Vehicle-Trajectory-Forecasting

Computer Vision Project

SAPIENZA
UNIVERSITÀ DI ROMA

Introduction to Vehicle-Trajectory-Forecasting

Vehicle trajectory forecasting is a critical component in autonomous driving systems, enabling vehicles to anticipate the movement and position of the vehicle itself, thereby enhancing the safety and efficiency of autonomous navigation.

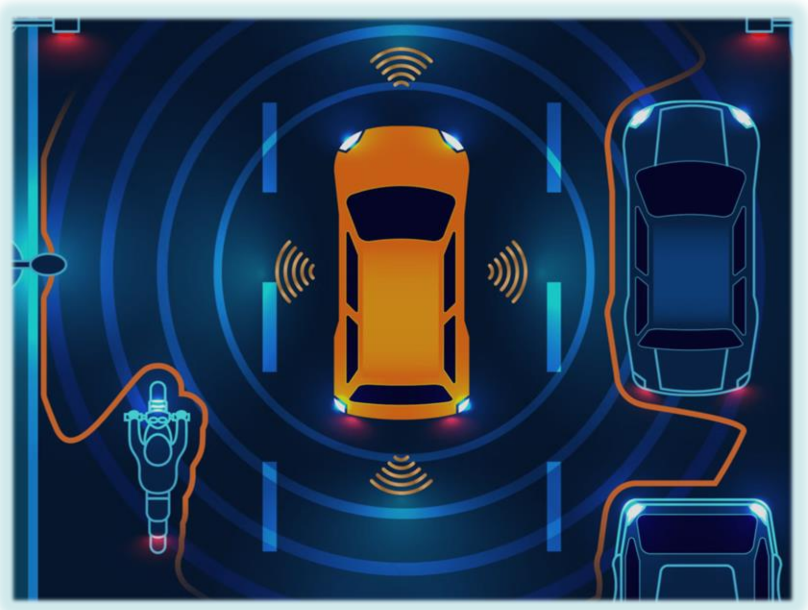


Fig 1: https://www.independent.co.uk/travel/news-and-advice/self-driving-cars-buses-autonomous-vehicles-b2413681.html

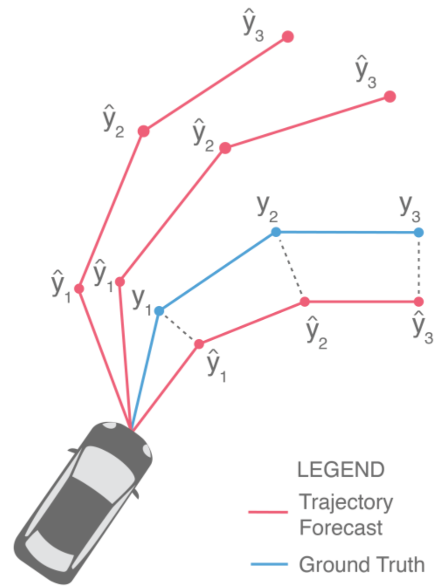


Fig 2: https://ai.stanford.edu/blog/trajectory-forecasting/

Goal of this project

The primary goal of this project is to predict future trajectories of vehicles based on their historical movements and information about neighboring vehicles. Our approach leverages Generative Adversarial Networks (GANs).

The generator predicts potential future trajectories, while the discriminator evaluates these predictions against real data to improve accuracy. This adversarial process enables the model to generate realistic and reliable trajectory predictions.

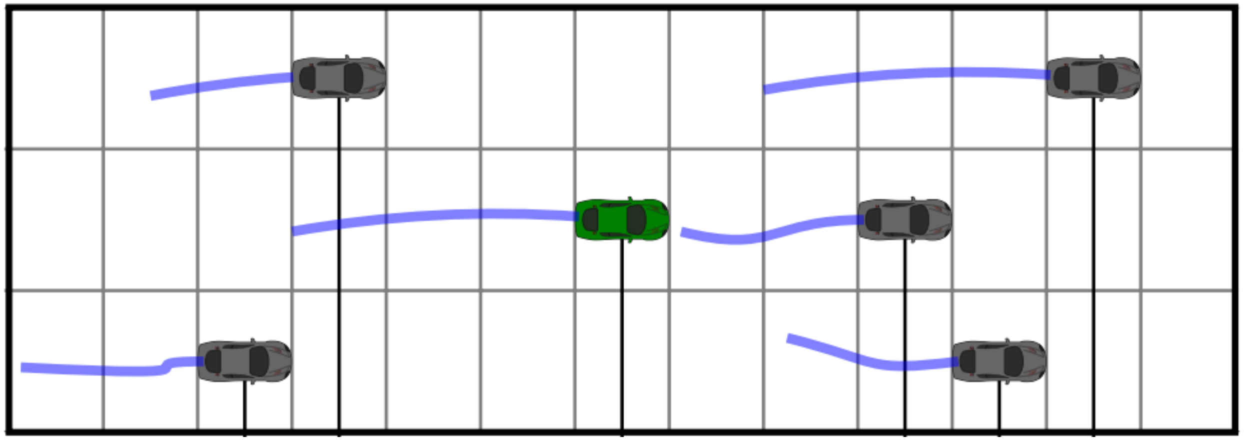
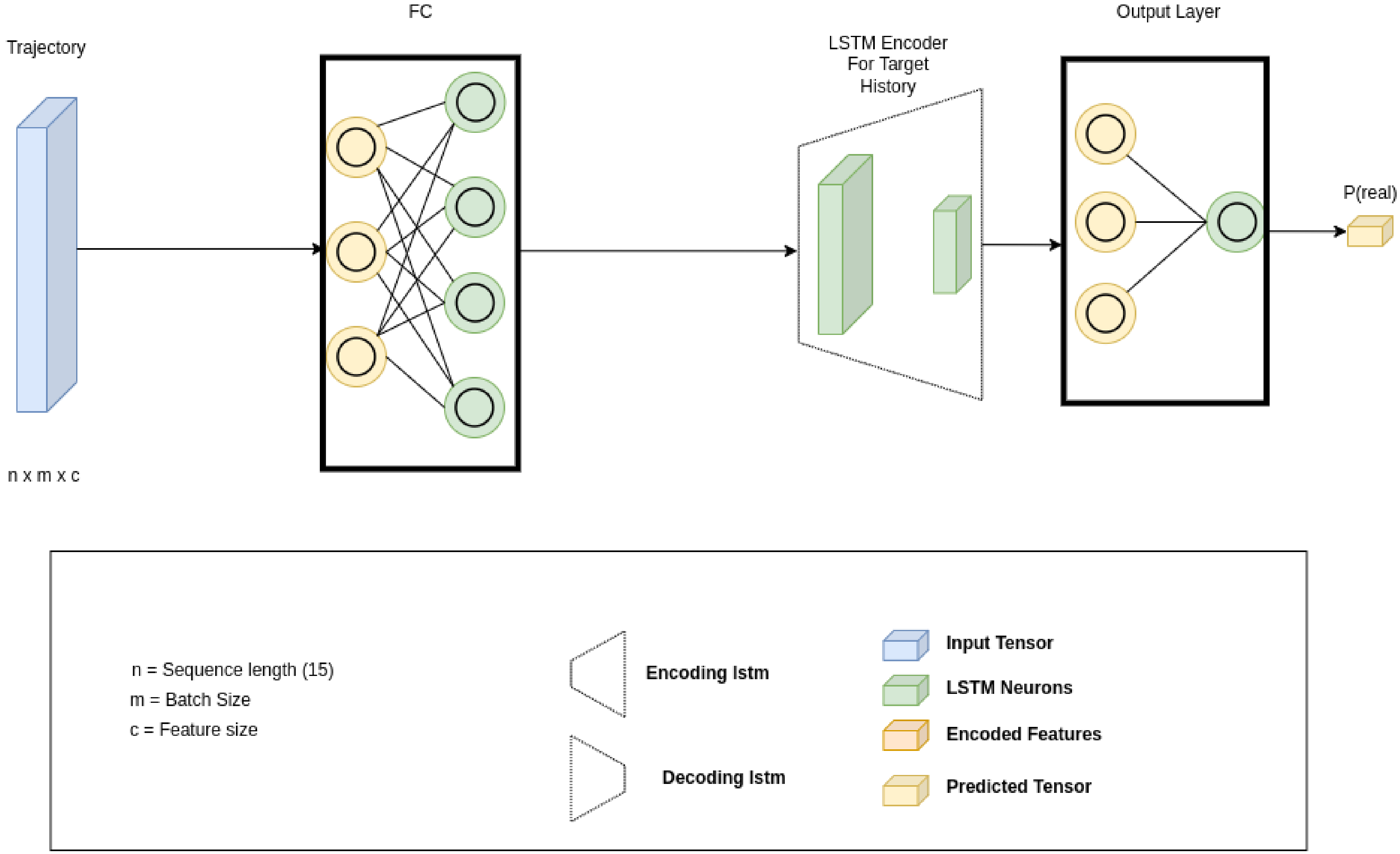


Fig 3: Kaouther Messaoud, Itheri Yahiaoui, Anne Verroust-Blondet, Fawzi Nashashibi. Attention Based Vehicle Trajectory Prediction. IEEE Transactions on Intelligent Vehicles, 2021, 6 (1), pp.175-185. ⟨10.1109/TIV.2020.2991952⟩. ⟨hal-02543967⟩

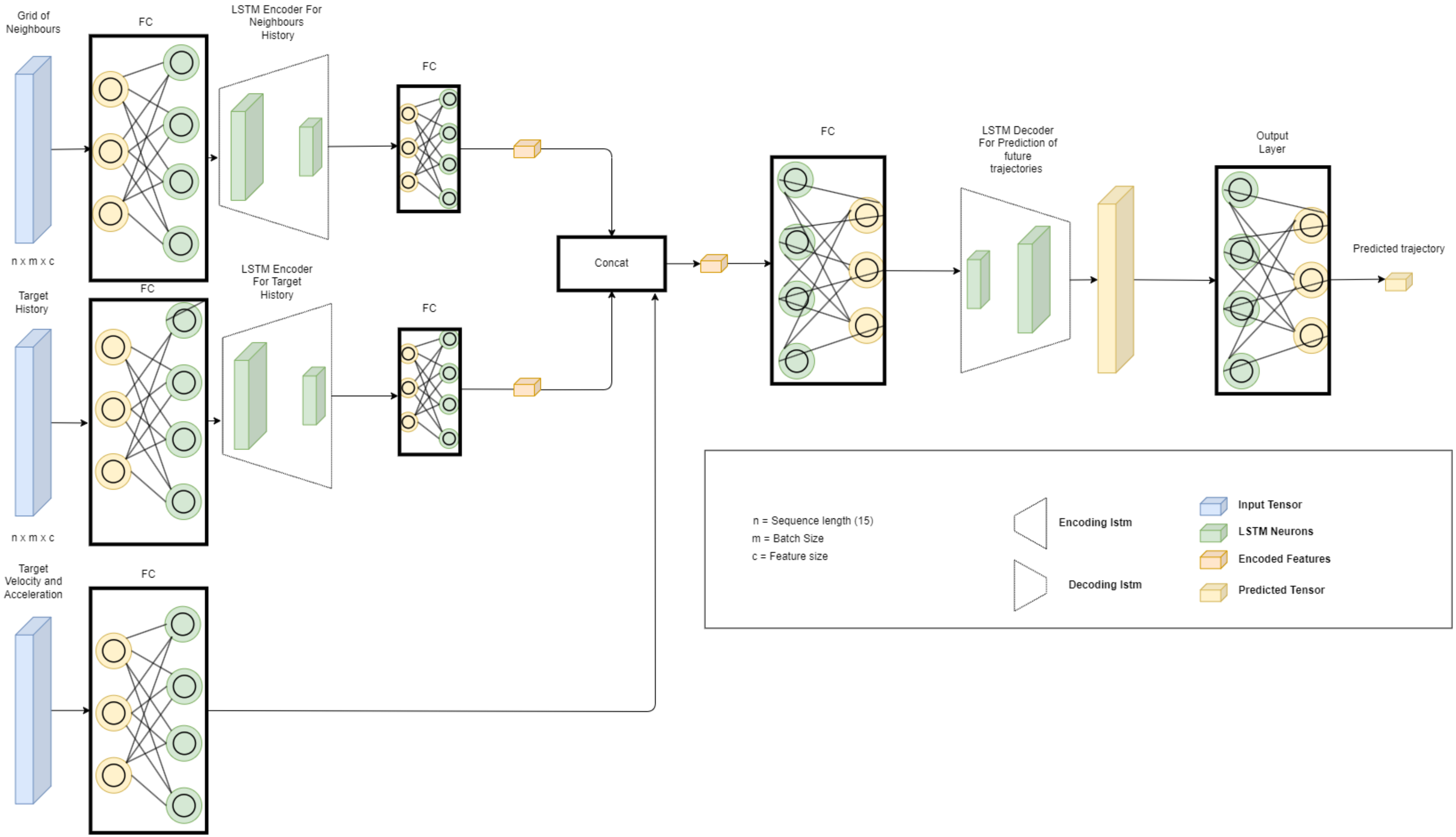
Datasets

The NGSIM (Next Generation Simulation) dataset is a comprehensive traffic dataset collected to support the development of traffic simulation algorithms and models. It includes detailed vehicle trajectory data recorded on specific road segments, The dataset includes CSV files extracted from each frame of video sequences, capturing the positions and movements of vehicles, These extracted features are crucial for our objective of predicting future

Proposed Method (Discriminator)

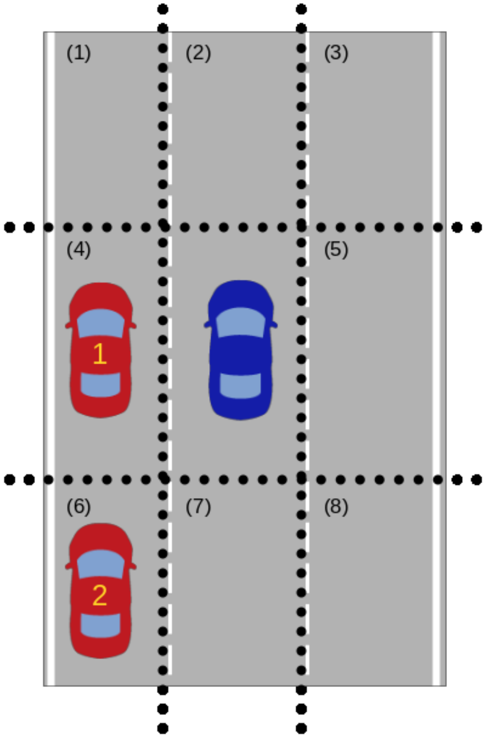


Proposed Method (Generator)



Social Grid

The social grid includes information about neighbors (3 seconds of past trajectory). The grid size is 3x3, with each cell measuring 4x4 meters. This design ensures that only nearby "social behavior" is considered.



Loss Function

BCE (Binary Cross Entropy): Is a standard loss function for binary classification tasks. In the context of GANs, it measures how well the discriminator distinguishes between real and fake data and how well the generator fools the discriminator.

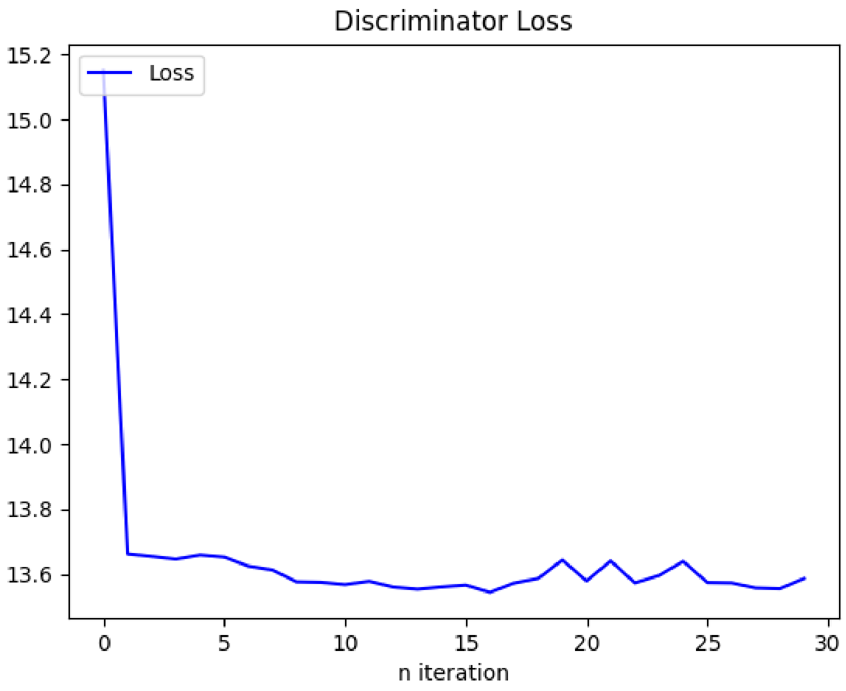
$$L_{BCE} = -\frac{1}{n}\sum_{i=1}^{n}(Y_i \cdot \log \hat{Y}_i + (1 - Y_i) \cdot \log(1 - \hat{Y}_i))$$

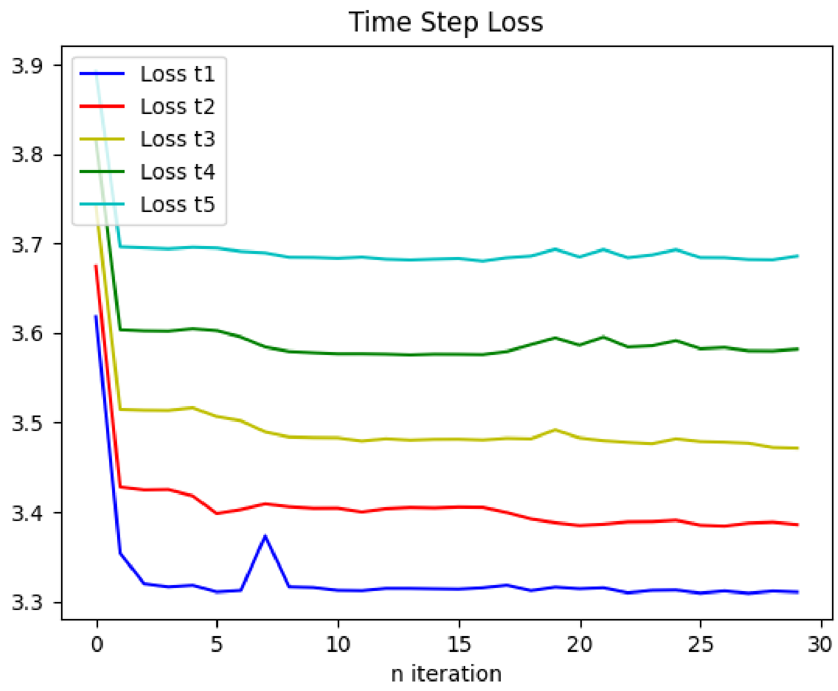
Loss Function

RMSE (Root Mean Squared Error): This metric measure the average magnitude of the prediction errors, providing insight into the accuracy of our model in predicting vehicle trajectories in meters over 5-second horizon for the models.

$$RMSE = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(yi - y'i)^2}$$

Loss


Discriminator Loss
Loss
15.2
15.0
14.8
14.6
14.4
14.2
14.0
13.8
13.6
0
5
10
15
20
25
30
n iteration


Time Step Loss
Loss t1
Loss t2
Loss t3
Loss t4
Loss t5
3.9
3.8
3.7
3.6
3.5
3.4
3.3
0
5
10
15
20
25
30
n iteration

Results

Dataset	Prediction Horizon (s)	MHA-LSTM	GAN-LSTM (Our Model)
NGSIM	T1	0.41	3.34
	T2	1.01	3.36
	T3	1.74	3.57
	T4	2.67	3.60
	T5	3.83	3.76

Conclusion

Future Work:

- Improving Maneuver Encoders
  - Enhance the maneuver encoder to better capture changes in vehicle direction.
- Multi-Scale Data Handling:
  - Address the challenges posed by data retrieved from different locations and at varying scales, applying transformations to ensure data consistency regardless of scale.