(1)

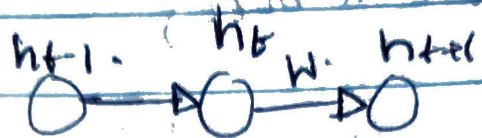
a) $V_2 = \begin{bmatrix} -0.165 & 0.245 & -0.059 \\ -0.196 & -0.032 & 0.209 \end{bmatrix}$

$S_2 = \cancel{\begin{bmatrix} 0.0106 & 0.0699 & .1099 \end{bmatrix}}$

$S_2 = \begin{bmatrix} 0.0106 & 0.070 & 0.110 \\ 0.141 & 0.170 & 0.021 \end{bmatrix}$

$W_2 = \begin{bmatrix} -0.182 & 0.308 & 0.674 \\ 0.502 & -0.858 & -0.934 \end{bmatrix}$

(2) a)



$$\frac{\partial L}{\partial h_t} = \frac{\partial L}{\partial h_{t+1}} \times \frac{\partial h_{t+1}}{\partial h_t}$$

~~$h_{t+1} = act(z_t) \times W$~~

$$h_{t+1} = act(\underbrace{z_t W}_{z_t \text{ as per question}})$$

$$\frac{\partial h_{t+1}}{\partial h_t} = \sigma'(z_t) W^T$$

$$\boxed{\nabla h_t = \nabla h_{t+1} \times \sigma'(z_t) \times W^T}$$

Dimension che

$h_t = 64$

$W = 64 \times 64$

$(64 \times 3) \, 2 \times$

1×64

(64×1)

64×32

$(32 \times) \, 32 \times 64$

b) $\sigma'(0) = 1/4$

$\nabla h_t = \nabla h_{t+1} \times 1/4 \times w$.

if $\boxed{w > 4}$ $\nabla h_t > 1$, so gradients will explode.

if $\boxed{w < 4,}$ $\nabla h_t < 1$, so the gradu will vanish.

$$\boxed{\alpha = 4}$$

$\boxed{\text{False}}$

3 a) $h_t = o_t \odot \tanh(c_t)$

$o_t = \sigma(W_o x_t + U_o h_{t-1} + b_o)$

$x_t = 0$

$= \sigma[U_o h_{t-1} + b_o)$

$c_t = f_t \odot c_{t-1} + i_t \odot \tilde{c}_t$ — (3)

$f_t = \sigma \times [U_f \cdot h_{t-1} + b_f]$ $x_t = 0$ — (1)

$i_t = \sigma[U_i h_{t-1} + b_i]$, $x_t = 0$ — (2)

$\tilde{c}_t = \tanh(W_c h_{t-1} + b_c)$ — (4)

Putting (1), (2), (4) in (3)

$c_t = \sigma[U_f \cdot h_{t-1} + b_f] \otimes c_{t-1} + \sigma[U_i h_{t-1} + b_i] \odot \tanh[U_c h_{t-1} + b_c]$

$h_t = \sigma[U_o h_{t-1} + b_o] \odot \{\sigma[U_f \cdot h_{t-1} + b_f] \odot c_{t-1} + \sigma[U_i h_{t-1} + b_i] \odot \tanh[U_c h_{t-1} + b_c]\}$

so $h_t \neq h_{t-1}$,

Qualitatively due to input zero also, network may decide to forget something from long term memory as even input to the long term Memory

$\boxed{\text{True}}$

3) b) By equation, the propagation of gradient

$$\frac{\partial h_t}{\partial h_{t-1}} = \frac{\partial h_t}{\partial o_t} \times \frac{\partial o_t}{\partial h_{t-1}} + \frac{\partial h_t}{\partial c_t} \times \frac{\partial c_t}{\partial F_t} \times \frac{\partial F_t}{\partial h_{t-1}}$$

$$+ \dots$$

$$\frac{\partial c_t}{\partial c_{t-1}} = F_t$$

~~So~~ In the long term part of the LSTM, cell $\partial c_t / \partial c_{t-1}$ becomes smaller when F_t is small.

By the concept of forget gate, if the previous input is to forgotten $F(t)$ should be small, so error does not affect previous states.

$\boxed{\text{True}}$

c) i_t, F_t = output of sigmoid $[0 \le \text{sigmoid} \le 1]$ so non-negative. for o_t, output gate also sigmoid ~~out~~ output. Sigmoid bounded between 0,1 so non-negative output

d) $\boxed{\text{False}}$

F_t, ~~it~~ i_t, o_t are independent of each other. F_t, i_t, o_t can be seen as individual probabilty of forgetting data, adding data and output data, but they do not sum to 1.

4.

$f_t = \sigma\left(W_f \cdot x_1 + U_f \cdot h_0 + b_f\right)$

dimension $= 1\times 1$

$i_t = \sigma\left[W_i x_1 + U_i h_0 + b_i\right]$

dimension $= 1\times 1$

$o_t = \sigma\left[W_o \times x_1 + U_o h_0 + b_o\right]$

dimension $= 1\times 1$

$\tilde{c}_t = 1\times 1$ dimension

$h_t = 1\times 1$

a) All of f_t, i_t, o_t, h_t are 1×1 dimension or a scalar

b) From python

$\boxed{h_1 = 0.2174}$

$\boxed{h_2 = [-0.18988]}$

c) MSE Loss:

$= \left[(0.5 - 0.2174)^2 + (0.8 + 0.18988)^2\right]$

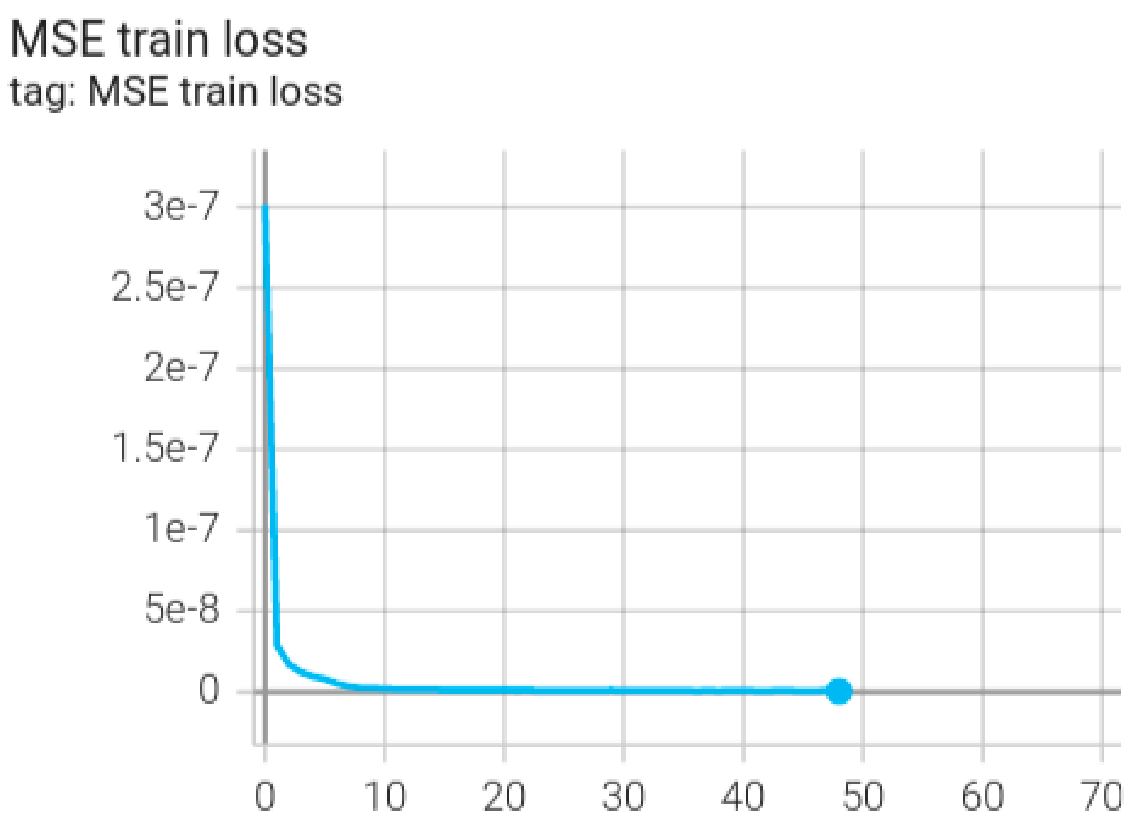
$\Rightarrow 1.0597$

Programming Exercises

Problem 1

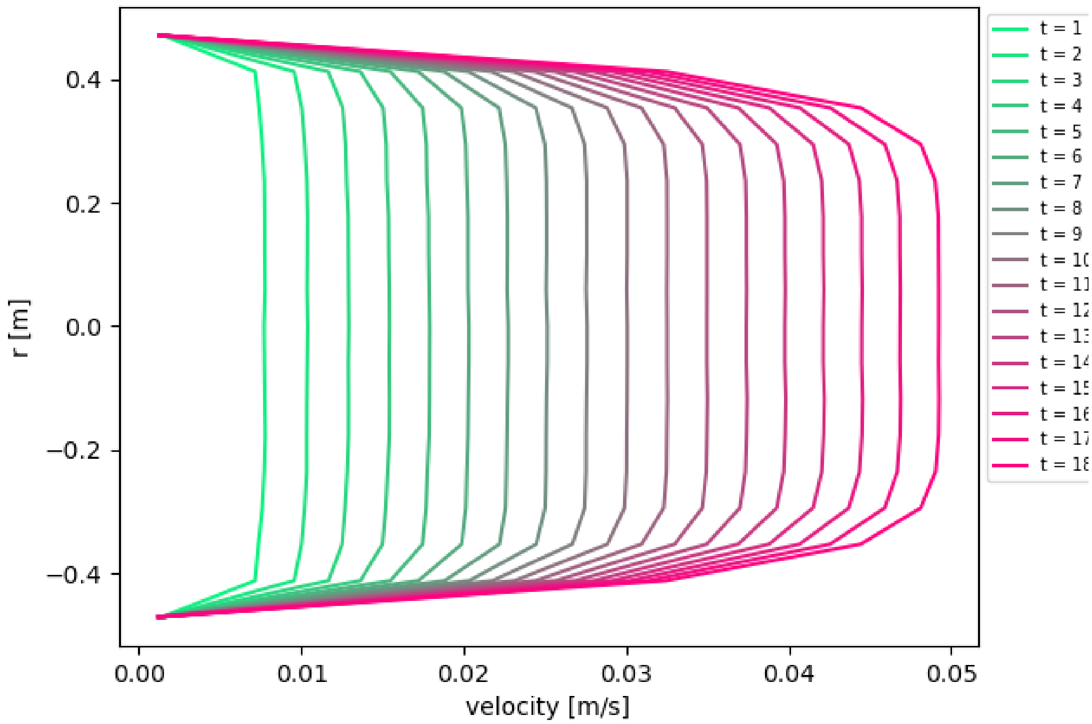
Network structure:

- Three lstm layers, of the following features
  - 1st lstm, Input size 17, hidden size 128
  - 2nd lstm, Input size 128, hidden size 256
  - 3rd lstm, Input size 256, hidden size 512
- One MLP of the following feature
  - Input size 512, output size 17
- Number of trainable parameters: 83985
- Number of iterations: 50
- Learning rate = 0.001
- Optimizer: Adam
- Train loss criterion: MSELoss
- Train loss vs batch number
- Batch size: 256
- Scheduler: Step LR with 0.1 gamma, and 25 epochs step size
  - Train MSELoss vs epoch

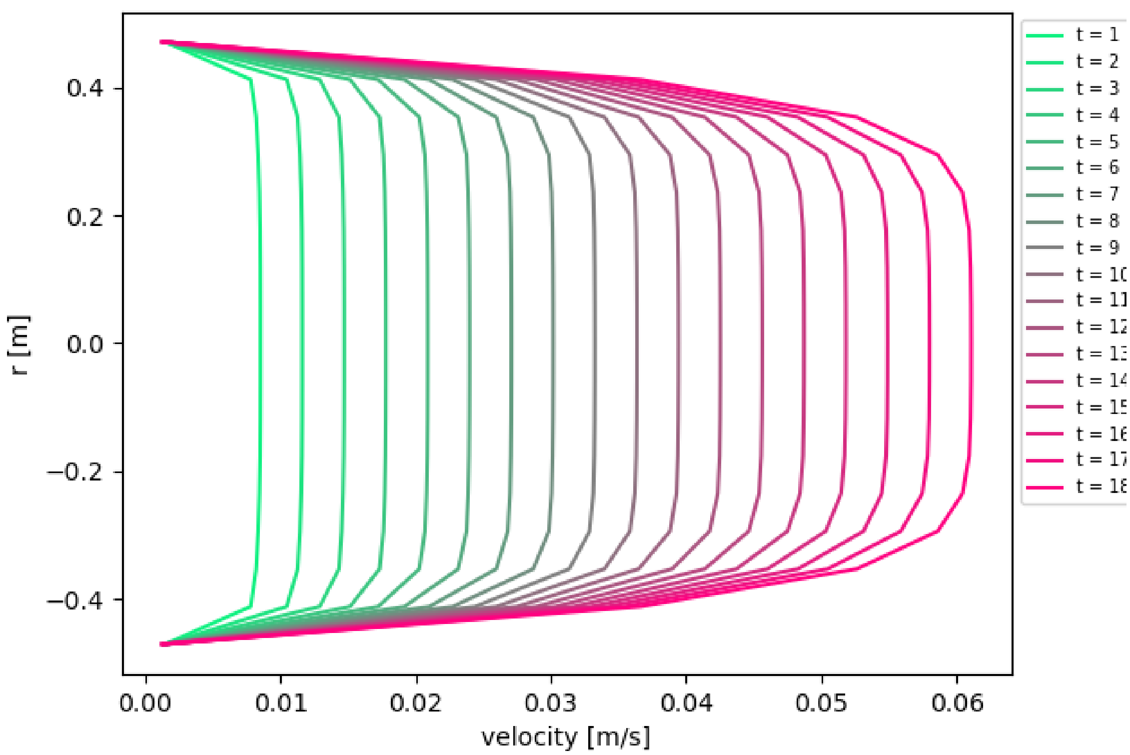


  - Final test MSELoss:**0.00028252945048734546**
  - Final test L1Loss: **0.06915978819597512**

Results diagram



Prediction



Ground truth