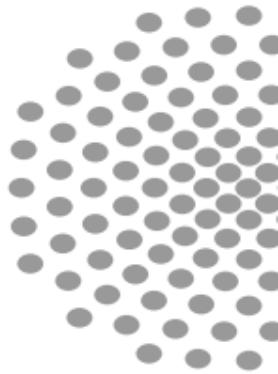


# **Deep Learning Beam Prediction Using Multi-modal Sensors**



Part of Master Thesis

Team MMJ: Junnan Wang

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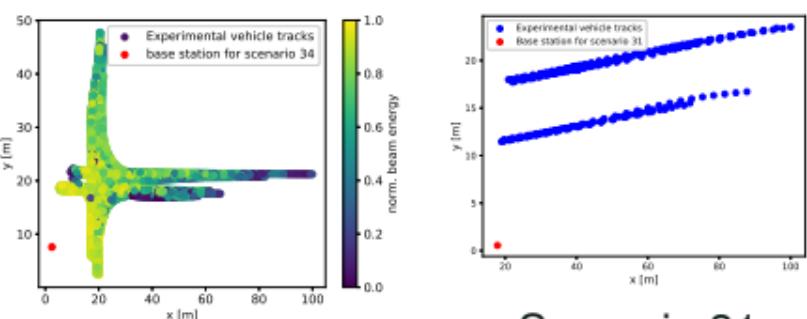
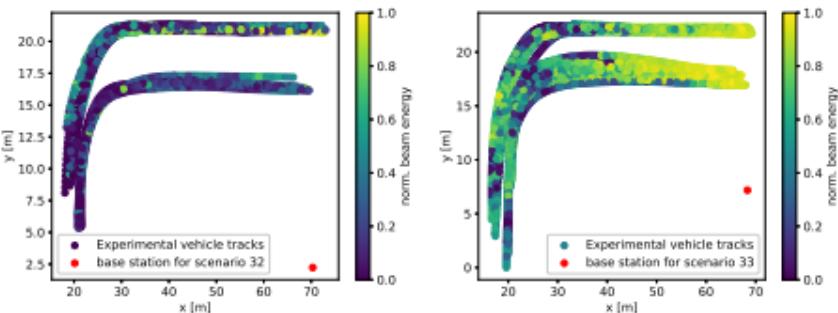
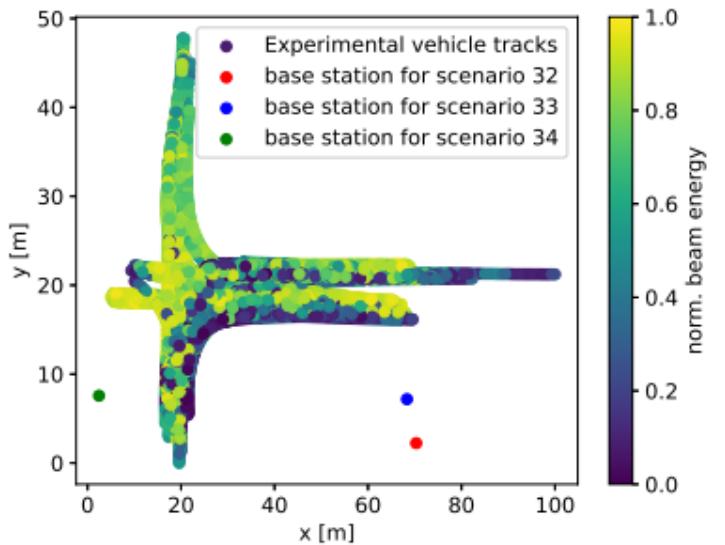


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Institute of Telecommunications  
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## Outline

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

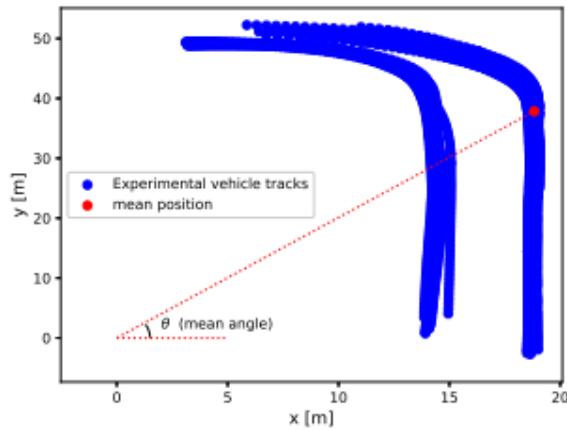
## Position data - Convert with UTM



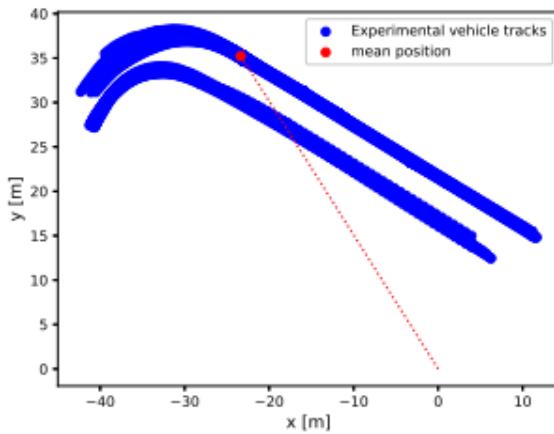
Top views of experimental car tracks

## 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

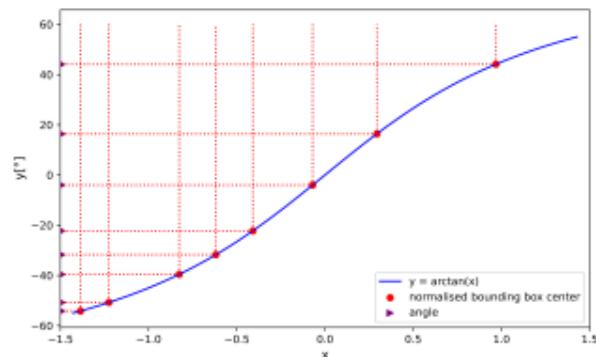
Range of distances and angles for experimental car tracks

## Example data - Camera

- YOLOv7 + DeepSORT



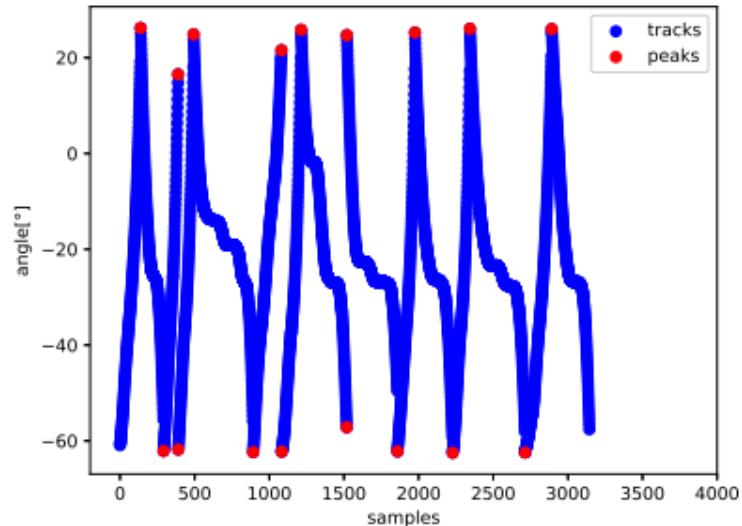
Detection result



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  $id_r$



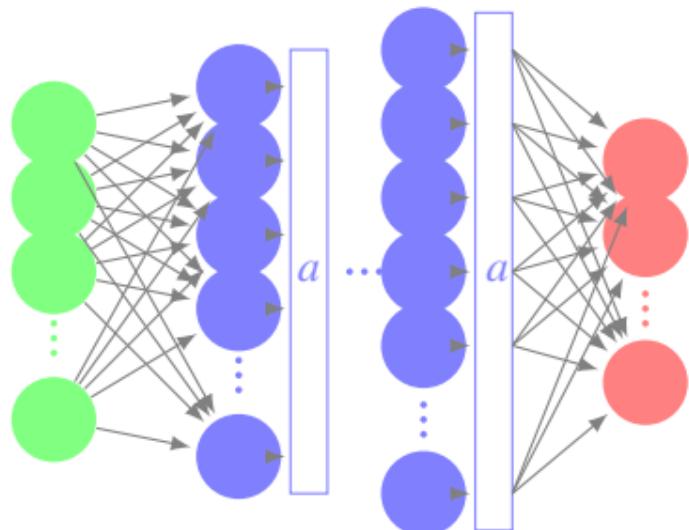
All tracks in scenario 32

## Data

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

## Neural Network

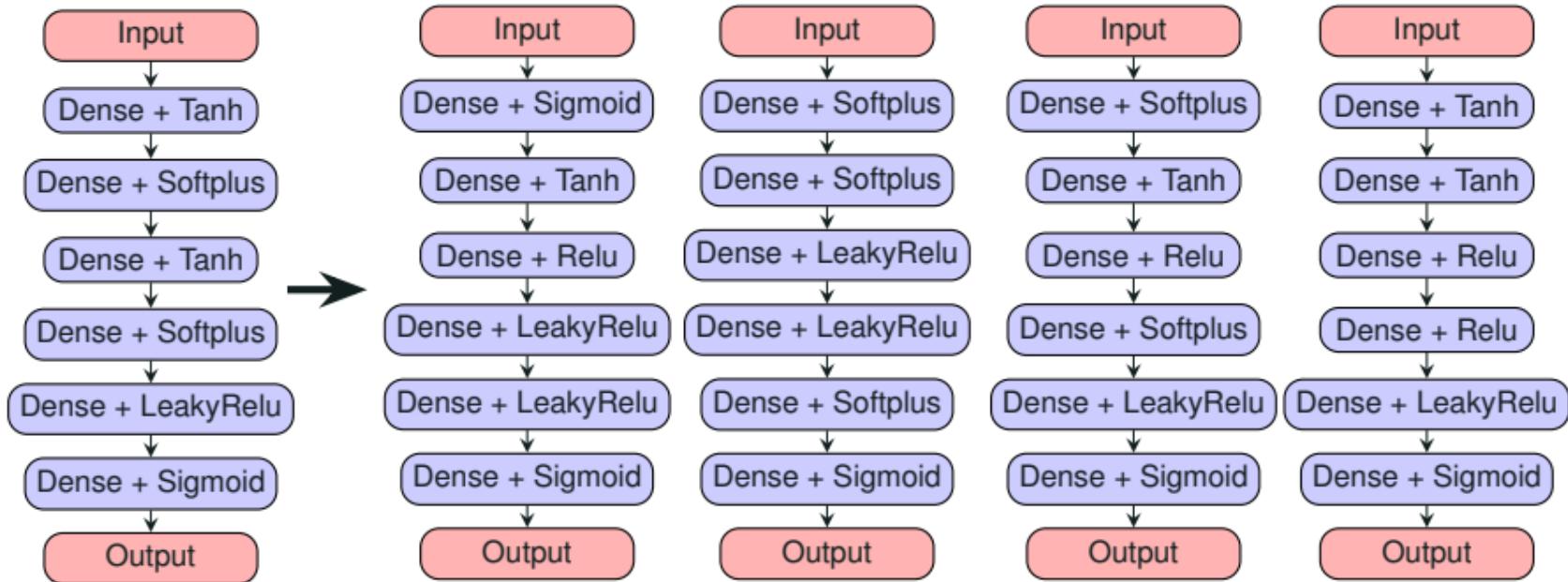
Input layer      Hidden layer      Output layer



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

Normal Neural network architecture

## Final model

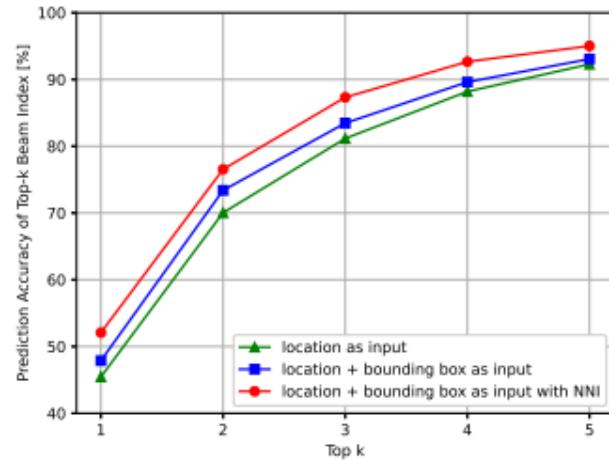


Model for all

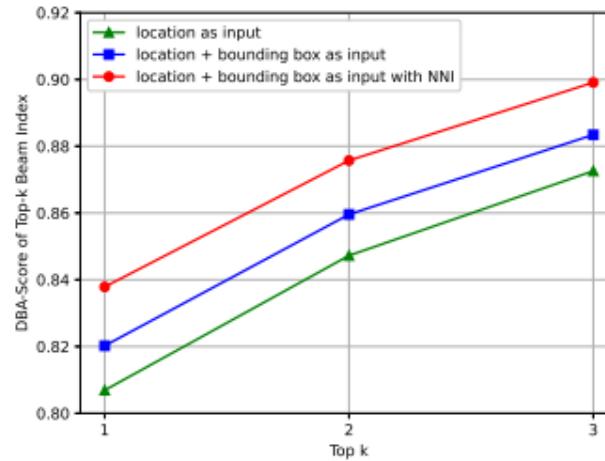
Scenario 32 Scenario 33

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	79.01	80.12
scenario 33	82.90	88.57
scenario 34	81.63	88.65
scenario 31	35.16	37.0

DBA-Score for top 3 beams in test dataset

# Thank you for your attention!

