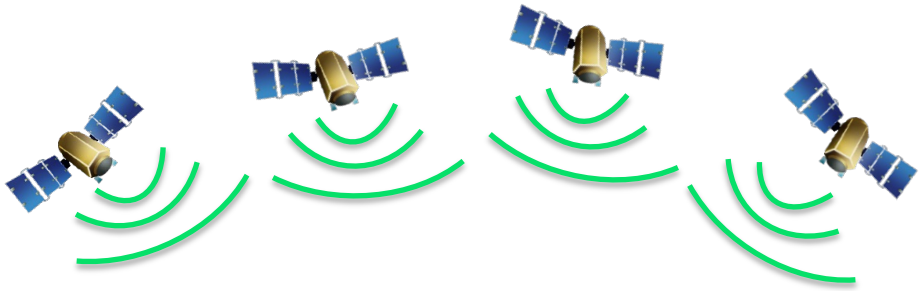
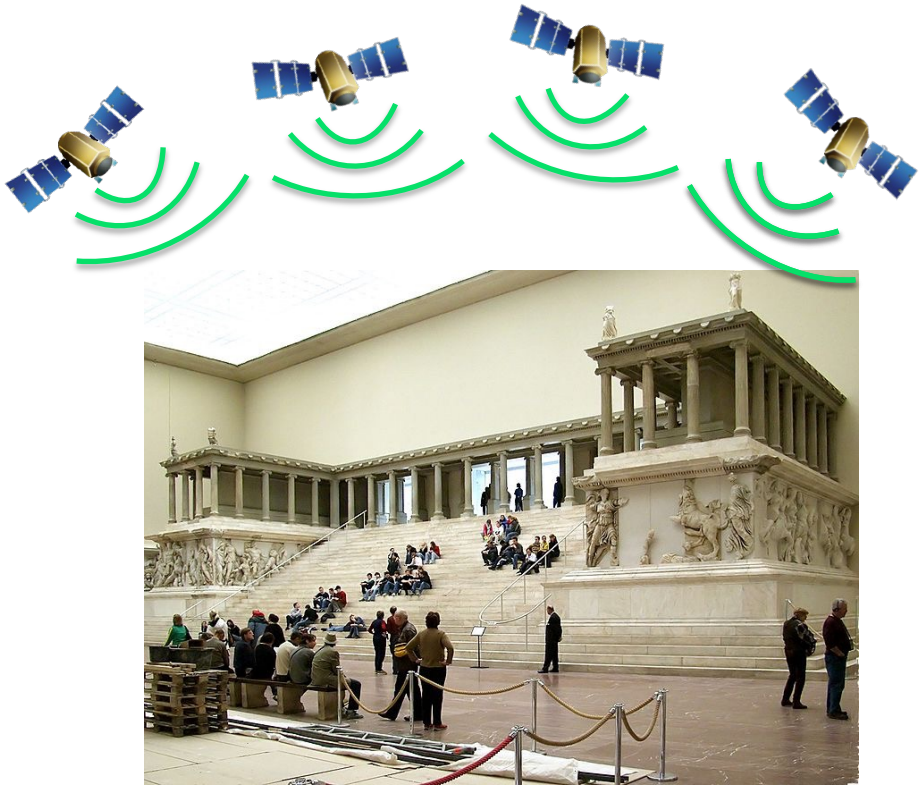


- **GNSS gives reliable position**



- **GNSS gives reliable position**
- **However, they do not work indoor.**

R&I

LBS 2023
18th Conference on Location Based Services
November 20-22, Ghent, Belgium

Convolutional Neural Network as sensor fusion algorithm applied to IPIN2019 Dataset

Gaetano Luca De Palma, Antoni Perez-Navarro, Raul Montoliu

22nd November, 2023

How can we get data to get indoor position?

- Acceleration
- Magnetic field
- Bluetooh
- GNSS
- Pressure
- UltraWideBand
- Celular networks
- Etc.

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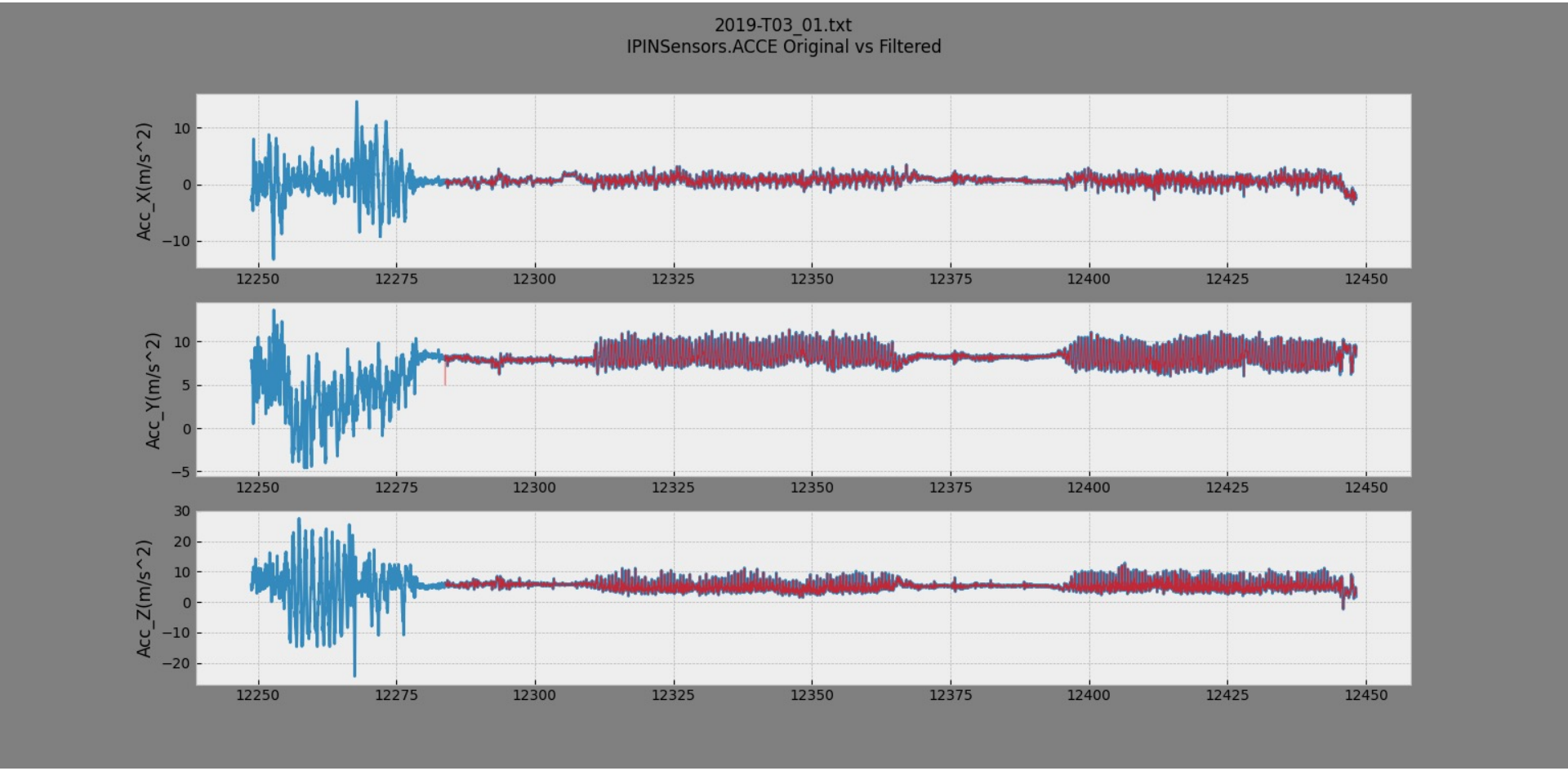
- Etc.

A smartphone can give us all the data we need

Most of people in the world ones a smartphone

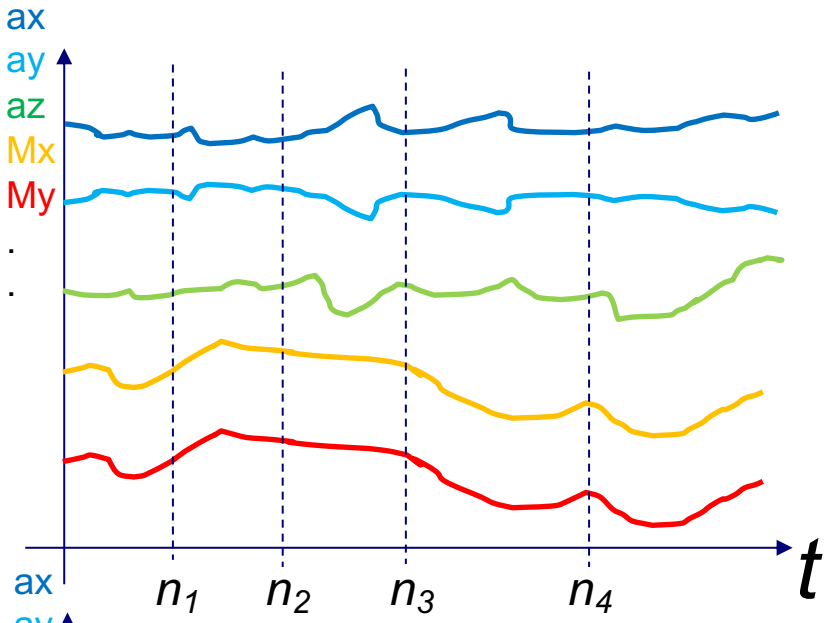
Example of accelerometer



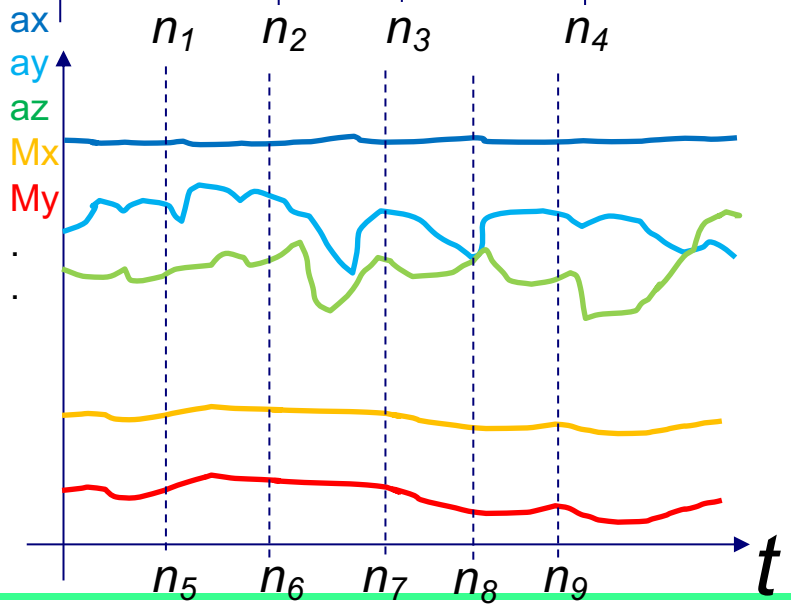
Fingerprinting philosophy

- Phase Offline: Database of tracks

Track 1

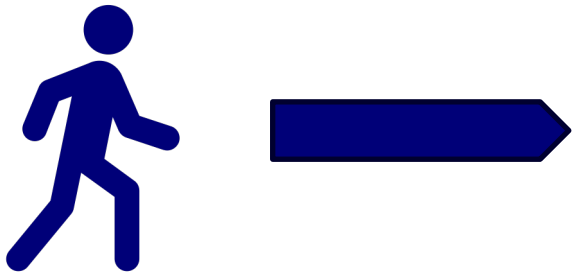


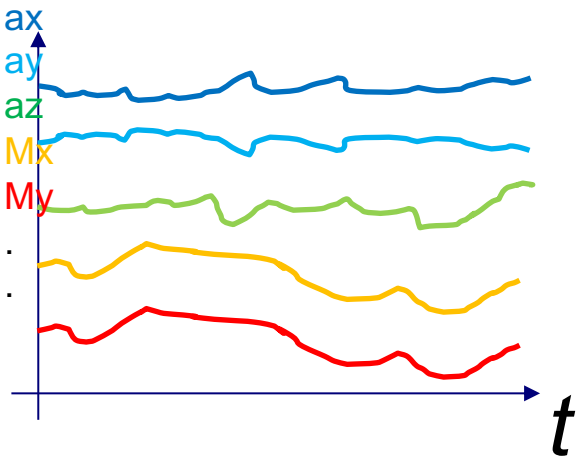
Track 2



Fingerprinting philosophy

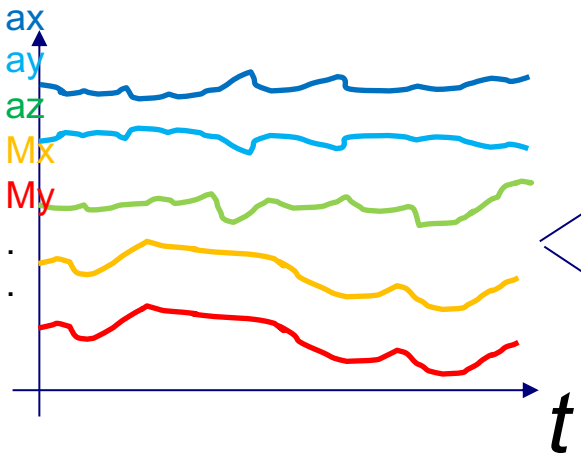
- Phase Online: Where is this track?





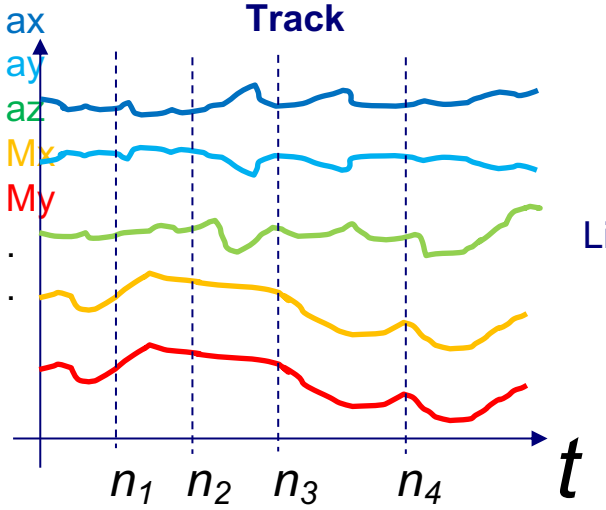
Fingerprinting philosophy

- Phase Online

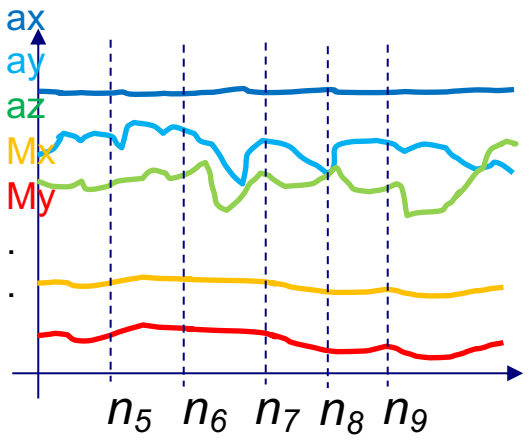


Database of fingerprints

Track **Label**



List of locations 1



List of locations 2

The track is compared with those obtained in the offline phase.

The hypothesis is that we are in the zone corresponding to the more similar track

How to compare tracks?

Image detection

Which is this car?

Image detection

Database of cars

Image	Label
	Benz “Velo”
	Citroën15 SIX D
	Tesla Model 3

Image detection

Which is this car?

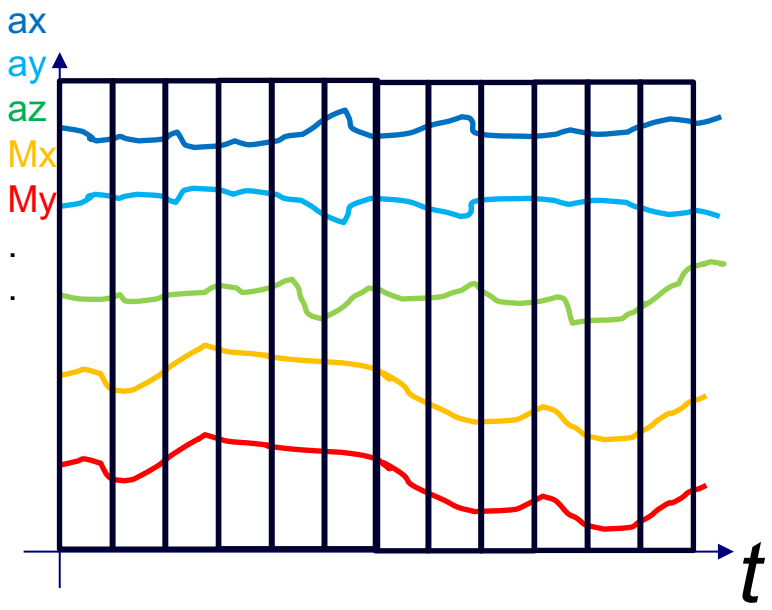
Database of cars

Image	Label
	Benz “Velo”
	Citroën15 SIX D
	Tesla Model 3

Why not to use the experience and success of image comparison to compare tracks?

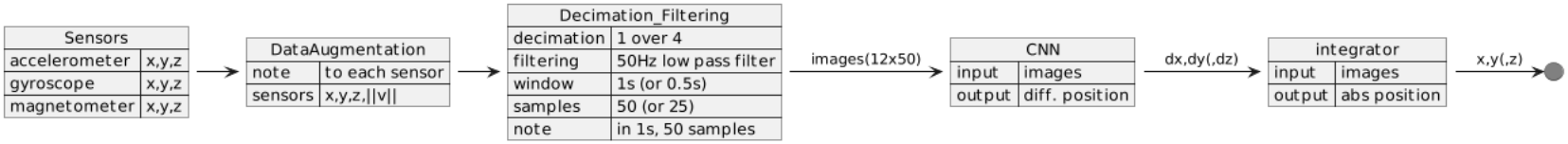
Transforming tracks in images

- It Is useful for comparing images.
- We transform the data in images.
  - We divide data in 1 s length parts
  - Every row of the image are the data of one sensor. If data is collected at 50 Hz, rows will be 50 pixels long.
  - There will be so many rows as sensors we have.
  - Every image is labelled with the latitude and longitude.



Source: Antsfeld, L., Chidlovskii, B., & Sansano-Sansano, E. (2020). Deep Smartphone Sensors-WiFi Fusion for Indoor Positioning and Tracking. https://arxiv.org/abs/2011.10799v1

Convolutional Neural Network (CNN)



Methodology

- Dataset with 40 tracks from IPIN2019.
- Data are composed of time, latitude, longitude and, sometimes, altitute.
- Validation with one-off technique plus Validation tracks (9) not used for training.
- Training Batch shuffled randomly before each training session
- Up to 600 epochs + callback function for early stop.
- Tests with several options: 1 internal layer and 2 internal layer
- Tests with several number of nodes in the layer : ... 24, 64, 96, 192, 384,512, 1024 (Layer 1)

Features

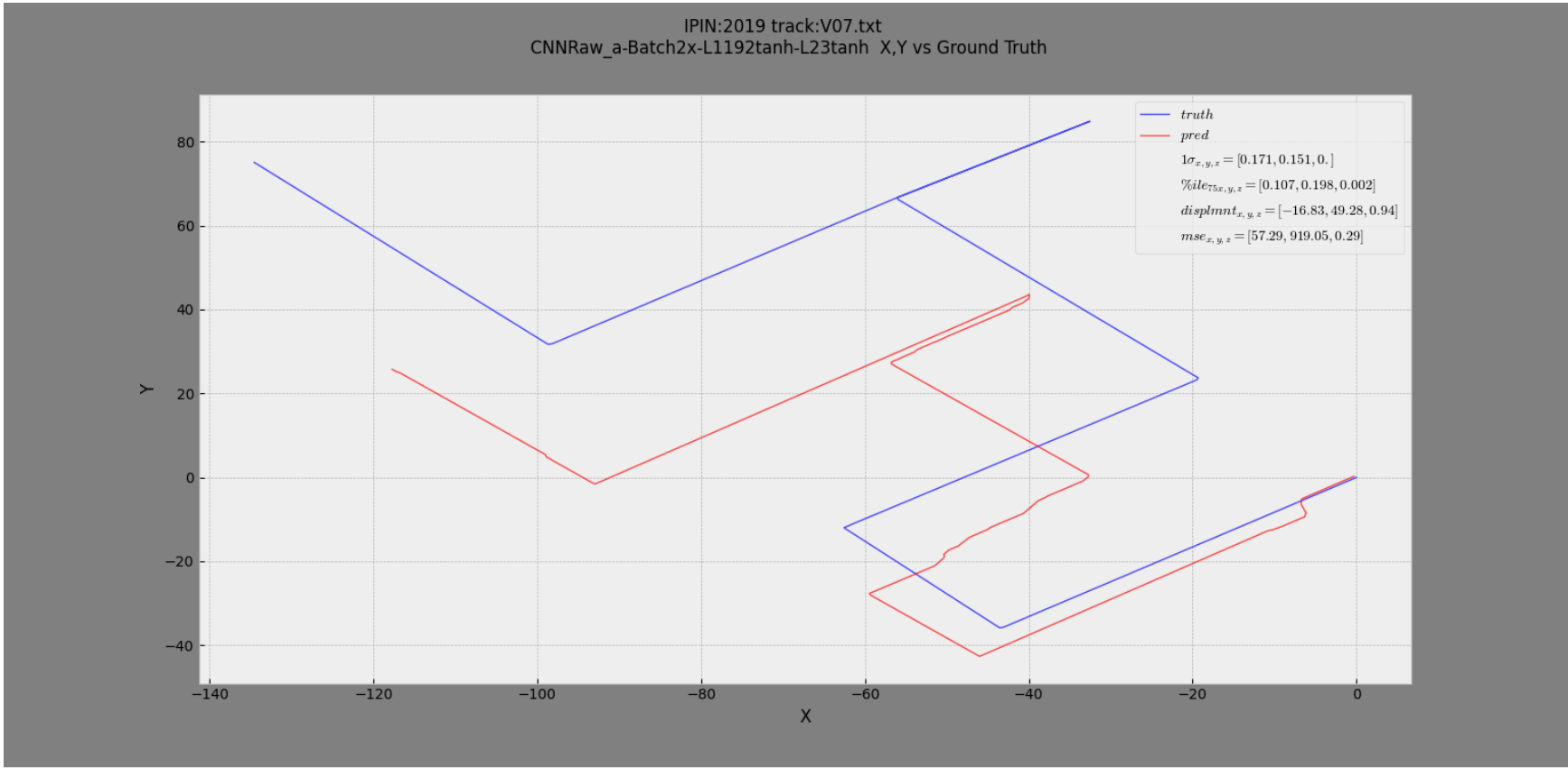
- Tensorflow 2.11 and Python 3.10
- Intel Core i7-8550U CPU, 256 GB SSD, and 16.0 GB memory.
- About 20 min training time total. But arrived up to 50 min

Results

- Using a second layer, with half of the nodes, improves convergence speed.
- With 24 nodes in layer 1 and 12 in layer 2 results we obtain acceptable results.

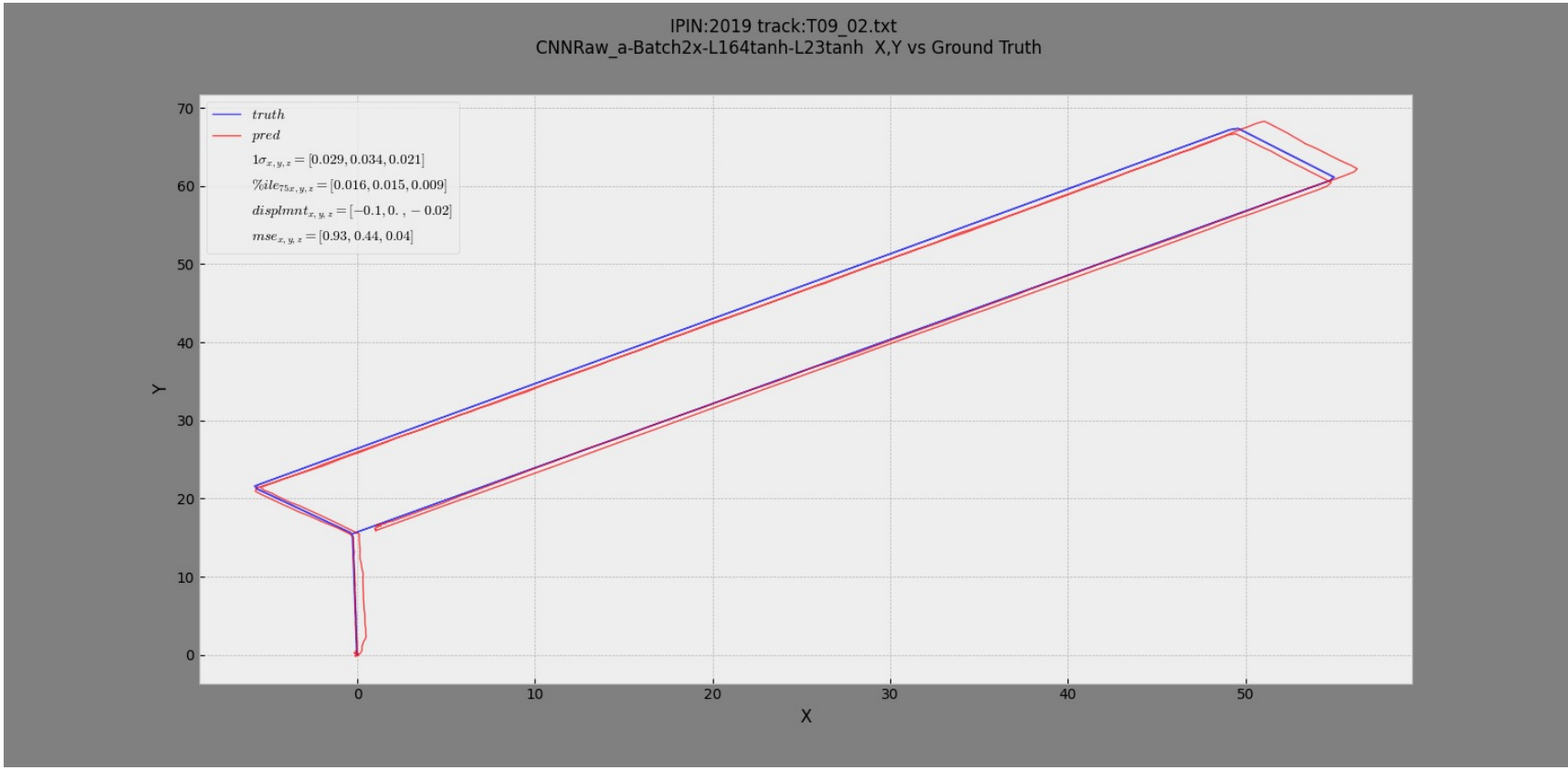
Results

- Promising



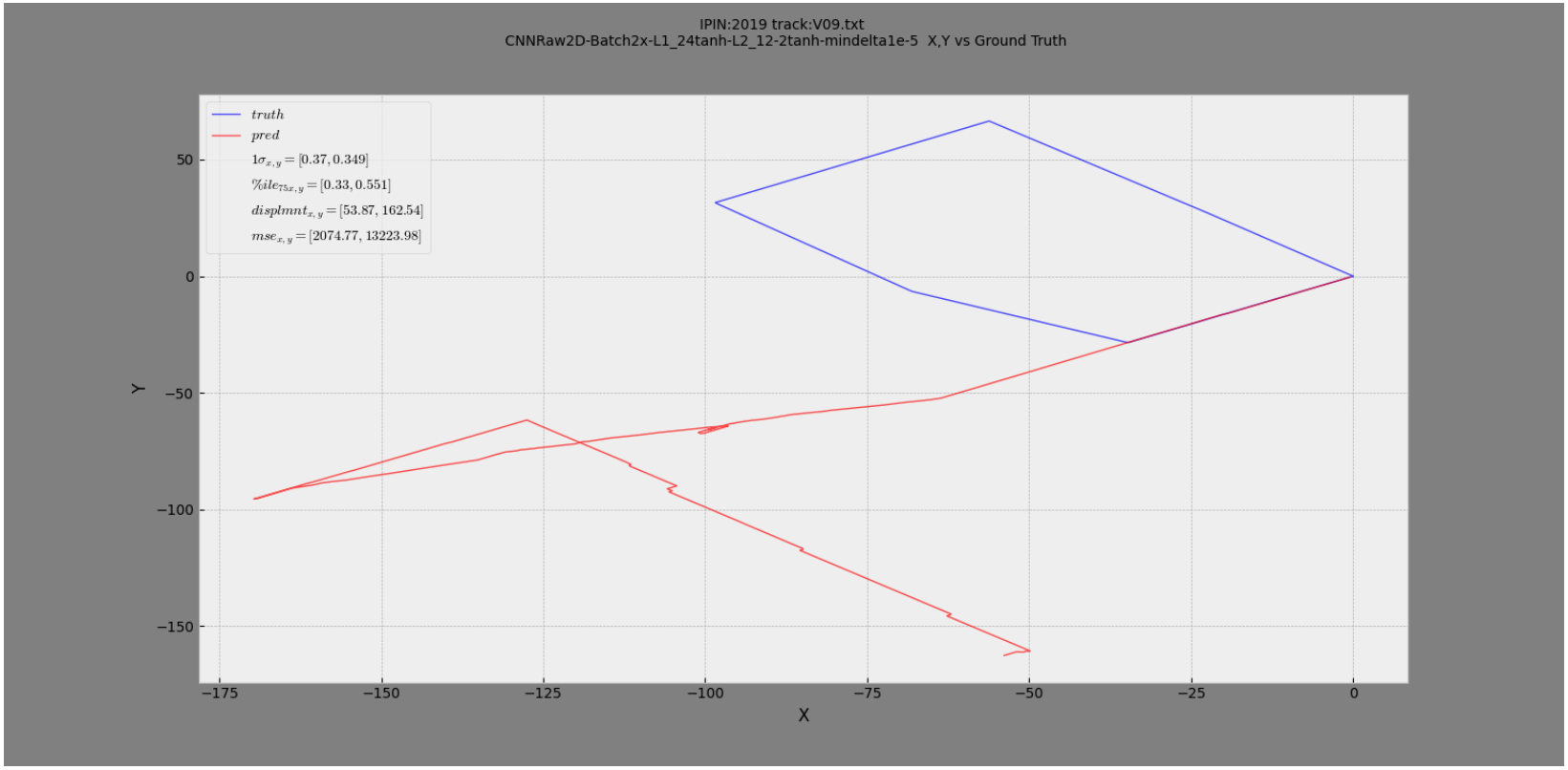
Results

- Too promising… But overfitting



Results

- Catastrophic



Conclusions

- Results are promising.
- Even simple CNN configurations give acceptable results.
- Training time is affordable.
- The system excels detecting changes of direction.
- Results are difficult to reproduce or generalize.

Future work

- Modern Neural Network with internal state (RNN, LSTM)
- Combine results with inertial navigation
- Lager dataset (IPIN 2020, IPIN2021)

Future Work

- To get real 5G data.
- To compare fingerprinting with 5G with different localization methods in a 5G stand alone scenario

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Questions?