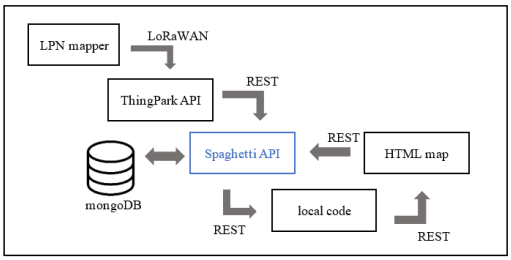
LoRa Localisation Improvement Using GPS Fingerprint and AI Algorithms

Micha Burger

Professor : Alcherio Martinoli
Assistant(s) : Dr. Ali Marjovi
Ext. expert : Alexandru Rusu (Swisscom)

LoRa Technology is a Low Power Wide Area Network (LPWAN) specification intended for wireless battery-operated Things in a global network. It is characterized by a low data rate requirement per single device, long range and heterogeneous application domains, which can lead to extremely high number of nodes coexisting in the same cell. Due to the high number of devices and the nature of the gathered data, determining the positioning of each node is crucial for many LPWAN applications.

Due to the nature of the signal, a lot of noise is present and determining a precise distance-to-RSSI function to use for trilateration is not possible, especially in urban areas where the signal propagation is highly dependent of the building structures. For this project, I tested a new fingerprinting technique on LoRaWAN signals of 24 gateways in reach of the EPFL campus. A massive data collection was done over all the EPFL campus to create a large reference database, also containing the GPS ground-truth position.

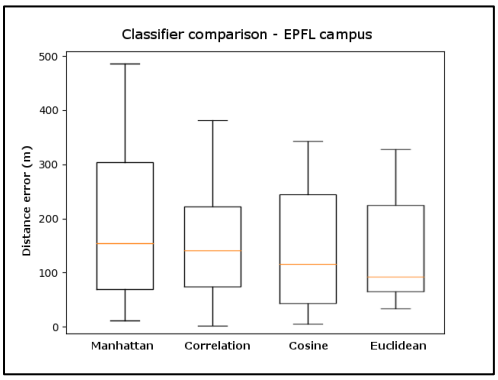


Spaghetti API was created to receive the LoRaWAN packets and store all the relevant data in a database. The rest of the code with the localization algorithms is run locally.

An initial geolocation-based agglomerative clustering is done on the reference database, to group close points together for some initial noise-filtering and fingerprint generation.

The fingerprints are based on a set of characteristics specific to LoRaWAN (RSSI, SNR…) for every gateway, and stored in a list for each location, creating a multi-dimensional feature-space. Due to the present noise, a highly important part of the fingerprint is the gateway frequency: Which gateway has been seen how many times from this point. Other measures like ToA or even a trilateration position estimate could be added to the fingerprint for more precision.

To create a position estimate for an unknown position, a fingerprint similar to the database is created out of several consecutive packet transmissions. The data of this feature-space is fitted to the zero-mean scaling of the reference database, then a simple KNN classification is done, leading to the N most probable positions (cluster centers).



KNN classifier functions comparison

As the N most probable position estimates can sometimes be far apart, it is dangerous to just take the mean position of them. Therefore, I propose a particle-filter style probabilistic position estimate, leading to a heatmap representation of the position's probability density. The best results under difficult conditions were obtained adding also a dynamical Cluster Filter on top, filtering out the clusters the furthest away from the last position estimate.

An overall mean position error below 90m could be reached in a cross-validation on urban scenarios at EPFL with many buildings and in the old-town of Lausanne. Mean errors below 200m are possible even in open fields close to Rolex Center and in the Flon quarter with large alleys. The mean error for this scenario could be reduced to below 150m using the dynamical filter.

The algorithm still has to be improved for a productive environment, for example using different Spreading Factors. The relation between gateway density and localization precision would also be interesting to find out. Or positioning to the last meter, using a gateway on a drone would be a useful project.