Nirapad Udaan - A Drone for monitoring Road Safety

Design Capstone Report

by

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1 Abstract

The project focuses on the use of Unmanned Aerial Vehicle/Drone for object detection cum traffic monitoring and road analytical purposes (road safety monitoring). Indian Roads are usually considered to be way too congested to drive on prevailing the various circumstances that need to be taken into consideration viz., Objects on the roads such as Potholes, Speed Bumps, Animals/Humans etc.

The major problem faced herewith is to detect where the objects are bound to be located in case of a person driving on the road in case of late hours which might be a cause of accidents which could've been repelled. Having attached a camera on the drone, it will help to capture the images of the patches/potholes present on the roads. Based on the camera feed, the objects/blockages present on the road would be detected using Deep Learning methodologies and Machine Learning based classification algorithms such as Support Vector Machine (SVM) etc. Classification of the potholes would be on the basis of the characteristics/severity such as its dimensions (depth, width) etc. and further, IoT is applied to boost the monitoring system with the power of ZigBee, a long-distance radio communication protocol. The transmitted data is stored permanently in cloud servers making it ubiquitously available to users for analytics. The experimental outcome projects the system to be up-and-coming for intelligent real-time road safety monitoring, thereby alerting the concerned authorities.

2 Introduction

The project aims to utilize Unmanned Aerial Vehicles (UAVs), commonly known as drones, to detect and classify objects on Indian roads. The use of drones in this way can help to improve road safety by providing a way to identify obstacles, such as potholes, speed bumps, and animals or humans, that might not be visible to drivers in low visibility conditions or at night.

The project proposes using a camera attached to the drone to capture images of the road surface. These images are then analyzed using deep learning methodologies and machine learning-based classification algorithms, such as Support Vector Machines (SVMs), to detect and classify the obstacles present on the road. The classification of potholes, for example, would be based on their characteristics and severity, such as their dimensions (depth and width). This will be done by using image processing techniques such as convolutional neural networks to extract features from the images and then using these features to train the classification algorithms.

To further enhance the monitoring system, the project also proposes the use of Internet of Things (IoT) technology, specifically the ZigBee long-distance radio communication protocol. The data collected by the drone and analyzed by the system is transmitted to cloud servers, making it available for analytics by concerned authorities in real-time. This will be done by using ZigBee protocol to send the data from the drone to a central hub and then sending it to the cloud servers.

The proposed system is expected to be an intelligent real-time road safety monitoring system that can alert authorities to potential hazards and improve road safety overall. The system can be used to detect and classify the objects on the road, which can be used by the authorities to take necessary actions. The data collected by the system can also be used to analyze the road conditions, identify the areas that require maintenance and improve the overall infrastructure of the roads.

Overall, the use of drones for object detection and traffic monitoring, combined with the use of deep learning and machine learning techniques, and IoT technology, promises to be a powerful tool for improving road safety on Indian roads, by providing real-time monitoring and alerts to concerned authorities, which will help them to take necessary actions and prevent accidents.

3 Literature Survey

3.1 DPM: Towards Accurate Drone Position Manipulation — Chen et al. 2023

The journal article ”DPM: Towards Accurate Drone Position Manipulation” presents a method called DPM (Drone Position Manipulation) for accurately controlling the position of a drone. The proposed system is based on using a combination of sensors, such as cameras, IMU (Inertial Measurement Unit), and GPS, to estimate the drone's position and a control algorithm to manipulate the drone's position.

The authors argue that traditional drone control methods, such as those based on visual odometry or pure GPS, can be inaccurate and unreliable in certain environments, such as those with poor lighting or GPS signal. The proposed DPM system addresses these issues by using a combination of sensors and a control algorithm to accurately estimate and manipulate the drone's position.

The article provides experimental results that demonstrate the effectiveness of the DPM system. The authors evaluate the performance of the DPM system in various environments, such as indoor and outdoor environments, and show that the system is able to achieve high accuracy in these environments. The authors also evaluate the performance of the DPM system in different scenarios, such as different lighting conditions and GPS signal availability, and show that the system is able to achieve high accuracy in these scenarios as well.

Additionally, the authors discuss the potential uses of the DPM system, such as in drone-based mapping, search and rescue, and delivery operations. They also discussed the future work directions, such as the integration of other sensors like LIDAR or stereo cameras to improve the accuracy of the system, or the use of machine learning techniques to improve the performance of the system.

In summary, the study presents a novel approach for accurately controlling the position of a drone called DPM (Drone Position Manipulation) by using a combination of sensors and a control algorithm. The proposed DPM system addresses the limitations of traditional drone control methods and demonstrated its effectiveness through experimental results in various environments and scenarios.

Findings -

- The proposed DPM system uses a combination of sensors and a control algorithm to accurately estimate and manipulate the position of a drone.
- The DPM system is able to achieve high accuracy in various environments and scenarios, such as poor lighting or GPS signal.
- The authors discuss potential uses of the DPM system and future work directions, such as integrating other sensors or machine learning techniques to improve performance.

3.2 Drone Navigation Using Region and Edge Exploitation-Based Deep CNN — Arshad et al. 2022—

The journal article ”Drone Navigation Using Region and Edge Exploitation-Based Deep CNN” presents a new method for drone navigation that utilizes a deep convolutional neural network (CNN) to navigate in both indoor and outdoor environments. The proposed approach is based on the exploitation of regions and edges in the images captured by the drone's camera. The authors of the article argue that this approach leads to more accurate and efficient navigation compared to traditional methods. The proposed method uses CNN to process the images captured by the drone's camera and make navigation decisions based on the features extracted from the images.

The article provides experimental results that demonstrate the effectiveness of the proposed method. The authors of the article compare the performance of their method with traditional navigation methods and show that the proposed method is able to achieve higher accuracy and efficiency. The authors also present results of experiments conducted in different environments, including indoor and outdoor environments, to show the robustness of the proposed method. The article also discusses the future work in this direction, such as incorporating sensor fusion to improve the navigation performance or using the proposed method to navigate drones in more complex environments.

In summary, the study presents a novel approach for drone navigation using deep learning techniques that exploit regions and edges in the images captured by the drone's camera. The proposed method is shown to be more accurate and efficient than traditional navigation methods and is able to navigate in both indoor and outdoor environments.

Findings -

- It presents a new approach for drone navigation that utilizes deep CNN to exploit regions and edges in the images captured by the drone's camera.
- The proposed method is shown to be more accurate and efficient than traditional navigation methods and is able to navigate in both indoor and outdoor environments.
- The authors also discuss future work in this direction, such as incorporating sensor fusion to improve the navigation performance.

3.3 A Resource-Efficient Online Target Detection System with Autonomous Drone-Assisted IoT — Wang et al. 2022

The journal article "A Resource-Efficient Online Target Detection System with Autonomous Drone-Assisted IoT" presents a new method for online target detection using a resource-efficient system that incorporates autonomous drones and the Internet of Things (IoT). The proposed system utilizes a drone equipped with sensors and cameras to detect and track targets in real-time, while also communicating with IoT devices to gather and analyze data.

The authors of the article argue that the proposed system is more resource-efficient than traditional target detection methods because it utilizes the capabilities of both drones and IoT devices. Drones are able to move freely and quickly in the environment to detect targets, while IoT devices are able to process and analyze large amounts of data in real-time. The authors also argue that by incorporating the capabilities of both drones and IoT devices, the proposed system is able to achieve high accuracy and efficiency in target detection.

The article provides experimental results that demonstrate the effectiveness of the proposed system. The authors of the article evaluate the performance of the proposed system in different scenarios, including tracking moving targets and detecting targets in cluttered environments. The authors also compare the performance of the proposed system with traditional target detection methods and show that the proposed system is able to achieve higher accuracy and efficiency.

The article also discussed the future work in this direction, such as the integration of Machine learning models to improve the target detection performance or the use of this system in various fields like surveillance, rescue, and search operations.

In summary, the study presents a novel approach for online target detection that utilizes the capabilities of autonomous drones and the Internet of Things (IoT) to achieve high accuracy and efficiency. The proposed system is able to detect and track targets in real-time and is more resource-efficient than traditional target detection methods.

Findings -

- Presents a new method for online target detection that utilizes the capabilities of autonomous drones and the Internet of Things (IoT) to achieve high accuracy and efficiency.

- Proposed system is claimed to be more resource-efficient than traditional methods, and experiments show it can detect and track targets in real-time scenarios.
- Future work includes integrating machine learning models to improve performance and applying the system in various fields like surveillance, rescue, and search operations.

3.4 Drone-Based RGB-Infrared Cross-Modality Vehicle Detection via Uncertainty-Aware Learning — Sun et al. 2022

The journal article "Drone-Based RGB-Infrared Cross-Modality Vehicle Detection via Uncertainty-Aware Learning" presents a new method for vehicle detection using a drone-based RGB-infrared cross-modality system that utilizes uncertainty-aware learning. The proposed system uses a drone equipped with both RGB and infrared cameras to capture images of the environment and detect vehicles. The system utilizes uncertainty-aware learning to improve the accuracy of the vehicle detection by taking into account the uncertainty present in the RGB and infrared images captured by the drone.

The authors of the article argue that the proposed system is able to achieve high accuracy in vehicle detection by utilizing the complementary information present in both RGB and infrared images. The system also utilizes uncertainty-aware learning to improve the accuracy of the vehicle detection by taking into account the uncertainty present in the images. The uncertainty-aware learning is achieved by using a deep neural network that has been trained to consider the uncertainty in the RGB and infrared images.

The article provides experimental results that demonstrate the effectiveness of the proposed system. The authors of the article evaluate the performance of the proposed system on a dataset of real-world RGB and infrared images and show that the proposed system is able to achieve high accuracy in vehicle detection. The authors also compare the performance of the proposed system with traditional vehicle detection methods and show that the proposed system is able to achieve better performance.

The article also discussed the future work on this direction, such as the integration of other modalities like LiDAR or Radar to improve the vehicle detection performance or the use of this system in various fields like autonomous driving, traffic monitoring and surveillance.

In summary, the study presents a novel approach for vehicle detection using a drone-based RGB-infrared cross-modality system that utilizes uncertainty-aware learning. The proposed system is able to achieve high accuracy in vehicle detection by utilizing the complementary information present in both RGB and infrared images and taking into account the uncertainty present in the images.

Findings -

- Presents a drone equipped with both RGB and infrared cameras to capture images of the environment and detect vehicles, and utilizes uncertainty-aware learning to improve the accuracy of the vehicle detection.
- The proposed system is able to achieve high accuracy in vehicle detection by utilizing the complementary information present in both RGB and infrared images.
- Future work on this direction, such as the integration of other modalities like LiDAR or Radar to improve the vehicle detection performance or the use of this system in various fields like autonomous driving, traffic monitoring and surveillance.

3.5 A Global-Local Self-Adaptive Network for Drone-View Object Detection — Deng et al. 2021

The journal article "A Global-Local Self-Adaptive Network for Drone-View Object Detection" presents a new method for object detection in images captured by drones. The proposed system, called "Global-Local Self-Adaptive Network (GL-SAN)," utilizes a deep neural network that is able to adapt to the specific characteristics of drone-view images. This network is capable of detecting objects in images captured by drones by using a global-local self-adaptive mechanism, which allows the network to learn both the global context of the image and the local details of the objects.

The authors argue that traditional object detection methods are not well-suited for images captured by drones due to the unique characteristics of these images, such as the high level of variation in object scales and the presence of large amounts of background information. The proposed GL-SAN network addresses these issues by using a global-local self-adaptive mechanism that allows the network to learn both the global context of the image and the local details of the objects.

The article provides experimental results that demonstrate the effectiveness of the proposed GL-SAN network. The authors evaluate the performance of the proposed network on a dataset of real-world drone-view images and show that the GL-SAN network is able to achieve better performance than traditional object detection methods. The authors also evaluate the performance of the proposed network in different scenarios, such as object detection in images with varying levels of occlusion, and show that the GL-SAN network is able to achieve high accuracy in these scenarios as well.

The article also discussed the future work on this direction, such as the integration of other modalities like LiDAR or Radar to improve the object detection performance or the use of this system in various fields like autonomous driving, traffic monitoring and surveillance.

In summary, the study presents a novel approach for object detection in images captured by drones using a deep neural network called "Global-Local Self-Adaptive Network (GL-SAN)." The proposed network addresses the unique challenges of object detection in drone-view images by using a global-local self-adaptive mechanism that allows the network to learn both the global context of the image and the local details of the objects.

Findings -

- The GL-SAN network addresses the unique challenges of object detection in drone-view images by using a global-local self-adaptive mechanism that allows the network to learn both the global context of the image and the local details of the objects.
- The experimental results demonstrate the effectiveness of the proposed GL-SAN network, achieving better performance than traditional object detection methods and high accuracy in various scenarios such as object detection in images with varying levels of occlusion.

3.6 Recognizing human violent action using drone surveillance within real-time proximity — S. Srivastava et al. 2021

The journal article "Recognizing human violent action using drone surveillance within real-time proximity" presents a method for detecting and recognizing violent actions of humans captured by drones in real-time. The proposed system is based on using drones equipped with cameras to capture images and videos of a given area, and then using computer vision and machine learning techniques to detect and recognize violent actions within the captured footage.

The authors argue that traditional surveillance methods are not well-suited for detecting and recognizing violent actions due to the high level of variability and complexity of these actions. The proposed system addresses these issues by using a combination of computer vision and machine learning techniques to detect and recognize violent actions.

The article provides experimental results that demonstrate the effectiveness of the proposed system.

The authors evaluate the performance of the proposed system on a dataset of real-world drone-captured footage and show that the system is able to achieve high accuracy in detecting and recognizing violent actions. The authors also evaluate the performance of the proposed system in different scenarios, such as crowded environments and low-light conditions, and show that the system is able to achieve high accuracy in these scenarios as well.

In summary, the study presents a novel approach for detecting and recognizing violent actions of humans captured by drones in real-time using computer vision and machine learning techniques. The proposed system addresses the unique challenges of detecting and recognizing violent actions by using a combination of techniques to analyze the captured footage.

Findings -

- A new method for detecting and recognizing violent actions of humans captured by drones in real-time using computer vision and machine learning techniques is proposed.
- The proposed system addresses the unique challenges of detecting and recognizing violent actions by using a combination of computer vision and machine learning techniques to analyze the captured footage.
- The proposed system showed high accuracy in detecting and recognizing violent actions in real-world drone-captured footage in different scenarios such as crowded environments and low-light conditions.

3.7 A Survey of Deep Learning Techniques for Vehicle Detection from UAV Images — A. Srivastava et al. 2021

The journal article "A Survey of Deep Learning Techniques for Vehicle Detection from UAV Images" presents a comprehensive review of current deep learning techniques used for vehicle detection from images captured by unmanned aerial vehicles (UAVs). The authors of the article provide an overview of various deep learning architectures, such as convolutional neural networks (CNNs), region-based CNNs, and single-shot multi-box detector (SSD), and discuss their strengths and limitations for vehicle detection from UAV images.

The authors begin by discussing the challenges of vehicle detection from UAV images, such as variations in vehicle scale, orientation, and lighting conditions, and the need for real-time processing. They then present an overview of traditional vehicle detection methods, including feature-based and template-based methods, and explain how deep learning techniques have been used to overcome the limitations of these methods.

The authors then provide a detailed review of various deep learning architectures for vehicle detection from UAV images. They discuss the strengths and limitations of CNNs, which are widely used for object detection and have been shown to be effective for vehicle detection from UAV images. They also review region-based CNNs, such as Faster R-CNN and R-FCN, which have been shown to be effective for detecting small objects in UAV images. They also discuss the single-shot multi-box detector (SSD) which has been demonstrated to be effective in detecting vehicles in UAV images with fast processing time.

Additionally, the authors also discuss the evaluation metric used to evaluate the performance of the vehicle detection models, such as precision, recall, and average precision (AP) and also discuss the current trends in this field.

In summary, the study presents a comprehensive survey of current deep learning techniques used for vehicle detection from UAV images. The authors provide an overview of various deep learning architectures, such as CNNs, region-based CNNs, and SSD, and discuss their strengths and limitations for vehicle detection from UAV images. Additionally, the authors also discuss the evaluation metric used to evaluate the performance of the vehicle detection models and current trends in this field.

Findings -

- The article presents a comprehensive review of current deep learning techniques used for vehicle detection from images captured by unmanned aerial vehicles (UAVs).
- The authors discuss the challenges of vehicle detection from UAV images, such as variations in vehicle scale, orientation, and lighting conditions, and the need for real-time processing..
- The authors provide a detailed review of various deep learning architectures for vehicle detection from UAV images, including CNNs, region-based CNNs, and SSD, and discuss their strengths and limitations for vehicle detection from UAV images.

4 Research Gap

After studying the features and characteristics required for the smooth functioning and output generation post our research, we found the following shortcomings/gaps:

- Incorporating sensor fusion to improve navigation performance.
- Navigating drones in more complex environments.
- Integrating machine learning models to improve target detection performance.
- Integrating other modalities like LiDAR or Radar to improve vehicle detection performance.

5 Objective

The objective of this project are the following:

- To design and develop a UAV Module with Camera.
- To test the developed module in laboratory.
- Predict the road condition using Deep Learning.

6 Methodology

The objective of this project is to design and implement a real-time road safety monitoring system using Unmanned Aerial Vehicles (UAVs) equipped with cameras, deep learning techniques, and IoT technology. The system will detect and classify obstacles on Indian roads and transmit the data to concerned authorities for real-time monitoring and action. The following methodology outlines the specific steps to be taken in order to achieve this goal.

- Identify the specific areas in which to deploy the UAVs, taking into consideration factors such as visibility, traffic volume, and accident history.
- Acquire and set up the necessary equipment for the UAVs, including cameras and communication devices.
- Calibrate the cameras and ensure that they are able to capture high-quality images of the road surface.
- Develop a deep learning model using convolutional neural networks to extract features from the images captured by the UAVs.

- Train the classification algorithms, such as Support Vector Machines (SVMs), using the extracted features to detect and classify obstacles such as potholes, speed bumps, and animals or humans.
- Develop and implement a communication system using the ZigBee protocol to transmit data collected by the UAVs to a central hub and then to cloud servers.
- Use the data collected by the UAVs and analyzed by the system to detect potential hazards in real-time and alert concerned authorities.
- Analyze the data collected over time to identify areas that require maintenance and improve the overall infrastructure of the roads.
- Regularly evaluate and update the system as necessary, including retraining the deep learning model and classification algorithms to improve performance and adapt to changing road conditions.
- Continuously monitor the system and make updates and improvements as necessary to ensure optimal performance.

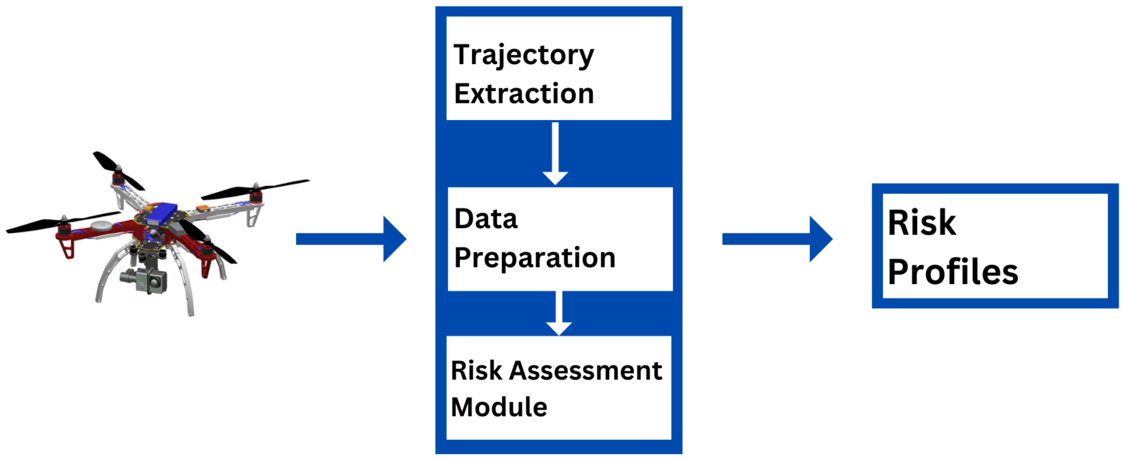

Figure 1: Methodology devising the objective of the project

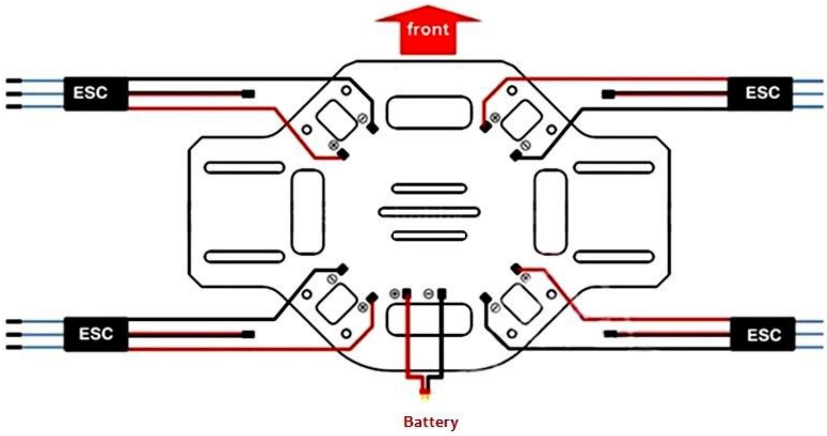

Figure 2: Connection Diagram for connecting Motors to the ESCs and further to the main frame along with Battery Connector

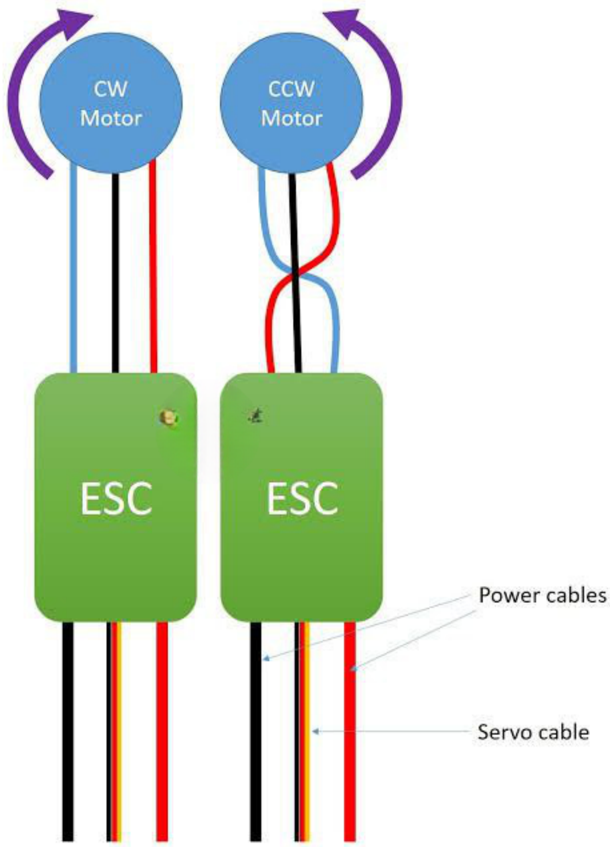

Figure 3: Denotes the Clockwise and Counter-Clockwise Connections of the ESCs with that to the Motors

7 Work done so far

- Literature Survey is completed.
- Procurement and Assembly of Parts is in progress.

- Methodology of the proposed work has been finalized.
- Assembling and Connections required for the Drone are somewhat complete.
- Accelerometer Calibration for the Flight Controller is complete using Ardupilot.
- RC Calibration for the Radio Controller is complete Mission Planner and Ardupilot.
- Calibration for the Electronic Speed Controller (ESCs) for each of the motors is complete.
- Programming and Binding of Transmitter for Flysky FS-CT6B using T6Config.
- Flashing and Installation of OS in Raspberry Pi 3B.

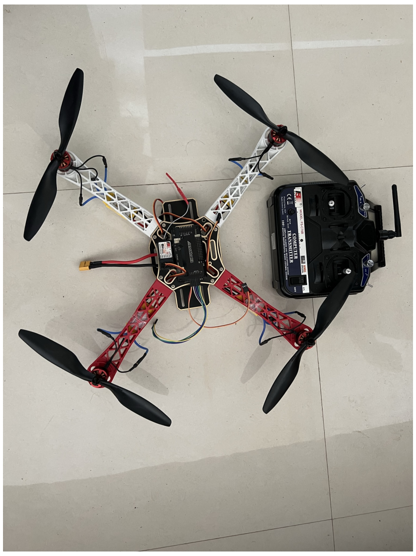

Figure 4: Drone with Connections post calibration

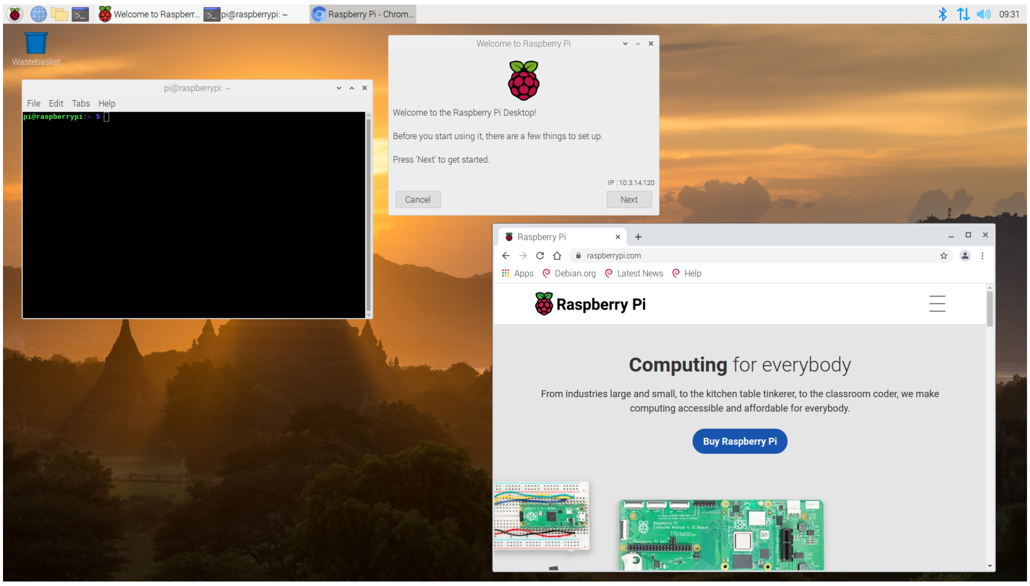

Figure 5: Flashing and Installation of OS in Raspberry Pi 3B

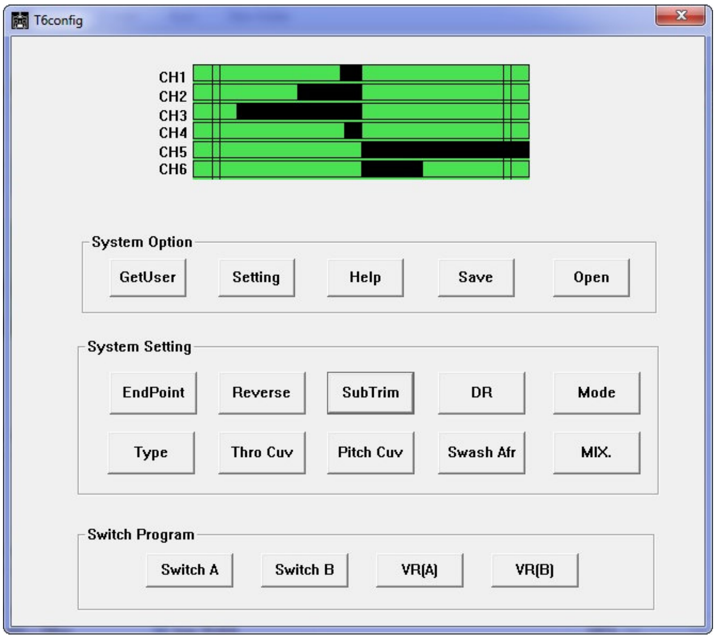

Figure 6: T6Config used for Programming and Binding

8 Work to be done

- Compass Calibration along with making the connections work with Input Pins of the Flight Controller to the RC Receiver.
- Incorporation of Camera alongwith Gimbal with the frame of the Drone.
- Integrating Raspberry Pi with GPS Module and WiFi for transmission and Capturing of High Resolution Images by controlling the Camera.
- Analysis of Captured images using Deep Learning Methodologies
- Classification of obstacles/objects on the basis of various characteristics.

9 Progress Graph

Time / Activity	Time period			
	Nov 2022 – Dec 2023	Jan 2023 – Feb 2023	March 2023 – April 2023	Jun 2023 – Aug 2023
Course Work	→	→		
Literature Survey		→	→	
Development of working model		→	→	→
Field test of working model		→	→	→
Classification and further analysis of output			→	→
Report writing	→	→	→	→

Figure 7: Workplan/Progress Graph of the project

10 Conclusion

In Conclusion, the proposed project aims to utilize Unmanned Aerial Vehicles (UAVs) to detect and classify objects on Indian roads in order to improve road safety. The project proposes using a camera attached to the drone to capture images of the road surface, which will then be analyzed using deep learning methodologies and machine learning-based classification algorithms such as Support Vector Machines (SVMs) to detect and classify the obstacles present on the road. The system will also use IoT technology, specifically the ZigBee long-distance radio communication protocol, to transmit the data collected by the drone to cloud servers for real-time analytics by concerned authorities. The proposed system is expected to be an intelligent real-time road safety monitoring system that can alert authorities to potential hazards and improve road safety overall. The use of drones for object detection and traffic monitoring, combined with the use of deep learning and machine learning techniques, and IoT technology, promises to be a powerful tool for improving road safety on Indian roads.

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