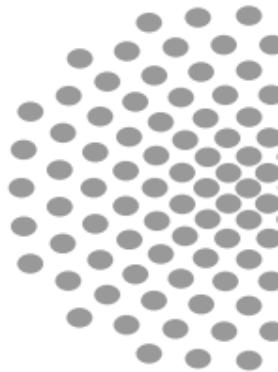


Deep Learning Beam Prediction Using Multi-modal Sensors



Part of Master Thesis

Team MMJ: Junnan Wang

November 29, 2022

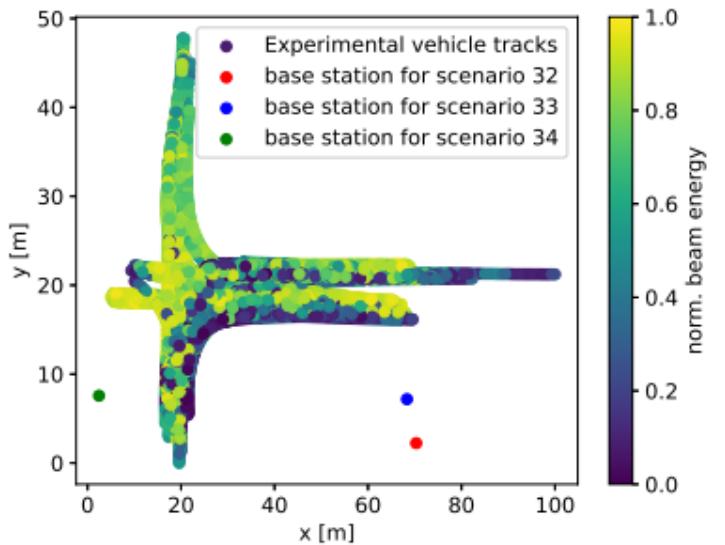


University of Stuttgart
Institute of Telecommunications
Prof. Dr. Ing. Stephan ten Brink

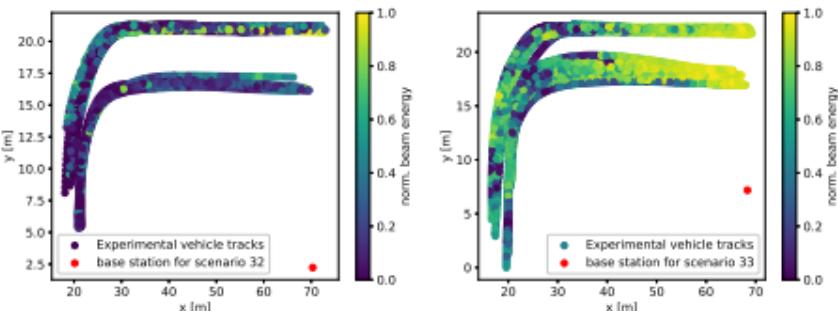
Outline

- Data processing - focus on position data and camera data
- Train and optimise model
- Results

Position data - Convert with UTM

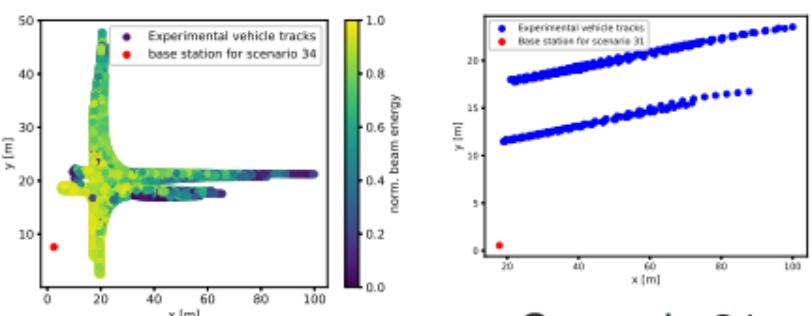


Top views of experimental car tracks



Scenario 32

Scenario 33

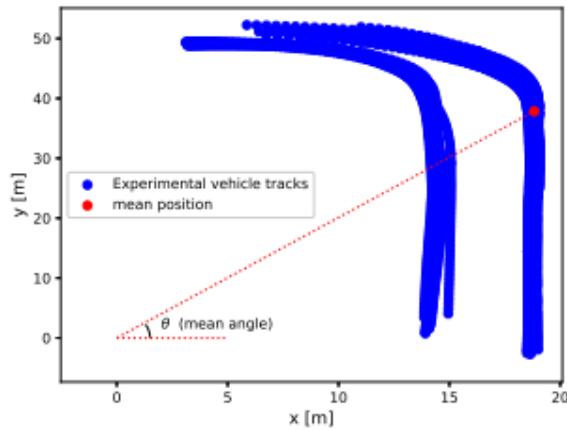


Scenario 34

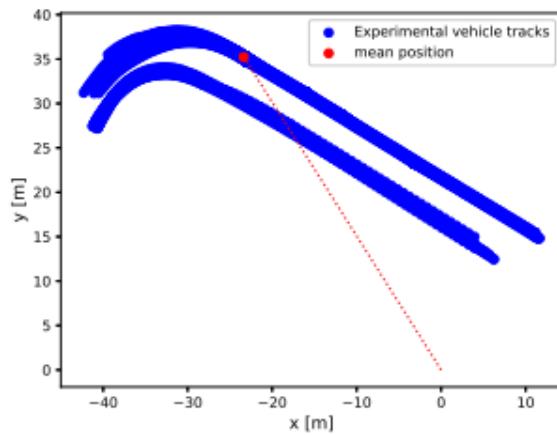
Scenario 31

Calibration of position data

- Reset the coordinates to the difference between the car and the base station
- New coordinates are rotated around the expected angle



Before calibration



After calibration



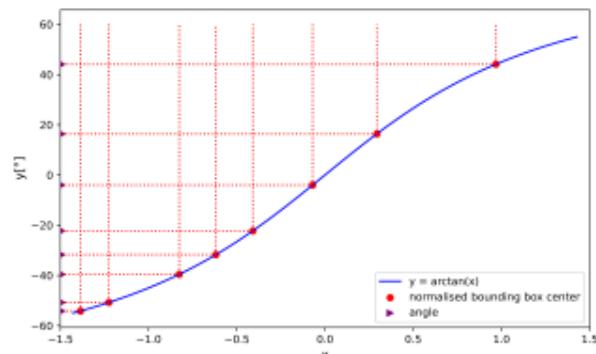
The range of position data

	Distance range[m]	Angle range[°]
scenario 32	13.9 ~ 53.1	-56.4 ~ 38.2
scenario 33	9.8 ~ 51.8	-38.4 ~ 63.7
scenario 34	11.0 ~ 98.5	-54.5 ~ 39.2
scenario 31	10.9 ~ 85.3	-39.2 ~ 32.0
overall	9.8 ~ 98.5	-56.4 ~ 63.7

Range of distances and angles for experimental car tracks

Example data - Camera

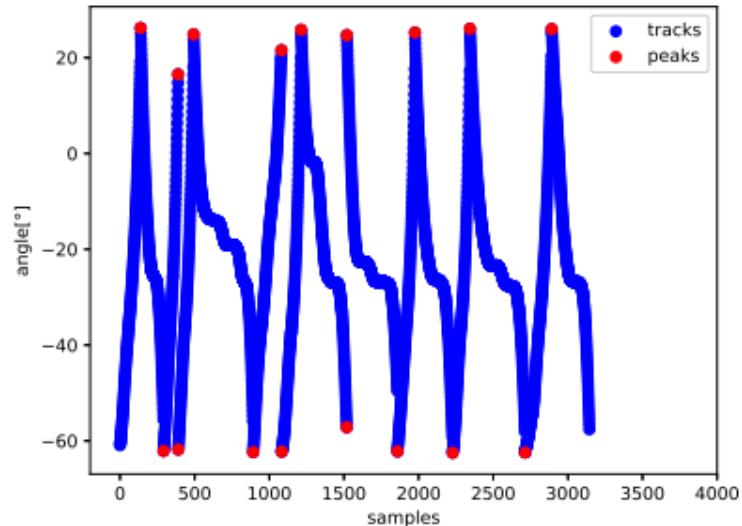
- YOLOv7 + DeepSORT



Calculation of the angle in RGB image

Filter out the experimental car

- Plot tracks
- Find peaks and determine each track
- Count all filtered out car ids id_x within $35m$ for each track
- The most frequent occurrence is recorded as id_r
- Reset all id_x to id_r
- Find the corresponding detection bounding box based on id_r



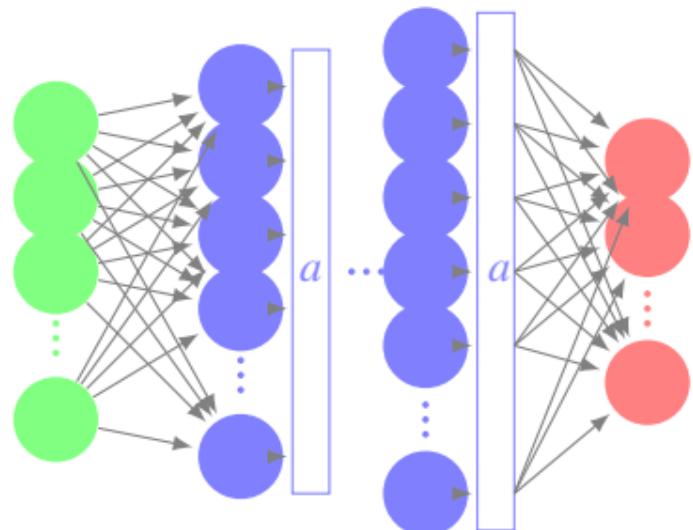
All tracks in scenario 32

Data

- Input data:
 - position sequence and bounding box sequence
 - 24-dimensional vector
- Output data:
 - beam indice
 - 64-dimensional one-hot encoding

Neural Network

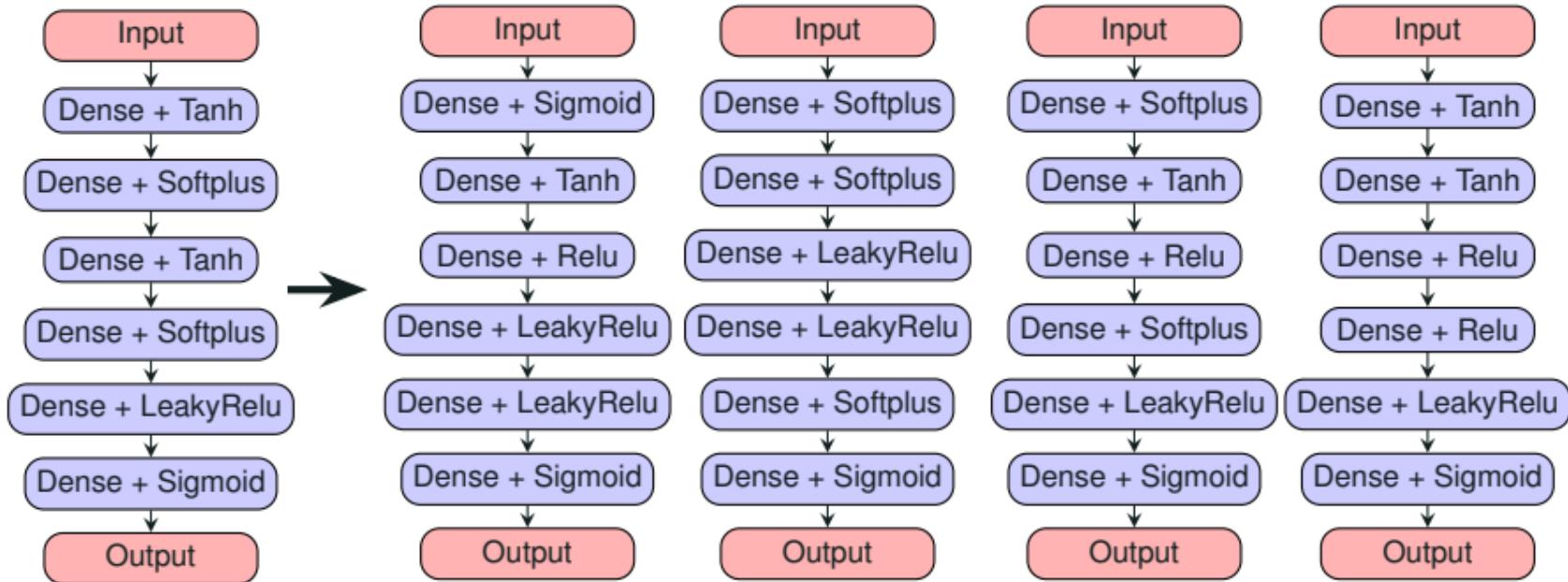
Input layer Hidden layer Output layer



Binary Cross Entropy (BCE) → Final model
Neural Network Intelligence (NNI)

Normal Neural network architecture

Final model

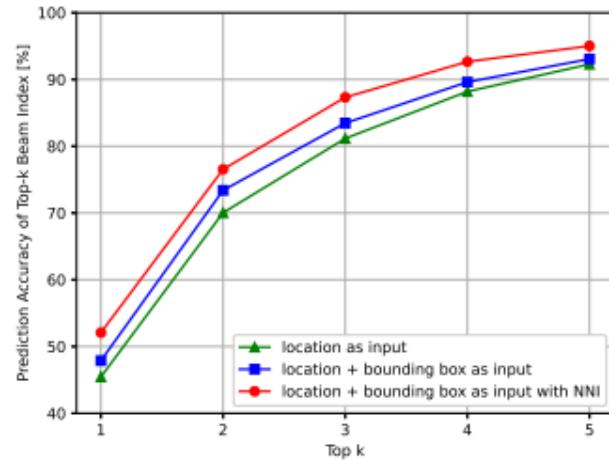


Model for all

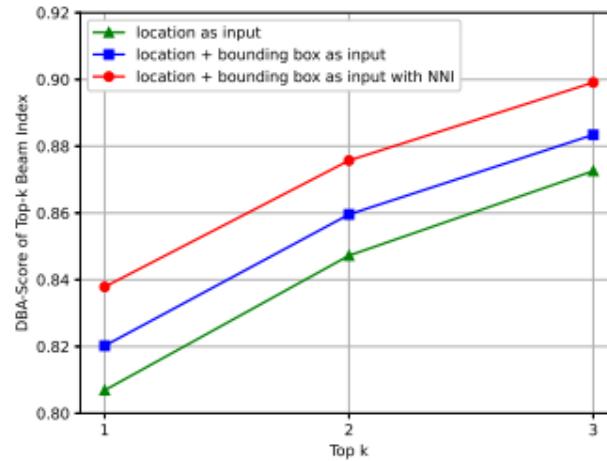
Scenario 32 Scenario 33

Scenario 34 Scenario 31

Performance in training dataset



Comparison of prediction accuracy for top k beams



Comparison of DBA-Score for top k beams



- Compared with original model

Models	Accuracy		
	top 1 [%]	top 3 [%]	top 5 [%]
Original model	31.87	63.64	77.24
Optimised model	52.08	87.32	95.02

Comparison of the prediction accuracy of the original and optimised model

- Results of unknown scenario 31

Accuracy of top 1 [%]	20.0
Accuracy of top 3 [%]	52.0
DBA-Score of top 3	0.65

Prediction accuracy and DBA-Score in scenario 31



Results in test dataset

	DBA-Score for top 3	
	model for all	model for each scenario
scenario 32	0.79	0.80
scenario 33	0.83	0.89
scenario 34	0.82	0.89
scenario 31	0.35	0.37
overall	0.59	0.63

DBA-Score for top 3 beams in test dataset

Thank you for your attention!

