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

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January 06, 2024

Agenda

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

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Previous Integration Model

Distance and Velocity Equations (Ballistic Integration):

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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):

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

Acceleration Equations:

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

Previous Integration Model

Distance and Velocity Equations (Ballistic Integration):

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

Acceleration Equations:

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\begin{aligned}
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)
\end{aligned}
$$

Problem: Accelerations dont add up!

Our Integration Model

Our Distance and Velocity Equations:

Our Integration Model

Our Distance and Velocity Equations:

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

Our Integration Model

Our Distance and Velocity Equations:

$$
\begin{aligned}
s(t+1) &= s(t) + dt \cdot v(t) + c_3 a(t) + c_4 a(t-1) \\
v(t+1) &= v(t) + c_1 a(t) + c_2 a(t-1)
\end{aligned}
$$

Our Acceleration Equations:

$$
\begin{aligned}
a(k) &= -\overline{c}_1 a(k-1) + \overline{c}_2 \big(s(k+1) - s(k) - dt \cdot v(k)\big) \\
a(k) &= -\overline{c}_3 a(k-1) + \overline{c}_4 \big(v(k+1) - v(k)\big)
\end{aligned}
$$

Our Integration Model

Model in matrix form:

$$\begin{bmatrix} a(k) \\ a(k) \end{bmatrix} = \begin{bmatrix} -a(k-1) & s(k+1) - s(k) - dt \cdot v(k) & 0 & 0 \\ 0 & 0 & -a(k-1) & v(k+1) - v(k) \end{bmatrix} \begin{bmatrix} \overline{c}_1 \\ \overline{c}_2 \\ \overline{c}_3 \\ \overline{c}_4 \end{bmatrix}$$

Our Integration Model

Model in matrix form:

$$\begin{bmatrix} a(k) \\ a(k) \end{bmatrix} = \begin{bmatrix} -a(k-1) & s(k+1) - s(k) - dt \cdot v(k) & 0 & 0 \\ 0 & 0 & -a(k-1) & v(k+1) - v(k) \end{bmatrix} \begin{bmatrix} \overline{c}_1 \\ \overline{c}_2 \\ \overline{c}_3 \\ \overline{c}_4 \end{bmatrix}$$

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

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Video demo of the scenarios

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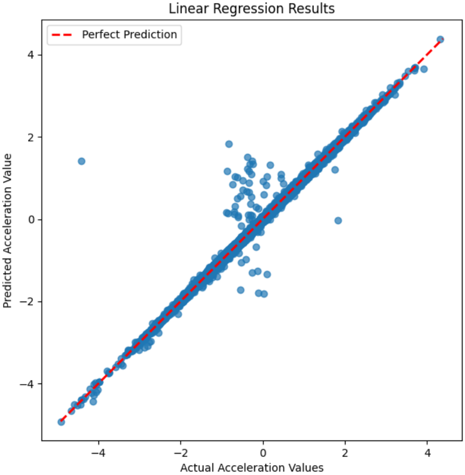
Results: Integration Method

Accuracy of the prediction for the acceleration (MSE): 3.0955e-03



Results: Integration Method

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

Video demo of predicted car

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Future Work

Scenario Filtering:

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

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Scenario Filtering:

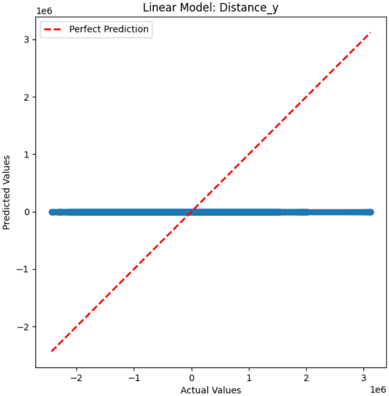
- Specify even more scenario for a broader range of use cases.
- Explore other datasets

Integration Model:

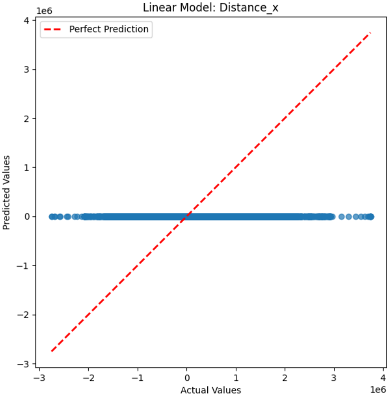
- Finetune the integration model (adding other parameteres)
- Test the integration model with the neural network for performance (task for the next team)

Thank you for your attention:)

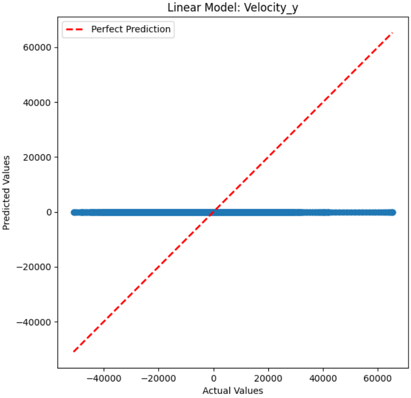
Acceleration Modification in the Y-axis



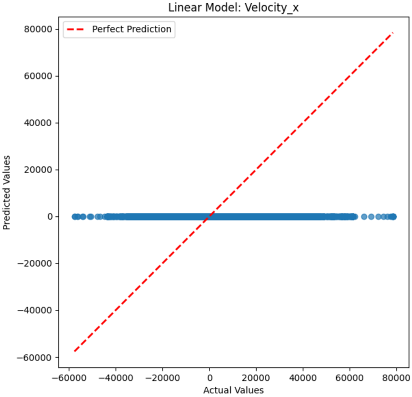
Acceleration Modification in the Y-axis



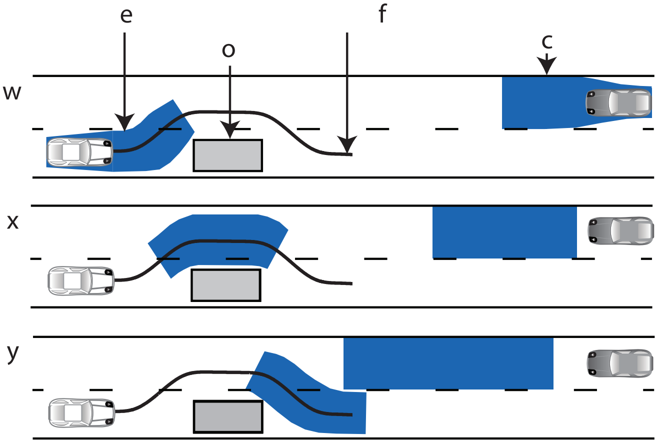
Acceleration Modification in the Y-axis



Acceleration Modification in the Y-axis



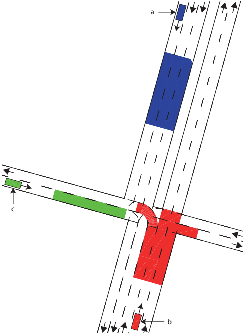
Motivation for Set-Based Prediction [1]



[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:

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

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

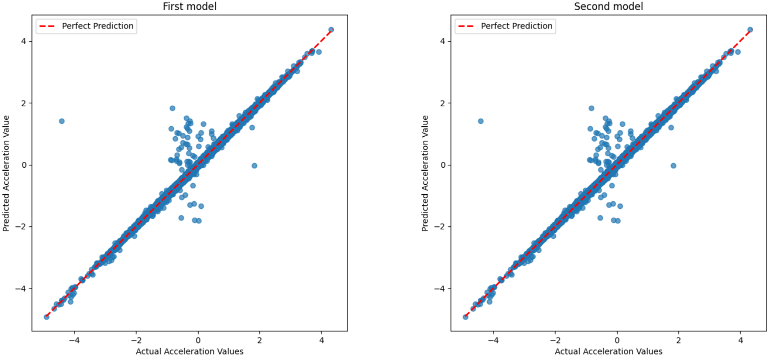
onslide¡2¿
Acceleration Equations:

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

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

endframe

Results: Integration Method



Results: Integration Method

Video demo of predicted car