



Visible Light Positioning powered by Machine Learning

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Outline

Introduction

Data set

Approaches

Evaluation

Results

Conclusion

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Problem statement

Outdoor



GPS



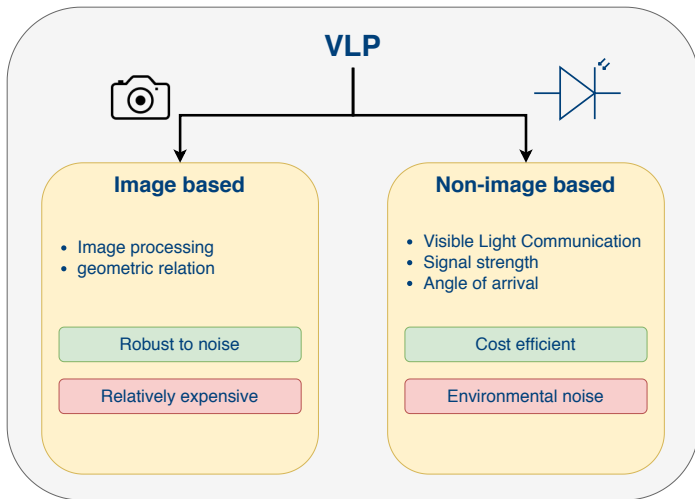
Indoor



Wifi/Bluetooth

VLP ?

Visible Light Positioning or VLP

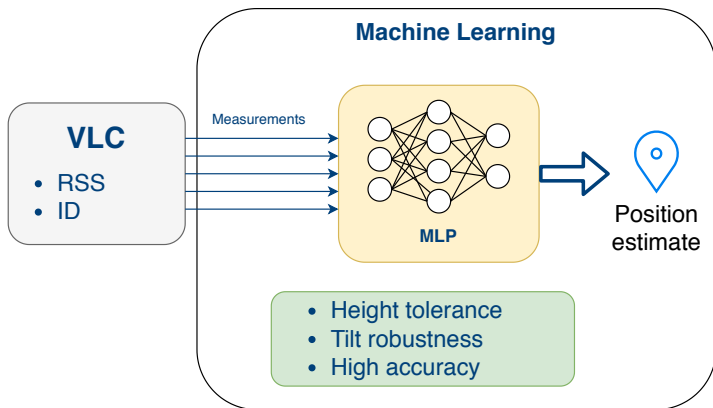


Non-image based positioning

- ▶ Each LED has its own unique ID
- ▶ Received IDs pinpoint to unit cell
- ▶ Position in cell with RSS
- ▶ Average position accuracy 3.65cm with 15cm height tolerance

[Hsu et al.(2018)Hsu, Liu, Lu, Chow, Yeh, and Chang]

Goal



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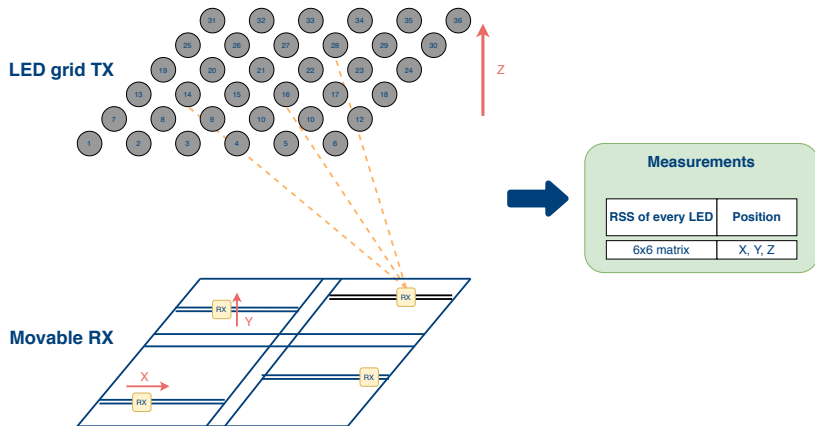
Approaches

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Experimental setup



Simulation

- ▶ Simulation based on Lambertian pattern
- ▶ Use simulation to calculate measurements

$$H = \frac{(m+1)A_{pd}}{2\pi d^2} \cos^m(\phi) g(\psi) \cos(\psi)$$

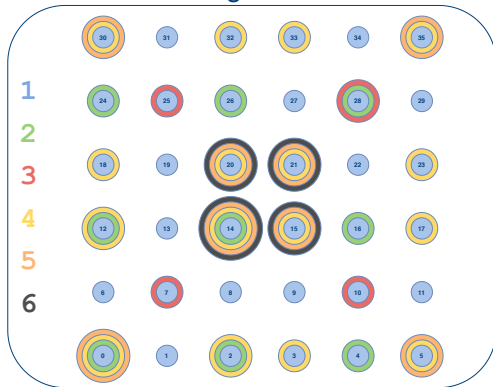
$$\text{with } m = \frac{-\log(2)}{\log(\cos(\phi_{1/2}))}, A_{pd} = 1.1, \phi_{1/2} = 15^\circ, g(\psi) = 1$$

[Beysens et al.(2018)Beysens, Galisteo, Wang, Juara, Giustiniano, and Pollin]

Data manipulations

1. Keep X best RSS
2. Different configurations

Configurations



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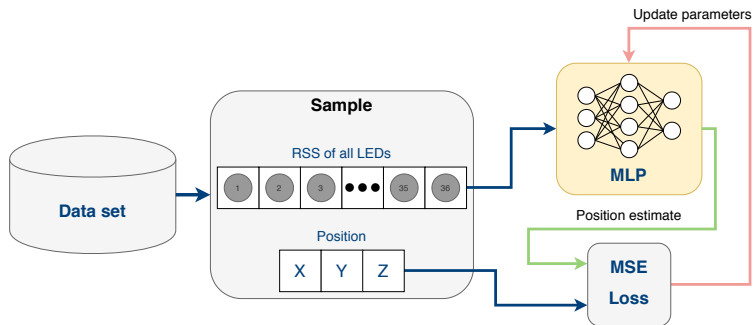
Approaches

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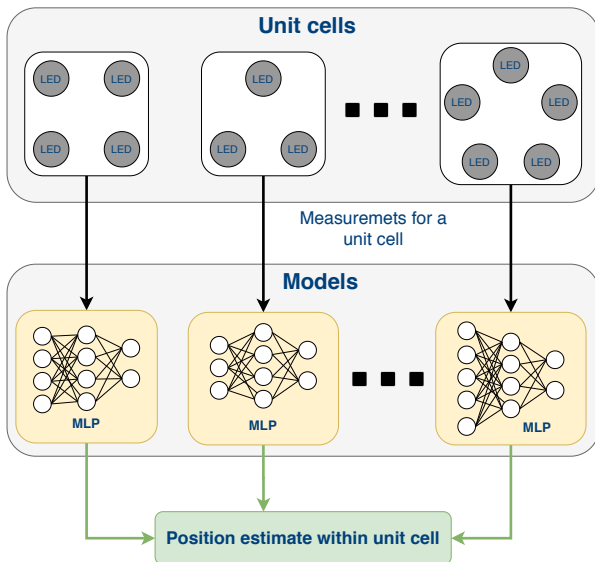
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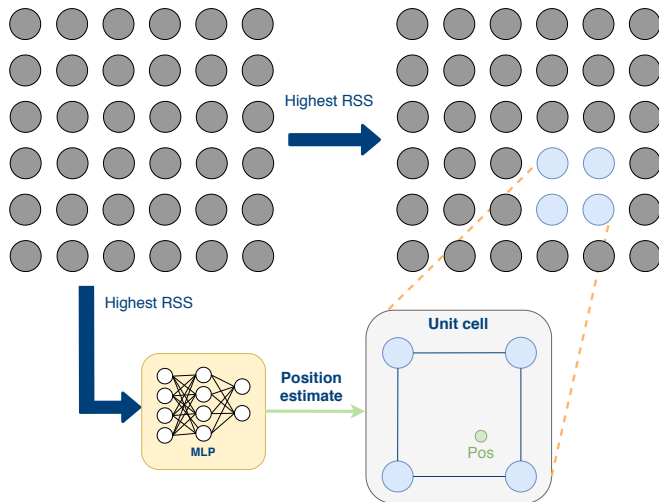
Approach one



Approach two



Approach two



Problems to locate unit cell with tilt?

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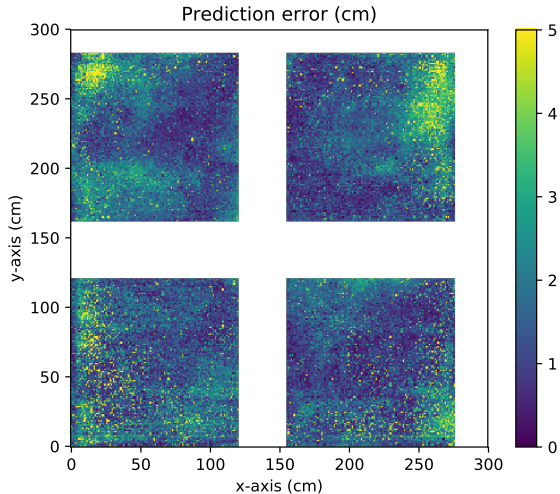
Distance metric

- ▶ Model is evaluated using train-validation-test set
- ▶ Performance metric is euclidean distance between prediction and true position
- ▶ Average distance over set

$$Error = \sum_{i=0}^{test\ set} \sqrt{(pred_i^x - x_i)^2 + (pred_i^y - y_i)^2 + (pred_i^z - z_i)^2}$$

Heatmaps

- ▶ Other way to visualise performance
- ▶ Heatmap shows error for each position in grid



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Preliminary results

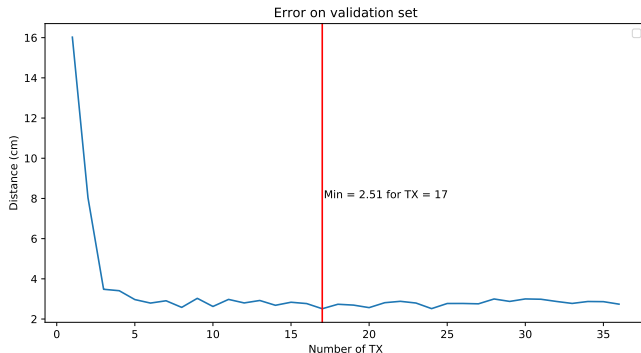
Train on simulation data

- ▶ Training model on simulation data
- ▶ Test model on experimental data
- ▶ Results in an error of $\pm 13\text{cm}$
- ▶ Knowing closest LED gives error $\pm 25\text{cm}$

Preliminary results

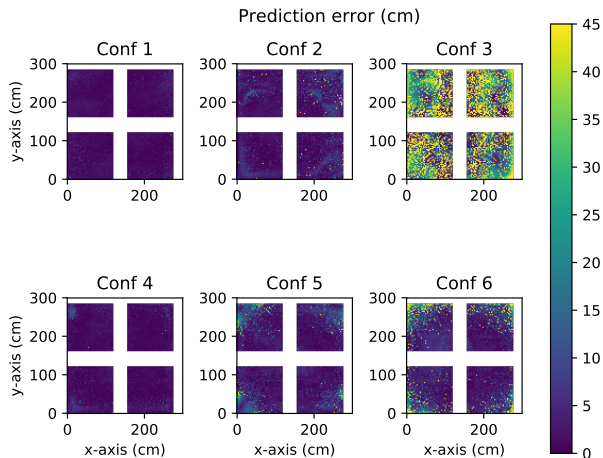
Experiment 1

- Use only highest RSS of X LEDs
- Sweep over all possible X: 1->36



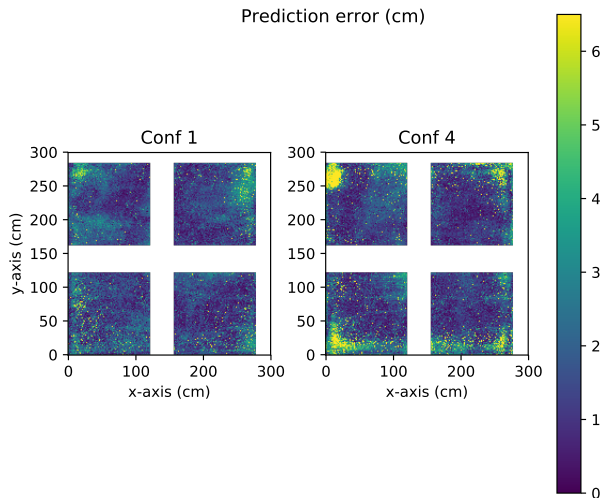
Preliminary results

Experiment 2



Preliminary results

Experiment 2

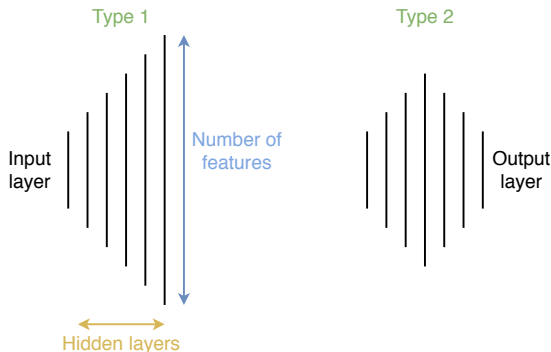


Preliminary results

Experiment 3

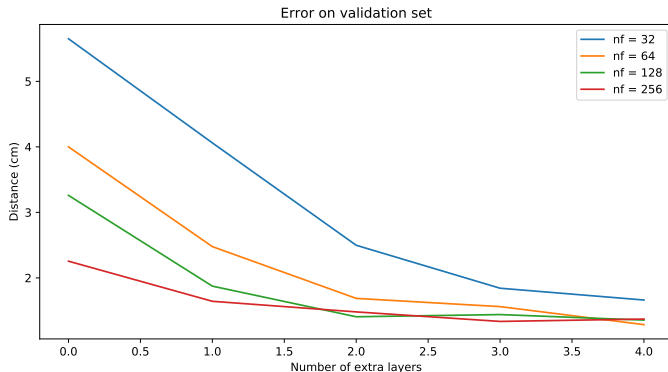
► Study influence of network architecture

1. Two MLP architecture types
2. Multiple hidden layers
3. Different number of features



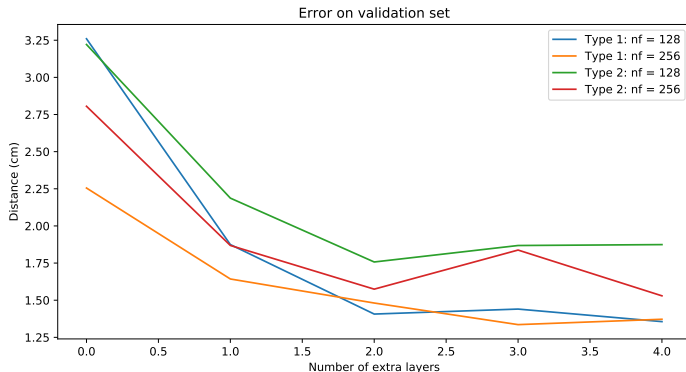
Preliminary results

Experiment 3



Preliminary results

Experiment 3



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Further improvements

- ▶ Possibly change to second approach
- ▶ Improve simulation
 - ▶ Add noise
 - ▶ Model PD
- ▶ Add tilt tolerance
- ▶ Improve height tolerance

Conclusion

- ▶ I believe I'm on schedule
- ▶ Still a lot of work for practical application
- ▶ Fine preliminary results

Bibliography



Jona Beysens, Ander Galisteo, Qing Wang, Diego Juara, Domenico Giustiniano, and Sofie Pollin.

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Chin-Wei Hsu, Siming Liu, Feng Lu, Chi-Wai Chow, Chien-Hung Yeh, and Gee-Kung Chang.

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