Learning-based multi-modal indoor localization

Final Presentation

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Master Semester Project

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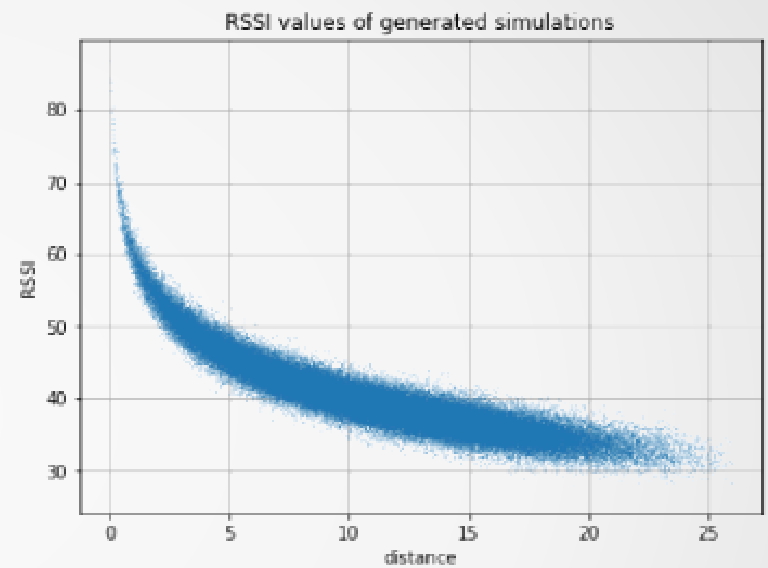
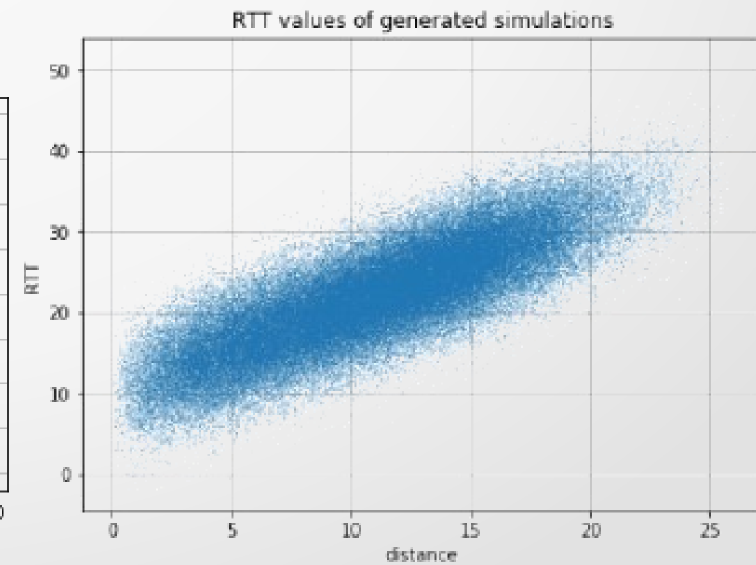
Indoor localization

Goal: predict user’s indoor position using commonly available signals : WiFi, Bluetooth

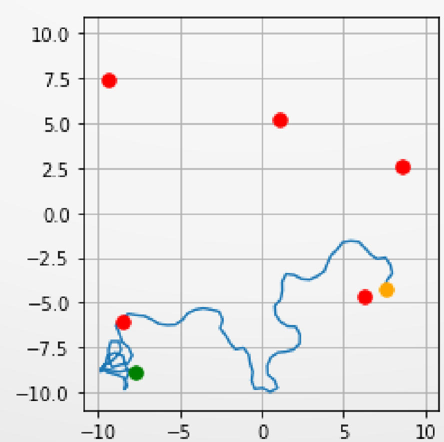
Challenges:

- Handle noisy and non-linear signals
- Capture complex dependencies

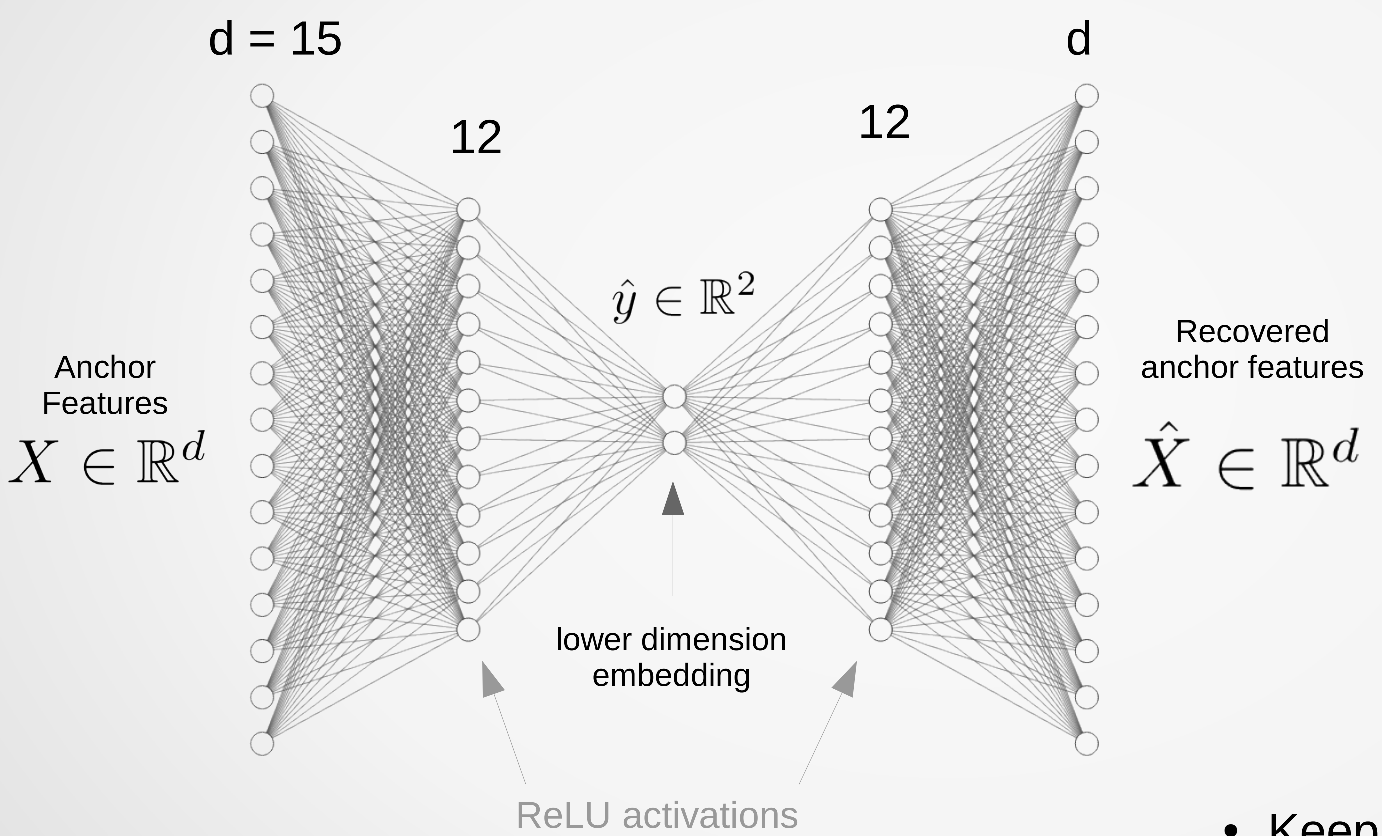




How: neural networks



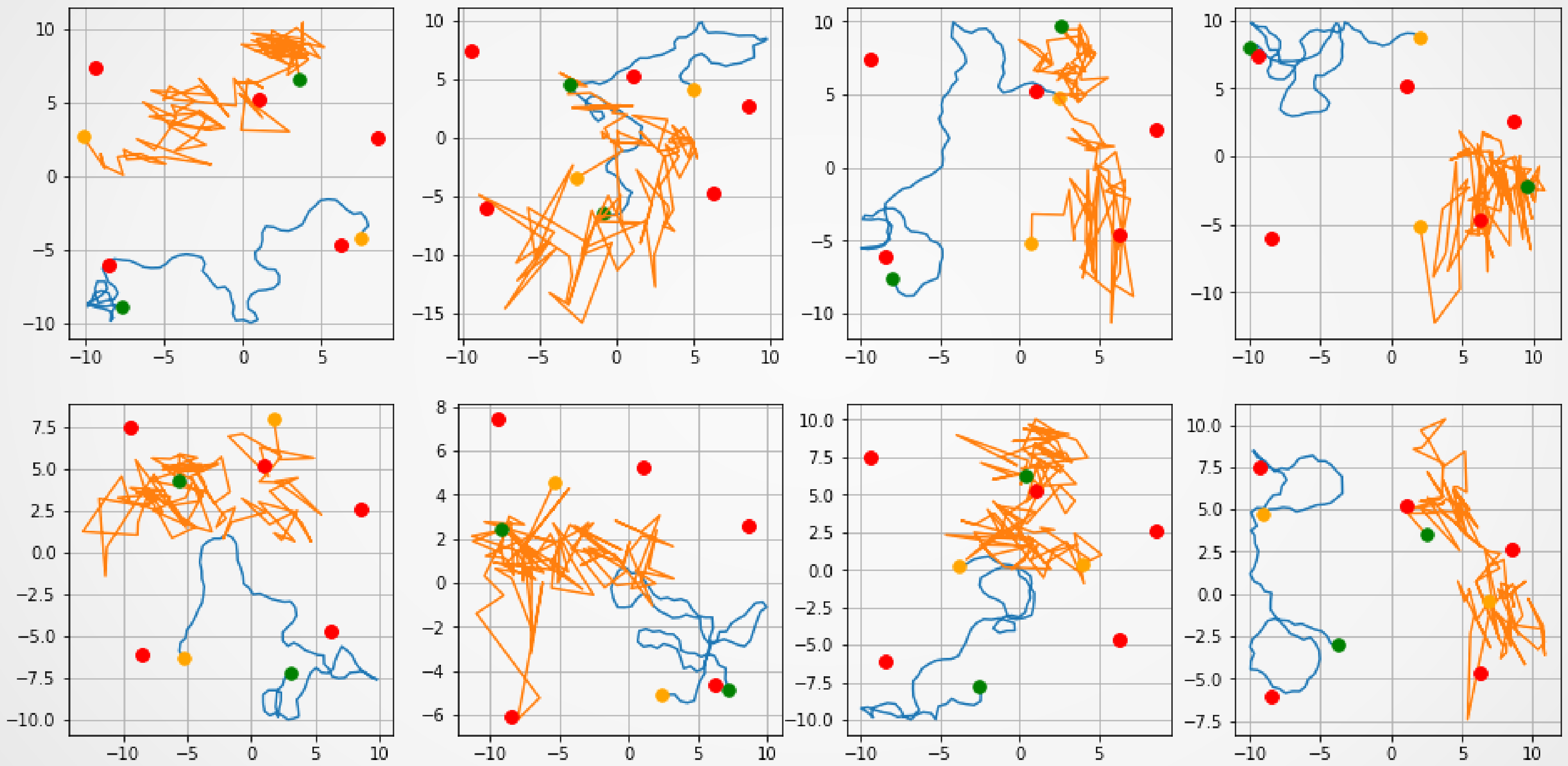
Candidate architecture : Autoencoder



- Keep best components
- Suppress noise
- Unsupervised

minimize $$w_r \frac{1}{d} \left\| X - \hat{X} \right\|_2^2$$

2D embeddings



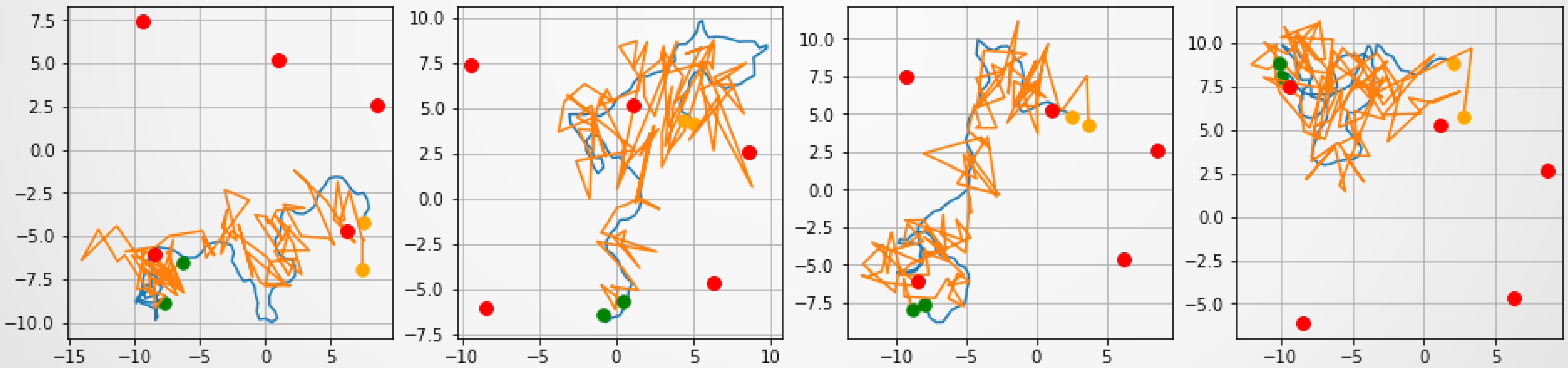
- Misalignment
- Noisy embeddings

The Autoencoder is free to choose its 2D representation

Adding constraints: Align the prediction shape

Correct the simulation shape
with some known positions

minimize $w_{\mathrm{fp}} \frac{1}{2} \|y - \hat{y}\|_2^2$



The general shape matches but it is still as noisy

Adding constraints: Smoothing the prediction (1)

Add a smoothing regularizer : first order finite differences

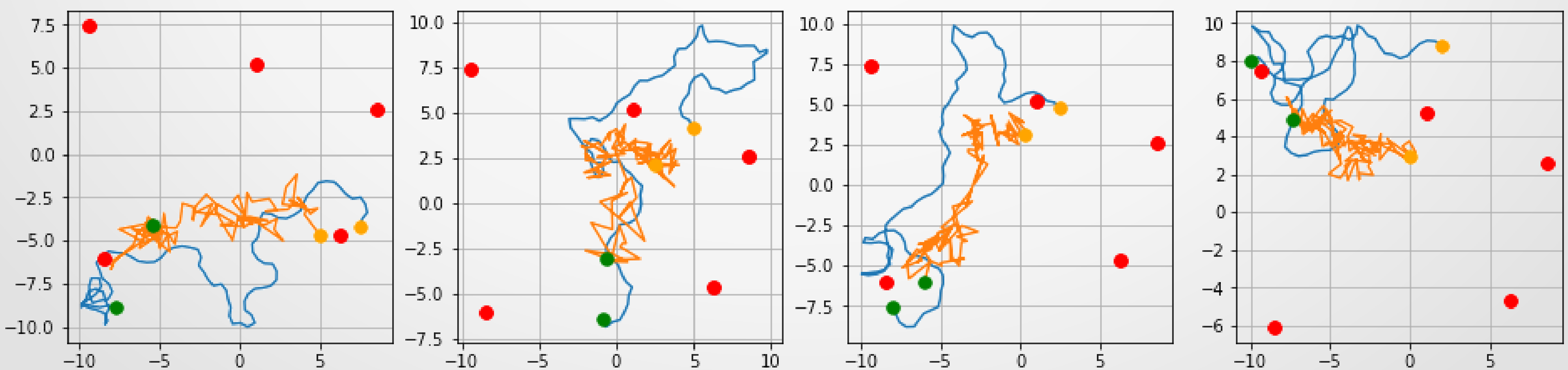
$$\mathbf{y} \in \mathbb{R}^{n \times 2}$$

$$D\mathbf{y} = \begin{bmatrix} -1 & 1 & & & \\ & -1 & 1 & & \\ & & \ddots & \ddots & \\ & & & -1 & 1 \end{bmatrix} \begin{bmatrix} y_1 \\ y_2 \\ \vdots \\ y_n \end{bmatrix} = \begin{bmatrix} y_2 - y_1 \\ y_3 - y_2 \\ \vdots \\ y_n - y_{n-1} \end{bmatrix}$$

minimize

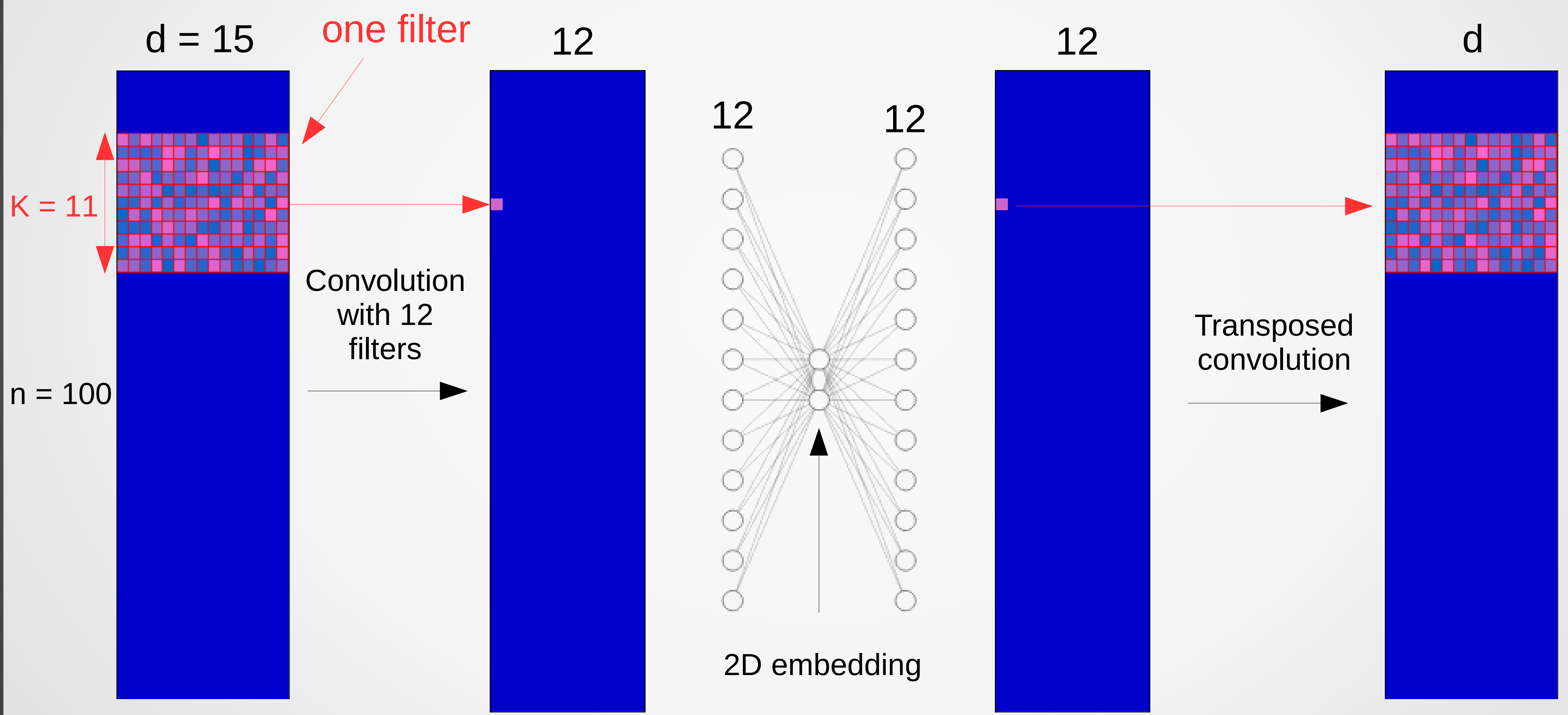
$$w_{\text{fofd}} \frac{1}{2(n-1)} \| D\mathbf{y} - D\hat{\mathbf{y}} \|_2^2$$

Corresponds to the direction that the path following



The predictions are not smoothed. The shape is just smaller

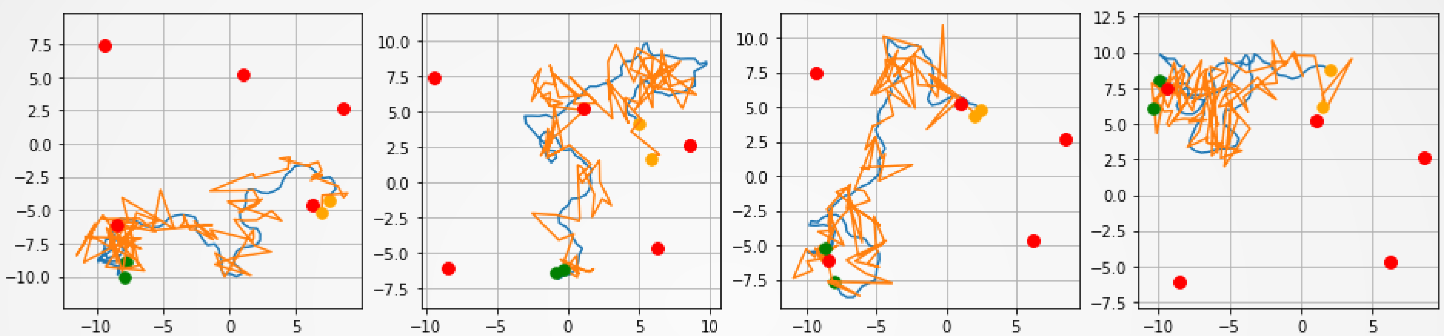
Autoencoder with convolution



Uses the neighbouring values to produce a new feature

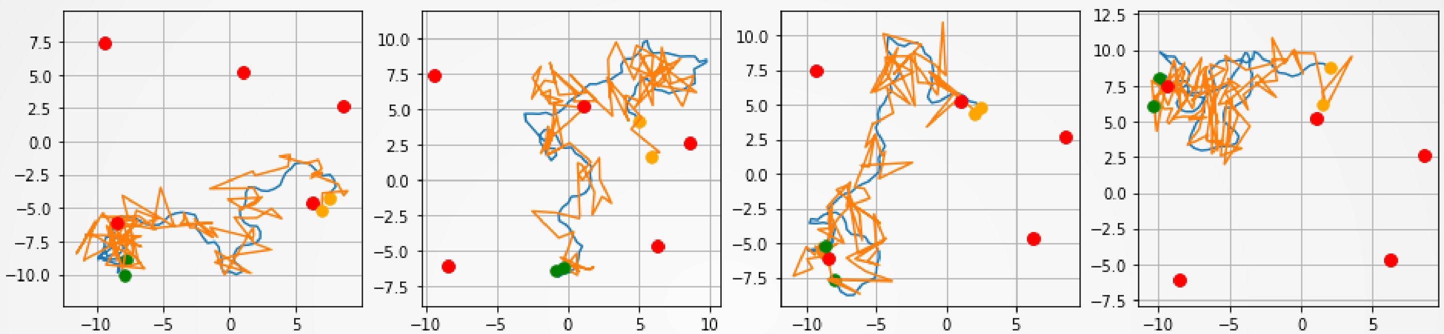
Autoencoder with convolution (results)

Convolution autoencoder with shape alignment

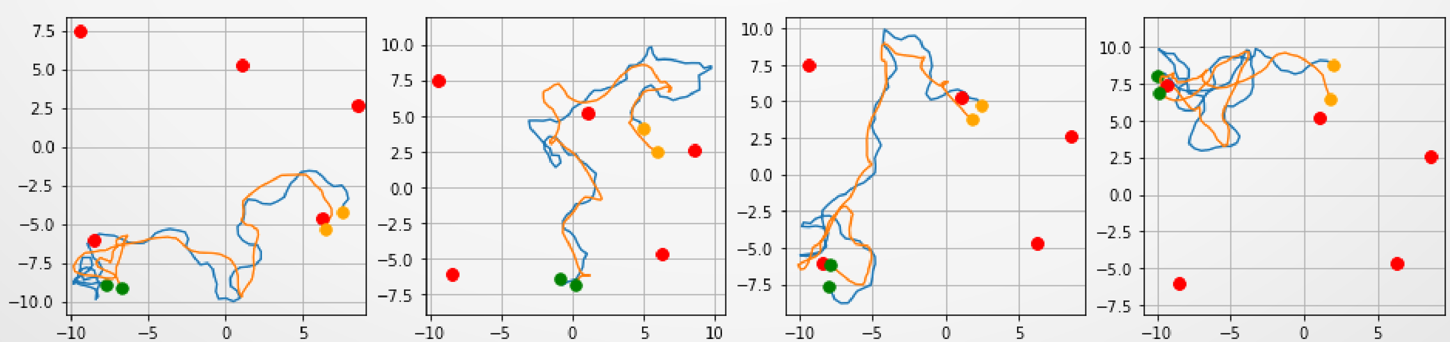


Autoencoder with convolution (results)

Convolution autoencoder with shape alignment



… and with the smoothing constraint



Conclusion

Indoor localization with autoencoder and constraints

- Path alignment with some known points
- Smooth predictions with the smoothing constraint and the convolution layer

Future directions

- Experiment on real data
- Further feature disentanglement using calibration data
- Explore other neural network architectures
  - Deeper architectures
  - Use other neural network primitives