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Towards Accurate Mobile Sensor Networks Localized in Noisy Environments

T. Divyapriya
M.Tech Student
Department of Computer Science and Engineering
PRIST University Pondicherry, India.

R. Backiyalakshmi
Assistant professor
Department of Computer Science and Engineering
PRIST University Pondicherry, India

Abstract— **The node localization problem in mobile sensor networks has received significant attention. Recently, particle filters adapted from robotics have produced good localization accuracies in conventional settings. In spite of these successes, state of the art solutions suffer significantly when used in challenging indoor and mobile environments characterized by a high degree of radio signal irregularity. New solutions are needed to address these challenges. We propose a fuzzy logic-based approach for mobile node localization in challenging environments. Localization is formulated as a fuzzy multilateration problem. For sparse networks with few available anchors, we propose a fuzzy grid-prediction scheme. The fuzzy logic-based localization scheme is implemented in a simulator and compared to state of the art solutions. Extensive simulation results demonstrate improvements in the localization accuracy from 20% to 40% when the radio irregularity is high. A hardware implementation running on Epic motes and transported by iRobot mobile hosts confirms simulation results and extends them to the real world.**

Keywords— ***Fuzzy Multilateration, Received Signal Strength (RSS), FLBL (Fuzzy Logic Based Localization)***

I. INTRODUCTION

Wireless sensor networks are increasingly a part of the modern landscape. Disciplines as diverse as volcanic eruption prediction and disaster response benefit from the addition of sensing and networking. A common requirement of many wireless sensor network (WSN) systems is localization, where deployed nodes in a network discover their positions. In some cases, localization is simple. For smaller networks covering small areas, fixed gateway devices and one-hop communications provide enough resolution. Larger networks may be provisioned with location information at the time of deployment. However, in many common environments, localization is more difficult. GPS-based localization may be unreliable indoors, under forest canopies, or in natural and urban canyons. For example, GPS is used for high-precision asset tracking in but fails indoors. Signal strength-based solutions similarly fail when there is a high degree of RF multi-path or interference. Relies on accurate measurement of RF TDOA and distance traveled and quickly degrades as accuracy decreases. Radio interferometry localizes nodes to within centimeters in but fails in multipath environments. Mobile beacons roam an outdoor environment in but localization requires a dense network and assumes favorable conditions. All these solutions rely on stable environments with low multipath, where measured or sensed ranges (which are typically obtained by time of arrival, angle of arrival or received signal strength techniques) reliably predict the actual distance between two nodes. For low multipath environments, accurate models have been proposed for estimating time of arrival, angle of arrival and received signal strength. Mobility complicates the localization problem since node to node distance variations *and environment changes* (e.g., due to node mobility or interference from an external source) introduce additional effects, such as small scale fading. Due to the relative motion between mobile nodes, each multipath wave experiences an apparent shift in frequency (i.e., the Doppler shift), directly proportional to the direction of arrival of the received multipath wave, and to the velocity/direction of motion of the mobile. Due to environment changes (i.e., objects in the radio channel are in motion), a time varying Doppler shift is induced on multipath components. Consequently, in such environments affected by small scale fading, it is challenging to use simple connectivity (which itself can vary dramatically) or Received Signal Strength (RSS) for accurate localization. Fuzzy logic offers an inexpensive and robust way to deal with highly complex and variable models of noisy, uncertain environments. It provides a mechanism to learn about an environment in a way that treats variability consistently. In one well-established fuzzy system, the Sendai railroad, fuzzy logic allowed the integration of noisy data related to rail conditions, train weight, and weather into acceleration and braking algorithms. Fuzzy logic can similarly be applied to localization. Empirical measurements are made between participating anchors in predictable encounters. These measurements are analyzed to produce rules that are used by the fuzzy inference systems, which interpret RSS input from unlocalized nodes and other anchors. The output of this process recovers the actual distance, compensated for variability in the local environment. This basic technique is employed in two constituent subsystems of FUZLOC - the Fuzzy Multilateration System (FMS) and the Fuzzy Grid Prediction System (FGPS). The contributions of this article are as follows:

- We formulate the mobile node localization problem for noisy environments, as a fuzzy inference process.
- We present fuzzy multilateration, a component of our fuzzy inference process, which obtains a node's location from noisy RSS measurements, using fuzzy rule sets.

- We present a fuzzy grid prediction scheme, which optimizes our fuzzy inference process, under conditions of low anchor density.
- We demonstrate the feasibility of our proposed technique, through an implementation using mote hardware hosted on iRobot.
- We perform extensive simulations and compare our solution with two state of the art algorithms, using both real-world and synthetic data.

II. EXISTING SYSTEM

Range-based localization methods require an estimate of the distance or angle between two nodes to localize and may operate in both absolute and relative coordinate systems. Typical drawbacks for these methods include higher computational loads, increased node size, higher energy consumption and increased cost. It assumes a fixed number of anchors but handles mobility very well. The computation and refining are not suitable for a resource-constrained computation platform like a MicaZ node. Range-free localization methods are typically used in systems where connectivity is the metric of choice and actual geographic distance is less important. Hop counting is a technique frequently used in these scenarios, where the distance between two nodes is inferred from the number of hops a packet takes and is based on some assumed or measured average hop length.

DISADVANTAGE OF EXISTING SYSTEM

- A major drawback is that it fails in networks with irregular topologies such as those with a concave shape. Mobility incurs large overhead since all hop counts must be refreshed frequently.
- Large amount of cost will use performed the system.

III. PROPOSED SYSTEM

Fuzzy logic offers an inexpensive and robust way to deal with highly complex and variable models of noisy, uncertain environments. It provides a mechanism to learn about an environment in a way that treats variability consistently. In our proposed fuzzy logic-based localization system, distances between a mobile sensor node and anchor nodes are fuzzified, and used, subsequently in a Fuzzy Multilateration procedure to obtain a fuzzy location.

In case two or more anchors are not available for performing localization using fuzzy multilateration, the sensor node employs a new technique, called fuzzy grid prediction, to obtain a location, albeit imprecise. In the Fuzzy Grid Prediction method, the node uses ranging information from any available anchor to compute distances to several fictitious "virtual anchors" which are assumed to be located in predetermined grids or quadrants.

ADVANTAGES OF PROPOSED SYSTEM

- Major advantage of our project is support with irregular topologies such as those with a concave shape.
- Mobility incurs large overhead since all hop counts must be refreshed frequently.
- Cost is low to implement the system. Increasing Speed.

IV. MODULE DESCRIPTION

A. *Fuzzy Logic Based Node Localization Framework Module*

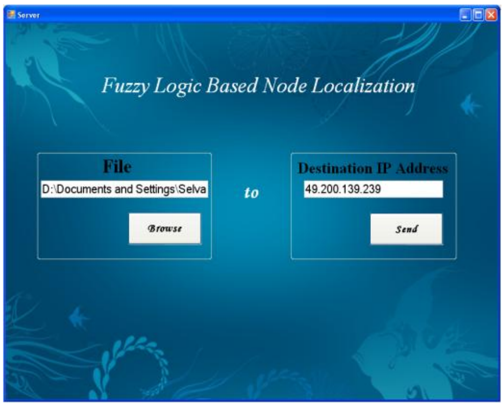
In this module, we develope a scenario with highly irregular radio ranges, typical of harsh indoor or extremely obstructed outdoor environments. The irregularity in the radio range is modeled in these simulators as a degree of irregularity (DoI) parameter. The DoI represents the maximum radio range variation per unit degree change in direction. We define a harsh environment as one in which the distance between sender and receiver cannot be accurately determined from the RSS alone, due to environmental phenomena such as multipath propagation and interference. For more complete problem formulation we mention that the aforementioned localization techniques assume that given a set of mobile sensor nodes, a subset of nodes, called anchors, know their location in a 2-dimensional plane. Also, nodes and anchors move randomly in the deployment area. Maximum velocity of a node is bounded but the actual velocity is unknown to nodes or anchors. Nodes do not have any knowledge of the mobility model. Anchors periodically broadcast their locations. All nodes are deployed in a noisy, harsh environment and they do not have any additional sensors except their radios.

Fuzzy Multilateration Module

We present fuzzy multilateration, a component of our fuzzy inference process, which obtains a node's location from noisy RSS measurements, using fuzzy rule sets

V. SCREEN SHOT

SOURCE:



LOCALIZATION:

VI. CONCLUSION

localization method suitable for wireless sensor nodes that are mobile in noisy, harsh environments. The constituent systems use fuzzy multilateration and a grid predictor to compute the location of a node as an area. The RSS is cast into bins which encode the imprecision; these bins are subsequently used in our mathematical framework. We remark here that the case of static anchors, considered by neither MCL, nor MSL, will be investigated in future work.

Our method has been evaluated based on a variety of metrics. They prove that our method is resistant to high DoI environments while providing a low localization error without any extra hardware. Only anchors need to have a slightly higher storage requirement. A deployment with more anchors at high DoI decreases the error. The ability to localize using both single-hop and two-hop anchors greatly increases the variety of topologies where localization succeeds. The system implementation proves that the algorithm functions well on resource constrained devices.

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