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Wi-Fi Localization using RSSI in Indoor Environment via a smartphone

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Abstract:

The widespread availability of wireless networks (Wi-Fi) has created an increased interest in harnessing them for other purposes, such as localizing mobile devices. While outdoor positioning has been well received by the public, its indoor counterpart has been mostly limited to private use due to its higher costs and complexity for setting up the proper environment. In this paper, we use local Wi-Fi network to localize a mobile user in an indoor environment.Wi-Fi (or 802.11 networking) works on the basic principal that data packets are sent using radio waves. These radio waves can be received by any compatible receiver placed in a pc, mobile phone, tablet pc or any other circuit. The aim of this research paper is to explore the application of 802.11 networking for localizing the user or the receiver by using RSSI i.e. Received signal strength indication. Through Wi-Fi, one may be able to track objects or people in real time,whilst adapting to changes in both the environment, and the Wi-Fi network, in a reliable manner. Since Distance and RSSI share a inverse relationship. RSSI can be used to locate the general location of the user.

An experiment is conducted in order to view the relationship b/w RSSI and Distance in an indoor environment using some basic domestic based equipment and an android phone.

Keywords:

RSSI, dBm, Wi-Fi, Localization, Triangulation, Ethernet, Android, Access Point

Introduction:

There has long been interest in the ability to determine the physical location of a device given only Wi-Fi signal strength. This problem, called Wi-Fi localization, has important applications in activity recognition, robotics, and surveillance. The key challenge of localization is overcoming the unpredictability of Wi-Fi signal propagation through indoor environments. The data distribution mayvary based on changes in temperature and humidity, as well as the position of moving obstacles, such as people walking throughout the building. This uncertainty makes it difficult to generate accurate estimates of signal strength measurements**.**

A wireless network uses radio waves. Using the following procedure:

- A computer's wireless adapter translates data into a radio signal and transmits it using an antenna.
- A wireless router receives the signal and decodes it. The router sends the information to the Internet using a physical, wired Ethernet connection.

- They transmit at frequencies of 2.4 GHz or 5 GHz. This frequency is considerably higher than the frequencies used for cell phones, walkie-talkies and televisions. The higher frequency allows the signal to carry more data.

The Transmitter of these signals is known as an Access point. In computer networking, a wireless access point (AP) is a device that allows wireless devices to connect to a wired network using Wi-Fi, or related standards. The AP usually connects to a router (via a wired network) if it's a standalone device, or is part of a router itself.

The Received Signal Strength (RSS) values measured by most radio transceivers can be used to estimate the distance between nodes and implement range-based localization schemes[2]. RSSI :Received signal strength indicator (*RSSI*) is a measurement of the power present in a received radio signal.
In an IEEE 802.11 system RSSI is the relative received signal strength in a wireless environment, in arbitrary units. RSSI is an indication of the power level being received by the antenna. Therefore, the higher the RSSI number (or less negative in some devices), the stronger the signal.[7]
In this paper RSSI is measured in "dBm".

The Received Signal Strength (RSS) values measured by most radio transceivers can be used to estimate the distance between nodes and implement range-based localization schemes. These schemes are popular because no additional hardware is required on the nodes to localize.

Methodology :

I conducted the study in an office environment with an Android phone.

At its core, the most basic of methods is the nearest sensor method [3]. The strongest RSSI of a wireless access point is assessed against a database where the maximum ranges of a variety of wireless access points are stored. RSSI denotes a ratio of a measurement of the power present in a received radio signal, and generally range from -20 to -100 dBm.
To put it otherwise, an RSSI capacity is an indication of the power level received by the antenna, where the larger number is an indication of a closer originating source [3]. As the maximum range indicates a circular perimeter due to the circular nature of propagation of Wi-Fi ,the receiving device is determined to be somewhere within the circular unit perimeter.

An extension of the Nearest Sensor method, this technique explores the use of multiple wireless access points to perform a triangulation of RSSI vectors. By using the signal strengths as distances, the angles of the RSSI vectors are derived. Using the angles, a common overlapping area is calculated to produce an area in which the receiving device can be found. This process results in a much more accurate method of geo-location than the Nearest Sensor methodIn order to show relation between RSSI and distance. distance between the wireless router and the receiver circuit is increased gradually and the strength of RSSI Is measured. [4].

Technology using Received Signal Strength Indicator; the client device measures the signal strength of the access points and sends the values to a server. On the server, the location of the client can be calculated if at least three values can be measured. RSSI performs better in indoor walled environments (e.g. hospitals, warehouses, distribution centers)[3] . in the end , the RSSI – distance characterization is plotted.

Experimental Setup :

The goal of this test was to obtain a characterization curve of RSSI as a function of distance. A router was placed on a table and I carried the phone and walked away from the router. At unequal increments, RSSI values were manually collected from the phone.

The experiment was conducted with the following description:

A simple home based wireless router is used as the transmitter: D-link ADSL router

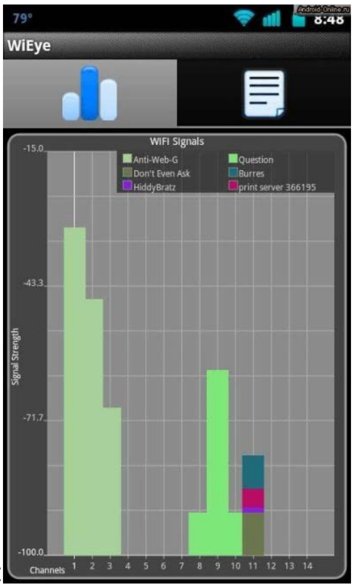
Receiver:

An mobile phone with a wireless adapter : Samsung galaxy s i9001,android os 2.3

Measuringtool: Android basedapp: *"WiEye"* It constantly measures accurate RSSI in dBm, fromthesource.

Distance is measured from the antenna in meters

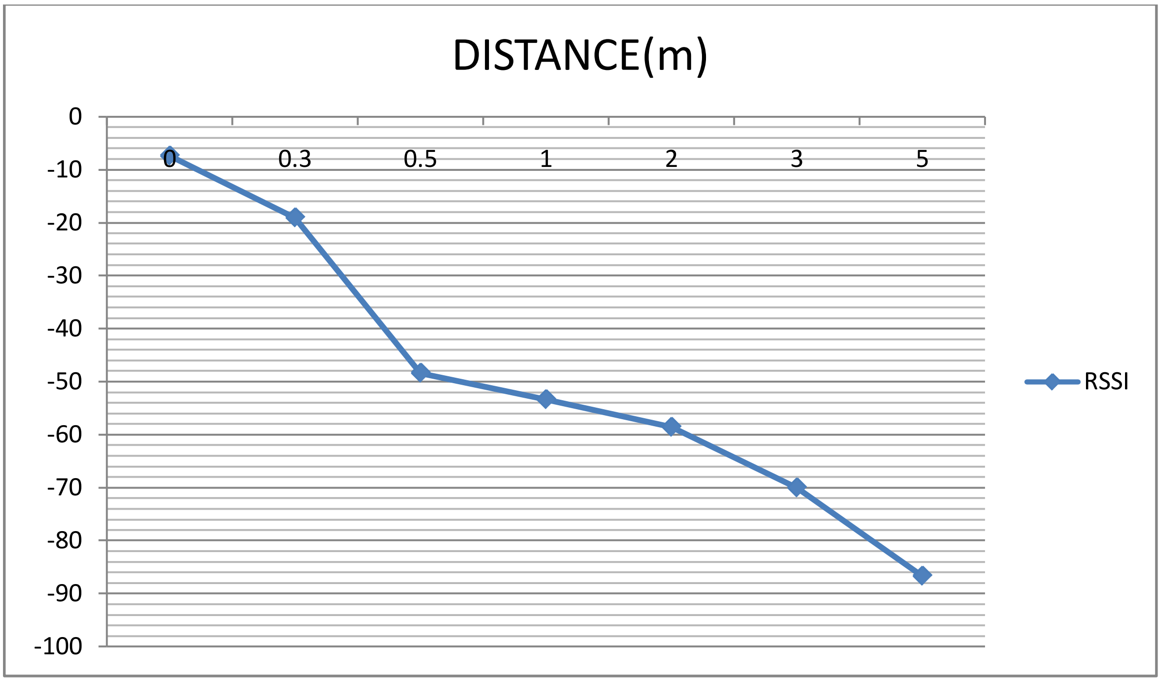
Screen shot



Observation :

S. no.	Distance(m)	RSSI (dBm)			Avg. RSSI(dBm)	Frequency
		R1	R2	R3	(R1+R2+R3)/3	
1	Negligible	-9	-7	-6	-7.33 dBm	2437 Mhz
2	0.3	-18	-17	-22	-19 dBm	2437 Mhz
3	0.5	-48	-49	-48	-48.33 dBm	2437 Mhz
4	1	-46	-55	-59	-53.33 dBm	2437 Mhz
5	2	-61	-55	-59	-58.55 dBm	2437 Mhz
6	3	-68	-72	-69	-69.99 dBm	2437 Mhz
7	5	-76	-89	-91	-86.66 dBm	2437 Mhz

RSSI- Distance Characterization:



(fig 1)

Result :

The RSSI characteristic (Fig.1) show an almost constant curve outside the 3 meter mark. The result also shows a very large variation in RSSI readings for a given distance relative to the change in RSSI as we move away from the router. This means that an RSSI for a given distance can fluctuate more than the difference in RSSI between two distances. Hence, it gives us an easy technique to provide a general localization , but not exact (x,y) coordinates using triangulation. After reaching a distance greater than 7 meters, RSSI reaches to a value lower than the threshold value. Hence signals can no longer be received by the adapter.Within the range of 7 meters, RSSI can be measured and hence the distance can be presumed using the graph.But it is only valid when the transmitter is transmitting at the same frequency.

Orientation errors :

The main source of error is the orientation estimate. A constant error in the heading would introduce an error that grows linearly with the distance from where the heading error was introduced. Once an error has been introduced to the heading it will affect all future updates of the position, since the orientation updates are relative to the previous estimate.

Discussion and conclusion:

In the initial round of experimentations, the results are crude and still have many untested cases. The probability of finding the correct match for the fingerprinting method can be significantly improved by incorporating certain database correlation algorithms such as K nearest neighbors, probabilistic algorithms like Hidden Markov Model or fingerprinting. There are difficulties in the current system to compute an accurate elevation using the trilateration method.

Main obstacle to designing an algorithm for smart phones is the limitations of the phones themselves. One major limitation for phones is battery life. This is in fact the single largest obstacle to designing more complex algorithms, as we cannot insist that the user constantly be scanning Wi-Fi networks in order to localize, as that would be an enormous strain on battery consumption. One aspect of phones that we could not account for at all was dealing with the wide variety of phones and corresponding hardware, putting limits on how much we could trust the data given to us. Finally, the computing and memory requirements have to be taken into consideration. While it is true that smart phones are highly capable machines, the users themselves don't want an application that takes gigabytes of data just to improve accuracy in localization. Indoor localization on smartphones is critical to enable novelfeatures for location based applications. However, existing approaches have yet to prove that they can satisfy what isdesiredin many business scenarios. Due to the prevalence of Wi-Fi infrastructure, it is imperative to study the accuracy that Wi-Fi localization can practically achieve on smartphones.

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