ScoutiFi

Safety you can Sense

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Introduction

ScoutiFi is a cutting-edge unmanned ground vehicle that pushes the boundaries of autonomous systems by integrating advanced context inference, computer vision, and WiFi-based sensing technologies into a single platform.
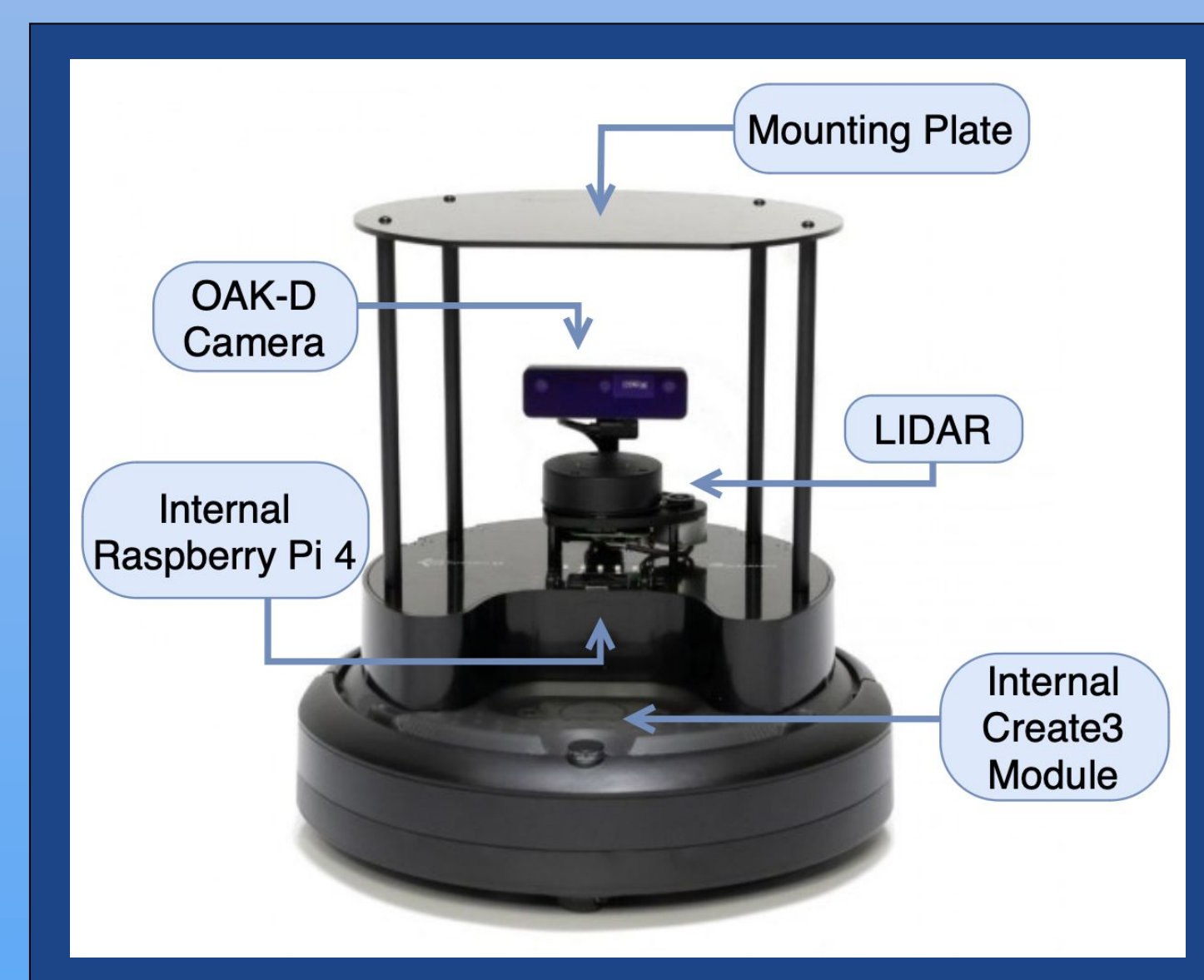
Capabilities:

- Autonomously navigate unknown, dynamic environments
- Recognize individuals, activities, and emotional states
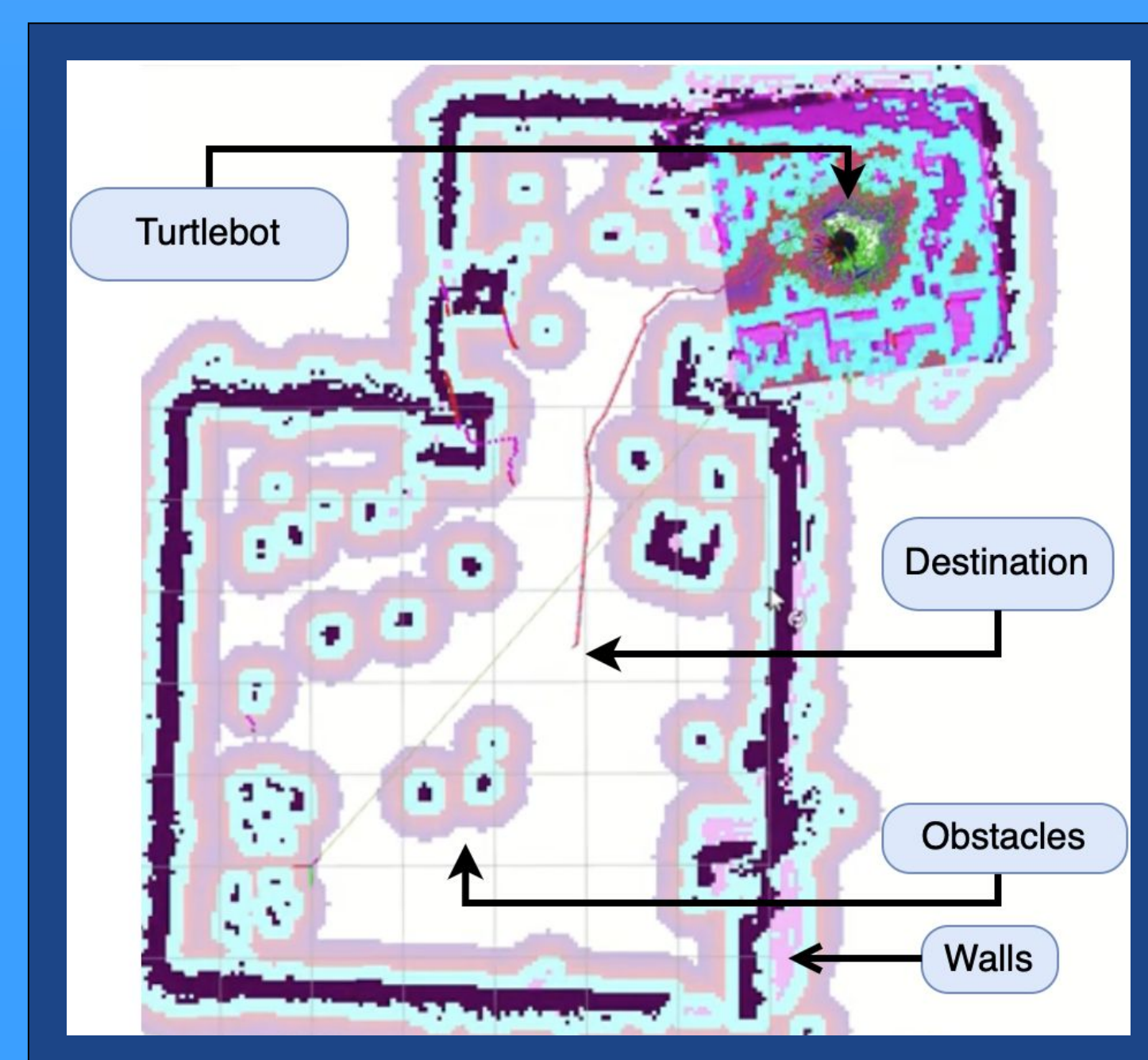- Conduct through-wall sensing using radio frequency signals

Applications:

- Security surveillance
- Search and rescue
- Human-computer interaction

Overview / Design Specs

Navigation System

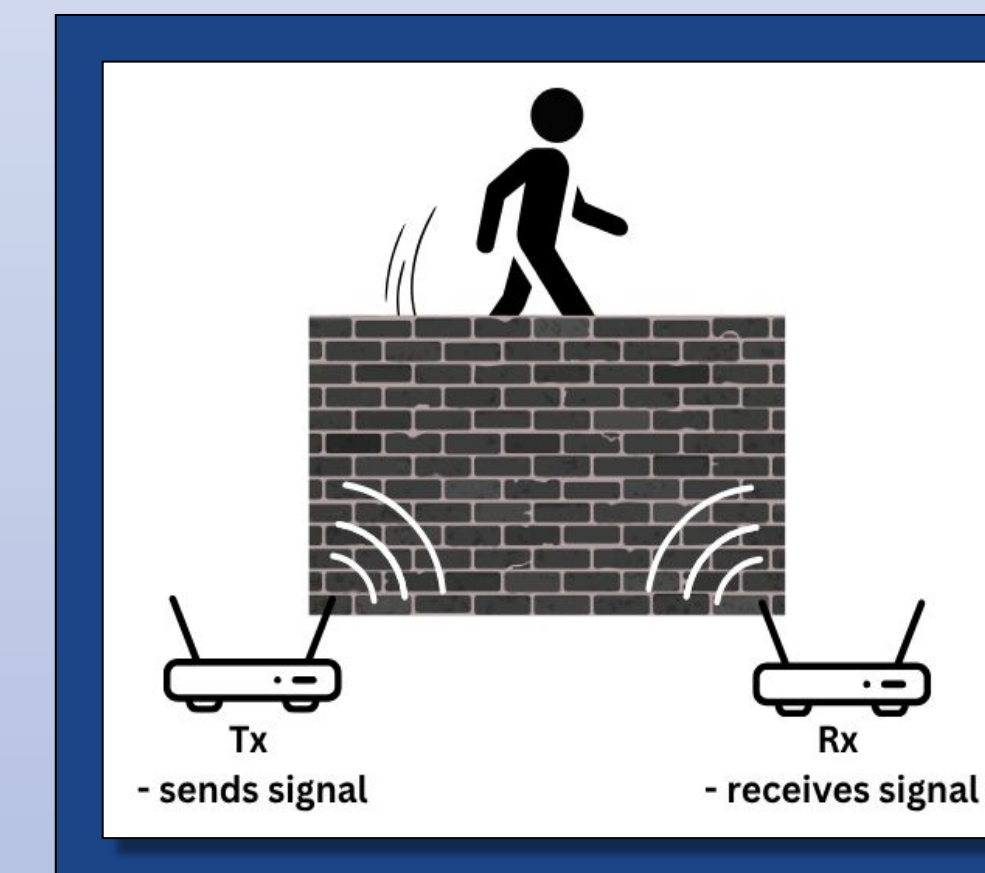- Uses SLAM and Nav2 to map out an environment
- Autonomous mapping using frontier exploration algorithm
- Autonomous patrolling with Behavior Tree

WiFi System

WiFi Sensing

- WiFi signals are just low-power microwaves
- By analyzing how WiFi packets are reflected by the environment, we can detect and isolate patterns of motion


Data Collection

- Two consumer-grade WiFi cards (Tx/Rx)
- 160 MHz BW packets with ~4000 subcarriers each are transmitted at 500Hz, Rx detects >99% of them
- Channel State Information (CSI) at Rx provides info on magnitude and phase of each subcarrier

Signal Analysis

- CSI data is filtered and converted to time-varying frequency spectrogram representing motion
- ~10 key features are extracted from spectrogram into a feature vector
- Test and training feature vectors are compared to identify likely identity matches
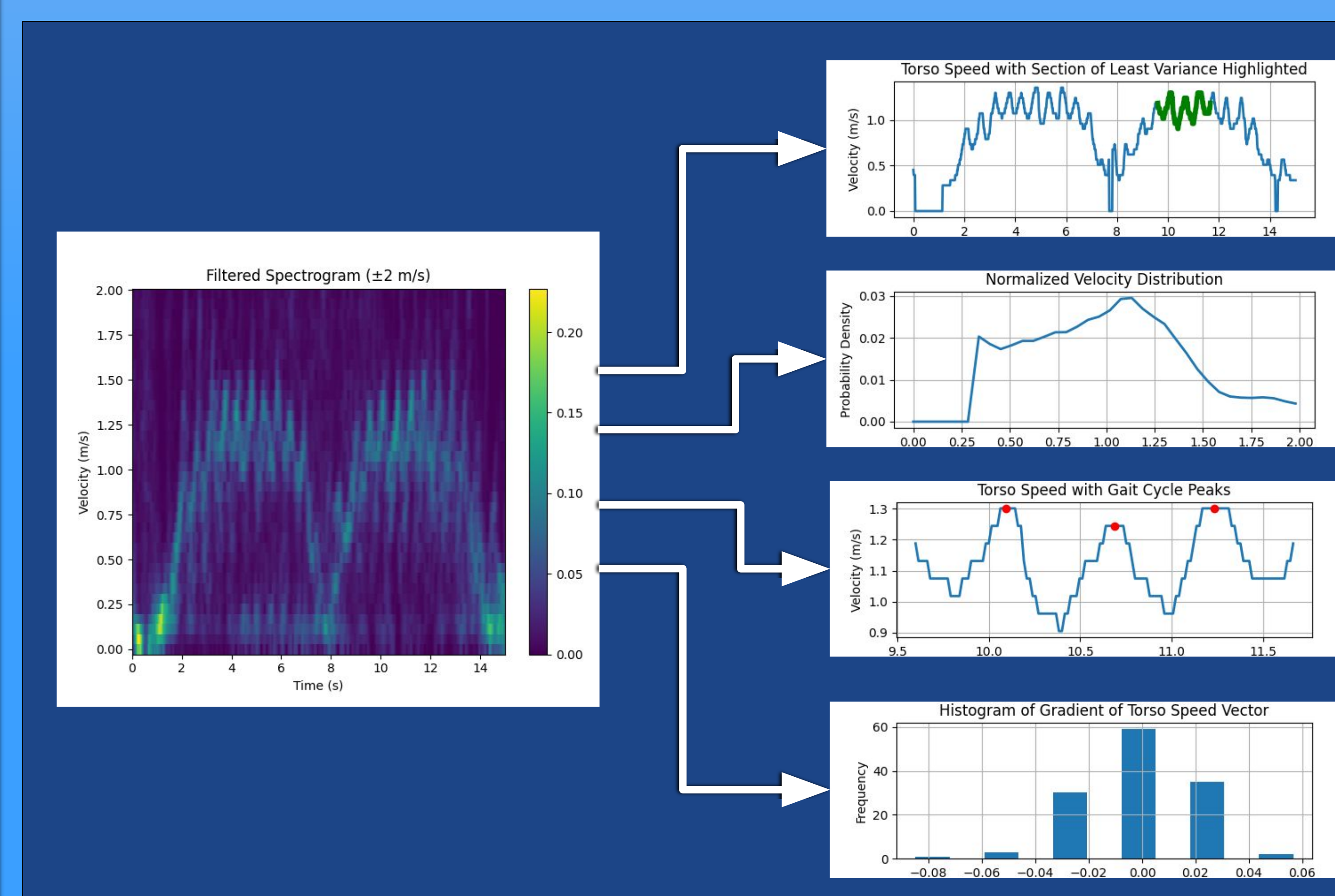
Vision System
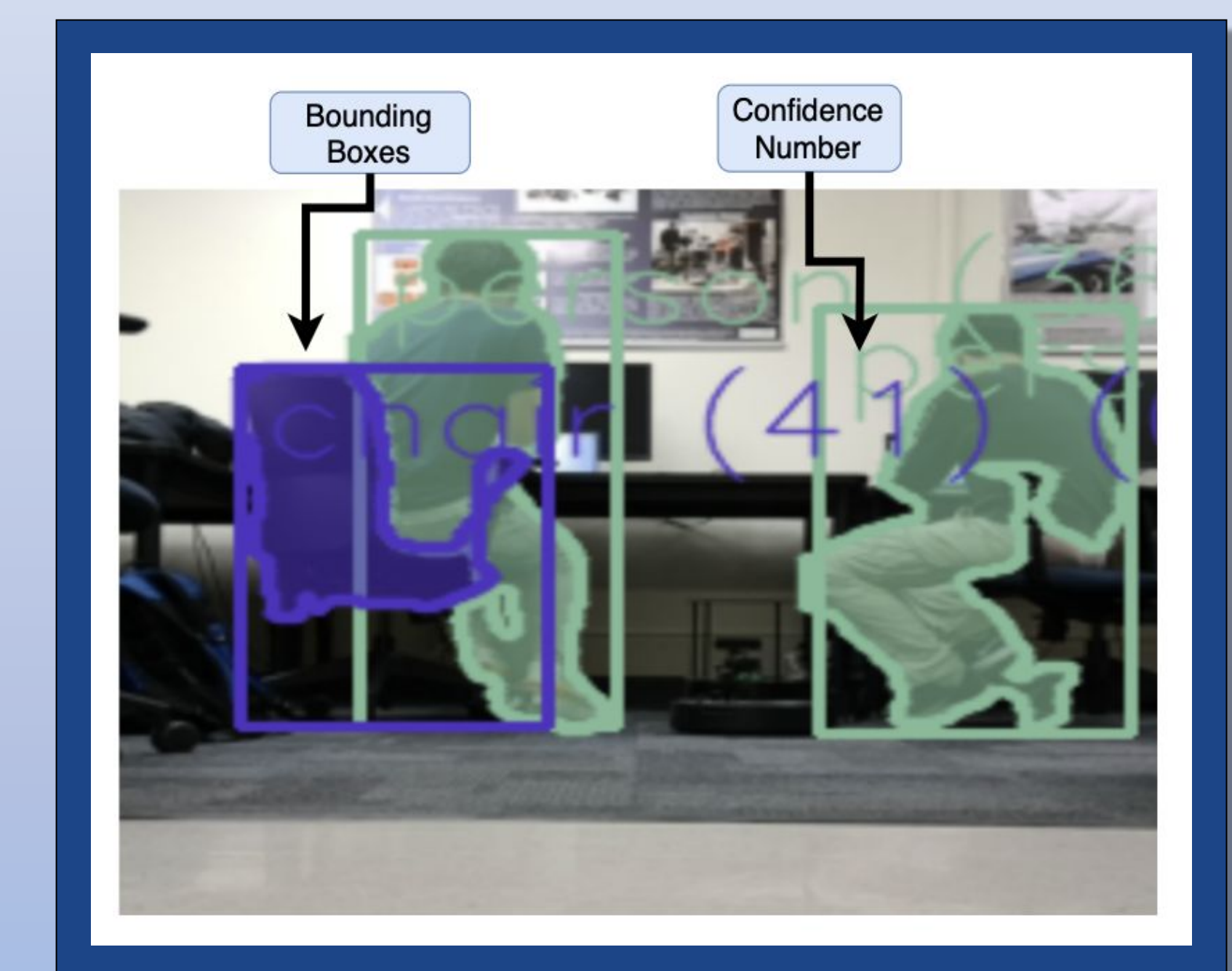
Object Detection

- Uses state-of-the-art Yolo v8 object detection model
- Accurately identifies common objects and people with high confidence scores

Facial Recognition

- Uses the DeepFace framework along with ArcFace (512 features) to identify people
- Able to match the faces to our database of collected face images

Final Results

Demonstration Sequence:

- Robot maps environment
- Detects objects using YOLO vision model
- Patrols and localizes dynamically
- Search and tracks individuals
- Navigates to transmitter robot for WiFi sensing
- Performs WiFi based sensing:
  - Transmits signal; Receiver captures signals
  - Matches against known profiles
  - Announces identified individual

Results:

- Accurately identified all 100% of mystery individuals within demonstration scope with up to 70% confidence margin
- Tracked objects with 90% accuracy and matched faces with around 75% accuracy
- Implemented autonomous navigation and mapping to patrol a previously unknown 65m^2 enclosed environment
- Showcased robust, multimodal, real-time context inference

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