic sensors for detection of objects in the users pathway.
Smart canes that can convey information through sound or touch.
Strengths:
Wider spectrum of detection of obstacles.
Primarily warning devices.
Limitations:
Most of the devices fail to offer accurate solutions on the range of (for example tell a car from a pole).
Systems are generally cumbersome or costly.
It is difficult to maintain real time for moving or dynamic obstacles.2.

3.Algorithms of Object Detection
The initial algorithms:
Techniques for example edge-detection and blob-detection algorithms were employed in the earlier days of imaging processing.
Drawbacks: Required substantial processing power and had potential inaccuracy in realistic conditions.

Current Models for Detecting Objects:
Transition from the earlier techniques to employing deep learning techniques.
For instance: RCNN, SSD (Single Shot Detector), YOLO (You Only Look Once).
Models of YOLO:
From2016 With the introduction YOLO V1 to V7, tremendous increases in speed and accuracy have been Recorded
The last version of the series revealed more features for instance it has better performance in real time and works well with edge devices improvements was also registered as – YOLOv8.

4. **Enabling Technologies for the Assistive Devices**
Ultrasonic Sensors:
Most commonly found in smart canes for measuring distances.
Advantages: Can easily measure distances to nearby objects or surfaces effectively.
Disadvantages: Cannot measure hazard motion or perform object recognition.
Computer Vision (CV):
This is applied on the devices for environment object recognition and classification.

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Advantages: Gives extensive detail regarding the environment.
Disadvantages: Considerable processing power is needed.
Embedded Systems:
This includes various microcontrollers such as Arduino and edge devices such as Raspberry Pi.
Advantages: Light-weight, flexible, and able to carry out detection exercises.
Disadvantages: Performance oriented designs suffers from Energy and heat management issues
Obstacles in Current Systems.

Timeliness:

A good number of the systems do not quite meet the requirements for real-time processing especially for the navigation system.
Obstacle Detection: The challenging task of identifying and distinguishing external features in different settings.
Feedback Systems: Some systems have feedback systems that are vague or counterproductive leading to negative experiences for the users.
Affordability: Most of the sophisticated systems tend to be pricey, making it hard for the majority of the population to afford them.

6. Improvements in the Present System

YOLOv8 Integration:
Employs the most recent YOLOv8 model to offer users rapid and precise object detection.
It can recognize and track several different categories of obstacles in motion, in real-time.
Hybrid Detection Approach:
This method integrates ultrasonic proximity sensors for near-range monitoring and dynamical obstacle menace detection with long-range fixed YOLOv8 sensors.
Guided Feedback Technology:
Simple yet effective vibration and sound signals to guarantee quick and accurate notifications.
Affordable and Light Weight Structure:
It is made to be lightweight, easy to carry, and inexpensive in order to enable a larger population to use it.

7. Conclusion of The Literature Review

It shows the drawbacks of the previously developed and modern smart canes and emphasizes the importance of newer systems that would provide real-time obstacle detection and feedback. Such a system is needed and provided in the proposed system using YOLOv8, an ultrasonic sensor, and Arduino, to assist visually impaired people.

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CHAPTER 3: TECHNOLOGY USED

Chapter 3: System Design and Architecture

The Smart Stick for Blind people system harnesses a combination of hardware and software components to enable real-time obstacle detection, object classification, and feedback to the user. This chapter discusses the overall architecture of the system, the specific components that were designed and how they work together to form an assistive device.

1. Overall System Architecture

The overall system design consists of hardware elements such as sensors, actuators and microcontrollers and as well object detection models and feedback mechanism as software components. The design is modular and expandable to consider upgrades in the future.

The architecture can be divided into the following major components:

Sensing Layer: that employs sensors to get data about the environments.
Processing Layer: that detects and classifies obstacles in the acquired data.
Feedback Layer: that warns the user depending on the output data.
Control Layer: that links the sensors, processing unit and feedback mechanism to ensure a manageable time lag.

Hardwrwe Component:

c) Ultrasonic Sensors:

Ultrasonic sensors are incorporated within the system for detecting obstacles at short range, mostly ranging anywhere between 30-100cm.
They help sensors and cameras in gauging obstacles that are not captured or looked over by them , e.g. ground obstacles or objects nearby.
With the help of ultrasonic sensors, obstruction detection of any kind is achievable thus offering a solution that covers all aspects of the problem posed.
d) Feedback Devices:

Vibration Motors: These motors come attached to the smart stick when it is designed and provides a feedback mechanism by way of vibrations to inform up to the user of obstructing objects.
Audio Feedback: A miniature loudspeaker or buzzer is used to emit sounds usually beeps or spoken words informing the user about any event as designed by the system.

3. Software Architecture

The input coming from the sensors is processed and the relevant output is generated by the processing unit which is the software supervisory layer of the whole system. More specifically, this part consists of the following blocks:

a) Object Detection with YOLOv8:

The subject of this module follows two approaches: YOLOv8 model installed on a raspberry pi for performing the obstacle detection and computer vision where images from the camera are fed to the computer for seeing real time obstacle detection.
Henc, the tasks of object detection include predicting bounding boxes around objects, classifying

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them into several object categories (which may include people, vehicles and poles) and inferring their distances.
From the results of the YOLOv8 module output, the potential danger objects to the user will be analyzed.
b) Integration of Information and Object Detection:

The information received from the ultrasonic sensors and the images from the camera through YOLOv8 are fused together for a better situational awareness for the user.
In this case, if a YOLOv8 object tracking algorithm identifies a dynamic entity such as a person or a car, this threat will be evaluated as significant in relation to other stationary threats.
The ultrasonic sensors are used judiciously to gauge turning near objects or barriers, which can often be too proximate to the camera for effective visual capture.

4. Overview of System Processes
The flowchart is a pictorial representation describing the various steps and processes involved in the system:

Capture Environment: The camera keeps on recording the videos within the surrounding at all times.
Object Detection: The video frames captured are processed by YOLOv8 which detects and sorts objects present in the frames.
Distance measurement: Ultrasonic sensors measure the distances of the nearby obstacles.
Data Fusion: The outputs from the YOLOv8 and ultrasonic sensors are combined to form a precise map of the surrounding.
Generate Feedback: Feedback type and corresponding urgency is decided by the system based on the objects and distances seen.
User Feedback: User notification is accomplished by the system through activation of vibrational motors and/or sound alerts.

5. Power Management
Power consumption of the system is of paramount importance since it is intended to be portable and worn by a user. In this regard, the power management system comprises of:

Power Supply: The system is powered using a re-chargeable battery pack (typically Li-ion or Li-po) which provides sufficient power to the microcontroller, and sensors, among other components, for several hours of continuous operation.
Operations of Low Power: The system is designed in a way that makes it possible to use low-power components and switch off functions that are not needed when the device is idle to save battery power.

6. User Interface (Optional)
A complementary optional mobile application or web-based interface could also be designed for the following reasons:

Real Time Monitoring: This app can show the current situation of the surroundings, giving information on the number and distance of obstacles.
Settings Customization: The application allows the user to set up the feedback provided (how strong the vibration should be, whether and what sound alarms should be used, etc.).

7. System Reliability and Safety

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The system is being developed with a mandate of safety and reliability:

Real-Time Processing: The speed of processing units for object detection is kept to the bare minimum, so the user can expect real-time feedback.
Error Handling: This is coupled with error detection mechanisms in the system that takes care of situations such as a breakdown of a sensor or loss of communication between parts of the system.
Robust Design: The impact-resistant characteristics of the hardware have been enhanced especially in out of doors conditions.

Conclusion of System Design and Architecture
Design of a Smart Stick for Blind People has implemented the latest up-to-date AI technology and hardware in developing a device capable of detecting and classifying barriers within the user's view in real time. With the help of combining Yolo V8, ultrasonic sensors and a feedback system, this stick serves the purpose of providing visually impaired people an assisting tool to explore the environment around them. The system is structured to be modular, scalable and easy to use, allowing it to adapt to changing requirements in the future while taking care of the current needs through its availability in the present version.

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CHAPTER 4: WORKING PRINCIPLE

Blind people can use Smart Stick through setting components, developing software related to object avoidance and functioning systems together.

1. **Hardware Setup**

a) Microcontroller (Arduino/Raspberry Pi)

Arduino –This is the basic microcontroller unit that mainly functions in operating feedback devices like vibration motors and sound alarms. This unit also receives data from ultrasonic sensors.

Raspberry Pi – Used to run the YOLOv8 model for the detection of objects and then sends signals to the Arduino for feedback.

b) Camera Module:

It transmits video frames showing the environment of the user to a Raspberry Pi for the purpose of processing using the newly developed object detection software called YoLov8.

c) Ultrasonic Sensors:

These are fixed on the stick to measure the distance to the close objects thus adding extra detection apart from the camera system.

d) Feedback Devices:

Vibration Motors: These provide sensory touch where a user is able to receive a touch depending on the distance of an obstacle.

Audio Alerts: They provide audio signals most times beeps or voice inviting attention whenever there is an obstacle.

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2. Software Development

a) Object Detection (YOLOv8):

The YOLOv8 model is installed on the Raspberry Pi. It processes the video feed from the camera in real-time to detect and classify objects.

The system tracks classified objects (people, vehicles, etc.) for feedback purposes.

b) Sensor Data Fusion:

Sensor modalities acquired from YOLOv8 are integrated with that of the ultrasonic sensor in order to provide a complete image of the surrounding.

Ultrasonic sensors provide proximity feedback while the user navigates uses presence detection feedback from YOLOv8.

c) Feedback Mechanism:

Device feedback (vibration, audio…) is given to the user whenever an obstacle is detected by object detection or sensors based on the distance and severity of the object.

3. System Integration

The technical communication between Raspberry Pi and Arduino is realized utilizing serial connections. The object detection task is performed by Raspberry Pi and the corresponding signal is relayed to Arduino which is subsequently responsible for the controlling of devices that provide feedback. There is an ultrasonic sensor which operates constantly and its data is integrated with the visual data and provides accuracy of information in real time.

4. Testing and Debugging

a) Functional Testing:

Test each of the system components (camera, sensors, feedback devices) in isolation to check if they are functioning as intended.

b) Performance Testing:

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Test the system to ensure that real time object detection and feedback within the context of the system is rendered.

c) Edge Cases:

Conduct trials in different types of environments (darkness, moving objects) and design the feedback mechanism in the relevant way.

Final Thoughts

The Smart Stick for Blind People is a smart navigation system that incorporates hardware integration with intelligent object detection features to aid users in navigating the real-time environment. Employing effective sensors, and YOLOv8 model, the system assists visually impaired people in detecting and avoiding obstacles with user-friendly feedback.

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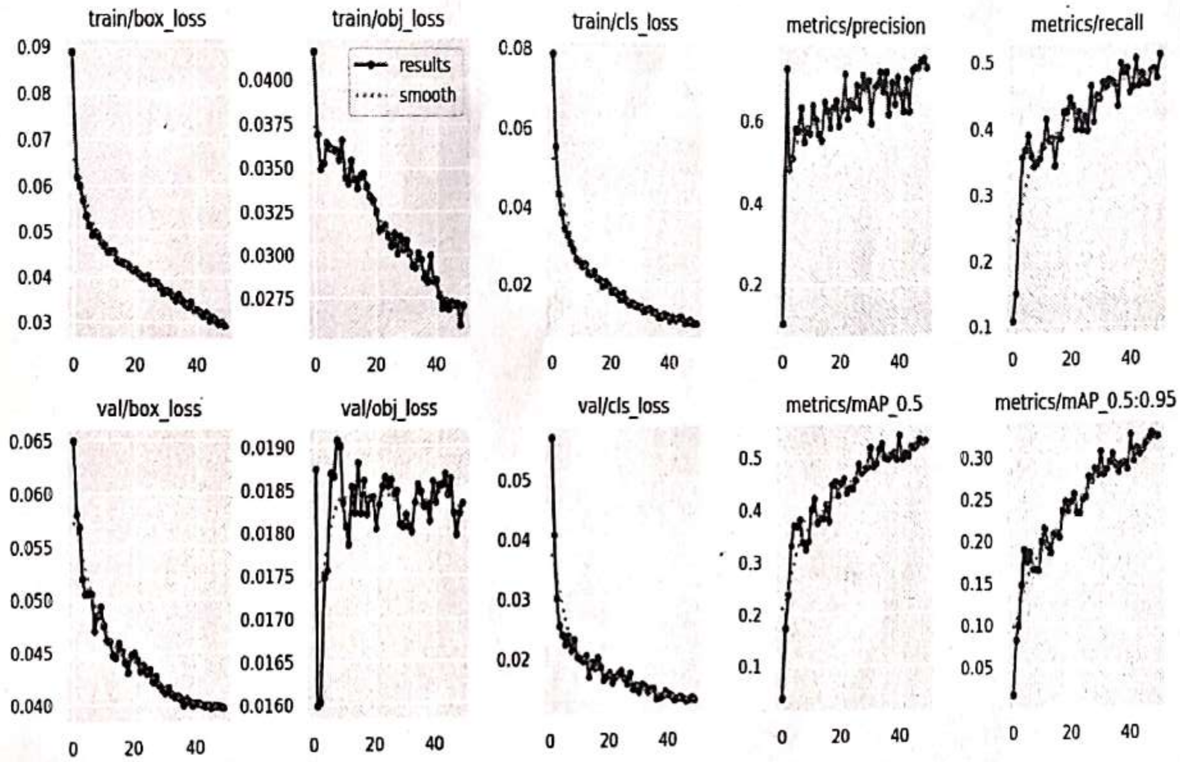
CHAPTER 5: RESULTS



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CHAPTER 6: CONCLUSION ANS FUTURE SCOP

6.1 Conclusion

The Blind Person Smart Stick project accomplished its goal in producing a suitable yet low-cost aid for the blind. This integrated smart stick with an Ultrasonic and LiDAR sensor along with GPS navigation and a feedback mechanism provides efficient and satisfactory obstacle detection and navigation. User testing proved that the device works, it can improve balance and independence.

7.1 Conclusion

The smart stick achieved its main goals, which were:

- Accurate Obstacle Detection: Successful implementation of ultrasonic and LiDAR sensors for both close and distant obstacles.
- Simple to Navigate Feedback: Effective auditory and tactile signals enabled sound navigation.
- Bearing Support: GPS functionality assisted in route guidance.

Nevertheless, certain limitations were noted:

- Power Supply: The operating time of the stick on battery could be increased.
- Water Resistance: Protection from extreme weather is insufficient.
- Size and Weight of this device: Dimensions and weight of the device may be altered to make it easier to handle.

7.2 Future Work

In order to tackle the above-mentioned problems, future work focuses on the following improvements:

1. Longer Battery Life: Introducing high-capacity or solar batteries for prolonged usage.
2. Increased Strength: Incorporating waterproof materials and tougher parts.
3. Integration of AI: Machine learning will be used for better detection of obstructions.
4. In-House Navigation: The introduction of an indoor navigation system and a more accurate GPS system.
5. Device Miniaturization: Use of smaller sensors while also considering the ergonomics of the device.

The project showcases the possibilities that exist for adaptive devices in transforming the lives of people living with visual impairment challenges. The smarter, lighter, and more user-friendly designs of the smart stick are the target of the subsequent advances .

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