# DNN-BASED WIRELESS POSITIONING IN AN OUTDOOR ENVIRONMENT

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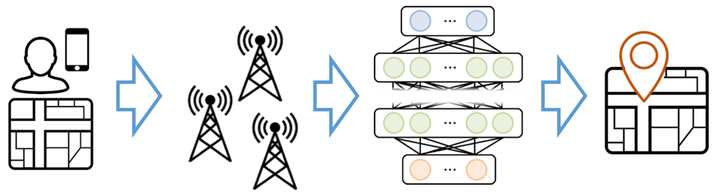
## Introduction

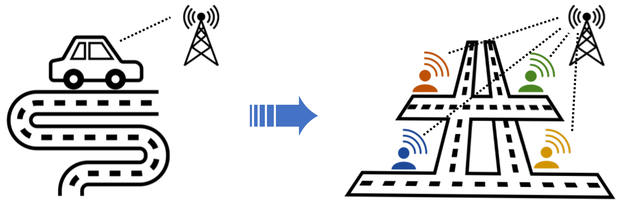
### ❑ Project purpose

- **Estimate the location of a user using RSRP* and the locations of base stations with a DNN* structure**



### ❑ Motivation

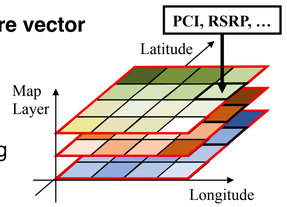
- To draw a coverage map,
  - Drive test is labor-intensive and costly
  - MDT* allows the **automatic monitoring** of the radio status of UE*
    ⇒ important to identify the location of the UE
- **DNN is successful for modeling a non-linear relationship between radio signals and the user location**



## Background

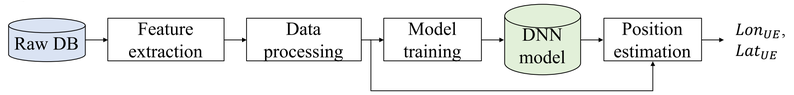
### ❑ Fingerprint-based localization

- Match geographical signatures to a map of previously measured signatures
- Training phase
  - Create a map represented by **signature vector** such as **RSRP** and **PCI***
- Matching phase
  - Determine best matching signature by calculating **Euclidean distance** among the grid unit




## Proposed Algorithm

### ❑ System overview

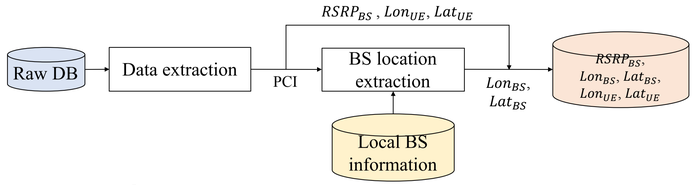



### ❑ Feature extraction

- Data extraction
  - Extract data that had **three** connected BS*
- **DNN input features**
  - RSRP
  - Longitude
  - Latitude of the **Top 1 to 3 BS**

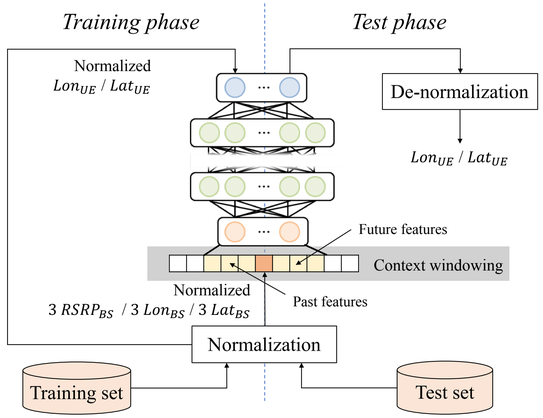
  ⇒ (9 x size of context window) dimensions
- **DNN output features**
  - Longitude
  - Latitude of the **UE**

  ⇒ 2 dimensions




### ❑ Data processing

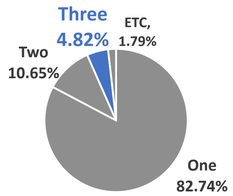
- Normalization: zero mean, unit variance
  - Prevent the problem of bias to certain parameters
- Context windowing
  - Use **past** and **future** features, as well as the **current** DNN input feature




## Experiments

### ❑ Database setup with field measurement

- Measurement environment
  - 1800 MHz LTE bands
- Data rate
  - Raw data: 77.01 (samples/sec)
  - Data connected to three BS: 3.83 (samples/sec)
- Median distance between UE and BS
  - 105.16 (m)




**Database ratio (The number of connected BS)**

### ❑ Network structure

| | | |
|---|---|---|
| Training | Data measured in detail | 26,061 (Samsung Galaxy S5) |
| | | 22,297 (Samsung Galaxy S5) |
| | | 31,511 (LG G5) |
| Test | Data measured sparsely | 10,875 (Samsung Galaxy S5) |
| Input layer | | (9 × size of context window) dim. |
| Output layer | | 2 dim. |
| Weight initialization | | Xavier |
| Activation function | | ReLU |
| Optimizer | | Adam |
| Cost function | | MSE |

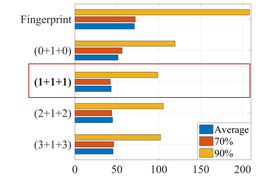
**Data measured in detail (Training)**

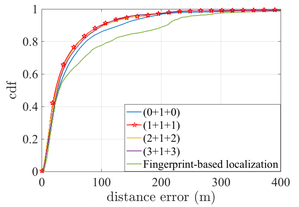
**Data measured sparsely (Test)**

### ❑ Experiment results

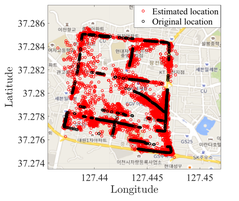
- Experiment by changing the size of context window
- Experiment to compare fingerprint-based localization and DNN-based localization

| Method | | Average distance err. (m) | Distance err. for 70% (m) | Distance err. for 90% (m) |
|---|---|---|---|---|
| Fingerprint-based localization | | 71.04 | 72.14 | 208.50 |
| DNN-based localization | (0+1+0) | 51.70 | 56.37 | 119.73 |
| | **(1+1+1)** | **43.51** | **42.33** | **98.97** |
| | (2+1+2) | 45.09 | 44.17 | 105.47 |
| | (3+1+3) | 45.78 | 46.41 | 102.19 |
| Performance improvement | | 38.75% | 41.32% | 52.53% |

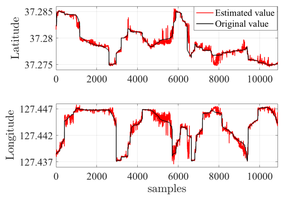



**CDF* of distance error**




**Estimated locations**




**Estimated values**

## Conclusion

- Data used in those experiments were measured in a real communication field
- The average distance error of the proposed algorithm was reduced by 27.53 m in comparison to the conventional method

RSRP: Reference Signal Received Power, DNN: Deep Neural Network, MDT: Minimization of Drive Tests, UE: User Equipment, RSS: Received Signal Strength, BS: Base Station, PCI: Physical Cell Id, CDF: Cumulative Distribution Function