



TECHNICAL DOCUMENTATION

Machine Learning with Blyott

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Introduction

This document provides some technical background about the algorithms used for the Blyott indoor positioning system. Algorithms are used in three different areas: data preprocessing, location prediction and postprocessing of the prediction history.

It also describes the different sensor types used and where these and the locators should be positioned to get optimal results.

1. Algorithms

1.1 Data Preprocessing

The data used for the prediction engine is the RSSI signal received from the sensors by the locators.

Data preparation is a crucial step in any machine learning project, as it lays the foundation for accurate and reliable results. Regardless of the model used, certain problems can arise during data preparation that can affect the quality of the model's output.

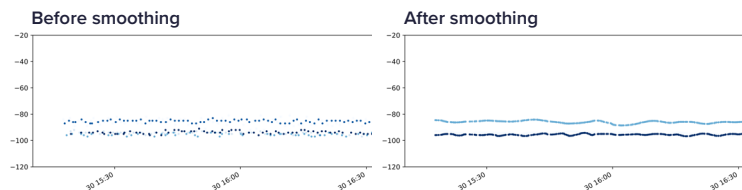
A very important element is the time gap between the data points received on the platform. If the time gaps between data points are too big, the platform will miss important events. The time gaps are primarily determined by the frequency at which sensors emit their data and the frequency at which the locators send their data to the platform.

What is RSSI?

RSSI is the Received Signal Strength Indicator or Received Signal Strength Indication (RSSI). RSSI is a measurement of the power present in a received radio signal.

Locators cache their data and only send information to the platform at certain intervals. Depending on the vendor it should be possible to adapt the locator settings to improve the data transmission frequency.

On top of that, two common problems can arise: missing data and noisy data. To address this, the data is smoothed.



Addressing these data issues is crucial for producing reliable and accurate results. Two important parameters need to be set: cache size and smoothing factor.

The cache size is expressed in minutes and determines how far the smoothing algorithm goes back in time to smooth the data.

The longer the cache size and the more data points available in that cache, the better the algorithm will be able to correct for missing data. This means that the cache size will be impacted by the average time gap between data points.

The bigger these gaps, the bigger the cache size will need to be. However, this cache size introduces a delay on the processed signals, roughly equal to the cache size, and in doing so, negatively impacts the responsiveness of the system.

Hence, a tradeoff will need to be made depending on the customer's use case.

Why use data smoothing?

RSSI values can vary a lot. That's why we preprocess the RSSI-based datasets combined with smoothing algorithms to eliminate noise and prevent location and floor hopping.

The smoothing factor is a parameter used in the smoothing algorithm that determines how much smoothing is applied to the data. An optimum value for this parameter can be calculated by the platform based on the data received.

1.2 Prediction

The preprocessed data is used to predict locations using 2 main algorithms: the RSSI algorithm and the Machine Learning algorithm.

Two important concepts need to be explained first: coverage and accuracy.

Coverage

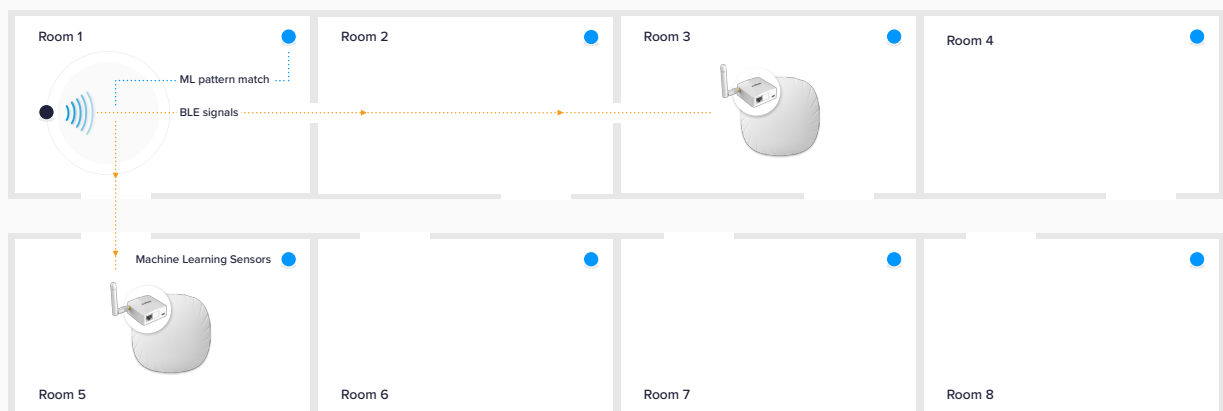
We use the term coverage to indicate how fine-grained we can predict locations. The algorithm will only be able to predict on the level of the locations that are known to it (either as a location of a locator, or as a location of a reference sensor).

So, if only 10 out of the 100 locations are known, the coverage will be rather low.

Accuracy

Accuracy refers to how good we can predict the correct location of a sensor. Even if we have full coverage of all locations, we might still predict the wrong room.

Different measures can be used to assess the accuracy of predictions (Precision, Recall, F1 Score).



Example of accuracy with machine learning sensors. Next to the two locators in Room 3 and Room 5, each room has also been equipped with a machine learning sensor (ML sensor). The system will now display Room 1 as the sensor location because the ML pattern of the mobile sensor corresponds with the machine learning sensor in Room 1.

1.2.1 RSSI Model

The basic idea behind this algorithm is that the signal strength of a locator will be strongest when a mobile device is closest to it, and weakest when the device is far away.

Hence, this algorithm will simply predict the location of the locator that picks up the strongest signal for a certain sensor.

As it can only predict locations in which there is a locator, the coverage of this model is limited by the density of the locator network.

If full coverage of all the rooms is needed, there are two options: install a locator in each room or use the Machine Learning algorithm.

1.2.2 Machine Learning Algorithm

In this algorithm, a Machine Learning model is trained to recognize the signals of reference sensors (so-called ML sensors) picked up by the neighboring locators. Data is collected throughout the day and the model is retrained every night.

The coverage of this algorithm is higher, as ML sensors can be fixed in each location. The RSSI algorithm will predict the location of the closest locator and the ML algorithm will predict the location of the closest ML sensor.

1.2.3 Hybrid Algorithm

If coverage does not need to be the same everywhere, it is possible to use a hybrid algorithm.

This algorithm uses the ML algorithm for locations that have been included in the training (i.e., in which we have ML sensors) and falls back on the RSSI algorithm for locations that have not been included in the training.

1.2.3 Hybrid Algorithm

It is important to be aware of the following limitation. As we don't know up front which location will be predicted, we don't clearly know which algorithm to use. This is specifically a challenge in locations that are on the edge of zones in which ML sensors were fixed. Therefore, it is recommended to not use individual locations for ML training, but rather use larger contiguous zones for ML training.

2. Hardware

2.1 Locators

Locators are used to pick up the signals emitted by the sensors. When placing locators for the ML algorithm, a density of at least one locator per 75-125 square meters is recommended.

For the RSSI algorithm, at least one locator per location to be predicted is required. In both cases, it is important to avoid symmetrical or regular patterns and instead opt for an evenly spread-out triangular setup to minimize interference and signal attenuation.

Overall, careful consideration of locator placement is essential to achieve accurate and reliable location-based services using these technologies.

2.2 Blyott Sensors

Sensors are small electronic devices used for various purposes, such as tracking, machine learning training, and calibration. We use and define the following types of sensors.

2.2.1 Mobile Sensors

A mobile sensor is a sensor that is fixed to an asset that could be moving from one location to another. For example, a mobile sensor can be attached to a wheelchair, and the sensor can be tracked as the wheelchair is moved from one location to another.



What are BLE locators?

BLE locators can be standalone fixed or mobile (4G) locators, but it can also be Wi-Fi access points with built-in Bluetooth[®] capabilities. Blyott connects directly to such Wi-Fi AP's.

2.2.2 Fixed Sensors

A fixed sensor is a sensor that is fixed to an asset that should never be removed from a certain location. For example, a fixed sensor can be attached to a high value asset. If for some reason we see it moving to another location, an alarm can be raised.

2.2.3 Calibration Sensors

Calibration sensors are used to fine-tune the parameters used in our algorithms and to assess the impact of changes to our algorithms. They need to be fixed in a location, so we know where they are located.

For instance, they are used to define the optimum value of the smoothing factor.

Before introducing new algorithms, it is important to test the impact on accuracy. For this we run evaluation tests, sometimes across all tenants, to see what the impact is on the accuracy for these calibration sensors.

The number of calibration sensors used should be between 5% to 10% of the total number of locators, with a minimum of 5 to 10 sensors.

To achieve the best results, calibration sensors should be evenly spread across the premises.

As the RSSI algorithm can only predict locations where locators are positioned, calibration sensors should preferably be positioned in locations that have locators. If this is not possible, the location of the closest locator must be registered in the platform.

Calibration sensors should also be placed at the same height as the actual assets to be located and not too close to an ML sensor.

2.2.4 ML Sensors

These sensors are used by the ML algorithm to provide data for training the model. They should be fixed to a location. It is essential that each location the model needs to recognize has at least one sensor. Additional sensors per location can result in improved accuracy.

In cases where a location is large or has long corridors, it may be necessary to split it into multiple (dummy) locations and install additional sensors accordingly.

When positioning ML sensors, it is recommended to place them in the back of the room if only one sensor is used.

If two sensors are used, they should be placed diagonally across from each other. If four sensors are used, they should be placed in the corners of the room.

It is also important to ensure that the sensors are installed at the same height as the actual assets to be located.

About Blyott

Blyott is at the forefront of transforming industries with innovative localization and monitoring solutions. Our platform integrates advanced data analytics and AI, supporting various sectors to navigate operational challenges, enhance efficiency, foster staff well-being, and achieve sustainability goals.



EASY TO SET UP

Works in a matter of minutes.



SCALABLE

Scale to millions of assets.



PAY-AS-YOU-GROW

Custom plans are available.



OPEN STANDARD

Integrate using REST APIs and webhooks.



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