A PROJECT REPORT ON

A Smart Stick Implementation For Visually Impaired Using YOLO : A Faster Object Detection Algorithm

SUBMITTED TO THE SAVITRIBAI PHULE PUNE UNIVERSITY , PUNE IN THE PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF THE DEGREE

BACHELOR OF ENGINEERING
(Computer Engineering)

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Acknowledgement

It gives us pleasure in presenting the project report on **A Smart walking stick powered by Artificial Intelligence for the Visually impaired**.

Firstly, we would like to express our indebtedness appreciation to our guide **Mr.S.N Deshpande**. His/Her constant guidance and advice played very important role in successful completion of the project. He/She always gave us his/her suggestions, that were crucial in making this report as flawless as possible.

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Last but not the least, the backbone of our success and confidence lies solely on blessings of dear parents and lovely friends.

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Abstract

Physical movement is a challenge for visually impaired people, because it is difficult to distinguish between obstacles that come across in day to day life, which makes it tedious for them to move from one place to another. Smart walking stick is especially designed to detect obstacles which may help the blind to navigate care-free.

Image recognition is the process of identifying and detecting an object or a feature in a digital image or video. Image recognition helps the visually disabled user to listen to a summarized one line description of his/her surroundings.

The smart stick presented, uses Machine Learning along with ultrasonic sensors to help the targeted user i.e. visually disabled people to navigate through their surrounding environment independently. The hardware implementation will have to use the capabilities of a portable device, such as a PDA or Mobile Phone or special built embedded system with microcontroller, and the images will be received though a small web-cam.

Keywords

Machine Learning
Internet Of Things
Raspberry Pi
YOLO

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CHAPTER 1
INTRODUCTION

1.1 Overview

1.2 Motivation

- To design a Smart Walking Stick for Visually Impaired People using IR Sensors, Raspberry Pie for detecting collisions.
- To Create an optimal path designed with the help of camera module for avoiding collisions.
- Navigating the required path and converting Image to Speech and giving instructions through headphone device.

1.3 Problem Definition and Objectives

To design and develop a system for visually impaired people to avoid collision using Machine Learning techniques.

1.4 Project Scope and Limitations

1.4.1 Project Scope

- To design a Smart Walking Stick for Visually Impaired People using IR Sensors, Raspberry Pi for detecting collisions.
- Navigating the required path and converting Image to Speech and giving instructions through headphone device.

1.4.2 Limitations

- To build a smart walking stick for the visually impaired which is affordable by low income households making the user less dependent.
- Detection of puddles and ditch.
- In case of discharge of power bank, Raspberry Pi shuts down.

1.5 Methodologies for Problem Solving

1.5.1 Problem Definition

To design and develop a system for visually impaired people to avoid collision using Machine Learning techniques.

1.5.2 Problem Analysis

The system needs to provide a fast processing and information extraction for the exchanged information between the user and the external peripherals such as sensors, pi/web cam. For example, the system that detects the obstacle that is 2m in front of the user the system needs to extract information from the live video or image and process it in order to determine the type of the obstacles and if the collision will occur and where it will occur and also provide alternate route to avoid collision.

1.5.3 Solution

Identifying the presence of an obstacles upfront in the user's route and warning him of a possible collision with the obstacles by providing an audio feedback are the tasks performed in collision detection. Image recognition deals with extracting information from the pi-cam captured images, extract the information using Microsoft azure and narrate this information back to the user about the type the obstacles in front of the user.

CHAPTER 2

LITERATURE SURVEY

2.1 Literature Survey

Sr. No.	Topic	Author	Analysis/Review
1	A Smart walking stick powered by Artificial Intelligence for the Visually impaired	Siddhi Degaonkar Mohit Gupta Musahib Singh Prajakta Hiwarkar Prof. Dr. S.A. Itkar	The proposed system is used for assisting visually impaired in their navigation. The system performs two main tasks image recognition and obstacle detection allowing user to navigate independently.
2	SMART WALKING STICK FOR BLIND PERSON	D.Sathya, S.Nithyaroopa, P.Betty, G.Santhoshni, S.Sabharinath, M.J.Ahanaa	The proposed system contains the ultrasonic sensor, water sensor, voice play back board, raspberry pi and speaker.
3	Raspberry Pi Based Reader for Blind People	Anush Goel, AkashSehrawat, Ankush Patil,Prashant Chougule, Supriya Khatavkar	In this research these images are converted into the audio output (Speech) through the use of OCR and Text-to-speech synthesis.
4	Understanding of Object Detection Based on CNN Family and YOLO	Yongjie Zhang, Jian Wang and Xin Yang	In this research paper, the algorithms for object detection such as YOLO, CNN, Fast CNN,Faster CNN and SDD are compared. The results show that YOLO is comparatively better than the other algorithms.
5	Real-Time Object Detection with Yolo	Geethapriya. S, N. Duraimurugan, S.P. Chokkalingam	The paper demonstrates the use of YOLO in the object detection.YOLO accesses to the entire image in predicting boundaries and also it predicts fewer false positives in background areas.

Table 2.1.1

CHAPTER 3

SOFTWARE REQUIREMENTS SPECIFICATION

3.1 Assumptions and Dependencies

• The surrounding environment in which user travels has obstacles in its way.
• The mobile device which user carries has good internet connectivity.
• The system is also dependent on power supply.

3.2 Functional Requirements

• The Sensors on the stick will detect obstacles in path of user.
• The images captured by Pi Cam will detect images in the surrounding and notify it to user in the form of audio.

3.3 External Interface Requirements (if any)

3.3.1 Hardware Interfaces

• Raspberry Pi 0W/4

Raspberry pi is a device that contains several important functions on a single chip. It is a system on a chip(SoC). The Raspberry Pi 4 uses Broadcom BCM2837 SoC Multimedia processor. The Raspberry Pi's CPU is the 4x ARM Cortex-A53, 1.2GHz processor. It has internal memory 1GB LPDDR RAM (900Mhz) and external memory can be extended to 64 GB. In Raspberry Pi 3, the two main new features are wireless internet connection 802.11n and Bluetooth 4.1 classic. It has 40 GPIO pins.

• Raspberry Pi Camera Module

The inbuilt camera captures the images of the text. The quality of the image captured depends on the camera used. We are using the Raspberry Pi's camera which 5MP camera with a resolution of 2592x1944.

• Microphone

The image captured will be converted to audio. This audio will be relayed to the user using a microphone

• **Walking Stick**

Walking stick is the main component used for the project

3.3.2 Software Interfaces

• Python 3.7
• Jupyter
• Visual studio Code

3.3.3 Communication Interfaces

• Microphone
• Earphone
• Raspberry Pi Camera Module

3.4 Nonfunctional Requirements

3.4.1 Performance Requirements

• The system should immediately notify the user if any obstacles are detected in their path to prevent mishaps from happening.
• The system should quickly notify the user about the image captured through audio feed-back to keep user updated about surrounding environment.

3.4.2 Safety Requirements

• The products required for creating smart walking stick should be tested properly before use and should be tested after placed on stick to check if they function properly under any circumstance.
• The Stick should not explode due to overload.

3.4.3 Security Requirements

3.4.4 Software Quality Attributes

• **Accuracy:**
The software must accurately recognize and distinguish between different objects of similar type and size.
• **Performance:**
Raspberry Pi should be able to handle the computational requirements and

the memory requirements required by the project.
• **Robustness:**
Robustness reduces the impact of operational mistakes, erroneous input data, and hardware errors.
• **Efficiency:**
The output of the program i.e. the speech playback should be done in limited amount of the time.

3.5 System Requirements

3.5.1 Database Requirements

• Kaggle
• Live dataset etc.

3.5.2 Software Requirements

• Python 3.7
• Jupyter
• Scikit learn
• TensorFlow
• Tesseract

3.5.3 Hardware Requirements

• Raspberry Pi Module 3
• Raspberry Pi Camera
• Microphone
• Walking Stick

3.6 Analysis Models:SDLC Model to be applied

For implementaion of our system we are using Spiral Model of Software Development Life Cycle. Spiral model is a risk driven software development process model. Based on the unique risk patterns of the given project, the spiral model guides a team to adopt elements of one or more process models, such as incremental, waterfall or evolutionary prototyping.

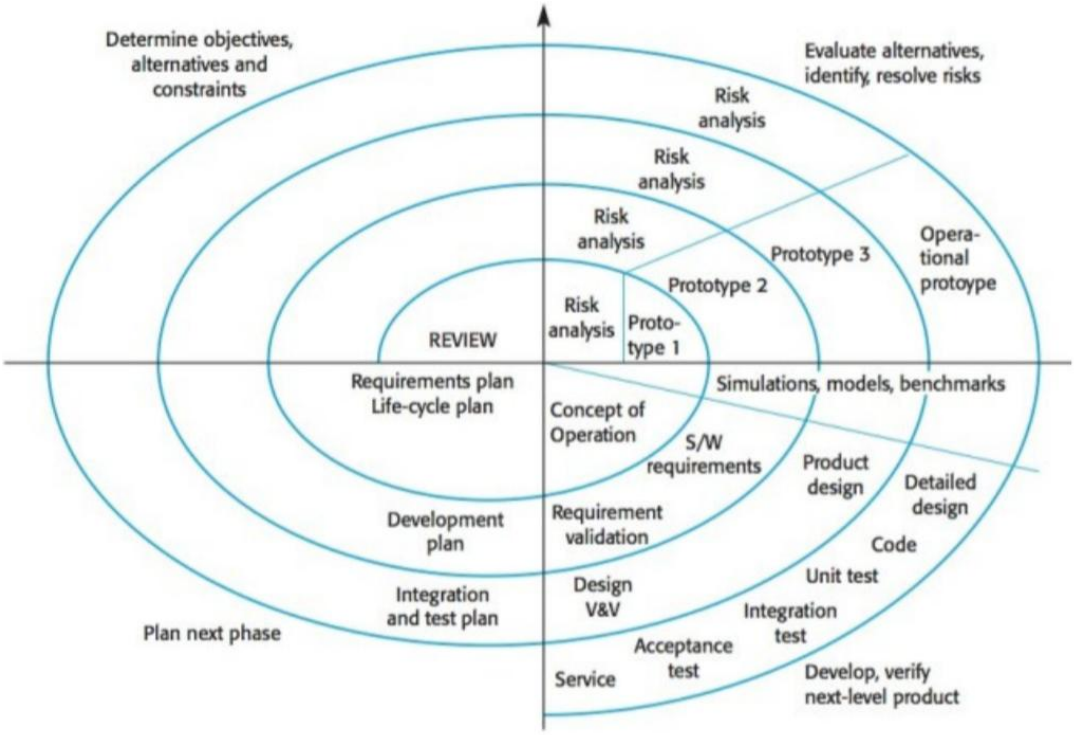


Figure 3.1: System Architecture

CHAPTER 4
SYSTEM DESIGN

4.1 System Architecture

• The system will mainly consist of input, process and output. The stick consists of a Raspberry Pi, ultrasonic sensors and web/Pi Cam.
• The smart application resides on the Raspberry-pi. The proposed system consist of two modules Obstacle Detection and Image Recognition.
• The Ultrasonic Sensors are used for identifying obstacles in user path.
• Image Recognition deals with extracting information from Raspberry Pi Camera module captured images and narrating it back to user.

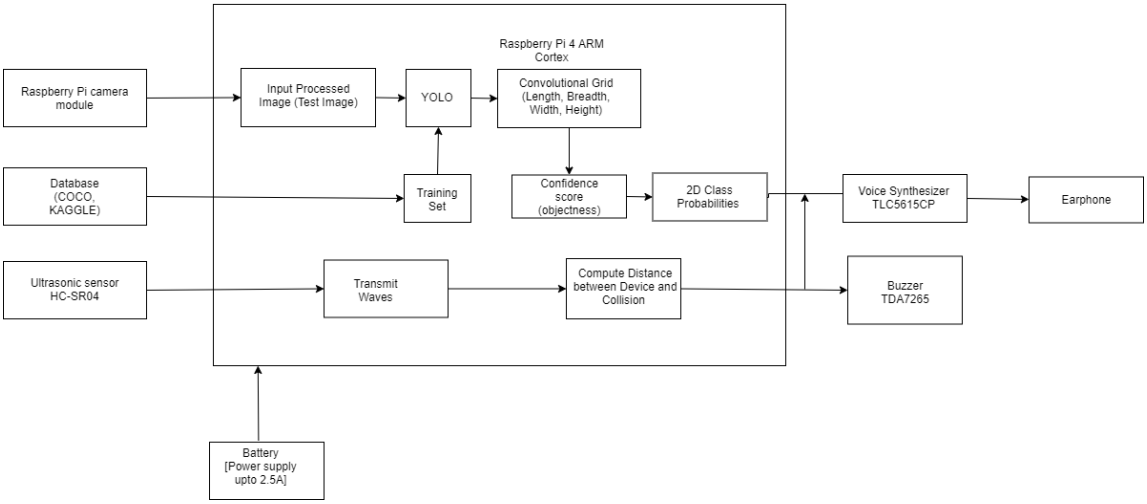
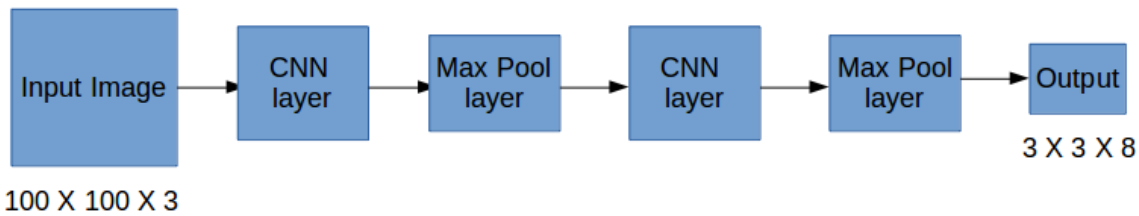


Figure 4.1: System Architecture

4.2 Mathematical Model

y =	pc
	bx
	by
	bh
	bw
	c1
	c2
	c3

- **pc** defines whether an object is present in the grid or not (it is the probability)
- **bx, by, bh, bw** specify the bounding box if there is an object
- **c1, c2, c3** represent the classes. So, if the object is a car, c2 will be 1 and c1 and c3 will be 0, and so on



- We will run both forward and backward propagation to train our model.
- During the testing phase, we pass an image to the model and run forward propagation until we get an output y.

4.3 Data Flow Diagrams / UML Diagrams

1.Use Case

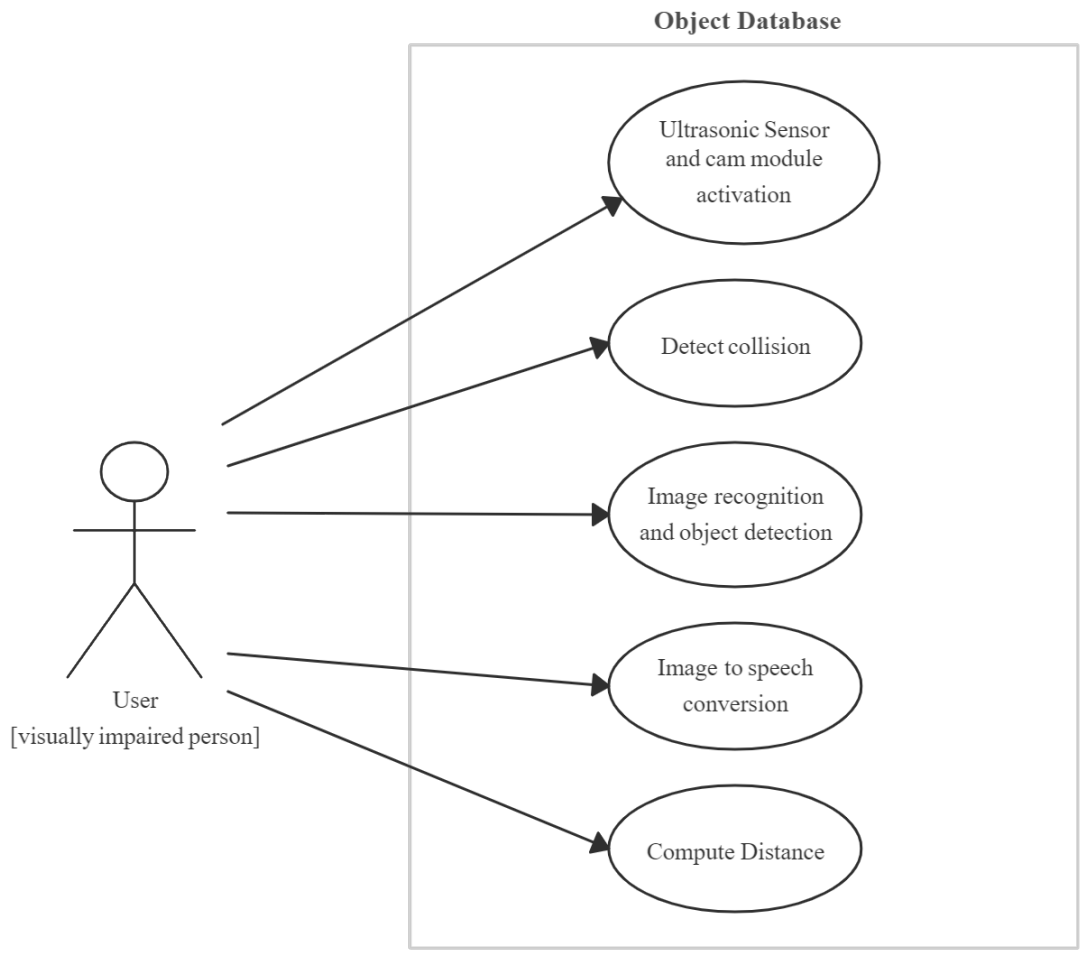


Figure 4.2: Use Case Diagram

2.Sequence

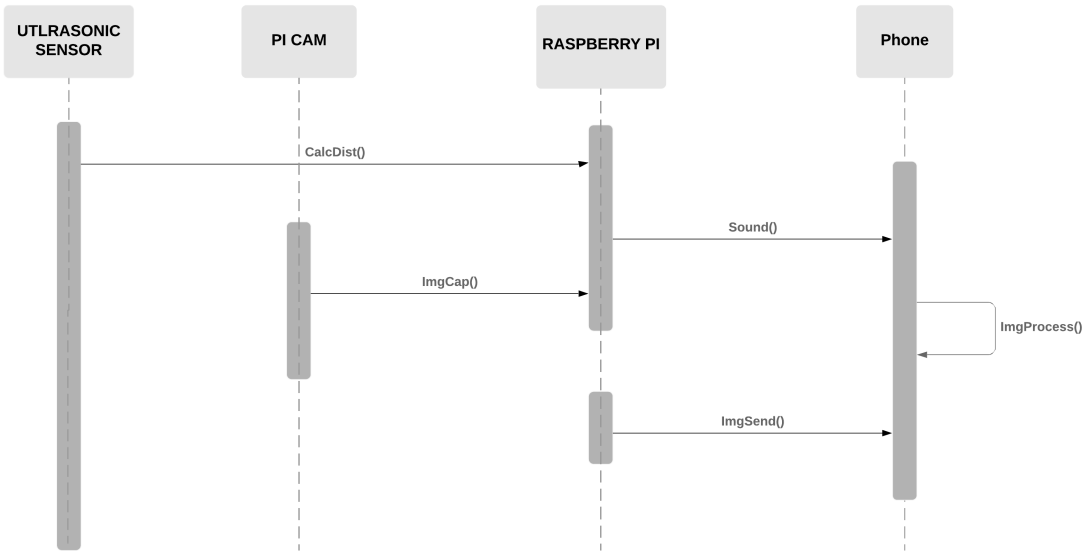


Figure 4.3: Sequence Diagram

3.Flowchart

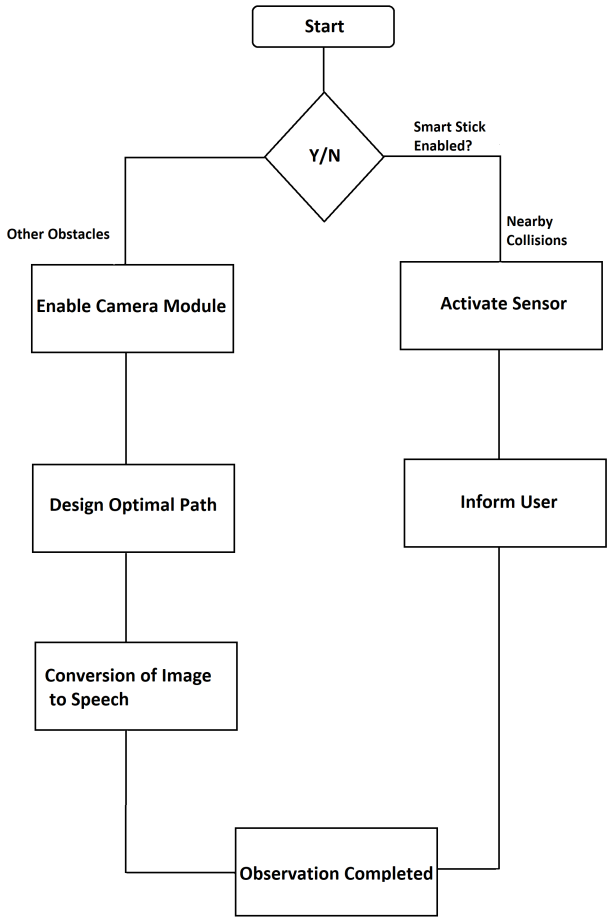


Figure 4.4: Flowchart

4.4 Entity Relationship Diagrams

1. Entity Relationship diagram

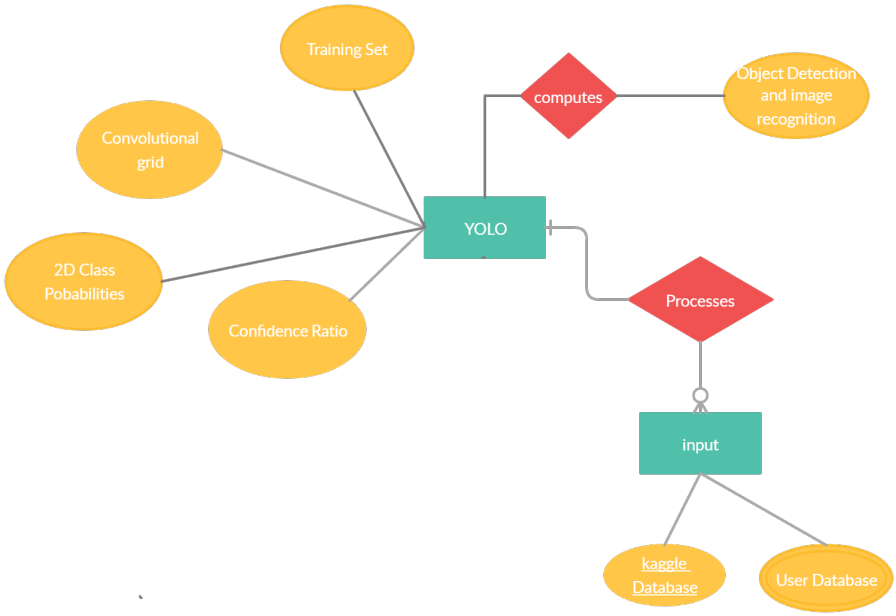


Figure 4.5: Entity Relationship Diagram

2. Components relationship

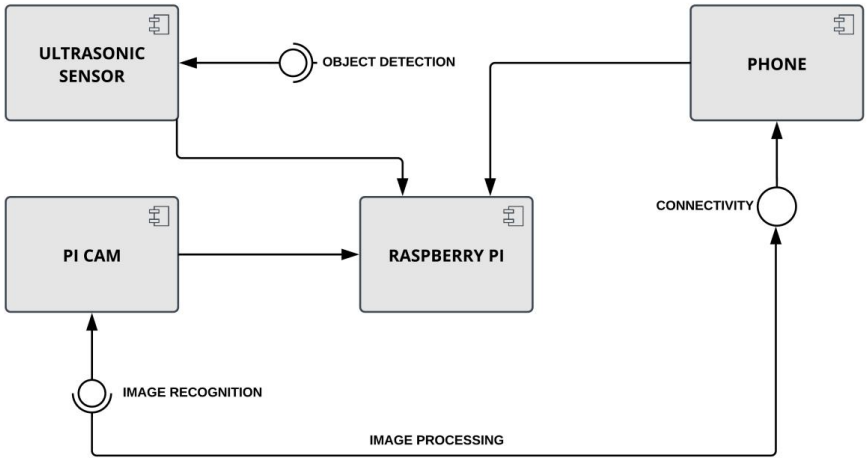


Figure 4.6: Components Diagram

4.5 Raspberry Pi-3 Pin Diagram

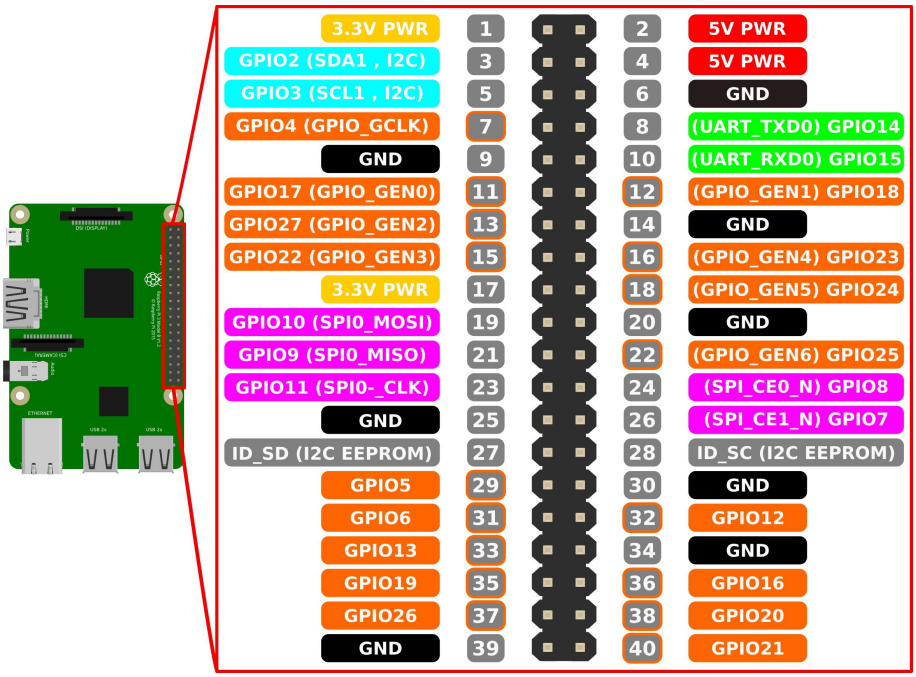


Figure 4.7: Pin Diagram

CHAPTER 5
PROJECT PLAN

5.1 Project Estimate

5.1.1 Reconciled Estimates

Hardware Cost Estimate:

- Raspberry Pi v3 Model b - Rs
- Ultrasonic Sensor HC-SR04 - Rs
- Breadboard -
- Pi Cam v2 -

5.1.2 Project Resources

- **Equipment**
  1)Raspberry Pi
  2)Ultrasonic Sensor
  3)Breadboard
  4)Pi Cam V2
- **Software**
  1)OpenCv
  2)Tensorflow
  3)Jupyter
- **Modeling Tools**
  Spiral Model

5.2 Risk Management

5.2.1 Risk Identification

For risk identification, review of scope document, requirements specification and schedule is done.

ID	Risk Description	Probability	Overall Impact
1	Network Connectivity	High	Medium
2	Operating System Failure	Low	High
3	Discharge of Powerbank	Medium	High
4	Camera Malfunction	Low	Low

Table 5.2.1

5.2.2 Risk Analysis

• In case of low network connectivity response time of image recognition module increases.
• Operating system failure will lead to whole system failure.
• In case of discharge of power bank, Raspberry Pi shuts down.
• In case of Pi Cam pins in Raspberry Pi get shorted, image recognition module will not work.

5.2.3 Overview of Risk Mitigation, Monitoring, Management

For risk identification, review of scope document, requirements specification and schedule is done.

Probability	Value	Description
High	Probability of Occurence	greater than 75 percent
Medium	Probability of Occurence	26 to 75 percent
Low	Probability of Occurence	lesser than 25 percent

Table 5.2.2

5.3 Project Schedule

5.3.1 Project Task Set

Sr. No.	Task	Start Date	End Date
1	Idea Research	13 June 2019	25 June 2019
2	Idea Finalization	04 July 2019	22 July 2019
3	Software and Hardware Requirements	29 July 2019	13 August 2019
4	Obstacle Detection	19 August 2019	21 September 2019
5	Raspberry PI	27 September 2019	11 October 2019
6	Prepare Database for Identification	15 October 2019	10 November 2019
7	Image Recognition	9 December 2019	18 December 2019
8	Image Recognition with Raspberry PI	13 January 2020	29 January 2020
9	Integration of 6th and 8th Module	01 February 2020	23 February 2020
10	Bash File Creation	24 February 2020	19 March 2020
11	testing	13 April 2020	Till Date

Table 5.3.1

5.3.2 Task Network

Task Network is a graphic representation of the task ow for a project. It depicts sequence, concurrency and dependency. It points out inter-task dependencies to help the team ensure continuous progress towards project completion.

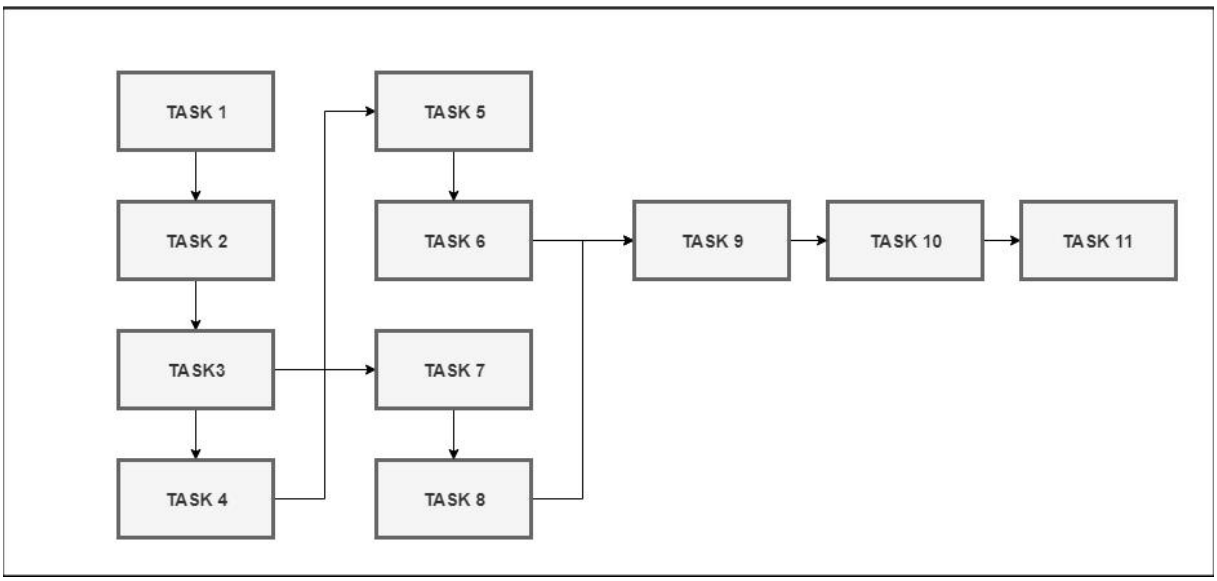


Figure 5.1: Task Network

5.3.3 Timeline Chart

Figure 5.2: Timeline Chart

5.4 Team Organization

5.4.1 Team Structure

The project team consist of four people:

- Mukta Joshi - Hardware Design, installations, implementation of Obstacle Detection,integration and partial documentation.
- Varad Junnarkar - Hardware Design, implementation of Image Recognition, talk back, integration.
- Mayuresh Deshmukh- Implementation of Obstacle Detection, talk back and documentation,testing.
- Shubham Raut - Hardware Design, installations, implementation of Image Recognition,integration and partial documentation.

5.4.2 Management reporting and communication

We have to report to the following staff:

- **Internal Guide** - Guidance on deciding project path, documentation, testing and deployment.
- **Project Coordinator** - Guidance on documentation and coding style. Any progress or doubts are cleared by internal guide. Any changes or suggestions are made adhered to.

CHAPTER 6

PROJECT IMPLEMENTATION

6.1 Overview of Project Modules

The system basically performs two main tasks i.e obstacle detection and image recognition. Obstacle Detection identities obstacles in users route and guides the user to avoid it. Image recognition helps visually impaired to get brief description of its surrounding. These two tasks are explained as follows:

- **Image Recognition:**
  Image Recognition deals with extracting information from Pi Cam captured images and narrating it back to user. For capturing images the Pi Cam is placed on the stick and it captures the images periodically according to timer set by us. The captured images are then analyzed by applications artificial intelligence which generate captions for the image. The sentence is then narrated to user using eSpeak. The Microsoft azure API is what really powers the artificial intelligence in our system.

- **Obstacle Detection:**
  The Ultrasonic Sensors are used for identifying obstacles in user path. These sensors work using ultrasound. The ultrasonic distance sensor works by sending out a burst of ultrasound. This sound will travel through air, but return back (echo) or hard surfaces. The sensor can detect the echo, when it returns. By knowing the time between the outgoing burst and returning echo, and the speed of sound, you can calculate how far an object is away from the sensor. The vibration motor is used to guide user through how far or close the obstacles are.

6.2 Tools and Technologies Used

- **Programming Language:** Python 3
- **Technologies:** Following Libraries and Frameworks are used: pip , numpy, OpenCV, tensorflow
- **IDE:** Microsoft Visual Studio

6.3 Algorithm Details

6.3.1 Algorithm

Object Detection

1. Start
2. Capture the input image using webcam
3. The framework then divides the input image into grids
4. YOLO then predicts the bounding boxes and their corresponding class probabilities for objects
5. YOLO then finds the probabilities of the class and its threshold
6. Define a function to calculate the IoU between two boxes
7. Define a function for Non-Max Suppression
8. YOLO will then define a function which will take the outputs of a CNN as input and return the suppressed boxes.
9. The ouput will be displayed along with the predicted class and the bounding boxes.
10. End

CHAPTER 7

SOFTWARE TESTING

7.1 Types of Testing

There are many types of testing as follows:

- **Unit Testing**
  Unit testing is the testing of an individual unit or group of related units. It falls under the class of white box testing. It is often done by to test that the unit he/she has implemented is producing expected output against given input. For Example: To test if distances are correctly calculated to test obstacle detection module.

- **Integration Testing**
  Integration means combining. For Example, In this testing phase, obstacle detection module and image recognition module when combined is tested if they work properly when integrated. Integrating testing checks the data ow from one module to other modules. This kind of testing is performed by testers.

- **System Testing**
  System testing is performed on a complete, integrated system. It allows checking system's compliance as per the requirements. It tests the overall interaction of components. It involves load, performance, reliability and security testing. System testing most often the test to verify that the system meets the specification. It evaluates both functional and non-functional need for the testing. For Example: Testing the stick system after creation of final bash file.

- **Functional Testing**
  Functional testing is the testing to ensure that the specified functionality required in the system requirements works. It falls under the class of black box testing.

- **Stress Testing**
  Stress testing is the testing to evaluate how system behaves under unfavorable conditions. Testing is conducted at beyond limits of the specifications. It falls under the class of black box testing.

- **Performance Testing**
  Performance testing is the testing to assess the speed and effectiveness of the system and to make sure it is generating results within a specified time as in performance requirements. It falls under the class of black box testing. For Example: Checking number of processor cycles.

- **Regression Testing**
  Every time new module is added leads to changes in program. This type of testing make sure that whole component works properly even after adding components to the complete program. For Example: In our stick we have obstacle detection module, and adding vibration motor to this and varying its pulses according to distance, and checking if on integration these module works fine is regression testing.

- **Beta Testing**
  Beta testing is the testing which is done by end users, a team outside development, or publicly releasing full pre-version of the product which is known as beta version. The aim of beta testing is to cover unexpected errors. It falls under the class of black box testing.For Example:When software testing is performed for the limited number of people

7.2 Test Cases Test Results

- Test Object -Laptop
  Result -Pass
- Test Object -Human
  Result -Pass
- Test Environment -Office
  Result -Pass
- Test Environment -Home
  Result -Pass

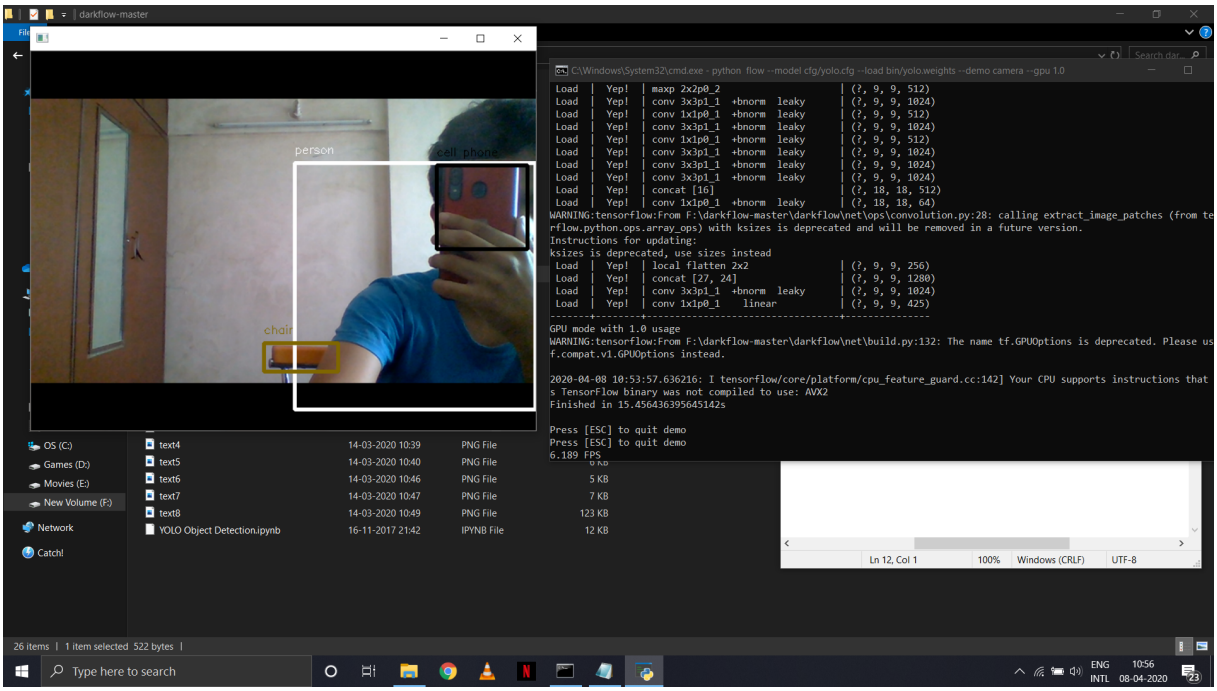
CHAPTER 8

RESULTS

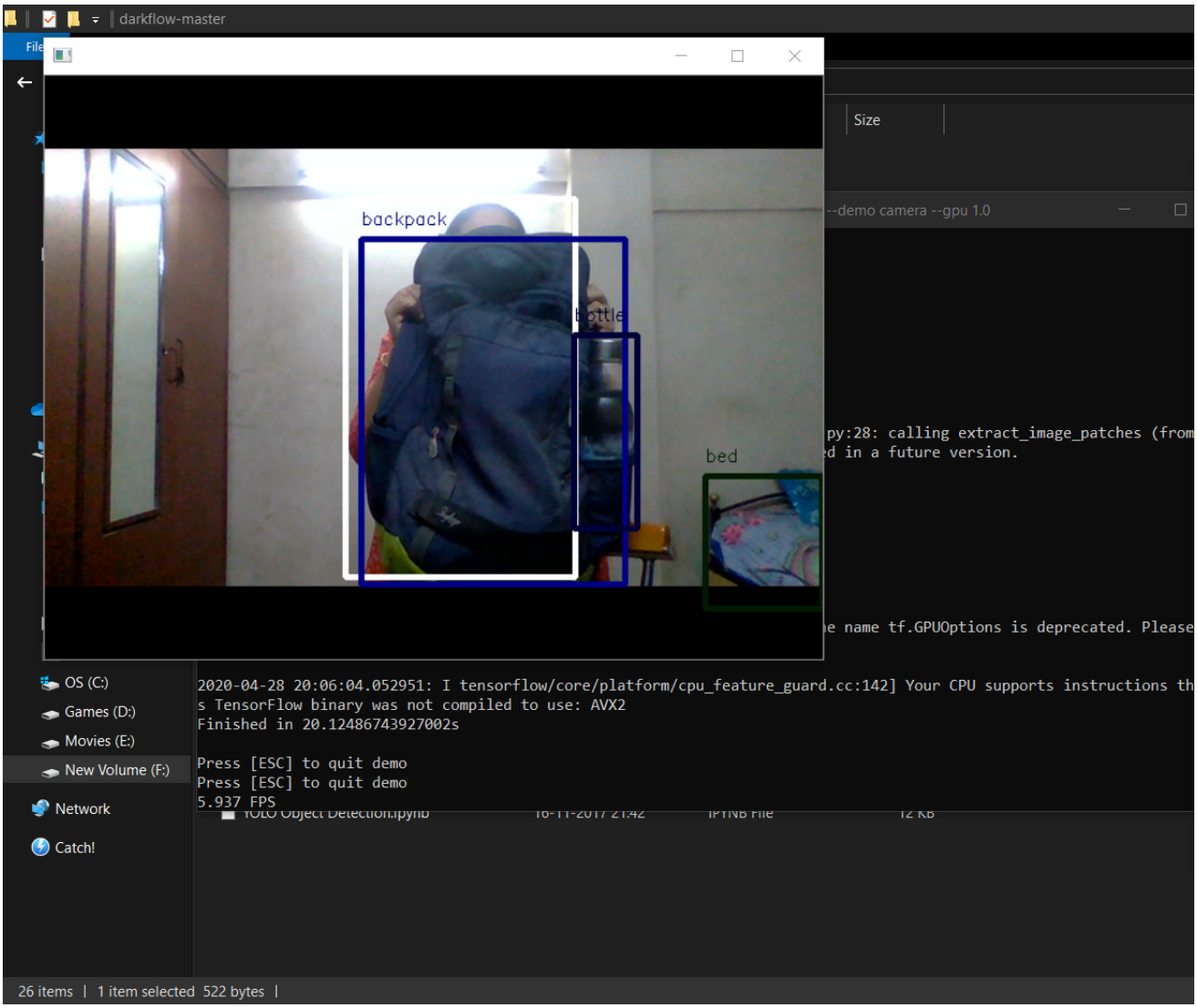
8.1 Outcomes

Object class detection uses the special features of every data object provided. The Convolutional Network will scan every feature and provide the optimum result.

1.Detection of a person



2.Detection of a backpack



8.2 Screen Shots

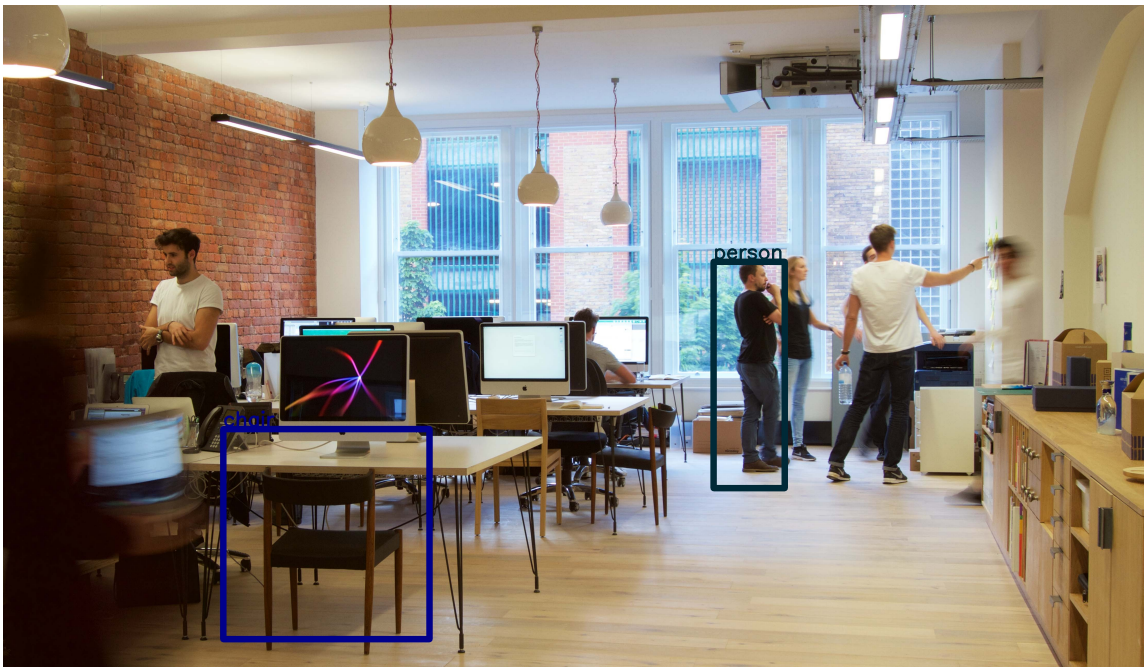


Figure 8.1: Object recognised at an Office

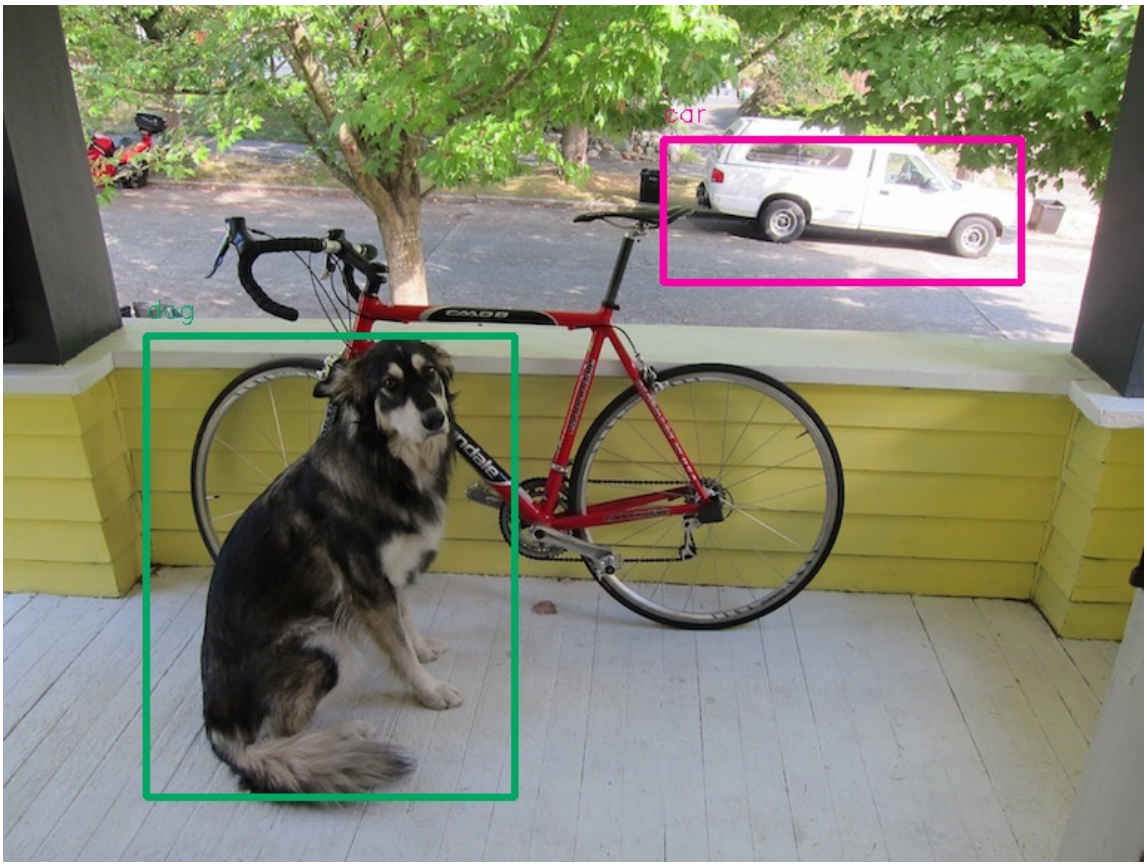


Figure 8.2: Object Recognition in a surrounding having multiple objects

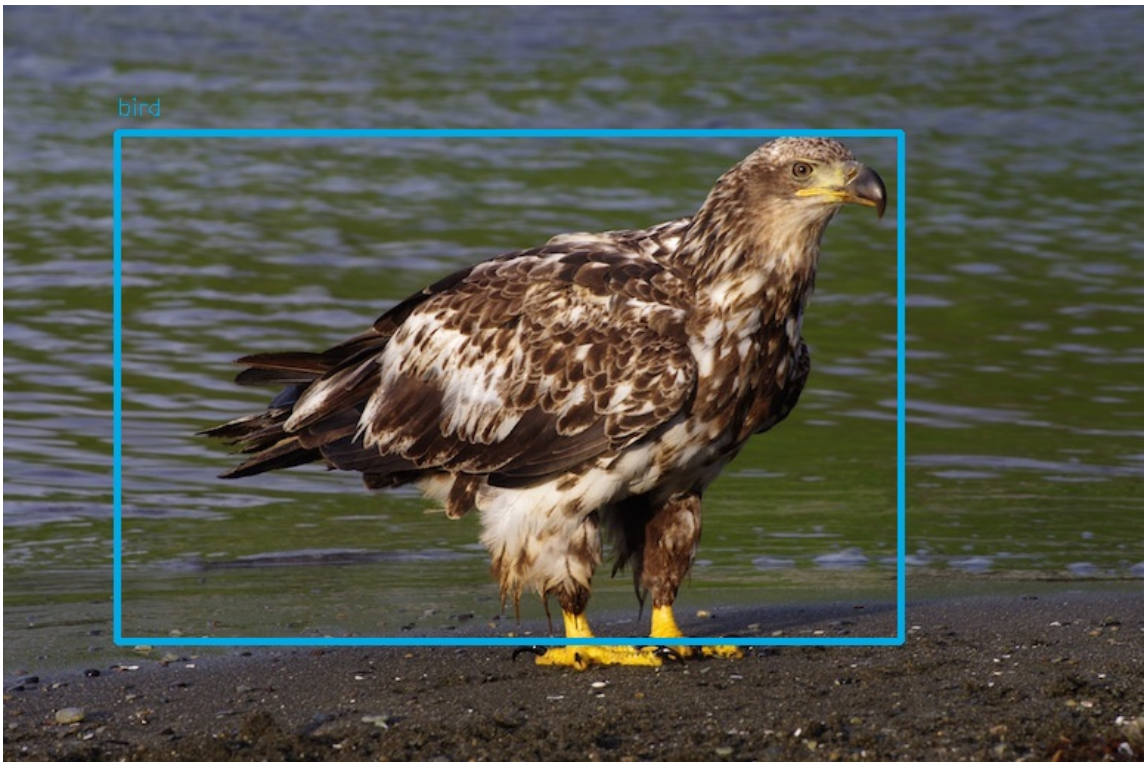


Figure 8.3: Isolated Object Identification

CHAPTER 9
CONCLUSIONS

9.1 Conclusions

- We proposed about YOLO algorithm for the purpose of detecting objects using a single neural network.This algorithm is generalized, it outperforms different strategies once generalizing from natural pictures to different domains.
- The algorithm is simple to build and can be trained directly on a complete image.Region proposal strategies limit the classifier to a particular region.
- YOLO accesses to the entire image in predicting boundaries.
- It is used for assisting visually impaired in their navigation. The system performs two main tasks image recognition and obstacle detection allowing user to navigate independently.
- Using appropriate hardware and developing application, our system manages to overcome hurdles of visually impaired. The said system is cost effective and will prove as a boon for the visually impaired.

9.2 Future Work

We plan to design an optimum path and give navigation instructions.Also we will try to reduce the time to detect objects.

9.3 Applications

- Smart stick will help the visually impaired to easily detect obstacles and help him or her to walk on the sidewalks with ease.
- Object detection and conversion to speech will be a much reliable option for the visually impaired people.
- Yolo will reduce the proccessing time of algorithm thus better results will help the blind with better efficiency.

ANNEXURE A

- **Technical Feasibility:-**
  The project is implemented using programming languages like python, java. The projectis implemented to analyze the image and detect the obstacles to the end user.

- **Economic Feasibility:-**
  The project is cost effective as it requires less hardware components and does not require any additional servers.

- **Operational Feasibility:-**
  The algorithm implemented can be improved to reduce power consumption and increase efficiency. The system will efficiently detect obstacles.

ANNEXURE B

- **Prof. Dr. S.A. Itkar, Siddhi Degaonkar, Mohit Gupta, Musahib Singh, Prajakta Hiwarkar, "A Smart walking stick powered by Artificial Intelligence for the Visually impaired"**
  The purpose of developing a cost-effective smart walking stick for the visually impaired and the need increased with a steady increase in their population worldwide. The smart stick presented in this paper uses artificial intelligence along with ultrasonic sensors to help the visually disabled people to navigate through the environment independently. Image recognition, Collision detection and obstacle detection are the tasks performed on a raspberry pi having high processing power. The task of obstacle detection and obstacle avoidance makes use of ultrasonic sensors to alert the user of the obstacles appearing in his path.

- **Drd.Alexandru Cazan, prof. Radu Vârbanescu and prof. Dan Popescu Politehnica University of Bucharest 313, Splaiul Independentei , Bucharest, Romania, "Algorithms and Techniques for Image to Sound Conversion for Helping the Visually Impaired People – Application Proposal"**
  This paper presents a system that transforms images acquired with a camera into sounds. The system is designed for the visually impaired people and will convert real time images into sounds, respecting a certain algorithm, to preserve the visual information, but not forgetting the limitations imposed by the human hearing system. The resolution used for images to be conversed is to be found out after some future tests and statistics.

- **Rajesh Kedia, Yoosuf K K, Pappireddy Dedeepya, Munib Fazal, Chetan Arora†, and M. Balakrishnan Indian Institute of Technology Delhi † Indraprastha Institute of Information Technology Delhi,"MAVI: An Embedded Device to Assist Mobility of Visually Impaired"** Considering the limitations with existing aids for mobility of visually impaired, we propose a new device to help visually impaired in their outdoor mobility. This device uses an RGB camera and image processing techniques to recognize the surrounding objects and inform/alarm the user accordingly. Our prototype incorporates signboard detection, face detection and surface texture detection to address issues related to mobility of a visually impaired user.

- **Geethapriya. S, N. Duraimurugan, S.P. Chokkalingam International Journal of Engineering and Advanced Technology (IJEAT) ISSN: 2249 – 8958, Volume-8, Issue-3S, February**

2019 Real-Time Object Detection with Yolo" The Objective is to detect of objects using You Only Look Once (YOLO) approach. This method has several advantages as compared to other object detection algorithms. In other algorithms like Convolutional Neural Network, FastConvolutional Neural Network the algorithm will not look at the image completely but in YOLO the algorithm looks the image completely by predicting the bounding boxes using convolutional network and the class probabilities for these boxes and detects the image faster as compared to other algorithms.

- **Juan Du 2018 J. Phys.: Conf. Ser. 1004 012029 *IOP Conf. Series: Journal of Physics: Conf. Series 1004 (2018) 012029 Understanding of Object Detection Based on CNN Family and YOLO"** As a key use of image processing, object detection has boomed along with the unprecedented advancement of Convolutional Neural Network (CNN) and its variants since 2012. When CNN series develops to Faster Region with CNN (R-CNN), the Mean Average Precision (mAP) has reached 76.4, whereas, the Frame Per Second (FPS) of Faster R-CNN remains 5 to 18 which is far slower than the real-time effect. Thus, the most urgent requirement of object detection improvement is to accelerate the speed. Based on the general introduction to the background and the core solution CNN, this paper exhibits one of the best CNN representatives You Only Look Once (YOLO), which breaks through the CNN family's tradition and innovates a complete new way of solving the object detection with most simple and high efficient way. Its fastest speed has achieved the exciting unparalleled result with FPS 155, and its mAP can also reach up to 78.6, both of which have surpassed the performance of Faster R-CNN greatly.

ANNEXURE C

Plagiarism Report pf project report

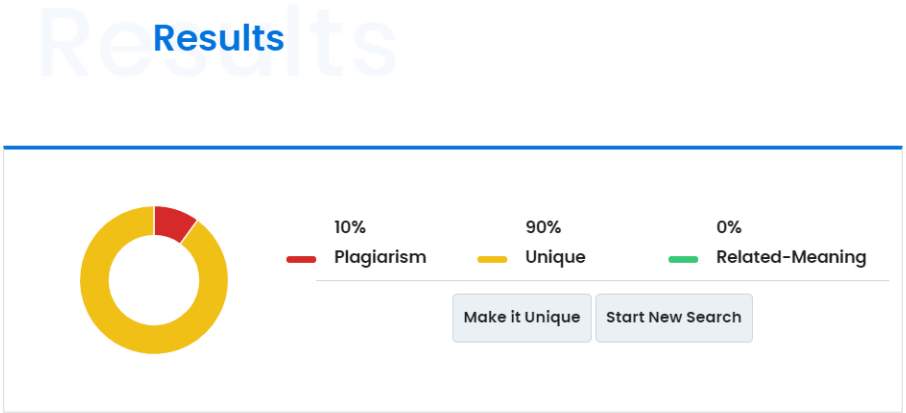


Figure 9.1

CHAPTER 10

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