ARC^2: AR Cycling Against Rearview Collisions

Meet the team

Engineering the next generation of AR cycling safety.

Notes/ To Do/Contents:

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Augmented Reality + Artificial Intelligence Cycling

We combine augmented reality (AR), sensors, and artificial intelligence (AI) to give cyclists real-time awareness and proactive safety

The Problem

Cyclists lack real-time awareness in urban environments.

Most accidents happen because riders can’t see or react to hazards coming from behind.

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Most accidents happen because riders can’t see or react to hazards coming from behind.

* This image is generated with AI

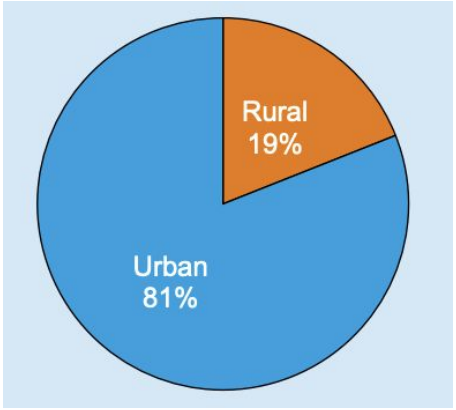
Why is this important?

- 30% of total vehicles during commuting hours in Boston
- 39,300 workers cycle to work in Massachusetts, up from 31800 before the pandemic
- In the US**, 1,166 bicyclists were killed in 2023**, up from 1,117 in 2022

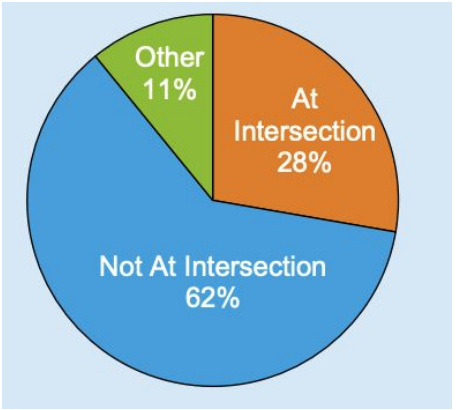
National Highway Traffic Safety Administration. (2024). *Traffic Safety Facts: 2023 Data — Bicyclists and Other Cyclists*.
https://crashstats.nhtsa.dot.gov/Api/Public/Publication/813739

Why use advanced technology?

- Most fatal bike crashes happen where AR warnings can help:
  - Urban (81%)
  - Mid-block road segments (62%)
- AR/HUD-style displays reduce eyes-off-road time



Cyclist Fatal Crashes Rural /Urban Classification



Cyclist Fatal Crashes Street Location Classification

National Highway Traffic Safety Administration. (2023). *Bicycle Safety*. In *Countermeasures That Work — Bicyclists*.

Why use advanced technology?

Safety systems in bikes have not advanced at the same rate as cars

Why use advanced technology?

* This image is generated with AI

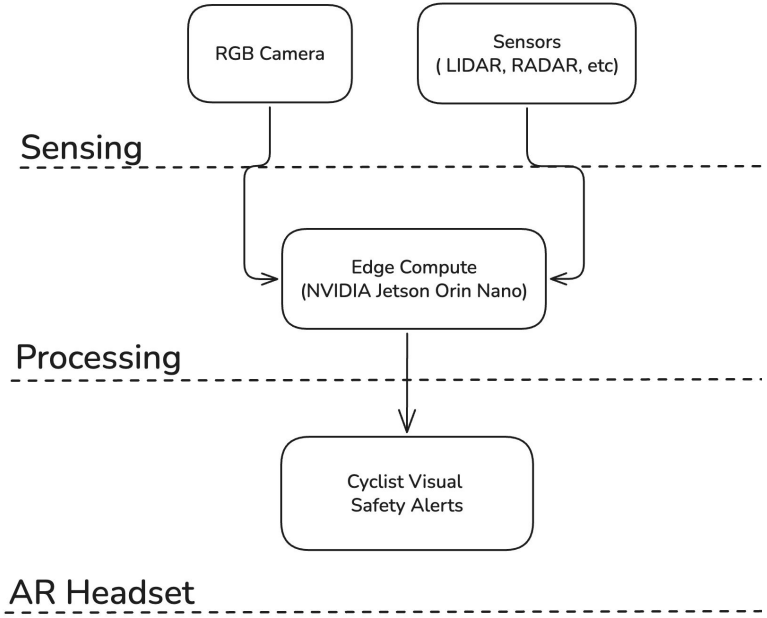
Why use advanced technology?

- Bikes are only gradually adopting “smart” systems and many innovations are still at very low levels.

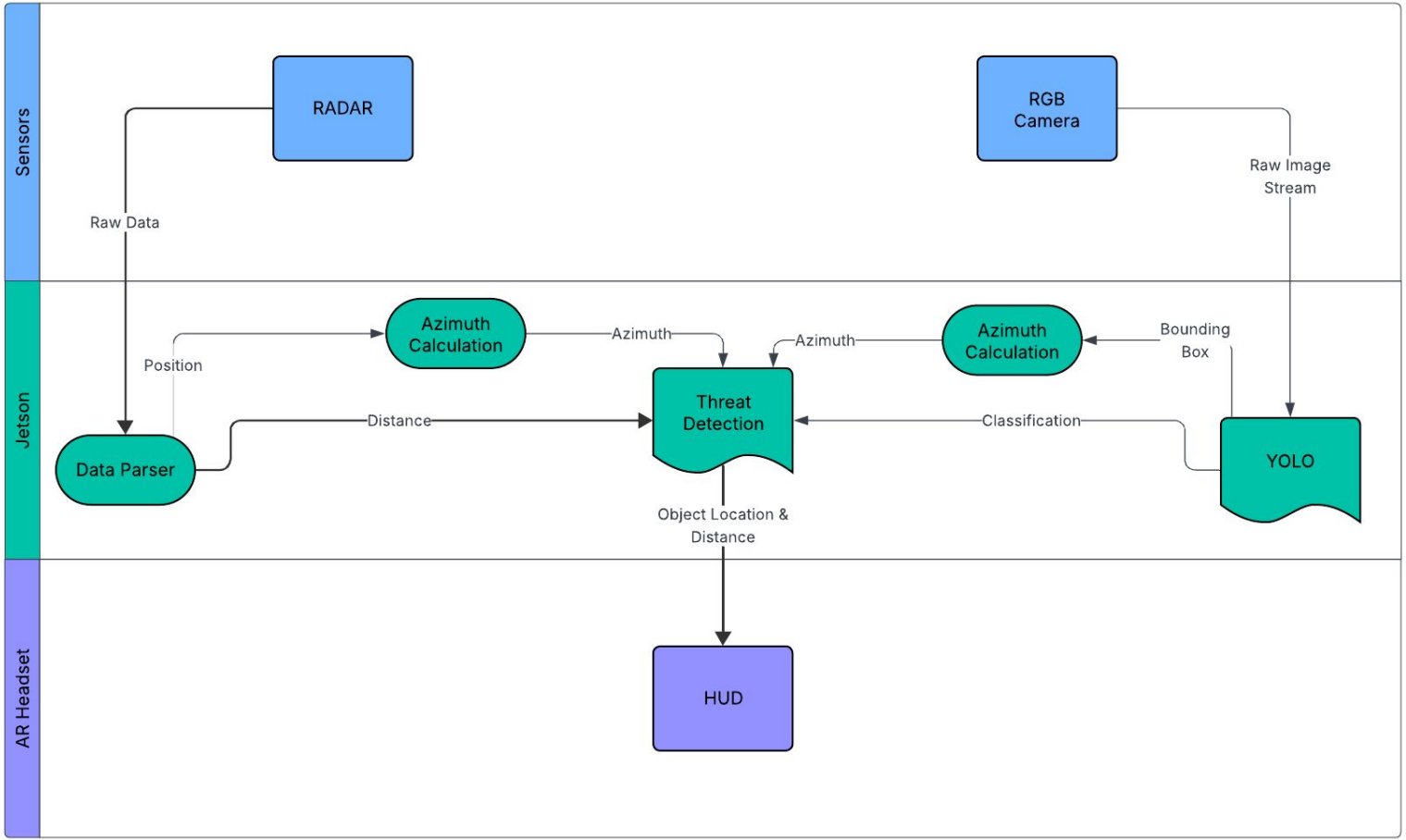
- In contrast, vehicle technologies (cars/trucks) have rapidly adopted driver-assist systems (lane-keeping, automatic emergency braking, rear-vehicle detection)

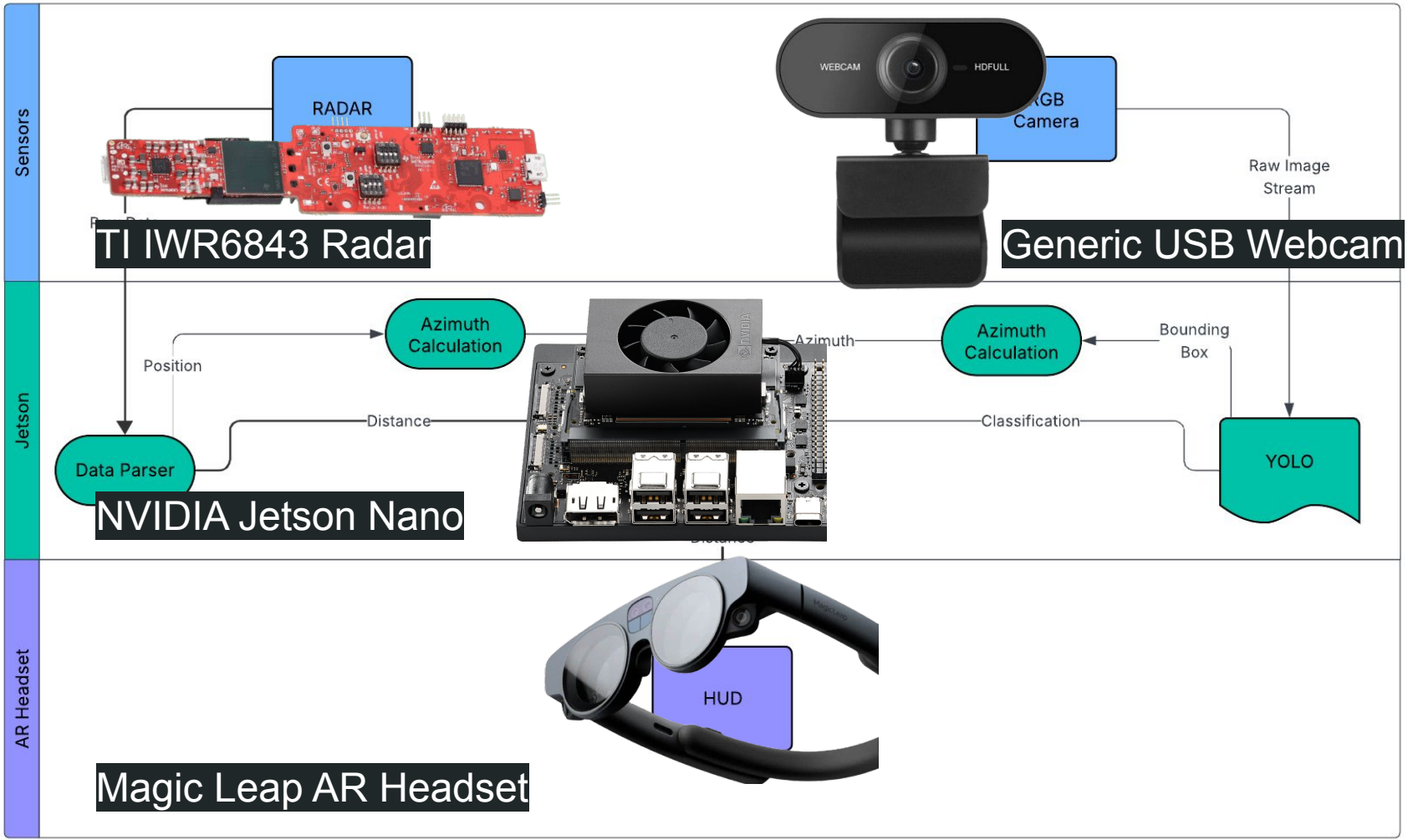
System Level Overview

- Hardware
  - Jetson
  - Webcam
  - Radar
  - Magic Leap
- Software
  - CV inference pipeline
  - Radar object detection pipeline
  - Fusion algo to combine both
  - AR headset application



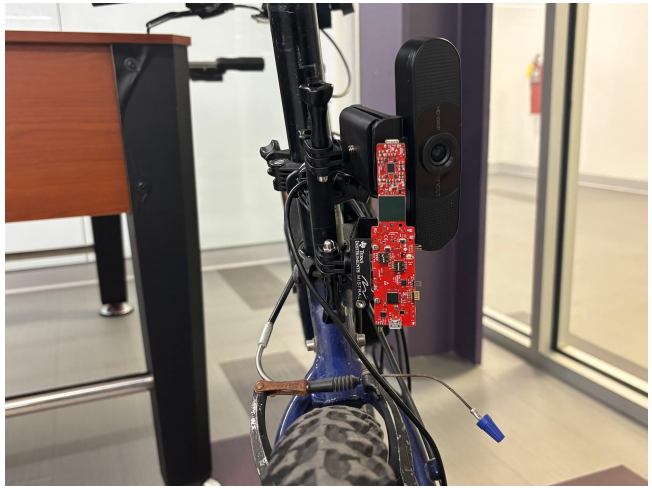
System Level Overview

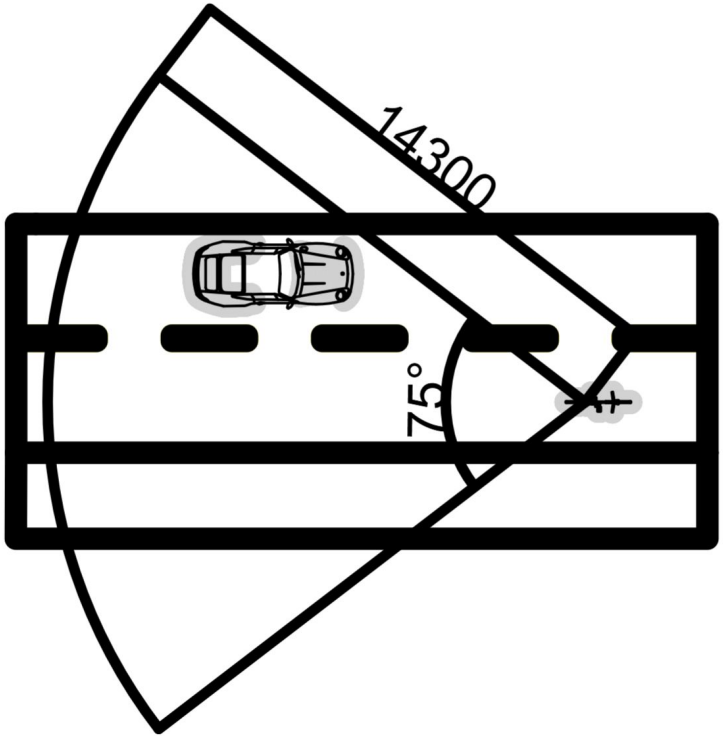



Sensors
RADAR
TI IWR6843 Radar
WEBCAM
HDFULL
RGB Camera
Raw Image Stream
Generic USB Webcam
Jetson
Azimuth Calculation
Position
Azimuth
Azimuth Calculation
Bounding Box
Distance
Classification
Data Parser
YOLO
NVIDIA Jetson Nano
AR Headset
HUD
Magic Leap AR Headset

Hardware Overview

- Designed for use by cyclists in urban traffic:
  - Maximum sensing distance: 14.3m
  - Horizontal FOV: 75°
  - Range Resolution (m): 0.0703





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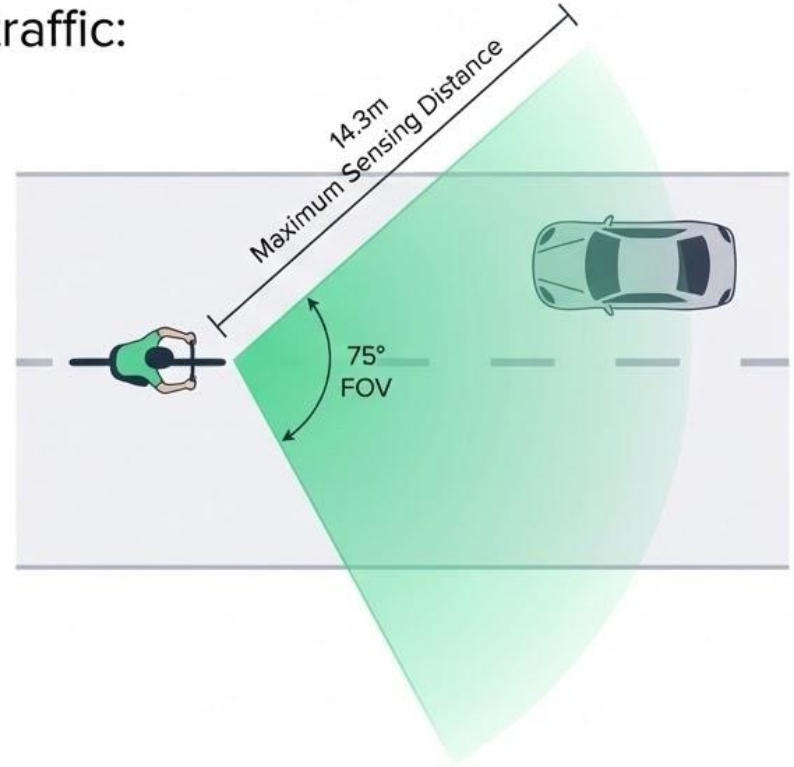


Software Overview

Webcam Detections

Radar Detections

```
Radar Frame 1: {objectID, posX, posY, posZ}
Radar Frame 2: {objectID, posX, posY, posZ}
Radar Frame 3: {objectID, posX, posY, posZ}
...
Radar Frame X: {objectID, posX, posY, posZ}
```

Threat Detection Algorithim

- frame synchronization
- azimuth calculation and matching

Threat Detections

```
Frame 1:
    left: {object (car or person), distance (m), confidence}
    center: {object (car or person), distance (m), confidence}
    right: {object (car or person), distance (m), confidence}
Frame 2:
    ...

Frame X:
    left: {object (car or person), distance (m), confidence}
    center: {object (car or person), distance (m), confidence}
    right: {object (car or person), distance (m), confidence}
```

Computer Vision

- **Classifies objects** seen in the rearview camera in **realtime**

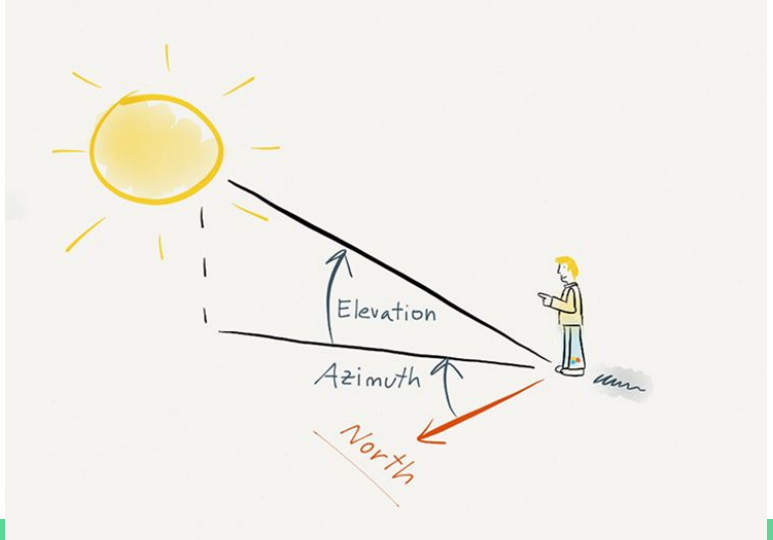
- **Classification** and **bounding boxes** are used in the **threat detection algorithm**

Back View

Front View

Threat Detection Algorithm

- **Compares** object detections from webcam and radar by horizontal angle from the bicycle
- Fuses separate sensor detections into single complete detection
- classification, confidence, and location (right, left, center, distance) are given to AR headset over WebSockets
- <5 meters is red
- 5-10 meters is yellow
- >10 meters is green

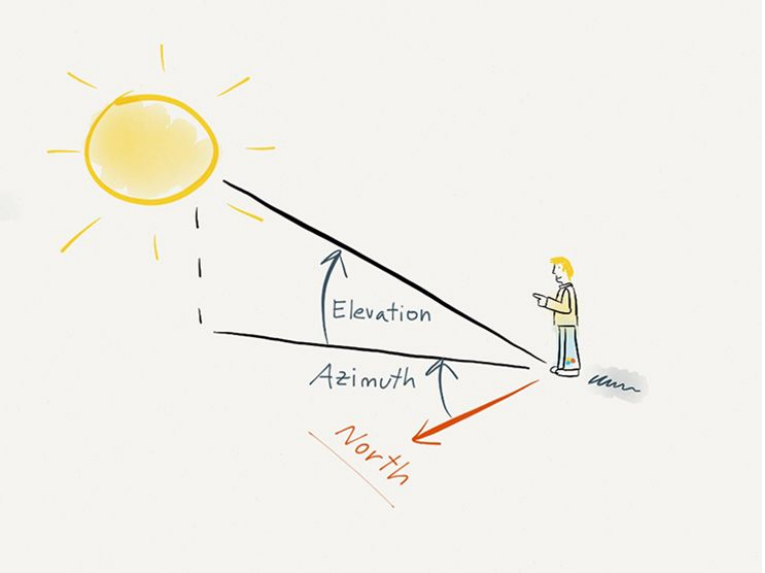


Threat Detection Algorithm

- Synchronizes webcam and radar timestamps

- Compares object detections from webcam and radar by horizontal angle from the bicycle

- Fuses separate sensor detections into single complete detection
  - Classification (Vehicle or Person)
  - Confidence (0-1)
  - Location (Left, Center, Right, Distance (m))

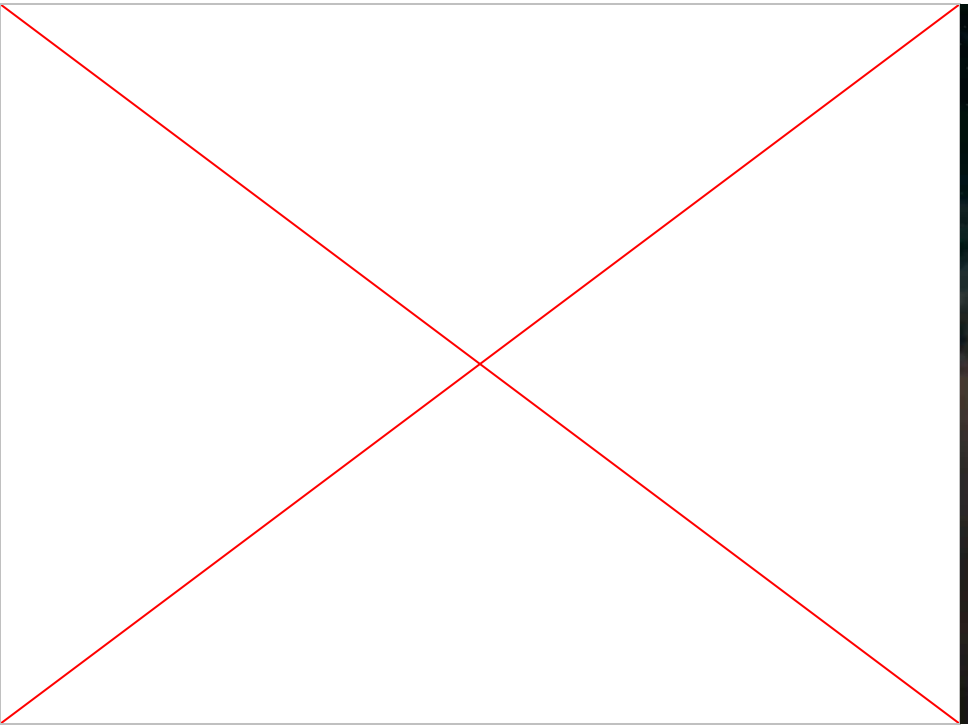


Magic Leap 2 AR Headset

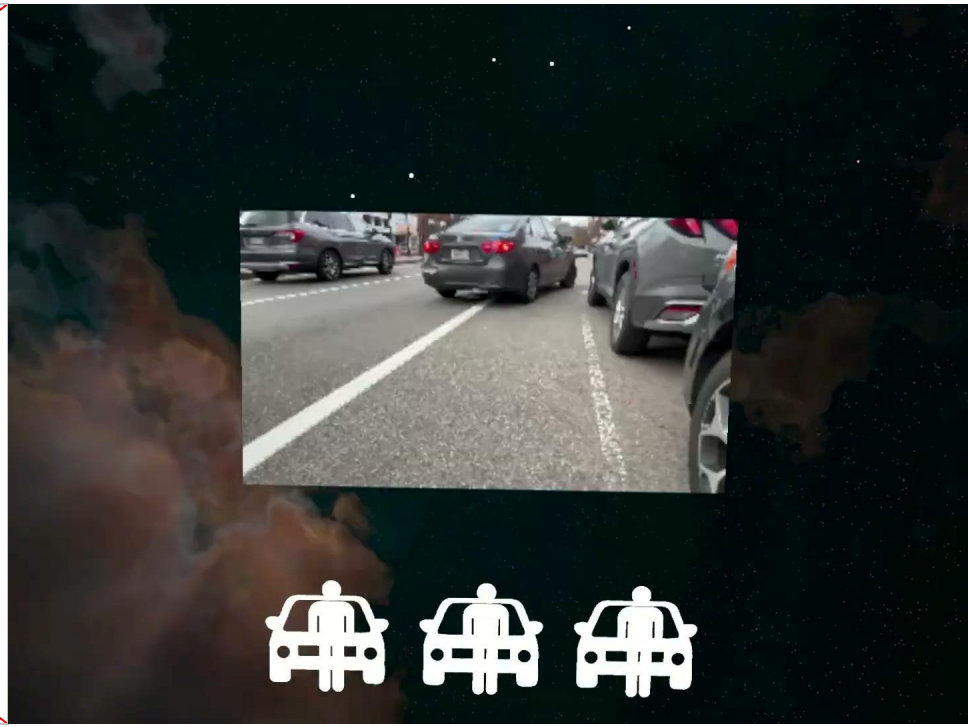
- Threat detections received from Jetson over websocket
- Custom adaptive HUD displays hazards within threat ranges.

CLOSE < 5m
NEAR 5m-10m
FAR > 10m

Demo



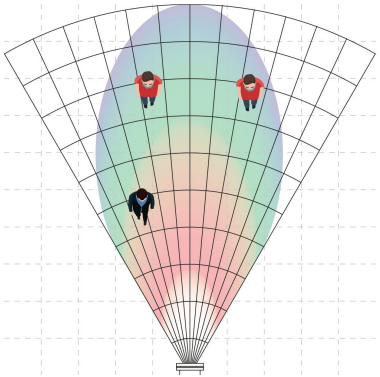
Rear webcam video with YOLO object detections



Magic Leap 2 HUD recording for demo

Takeaways

Sensors



AR+AI

Safer Biking!!!

Thank You!

Takeaways

- We are advancing biking in the same way that modern car systems have evolved.
  - using Augmented Reality and Artificial Intelligence
  - ARC^2 adapts modern car safety features to vulnerable bicycle users in open, unstructured environments by combining sensors, augmented reality, and machine learning.

Problem:
- Bikes have not modernized since their invention
- inadequate bike safety systems

Solution: