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# Android Smartphone Location Detection on Indoor Using Trilateration Method and Kalman Filter

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## Abstract:

*Detection devices in the room difficult to do using GPS as there are obstacles that result in a signal to the satellite is not* line-of-sight. Based on these problems, developed a system Indoor Positioning System (IPS) with fingerprint method. But the weakness of this method is the required process of data collection (offline stage) in advance who will take time before the system can be used (phase line). In this study using trilateration method by measuring the receive signal strength (RSS) of the sensor WiFi on Android-based smartphone. The problem that there is no stability of the RSS measurement results obtained, therefore, do filter the data using a Kalman filter RSS to reduce noise so that more accurate detection results. Results of research on measuring 8x12 meters closed room getting an average deviation of 1.6 meters.

*Keywords* ***—indoor positioning*****, Trilateration, Kalman filter.**

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## I. INTRODUCTION

With the rapid development of mobile Internet, the demand for location-based services or Location-Based Services (LBS) continues to increase, the service allows users to obtain and utilize the location information via smartphones, tablets, and other mobile devices. Location-Based Services are becoming increasingly necessary as it can support the needs of everyday people. Meanwhile, a variety of wireless network communications technology has become commonly used, such as Wireless Local Area Network (WLAN) and Fourth-Generation technology (4G).

Currently the Global Position System (GPS) is commonly used to locate the device outdoors with accuracy levels of up to 50 meters (Brena et al., 2017). However, the accuracy of GPS is strongly influenced by the environment around, because of the way it works is sending a wireless signal is line of sight (LOS) between the sending signals (satellite) signal receiver itself. So if the receiver is at a location that there are barriers to solid objects (eg buildings, basement, etc.) to the satellite's position in the sky, the accuracy of GPS can decrease. This causes the GPS is less suitable for use as a detection system in the room (indoor). To fill this void,

A common technique is applied to make the detection device in the room is that fingerprinting pattern recognition based on the signal strength of the receive signal strength (RSS), which will be matched with a database of signal patterns that have been collected previously.

Therefore this technique requires previous data collection activities pattern is commonly called the offline phase to build the data base [1], While the phase detection or pattern matching with an online database called phase pattern. Collecting the data base of this pattern is usually done manually, noting the pattern at each site to be detected, so the more locations that will do the detection, the more time it takes to build the database. The downside of this technique is that the process must be redone offline phase when there are changes that affect signal reception RSS as changes in the interior layout of the room, change the position of the access point and others.

The next technique is multirateration which basically uses geometry to measure the distance estimation of the various devices associated [2], Estimates range can be produced from different types of measurements such as RSS (Received Signal Strength), TOA (Time of Arrival) and AoA (Angel of Arrival), if there are three related devices is called trilateration. RSS measurement data can be generated from a Bluetooth device or WiFi.

The weakness of RSS-based detection is the receiving sensor data which fluctuate due to several factors such as electromagnetic noise, physical barriers, and variations in device specifications [3], To solve this problem, it needs filter algorithms so that the received data becomes more stable. Algorithms filter the data used by the GPS is is the Kalman Filter[4].

From the study of literature before, will be examined to detect locations using trilateration method which does not require the collection of RSS data base first and then will be filtering RSS received using Kalman Filter that are expected to get more accurate results.

## II. THEORETICAL BASIS.

### 2.1. Indoor Positioning System

Indoor Positioning Systemis a system that can determine the position of the device in a closed room or building. IPS implementation can be done using several technologies such as ultrasonic sensors, infrared sensors, RFID and some other equipment[5], This research will use the technology commonly found on smartphones and has the most comprehensive coverage according to the table above, namely WiFi. Bluetooth sensor is also commonly found in today's smartphones, but has a short range, in addition to the bluetooth is designed to adjust the signal strength when the signal is turned into a too strong or too weak, so that measurements based on signals become unreliable[6].

### 2.2. Trilateration

*trilateration*is a method to estimate the position coordinates of the target node by calculating the distance between some stationery (at least there are three stationery) with a target node. The concept of trilateration shown in Figure 1.

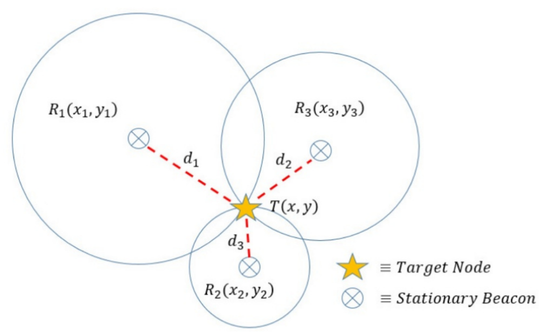


Figure 1: Concept trilateration

In this figure, the position of the target node can be calculated by the following equation as a public circle [7].

$$(x_t - x_1)^2 + (y_t - y_1)^2 = {d_1}^2 \quad (2.1)$$

$$(x_t - x_2)^2 + (y_t - y_2)^2 = {d_2}^2 \quad (2.2)$$

$$(x_t - x_3)^2 + (y_t - y_3)^2 = {d_3}^2 \quad (2.3)$$

Based on these equations, variables and are the coordinates of the user's position to be searched,,, are the coordinates of each stationary, whereas,, are the coordinates of a stationary transmitter, and,, is the distance between the stationary target node. Of the equation, then and later can be obtained through the steps of substitution and elimination.

$x_t y_t x_1 x_2 x_3 \; x y_1 y_2 y_3 y d_1 d d_3 x_t y_t$

### 2.3. Receive Signal Strength (RSS)

To determine the strength of the wireless signal reception between WiFi Access Point, can be done by measuring the receive signal strength. The smaller the received signal strength, it is assumed that the greater the distance between the two points. Conversely, if the bigger or stronger signal is received, it is assumed that the distance the two points closer. Therefore, the value of RSS should be obtained within. But unfortunately not so easy to get a distance based on the value of RSS because RSS value is a combination of the strength of the reflected signals and not just the signal obtained by line-of-sight. Shown in Figure 2 is a comparison chart of the RSS in a distance of 1 meter.

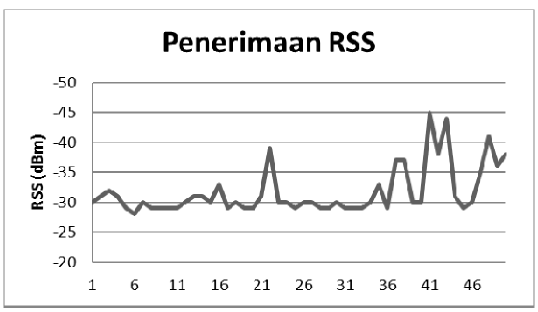


Figure 2: Graph RSS within 1 meter[3]

In Figure II-5 WiFi signal is measured at several distances ranging from 1 to 8 meters. In the error bar indicates the value of RSS at each distance measured, where the variation is so large that the value of RSS RSS is not suitable for accurate positioning.

### 2.4. Free Space Path-Loss (FSPL)

A formula for calculating the distance estimation based on RSS[8] by the following equation:

$$RSSI = -(10n \log_{10} d + A) \qquad (2.4)$$

RSSI is the RSS value received on measurement, n is the value of the spread signal, d is the distance between sender and receiver, and A is RSS obtained from measurements within 1 meter. Equation (2.4) can be lowered to get the distance (d) to be:

$$Distance(d) = 10^{\frac{A - RSSI}{10 * n}} \qquad (2.5)$$

For the value n is distributing signals, depending on the environment [9], For example, the barrier-free environment (free space) the value of n is 2.

### 2.5. Kalman Filter

Kalman Filter did forecast or estimate a process using feedback control, the first filter will create a state estimation process at one time, and then receive feedback in the form of measurement sensors usually contain noise. Thus the Kalman filter equations can be divided into two parts, namely the equation time update equations and measurement update. Equation time updates serve to establish the current state estimate and error covariance to obtain the estimates for the next time step. Measurement equation update function to incorporate the new measurement to the previous estimate for the next get better estimates. Equation time updates can be referred to the predictor equations, while the measurement update equations can be referred to the equation corrector [10].

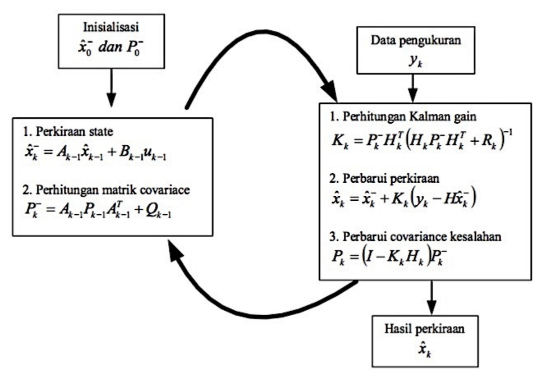


Figure 3: The process of calculating Kalman Filter[11]

## III. SYSTEM DESIGN AND APPLICATIONSPAGE STYLE

In this study used methods of literature study conducted by collecting literature and references related to implementing coordinates detection Android smartphone with trilateration method utilizing the WiFi signal strength. In addition, researchers also collected literature and references associated with the Kalman Filter to remove the data noise.

Reference or data that has been collected, sorted according to the field of detection discussion in indoor locations. In the process of detection of the location of the first things to do is to determine the tracking method will be used, in this case the researchers decided to use trilateration method for based on the literature and references are collected, this method has good accuracy.

Furthermore, installing the access point as many as three in a 4x4 meter room that will be used to detect the Android smartphone device. Then provides the object to be tracked, the Android-based smartphone devices that have WiFi sensor.

### A. Draft Process

The process begins by checking whether WiFi is activated on smartphones, if not then providenotification to the user to mengaktikannya first. If it is akftif then continued with the process of scanning all APs already adjusted its position in the previous process. During the scan takes place, will get the RSS signal strength of each AP for later filtering using a Kalman filter which aims to reduce the noise which can make detection becomes inaccurate results. RSS data that was filtered then be converted into the distance. Having obtained estimates of the distance to each AP then continue on the last process is determining the location of a smartphone based on the distances using trilateration method with the results in the form of coordinates.

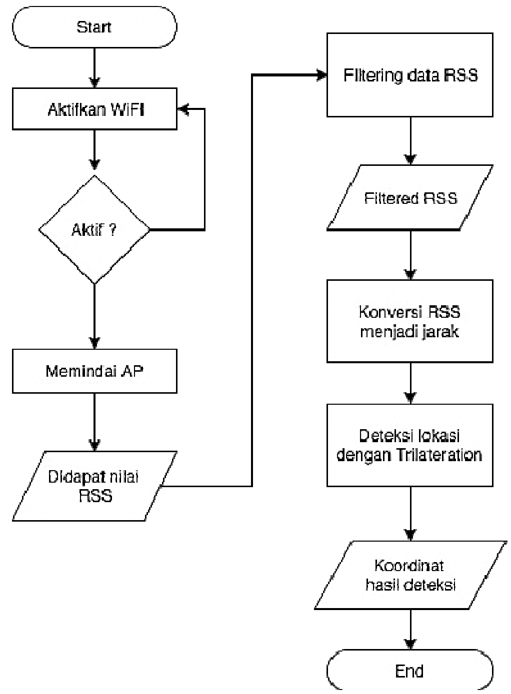


Figure 4: Flowchart Applications

Information :

- The process begins by checking the availability of WiFi on the smartphone
- If WiFi is active then further process the AP scan in the surrounding
- If there are AP around the smartphone, it will get a signal strength that is RSS
- Perform filtering RSS obtained using a Kalman filter and be "filtered rss"
- Conversions "rss filtered" into the distance
- Perform calculations by calculating respective distances maing obtained from the AP using trilateration in order to get the coordinates of the device being searched

### B. Draft Views

The prototype screen design describes the implementation of location detection smartphones that will be displayed through the smartphone screen. Here is a picture of a prototype of the application's main page

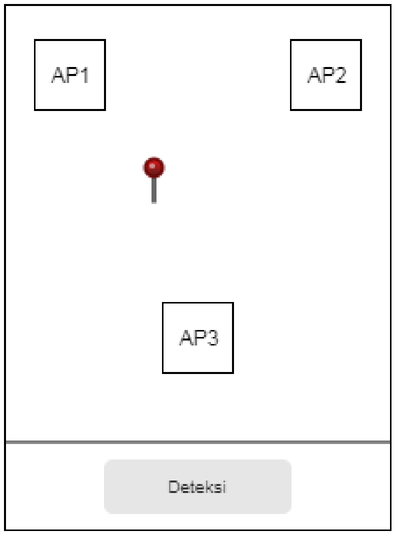


Figure 5: Design Views

## IV. RESULTS AND DISCUSSION

This research will be tested in a closed room measuring 8x12 meters on the 4th floor with conditions there is no obstacle in the form of a solid object or electronic equipment other than the equipment needed in research. It aims to determine the accuracy of the research to minimize the noise that exists.

A. Testing at a distance of 1 meter

This test puts the smartphone with the AP at a distance of 1 meter with both idle position. Data taken as many as 50 pieces. The measurement results the average distance for No. Filter (0.92 meters) closer to the actual position (1 meter) than the Kalman Filter (0.82), but when seen in the overall graph the data in Figure 6, the data that has been do filtering, deviations of the actual distance to the measurement results are relatively stable when compared to the data without the filtering.

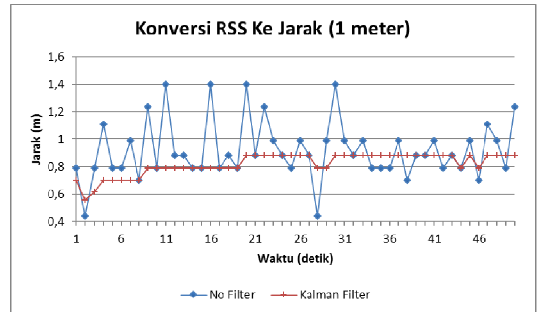


Figure 6: Convert RSS into a distance of 1 meter

B. Testing at a distance of 2 meters

In this test do the same thing with the previous test, only this time between devices by a distance of 2 meters. The results of taking 50 data, the average distance obtained without the filter of 1.44 meters, while the average distance using a Kalman filter of 0.9 meters. But if you look at the data to-32 in Figure 7 seen a surge in RSS received (most likely caused by noise occurs), so that the measurement data without the use of filters also surged, while the data using a Kalman filter not participate soaring. This shows that the Kalman Filter can detect the noise contained in the data.

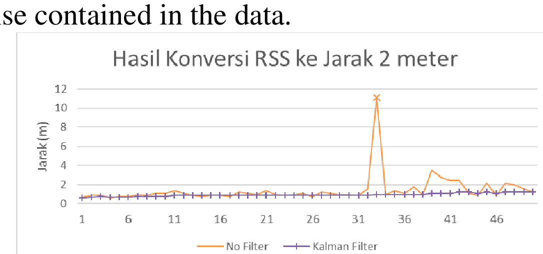


Figure 7: Convert RSS into a distance of 2 meters

C. Testing moves at a distance of 1 and 2 meters

This test aims to determine if the pattern changes between devices RSS is first placed at a distance of 1 meter, then 30 seconds later eliminated smartphone to be 2 meters away from the AP then returned to the original distance is 1 meter from the AP. The graph in Figure 8 shows the trend of the movement of data without the filter can reach up to 3.5 meters (second-to-21-35), whereas the actual distance is less than 2 meters. While the data do Kalman Filter, the trend is more stable movement of data, this suggests that the Kalman filter can detect trends that data changes are not caused by noise.

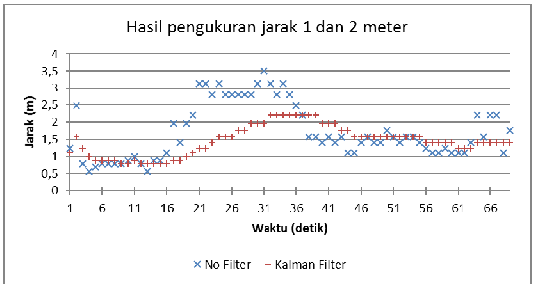


Figure 8: Conversion RSS distance of 1-2 meters

D. Tests using three APs

This final testing is done with three APs that have been previously set so that the known coordinates. The measurement process is bringing smartphone testers will run in a straight line as far as 1 meter every 20 seconds, after running as far as 4 meter test data generated as many as 100 pieces. On this measure aims to calculate the distance deviation between the actual position coordinates with the coordinates of the measurement results using euclidean distance, the results are average deviation for the measurement without the filter of 2.53 meters. While the average deviation using the Kalman Filter 1.32 meters. For deployment data can be seen in Figure 9.

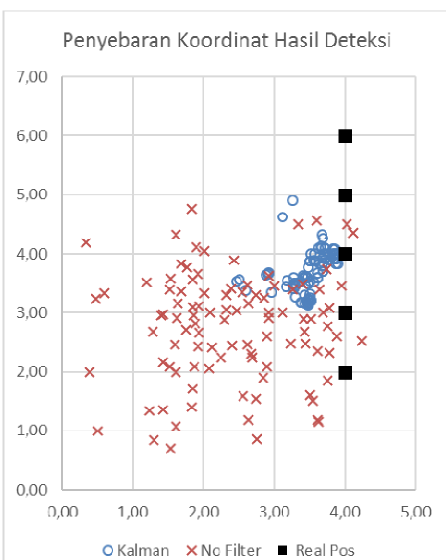


Figure 9: Graph data dissemination detection results

## V. CONCLUSION

Based on research that has been done, this study can answer the hypothesis at the beginning of the study is formula FSPL can be used for the conversion of RSS feeds into the distance with the result that approached within true, then the distance measurement results of the three APs to be used in the method of trilateration to detect the coordinates of the device in indoor. Then by using a Kalman filter data filter can minimize the noise on the measured data RSS. The test results without using the Kalman filter detection indicates an average deviation of 2.5 meters.

While the results of measurements using a Kalman filter shows average deviation smaller at 1.6 meters. For further research can be done on a longer distance and a larger room. Then conditions in the room given the variation with many obstacles in it or electronic devices that can describe the ideal conditions. Then from the side of the device used for testing can be done using other smartphone or WiFi device with better ability. Moreover, it can be tested with several smartphones in the same scope.

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