Trajectory estimation and step detection

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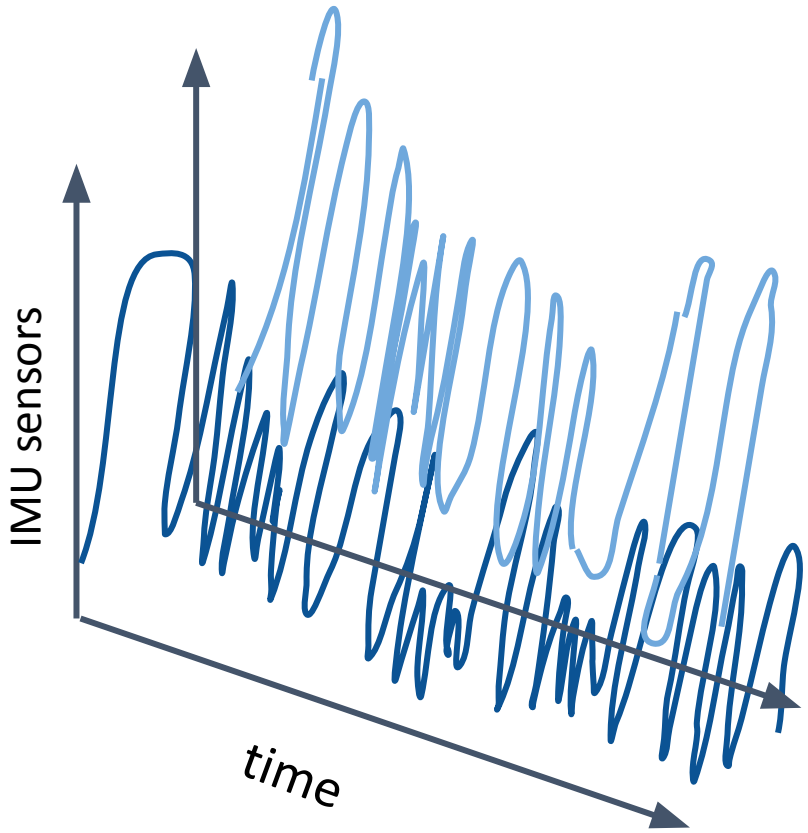
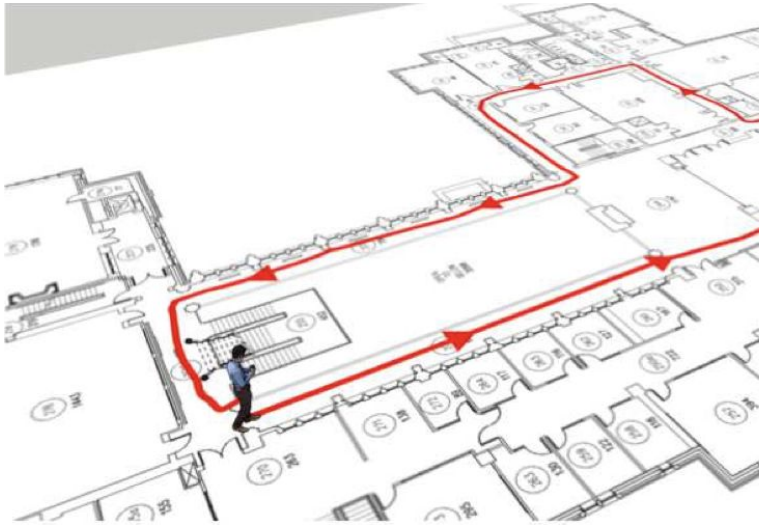
Plan

- Problem statement
- Motivation
- Improvement baseline
  - Step detection
  - Instance velocity
  - Attention method
- Result
- Future work

Problem statement

Task: to estimate the trajectory, detect steps, count number of steps





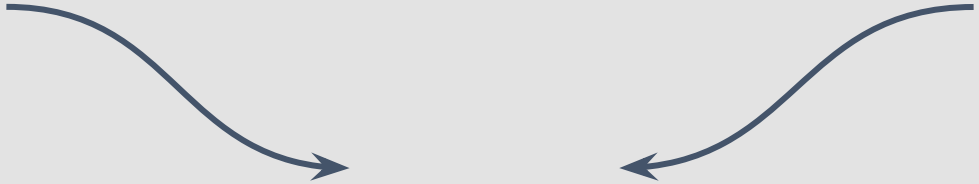
Motivation

Indoor trajectory estimation

- disadvantage of GPS navigation
  - requires open space
  - depends on landscape

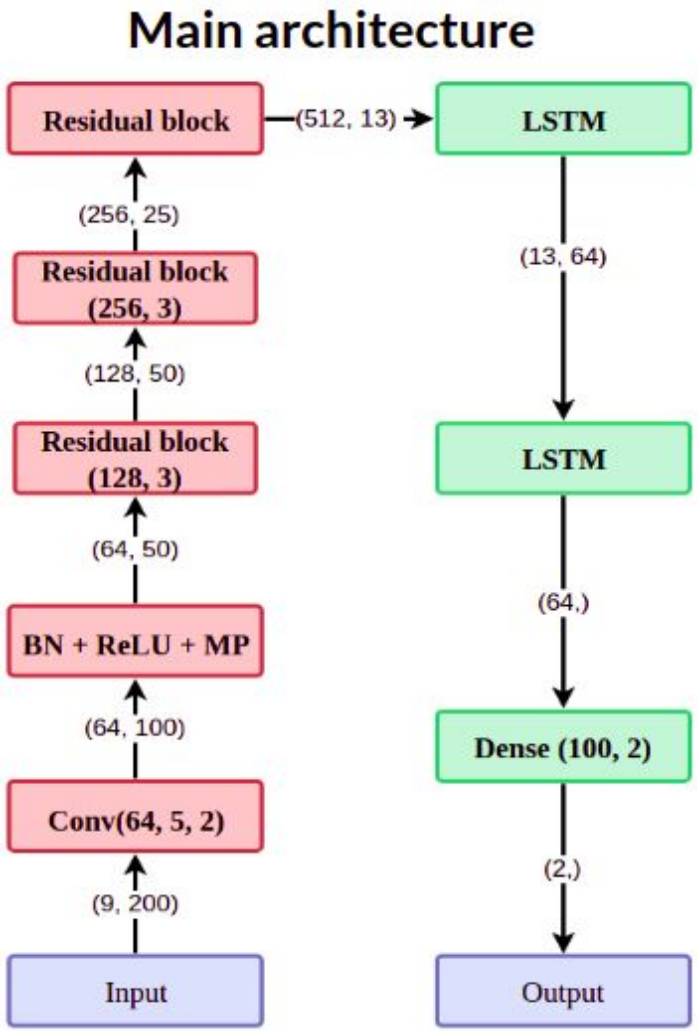
Step detection

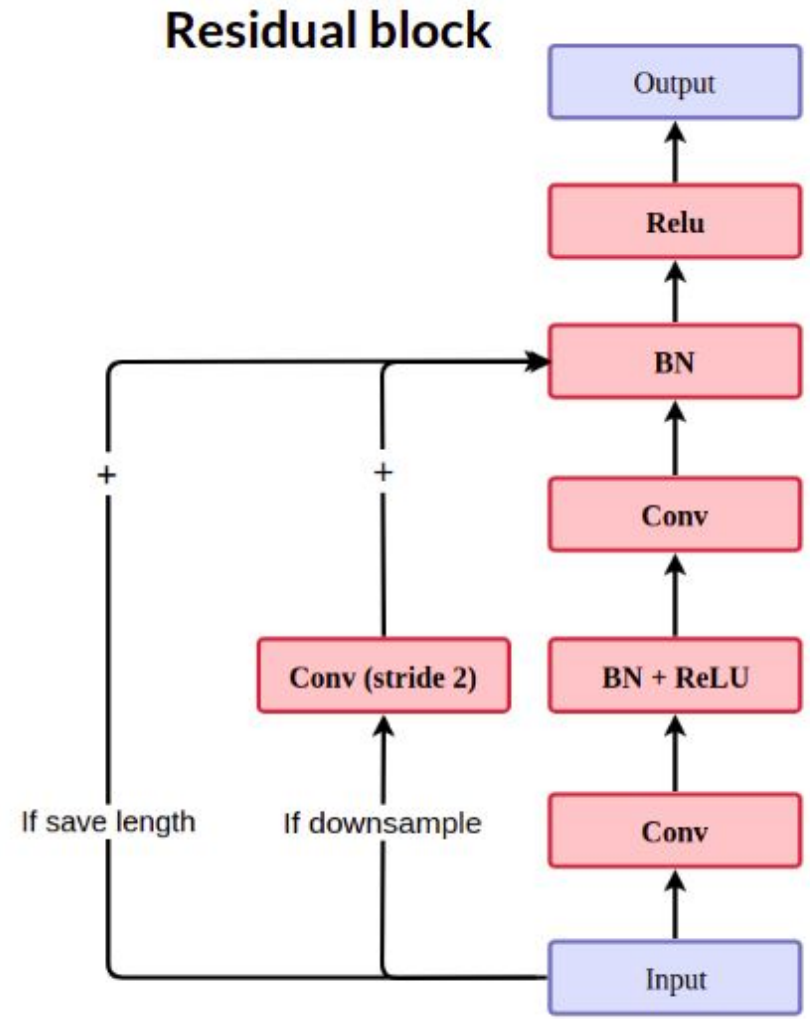
- different type of shows
- people with disabilities
- simple mechanism can’t catch details



combine tasks

baseline model





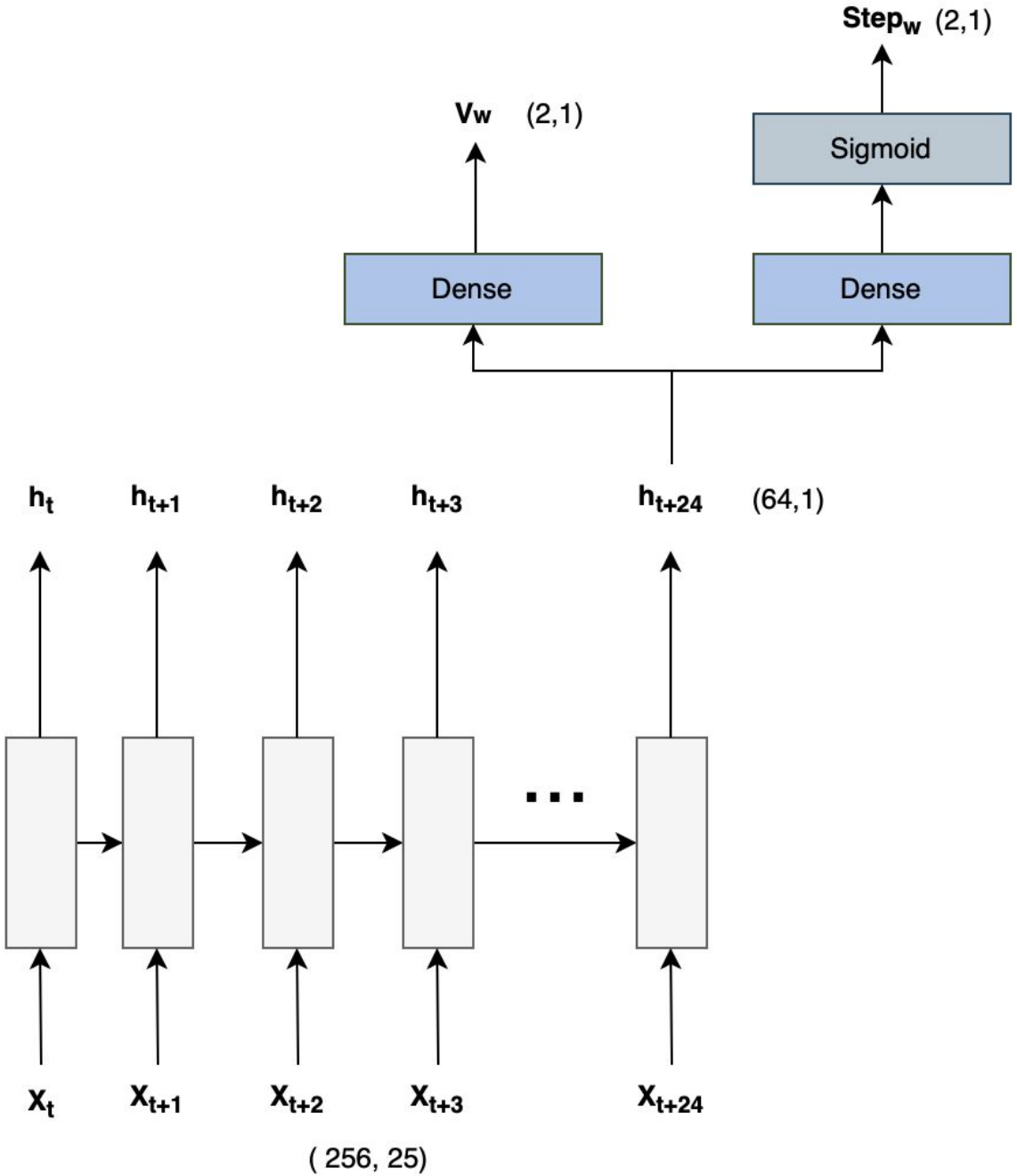
BN - Batch Normalization
MP - Max Pooling

Residual block (A, B)

A - channels number
B - kernel size

(X, Y)

X - channels number
Y - Sequence length



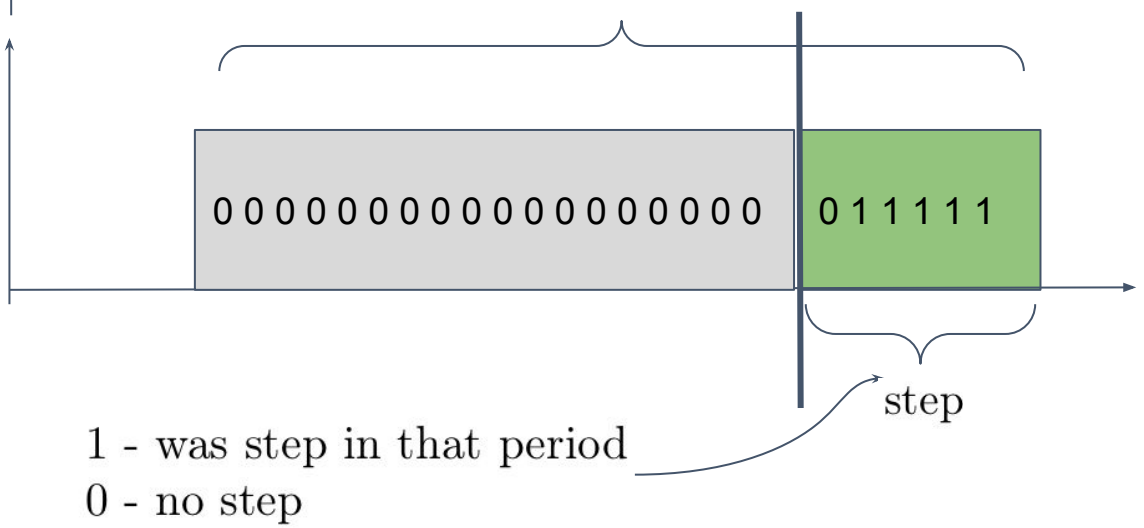
$$\mathcal{L}_w(\mathbf{y}_{true}, \mathbf{y}_{predict}) =$$

$$MSE(\mathbf{v}_{true}, \mathbf{v}_{predict}) + BCE(\mathbf{s}_{true}, \mathbf{s}_{predict}) =$$

$$\|\mathbf{v}_{true} - \mathbf{v}_{predict}\|_2^2 - w(p_{right}(\log s_{right}) + p_{left}(\log s_{left}))$$

$$y = \begin{pmatrix} v_x \\ v_y \\ s_r \\ s_l \end{pmatrix}$$

$w-$ weight for step loss.



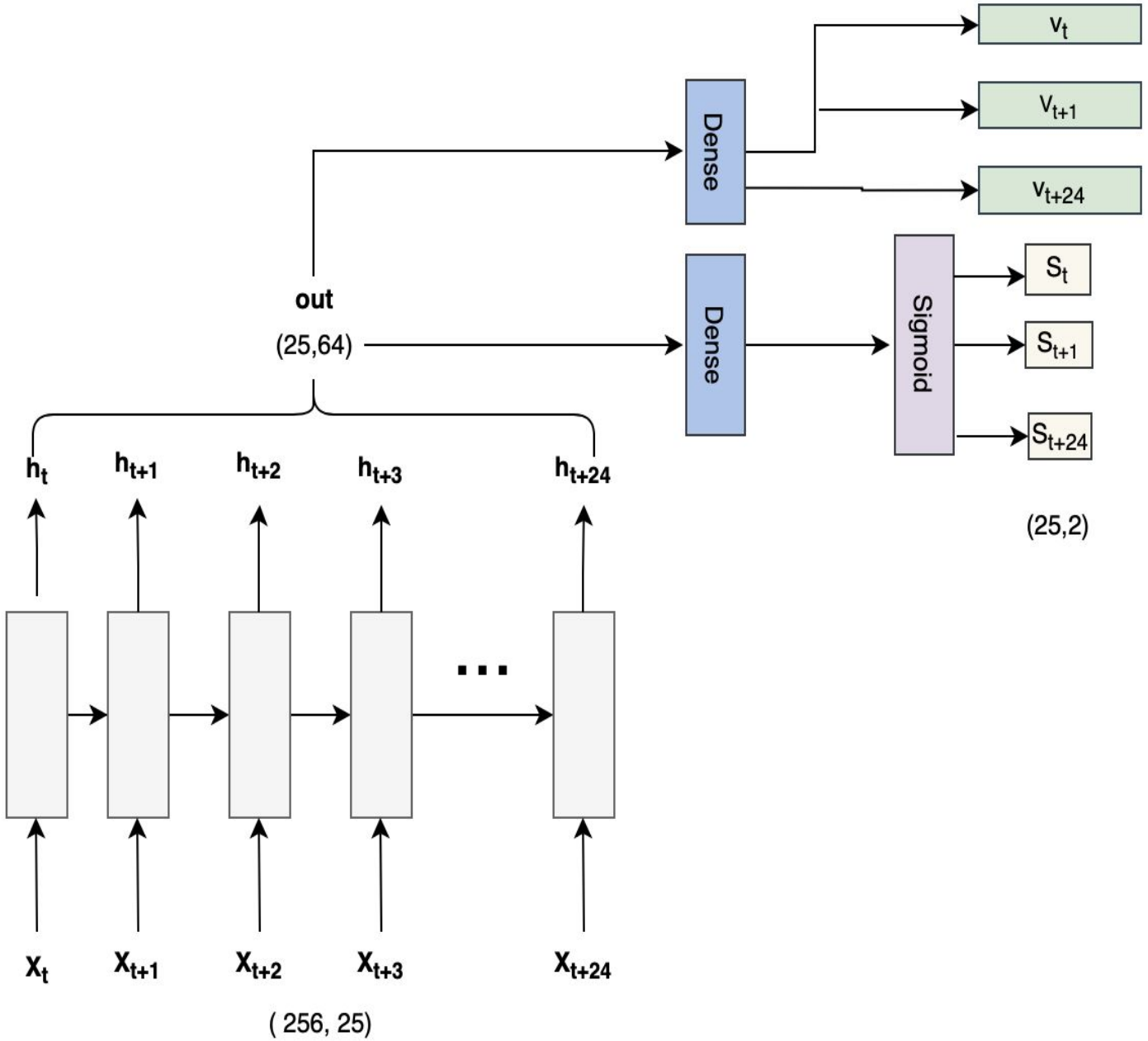
1 - was step in that period
0 - no step

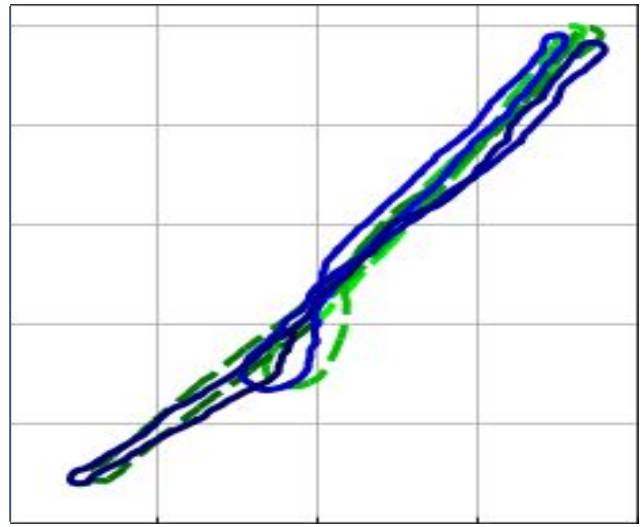
ResNetLSTM+step detection results

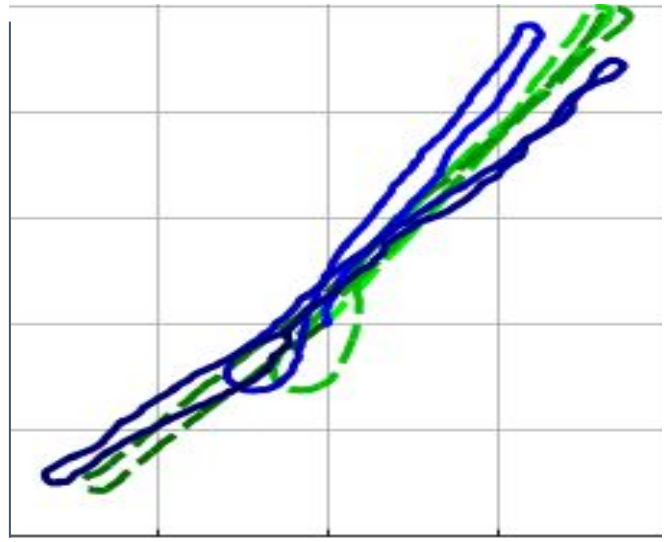
Model	GAP	MIE	RMSE	RTE		
	$\mathcal{G}_{\mathbf{tr}}$	$\mathcal{D}_{\mathbf{tr}}$	$\mathcal{L}_{\mathbf{tr}}$	$\mathcal{R}_{\mathbf{tr},\, w=10}$	$\mathcal{R}_{\mathbf{tr},\, w=30}$	$\mathcal{R}_{\mathbf{tr},\, w=60}$
RL	**11.69**	6.57	8.03	6.56	6.83	7.26
RL_step_bce_0.01	13.52	**5.72**	**7.56**	**5.96**	**6.26**	**6.75**
RL_step_bce_0.1	14.13	6.17	8.10	6.38	6.70	7.18
RL_step_mse_0.01	13.08	6.27	8.01	6.42	6.23	7.15

Model	PRECISION		RECALL		F1	
	Right	*Left*	*Right*	*Left*	*Right*	*Left*
RL_step_bce_0.01	0.60	0.63	0.55	0.60	0.60	0.60
RL_step_bce_0.1	0.67	0.68	0.65	0.64	0.66	0.65
RL_step_mse_0.01	0.65	0.67	0.64	0.63	0.64	0.64

Instant Velocity





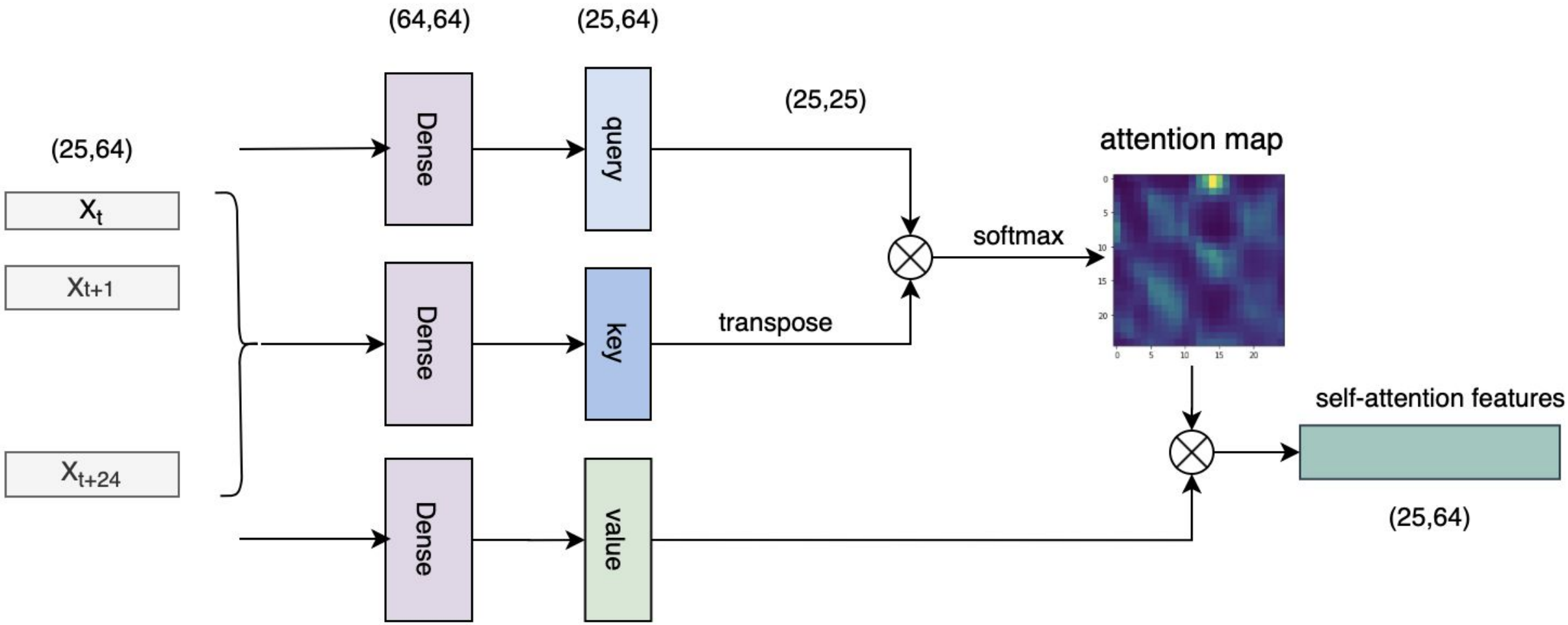


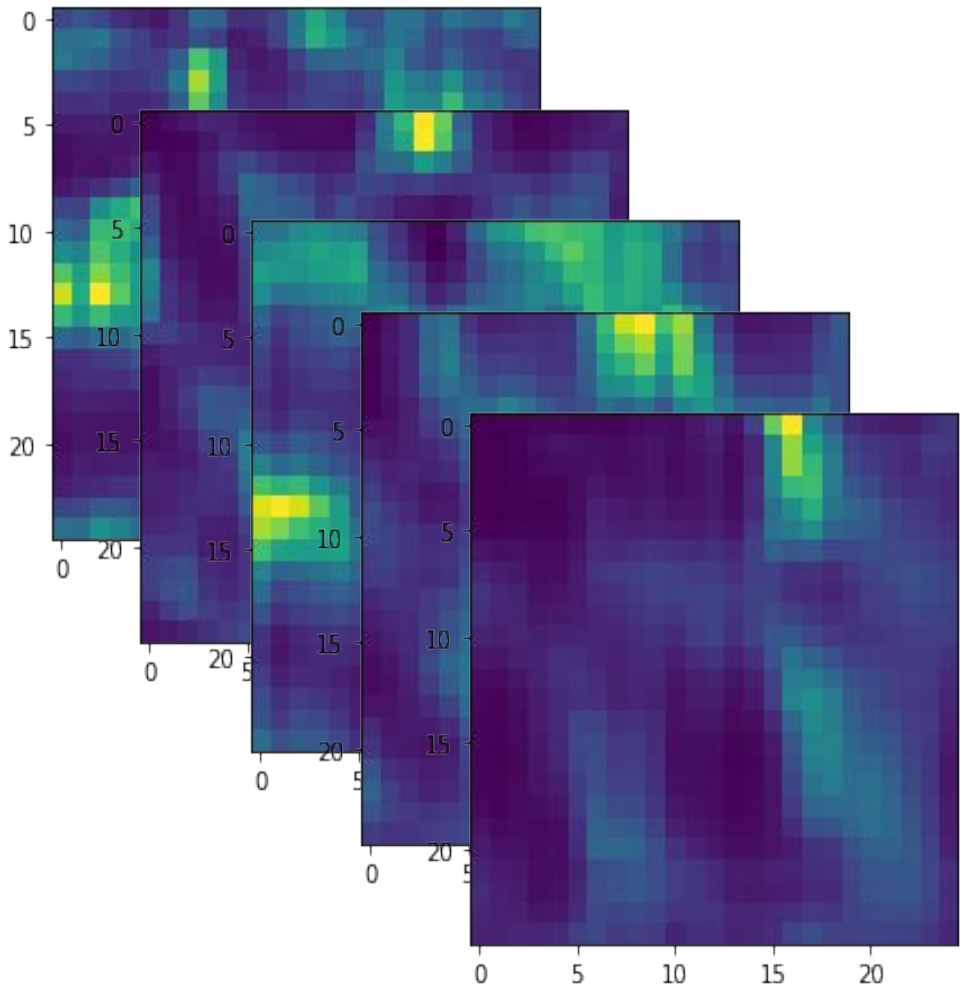
ResNetLSTM Instant velocity+step detection results

Model	GAP	MIE	RMSE	RTE		
	$\mathcal{G}_{\mathbf{tr}}$	$\mathcal{D}_{\mathbf{tr}}$	$\mathcal{L}_{\mathbf{tr}}$	$\mathcal{R}_{\mathbf{tr},\, w=10}$	$\mathcal{R}_{\mathbf{tr},\, w=30}$	$\mathcal{R}_{\mathbf{tr},\, w=60}$
RLI_step_bce_0.1	13.95	6.73	8.38	6.89	7.21	7.67
RLI_step_mse_0.005	12.85	5.98	7.79	6.18	6.47	6.91
RLI_step_mse_0.01	12.97	6.21	7.99	6.36	6.66	7.09

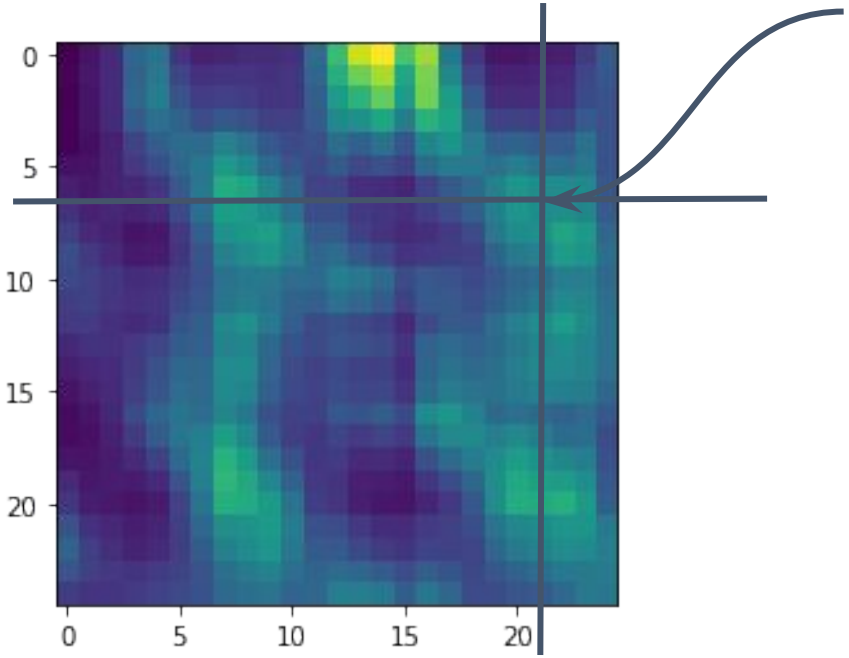
Model	PRECISION	RECALL	F1	AVERAGE RELATIVE ERROR
RLI_step_bce_0.1	**0.89**	**0.81**	**0.84**	**0.20**
RLI_step_mse_0.005	0.80	0.68	0.74	0.27
RLI_step_mse_0.01	0.81	0.73	0.77	0.25

Attention


(64,64)
(25,64)
(25,64)
Dense
query
(25,25)
attention map
softmax
Xt
Xt+1
Xt+24
Dense
key
transpose
Dense
value
self-attention features
(25,64)

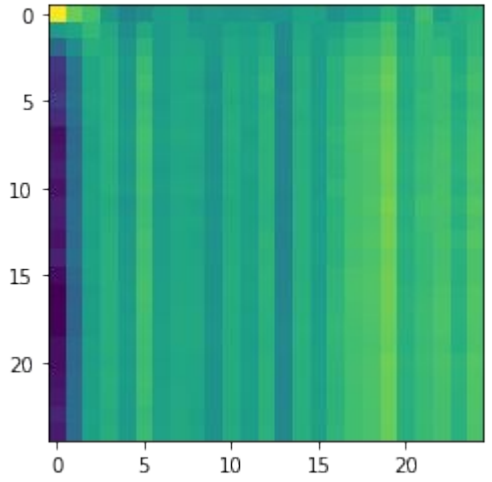


middle of trajectory

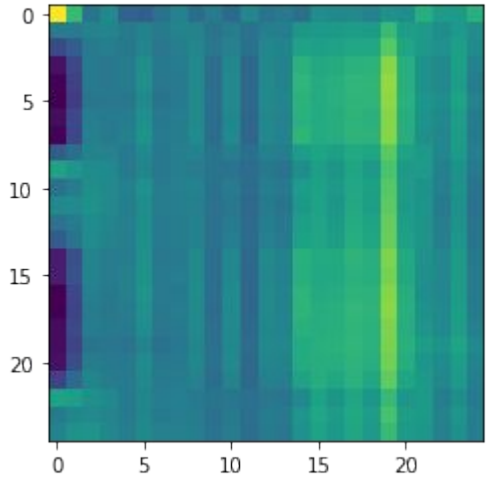


the importance of j at moment i

start



end



Attention results

Model	GAP	MIE	RMSE	RTE		
	$\mathcal{G}_{\mathbf{tr}}$	$\mathcal{D}_{\mathbf{tr}}$	$\mathcal{L}_{\mathbf{tr}}$	$\mathcal{R}_{\mathbf{tr},\, w=10}$	$\mathcal{R}_{\mathbf{tr},\, w=30}$	$\mathcal{R}_{\mathbf{tr},\, w=60}$
RLIA_step_bce_0.1	13.97	6.09	8.07	6.34	6.64	7.14
RLIA_step_mse_0.01	13.46	5.85	7.75	6.10	6.40	6.88

Model	PRECISION	RECALL	F1	AVERAGE RELATIVE ERROR
RLIA_step_bce_0.01	0.87	0.77	0.81	0.21
RLIA_step_mse_0.01	0.82	0.74	0.78	0.24

Thank you for your attention!