# Indoor Tracking Persons Using Bluetooth: A Real Experiment with Different Fingerprinting-Based Algorithms

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**Abstract.** In outdoor localization, global positioning systems (GPS) has been widely used. Indoor applications require a precise estimation that GPS can not achieve. Several technologies have been tried out as WI-FI, RFID, Bluetooth, Zigbee and others. This paper describes an experiment conducted in a medium-sized room in which six zones have been identified and two Bluetooth transmitters were installed. The aim is to enable continuous monitoring of areas where a person moves. For this purpose, we have used the technique of RSSI fingerprinting and tested three different algorithms. The best results were obtained with an algorithm based on SVM, which yielded success rates of 88.54%. Based on this algorithm, we intend to develop a cheap and easily configurable indoor localization system.

## 1 Introduction

Global Positioning System (GPS) is a well known outdoor localization and navigation system; however this technology does not work in indoor environments [1]. There have been numerous attempts at indoor localization tracking [2] but none of them have been widely adopted, primarily due to the cost of deploying and maintaining building-wide location technology [3]. Real-world location-aware applications are continuously expanding: location of products stored in a warehouse, people location in buildings, way-finding systems, etc. Different technologies have been tested in numerous systems, such as infra-red beacons in the Active Badge Localization System [4], ultrasound time of arrival in Cricket [5] or Radio Frequency Identification in LANDMARC [1].

At this moment, most of the researchers are currently focussed on two wireless technologies: Wi-fi and Bluetooth. Wi-fi has high power demands, is more difficult to set-up and maintain and is also less common in mobile phones. Instead, Bluetooth was designed for low power devices and the vast majority of the mobile phones supports it. For these reasons our research is based on Bluetooth technology [3, 6].

When using Bluetooth, RSS is a widely employed parameter, either with trilateration or with fingerprinting. Trilateration is a trigonometric approach for tracking mobile objects considering the concept of triangles. It requires a theoretical propagation model that relates RSS values with distances. Fingerprinting is the most accurate and popular method and is based on matching some characteristic of the signal that is location dependent [7, 8].

A. van Berlo et al. (Eds.): *Ambient Intelligence – Software & Applications*, AISC 219, pp. 25–32.
DOI: 10.1007/978-3-319-00566-9_4 

We intend to design and implement a system for locating and tracking people at home. Many people living alone may have issues in their daily routines, both due to physical limitations inherent to age or caused by some disease. These people can benefit from some kind of non-intrusive supervision, so the use of cameras or regular visits by social workers is not considered as a first option. A computational system that makes a regular tracking of the subject will be useful in these cases. The daily routine can be monitored and any anomaly can be detected. The point is to select which locations would be considered of interest and the system will report in which zones the subject has been stayed and for how long. The system must be cost-effective, easy to manipulate and install by non skilled people.

This paper presents the results of the first stage of this project, specifically a comparison of different algorithms to process RSS information obtained from Bluetooth in order to obtain information about location of a mobile object. The paper is organized as follows: Section 2 contains some information about Bluetooth and its use for indoor location. Section 3 describes the experimental set-up, the protocol followed for data collection and the algorithms we tested. Section 4 includes the experimental results and some discussion about them. Finally, in section 5 some conclusions are given and future improvements are proposed.

## 2 Related Work

As previously said, different techniques and technologies have been used for indoor location [9, 2]. The reasons for choosing Bluetooth are that is it easy, cheap and it can be embedded in very small devices. Bluetooth was the technology used in many projects [10–13] based on a wide range of algorithms: proximity-based, trilateration, ad-hoc approaches, received signal strength indicator, fingerprinting and combinations of them and even fusion with others technologies [14, 15].

Proximity-based methods are simple to implement and relatively reliable [16]: if a user is contacted by a beacon, then the user is located in an area defined by the Bluetooth range of transmission. In trilateration, distance from the mobile node to three fixed nodes whose positions are already known is estimated using a radio propagation model; accuracy depends on signal and environmental conditions [7]. The idea is to use RSS values as a measurement of signal attenuation. Although there is no deterministic relationship between distance and RSS values, there is a qualitative trend [17, 3], where the relation can vary due to many factors [18].

Fingerprinting-based methods consist of two stages: set-up stage and online stage. During the set-up stage, a mapping is created using RSS values obtained in distinct positions of the room. In the online stage, object position is estimated based on the database obtained in the first stage [19]. RSS can be affected by diffraction, reflection, and scattering in the propagation [2]. There are several fingerprinting location algorithms based on pattern recognition techniques: probabilistic methods, kNN [20], neural networks, support vector machine (SVM) and others [2]. This paper describes an experiment using Bluetooth and fingerprinting for indoor location. Different techniques related with pattern recognition are evaluated to determinate which one gives more accuracy.