Activity recognition and trajectory estimation using IMU and Lidar data

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December 16, 2020

Purpose

Propose a new pipeline for human activaty recognition and trajectory estimation with Inertial Measurement Unit (IMU) sensors.

Motivation

- Indoor trajectory estimation
- Measure activity level
- Human activity recognition

Approaches and methods

- Parametr
- Collect dataset human activity recognition and trajectory estimation (in process)
- Smooth ground truth to reduce noise
- Use augmentations for robustness
- Use conditional GANs for smart data augmentation (future)
- Combine Lidar data with gyroscope data to reduce bias (future)

Find the superposition of functions F_{tr}, which transforms sensors data to trajectory estimation and F_{st} - to step labels.

Data

1. $\mathcal{A} \in \mathbb{R}^{3\times T}$ - accelerometer readings
2. $\mathcal{W} \in \mathbb{R}^{3\times T}$ - gyroscope readings

Minimization of loss function

$$\arg\min_{F_{\text{tr}}, F_{\text{st}}} \mathcal{L}\left(\left(F_{\text{tr}}\left(\mathcal{A}, \mathcal{W}\right), \mathcal{T}\right)\right) \tag{1}$$

RMSE

Absolute trajectory error (**RMSE**) defined as the root mean square error between predicted and ground truth trajectories:

$$\mathcal{L}_{\mathrm{tr}}(\hat{\mathcal{T}}, \mathcal{T}) = (\frac{1}{N}\sum_{i=1}^{N}((\hat{t_{x\,i}} - t_{x\,i})^2 + (\hat{t_{y_i}} - t_{y_i})^2))^{1/2} \tag{2}$$

MHE

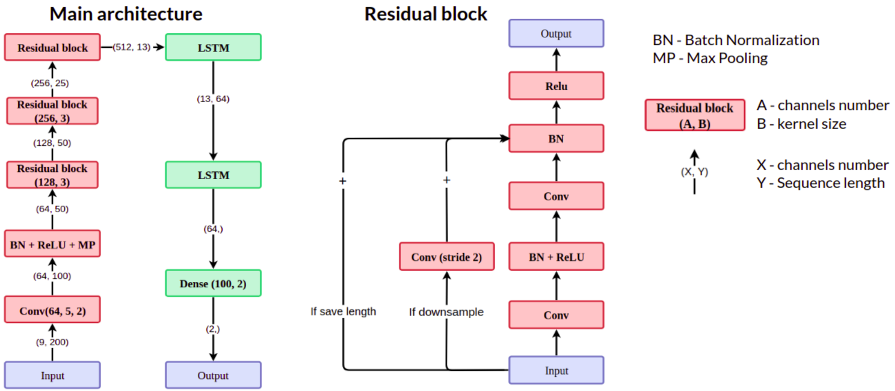
Mean Heading Angle Error: Average angle between velocities during whole experiment / (length /100 m).

GAP

Distance between the first and the last points (**GAP**):

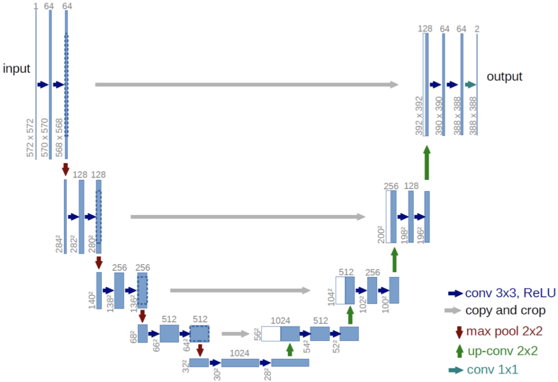
$$\mathcal{G}_{\text{tr}}\left(\hat{\mathcal{T}}\right) = \left(\left(\hat{t_x}_1 - \hat{t_x}_N\right)^2 + \left(\hat{t_y}_1 - \hat{t_y}_N\right)^2\right)^{1/2} \tag{3}$$

ResNet-18 without the last layer stacked with two LSTM layers



Baseline model

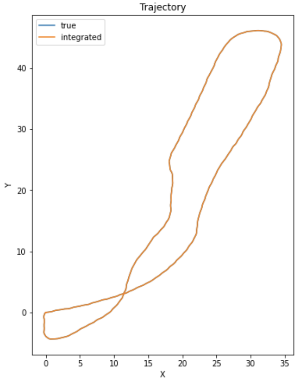
UNet: results

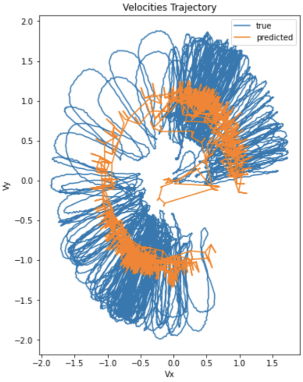


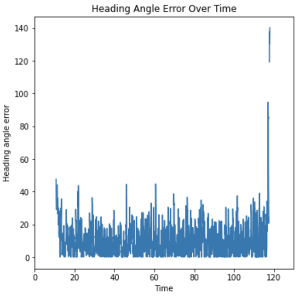
5 epochs training on RuDaCoP

	ResNet	UNet
MPE, %	10.5±0.5	**8.0±0.6**
MHAE, °	11.3±0.9	**7.0±0.6**
RMSE, m	11.2±1.4	**10.0±1.5**
Gap, m	18.6±3.0	**15.5±3.2**

MHAE metric: original data



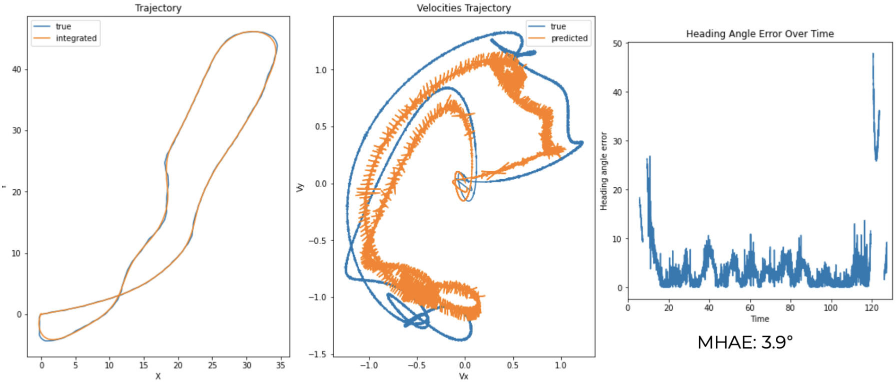




MHAE: 11.1°

Ground truth trajectory with out smoothing

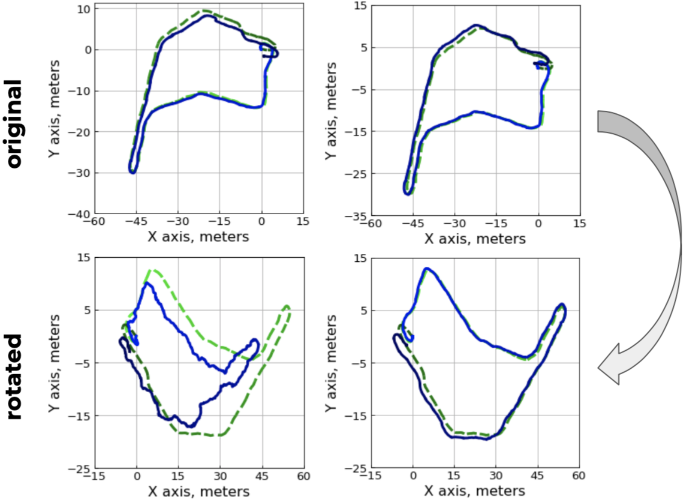
MHAE metric: smoothed data - fft



MHAE: 3.9°

Smoothed ground truth trajectory

Augmentations: recall



Future work

1. Collecte dataset for activity recognition and trajectory prediction in 3D space for testing hypothesis.
2. Use Lidar data (data from camera)
3. Use Generative neural network for data augmentation.
4. Use open-source data for training as well as collected data.

Список литературы

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