ACCES: Offline Accuracy Estimation for Fingerprint-based Localization

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Introduction

Why: Lack of theoretical offline accuracy estimation frameworks for pure fingerprint localization approaches.

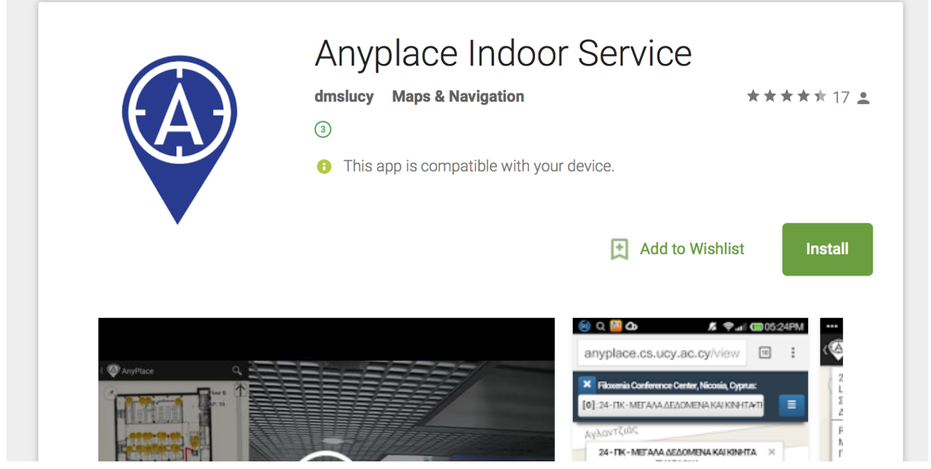
Goal: Provide offline accuracy estimation and fingerprint map assessment for arbitrary fingerprint data sources disregarding data model and in a theoretical manner.

Pipeline

1. **Interpolation:** fingerprint map + *Gaussian Process Regression* (GPR) $\Rightarrow$ *likelihood* $p(\mathbf{m}|\mathbf{r})$
2. **Accuracy estimation:** *likelihood* $p(\mathbf{m}|\mathbf{r})$ + *Cramer-Rao Lower Bound* (CRLB) $\Rightarrow$ lower bound on RMSE
3. Bound on RMSE $=$ *ACCES* navigability score

Demo: Collection

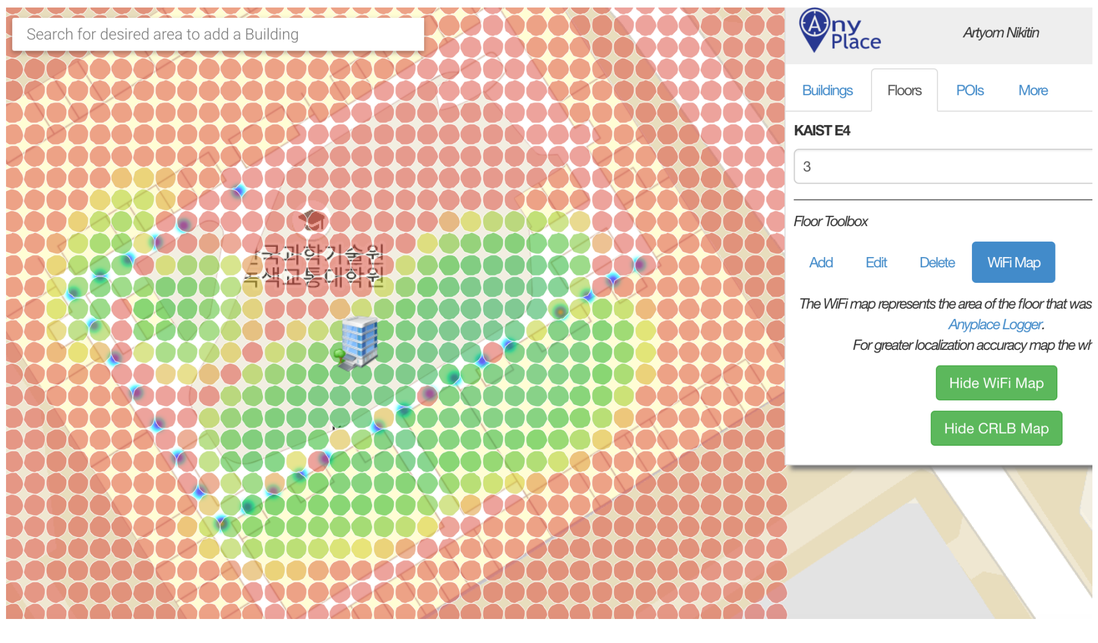
1. Download **Anyplace Indoor Service** from Google Play or Windows Store



2. Find KAIST E4 building
3. Go to **Logger**
4. Collect fingerprints around the building!

Demo: Reflection

5. Come back to the demo site to observe how predicted accuracy changes!



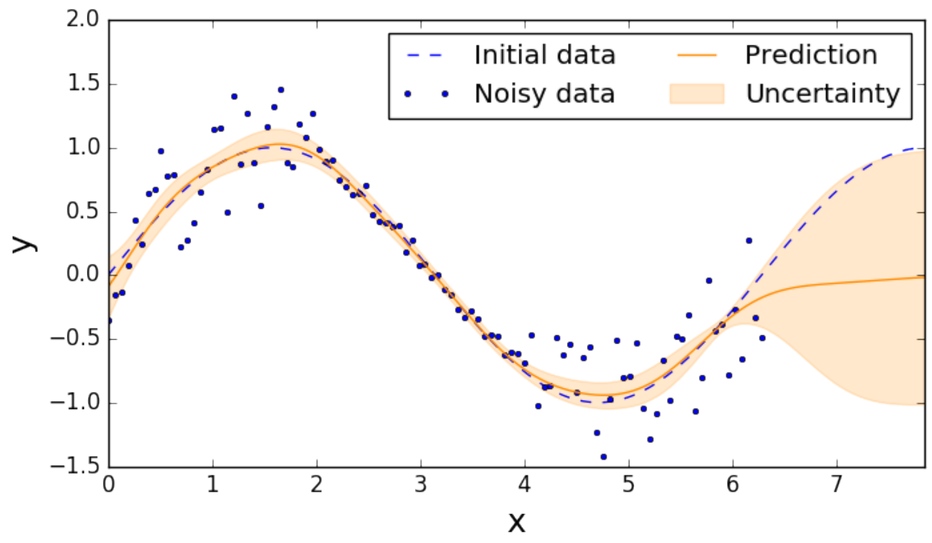
Notation

- $\mathbf{r}$, d_r - Coordinate-vector and its size
- $\mathbf{m}$, d_m - Measurement vector and its size
- $p(\mathbf{m}|\mathbf{r})$ - Likelihood of observing $\mathbf{m}$ at $\mathbf{r}$
- $\mathcal{I}(\mathbf{r})$ - Fisher Information Matrix
- $\mathbb{E}(\cdot)$ - Expectation of a random variable
- μ, σ - mean and covariance matrix diagonal of a normal random vector
- H, tr - Hessian matrix, trace of a matrix

Interpolation

Gaussian Process Regression:

- measurements are Gaussian random variables
- measurements are spatially correlated



Accuracy Estimation

Cramer-Rao Lower Bound:

- *likelihood* = probability to measure $\mathbf{m}$ at $\mathbf{r}$
- new measurements $\Rightarrow$ insight on $\mathbf{r}$
- lower bound on RMSE for unbiased estimators

$$RMSE \geq \sqrt{tr(\mathcal{I}^{-1}(\mathbf{r}))},$$

$$\mathcal{I}(\mathbf{r}) = \frac{1}{2}\sum_{k=1}^{d_m}\Big[(\sigma_k^2+\mu_k^2)H(\sigma_k^{-2})+$$

$$H(\mu_k^2\sigma_k^{-2}) - 2\mu_k H(\mu_k\sigma_k^{-2}) + 2H(\log\sigma_k)\Big]$$

Conclusions

- *ACCES*: offline accuracy estimation framework
- CRLB-based
- No data source and model dependence

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