Scene-aware and Social-aware Motion Prediction for Autonomous Driving

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Technical University of Munich

January 06, 2024

Agenda

Introduction

Autonomous Driving Promise

- Efficiency and Safety

Challenges in Motion Prediction

- Multimodality
- Scene Dependence
- Social Acceptability

Crucial Understanding

- Human-Driven Behavior Key

Limitations of Current AI Tools

- Control Perspective Absent
- Intent Interpretation Challenge

Overview of Our Approach

Testing and Evaluating State-of-the-Art Tools

- Understanding the real-world applicability and limitations of these tools

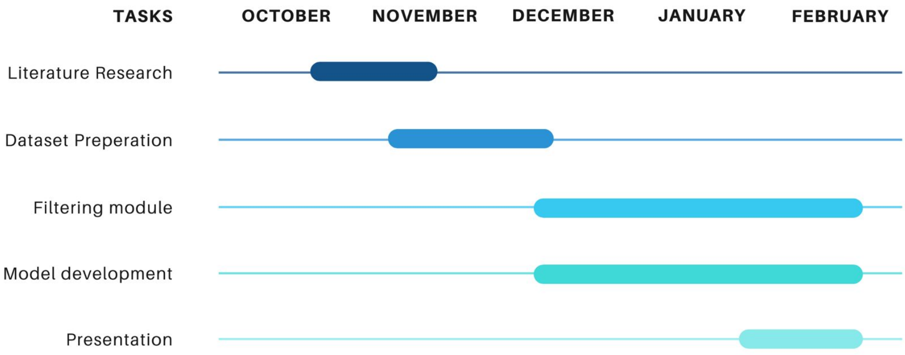
Developing Control-Oriented Tools

- Introduce virtual forces between vehicles to improve the accuracy of movement predictions

Specific Focus on Vehicle Interactions

- Formulate more accurate and socially-aware predictive models based on these analyses.

Timeline



Alfred

Literature Research
Dataset Preperation
Model development

Baris

Literature Research
Dataset Preperation
Filtering module

Dataset Collection

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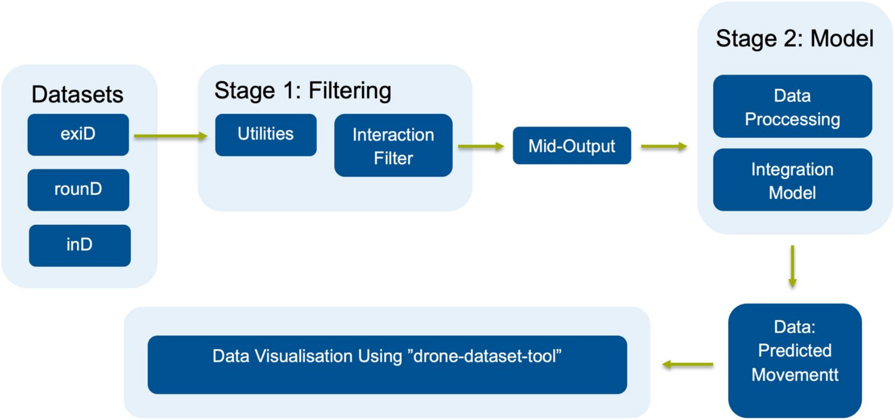
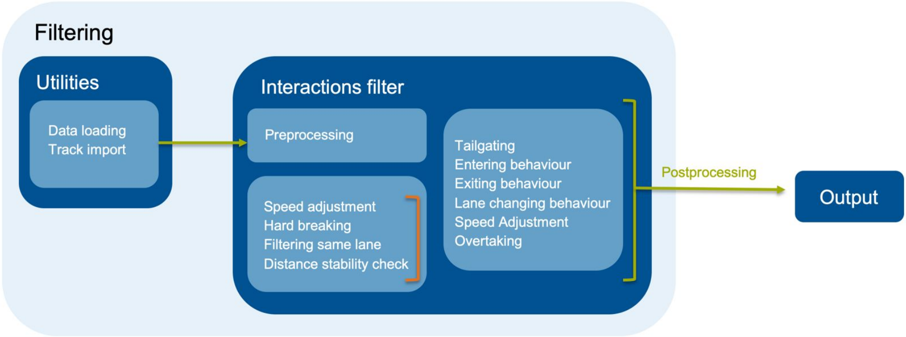
Method Description - Overview



Method Descripion - Stage 1



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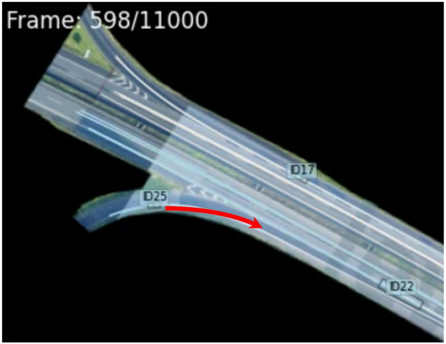
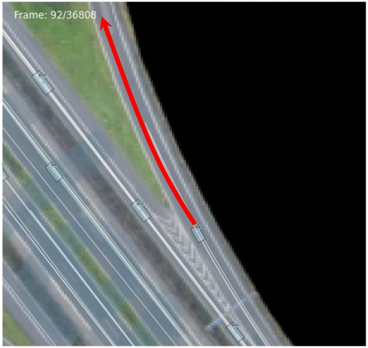


Merging Lane Entering Scenario

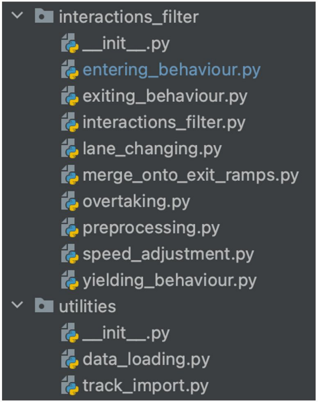


Merging Lane Exiting Scenario

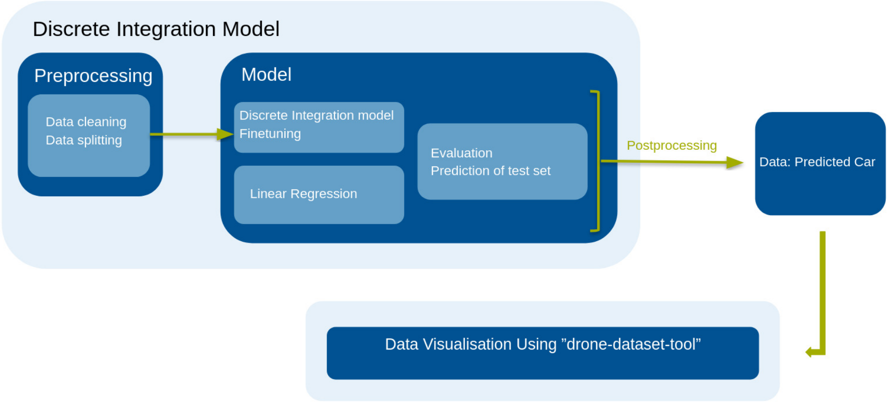
Method Descripion - Stage 1

Filtering Stage: Identifying Vehicle Behaviors

- Preprocessing
- Behavior Detection
  - Entering/Exiting Behavior
- Interaction Analysis
- Lane Change Detection
- Thresholds and Conditions
- Data Grouping and Sorting



Method Descripion - Stage 2



Our Discrete Integration Model

Distance and Velocity Equations:

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$$s(k+1) = s(k) + dt \cdot v(k) + c_1 a(k) + c_2 a(k-1)$$
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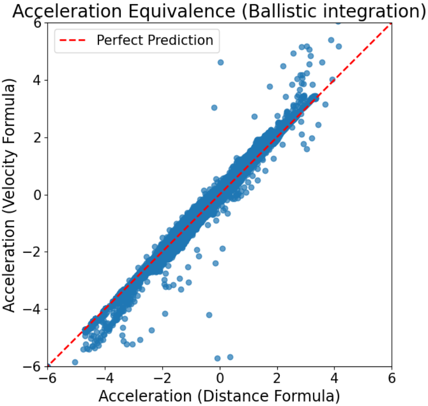
Note:

- The acceleration resulting from both formulas should be equal
- Model can be solved using linear regression.

Scenario filtering

Video demo of the scenarios

Results: Comparison to the old acceleration model



MSE: 3.0786e+02

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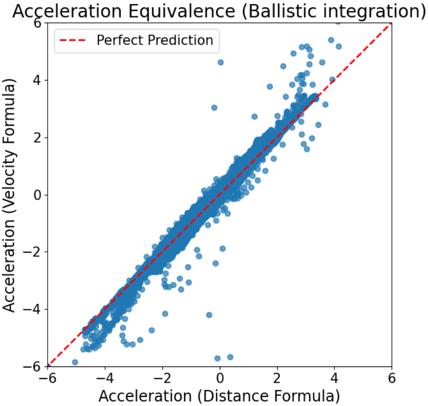

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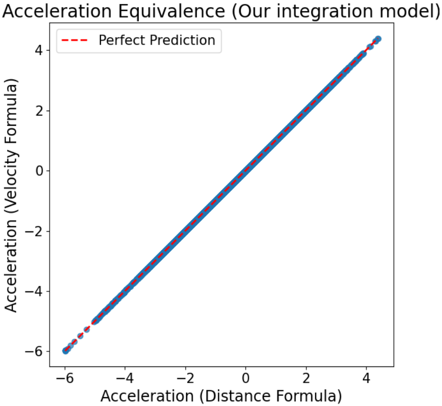

MSE: 1.9220e-09

Results: Integration Method

Rearranging the formula to the distance and velocity gives us these results:

Video demo of predicted car

Future Work

Scenario Filtering:

- Specify even more scenarios for a broader range of use cases.

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- Specify even more scenarios for a broader range of use cases.
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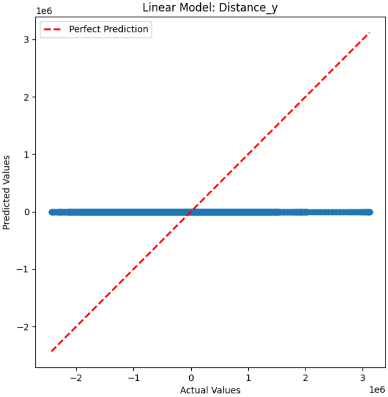
Integration Model:

- Finetune the integration model (adding other parameteres)
- Test the integration model with the neural network for performance (task for the next team)

Q&A

Acceleration Modification in the Y-axis



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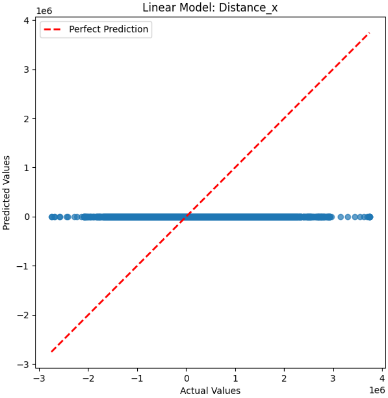

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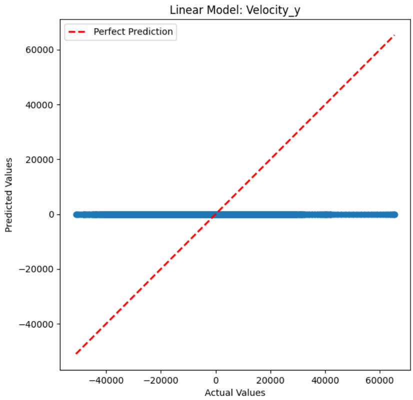

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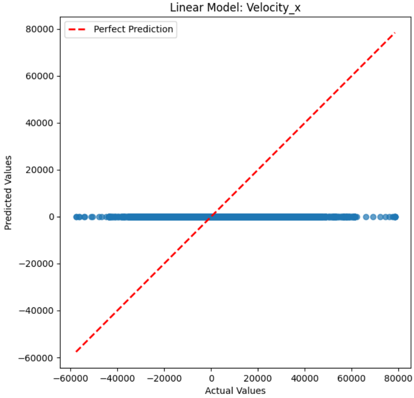
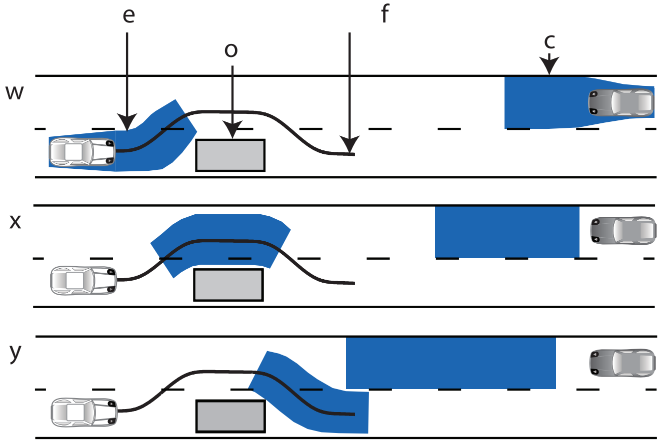


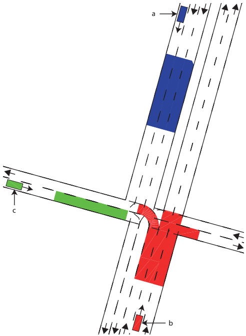
Motivation for Set-Based Prediction [1]



[1] M. Althoff and S. Magdici, "Set-based prediction of traffic participants on arbitrary road networks," IEEE Transactions on Intelligent Vehicles, vol. 1, no. 2, pp. 187–202, 2016.

SPOT

SPOT: A tool for set-based prediction of traffic participants [2]



Initial configuration and $\mathcal{O}(t)$ for $t \in [1.5\,\mathrm{s}, 2.0\,\mathrm{s}]$

[2] M. Koschi and M. Althoff, "SPOT: A tool for set-based prediction of traffic participants," in Proc. of the IEEE Intelligent Vehicles Symposium, pp. 1679–1686, 2017.

Conclusions

- Item
- Item
- Item

beginframe

Distance and Velocity Equations:

$$s(k+1) = s(k) + dt \cdot v(k) + \frac{dt^2}{2} a(k) \qquad v(k+1) = v(k) + dt \cdot a(k)$$

onslide¡2¿

Acceleration Equations:

$$a(k) = \frac{2}{dt^2}\Big(s(k+1) - s(k) - dt \cdot v(k)\Big) \qquad a(k) = \frac{1}{dt}\Big(v(k+1) - v(k)\Big)$$

endframe

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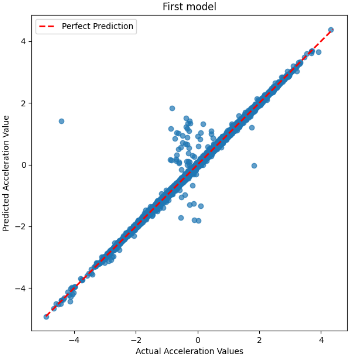

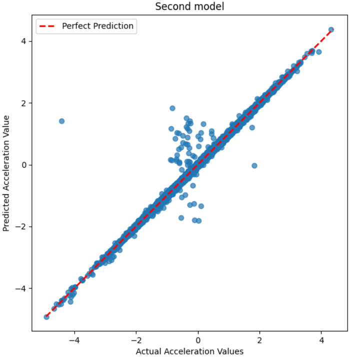

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Video demo of predicted car

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Model in matrix form:

$$\begin{bmatrix} a(k) \\ a(k) \end{bmatrix} = \begin{bmatrix} -a(k-1) & s(k+1) - s(k) - dt \cdot v(k) & 0 & 0 \\ 0 & 0 & -a(k-1) & v(k+1) - v(k) \end{bmatrix} \begin{bmatrix} \overline{c_1} \\ \overline{c_2} \\ \overline{c_3} \\ \overline{c_4} \end{bmatrix}$$

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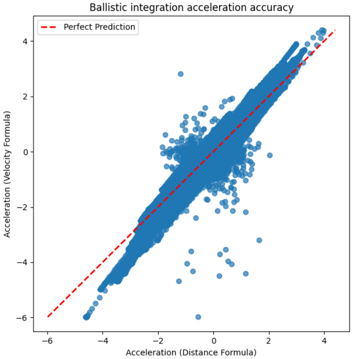
$\Rightarrow$ This can be solved using linear regression.

Results: Integration Method

Accuracy of the prediction for the acceleration using the Ballistic Integration method (MSE): 4.3249e-02



Previous Integration Model - Accuracy

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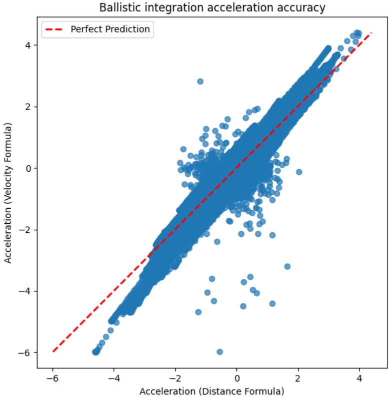

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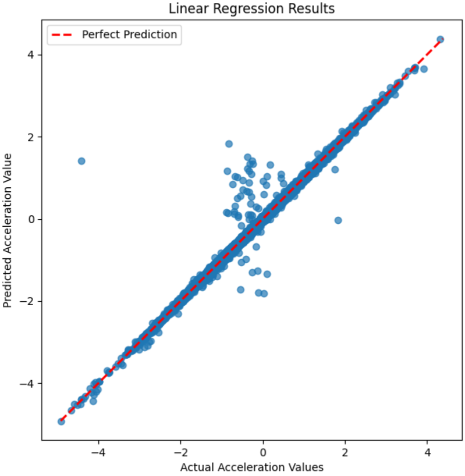

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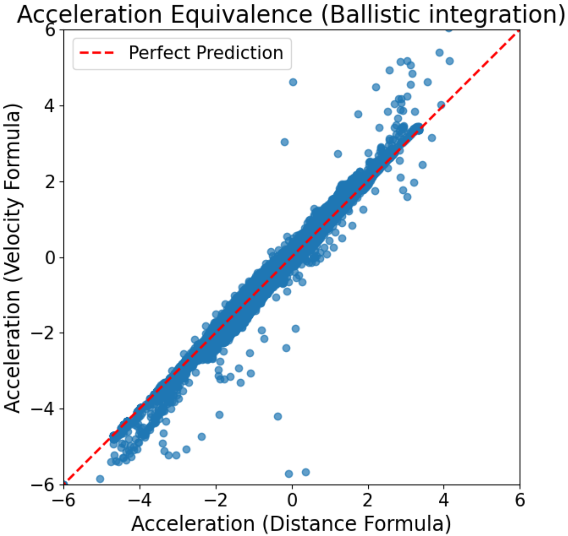

Our Integration Model - Matrix Form

Acceleration from Distance formula:

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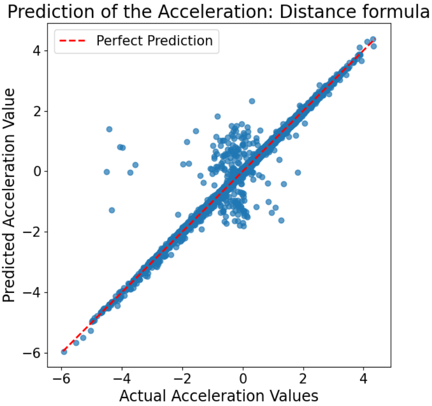

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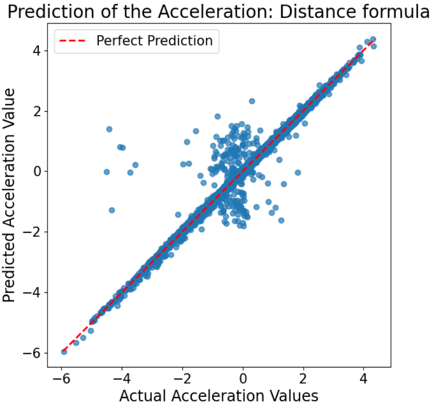

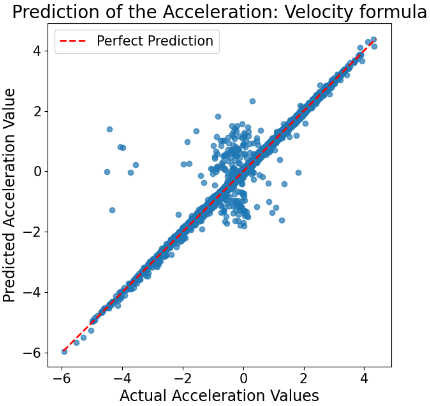

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- Successfully implemented the filtering mechanism
- Able to filter out X different scenarios in Y datasets
- Found a better integration method where the accelerations match
- Able to visualize the integration method and modulate the movement of a car

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