Adaptive Vehicle Control Based on Pedestrian Behavior

ILLINOIS | Het Patel

Keisuke Ogawa
(ogawa3)

Het Patel
(hcp4)

Sunny Deshpande
(sunnynd2)

Ansh Bhansali
(anshb3)

ECE 484 PROJECT

Problem statement

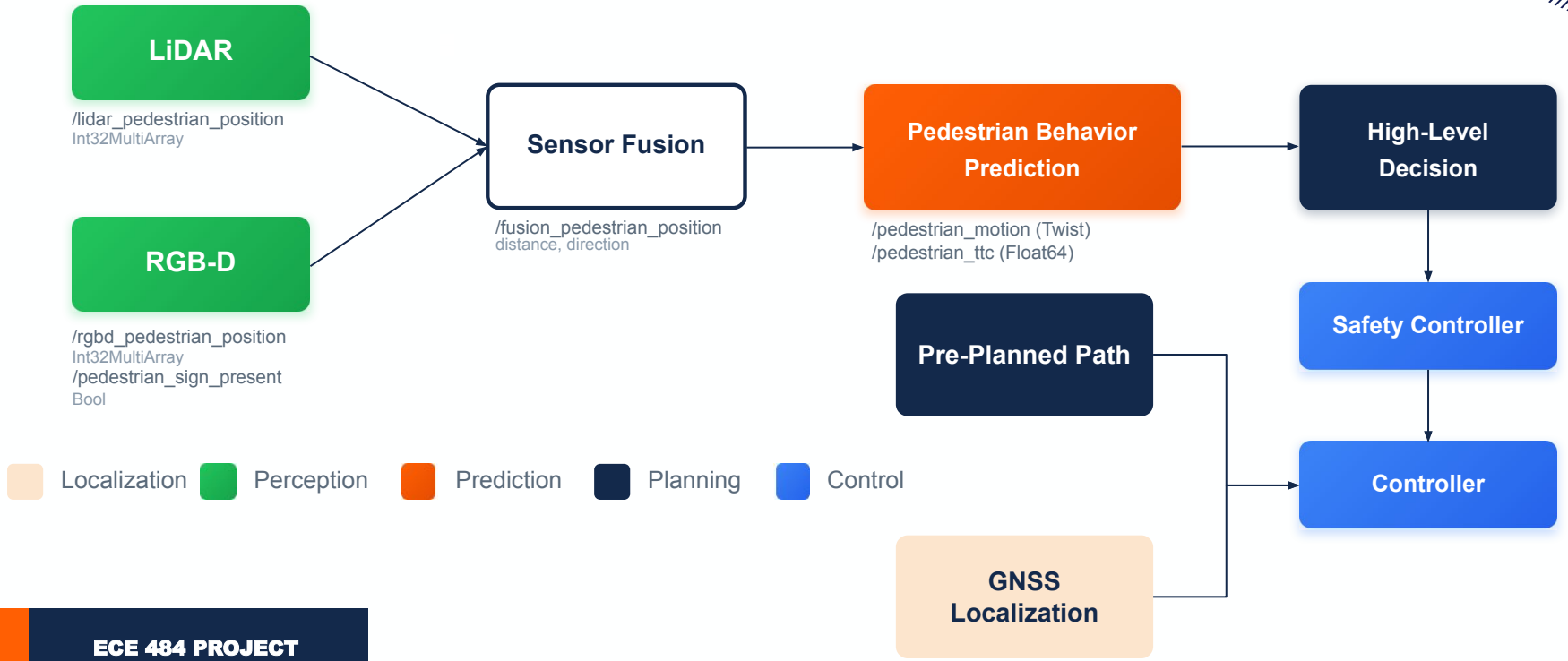
The Gap: Reactive vs. Predictive

Current Limitation: Traditional AV navigation treats pedestrians as static obstacles outside of the road during cruising, relying on simple reactive braking once they cross.

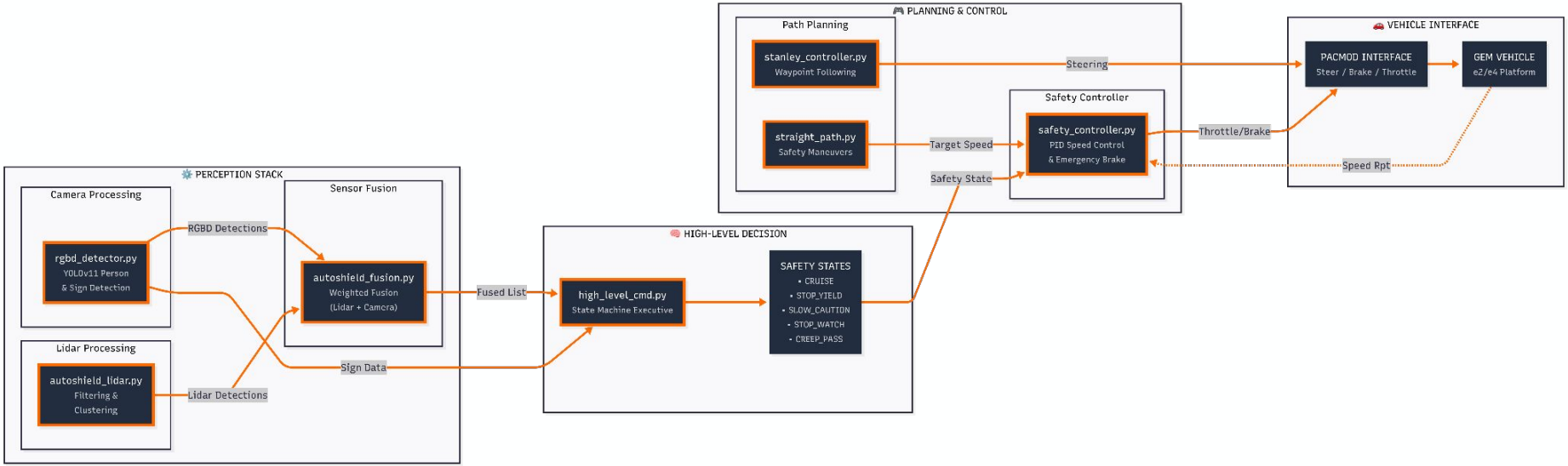
Challenge: Human movement is uncertain. Reactive systems cannot handle complex interactions or anticipate intent.

Specific Problem: We lack a control framework that dynamically adjusts vehicle speed and control in real-time based on pedestrian behavior cues, rather than just proximity.

Autonomy Stack Approach



Approach


PERCEPTION STACK
Camera Processing
rgbd_detector.py
YOLOv11 Person & Sign Detection
RGBD Detections
Sensor Fusion
autoshield_fusion.py
Weighted Fusion (Lidar + Camera)
Lidar Processing
autoshield_lidar.py
Filtering & Clustering
Lidar Detections
Sign Data
Fused List
HIGH-LEVEL DECISION
high_level_cmd.py
State Machine Executive
SAFETY STATES
• CRUISE
• STOP_YIELD
• SLOW_CAUTION
• STOP_WATCH
• CREEP_PASS
Safety State
PLANNING & CONTROL
Path Planning
stanley_controller.py
Waypoint Following
straight_path.py
Safety Maneuvers
Steering
Target Speed
Safety Controller
safety_controller.py
PID Speed Control & Emergency Brake
Throttle/Brake
Speed Rpt
VEHICLE INTERFACE
PACMOD INTERFACE
Steer / Brake / Throttle
GEM VEHICLE
e2/e4 Platform

Perception - LIDAR

PREPROCESSING
Voxelization
Ground filtering
Remove outliers

PointCloud2

CLUSTERING
DBSCAN
Extract static/dynamic object

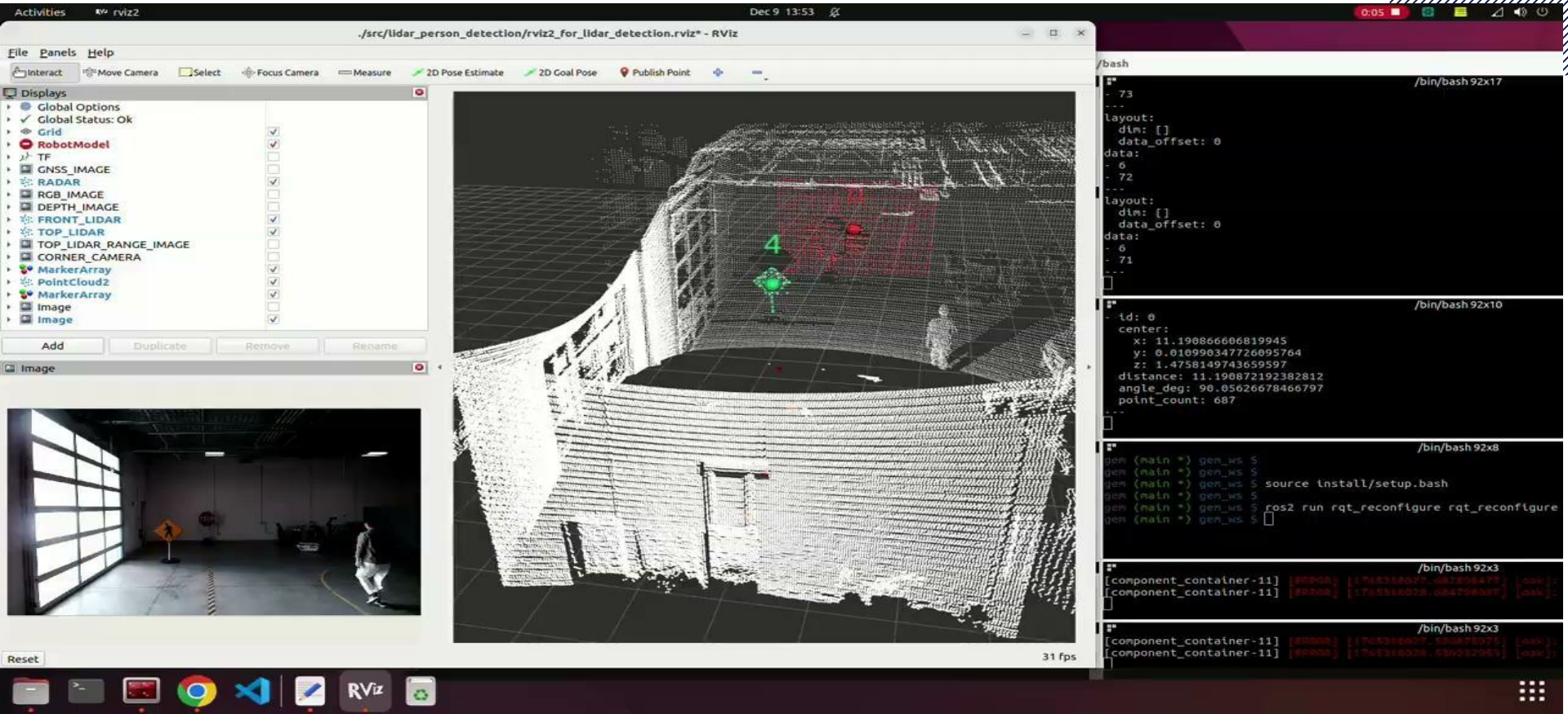
TRACKING
Nearest-centroid matching
smooth centroids by EMA
Track metrics

Visualize clusters, human

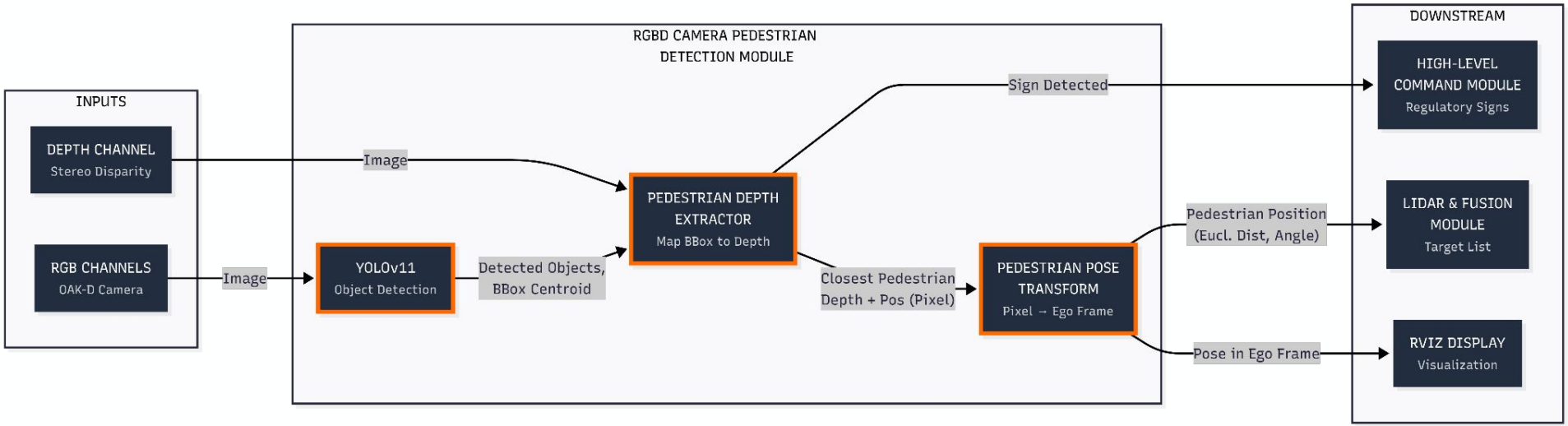
HUMAN DETECTION
Geometric filtering
Motion filtering
Distance sorting

output publishing
- Euclidean dist
- Angle

Perception - LIDAR

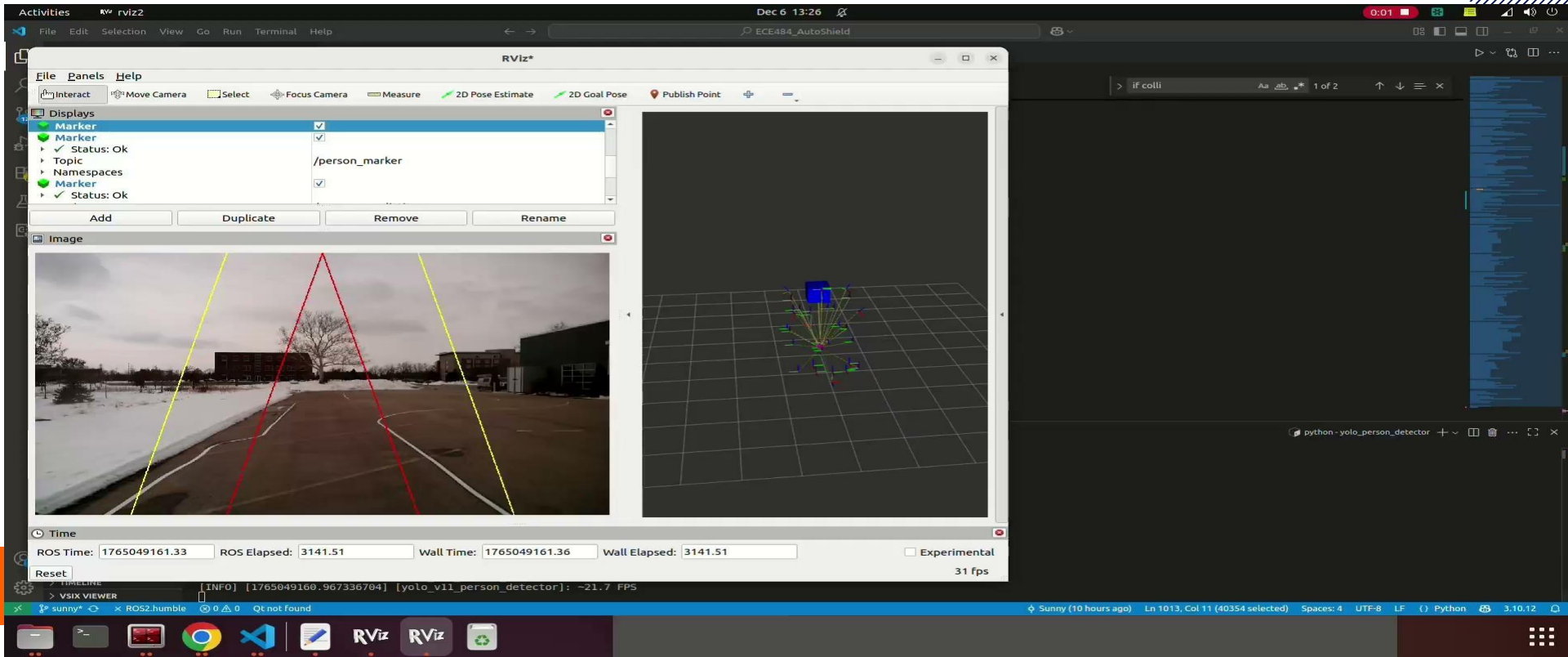


Perception - RGB-D Camera

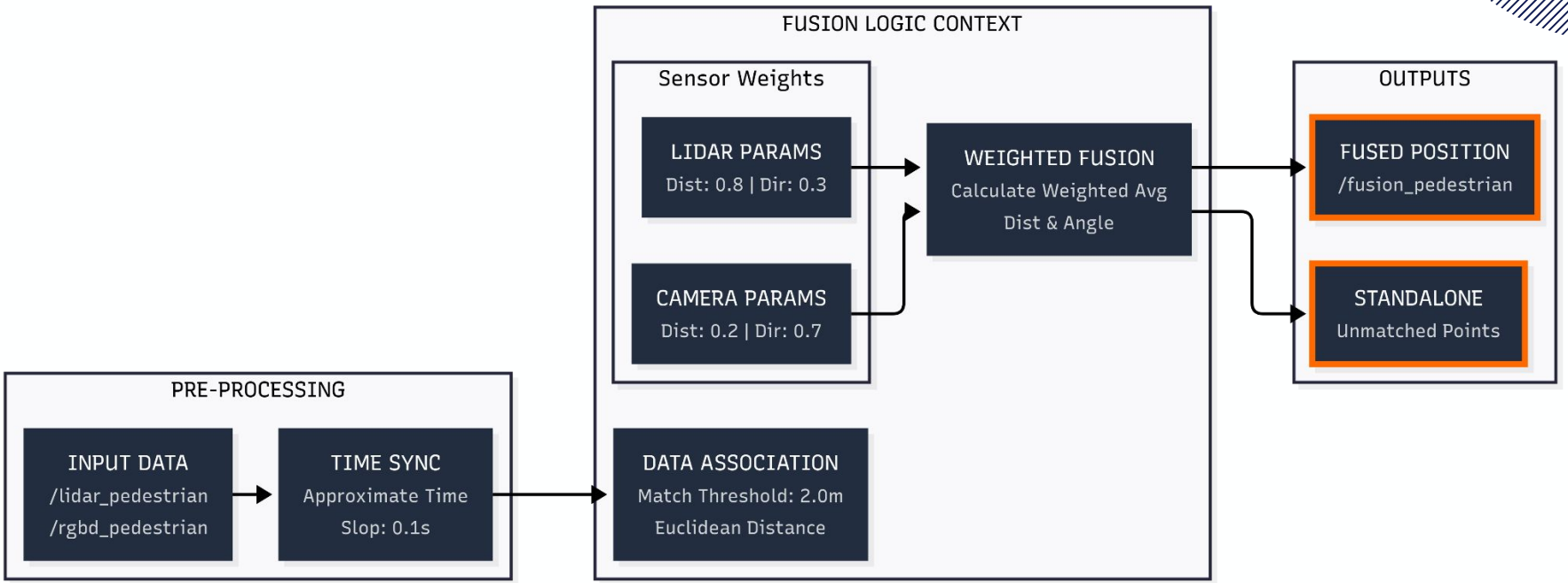


Methodology

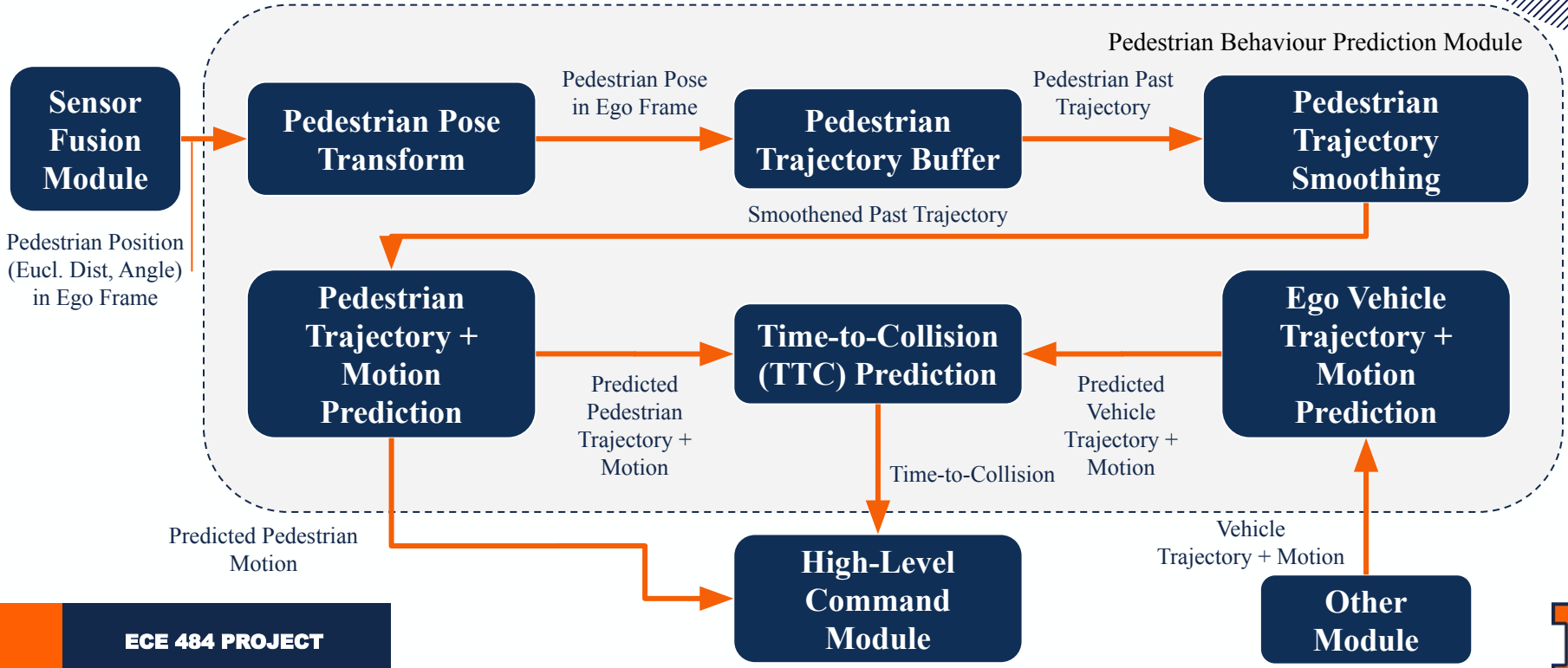
Perception - RGB-D Camera



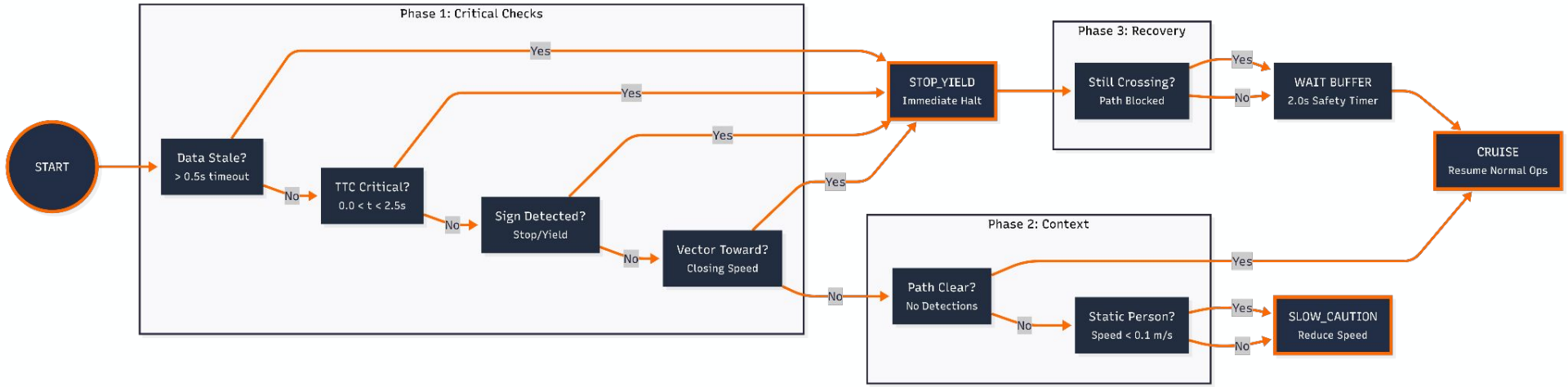
Sensor Fusion



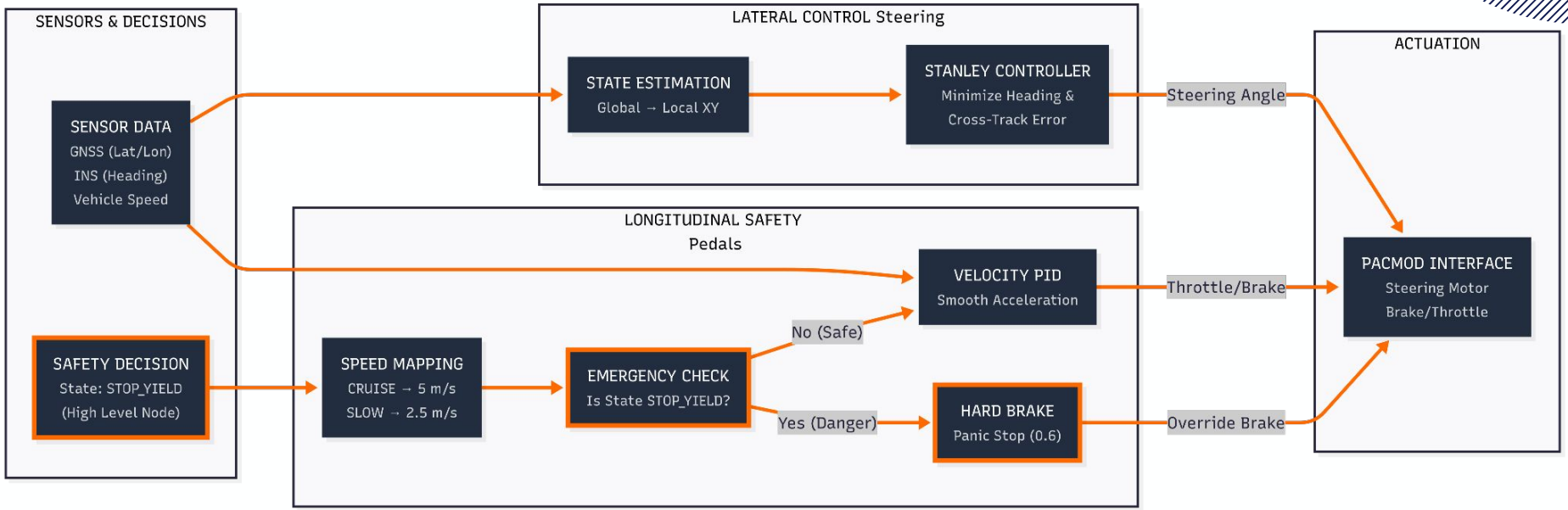
Pedestrian Behaviour Predictor



High-Level Command



Controller


SENSORS & DECISIONS
SENSOR DATA
GNSS (Lat/Lon)
INS (Heading)
Vehicle Speed
SAFETY DECISION
State: STOP_YIELD
(High Level Node)
LATERAL CONTROL Steering
STATE ESTIMATION
Global → Local XY
STANLEY CONTROLLER
Minimize Heading &
Cross-Track Error
LONGITUDINAL SAFETY
Pedals
VELOCITY PID
Smooth Acceleration
SPEED MAPPING
CRUISE → 5 m/s
SLOW → 2.5 m/s
EMERGENCY CHECK
Is State STOP_YIELD?
No (Safe)
Yes (Danger)
HARD BRAKE
Panic Stop (0.6)
Steering Angle
Throttle/Brake
Override Brake
ACTUATION
PACMOD INTERFACE
Steering Motor
Brake/Throttle

Results - Qualitative Demo Video

Results - Quantitative Metrics

Experiment Type	Number of Experiments	Success Rate (%)
Cruise Mode	5	100 (5/5)
No Pedestrian w Sign	10	100 (10/10)
Crossing Pedestrian w Sign	10	90 (9/10)
Stationary Pedestrian	5	100 (5/5)
Crossing Pedestrian	10	90 (9/10)
Pedestrian walking along road	10	80 (8/10)
Vehicle stanley control	8	87.5 (7/8)

Acknowledgement

Thank you to Dr Zhang,
our TAs: Xiangru, Hanna, Fatemeh, Hanna, and Will
for helping us during our gem slots.
We are also grateful to Suraj for help on GEM as well

THANK YOU!

ILLINOIS

Appendix

Work Distribution