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

Alfred Nguyen, Baris Sözüdogru

Technical University of Munich

January 06, 2024

Agenda

1. Motivation
2. Method
   - Data collection
   - Filtering process
   - Integration Model
3. Results
   - Scenario Filtering
   - Integration Method
4. Future Work

Agenda

Agenda

Agenda

Previous Integration Model

Distance and Velocity Equations (Ballistic Integration):

Previous Integration Model

Distance and Velocity Equations (Ballistic Integration):

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

$$v(k+1) = v(k) + dt \cdot a(k)$$

Previous Integration Model

Distance and Velocity Equations (Ballistic Integration):

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

Acceleration Equations (Rearranged):

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

Previous Integration Model

Distance and Velocity Equations (Ballistic Integration):

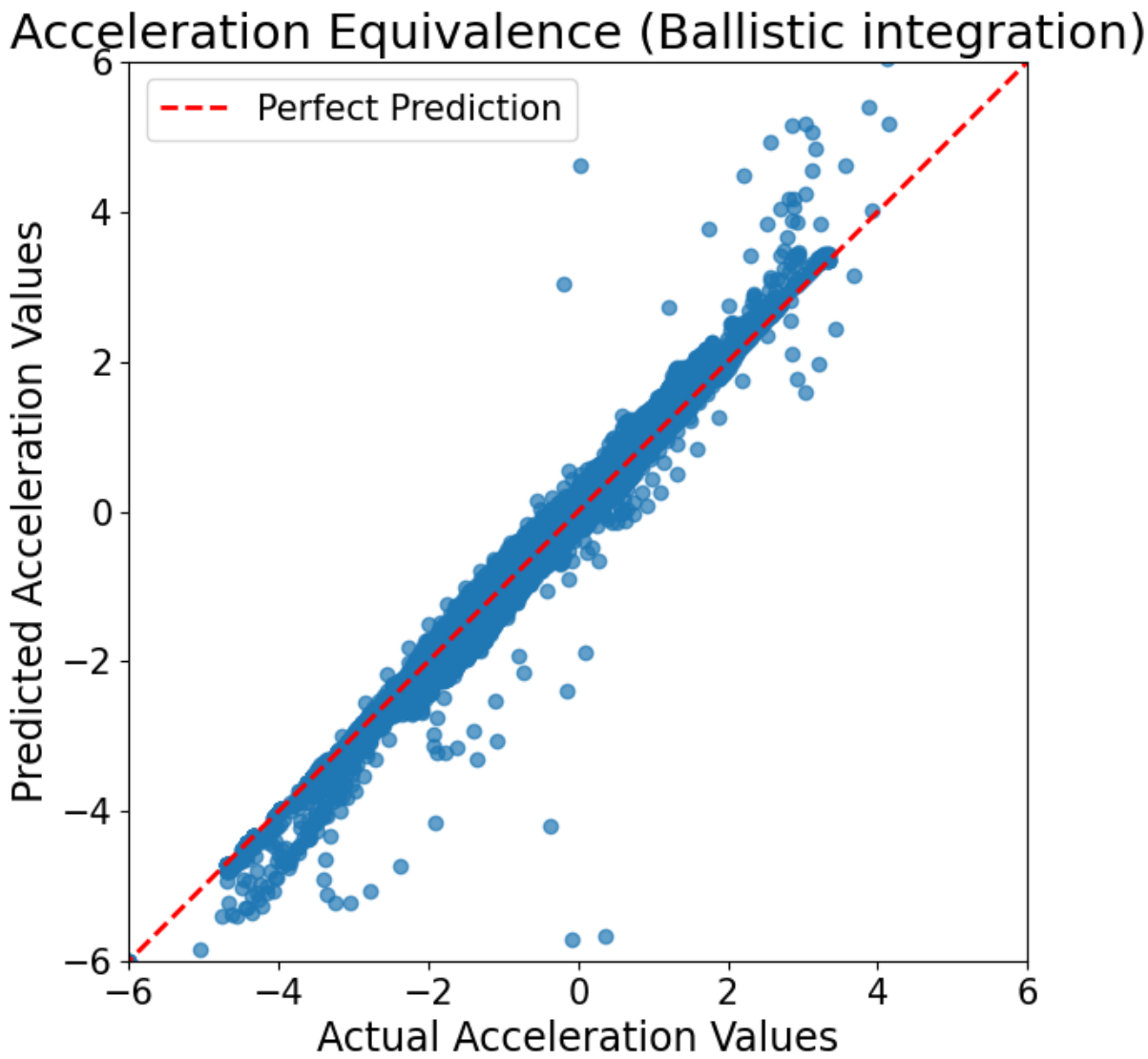
$$s(k+1) = s(k) + dt \cdot v(k) + \frac{dt^2}{2} a(k)$$
$$v(k+1) = v(k) + dt \cdot a(k)$$

Acceleration Equations (Rearranged):

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

Problem: Accelerations are not equal!

Previous Integration Model - Accuracy



Our Integration Model

Distance and Velocity Equations:

Our Integration Model

Distance and Velocity Equations:

$$s(k+1) = s(k) + dt \cdot v(k) + c_1 a(k) + c_2 a(k-1)$$
$$v(k+1) = v(k) + c_3 a(k) + c_4 a(k-1)$$

Our Integration Model

Distance and Velocity Equations:

$$s(k+1) = s(k) + dt \cdot v(k) + c_1 a(k) + c_2 a(k-1)$$
$$v(k+1) = v(k) + c_3 a(k) + c_4 a(k-1)$$

Acceleration Equations:

$$a(k) = -\overline{c_1} a(k-1) + \overline{c_2}\big(s(k+1) - s(k) - dt \cdot v(k)\big)$$
$$a(k) = -\overline{c_3} a(k-1) + \overline{c_4}\big(v(k+1) - v(k)\big)$$

Our Integration Model - Matrix Form

Acceleration from Distance formula:

$$\begin{bmatrix} a(k) \end{bmatrix} = \begin{bmatrix} -a(k-1) & v(k+1) - v(k) \end{bmatrix} \begin{bmatrix} \overline{c_1} \\ \overline{c_2} \end{bmatrix}$$

Acceleration from Velocity formula:

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

Our Integration Model - Matrix Form

Acceleration from Distance formula:

$$\begin{bmatrix} a(k) \end{bmatrix} = \begin{bmatrix} -a(k-1) & v(k+1) - v(k) \end{bmatrix} \begin{bmatrix} \overline{c_1} \\ \overline{c_2} \end{bmatrix}$$

Acceleration from Velocity formula:

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

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

Agenda

Scenario filtering

Scenarios we filtered the dataset with:

- Lane merging

Scenario filtering

Scenarios we filtered the dataset with:

- Lane merging
- Lane exiting

Scenario filtering

Scenarios we filtered the dataset with:

- Lane merging
- Lane exiting
- Entering behaviour

Scenario filtering

Scenarios we filtered the dataset with:

- Lane merging
- Lane exiting
- Entering behaviour
- Exiting behaviour

Video demo of the scenarios

Agenda

Reminder: Our Integration Model - Matrix Form

Acceleration from Distance formula:

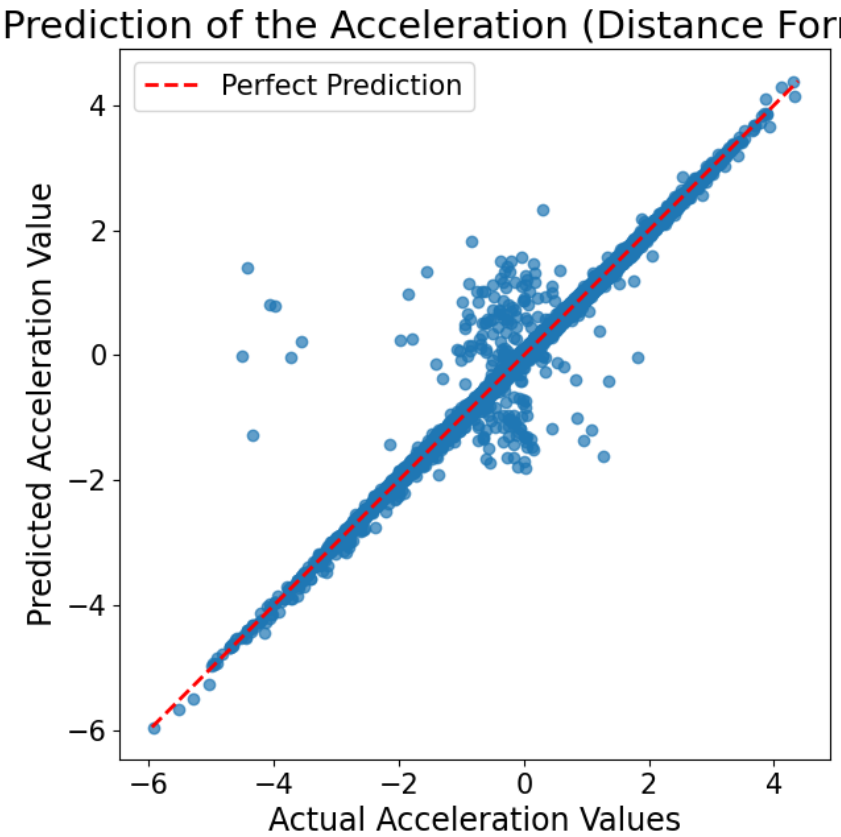
$$\begin{bmatrix} a(k) \end{bmatrix} = \begin{bmatrix} -a(k-1) & v(k+1) - v(k) \end{bmatrix} \begin{bmatrix} \overline{c_1} \\ \overline{c_2} \end{bmatrix}$$

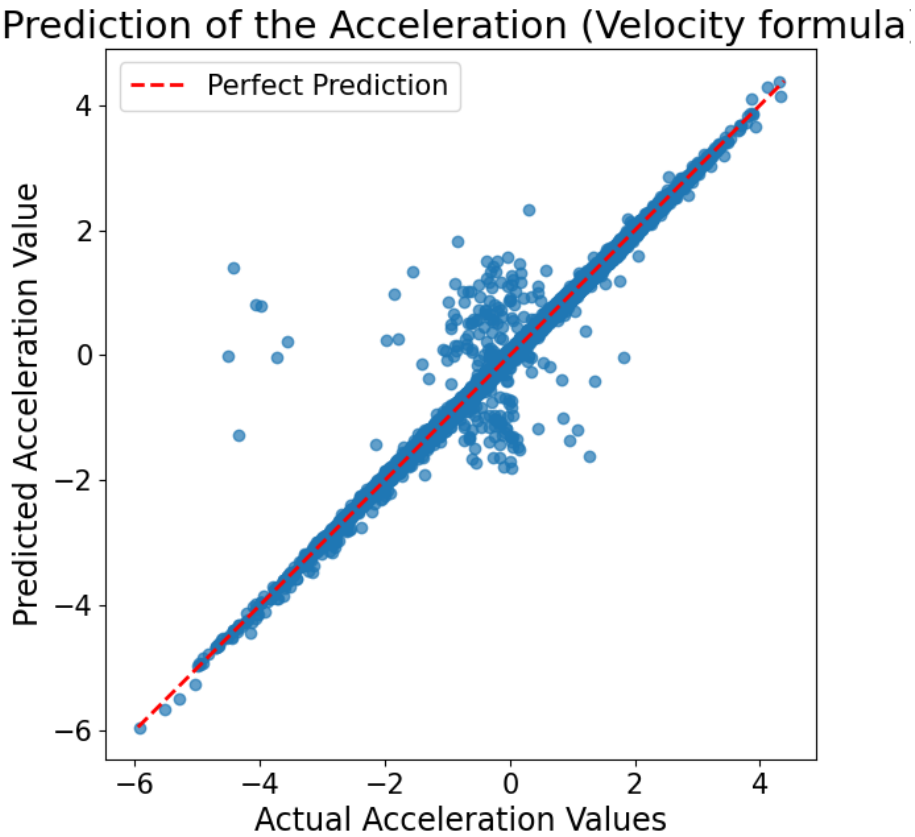
Acceleration from Velocity formula:

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

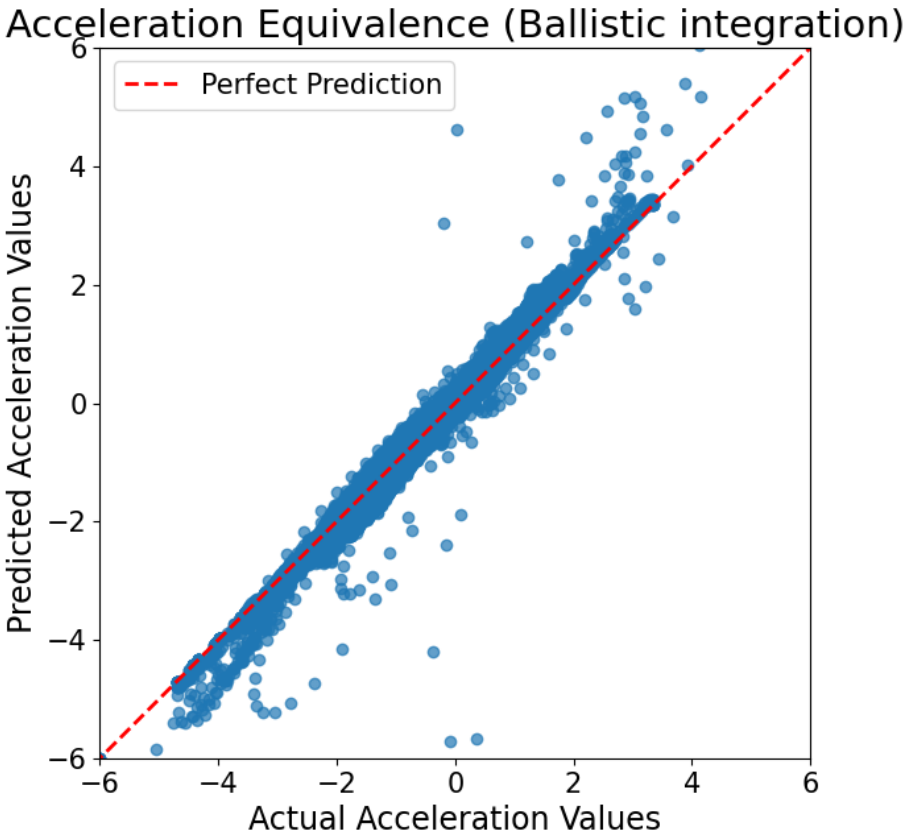
$\Rightarrow$ This can be solved using linear regression.

Results: Integration Method



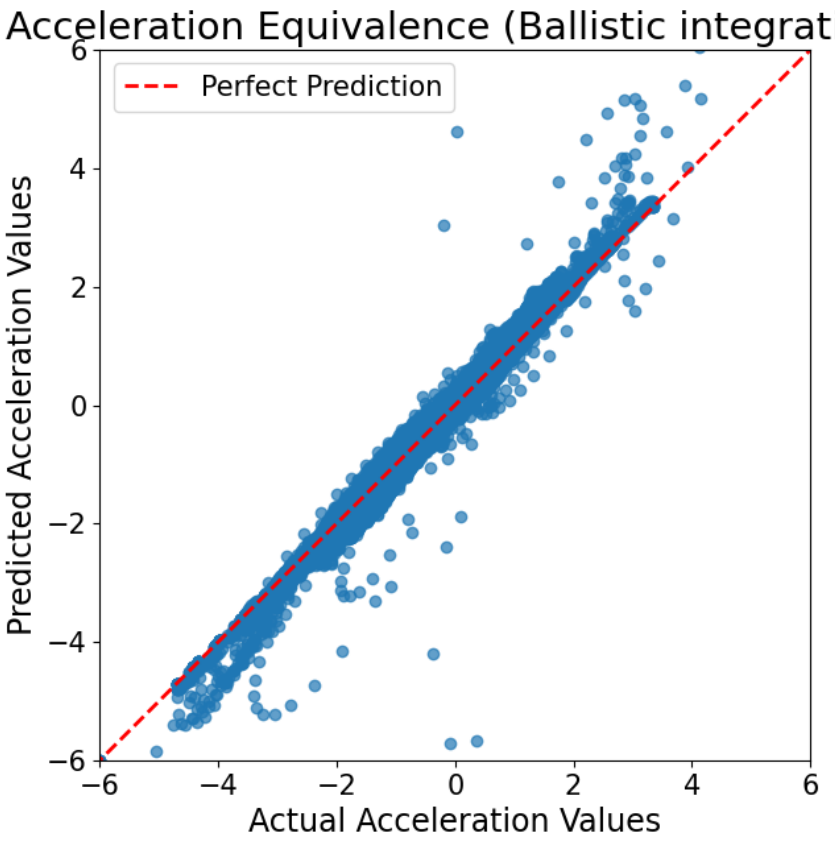


Results: Comparison to the old acceleration model

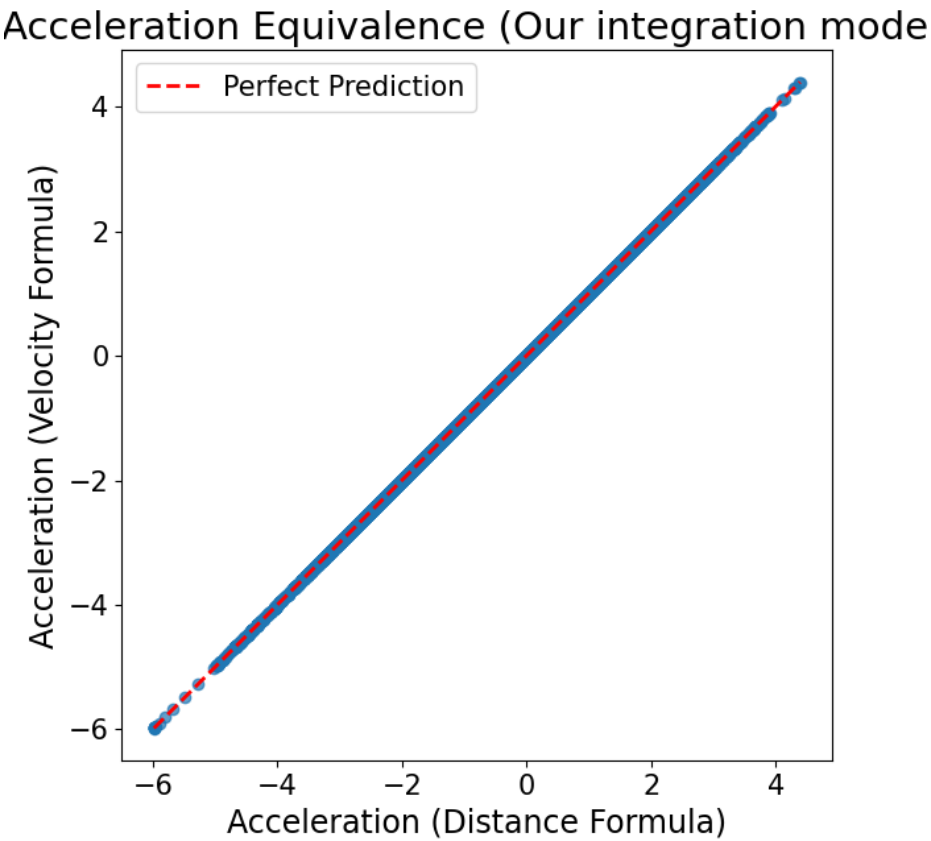


MSE: 3.0786e+02

Results: Comparison to the old acceleration model



MSE: 3.0786e+02



MSE: 1.9220e-09

Results: Integration Method

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

Video demo of predicted car

Results

Summary:

- Successfully implemented the filtering mechanism

Results

Summary:

- Successfully implemented the filtering mechanism
- Able to filter out X different scenarios in Y datasets

Results

Summary:

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

Results

Summary:

- 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

Agenda

Future Work

Scenario Filtering:

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

Future Work

Scenario Filtering:

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

Future Work

Scenario Filtering:

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

Integration Model:

- Finetune the integration model (adding other parameteres)

Future Work

Scenario Filtering:

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

Integration Model:

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

Questions?