

Master's Thesis

A Robust Received Signal Strength Based Positioning Algorithm for Indoor Environments

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Project Overview

Localization for mobile wireless sensor networks has been intensively studied in recent years due to its many applications in mobile networking as well as various public safety problems. However, the complexity of indoor radio propagation, especially when considering mobile users, makes indoor positioning a challenging task. This is mainly due to the severe multipath phenomenon where multiple copies of the transmitted signal are received from many directions (i.e. reflections, diffractions and scattering).

A simple approach is to have all mobile nodes equipped with a Global Positioning System (GPS). This cannot be implemented in an indoor environment, where walls and other obstacles obstruct view of the GPS satellites. Moreover, this approach might not be economically feasible due to the size, cost, and power consumption constraints of sensor nodes.

Generally, in sensor networks, a small portion of nodes, called beacon or reference nodes are aware of their own positions. Positions of other nodes are determined through some interaction with these reference nodes. For example, in range-based positioning, a mobile node first estimates its distance to all (or some) of the reference nodes, and then calculates its position by using algorithms such as Multilateration.

Techniques based on the Received Signal Strength (RSS) ([1],[2]) have been extensively studied in the literature. These techniques, although less accurate compared to more complex range-based techniques, are very simple to implement and offer low cost and effective alternatives for some applications. The core idea is to establish a relation between the received signal

strengths from at least three reference nodes and the current position of the mobile.

The main drawback of such techniques is the need for a measurement-based training phase, where a ‘Radio Map’ of the environment is created. This map essentially contains the received signal strengths from the reference nodes at all possible (i.e. candidate) locations. The process to generate a radio map is not only labor-intensive but also very sensitive to possible sources of interference in the building. While maintaining the simplicity of an RSS-based positioning system, the objective of this project is to see the effect of eliminating this training phase.

Problem Statement

1. Study the performance impact of replacing the training-based radio map by a model-based radio map (e.g. ray-tracing).
2. Investigate RSS-based algorithms that enhance the performance of such model-based indoor positioning systems.

Description

An appropriate propagation model can be used to generate the radio-map required for RSS-based positioning systems. A candidate solution for this model is based on ray-tracing. Although high-level building information such as layout is used in a ray-tracing model, other detail information about the environment such as the exact radio properties of the walls, and other obstacles affecting the RSS such as furniture are often ignored. The accuracy of the predicted signal strengths is highly dependent on this detail information which is almost impossible to capture in the model. Therefore, the performance of the positioning system (based on the Euclidean distance of the RSS vector) heavily depends on the model detail. For example, figure 1 illustrates this dependency for various wall types in a sample building layout.

The observed variation in performance is mainly due to the fact that the algorithm is based on the numeric values of the received signal strengths; therefore any error in the predicted RSS values (caused by the ray-tracing model) will directly reflect on the accuracy of the positioning system. Thus, other positioning algorithms that do not rely on the exact values of the predicted RSS values could improve the system performance. In [3] a novel algorithm called Ecolocation is presented, that relies on the relative RSS values. Here, the term relative means that the algorithm only uses the ordering of the received signal strengths and not their exact numeric values. The potential of this approach has not been investigated for indoor environments.

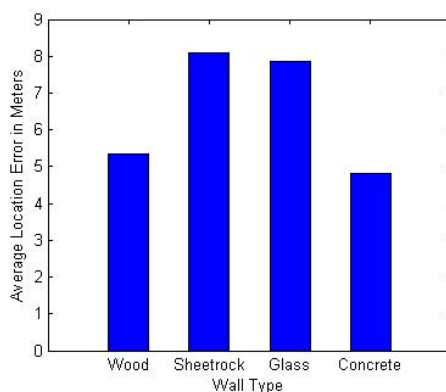


Figure 1: Average location error of RADAR using ray-tracing with different building wall types.

Plan of Study

- Study the applicability of the relative RSS-based method and explore possible extensions in order to eliminate the training phase for an indoor positioning algorithm.
- Implement code (Matlab) to simulate such systems in conjunction with a ray-tracing tool.
- Investigate the effect of several parameters such as node density, node deployment strategy and node transmission power and frequency.
- Perform experiments with Berkeley notes to measure the performance at the NIST North building.
- Perform experiments with 802.11-based nodes to measure the performance at the NIST North building. Also, cross-validate the results of both experiments with the simulation results.

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