BOROSA – Bosch Road Safety Hackathon 2024
Prelim Hackathon

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Abstract

The problem statement aims to design a two-wheeler surround awareness system to enhance the rider’s awareness and reduce accidents. The system should utilize up to maximum of six sensors to detect objects within a 1.5-meter radius of the vehicle. Object distance and angle from the rider's position should be displayed on a radar chart, with audio alarms triggered if an object is within 1 meter distance. Detection is not required for objects in the front 60-degree angle.

Scenarios

Real Life Scenarios:

Being acutely aware of our surroundings is absolutely crucial when operating a bike, as any misstep could prove fatal not just for ourselves, but also for those around us. The primary objective behind developing this system is to mitigate potentially hazardous scenarios such as:

a) Ensuring timely action to accommodate fast-moving vehicles approaching from behind, thereby averting potential collisions.

b) Implementing precautionary measures, particularly on high-speed thoroughfares, to execute lane changes safely and minimize the risk of severe accidents.

c) Providing comprehensive visibility of the surrounding environment to the rider through alarm systems, thereby promoting vigilance in situations where obstacles are in close proximity to the vehicle, reducing the likelihood of collisions.

1) Low Speed Driving:

i. The system automatically deactivates when the vehicle's speed is 20 km/hr or less, or when a configurable speed set by the user is reached.

ii. This proactive measure considers situations where multiple vehicles might be within close proximity, such as when waiting at traffic signals.

iii. By doing so, it minimizes the chances of unnecessary alerts and disturbances for the rider.

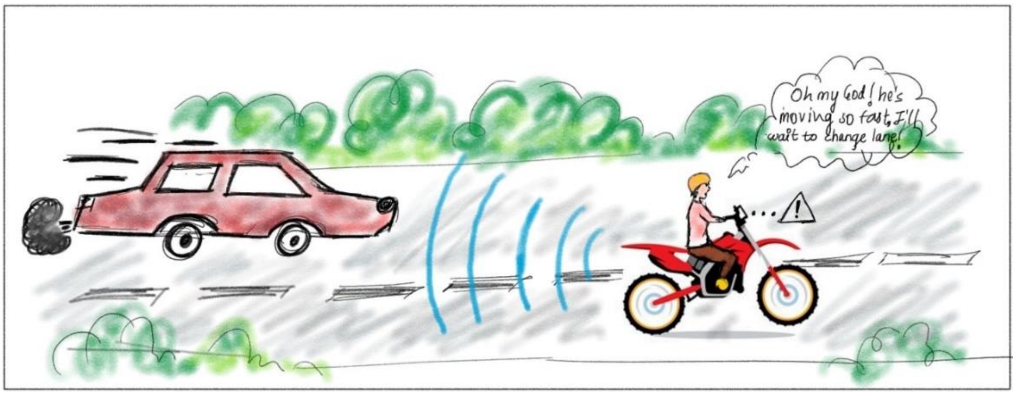
iv. However, the system remains fully operational and vigilant at higher speeds, ensuring timely detection and warning of potential rear-end collision risks when needed.

2) Blind Spot Reduction:

   i. Blind spots are areas around a vehicle that are not directly visible to the driver, particularly through the rearview mirrors.

   ii. When riding on highways or busy roads, being aware of and effectively managing blind spots is crucial for safety.

3) Partial Lane Change Assistance:



   i. When changing lanes, it's crucial for your vehicle to be aware of surrounding objects on both sides.

In this scenario, sensors communicate with the bike's system. If they detect obstacles on either side, the corresponding LED lights will start blinking. This serves as a visual alert, notifying you and others of nearby objects.

4) Rear end collision detection:

   i. On a busy highway, motorcycle riders are often focused on navigating through traffic. The rapid acceleration of a car behind the rider could pose a significant danger.

   ii. Upon detecting the fast-approaching vehicle, the system promptly alerts the rider with a signal, instantly notifying them of the potential danger.

   iii. This intervention has the potential to avert accidents and ensure the safety of everyone involved.

Solution

- After considering three potential solutions—embedding an LED system on the rear-view mirror, implementing a display on the cluster, and integrating a Bluetooth helmet via a surround sound system—the survey results revealed a strong inclination towards the LED system.
  This preference is influenced by the limitations of the other systems. The display on the cluster requires riders to divert their attention away from the road to check alerts, posing safety concerns. Additionally, this solution is deemed less cost-effective. Meanwhile, the Bluetooth system, while offering immediate sound alerts, may introduce distractions, battery life and security concern.

- Our solution integrates three innovative features to enhance rider awareness of their surrounding environment:
  1. Rear end collision detection:

     Our system continuously monitors the entire 300-degree space around the two-wheeler. If any object is detected within a range of 1.5 meters, the rider is promptly alerted through the LED fitted on the rear-view panel.

  2. Blind Spot Detection:

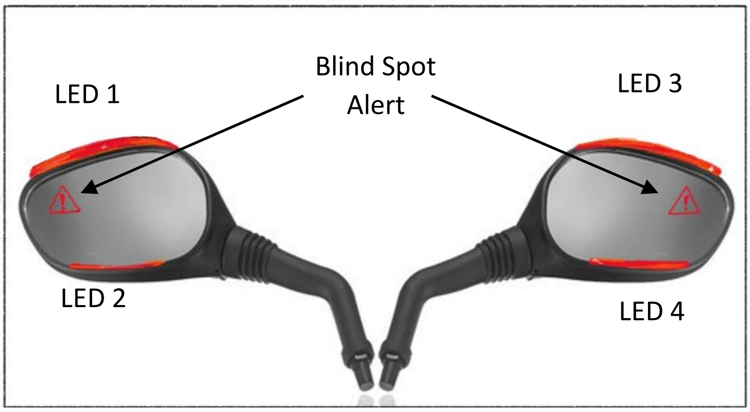
     Utilizing strategically positioned sensors, our system identifies vehicles within the rider's blind spot area, up to 1.5 meters away. The system then alerts the rider through visual cues, such as an alert sign on the rear-view mirror.

  3. Partial Lane Change Assist:

     Lane Change Assist (LCA) serves as an extension of Blind Spot Detection (BSD). When the rider initiates a lane change, side sensors detect vehicles in the blind spot. An LED on the side mirror panel warns the rider of nearby vehicles, promoting caution.

- The proposed two-wheeler surrounding awareness system incorporates visual and auditory alerts to convey important information to the rider in real-time. These alerts are designed to promptly notify the rider of potential hazards and risks, enabling them to react quickly and make informed decisions while riding. The following methods are utilized to convey alerts to the rider:

I. LED Indicators on Rear-view mirror Panel:



- LED indicators are mounted on the panel of the rearview mirrors to provide visual cues to the rider. These indicators illuminate or blink in response to various stimuli detected by the system, such as nearby objects, blind spots, or lane departure risks.
- These LEDs serve to provide visual cues to the rider regarding nearby objects distance and degree from the rider. When the object is in the range of 1.5 m the LED's lit up yellow light and when the object is in the range of 1m the LED's lit up in red colour accompanied by an audio alarm.
- Segmented Coverage: The two LEDs on each rear-view mirror panel are strategically distributed to cover specific angular ranges:

i. Number of LED Indicators: We have planned to install 2 LEDs on each rear-view mirror panel.

ii. The top LED mounted on the left rearview mirror will indicate the presence of objects detected by the sensor placed in the left tail region.

iii. The bottom LED will provide indications for objects detected by the sensors placed at the sides of the rear-view mirror.

iv. The same mechanism will be utilized for the other side of the mirror to ensure uniformity and consistency in signalling.

II. Auditory Alerts:

- Alarm System: The system incorporates an auditory alarm to alert the rider of critical situations. The alarm is triggered when the system detects an object within close proximity of 1m from the two-wheeler, posing a potential collision risk.

➢ According to scenarios as we mentioned above, we are using sensors to detect the object so that the awareness of rider will increase. Among the available sensor options, including Ultrasonic Sensor, Radar Sensor, Short-Range Radar, Medium-Range Radar, and Lidar sensors, ultrasonic sensors are deemed the most suitable for several reasons:

i. **Cost-Effectiveness:** Ultrasonic sensors offer a cost-effective solution for object detection compared to more advanced alternatives such as Radar and Lidar sensors.

ii. **Proximity Sensing:** Ultrasonic sensors excel in proximity sensing, making them well-suited for detecting objects within close range, such as those encountered in urban environments. Their ability to accurately measure distances up to a few meters aligns with the close proximity range requirements of the surrounding awareness system, enhancing rider awareness of nearby obstacles and potential collision risks within the 1.5m range.

iii. **Reliability in Urban Environments:** Ultrasonic sensors demonstrate reliable performance in urban environments characterized by complex traffic scenarios, Unlike Radar and Lidar sensors, which may experience signal attenuation or inaccuracies under adverse weather conditions.

Utilizing the sensors and LED display, riders can easily discern the location of objects and their proximity by observing the colour of the light emitted. This arrangement ensures critical information is readily visible to the rider, as the system is integrated into the side mirror. By eliminating the need for riders to divert their gaze downward to gather information about their surroundings, the journey becomes inherently safer with fewer distractions. Additionally, this design approach helps minimize costs associated with radar displays, rendering it cost-effective.

Assumptions

1) **Sensor Accuracy:** Assuming that the ultrasonic sensors used in the system provide accurate and reliable detection of objects within the specified range.

2) **Vehicle Speed:** Assuming that the vehicle's speed can be accurately measured and that the system can effectively activate or deactivate certain features based on speed thresholds.

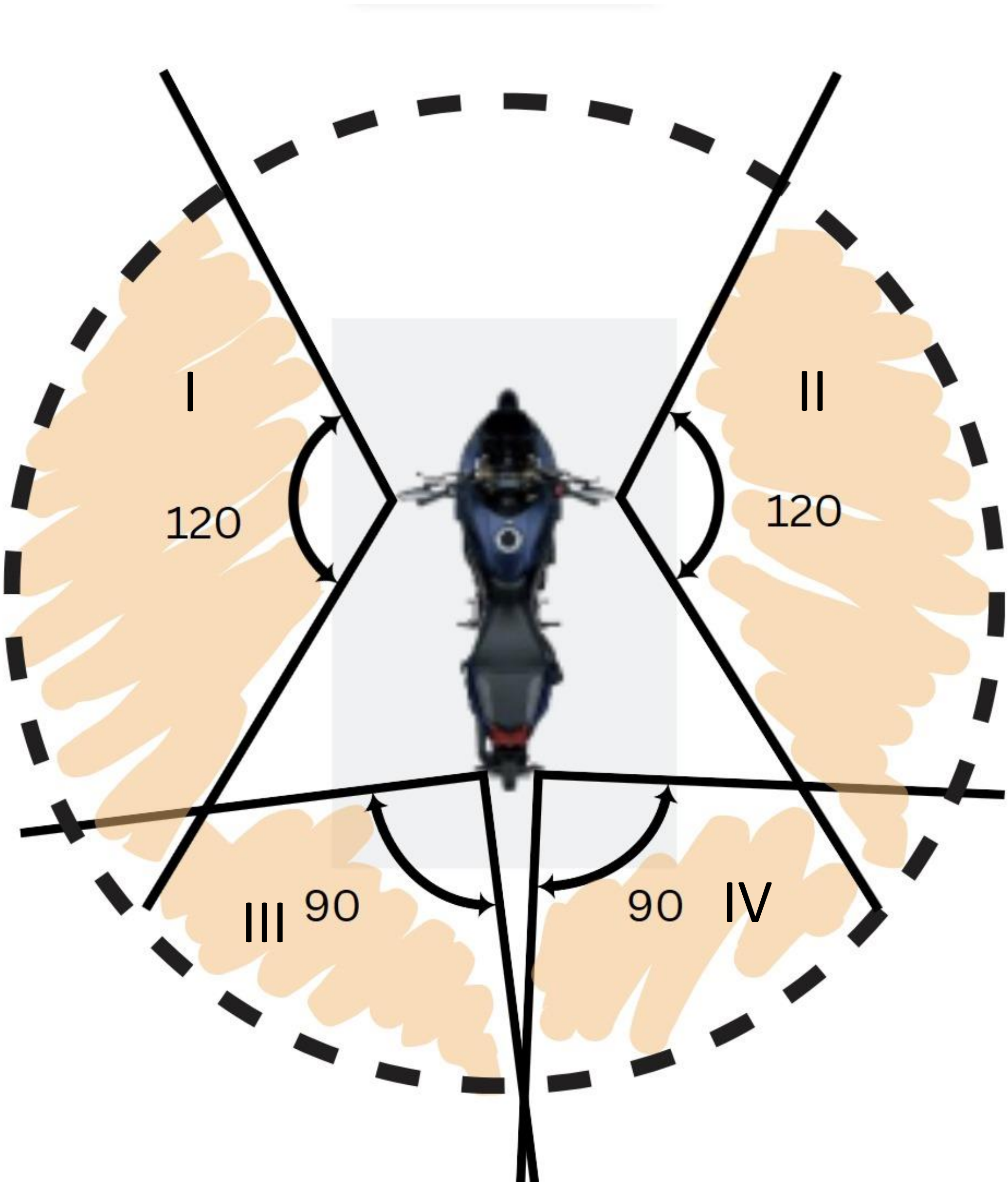
3) **Availability of Speed Monitoring System:** Assuming that the two-wheeler is equipped with an existing speed monitoring system, such as an electronic speedometer or onboard diagnostic system (OBD-II), capable of providing accurate real-time speed data.

4) **Environmental Conditions:** Assuming that the system operates effectively in various environmental conditions, including different weather conditions and lighting conditions.

5) **System Integration:** Assuming that the system can be seamlessly integrated into existing two-wheeler designs without significant modifications or disruptions to the vehicle's functionality.

Design

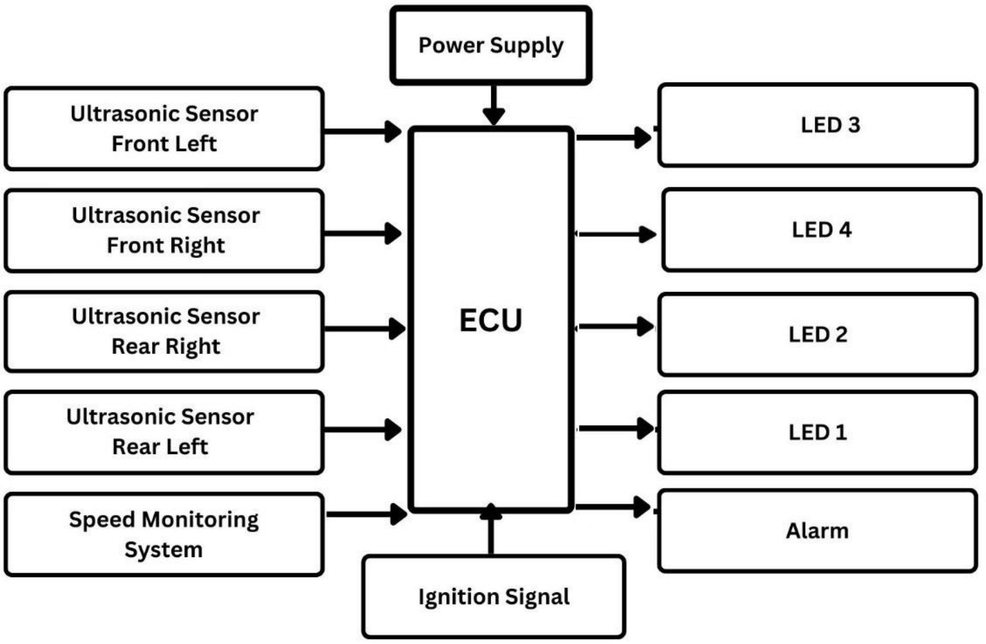
1. Sensor Placement -



The sensor placement is carefully arranged to ensure optimal coverage of the surrounding area. Specifically:

- Two sensors are positioned at the front of the rear-view mirror side, strategically placed to cover a 120-degree region each. Importantly, their placement is meticulously arranged to avoid overlapping with the front 60-degree angle.
- The remaining two sensors of 90-degrees are located at the back indicator light. This configuration ensures that they do not interfere with the front sensors' area of interest, maintaining clear and unobstructed detection capabilities.

2. Block Diagram



1. Ultrasonic sensors work by emitting high-frequency sound waves (ultrasonic waves) and measuring the time it takes for these waves to bounce back after hitting an object. The basic components of an ultrasonic sensor include a transmitter, a receiver, and a control circuit.
    - Transmitter: The transmitter generates ultrasonic waves and sends them out into the surrounding environment.
    - Receiver: The receiver picks up the ultrasonic waves that bounce back after hitting an object.
    - Control Circuit: The control circuit manages the timing of the ultrasonic pulse and calculates the distance to the object based on the time it takes for the wave to return.

2. The raw output of the sensor, which is in the form of frequency or time measurements, needs to be calibrated and processed by the Electronic Control Unit (ECU) to convert it into meaningful distance measurements. The ECU performs calculations using the known speed of sound in the medium (such as air) to translate the raw data into accurate distance readings.

3. One common algorithm used by the ECU to detect objects within a certain radius, such as 1.5 meters, is thresholding.

4. Thresholding involves setting a threshold value for the received frequency or time measurement. If the measured frequency or time falls below or above this threshold, it indicates the presence of an object within the specified radius.

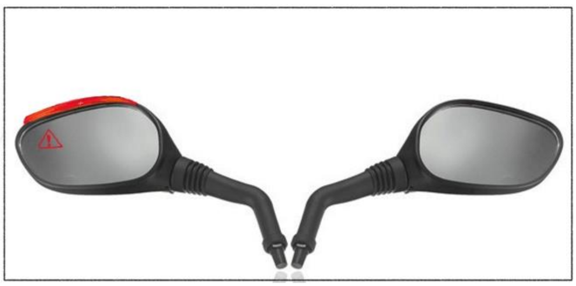
5. For example, the ECU can be programmed to consider any frequency measurement corresponding to a time-of-flight within the range expected for objects within 1.5 meters as indicating the presence of an object in close proximity to the vehicle.

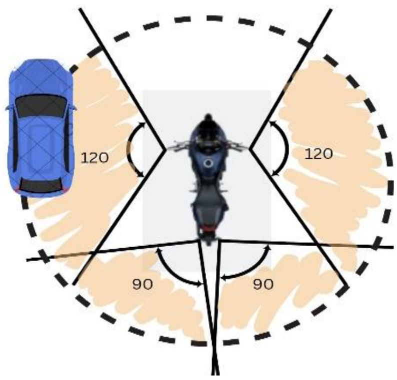
6. Once the threshold is set and the raw data is processed accordingly, the ECU can trigger appropriate actions, such as activating warning signals or initiating collision avoidance maneuvers, based on the detected object's proximity to the vehicle.

7. In our case, once the ECU understands that an object is detected it will illuminate the LED's.

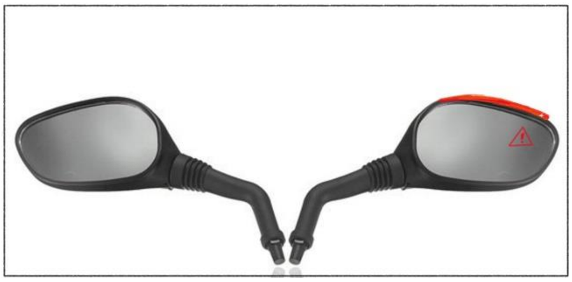
8. LED embedded in rare view mirror:
    - The diagrams below illustrate the system utilized for lane change assistance and rear-end collision detection.
    - The left side of the table represents various scenarios, while the right side indicates the corresponding reactions of the system.
    - If an object is detected within a range of 1.5 meters, the LED light will illuminate in yellow. If the object is within a 1-meter range, the LED light will turn red accompanied by an audio alarm.

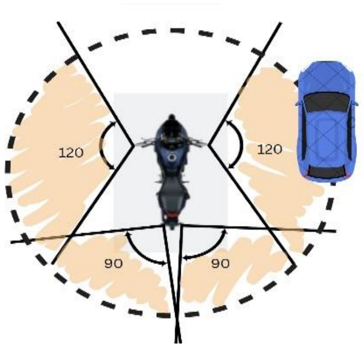
i. Case 1



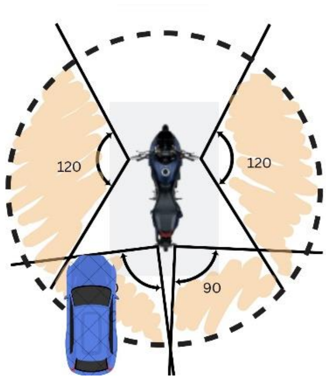


ii. Case 2

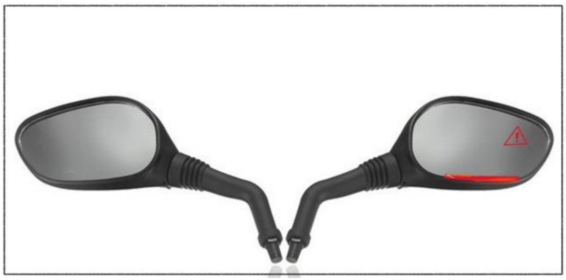


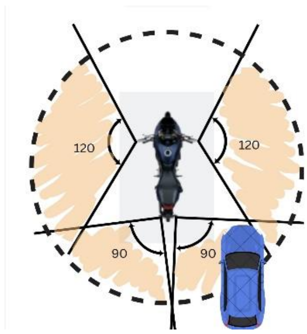


iii. Case 3

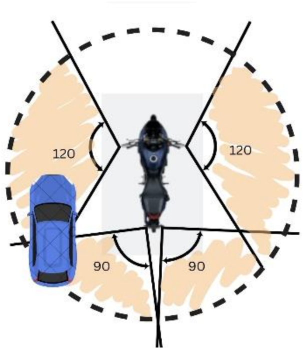


iv. Case 4:

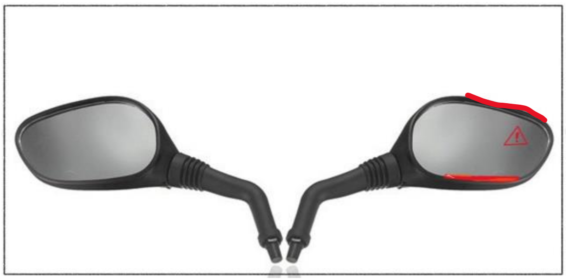


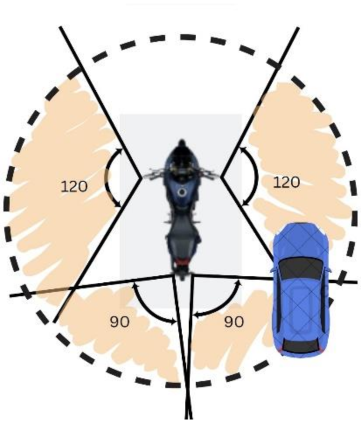


v. Case 5:



vi. Case 6:





vii. Case 7: