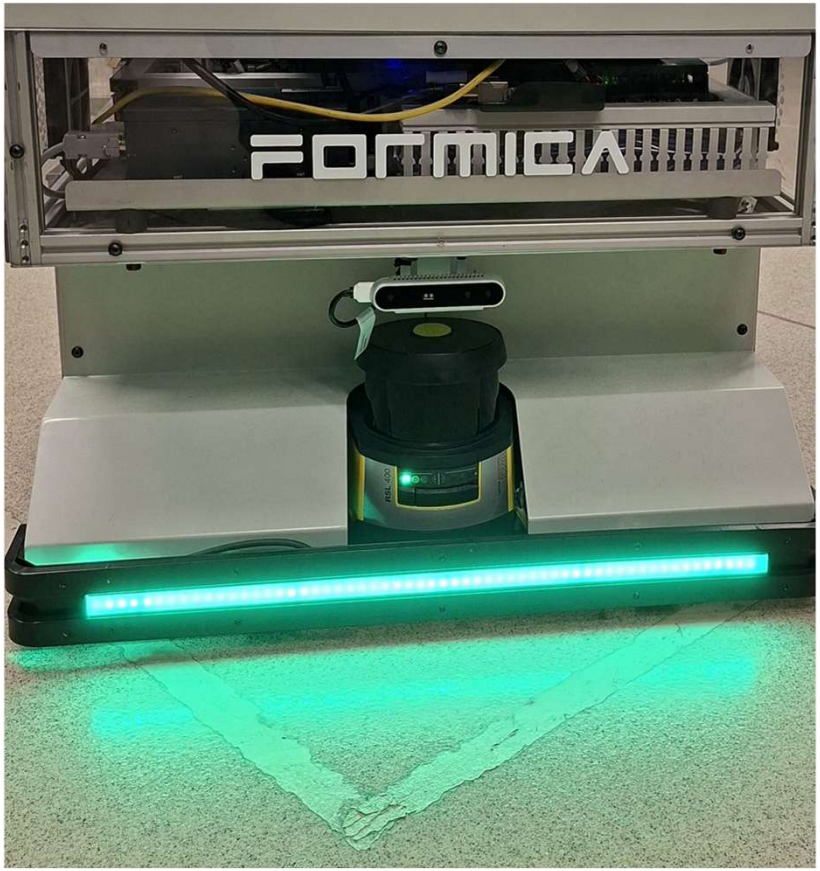
Lightweight Model for Collision Avoidance of AGVs in Crowded Environments

OUTLINES

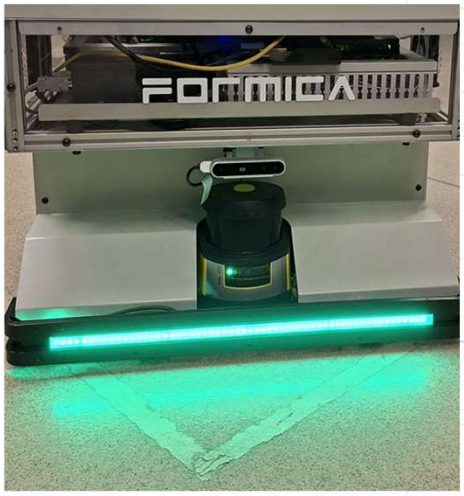
- Data type
- Data preparation and loading
- Preprocessing
- Model Architecture
- Training and Evaluation
- Risk Assessment
- Future direction

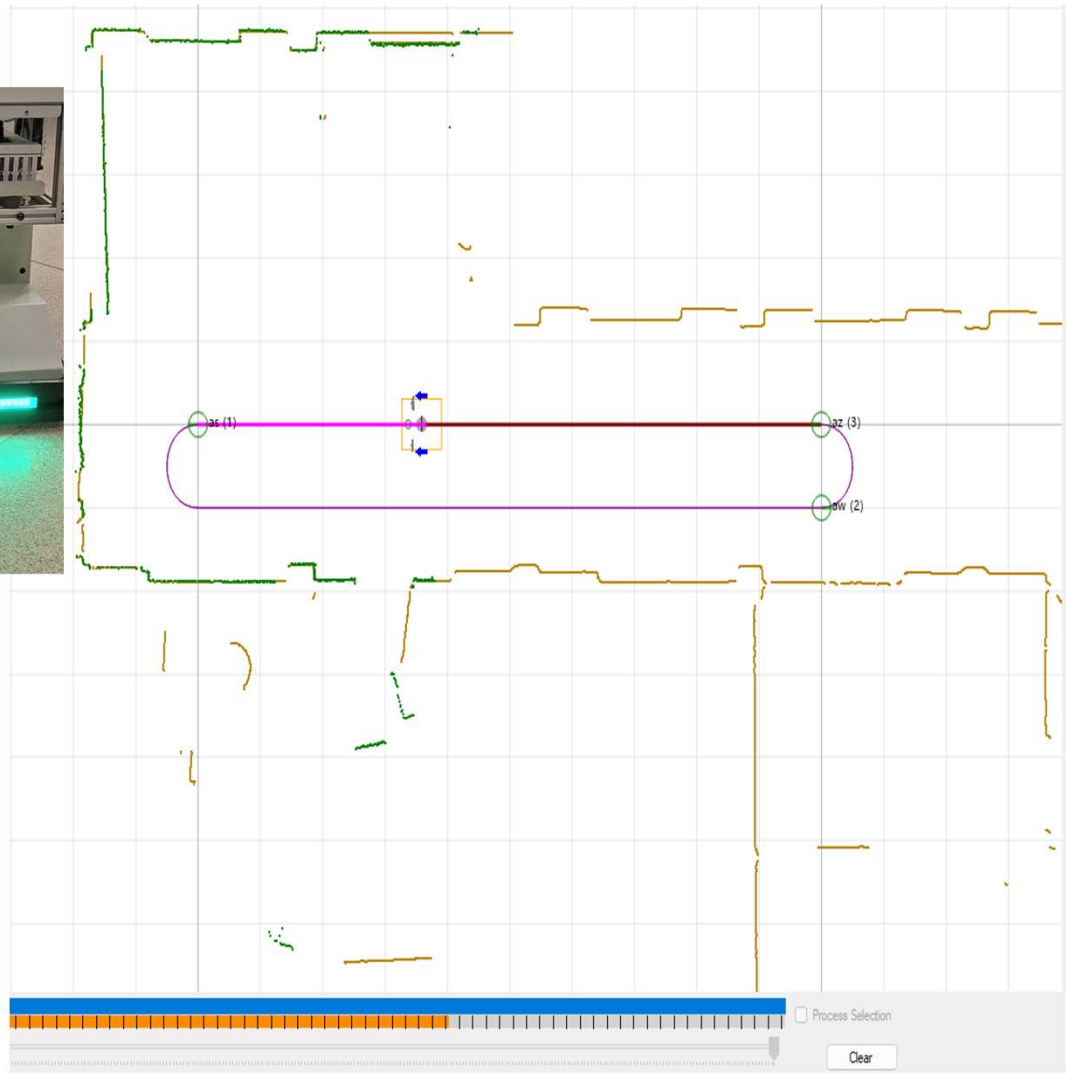
Data type

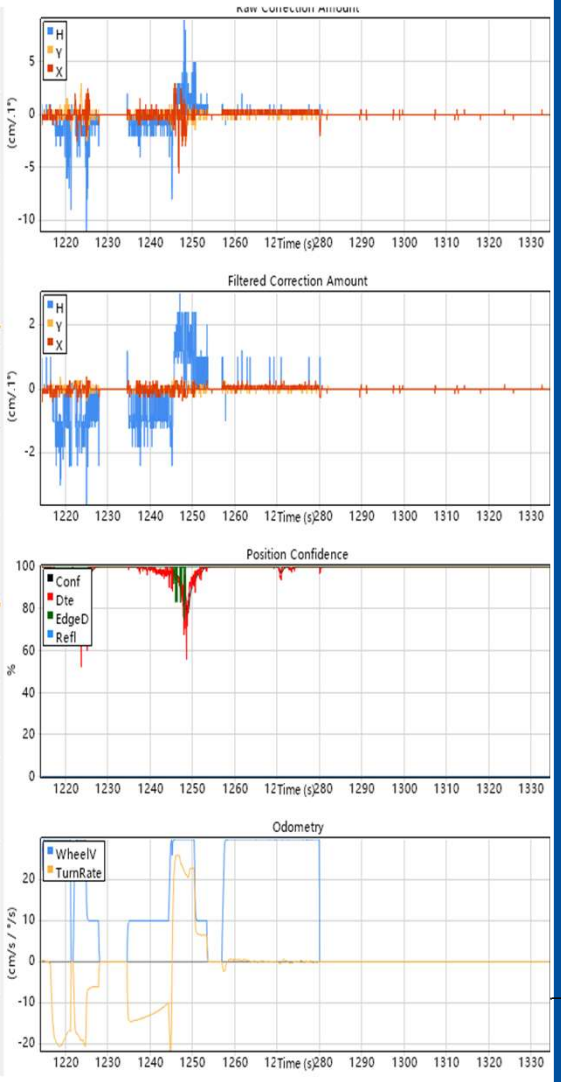


	Lidar RSL 400
Data type	Numerical
Dimension	2D
Parameters	- Distance - Angle (**-135 to +135**) - Start and stop Index (**0 to 2700**) - Warning field (0 or 1) - Safety field (0 or 1) - Index Interval (40ms) - Scan number (517 scans)

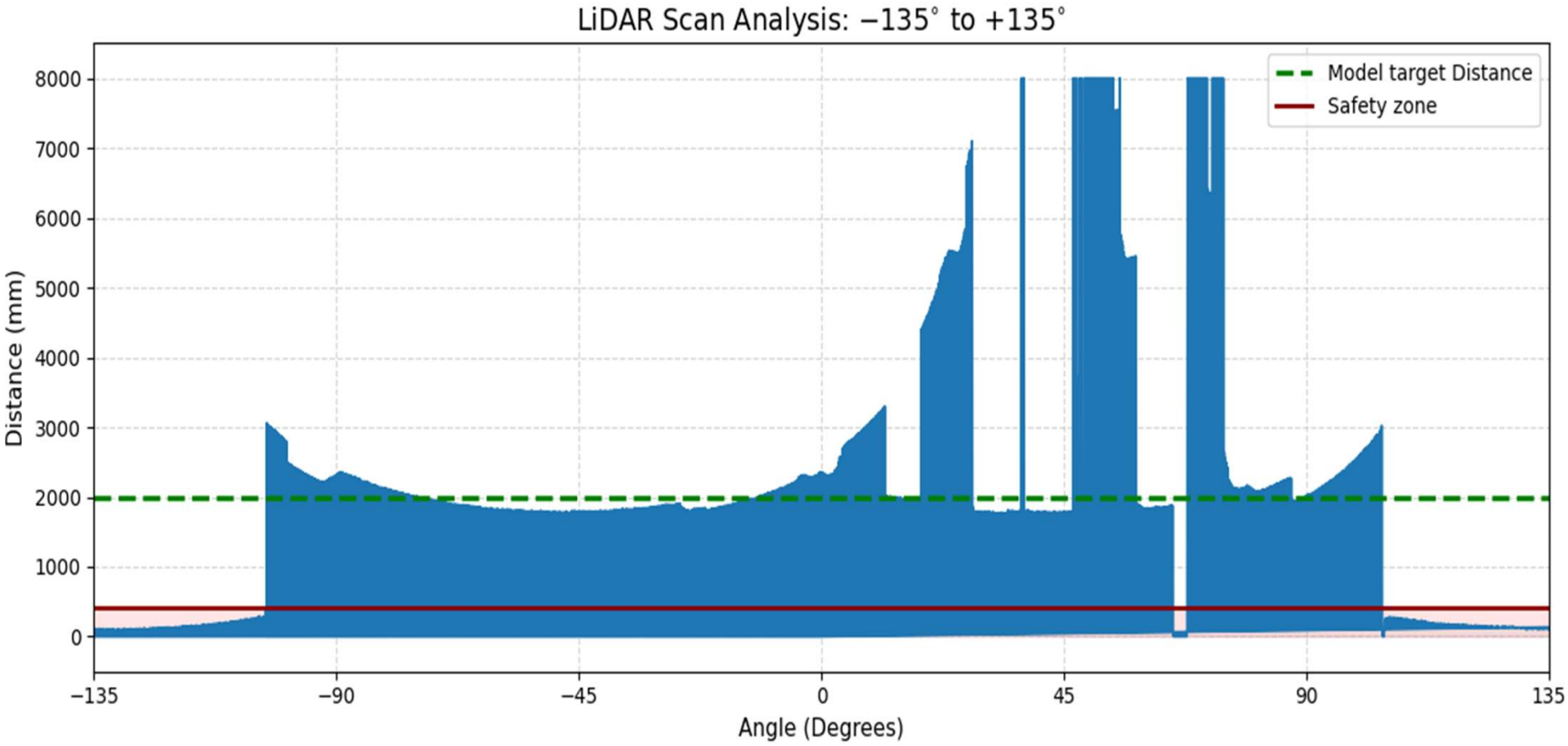
AGV Real-Time Data Acquisition







Lidar rsl 400 Data Visualization



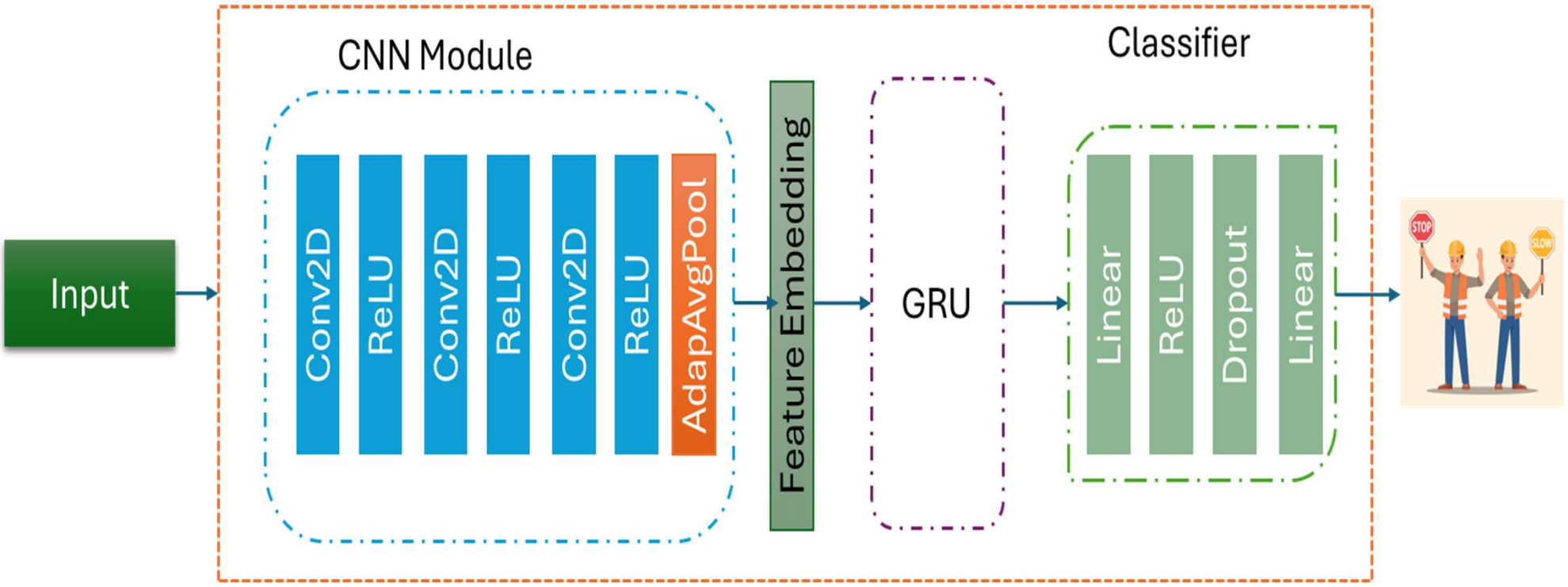
Data Preparation and Loading

- Key challenges: **limited dataset** + **class imbalance**

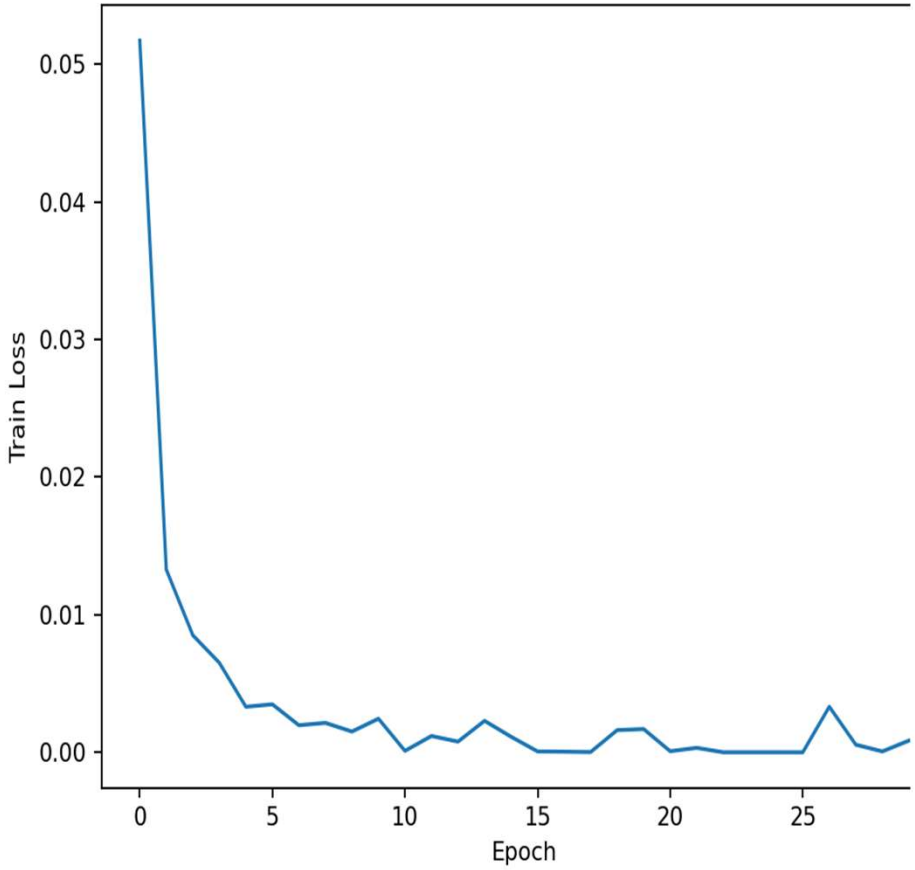
Resampling & **Balancing**

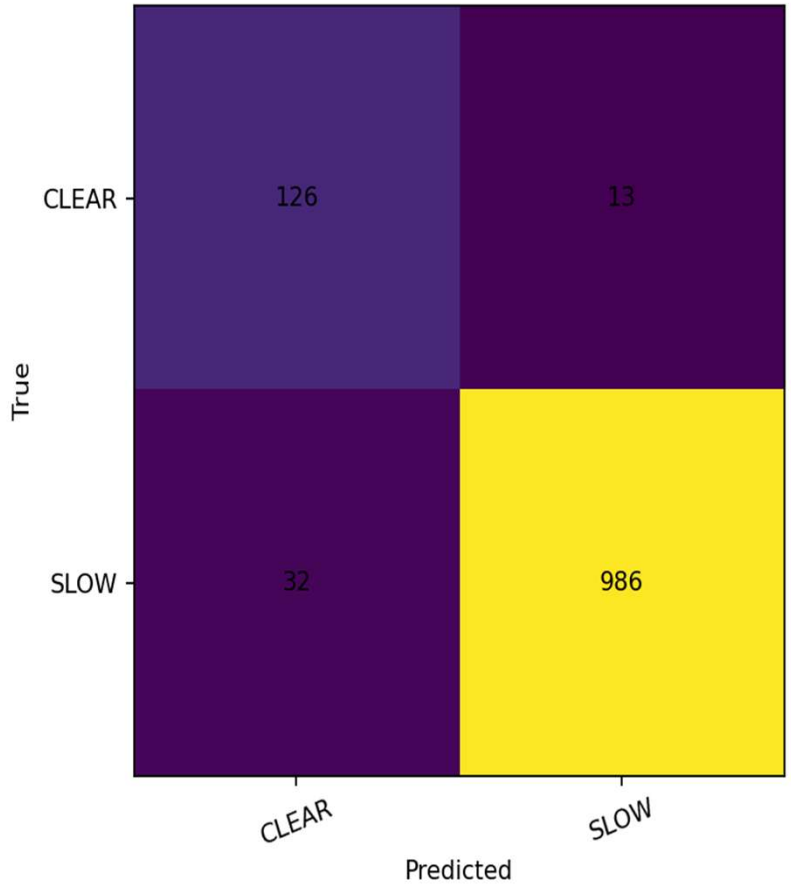
Bootstrapping with replacement	SMOTE (Synthetic Minority Over-sampling Technique)
• Sampling with replacement to create a larger training set with factor = 5. • Applied only on training set (test set remains untouched)	• Generates synthetic samples for minority class to equalize class distribution in training set. • SMOTE parameter k = 3 (3 nearest neighbors).

Model Architecture and Training



Training and Evaluation





Risk Assessment

Fuzzy inputs

LiDAR Sector-Based Perception

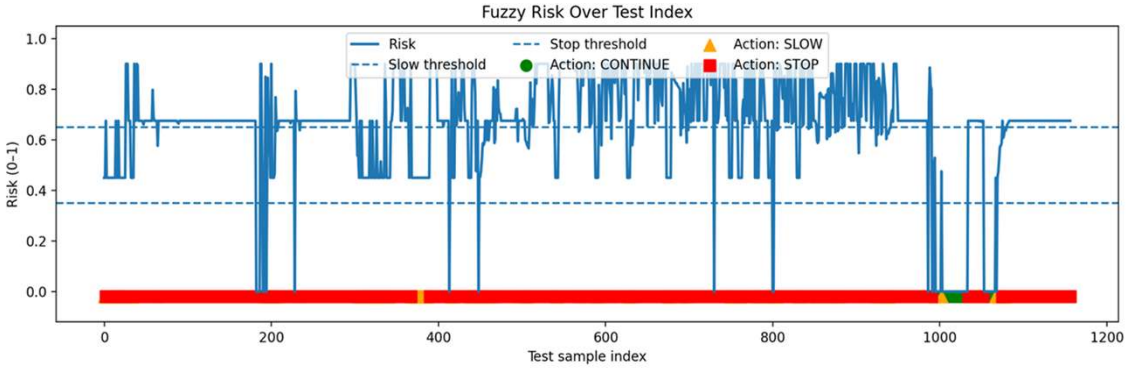
- 1351 LiDAR distance beams: $Dist_0$ … $Dist_{1350}$
- Sector division:
  - Left sector: beams 0–450
  - Front sector: beams 451–900
  - Right sector: beams 901–1350
- **Final input: distance in closest sector**

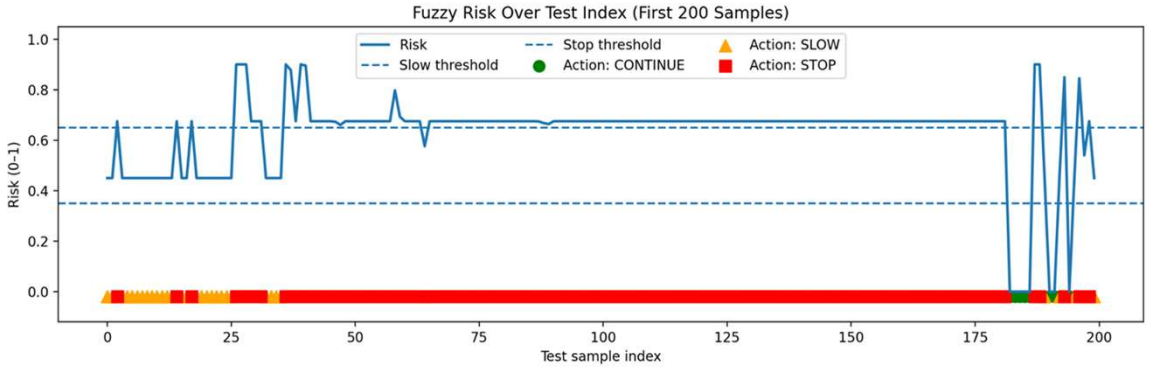
Time-to-Collision (TTC)

- Computed for each sector
- **Final input: TTC corresponding to the closest sector**

Collision Probability

- From 2D CNN-GRU output
- **Final input: the probability** represents the model's confidence that the scene is unsafe





Risk Level	Action	Control Meaning
< 0.35	Continue	Normal operation
0.35 - 0.65	Slow	Preventive deceleration
> 0.65	Stop	Emergency avoidance