BMS INSTITUTE OF TECHNOLOGY AND MANAGEMENT

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Department of Electronics and Telecommunication Engineering

Project Work Phase-2 Presentation (18TEP83)

on

"SafePath: Advanced Obstacle-Aware Cruise Control System"

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CONTENTS

INTRODUCTION

- In today's fast-paced society, the persistent threat of automobile accidents remains a critical concern, particularly in countries like India where road transport is predominant.
- According to the Ministry of Road Transport and Highways (MoRTH) data, the total number of road accident deaths due to potholes in 2018, 2019 and 2020 stood at 2,015, 2,140 and 1,471, respectively.
- Potholes, prevalent on Indian roadways, significantly contribute to accidents due to heavy traffic and inadequate maintenance.
- Adaptive Cruise Control (ACC) represents a significant advancement in automotive technology, dynamically adjusting vehicle speeds to maintain safe distances from other vehicles, thereby enhancing road safety.
- The proposed initiative aims to revolutionize vehicle safety and driving efficiency by integrating Adaptive Cruise Control (ACC) with Object Detection (YOLOv8) technology. This integration aims to develop an intelligent vehicle capable of identifying potholes, assessing their severity, and autonomously determining the optimal action for safety and comfort.

LITERATURE SURVEY

TITLE	YEAR	AUTHOR	PUBLICATION	METHODOLGY
Realtime Detection of Humps and Potholes	2023	Tejas B S; V Pavan; Rohith H; Pranam J; Veena N. Hegde	International Conference on Smart Systems for applications in Electrical Sciences (ICSSES)	The Custom Object detection TensorFlow Lite model has been implemented to detect hump and pothole classes from live images captured by the webcam on the Raspberry Pi 3. Also, the Python script evaluates the detection by checking the variations in Gyroscope readings on the MPU6050 sensor verified for real world scenarios. Upon positive detection by computer vision followed by positive verification from the sensor, the result class is published along with the latitude and longitude.

LITERATURE SURVEY

TITLE	YEAR	AUTHOR	PUBLICATION	METHODOLGY
Laser-based Detection and Depth Estimation of Dry and Water-Filled Potholes: A Geometric Approach	2019	Kiran Kumar Vupparaboina; Roopak R. Tamboli; P. M. Shenu; Soumya Jana	National Conference on Communications (NCC)	The laser source projects a laser onto the pothole and then the camera captures the image of the laser. The laser line captured by camera is separated from the background using thresholding operation. The binary output is compared with the reference template to detect the deformation. The template consists of an image of laser line on road without pothole. A mismatch between the template image and its binary version immediately indicates the unevenness of the road, possibly a pothole.

LITERATURE SURVEY

TITLE	YEAR	AUTHOR	PUBLICATION	METHODOLGY
IoT Based Humps and Pothole Detection on Roads and Information Sharing	2020	Chellaswamy C Anusuya T Famitha H Amirthavarshini S	International Conference on Computation of Power, Energy, Information and Communication (ICCPEIC)	An internet of things-based road monitoring system (IoTRMS) is proposed to identify the potholes and humps in the road.an accelerometer has been included with the ultrasonic sensor to measure variation present in the signal and optimized using honeybee optimization (HBO) technique. The IoT-RMS automatically updates the status of the road with location information in the cloud. Each road vehicles can access the information from the server and estimate the speed according to the potholes and humps present on the road.

LITERATURE SURVEY

TITLE	YEAR	AUTHOR	PUBLICATION	METHODOLGY
A Modern Pothole Detection technique using Deep Learning	2020	Abhishek Kumar Chakrapani Dhruba Jyoti Kalita Vibhav Prakash Singh	International Conference on Data, Engineering and Applications (IDEA)	The proposed system can detect potholes in real-time in images/videos captured by a camera mounted on the vehicle and to give an alert to the driver about the pothole on road in front of the vehicle. The system will detect the location of the pothole and upload the same on map so that other users who have no camera mounted on their vehicle can get alert about the pothole using the app only. This system uses complex CNN architectures like Inception v1 (GoogLeNet), inception v2 and finally select inception v2.

LITERATURE SURVEY

TITLE	YEAR	AUTHOR	PUBLICATION	METHODOLGY
Accelerometer Sensor Network for Reliable Pothole Detection	2021	Teodor Kalushkov Georgi Shipkovenski Emiliyan Petkov Rositsa Radoeva	International Symposium on Multidisciplinary Studies and Innovative Technologies (ISMSIT)	This system for pothole detection uses detection nodes with two accelerometers. The system exploits two detection methods, based on z-axis algorithms, to determine the number and location of potholes using a mobile phone and an external controller with a GY-521 sensor. When both devices detect a pothole, the sensor node sends an alert with GPS coordinates to a central node, which maintains the database. In such manner, the system response is delayed inversely with the route load, but the reliability increases significantly.

LITERATURE SURVEY

TITLE	YEAR	AUTHOR	PUBLICATION	METHODOLGY
Road Pothole Detection System Based on Stereo Vision	2020	Yaqi Li Christos Papachristou Daniel Weyer	IEEE National Aerospace and Electronics Conference	A stereo vision system is proposed which detects potholes during driving. This system contains two USB cameras that take photos simultaneously. Parameters are obtained from camera calibration with checkerboard to calculate the disparity map. 2-dimensional image points can be projected to 3-dimensional world points using the disparity map. With all the 3-dimensional points, the bi-square weighted robust least-squares approximation for road surface fitting is used. All points below the road surface model can be detected as pothole region.

PROBLEM STATEMENT

"The condition of roadways, particularly the prevalence of potholes, poses a significant challenge to road safety and driving comfort."

OBJECTIVES

1. To detect potholes in real-time.

2. To classify potholes based on its depth.

3. To change the speed of the vehicle based on its classification.

PROPOSED METHODOLOGY

- This project proposes a novel technology which uses the Adaptive Cruise Control (ACC) with the Object detection system to detect potholes and dynamically control the speed to the vehicle.
- The object detection algorithm used here is YOLOv8. It is trained based on the data sets and detect the potholes.
- The potholes are detected and classified based on its depth. LiDAR sensor is used for depth estimation. It classifies the potholes as safe, medium and risk.
- This depth data is serially communicated to the Arduino which controls the speed of the vehicle.
- For a safe pothole, the vehicle speed remains the same. For a medium pothole, the vehicle speed reduces and for a risk pothole, the vehicle stops.

BLOCK DIAGRAM

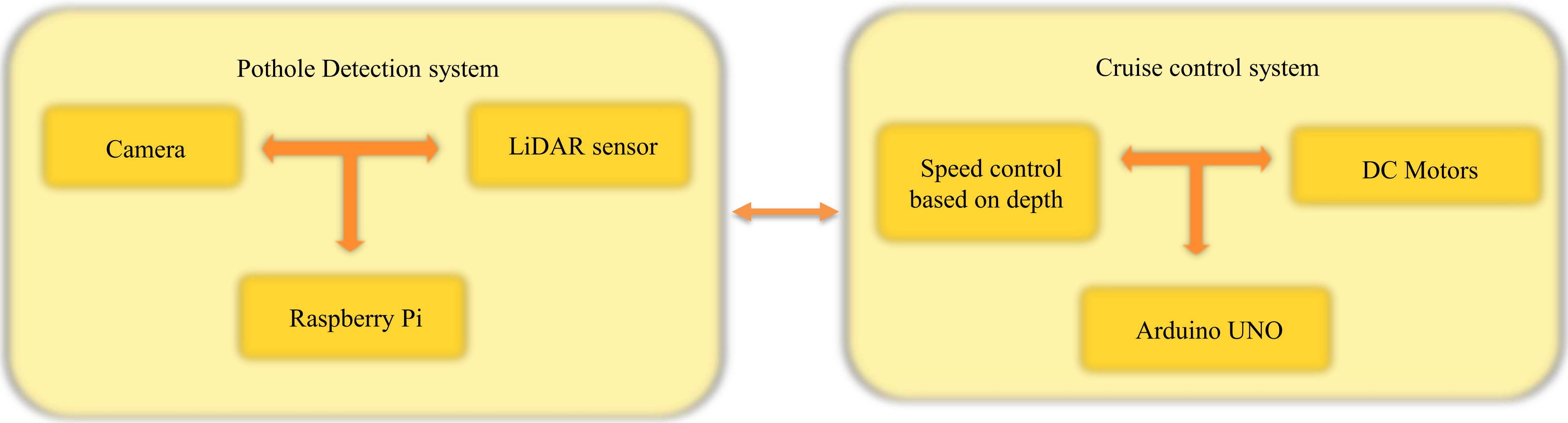


Fig 1: Block diagram of SafePath

REQUIREMENT SPECIFICATIONS

Hardware Requirements:

- Four Wheel Chassis
- DC Motors
- Arduino UNO
- Motor Driver (L298N Module)
- LiPo Battery (3.7 V, 2000 mAh)
- Ultrasonic Sensor (HC-SR04)
- LIDAR Sensor (VL53L0X)
- Raspberry Pi 4 Model B
- Raspberry Pi Camera module
- Raspberry Pi Display (3.5 Inch)

Software Requirements:

- Raspberry Pi OS
- Arduino IDE
- Python

CIRCUIT DIAGRAM

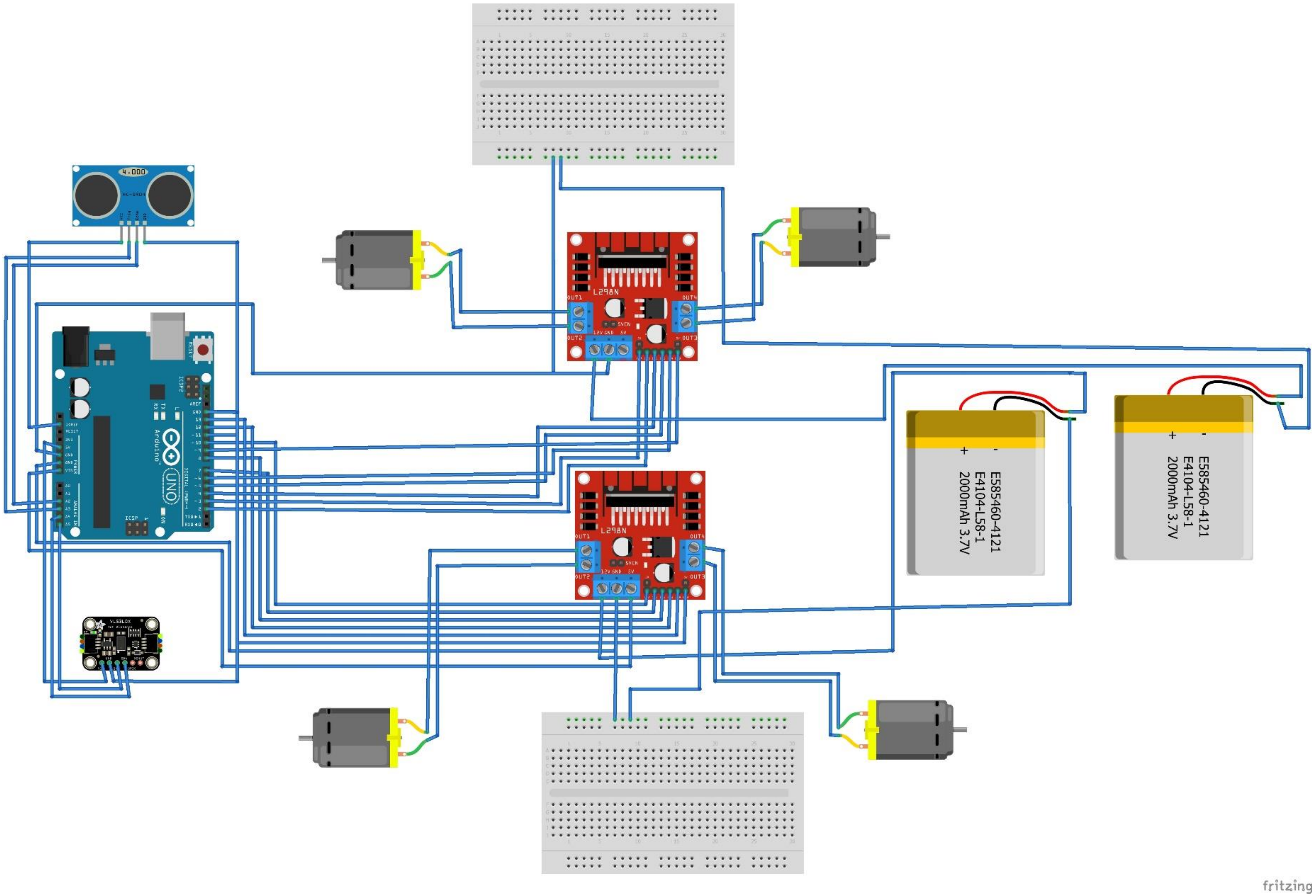
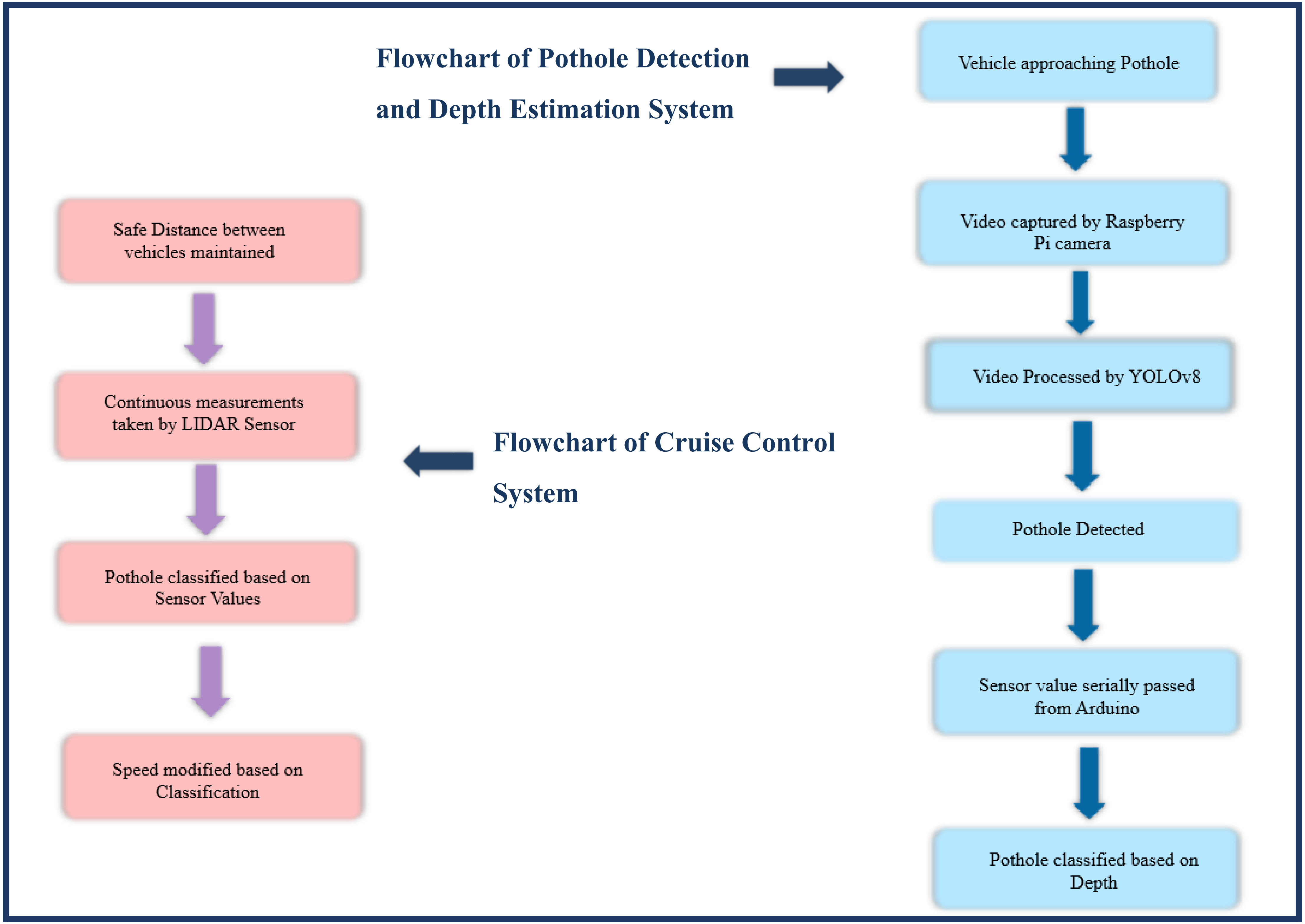
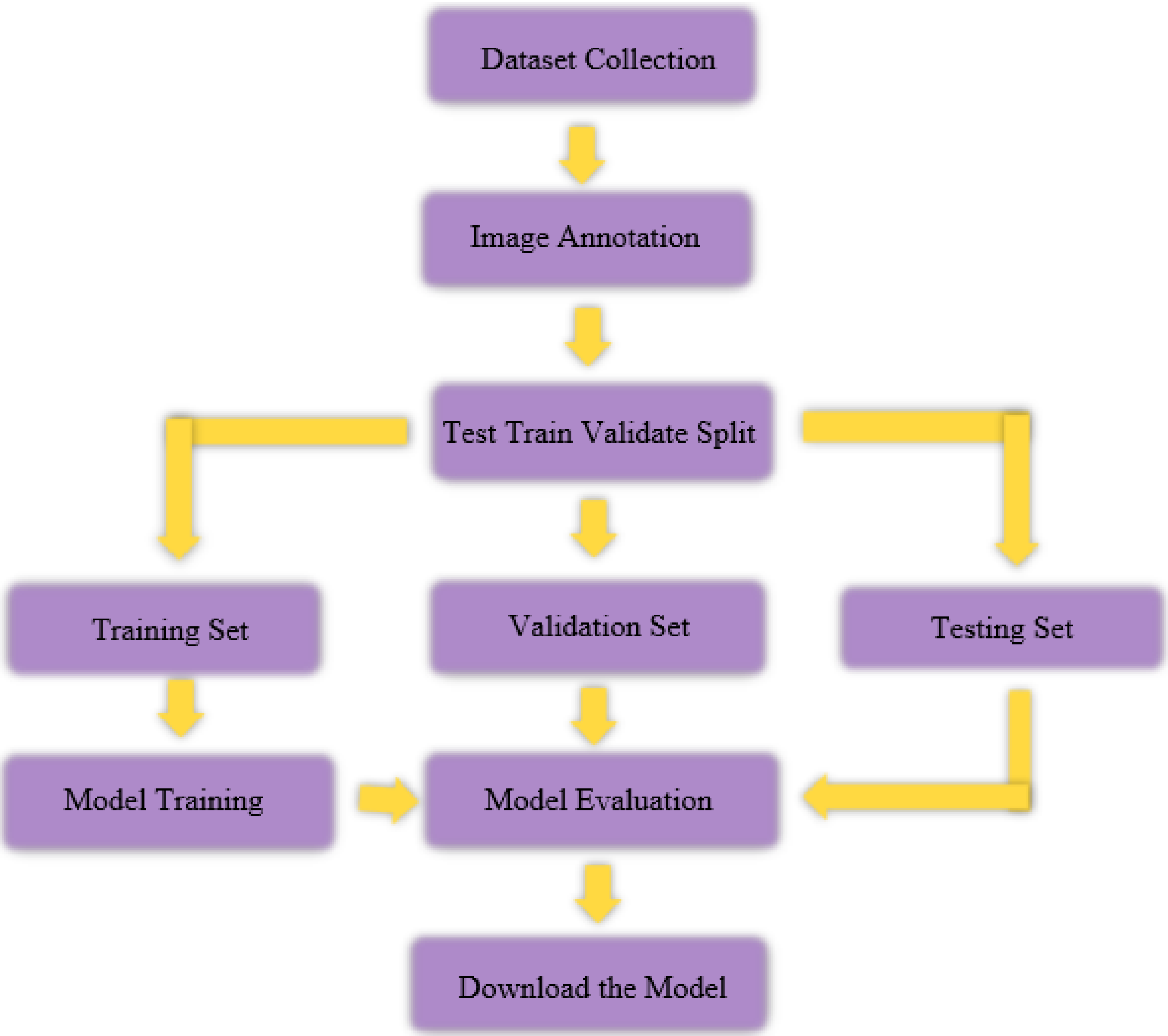


Fig 2: Circuit diagram of the implemented hardware

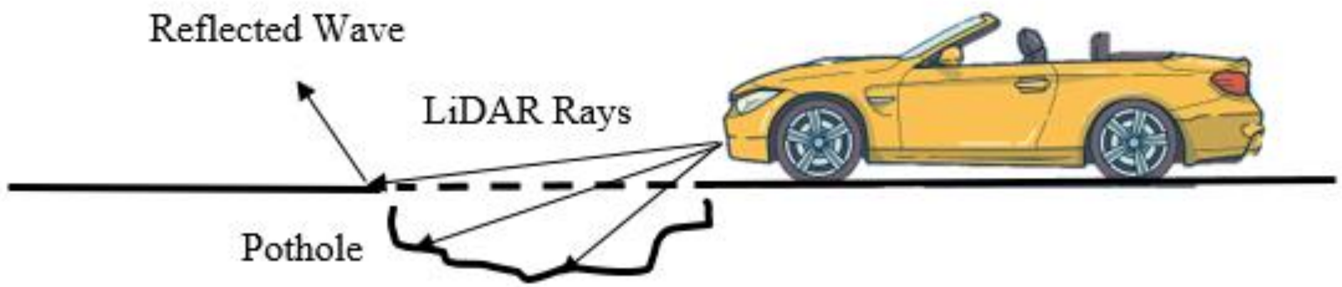

Flowchart of Pothole Detection and Depth Estimation System
Vehicle approaching Pothole
Video captured by Raspberry Pi camera
Video Processed by YOLOv8
Pothole Detected
Sensor value serially passed from Arduino
Pothole classified based on Depth
Flowchart of Cruise Control System
Safe Distance between vehicles maintained
Continuous measurements taken by LIDAR Sensor
Pothole classified based on Sensor Values
Speed modified based on Classification

YOLOv8 IMPLEMENTATION FLOWCHART



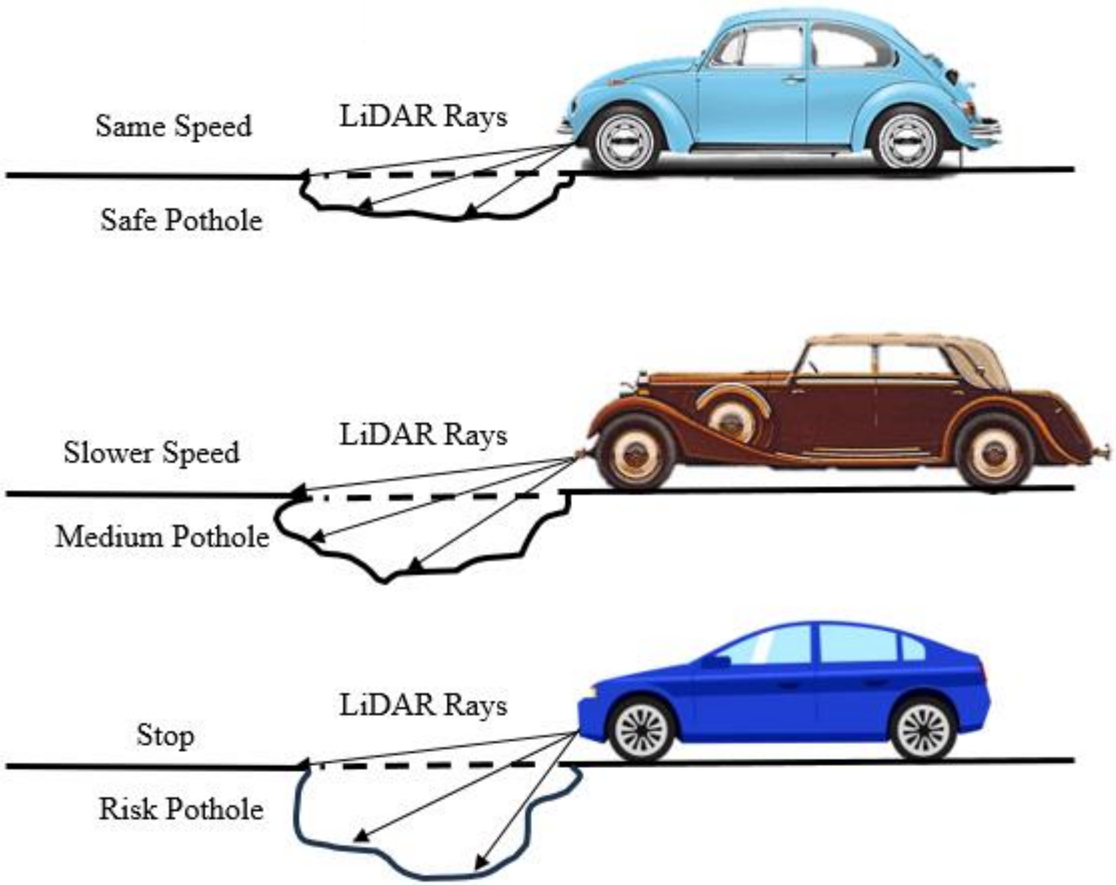
POTHOLE DEPTH ESTIMATION

- Pothole depth estimation relies on a LIDAR sensor mounted on the vehicle emitting laser pulses towards the road surface, accurately measuring the distance to various points along their path maintaining a consistent distance from the ground.
- When encountering a pothole, distance between the sensor and the road surface increases, as the laser pulse reflects off the bottom of the pothole instead of the road's surface, allowing for calculation of the depth based on the disparity between these distances.
- This difference between distances is used to classify the potholes as Safe, Medium or Risk.



CRUISE CONTROL SYSTEM

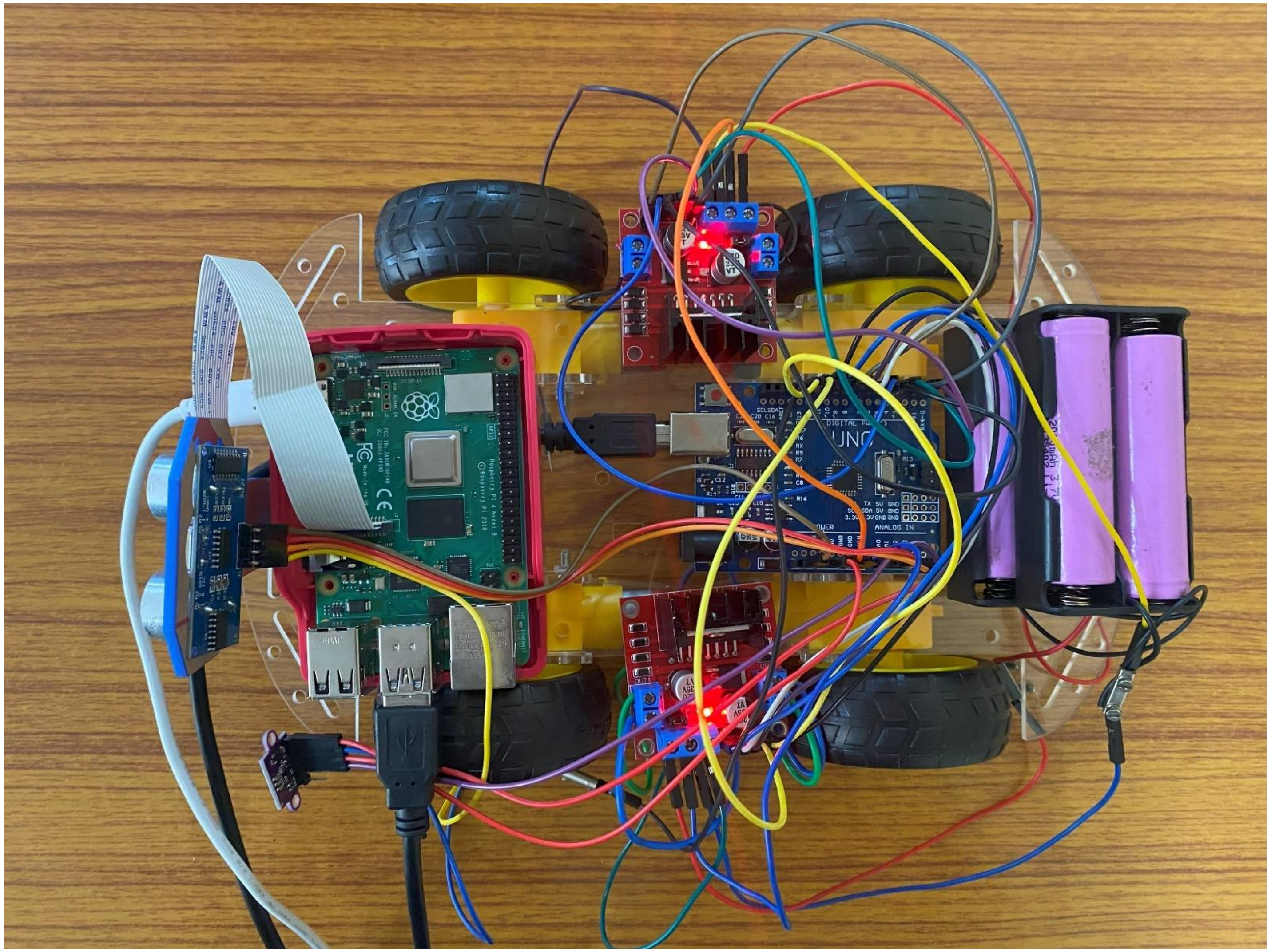
- The cruise control system operates by categorizing potholes into different classes. Initially, it ensures a safe distance from the leading vehicle. Then, it adjusts the vehicle's speed based on the pothole classification: for safe-class potholes, the speed is slightly reduced, for medium-class, it is decreased further, and for high-risk-class potholes, the vehicle is brought to a complete stop.



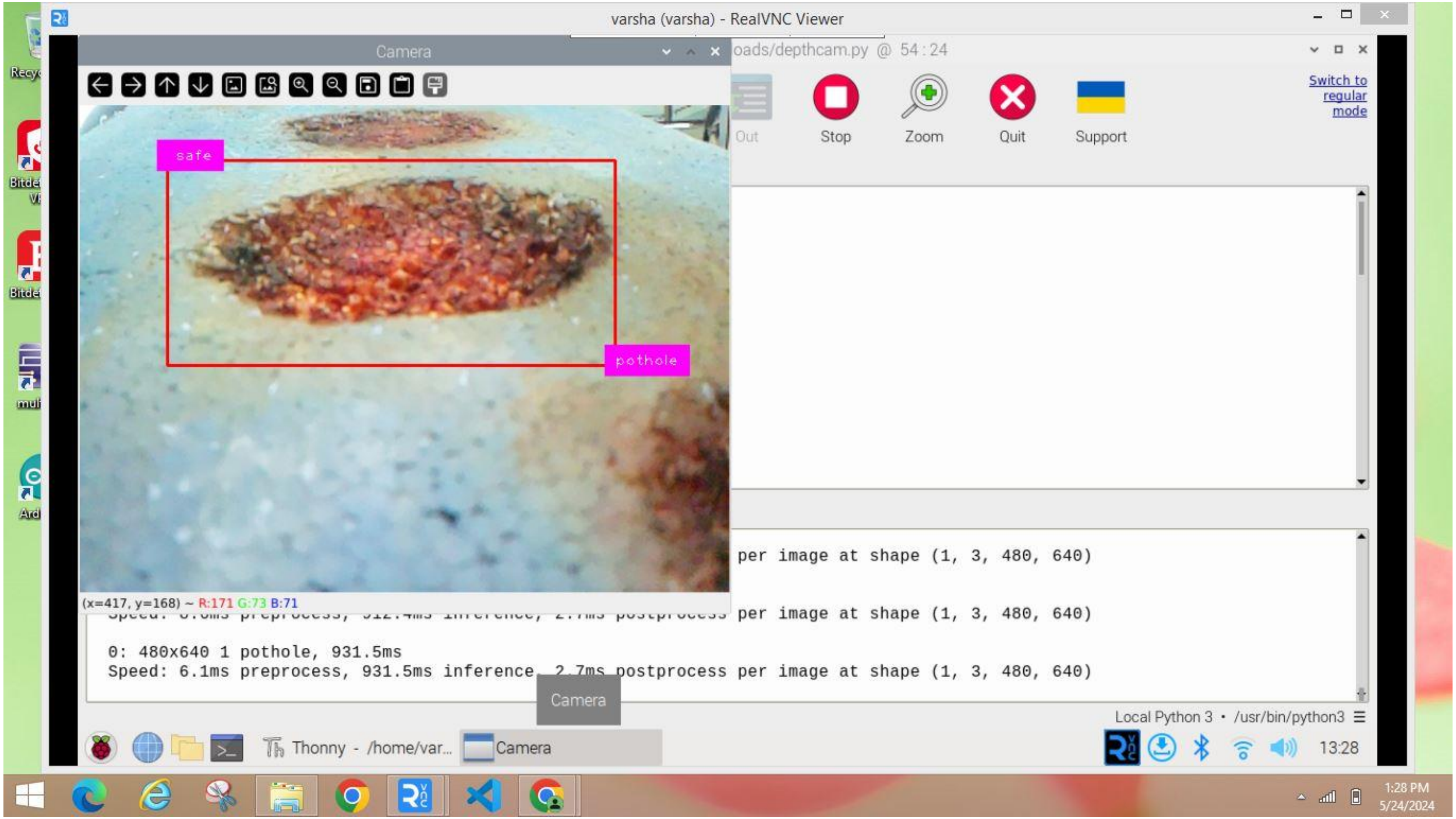
RASPBERRY PI IMPLEMENTATION

- The Raspberry Pi 4 serves as the core system, hosting all components necessary for the operation.
- Upon program execution,
  1. The camera activates to scan for potholes.
  2. Upon detection, the LiDAR sensor continuously measures sensor values.
  3. These readings aid in classifying the pothole, with the identified class relayed from Arduino to the Python program via the Pi's serial port.
  4. The detected pothole and its class are then displayed within a bounding box.
  5. Vehicle speed is subsequently adjusted accordingly.

HARDWARE IMPLEMENTATION



FINAL OUTPUT



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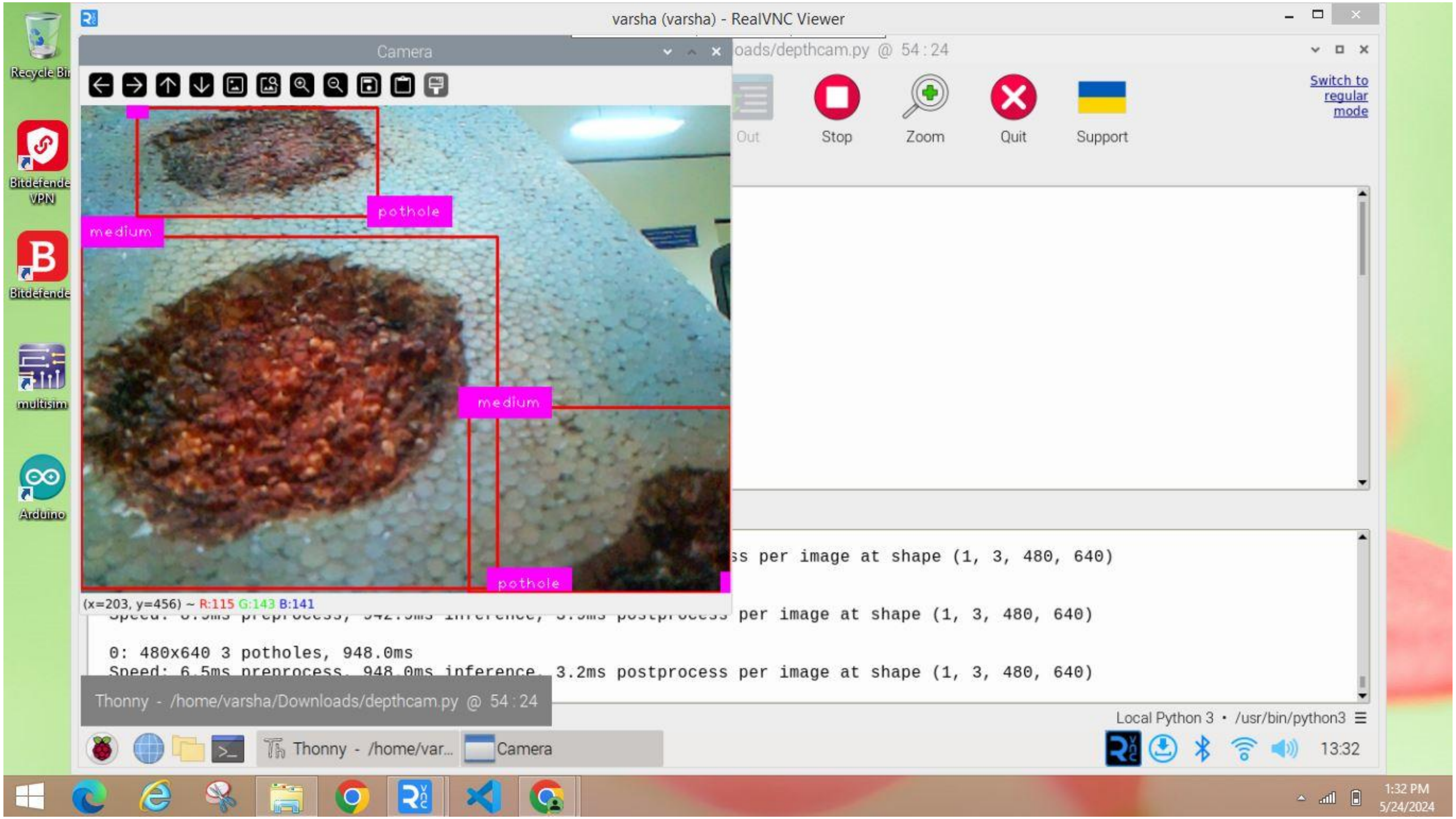
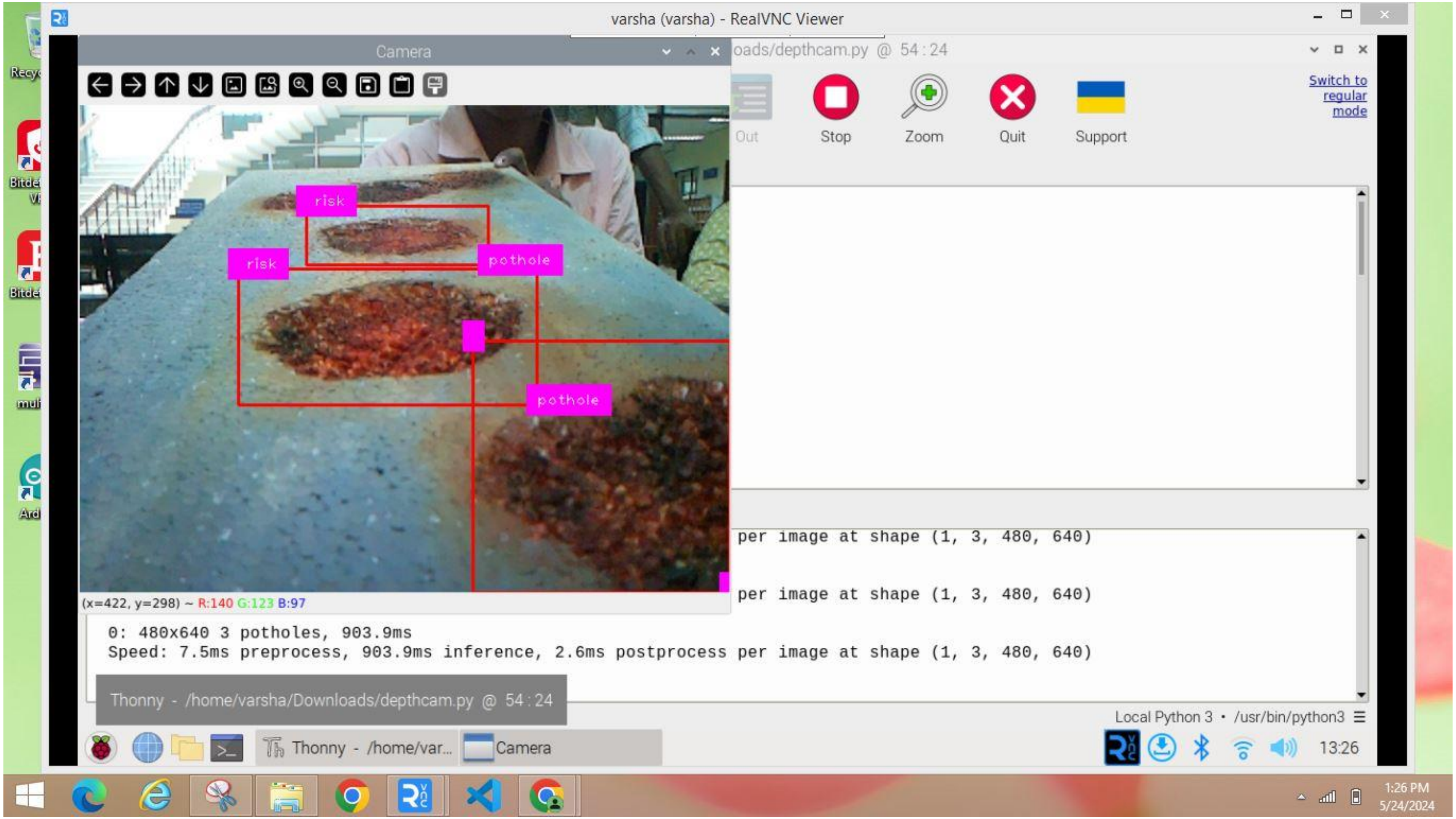


FINAL OUTPUT



ADVANTAGES

- Enhanced Safety: Reduces the risk of collisions, thereby enhancing overall safety for both the vehicle occupants and pedestrians.
- Minimized Accidents: Helps minimize accidents caused by sudden obstructions on the road.
- Reduced Driver Stress: Drivers can experience reduced stress and fatigue knowing that the vehicle is equipped to handle potential obstacles effectively.
- Enhanced Comfort: Ensures a smoother and more comfortable ride for vehicle occupants, particularly in situations where sudden maneuvers would otherwise be necessary.

DISADVANTAGES

- Technology Reliability: Relies on sensors and technology, occasionally may encounter technical issues or malfunctions. Regular maintenance and testing are essential to address this concern.

APPLICATIONS

- Autonomous Vehicles: The system is integral to the development of fully autonomous vehicles, allowing them to navigate complex environments safely and effectively without human intervention.
- Urban Transportation: Obstacle-avoiding cruise control can be utilized in public transportation systems, such as buses and trams.
- Agriculture: In agricultural machinery, such as tractors and harvesters, it can help prevent collisions with obstacles in the field, reducing the risk of damage to equipment and crops.
- Mining and Construction: The system can be deployed in heavy machinery used in mining and construction sites.
- Military Applications: Obstacle-avoiding cruise control can be utilized in military vehicles to enhance situational awareness in challenging terrain and combat environments.
- Emergency Response Vehicles: Emergency response vehicles can benefit from the system to navigate through traffic and obstacles safely and efficiently during emergency situations.

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