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CTRL - B

By Team Ctrl

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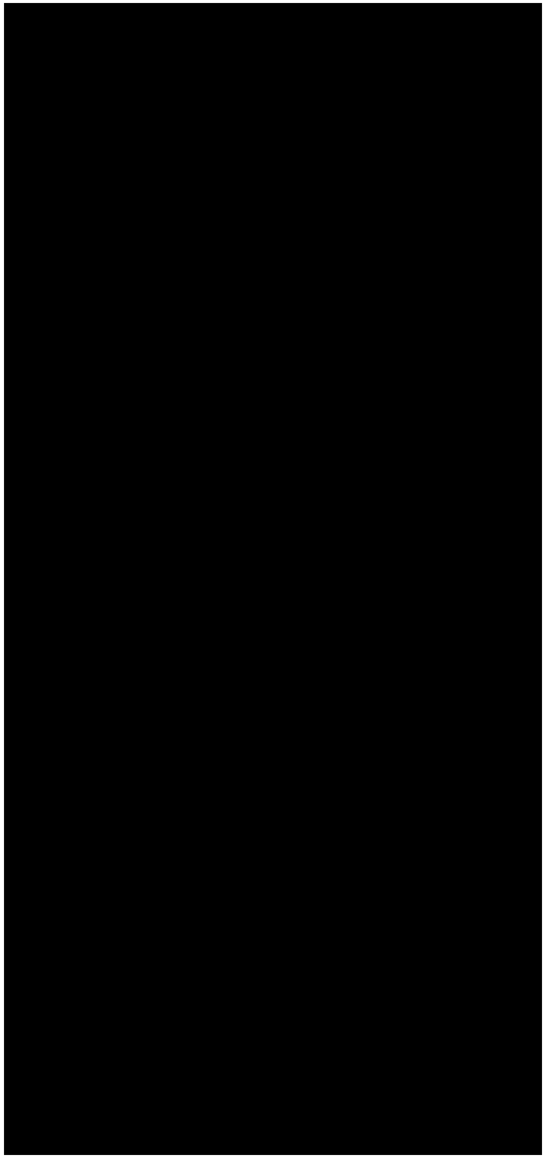
Background

Imagine riding an e-scooter and suddenly colliding with an obstacle you didn’t notice in time. If there were a cutting-edge braking system made especially to help avoid those unplanned collisions, wouldn't that be fantastic? This project addresses that very need, aiming to enhance safety and provide a more reliable solution for riders in such scenarios.



Ctrl-B

Ctrl-B is a portable braking device for non-motor vehicles like e-bikes and e-scooters.

Non-motor vehicles have limited visibility and it is difficult to timely locate pedestrians/objects to prevent collisions. The rider will have a portable device that will assist them in braking when approaching an object with a fast response time. This device when attached to non-motor vehicles will reduce the likelihood of collisions when experiencing limited visibility.

Benefits

- This will increase safety and shorten braking response times to objects in line of sight
- It will be usable and compatible with the current braking system on any non-motor vehicle
- Will allow riders to be able to better avoid collisions when operating non-motor vehicles when experience limited visibility, for example during bad weather

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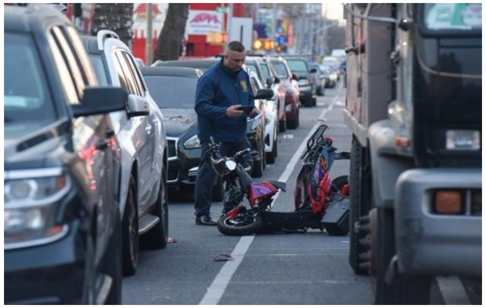
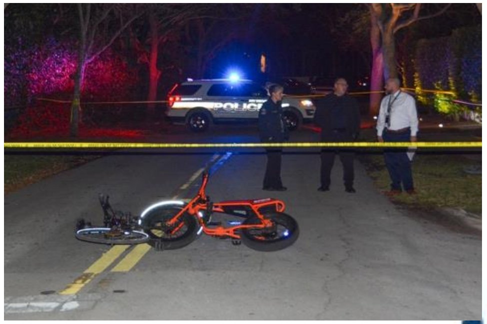
Needs and Demands



- ❖ Limited visibility on scooters/bike can lead to unsafe conditions and injury

- ❖ Undesired collisions with pedestrians or any oncoming objects



- ❖ Difficult to timely locate pedestrians/objects to prevent collision

Problem Statement

Limited visibility on non-motor vehicles can make it difficult to detect incoming objects or pedestrians in time to prevent collisions. The developed system will be equipped with portable, mobile sensors that utilize object detection to assist in braking when approaching objects at high speeds. When attached to scooters, this device will reduce the likelihood of collisions in low-visibility conditions.

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Product Specifications

Items	Quanity
XM125 Radar Sensor	1
Lithium Battery	1
Raspberry Pi 4 Processor Model B	1
Object Detection Camera	1
Google Coral Dev Board	1
Waterproof Servo	1
Cord Lock	1
Jumper Wires	1
Nylon Double-Knotted Rope	1
Protective Casing	1

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Design Constraints

Consumer Product Safety Commission (CPSC)

- ❖ Is responsible for protecting the public from unreasonable safety risks that propose fire, electrical, mechanical, or chemical hazards or injury to the thousands of consumers.
- ❖ No specific regulations for scooters

IEEE P2020 - Automotive Sensors

- ❖ Standards for automotive system image quality for all manufacturers to meet regulatory requirements and to align with performance expectations.
- ❖ As vehicles increasingly rely on vision systems for safety and automation, this standard ensures baseline quality and reliability across the industry.

Design 1

Object Detection Camera-Triggered Braking System

This solution uses a Raspberry Pi object detection camera mounted at the front of the scooter or bike to detect obstacles. The camera sends real-time images to the Raspberry Pi, which runs an object detection algorithm. When an obstacle is detected within a predefined range, the Raspberry Pi activates the micro electric actuator, which engages the brake mechanism. The lithium battery powers the system, while a radar sensor helps verify the distance between the vehicle and obstacles.

Design 2

Radar Based Proximity Sensor

The Radar Sensor-Based Automatic Braking System utilizes a Acconeer XM125 Radar Sensor, which has the capability to detect objects' speed and distance as it relates to the position of the vehicle. The radar continuously scans the path in front of the scooter or bike, sending data to a Raspberry Pi 4 that serves as the system's processor.
The Raspberry Pi 4 processes this data to determine whether an object or person is too close and could result in a collision. When an obstacle is detected within a dangerous proximity, the micro-electric actuator is activated, applying a force to the brake lever to stop the vehicle.

Design 3

Hybrid Object Detection and Radar System with Adaptive Braking

In this solution, the object detection camera and radar sensor work together in a hybrid system. The camera detects obstacles and classifies them, while the radar measures their distance and speed. Based on the combined input, the Raspberry Pi calculates the required braking force and adjusts the activation of the micro electric actuator for smooth braking. The lithium battery powers the entire system.

Object Detection Camera-Triggered Braking System

Pros	Cons
Real-time object detection: Efficient in dynamic environments with a lot of movement (e.g., pedestrians, cars)	Power consumption: Running object detection algorithms and radar sensor simultaneously could drain the battery quickly
Dual verification system: Combines image-based detection with radar for improved accuracy	Complexity: Object detection requires advanced algorithms and processing power, which could lead to latency issues.
Smart braking: Can differentiate between relevant and irrelevant objects (e.g., parked cars vs. moving pedestrians)	Environmental sensitivity: Poor performance in low-light conditions or bad weather (e.g., rain or fog)

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Radar Based Proximity Sensor

Pros	Cons
Reliable detection in low visibility conditions such as around corners, in rain/fog, and in low sunlight	Limited detection range: the system is limited by the detection range of the radar sensors used
Radar sensors provide real-time response times in object detection, combined with the raspberry pi's processing speed identified objects can be responded to within milliseconds	Radar sensors could potentially detect irrelevant objects such as small debris or low hanging branches triggering unnecessary braking
The system offers minimal power consumption making it ideal for portable conditions when paired with a lithium-ion battery	Heavy Dependence on electric actuator: the system relies on the actuator to physically engage the brake, so mechanical stress over time could reduce the effectiveness of the response time

Object Detection and Radar System with Adaptive Braking

Pros	Cons
Precision braking: The system adapts braking force based on object speed and distance, providing smoother stops	High power consumption: Running two sensors simultaneously increases battery drain
Reduced false positives: The object detection camera helps eliminate irrelevant objects from triggering the brakes	Processing demands: Combining two data sources increases the complexity of the software running on the Raspberry Pi, possibly leading to delays
Versatile: Works well in a variety of environments, from urban to suburban settings	Cost: The integration of two sensor types and adaptive braking adds to system cost and complexity

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Decision Matrix

Radar Based Proximity Sensor

Object Detection and Radar System with Adaptive Braking

Criteria	Weight	**Design 2**	Score	Agg. Score	**Design 3**	Score	Agg. Score
Power	2	Lower power consumption, less components	5	10	High power consumption, powers more components	4	8
Functionality	5	Detection Algorithm Actuator Output Force	3.5	17.5	Object detection camera and radar sensor with use of raspberry pi and micro electric actuator	5	25
Convenience	4	Portable, connects to body of the non-motor vehicle via outer casing	4	16	Portable, simple connectivity to non-motor vehicle	4	16
Weight	1	Approx. 970g	5	5	Approx. 1050g	4	4
Response Time	3	Raspberry Pi processing speed Sensors have limited detection range	4	12	More complex software running, could lead to delays, more precise	3	9
Total				60.5			62

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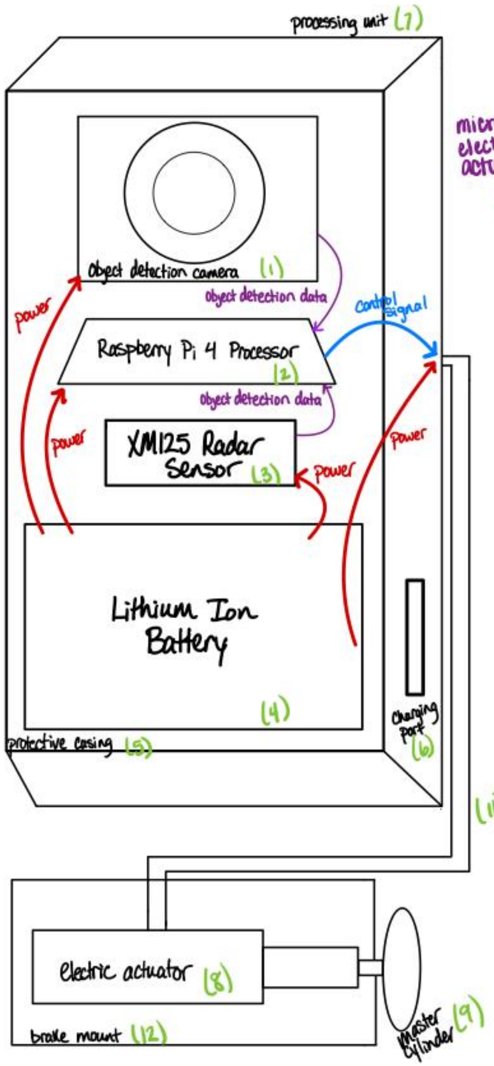
Details of the Top Design



The developed system uses object detection to assist in braking when approaching objects at high speeds. A processing unit (7) that is in a protective casing (5) is connected via straps (10) to the non-motor vehicle. A protective casing (5) houses an object detection camera (1), Raspberry Pi 4 processing unit (2), XM125 Radar Sensor (3), and Lithium Ion Battery (4). The processing unit (2) intakes data from the object detection camera (3) that continuously scans the environment for obstacles and radar sensor (3) that assesses/monitors the object’s speed. Theses components are interconnected via a bus system where the processing unit (2), uses a detection algorithm to calculate the whether an object is within critical distance of the non-motor vehicle. The processing unit (2) then sends a control signal through a wire connection (11) to the electric actuator (8), which converts the an electrical control signal to mechanical force which is applied to a master cylinder (9). The actuator (8) is mounted to the scooter’s braking interface by a mount (12). The control signal determined by the detection algorithm creates the appropriate force to apply to the cylinder (9) for assisted braking. The system is powered by a lithium ion battery (4), which can be recharged via USB port (6).

Component-Level Schematic

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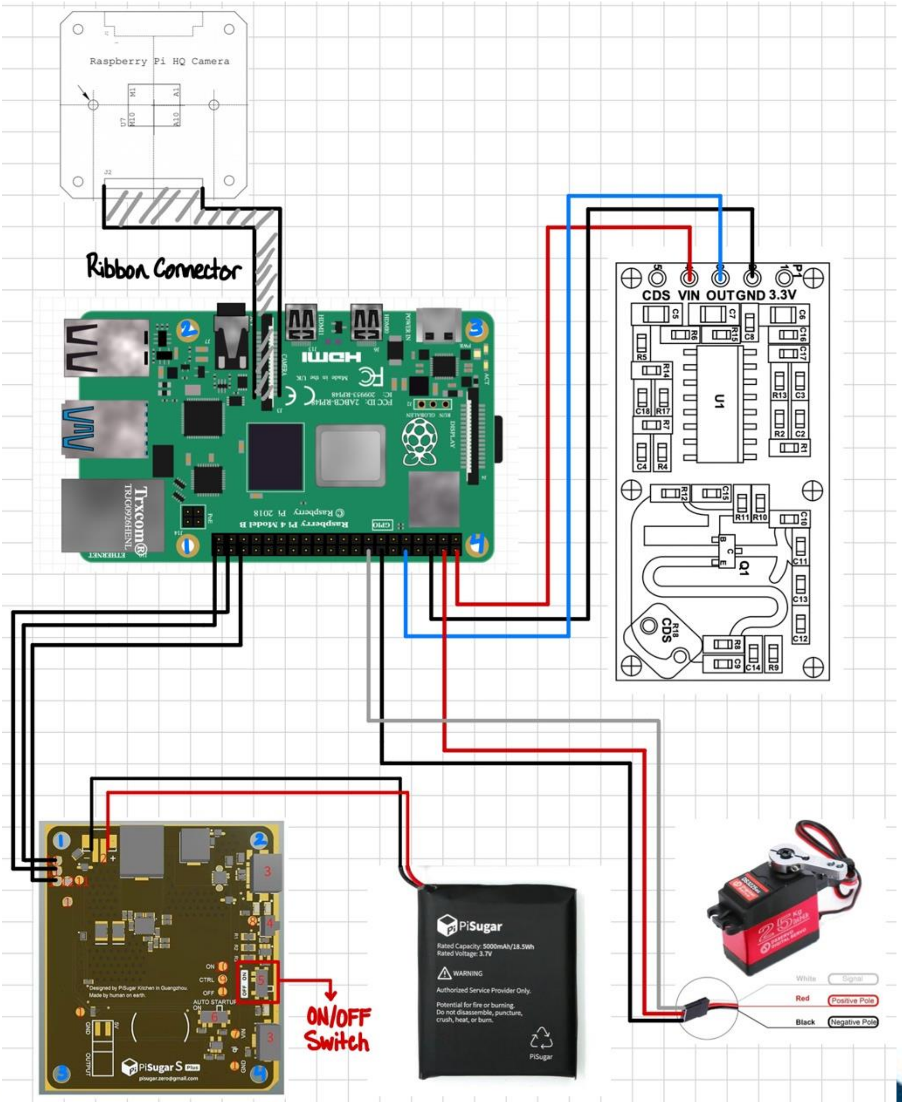
- Battery Pack 5V3A Input/Output (Approx. ~8+hrs)
- Connected to Raspberry Pi using 4 screws, making contact via pins (11)
  - GPIO On/Off Switch (5)
- Raspberry Pi HQ Camera and ribbon connector
- Radar Sensor (GPIO 15)
- Servo Motor (GPIO 23), applies mechanical force to the external string
- Detection Algorithm



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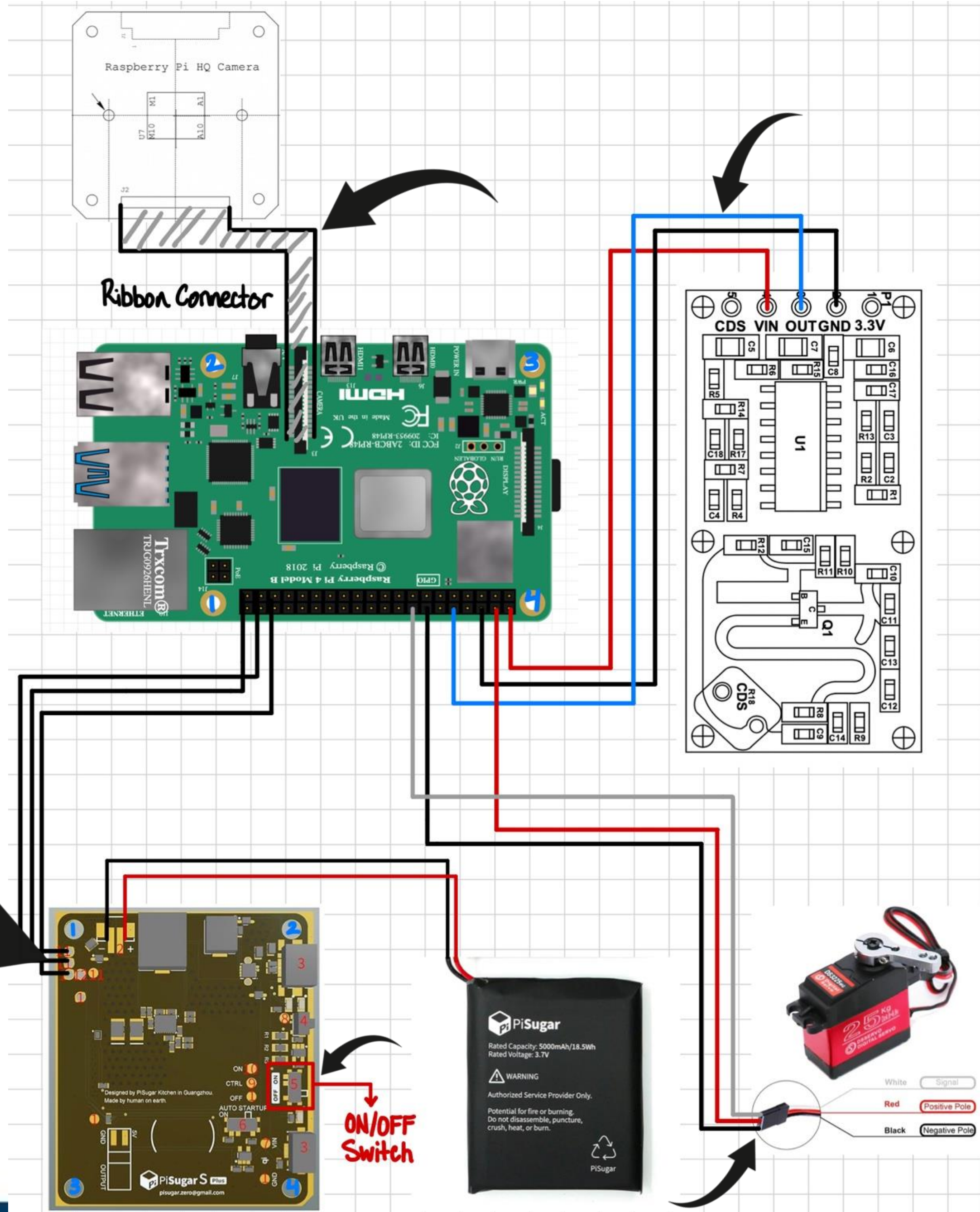

Conclusion

- Need an extra layer of protection?
- Under limited visibility conditions, CTRL-B is designed to provide users with enhanced braking capabilities to decrease the likelihood of collisions.
- With this device, users will have a more controlled riding experience with increased safety measures on the go!

Thank You!