Team A3: BikeBuddy

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Use Case & Design Requirements

Bike Safety Hub

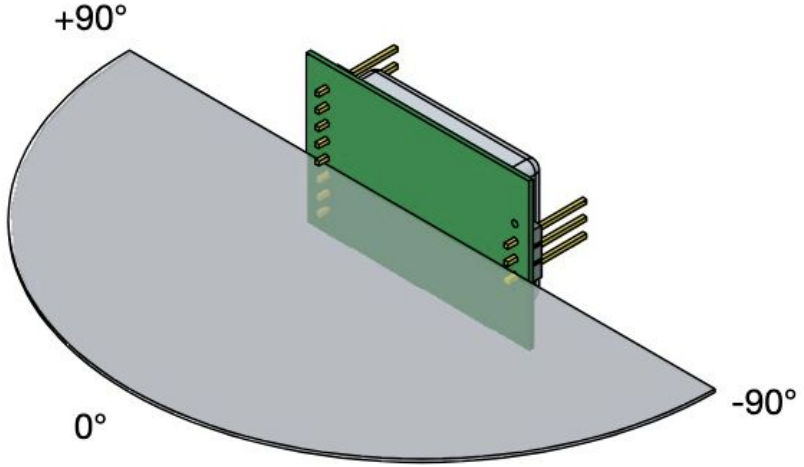
- Blind Spot Detection
  - Warn if car or large object is within 10-meter range
- Collision Alerts
  - Relative speed of car behind is >= 15 mph
  - Near insufficient distance left to brake before hitting car in front[1]
- Turn signals
  - Capable of self-canceling when making 90 deg. Turns
- Centralized Warning Display
  - Flash red on section of display if having potential of being hit

Category	Metrics
Cost	<= $200 Market Price
Power Consumption	>= 2 hrs endurance
Detection Range	>= 10 m
Uptime	>= 99.999%
Confusion Matrix	<= 40% False Negatives <= 30% False Positives
Ruggedness	IPX4
Difficulty of Installation	Easy (user survey)

[1]Equation for stopping distance from AASHTO “Guide for the development of bicycle facilities”, 4th ed.

Solution Approach

Cars Can’t See Bikers vs Bikers Can’t See Cars



- “Man Riding Bicycle during Nightfall” from Pixabay under CC0
- “Bicyclist with a rearview mirror attached to his helmet” from Oregon DOT under CC-BY 2.0

Why Radar?

Radar

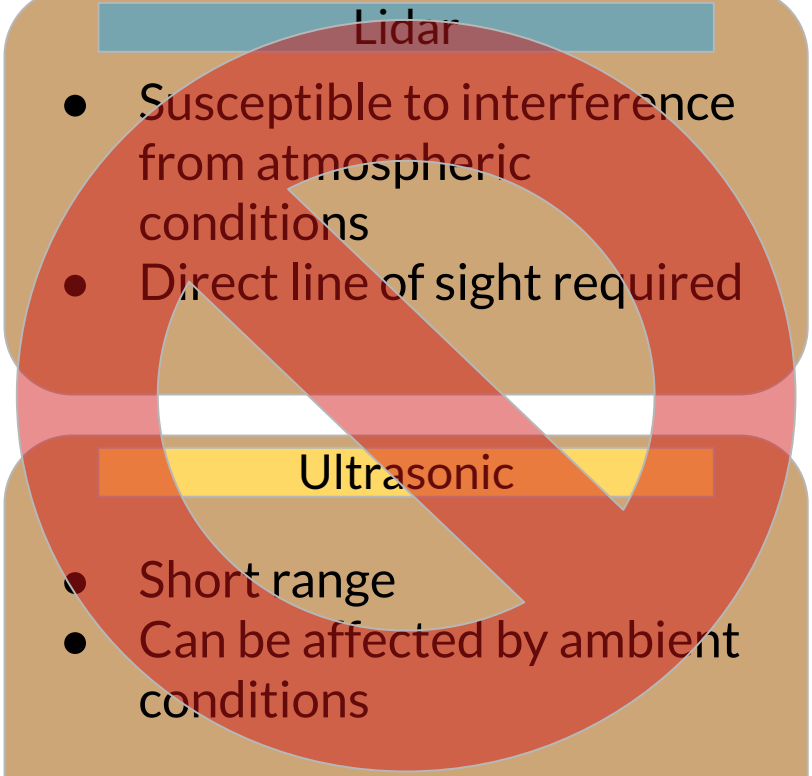
- All-weather operation
- No direct line of sight requirements
- Speed measurement
- Direct serial output (K-LD7)

Lidar

- Susceptible to interference from atmospheric conditions
- Direct line of sight required

Ultrasonic

- Short range
- Can be affected by ambient conditions



Other Possible Benefits

Public Health

Making biking safer
More people biking

Safety

Reduce collision rates between cyclists and vehicles

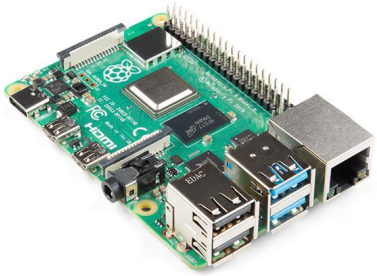
Economic

Reduce healthcare, repair costs due to less rate of collisions

System Specification

- K-LD7 Radar
- RPi 4
- Hosyond IPS 5 INCH LCD
- Hyunduo 5V LED CHIP light bulb
- Anker 337 power bank
- Button
- Rapid prototyped waterproof enclosure

https://rfbeam.ch/wp-content/uploads/2022/11/K-LD7-EVAL-1024x1024.png



https://www.sparkfun.com/products/15447

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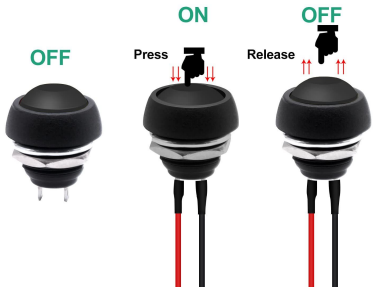

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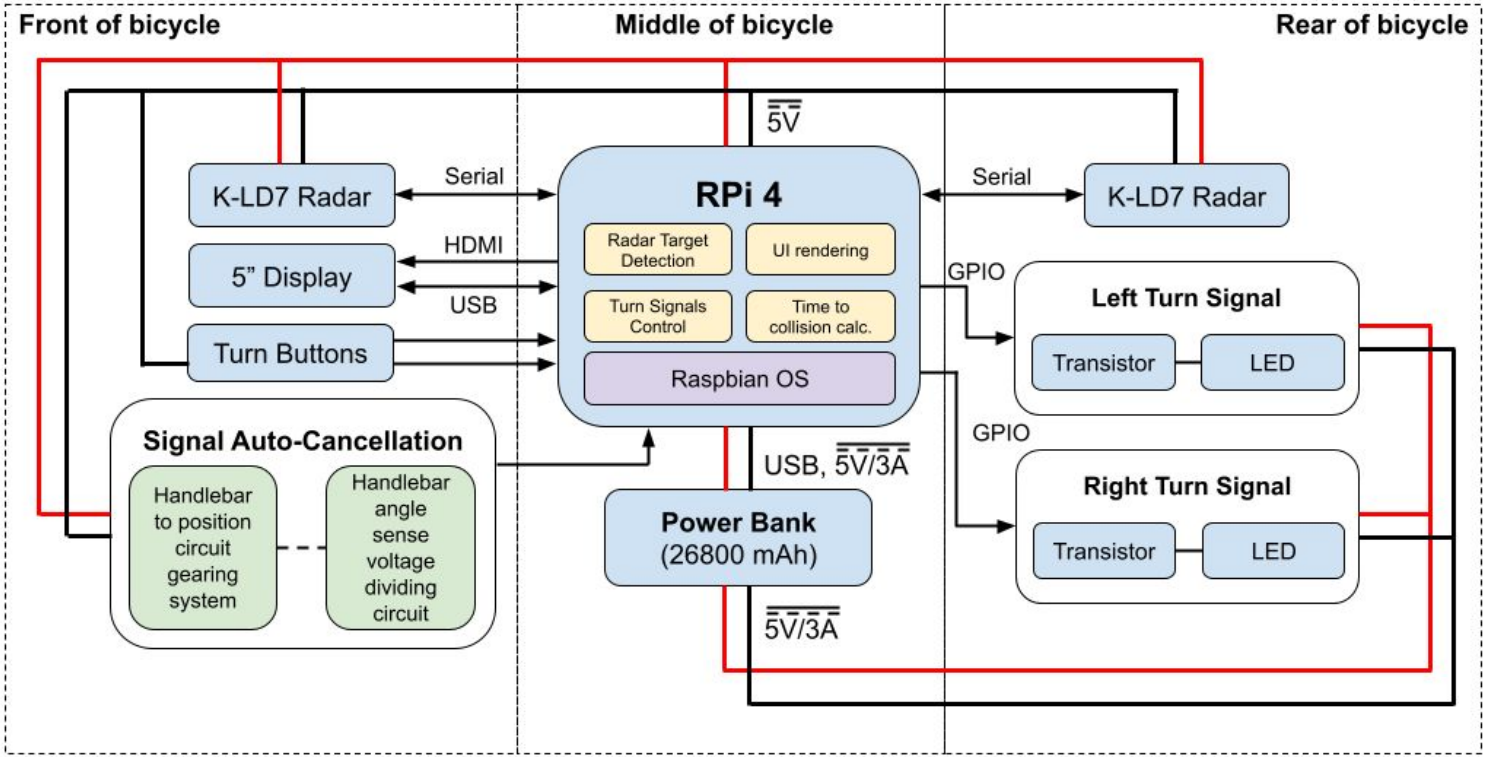
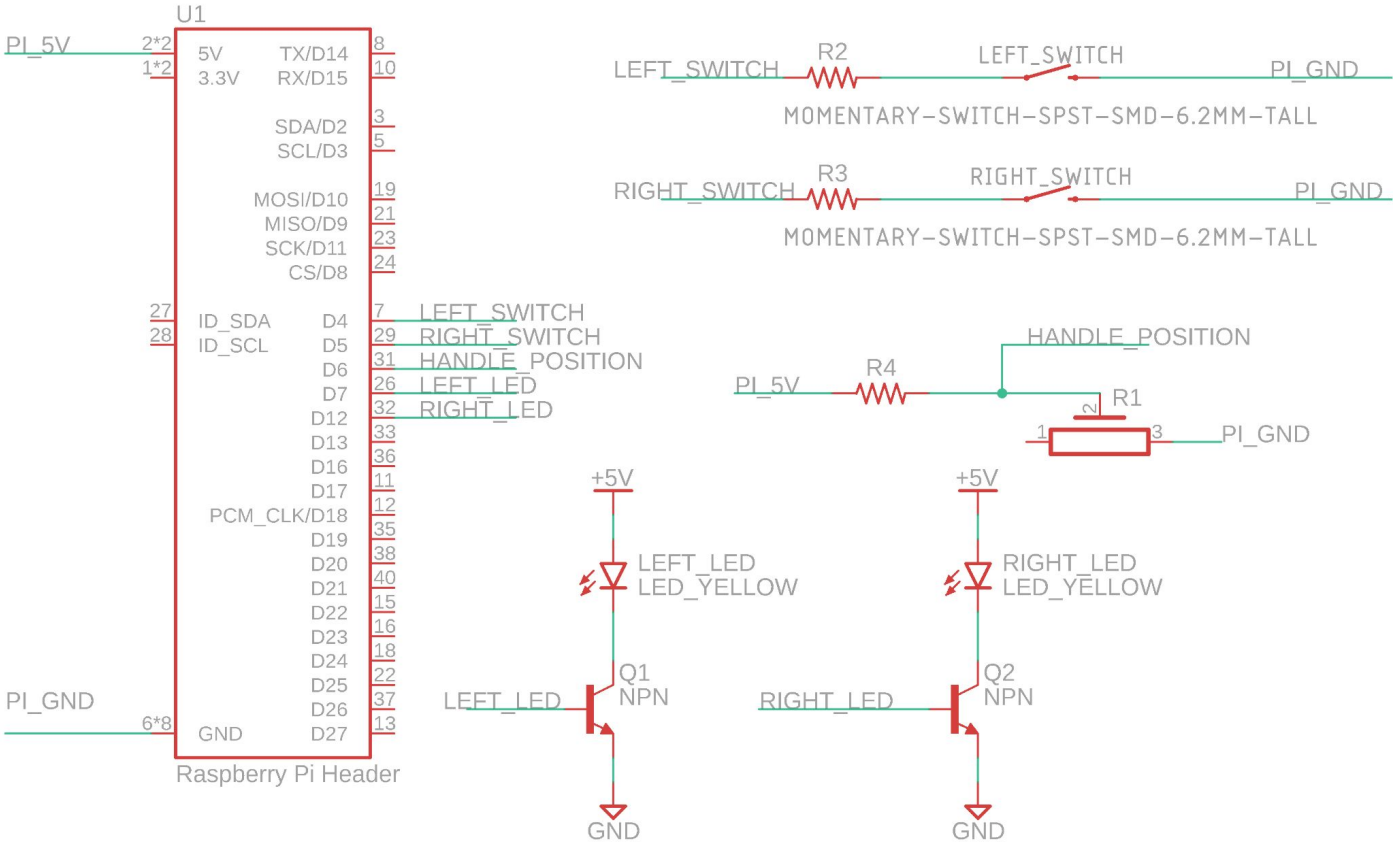


(Based off the example block diagram in the handout)

Turn Signal Schematics



Turn Signal
led blinking
switch activation
handlebar position sensing
self cancellation

UI
hello world GUI
design mockup
UI implementation
sensor integration

Radar
radar basic bring up
raw data processing
tuning for BSM*, RCW*, FCW*

Exterior Case
bike attachments
fitment check
waterproof check

*BSM - Blind Spot Monitoring, RCW - Rear Collision Warning, FCW - Forward Collision Warning

Testing, Verification and Metrics

Metric	Test Plan	Pass Metric	Mitigation Plan
Uptime	• Record time that radars respond to data queries on RPi, divide by total application runtime	>= 99.999% uptime	• Analyze why system is not available and address accordingly - e.g., if wiring is loose, tighten them
Confusion Matrix	• Static testing - Record radar performance with and without objects in front in a controlled environment • Real world testing - Record video, manually count both types	<= 40% False Negatives <= 30% False Positives	• Try with different enclosure materials and radome configurations • Tune radar parameters (max speed, distance, frequency) • Switch to other method (LIDAR)
Power Consumption	• Measure average current draw using ammeter and extrapolate total time • Record the running time of the system under normal use	Endurance time >= 2 hrs	• Measure current draw of each component to identify excess usage • Use a lower power device that still meets perf. need • Increase battery size

Testing, Verification and Metrics

Metric	Test Plan	Pass Metric	Mitigation Plan
Detection Range	• Static testing - Verify radar on bike can see parked car beyond 10 m in a controlled environment • Real world testing - Record both display and behind bike, manually analyze distance of vehicle when alert is triggered	Car >= 10 m detected	• Try with different enclosure materials and radome configurations • Tune radar parameters (max speed, distance, frequency) • Switch to other method (LIDAR)
Ruggedness	• Test with IPX4 test protocol • Test functionality of system in case by riding around in poor conditions and verifying functionality still works	Passes IPX4 test, functionality unimpeded by case	• Identify points of water entry and seal • Verify all wiring is tight and undamaged • Verify radome to sensor distance is correct
Difficulty of installation	• Ask 5+ bike riders to try the product and gather their opinions	Rated “easy” on rating scale	• Survey what people want and redesign if possible

Project Management

Jack:

- Radar Bring up & Tuning

Jason:

- RPi software/UI

Johnny:

- Turn signals
- Enclosure fabrication
- Part Installation