

Intelligent 2D Outdoor Location Tracking System

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Abstract

This paper presents results of ongoing work on development of a real-time outdoor positioning system for an escaping target. The overall goal is determination of the location of the target relative to the pursuer in real time and determination of the speed and direction of escape of the target from a pursuer. This paper highlights on the location of a ground moving target confined in a two dimensional (2D) arena. The location parameters of the target are obtained by use of global positioning system (GPS) then transmitted to a central computer for analysis. Velocity of the target in the arena is obtained by use of haversine equation and direction of escape is determined from triangle's equations. From the data the system determines if the target is escaping and the direction of escape. The results obtained can be used to inform the development of a pursuit algorithm.

Keywords: Outdoor Tracking , Positioning, Real-time tracking

Introduction

Diverse applications of electronic based positioning systems have necessitated widespread research in hardware and software for localization and tracking. Such applications include traffic navigation, military asset monitoring and wildlife management. The setup usually consist of a mapped arena, a target and computation algorithm.

In literature, many approaches have been proposed such as GPS compressive sensing for location acquisition (Song 2018), hybrid systems (Jiang,et-al 2010) and smartphone based systems. These approaches present stand-alone systems that presents results to the end user but are not easy to integrate with other electronic systems such as pursuit systems. In this paper, a platform is presented for locating a target in a 2D arena and determining whether the target is escaping or not.

Platform Design

The platform as shown in Figure 1 consists of a portable electronic station that can be attached to the target and a central computer running a program designed to monitor a randomly moving ground target.

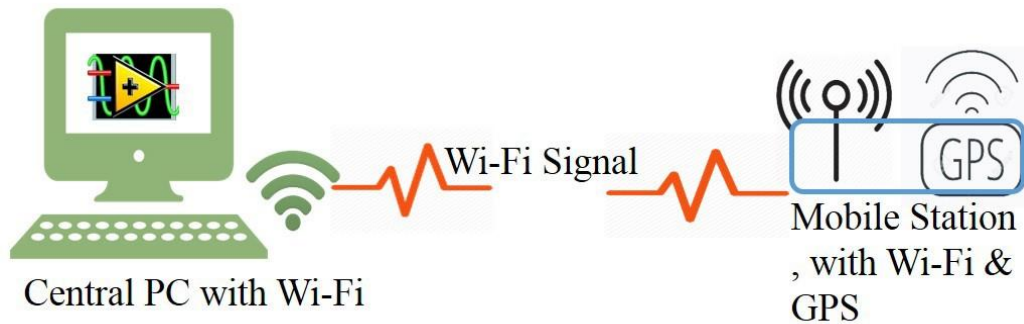


Figure 1: Platform

Communication between the central computer and mobile station is through Wireless fidelity (Wi-Fi). Wi-Fi is a wireless communication standard based on IEEE 802.11a with a range of about 100 metres (Lee& Shen 2007). The mobile station is equipped with GPS receiver and it receives the signals of several transmitters in known locations and computes its location based on the measured signals. The mobile GPS receiver is portable and with ability to endure outdoor environment for long. It should have a mobile power supply unit that could sustain it for a long time before recharging it.

The hardware for the system consist of Pmod GPS receiver, chipKIT WF32 both by Digilent and a rechargeable Li-ion 5V battery. The *PmodGPS* sensor uses UART interface for communication and was connected to WF32 TX (transfer data) and RX (receive data) pins. The chipKIT WF32 is a WiFi enabled Arduino based board with a PIC32 microcontroller (80 MHz). Detailed information of these boards are presented in their reference manuals (Micro, Czernek et-al 2016). The hardware also consists of a long range WiFi access point for connection of the mobile unit to the monitoring PC. The Station then uses triangulation in order to determine its location in latitudes and longitudes. This information is transmitted to the master station through a wireless data link.

The master station receives the data encoded in form of National Marine Electronics Association (NMEA) sentences. NMEA is a standard data format for GPS devices (Si 2011). NMEA data contains multiple data items in a single line separated by commas (Al-Tae et-al 2011). Each NMEA sentence begin with \$ and cannot be longer than 80 characters including line terminators (Shoab 2013). In these sentences the data items are separated by commas. The main data items are

Satellites in view, Longitude, Latitude, Altitude and Time. The sentences are then interpreted using a code in LabVIEW then distance and bearings are determined.

Once the coordinates are acquired, it is possible to determine the distance of the point of interest (say Q) from any other point on earth surface (say P) by use of haversine function (Winarno et-al 2017).

$$d = 2r \sin^{-1} \left(\sqrt{\sin^2 \left(\frac{\phi_2 - \phi_1}{2} \right) + \cos(\phi_1) \cos(\phi_2) \sin^2 \left(\frac{\lambda_2 - \lambda_1}{2} \right)} \right) \text{ where}$$

d is the space between two coordinates. r is the radius of the sphere

ϕ_1, ϕ_2 Longitude of position p and q.

λ_1, λ_2 Latitude of position p and q.

The function provides a means of determining the great circle distance which is the shortest distance between two points, measured along a sphere (Mishra 2016). See Figure 2.

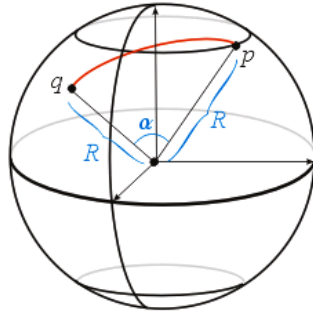


Figure 2: Great Circle Distance

In this case the sphere is the earth whose average radius at the equator is R . The equation determines the distance from point P to point Q along the indicated path as shown in the figure. The bearing is then computed from triangle geometry equations.

Test Setup and Results

Setup

The system was deployed for testing, where first the coordinates of a stationary pursuer were acquired and distance obtained against a stationary target as shown in Figure 3.

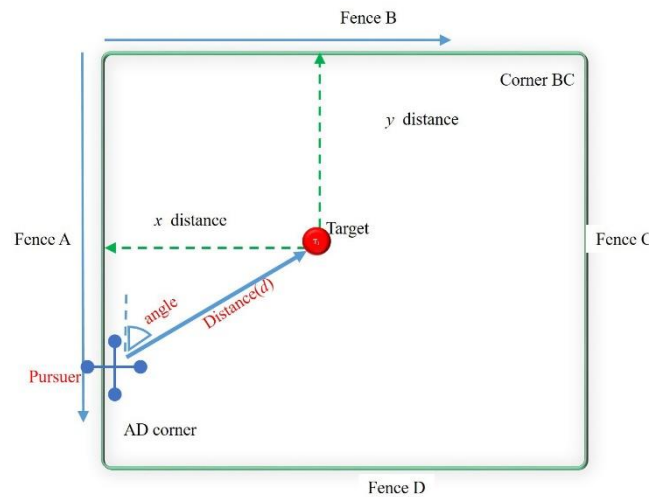


Figure 3: Target Distance

A program was developed in LabVIEW for acquisition of coordinates from microcontroller through WiFi as shown in Figure 4.

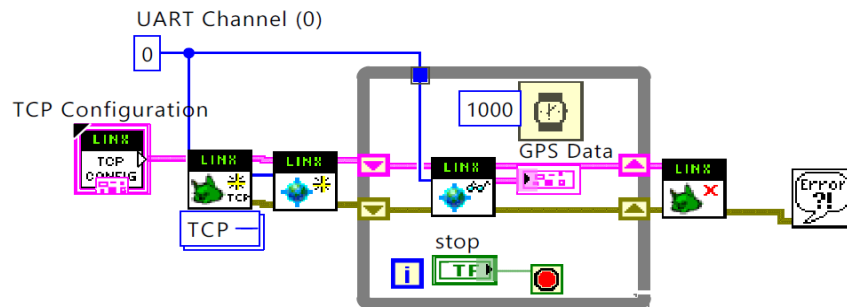


Figure 4: LabVIEW Screen-shot for Location Acquisition

The program acquires NMEA sentences from ChipKit WF32 through WiFi from UART channel 1. The sentences are then interpreted to give 11 parameters. These parameters include: -the Number of satellites in view, Time, Date, Longitude, Latitude, Altitude, Speed, Status and Fix type. The results obtained are represented in a graph and the distance of the target from reference points is obtained.

Experiments were carried out at the iPIC centre (JKUAT), sample was taken for the pursuer as shown in the screen-shot Figure 5.

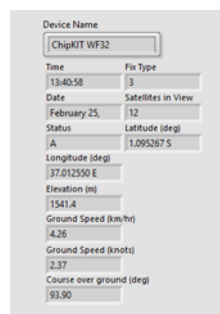


Figure 5: GPS Parameters of Target

The device name box indicates the identity of the hardware used by the computer for data acquisition, Time provides the 24 hour clock data on the time of the experiment 10:23am, Date is the date when the data was taken (25th February).

Fix type (3) means that the data obtained is for three dimensional locations. The Status provides Navigation receiver warning status where A means OK and V indicates presence of a warning. Satellite in view gives the number of satellites available, the higher the number the better. The Latitude and Longitude data is given in decimal degrees while the altitude is in metres. Of these parameters, only the Latitude, the Longitude and Time are of interest to the research.

Results

The location of the target monitored and the motion pattern plotted as shown in Figure 6. The samples were taken at a constant time interval of 1 Second. The graph shows the Longitudes and Latitude location of the target.

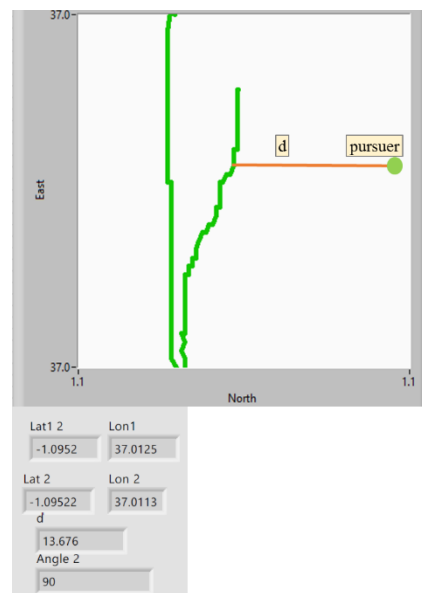


Figure 6: Target Map

The distance of the target from each wall was monitored and it was regarded as escaping when it was close to any of the walls and approaching it (speed is positive). This is shown in the screenshot of Figure 7. From the screenshot, the target state is "escaping" since it is close to wall C (0.9717m) hence the red dot on the screenshot and the speed of approach to wall C is positive (20.95m/s).



Figure 7: Target data

The distance from all other walls is above 5 metres (wall A=32.33m, wall B=53.1m and wall D=21.41m). The speed of approach to walls A and D is negative meaning it is moving far from the two walls. The speed of approach to wall B is positive (10.73m/s) but the target is not escaping through B since its far (53.1m) from wall B.

Conclusion

In this paper, partial results of development of a real-time outdoor positioning system for an escaping target are presented. Location parameters of the target in a two dimensional (2D) arena are obtained by use of global positioning system (GPS) then transmitted to a central computer for analysis. Velocity of the target in the arena is obtained by use of haversine equation and direction of escape is determined from triangle equations. From the data the system intelligently determines if the target is escaping. The results obtained can be used to inform the development of a pursuit algorithm.

References

Al-Tae, M. A. Khader, O. B. & Al-Saber N. A. (2007). *Remote Monitoring of Vehicle Diagnostics and Location Using a Smart Box with Global Positioning System and General Packet Radio Service*, In 2007 IEEE/ACS International Conference on Computer Systems and Applications, pp. 385–388, IEEE.

Czernek, W. Margas, W, W y z g o l i k , R. Budzan, S Zikebinski, A and R. Cupek, R (2016). Gps and Ultrasonic Distance Sensors for Autonomous Mobile Platform, *Studia Informatica*, Vol. 37, no. 4A, pp. 51-67

Jiang L, Hoe L. N., and Loon L. L., "Integrated uwb and gps location sensing system in hospital environment," in *2010 5th IEEE Conference on Industrial Electronics and Applications*, pp. 286-289, IEEE, 2010.

Lee, J.S, Su, Y.W, Shen, C.C. (2007). A comparative Study of Wireless Protocols Bluetooth, UWB, Zigbee, and Wi-Fi, *Industrial Electronics Society*, Vol. 5, pp. 46-51.

Mishra, P.P. (2016). Deriving and Deducing the Equation of the Curve of Quickest Descent, *International Journal of Mathematics and its Applications*, Vol. 4, p. 7.

S. Micro, "ChipkitTM WF32TM board reference manual,"

Shoab, M, Jain, K, Anulhaq, M & Shashi, M. (2013). *Development and Implementation of Nmea Interpreter for Real Time Gps Data Logging*, in *2013 3rd IEEE International Advance Computing Conference (IACC)*, pp. 143-146, IEEE.

Si, H & Aung, Z.M. (2011). Position Data Acquisition from Nmea Protocol of Global Positioning System. *International Journal of Computer and Electrical Engineering*, Vol. 3, no. 3, p. 353.

Song G. He, M., and Song P., "Gps signal acquisition based on compressive sensing," in *2018 IEEE 18th International Conference on Communication Technology (ICCT)*, pp. 1013-1016, IEEE, 2018.

Winarno, W, Hadikurniawati, W & Rosso, R.N (2017). *Location based service for presence system using haversine method*, in 2017 International Conference on Innovative and Creative Information Technology (ICITech), pp. 1-4, IEEE,