BOROSA – Bosch Road Safety Hackathon 2024

Problem Statement:

Design a two-wheeler safety system that detects helmet usage, identifies obstacles with radar technology, and implements an anti-lock braking system (ABS) to enhance rider safety, prevent accidents, and reduce brake wear.

Abstract:

Pune, a dynamic city with a large number of two-wheeler commuters, is facing road safety difficulties. The increasing traffic congestion, different road conditions, and a wide range of two-wheeler users all add to the complexity of maintaining safe commuting experiences. This hackathon aims to generate new solutions that use technology and data to improve two-wheeler traffic safety in Pune.

The continuous mobilization of vehicles has led to a surge in the number of road accidents across the world. So, our main idea is to introduce a helmet detection mechanism as most of the deaths caused are due to the absence of helmet. The practice of direct observation is found to be time taking and a lot of human effort is needed. Our project attempts to implement a detection process through a few machine learning algorithms by using pre-defined libraries which notices a person with/without a helmet thereby imposing fines on the detected candidates. Additionally, radar system for object detection and Anti-lock braking system to avoid the accidents which enhances the safety of rider.

Scenario:

This hackathon in Pune focuses on addressing challenges related to two-wheeler road safety in a bustling city environment. With increasing traffic density, diverse road conditions, and a variety of two-wheeler users, ensuring safe commuting experiences is complex. The objective is to leverage technology and data to innovate solutions that enhance road safety for two-wheeler commuters in Pune. The hackathon aims to implement these innovative solutions to improve overall road safety for two-wheeler users in the city.

This project focuses on improvement of two-wheeler road safety in Pune by addressing various scenarios. Each constrain poses unique challenges and our approach is to develop innovative and cost-effective solution for the same. Our aim is about inventing new technologies to help riders see better and be more aware of their surroundings. We want to improve brakes, use smart signals, and add systems to avoid crashes. The idea is to help riders move through city traffic more safely and prevent accidents. Driving in the busy city involves special challenges. Our goal is to make city driving less stressful and more convenient for everyone. Making two-wheeler travel safe on highways is tricky because of high speeds and long distances. Our project is looking into solutions which provides emergency response tools like object detection within a specific range integrating with alarm system, Anti-lock braking system and Helmet detection to make ride safer.

Solutions:

1. Our first approach towards safety of rider is ***helmet detection using Machine learning algorithm***. Detecting riders who wearing helmets involves image processing and computer vision techniques. There are various machine learning algorithms which we can use for detection but Convolutional Neural Networks (CNNs) have proven to be highly effective for image classification tasks, making them a suitable choice for helmet detection. Specifically, a pre-trained CNN model or a custom CNN architecture can be fine-tuned for this specific task. One popular pre-trained CNN model for image classification is the MobileNetV2, which is lightweight and suitable for real-time applications like helmet detection. Alternatively, we can also use more powerful architectures like VGG16, ResNet, or Inception, depending on available computational resources and the desired level of accuracy.

   Here is a simple approach using pre-trained CNN for detection of helmets:

   a) Data Preparation : contains images of riders with and without helmets and splits the dataset into training and testing sets.
   b) Model Specification: Choose a pre-trained CNN model as the base and modify the final classification layer to have two classes: with Helmet and without Helmet.
   c) Fine Tuning: Retrain the modified model using labels dataset and fine-tune the model on the task of helmet detection.
   d) Evaluation: Evaluate the model on the testing set to ensure its accuracy and generalization.
   e) Integration: Integrate the trained model into system for real-time helmet detection.

Algorithm for the Helmet Detection:

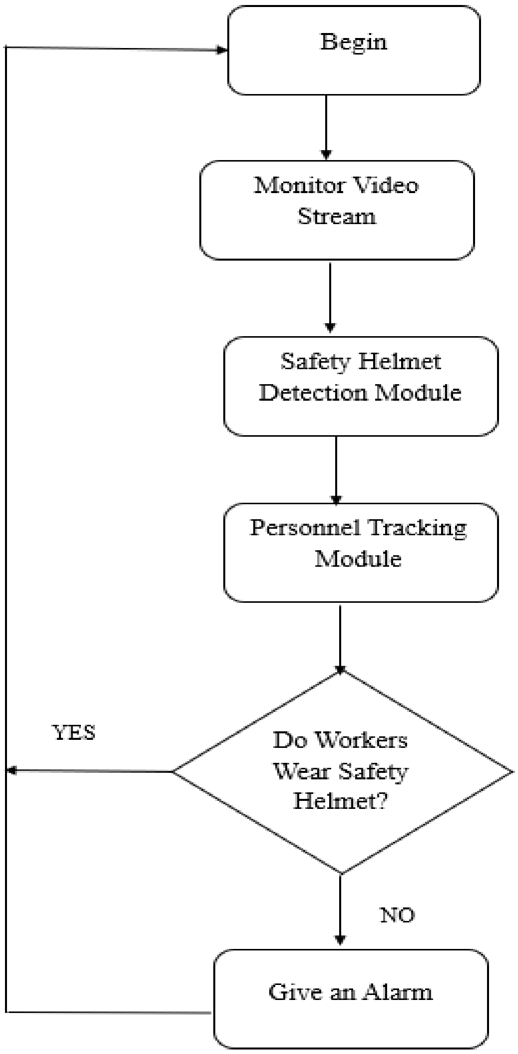

Figure 1: Flowchart for Helmet Detection

2. The second approach is using ***RADAR IN BIKES with object detection*** within a specify range.

✓ How it works?

The electronic principle on which radar operates is very similar to the principle of soundwave reflection. If you shout in the direction of a sound-reflecting object, you will hear an echo. If you know the speed of sound in air, you can then analyse the distance and general direction of the object. The time required for an echo to return can be converted to distance if the speed of sound is known. Radar principle Radar uses electromagnetic energy pulses in much the same way. The radio-frequency energy is transmitted to and reflected from the reflecting object. A small portion of the reflected energy returns to the radar set.

This returned energy is called an ECHO. Radar sets use the echo to determine the direction and distance of the reflecting object.

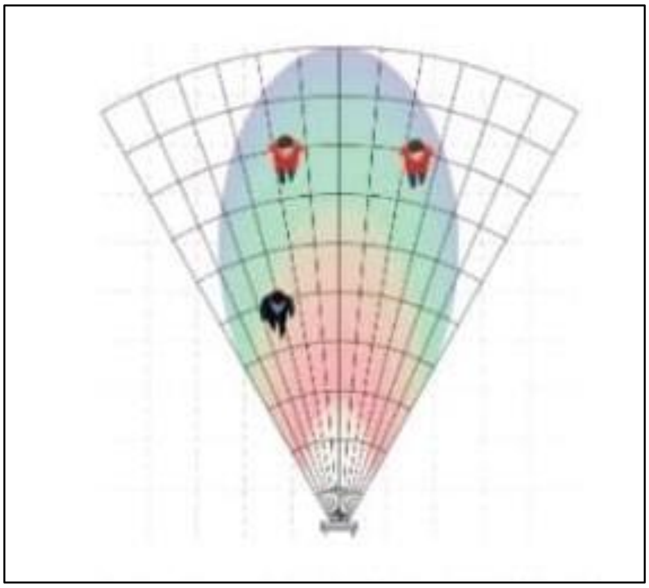

Figure 2.1 : Object Detection using Radar System

These radars have multiple transmitting and receiving antennas. Each transmitted signal can be received by any antenna. The special arrangement of multiple antennas improves spatial resolution and reduces susceptibility to interference RADAR resolution. *Separation of objects by:* **Speed, distance and angle**. Objects with the same speed, distance and angular position can be separated.

✓ How RADAR works in bikes for object Detection?

Radio waves or microwaves are radiated out from the radar into free space. Some of these waves are intercepted by reflecting objects. These intercepted radio waves hit the target and are reflected in many different directions. Some of these waves can be directed back toward the radar, where they are received and **amplified**. If these waves are received again at their origin, then it means an object is in the propagation direction.

Required components for the RADAR in bikes:

1. Ultrasonic Sensor: An **ultrasonic sensor** is a proximity sensor that is used to measure the distance of a target or object. It detects the object by transmitting ultrasonic waves and converts the reflected waves into an electrical signal. These **sound waves** travel faster than the speed of the sound that humans can hear.

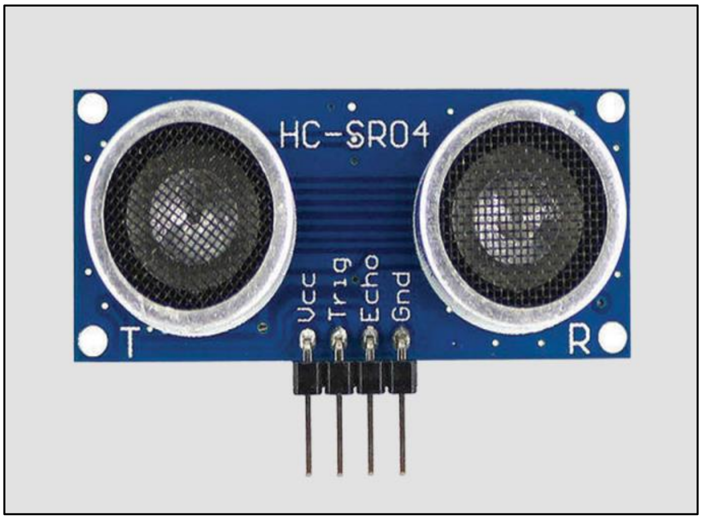

Figure 2.2 :An Ultrasonic Sensor

It has two main components: the transmitter and the receiver. The transmitter emits the sound using a piezoelectric crystal, and the receiver encounters the sound after it has travelled to and from the target.

For the calculation of the object distance, the sensor measures the time taken by the signal to travel from the transmission of the sound by the transmitter to the reflection back toward the receiver.

The formula for this calculation is,

D = ½ T x C

Where,

- D = distance,
- T = time
- C = speed of sound, which is 343 meters per second.

In this way it calculates the time required and the distance from the bike to the object.

2. servo motor:

A servomotor is a closed-loop servomechanism that uses position feedback to control its motion and final position. The input to its control is a signal representing the position commanded for the output shaft. This motor will only rotate as much as we want and then stop. The servo motor is a closed-loop mechanism that uses positional feedback to control the speed and position. This closed-loop system includes a control circuit, servo motor, shaft, potentiometer, drive gears, amplifier, and either an encoder or resolver.

The servo motor is unlike a standard electric motor, which starts and stops according to the power input. According to the signal, the servo motor will work.

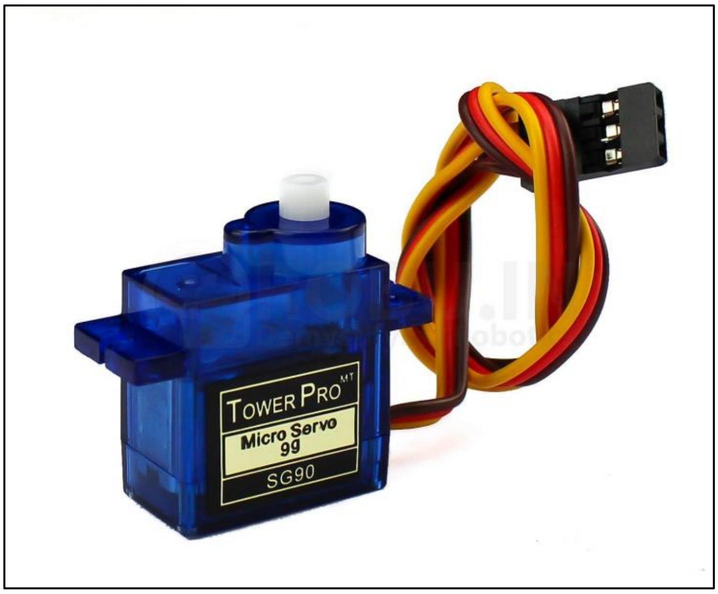

Figure 2.3: Servo Motor

3. **Mounting Bracket for Ultrasonic Sensor**

To build the fixture for this construction, we are going to use a mounting bracket to fix then ultrasonic sensor in the Arduino radar.

Figure 2.4: **Mounting Bracket for Ultrasonic Sensor**

After fixing it, the **mounting bracket** is screwed to the servo motor.

4. Arduino UNO

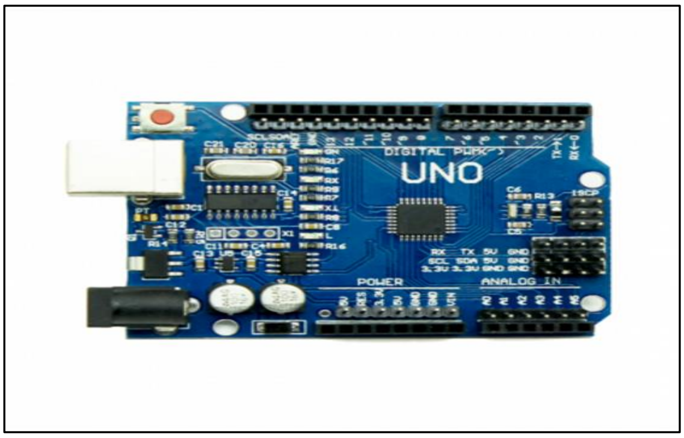

Figure 2.5: Arduino UNO

✓ How Arduino UNO works with RADAR system?

In a radar system designed for object detection, the Arduino Uno serves as the central brain, managing several crucial tasks to ensure effective functionality. It starts by listening to information from the ultrasonic sensor, interpreting details such as the distance, speed and angle of detected objects. The Arduino then processes and organizes this data to make sense of it. Utilizing a specialized algorithm, the Arduino identifies and recognizes objects within the radar's range. Subsequently, it makes decisions based on its observations, potentially triggering alarms or displaying relevant information. Arduino convey the detected objects information through displays. Additionally, it may facilitate communication with other devices or systems and integrate with user interfaces if present. The Arduino Uno also handles power management, ensuring that all components receive the necessary power supply. Overall, the Arduino Uno's role is central to orchestrating the various aspects of the radar system for efficient object detection.

5. Display(LCD1602):

Figure 2.5: Display(LCD1602)

The LCD1602 display in a radar system for object detection is used to provide real-time visual feedback on the system's observations. It serves as a user interface, showing information like object distance or speed, making the system more user-friendly. It enhances the overall user experience and can be integrated with alarms or alerts for critical detections. In summary, the LCD1602 adds a valuable visual component, improving the usability and functionality of the radar system.

6. 5V Active Alarm Buzzer Module for Arduino

Figure 2.6: 5V Active Alarm Buzzer Module for Arduino

Integrating a 5V Active Alarm Buzzer Module with Arduino, an ultrasonic sensor, and an LCD1602 display enhances an object detection system. The active buzzer provides an audible alert when the ultrasonic sensor detects objects within a specified range. This combination offers both visual feedback on the LCD1602 displays, showing details like object distance, and an audible alert for immediate user awareness, making it valuable in emergency situations or safety-critical applications. This multi-sensory approach improves the effectiveness of the object detection system, ensuring users are promptly notified of detected objects.

System Architecture:

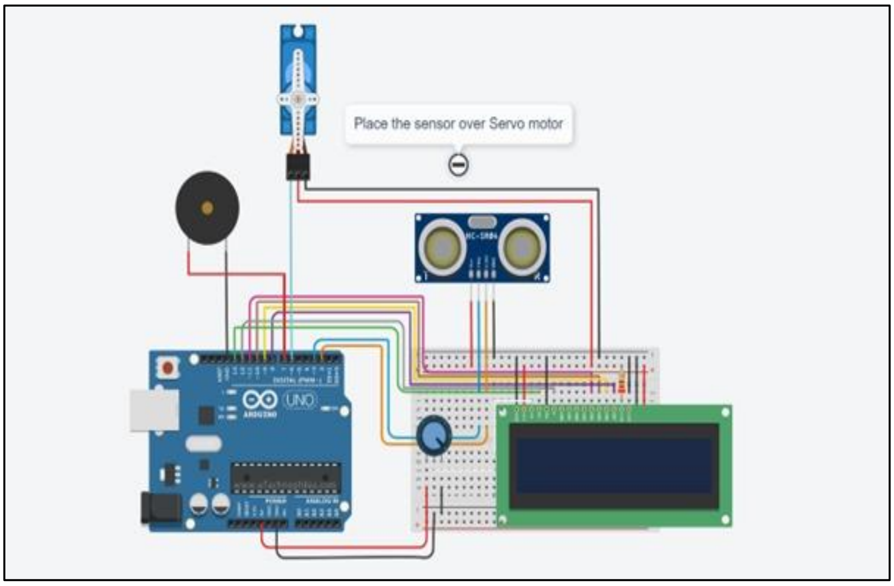

Figure 2.7: System Architecture of Radar System

Flowchart for Object Detection in RADAR SYSTEM:

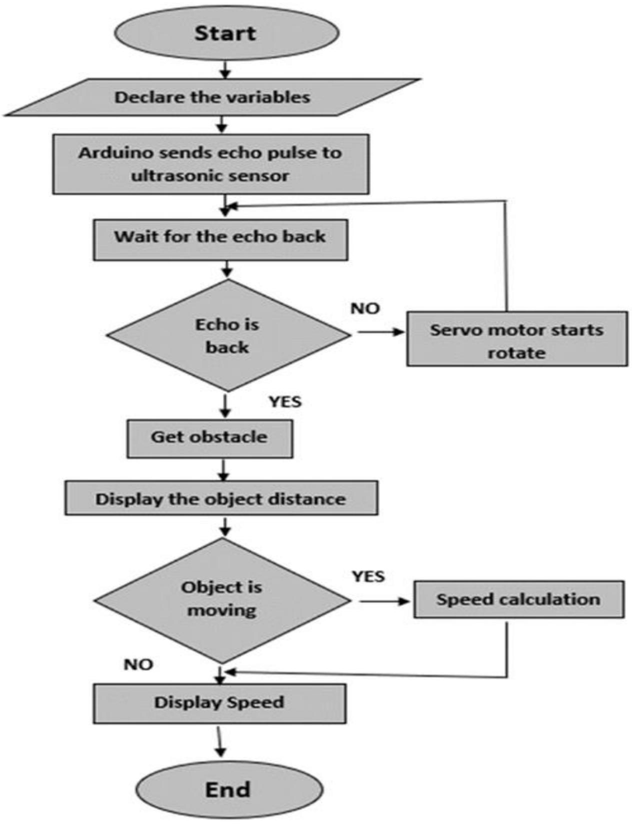

Figure 2.8: Flowchart for Object Detection

3. Third Approach for rider safety is Antilock Braking System to avoid the wear and tear and avoid the number of accidents.

   ABS is like having a smart brake system on your bike. When you hit the brakes hard, it stops your wheels from suddenly locking up, which can make you lose control and skid. Instead, it makes sure your wheels keep turning smoothly while you stop. This helps you stay in control of your bike, especially in sudden stops or slippery conditions, making your ride safer.

✓ Importance of ABS in Bikes:

There was a time when ABS was limited to bigger vehicles like cars, buses, etc. However, with the increasing number of bike accidents, It is important to add ABS in bikes as a standard feature to improve road safety and provide more control to the rider, irrespective of the road surface. It has Greater control as it helps the rider brake more effectively and take control of the situation. It provides lower wear and tear with an anti-lock braking system; the rider would have to manually release the brake to reduce the chances of the wheels locking up. It can cause uneven tyre wear and increased stress on the brakes. ABS mitigates this wear and tear by automatically detecting the lock-up and modulating the brake pressure .ABS does come with an additional cost, but it is worth the money as it can save you from a potential crash. Hence, ABS is one of the essential safety equipment for a bike.

Components required for the Anti-Lock Braking system:

Here we required only 3 components as Brakes, ECU kit and out of this brakes and ECU kit is already present in most of bike. However, some well-known manufacturers of ECU kits include Bosch, Continental, and Nissin as mentioned all these companies and a Bosch itself provides ECU kit .

So let’s discuss about the wheel speed sensors:

Wheel Speed Sensor (Hall effect sensor):

The working principle of Hall effect sensors involves detecting changes in the magnetic field caused by the rotation of toothed wheels or ferromagnetic targets attached to the wheel hubs. As the teeth or targets pass by the sensor, they generate a voltage signal proportional to the wheel speed. This signal is then processed by the ABS control unit to determine the speed of each wheel and make necessary adjustments to prevent wheel lock-up.

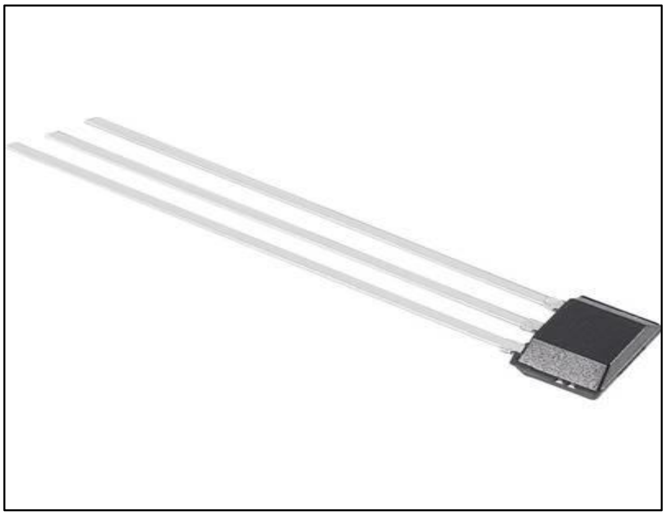

Figure 3.1: Hall Effect Sensor

Flowchart of ABS working system:

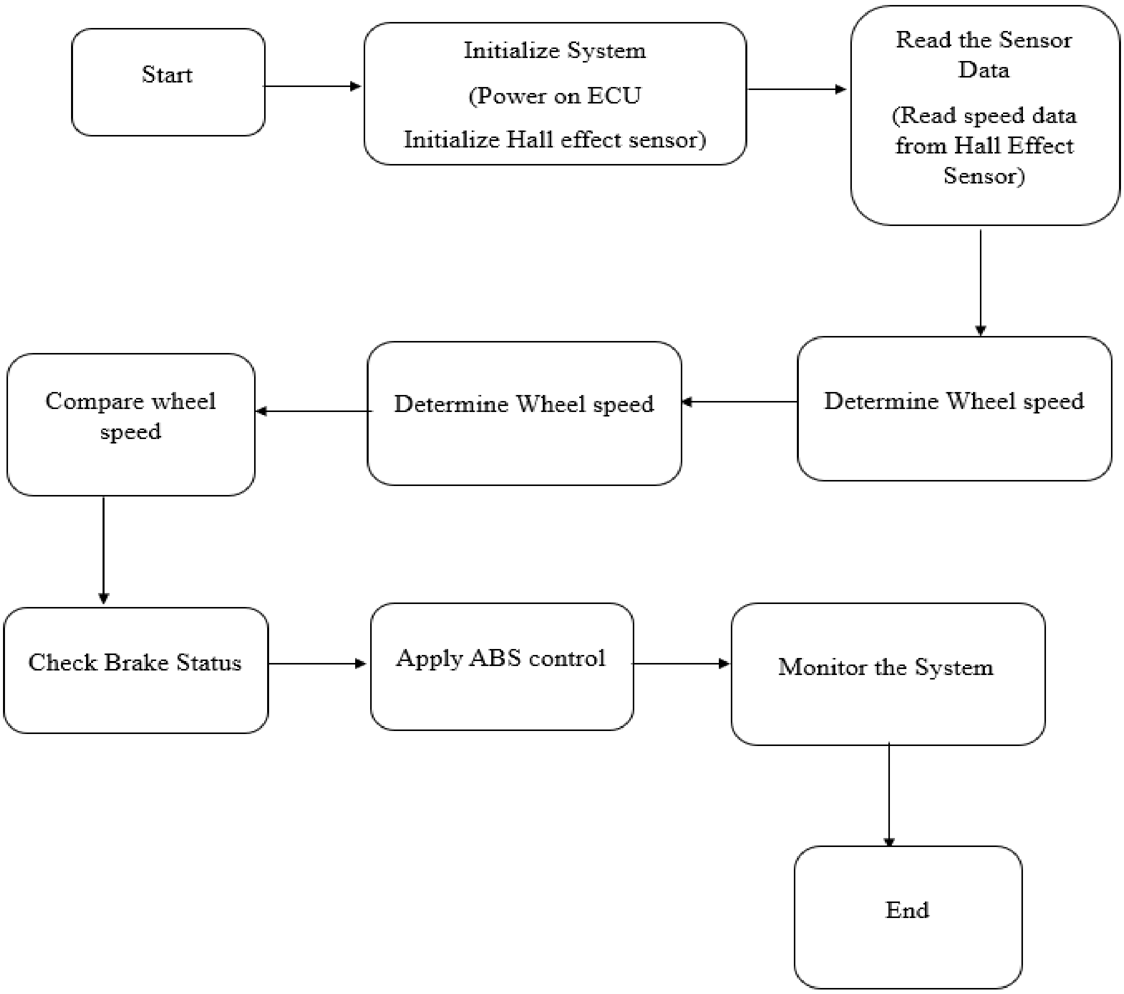

Figure 3.2: Flowchart of ABS

Component used:

ultrasonic sensor: Rs. 196

servo motor : Rs. 201

Mounting Bracket: Rs. 101

UNO Arduino: Rs. 240

Display: Rs.145

5V Active Alarm Buzzer: Rs. 39

Hall Effect Sensor : Rs.213

Estimate Cost: **Rs. 1,135**

Conclusion:

The proposed safety system for bike riders integrates advanced technologies such as machine learning for helmet detection and radar-based object detection, along with an Anti-Lock Braking System (ABS). In this we have scaled different approach for helmet detection using Convolutional Neural Networks (CNNs), emphasizing real-time deployment and accurate identification of helmet usage. The radar-based object detection system employs ultrasonic sensors, ABS, and Hall Effect sensors. The importance of ABS in bikes is underscored for its role in preventing wheel lock-up, reducing wear and tear, and contributing to standard road safety features. Overall, the integrated system aims to provide a comprehensive solution for enhancing rider safety through multiple safety measures and with real-time information.

References:

1) https://youtu.be/ARHjcG509jo?si=s4804Qqn5fThdUxV
2) https://www.academia.edu/42582814/PUNE_TRAFFIC_CONGESTION_REALITY_CAUSE_AND_REGULATION_A_CASE_STUDY
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