UNIVERSITI TEKNIKAL MALAYSIA MELAKA

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ANALYSIS AND SIMULATION OF OBJECT LOCATOR IN TRILATERATION GPS SYSTEM

This report is submitted in accordance with the requirement of Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor Degree of Engineering Technology (Telecommunications) with Honours

by

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ABSTRACT

This project gives an overall description about GPS trilateration system to get the complete idea on how the trilateration GPS system has work. Besides that, this project also discusses about technique and method has been used in trilateration GPS system. Trilateration GPS system is to determine user position, speed, and elevation. GPS navigators constantly received and analyse radio signal from GPS satellites, calculating precise distance to each satellite being tracked. The problem has been face is the accuracy of the GPS system to calculate the distance sometimes error. As the GPS signal propagate from the GPS satellite to the receivers located on the ground sometimes not accurate. The error is about 3.0 meter. Therefore in this project, focus on how to improve the performance of the object locator by using trilateration GPS system. To complete this project method of calculation, measurement, parameter, animation and simulation has been used. Formula to achieve calculation has been study and analyse. Animation of this project is completed using flash adobe software. Meanwhile, simulation program and test of object locator of trilateration GPS using MATLAB software and GUI were completed and present successfully.

ABSTRAK

Projek ini memberi penerangan menyeluruh mengenai sistem GPS trilateration untuk mendapatkan gambaran yang lengkap tentang bagaimana sistem trilateration GPS beroperasi. Selain itu, projek ini juga membincangkan mengenai teknik dan kaedah telah dalam sistem trilateration GPS. Sistem Trilateration GPS adalah untuk menentukan kedudukan pengguna, kelajuan, dan ketinggian. GPS navigator sentiasa menerima dan menganalisis isyarat radio daripada satelit GPS, mengira jarak yang tepat untuk setiap satelit yang dikesan. Masalah ini telah menjadi punca utama ketepatan sistem GPS untuk mengira jarak sehingga menghasilkan kesilapan. Isyarat GPS mengradiasi isyarat dari satelit GPS kepada penerima yang terletak di atas tanah yang kadang-kadang tidak tepat. Kesilapan itu adalah kira-kira 3.0 meter. Oleh itu dalam projek ini, tumpuan diberi kepada cara bagaimana untuk meningkatkan ketepatan objek dengan menggunakan sistem trilateration GPS. Projek ini dilengkapkan dengan pengiraan, pengukuran, parameter, animasi dan simulasi. Formula untuk mencapai pengiraan telah dipelajari dan dianalisis. Animasi projek ini siap dibina menggunakan perisian Adobe Flash. Sementara itu, program simulasi dan ujian pencari objek trilateration GPS menggunakan perisian MATLAB dan GUI telah berjaya dilaksanakan.

DEDICATIONS

I dedicate this report to my loving parents and husband. I am deeply indebted and grateful for their continuous support throughout my social and academic life.

ACKNOWLEDGMENTS

All the praise to all mighty ALLAH, for His bestowing with the courage, knowledge, health and wisdom to carry out this project. I would like to express my gratitude and appreciation to all those who gave me the possibility to complete this report. A special thanks to my parents and husband, without endless moral support, patience and prayers the very idea of this project was impossible. I would like to pay our humble gratitude to our project supervisor Mr. Chairulsyah b. Wasli. His encouragement was the main source and strength to drive me to complete the project.

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INTRODUCTION

1.0 Background Project

The project gives an overall description about how the Trilateration GPS system works as well as technique and method adapted by the system. Trilateration GPS system is used to determine user's position, speed, and elevation. GPS receiver constantly receives and analyses radio signal from GPS satellites, and calculating precise distance to each satellite being tracked. There is sometimes error in the accuracy of the GPS system, since the calculated GPS signal propagation between the GPS satellite and the GPS receiver is not accurate, which is about 3.0 meter. Therefore this project focuses on how to improve the performance of the object locator by Trilateration GPS system.

1.1 Objective

Objective of this report is to gain knowledge about the GPS system especially in the Trilateration GPS system. Besides that, this report will show how to find location of an object using 3 dimensions in Trilateration GPS system. Once working principle of Trilateration GPS system is understood, performance of object locator can be improved. Last objective is to learn how to make animation and simulation program about object locator in Trilateration GPS system.

1.2 Problem Statement

Trilateration GPS system is used to determine user's position, speed, and elevation. GPS receiver constantly receives and analyses radio signal from GPS satellites, and calculating precise distance to each satellite being tracked. There is sometimes errors in the accuracy of the GPS system, since the calculated GPS signal propagation between the GPS satellite and the GPS receiver is not accurate, which is about 3.0 meter. Therefore this project focuses on how to improve the performance of the object locator by Trilateration GPS system.

1.3 Work Scope

The scope of this project is to design and analyse coordinate location in GPS using Trilateration GPS system. After identifying the project title, detailed studies and researches through reference materials available from the internet and books are carried out. The next step is to present the animation that shows how the GPS receiver uses trilateration to determine its position on earth by timing signals from three satellites in the Global Positioning System. The GPS satellite sends a signal to GPS receiver providing precise details of the receiver's location, the time of day, and the speed of the receiver in relation to all three satellites. Once a GPS receiver has distances from at least three satellites, it can perform the trilateration calculations. Trilateration works in a similar way to pinpointing your position on a map knowing the precise distance from three different landmarks using a pair of compasses. Your location is where the three circles, centred on each of the landmarks, overlap; given the radius of each circle is your distance from each landmark. The next step is calculations. The calculations are carried out in three dimensions with an imaginary set of 3D compasses, so that position of the observer is where all three spheres, with radius given by the distance to each of three satellites, overlap. If the GPS device can see a fourth satellite, then the measurements can be double-checked. The calculation process happens very quickly, allowing the

GPS receiver to determine its location, altitude, speed and direction. The calculation involves many aspects such as delay time, operating frequency, pulse, power transmit, loss, accuracy and other affected parameters. When all the processes are completed, last step is to arrange the information and preparing final report.

1.4 Result Expectation

The expected results from this project are:

I. Successful improvement of object locator using trilateration GPS system,
II. Location of an object in 3 dimension used trilateration GPS system has been identified successfully,
III. The theoretical, design and measurement aspect of trilateration system in GPS system has been designed and analyzed,
IV. Suggest improvement 3 meter for enhance accuracy,
V. Simulation program and test of object locator using trilateration GPS system completed and presented successfully.

CHAPTER 2

LITERATURE REVIEW

2.0 Introduction

Literature review gives overall description of past related researches. A few case studies about the trilateration GPS system will be carried out. This review also will discuss about theory explanation of Trilateration GPS system.

2.1 Past Related Research

This sub-topic explains about cases related to Trilateration GPS system that has been conducted by other researchers. More understanding and knowledge gained after going through these cases, hence making it more interesting to explore further about the system.

2.1.1 Indoor and outdoor location sensing using GPS system

This case study is about indoor and outdoor location sensing using GPS system. The main point of this study is to discuss about the trilateration system. The indoor location trilateration is measuring the distance between the object and some reference positions. Calculating in two dimensions distances measurements from three non-collinear points or by calculating in three dimensions, distance measurements from four non-collinear points are required in this situation is shown. This measurement uses the velocity and movement to measure the time between two points. Concern the round trip reaction of the signal in the measurement. Example is GPS receivers, while it's too hard

to measure the time from the space to the object; it uses local time in transmitting where the GPS receivers estimates the time of flight.

This study of indoor and outdoor location sensing using GPS system used has been explained in this study. The radio signal is used to get the distance and position to each satellite, the receiver computes its position using trilateration. GPS receivers can relay position data to a PC or other device using the NMEA 0183 protocol. GPS Receiver as an example to understand how GPS Location sensor works: GPS consists of 27 satellites; each of these 3000 to 4000 pound solar powered satellites surrounding the globe at about 20000 Km, making two complete rotations every day.

Every satellite has its own atomic clock for time measuring in an accurate way, when the satellite emits a signal, it indicates the time when the signal start emitting. On the ground the GPS receivers contains usual clock, when the signal arrives, the GPS receiver is able to recognize the satellite, and the time taken. This way it's possible to calculate the distance, and this occurs after getting four signals from different satellites (at least).and as a result the user will get the numbers regarding to longitude latitude, altitude, and some other information this depends on the GPS receiver. Others cases is might lose the communication, such as facing a long building, thick clouds, forest, storm etc. Those reasons make positioning takes much more time to reach the aim. Sometimes it might be satellite working issues, for example not finding enough satellites, where you can't have fix position for the desire point.

2.1.2 Improving Localization Given Noisy Data In GPS Equipped VANETs Using Trilateration With Cluster Analysis

This study looks at ways of using VANETs to improve the accuracy of the location estimates provided by GPS devices. The algorithm Location Improvement with

Cluster Analysis (LICA) presented in this paper achieves and can also be implemented Sensor Networks (WSN) where some, if not all, nodes are equipped with GPS devices. In this study has discussed about LICA can improve the accuracy of location estimates with certain levels of noise and corrupt data present in the system. One possible solution to this problem is to develop a system which uses GPS and VANETs to provide more accuracy in computing each vehicle's locations. Here, the GPS is used to provide the initial location estimates for each vehicle then afterwards the vehicles communicate with each other to improve the accuracy of their own location estimates or maintain a certain level of accuracy until the next GPS update is available.

There are some situations where the accuracy and reliability of the GPS decreases or the vehicle cannot receive signals from the GPS satellites. These situations can arise when the vehicle is travelling through a tunnel or between high rise buildings. Providing accurate location systems will allow vehicles to construct detailed models of the current state of the traffic, allowing individual vehicles to compute the ideal route/detours to take. When messages detailing accidents are passed onto other vehicles connected to the VANET, the drivers may incorrectly conclude they are not travelling towards the accident site because of their inaccurate location system and therefore not take early action to avoid further collisions or contribute to the build-up of congested areas. One possible solution to this problem is to develop a system which uses GPS and VANETs to provide more accuracy in computing each vehicle's locations. Here, the GPS is used to provide the initial location estimates for each vehicle then afterwards the vehicles communicate with each other to improve the accuracy of their own location estimates or maintain a certain level of accuracy until the next GPS update is available.

2.1.3 User Position Detection in an Indoor Environment using trilateration GPS system

This study discusses about User Position Detection In An Indoor Environment using trilateration GPS system. The study is based on the issue in order to determine the position of an object in indoor environment or inside a building. The problems arise

when the position of an object inside a building cannot be determined using GPS. This journal proposed the implementation of trilateration technique to determine the position of users in indoor areas based on Wi-Fi signal strengths from access points (AP) within the indoor vicinity. In this paper, percentage of signal strengths obtained from Wi-Fi analyzer in a smartphone were converted into distance between users and each AP. A user's indoor position could then be determined using a formula proposed based on trilateration technique. Global positioning system GPS and Wi-Fi positioning technique using Wireless Local Area Network (WLAN) to achieve the accurate coordinates in indoor environment, however a GPS also have limitations in indoor environment because of GPS is unable to decode data from satellites. This paper proposes indoor position detection using Wi-Fi signal strength with trilateration technique.

In this study explained that trilateration technique is a mathematical process that is used by GPS receiver to calculate the position of an object in two dimensional or three dimensional spaces. The definition of trilateration in a geometry part is the process of determining the absolute location or relative locations of point by measurements of distances, using geometry of circles, spheres or triangles. In this study, the measurement of distance is used in the geometry part to propose a method in indoor position. Then, the measurement of this distance is used to form three equations of a circle that will be solved using linear system of equation (Nor Aida Mahiddin, Elissa Nadia Madi).

2.1.4 Beyond Trilateration: GPS Positioning Geometry and Analytical Accuracy

This case study discuss about trilateration in GPS positioning geometry and analytical accuracy. Trilateration is the fundamental basis for most GPS positioning algorithms. It begins by finding range estimates to known satellite positions which provides a spherical Locus of Position (LOP) for the receiver. Ideally four such spherical LOPs can be solved to precisely determine the receiver position. Thus, it is an analytical approach that finds receiver position by solving required number of

linear/quadratic equations. This method can determine the receiver position precisely when the equations are perfectly formulated.

However, determining the exact range is nearly impossible in real life due to many external factors such as noise interference, signal fading, multi-path propagation, weather condition and clock synchronization problem. Hence, trilateration fails to achieve sufficient accuracy under real world conditions. It is also argued that GPS algorithms are not at all trilateration rather they are difference of measurement. In addition, this study is discussed about the analytical accuracy of trilateration based positioning algorithms and also shows how noise can impact positioning accuracy in real world. This study shows the calculation of trilateration and how to approach the accuracy. Detailing about calculation will show in methodology part.

2.2 Theory of trilateration GPS system

This part will briefly describe about Trilateration GPS system theoretically; the definitions, how the Trilateration GPS system works and figures explaining the system.

2.2.1 Definition

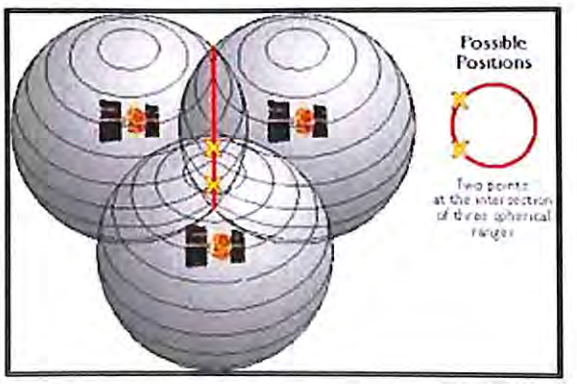

Figure 2.1 shows two point at the intersection of three spherical ranges of Trilateration GPS system

Trilateration GPS system is a method of determining position by measuring distances to points at known coordinates. Trilateration requires a minimum of three ranges to know three points (Ahmed El-Rabbany). Two point at the intersection of three spherical ranges of Trilateration GPS system as shown in Figure 2.1.

Trilateration GPS system use mathematical technique to determine user's position, speed and elevation in Global Positioning System (GPS) navigation system. The system connects with three GPS satellites also known as three dimensions surrounding the receiver. GPS receiver will constantly receive and analyse radio signals from these satellites and calculating precise distance range to each satellite being tracked.

In Trilateration GPS system, initially a data from the first satellite narrows position down to a large area of the earth's surface. Then, second satellite narrows position down to the region where two spheres of these satellites overlap. Finally, third satellite provides relatively accurate position. In addition, data from fourth satellite enhances precision and also the ability to determine accurate elevation or altitude.

2.2.2 Trilateration Operation

The Global Positioning System (GPS) is a network of GPS satellites that orbit the earth and send signals to GPS receivers providing precise details of the receiver's location, the time of day, and the speed of the receiver in relation to the speed of the satellites. A GPS receiver uses trilateration operation to determine its position on earth by timing signals from at least three GPS satellites (Rick Broida).

Each satellite in the GPS constellation sends out periodic signals along with a time signal. The signals are received by GPS receivers on earth, which then calculate the distance between the receiver and each satellite based on the delay between the time the signal was sent and the time when it was received. The signals travel at the speed of

light, but there is a delay because the GPS satellites are at an altitude of tens of thousands of kilometers above the earth.

Once a GPS receiver has distances for at least three GPS satellites, it can perform the trilateration calculation. Trilateration calculation works in a similar way to pinpoint observer's position on a map when precise distances from three different landmarks to the observer's position are known, using a pair of compasses. The position will be the overlapping of three circles, centered on each of the landmarks, given the radius of each circle is distance from each landmark to the observer's position.

In the GPS version, the calculations are carried out in three dimensions with an imaginary set of 3D compasses so that receiver's location is where three spheres of radius given by the distance to each of three satellites overlap. If the GPS receiver can see a fourth satellite, then the measurements can be double-checked. The calculation process happens instantaneously, allowing the GPS receiver to ascertain its location, altitude, speed and direction. Explanation above refer to Figure 2.2(a) position is somewhere on the circumferences of the circle. Figure 2.2(b) position must be one of the intersection between Point A or Point B and Figure 2.2(c) position is on point A.

The transmissions are programmed to begin precisely on the minute and the half minute as indicated by the satellite's atomic clock. The first part of the GPS signal tells the receiver the relationship between the satellite's clock and GPS time. The next chunk of data gives the receiver the satellite's precise orbit information.

Refer to Figure 2.2(a) position is somewhere on the circumferences of the circle. Figure 2.2(b) position must be one of the intersection between Point A or Point B and Figure 2.2(c) position is on point A. Aid with this figure ccordinate of point A is identify easily.

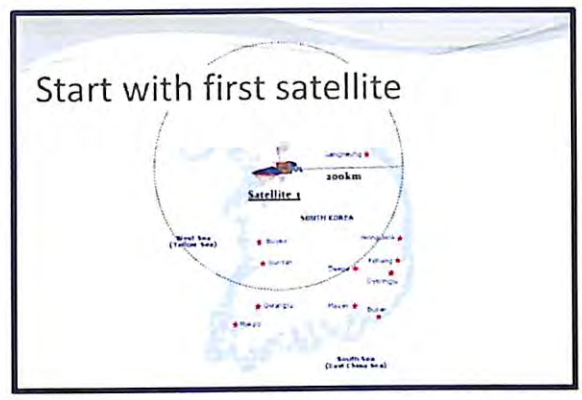

Figure 2.2(a) shows position is somewhere on the circumferences of the circle

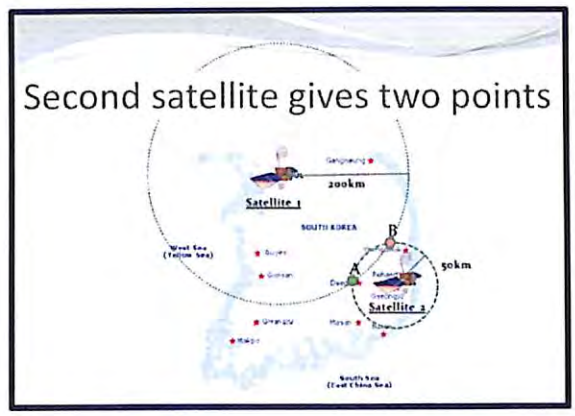

Figure 2.2(b) shows position must be one of the intersection between Point A or Point B

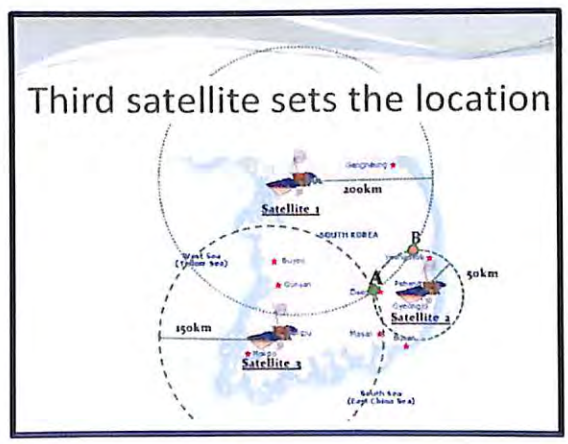

Figure 2.2(c) shows position is on point A