Friedrich-Alexander-Universität
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Modeling of nonlinear systems with LSTMs

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Problem description

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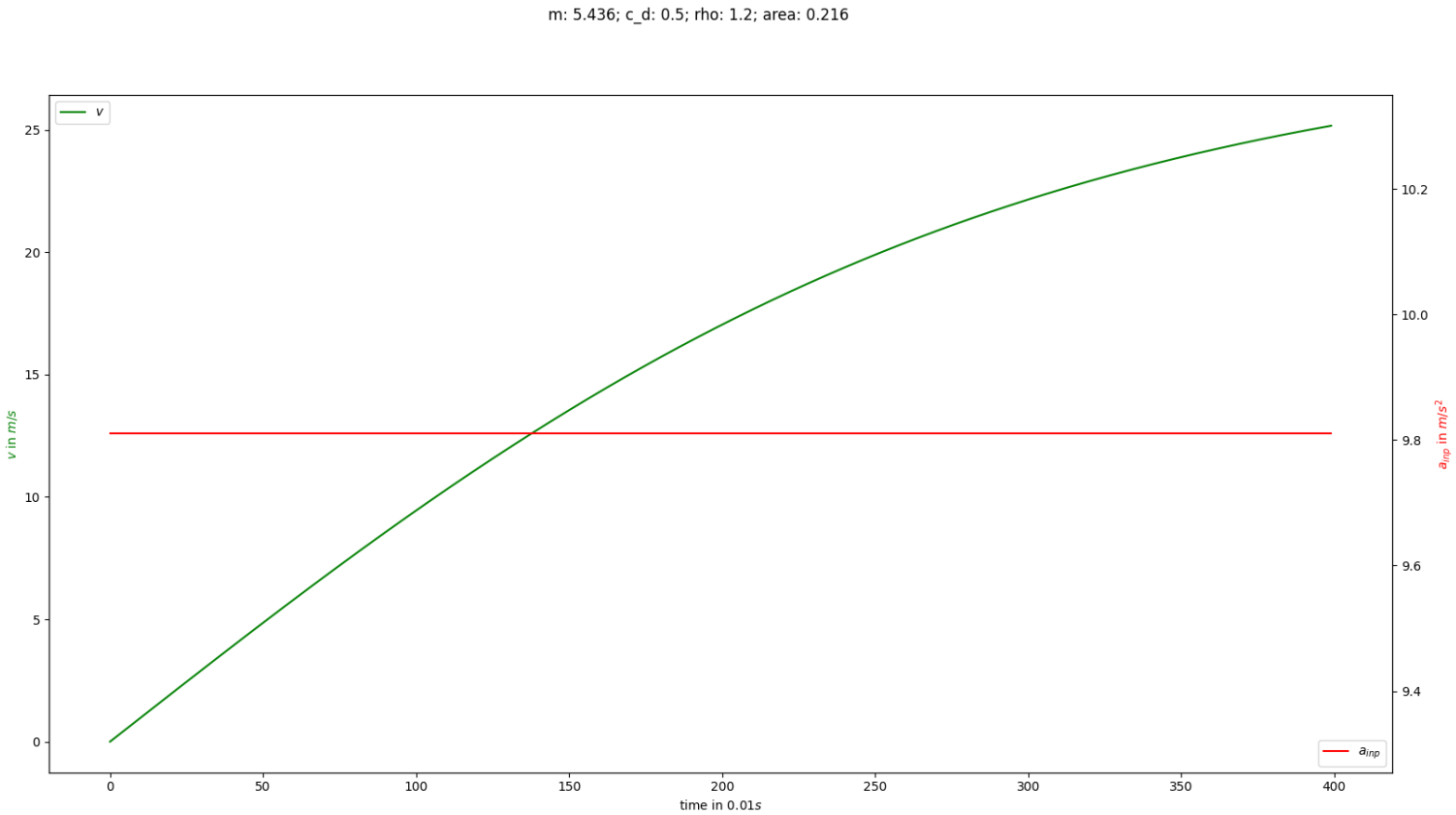
- Pushing force:
  - $F_p = ma$
- Air resistance (Drag):
  - $F_d = \frac{1}{2}\rho v^2 C_D A$
- Simplification:
  - $b = \frac{1}{2}\rho C_D A$
- Resulting force:
  - $F = F_p - F_d$

Problem description

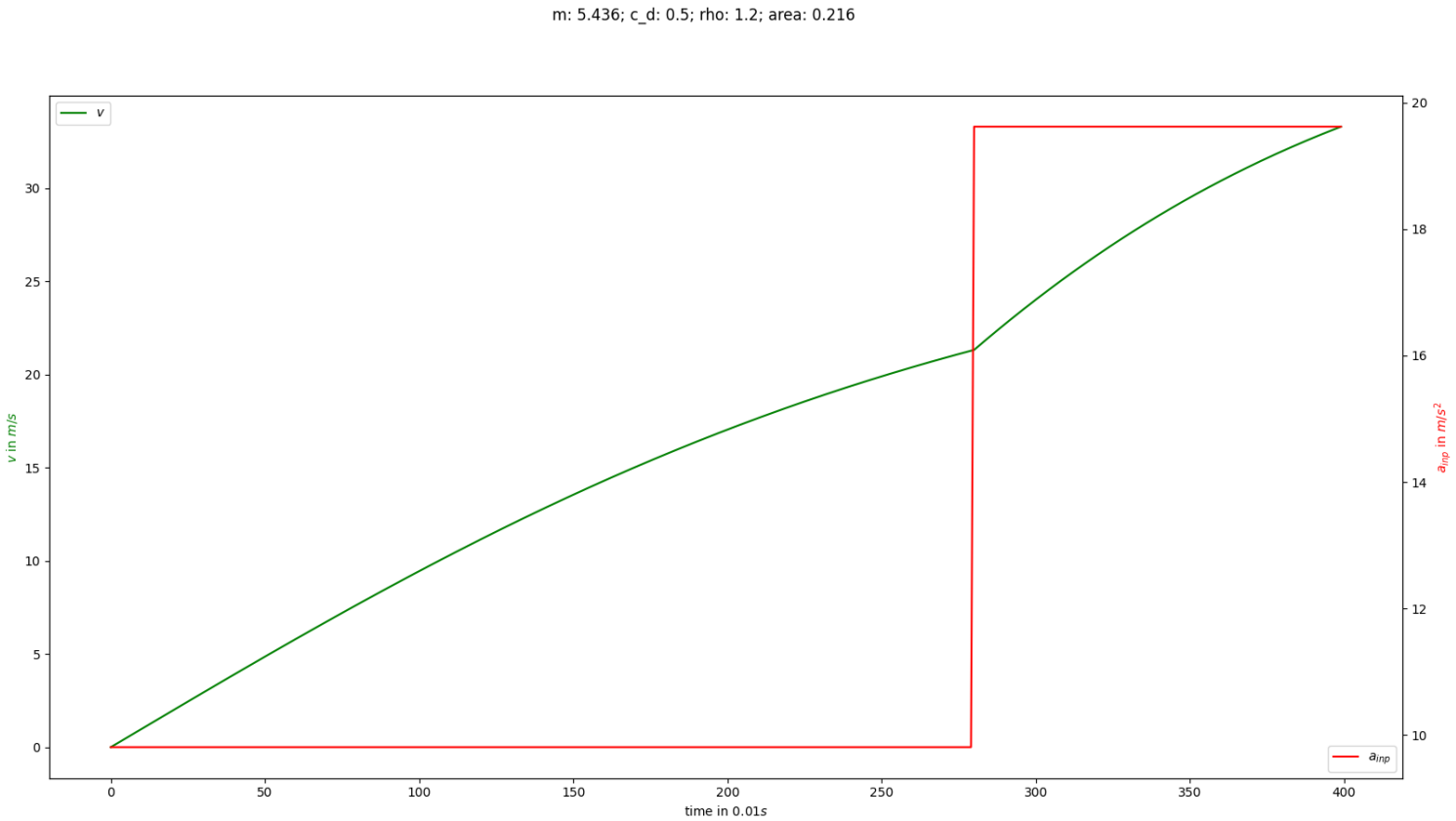
- Resulting force:
  - $F = F_p - F_d$
- Express as second order differential equation:
  - $m\frac{d^2x}{dt^2} = F_p - b\frac{dx}{dt}$
- Transform into system of two first order equations:
  - $\frac{dx}{dt} = v$
  - $\frac{dv}{dt} = \frac{F_p - bv^2}{m}$
  - → use in odeint python function to get values of velocity and/or position

Visualization

Visualization



Visualization



Prediction on Trainingset

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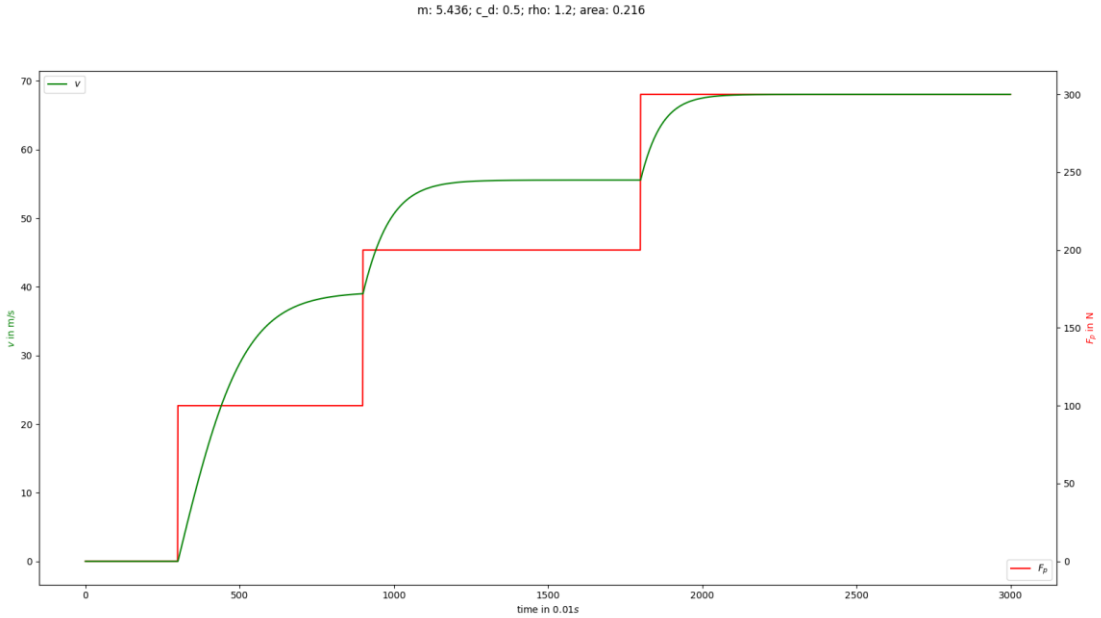
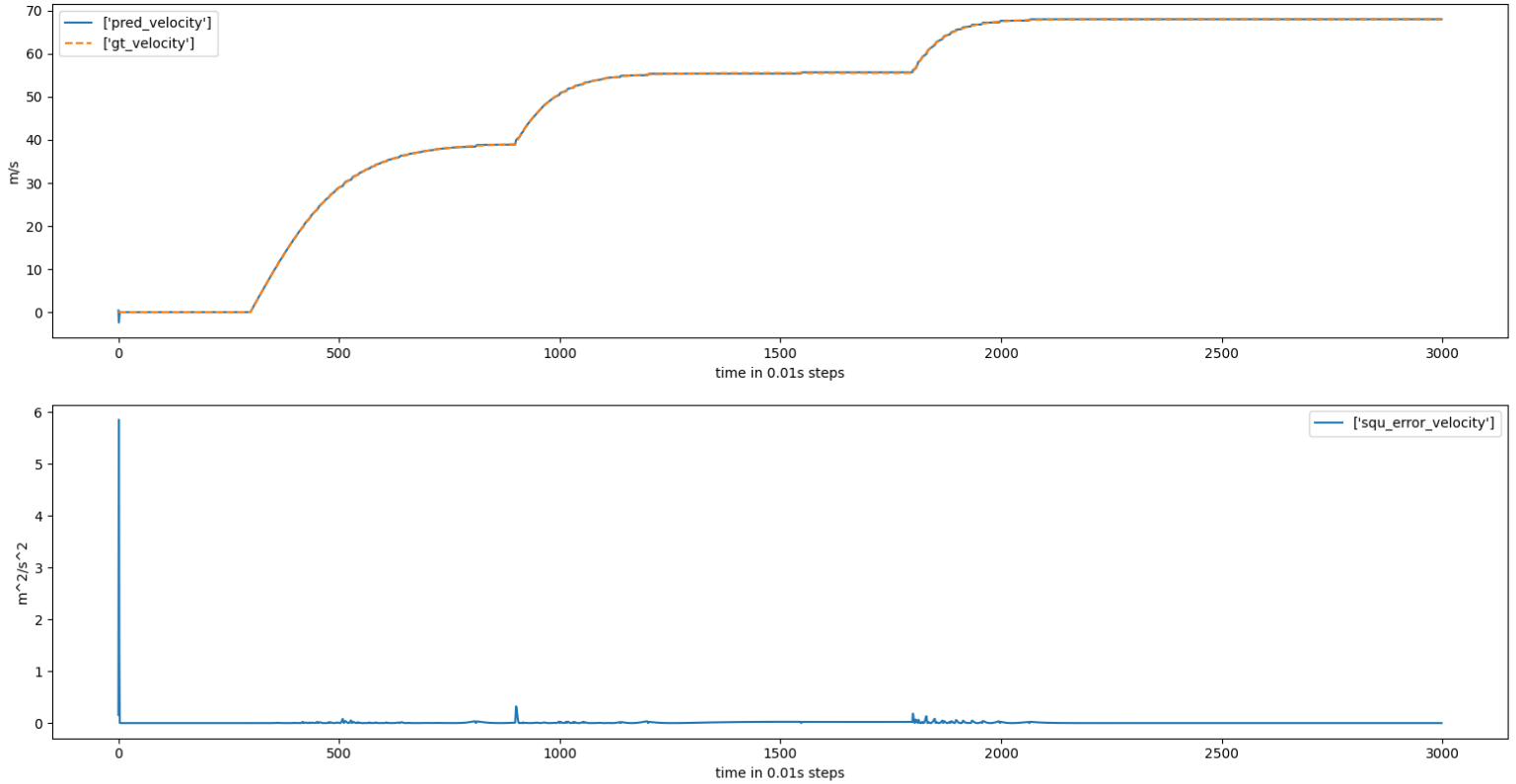
- Setup:
  - 1 Sample with 3 “Force steps”; So, Training, Validation and Test sets are the same in this case.



  - Try to make sure that is at least capable of learning the nonlinearities.
  - No normalization, yet.

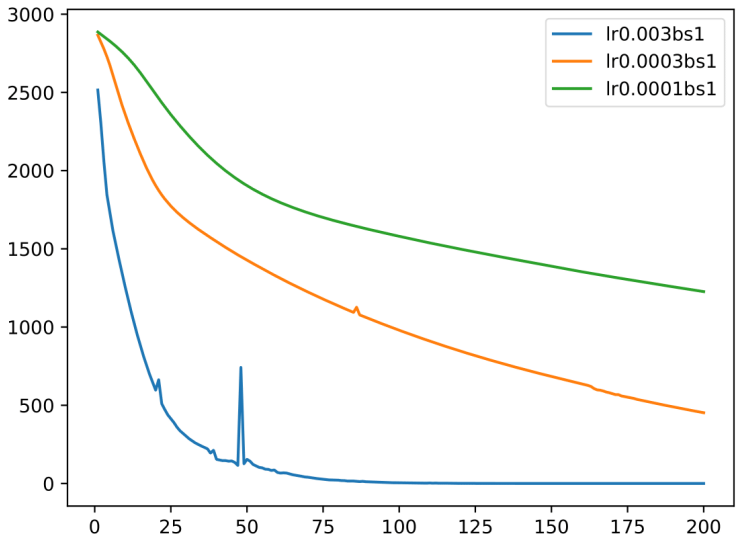
Prediction on Trainingset

- It learns. The prediction (pred) lies on the ground truth (gt) almost the entire time



Error?

- Why is there still a large error around the start of the sequence?
  - Maybe because it is difficult to learn that the starting condition is given at the first timestep, but not at the later ones. Shouldn’t be the issue in this case, as that input is 0 for the first 300 timesteps, so not different for the first.
  - Or longer training necessary; lower learning rates have not converged yet and might find lower minimum (could try reducing learning rate after certain number of epochs as well)



ToDo

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- Normalize! Probably doesn’t hurt.
- Evaluate on new data!
  - Need more similar data samples, variety of steps.
  - Train again on **now multiple** different training samples
  - Evaluate on the training data again, to make sure it can learn one sample of the multiple training samples well.
  - Then evaluate on new data!

Vielen Dank
für Ihre Aufmerksamkeit!