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IMU Based Indoor Mobility Alignment and its 3D Cloud Point Generation

Saravanan P.D, Baskar S
Vel Tech Dr.RR & Dr.SR.Technical University, Chennai, India.

Abstract*— The positioning a person in indoor environment with precise point is a challenging requirement in emergency situation and also to track the person in high security buildings. The advanced location based applications and technologies are emerging in recent times and researchers are more focusing on indoor space positioning. In an indoor environment it becomes prerequisite to predict the position and the direction of person with high accuracy. A GPS based positioning in outdoor environment can be fine tune according to the pre-decided maps and signals from satellite. But GPS failed to locate inside the building because of attenuated and scattered signals from satellite. To determine the exact location of a person in indoor and to define a path he travels, it needs additional information of number of steps he makes in a particular direction. The complex and challenging direction determination can be made possible through Inertial Measurement Unit. An IMU integrated with RF Transceiver module sounds a better technique to track and locate a person in indoor.

***Index Terms*— IMU, Indoor environment, RF Transceiver, Lab VIEW.**

I. INTRODUCTION

The propagation of radio frequency signals emitted by wireless communication nodes are utilized in localization methods. In most cases location has to be inferred indirectly from the received signal strength. Inertial measurement unit is typically utilizing in navigation purpose because of its compact sized single chip. IMU finds applications in Land navigation, Photogrammetry to measure the exterior orientations and thereby produce maps with less GCPs (Ground control point) and without Aerial Triangulation (AT). IMU integrated with Differential Global Positioning System (DGPS) can be used for land vehicle navigation as it gives high position accuracy. In military IMU can meet the requirement of indoor localization of mobile agents with precise steps and the challenging requirement of man motion navigation. It can be used to maneuver aircraft as these can measure and report a vehicle's velocity, orientation, and gravitational forces [1]. Civil applications of IMU include the monitoring of rescue service personnel working in hostile environments, the management of large scale crises and the security control of large scale events [2].

RFID technology uses tag to the track the objects. It has two-way radio frequency transmitter-receiver communication [3]. Receiver board reads the RF signal transmitted by the tag. In indoor environments the rf signal strength depends not only on the range from emitter to receiver but also get disturbed by phenomena like multipath propagation interference blocking caused by obstacles and people. Positioning a person inside a room by placing four RFID readers of limited range in four corners and by considering the room as grid with cells also failed to track an indoor person [3][4].

Global Positioning System (GPS) makes the tracking easier in the outdoor environment. In a free space signal strength of GPS is higher that's makes the precision result in real-time tracking. GPS signal can only penetrate to thin metal body of car which senses the same amount of accuracy in the result. Once the GPS devices moves into the indoor environment the signal gets highly scattered by the roof and walls of the building, thus resulting the inaccuracy in positioning the object. To overcome those problems an IMU based technology is used in indoor localization.

An IMU comprised with high precision sensors placed in a moving unit will track the indoor position of the object. It normally gives the combination of three axis output from the gyro, magnetometer, and accelerometer sensors and with one axis barometer. Gyro is commonly known to be gyroscope sensor which measure angular rate of the object without external reference. Inertial sensor focused on MEMS gyro sensor technology which is small in size, light weight and with high performance. A microcontroller interfacing the IMU module gets the combined output signal in UART pins from the IMU sensors and the controller directs the data to RF transceiver. RF transceiver unit

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in the receiver module captures the data and the same is given to the serial COM port of PC. Lab VIEW based monitoring panel is used to monitor the position of the object in 3D cloud point with precision.

II. INDOOR LOCALIZATION-BASED ON IMU

In the proposed methodology pedestrian positioning in indoor with high accuracy can be obtained with the help of IMU (Inertial Measurement Unit) which is shown in fig 1.

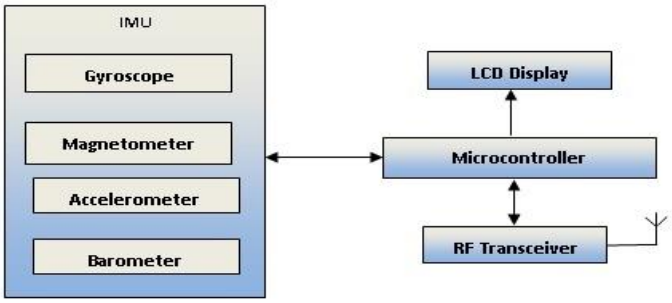

Fig 1: IMU based Indoor Positioning

Some of existing technologies which are used to positioning/tracking in indoor are 1D/2D based GPS positioning and RFID based positioning [3][4]. To make it more comfy positioning/tracking the pedestrian in indoor environment we are using IMU based technology. It has 10DOF with combination of four sensors with more compact and single chip which produces accurate position of the indoor pedestrian with its altitude and longitude. The object to be tracked is fixed with IMU which is controlled by a microcontroller. Here we used PIC 18F4xxx microcontroller which is built with features such as in ADC, UART, SPI, etc. Signal from microcontroller is transferred to RF transceiver for wireless communication which operates with 2.4 GHz frequency and the receiver unit shown in Fig 2 which is connected in the PC for monitoring receives the signal with the same frequency [5].

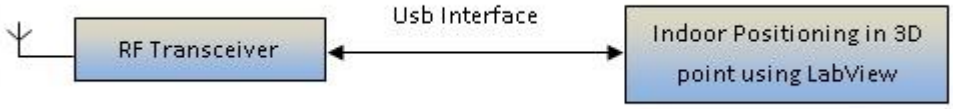

Fig 2: Receiving unit

a) *IMU (Inertial Measurement Unit):* It estimates the position, orientation and velocity with the aid of combination of four sensors: Gyroscope, Magnetometer, Accelerometer, Barometer. Here we used GY-80 IMU which is single-chip 10DOF with more precision output. Gyroscope is used for measuring the orientation of the object based on angular momentum [9]. The main objective of the MEMS gyroscope is the navigation purpose. Magnetometer sensor measures the strength and direction of magnetic field.[10]

A. Gyroscope for measuring acceleration,
B. Magnetometer for measuring direction (navigation purpose),
C. Accelerometer for measuring the angle,
D. Barometer for measuring the pressure.

Angular momentum = amount of rotation on object in account of mass, speed, shape.

Here the graph shows the difference between the IMU output and the individual sensor output [6]. The fig 3 shows the individual output of the four different sensors which positions the readings in multiple points in the graph. To makes those outputs into single point it requires more mathematical calculations as well. But in the IMU unit it gives a combinational output of four sensors into single point which is shown in the fig 4. It makes positioning in the indoor environment with higher precision point in comparatively easier manner.

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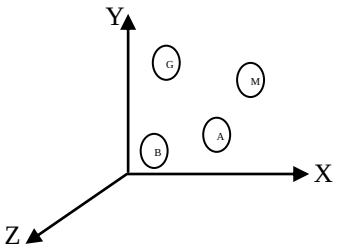

Fig 3: Individual Output of the Sensors.

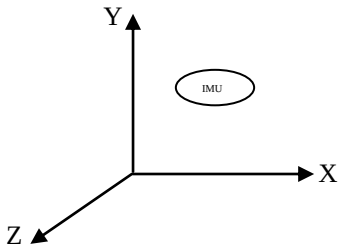

Fig 4: IMU positioning the Object.

b) RF Transceiver module: Tarang FH4 wireless module is used in RF communication. It operates at frequency of ISM 2.4 to 2.484GHz with data rate about 250Kbps. It is more suitable for almost all kind of additional wireless competency to any products with serial data interfaces.

c)

d) ICSP: In-Circuit Serial Programming (ICSP) is shown in Fig 5, as the ability of some programmable logic devices to be programmed while installed in a complete embedded system. (ICSP) is a protocol primarily implemented by Microchip Technology. Application Circuit, Programmer and Programming Environment are the three main components that play a vital role in implementing ICSP into an application. ICSP programming is done using two pins, clock (PGC) and data (PGD) with a high voltage (12V) is present on the Vpp/MCLR pin. This allows the manufacturers to program the chips in their own interest while the chip is attached to the application circuit and no more chip swapping is required.

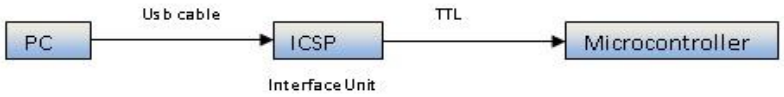

Fig 5: ICSP Connection Diagram

III. SIMULATION RESULTS

LabVIEW of National Instruments contains a comprehensive set of tools for acquiring, analyzing, displaying, and storing data. As the appearance and operation of LabView programs imitate some physical instruments they are called virtual instruments (VI). In LabVIEW, a front panel can be used to create user interface with controls and indicators. Front panel objects are controlling through the code consisting VIs and structures in the block diagram.

Receiver module is connected in COM port and the simulation results can be viewed in the labview. Serial communication is established using VISA functions like VISA Configure Serial Port, VISA Read, VISA Write and Visa close. Configuration of serial port in 9600 baud rate, 8 bit data, 1 stop bit, and no parity is done by **VISA configure serial port.** VISA Read and write functions perform read and write operation in COM port specified.

RF tarang module with 2.4GHZ frequency, 250kbps data rate and 22dBm power level operates in 3.3 to 3.6V power supply. It has a range of 80-300m. The IMU transmitter module and RF receiver module communicates with the RF tarang transceivers. IMU transmitter will measure the altitude, X-Y position and number of foot steps taken by the pedestrian in the building. The receiver end will receive the data from the transmitter module which is connected to a PC with LabVIEW software [10]. RF module will perform serial communication with LabVIEW. In LabVIEW serial communication configuration are made using serial VISA resources such as serial open, serial read, serial write, serial close etc., It configure serial communication in a particular COM port with 9600 baud rate, 8-bit data, one stop bit, and no parity bit. LabVIEW displays number of steps, direction and path travelled by the person using the X-Y positions, altitude etc in the front panel VI. 2D compass shows the direction in degrees and length of the pointer as the number of steps taken [9].

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3D plot shows a point that describes the location of the person in three dimensional axes. X, Y axis graph will plot the path taken by the indoor pedestrian. Initial position is marked as the origin of the graph. When the module gets the powered up the point will be in the origin.

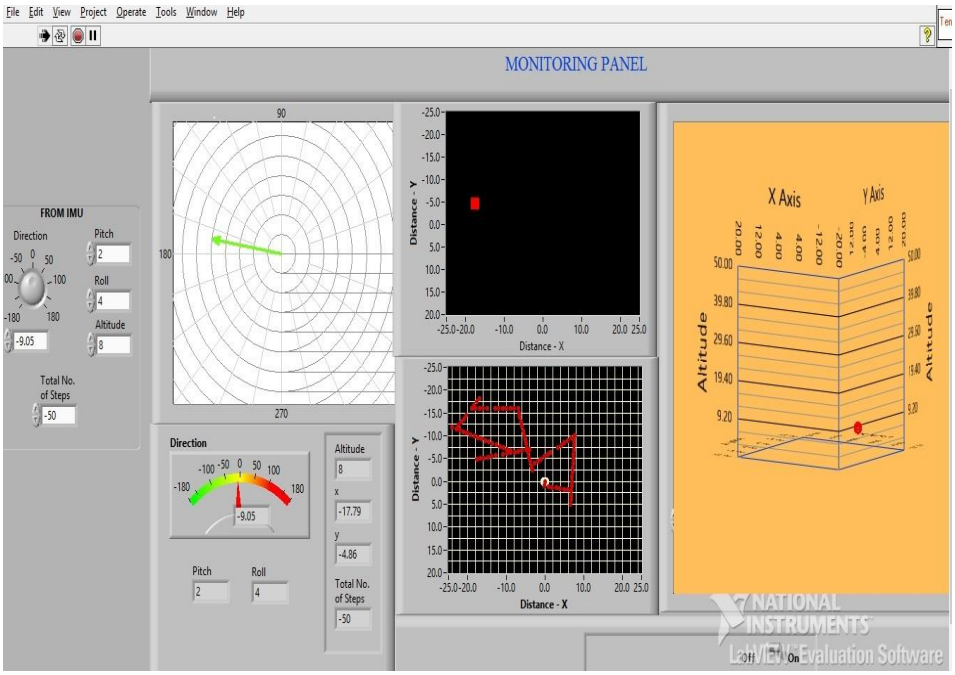

Fig 6: LabVIEW based 3D plot for indoor pedestrian position monitoring panel

IV. HARDWARE IMPLEMENTATION

An IMU which operates at 3.3-5V power supply is connected over PORT D in the pic microcontroller. PIC18Fxxx is a high performance RISC CPU with 1024bytes of data EEPROM and 64kbps of linear program memory addressing. The operational power of PIC is about 2.3-5.5V which has in-build ICSP, ICD, PWM, ADC. The three different type of power supply are used in the hardware implementation 12V, 3.3V, 5V.

A 15V battery power supply is given to enable the overall function of the board which as the rectifier to minimize the supply current. PIC microcontroller is required only about 3.3V power supply, so LM317 regulator is used to reduce the supply and two capacitors are used for filtering purpose. RF transceiver module has transmitting power in the range of 18dBm. Both the transmitter as well as receiver function pins are connected in PORT C in the microcontroller. A master clear pin is used as reset function in microcontroller instead of cutting overall power supply. LCD display unit is connected in the IMU unit which displays the number footsteps, altitude, and direction of the object in the indoor environment. At the receiving end RF receiver which is connected in the PC with LabVIEW environment in it. It used to monitor the each and every step movement and direction in the indoor environment. FT231x UART cable is used to connect the RF receiver and PC. It transfers the RF signaling data into PC language.

A mobile IMU transmitter module has the IMU and it is connected with its supporting driver IC, Pic microcontroller, RF transceiver module and LCD display. A 12V battery power supply is given to the board. LCD display shows the corresponding direction and its altitude of the indoor pedestrian position.

An RF transmitter section is connected to UART2 pin in the PIC microcontroller which gives the power supply of about 5V to the transmitter section. In the monitoring panel of the LabVIEW is used to positioning the pedestrian in the indoor environment with high precision. The fig 7 shows the LabVIEW based indoor pedestrian monitoring panel in -0.08˚ direction with 47 steps moment and it altitude of about 17.43.

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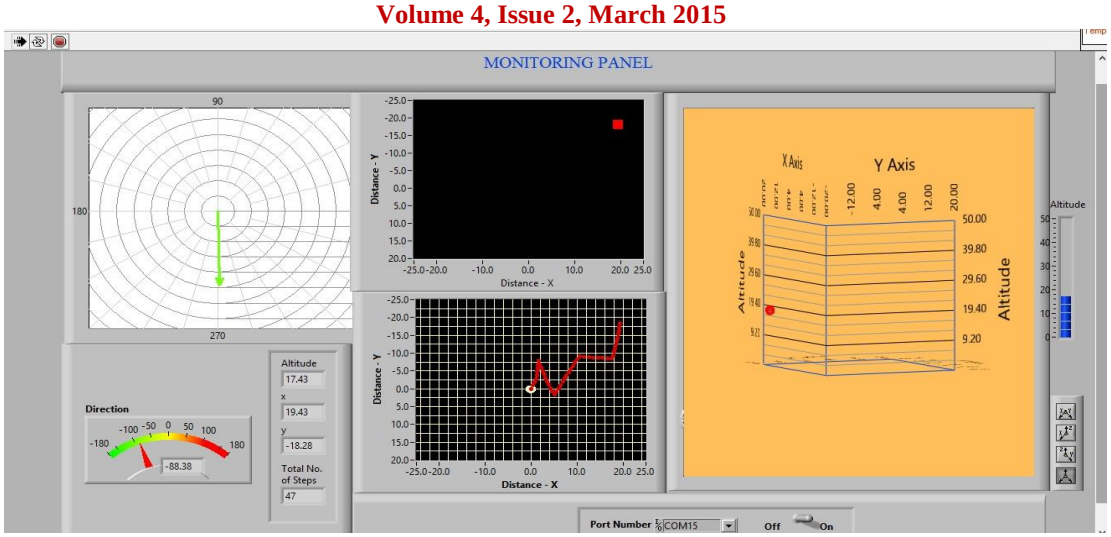

Fig 7: LabVIEW based indoor pedestrian monitoring panel in -0.08˚ direction with 47 steps

Those monitoring panel gets the RF data signals from the transmitter end. Mobile IMU unit as the transmitter end which gives those RF signals to the receiving unit. The LCD display in the mobile IMU module is shown in the fig 8 that gives the positioning values and the same is displayed in the monitoring panel.

Fig 8: Corresponding LCD display in mobile IMU transmitter module

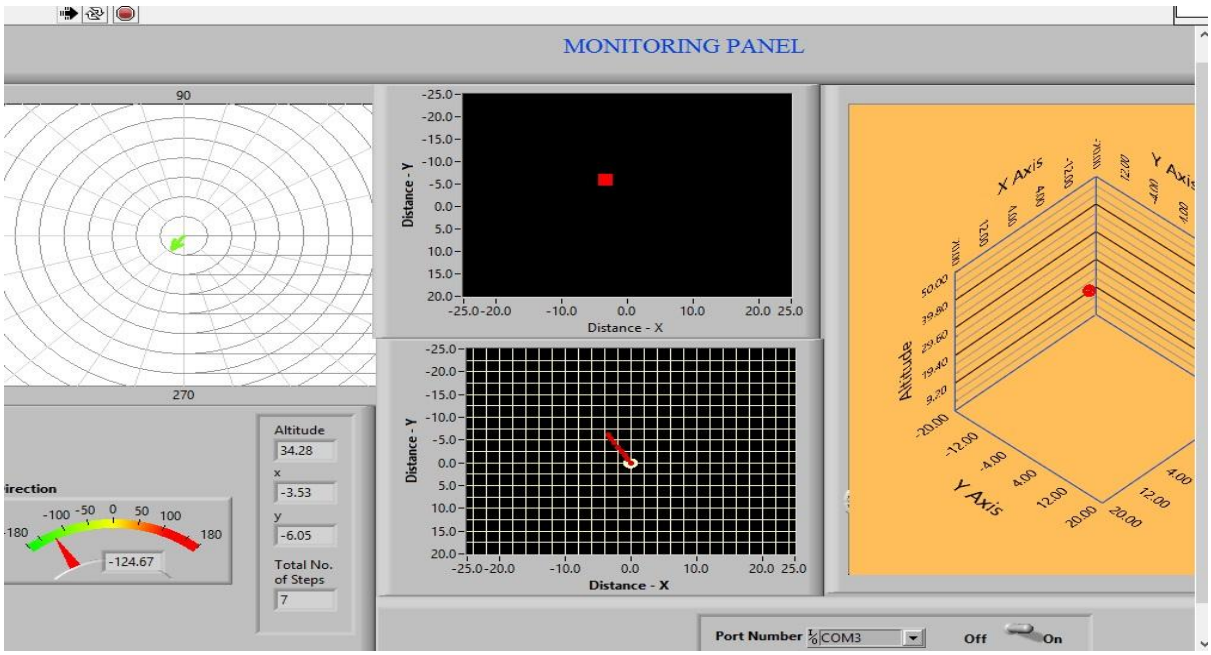

Fig 9: LabVIEW based indoor pedestrian monitoring panel in -124.8˚ direction with 07 steps

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In the fig 9 shows the LabVIEW based indoor pedestrian monitoring panel in -124.8˚ direction with 07 steps movement with 34.28 altitude. In indoor environment it can position with the 360 ˚ with each and every step movement with high point of precision. The monitoring panel shows the free plan plot as well as the tracking view in the X, Y plot. It gives the complete travelling path from the origin point to the destination point. In the Fig 10 the corresponding LCD display in mobile IMU transmitter module is shown.

Fig 10: Corresponding LCD display in mobile IMU transmitter module

V. CONCLUSION

The proposed model illustrated the LabVIEW based monitoring that automatically traces the pedestrian indoor position and 3D cloud point with its précised direction and altitude. To show the performance of the system few experiments with various points and altitudes are done compared the collected data. The results figured in Fig 8 and Fig 10 show the two different direction of the pedestrian position in the indoor environment. Magnetic field fluctuations due to obstacles and person in RFID based technology makes the system to position the person with less accuracy. In proposed system IMU with magnetometer alleviated the influence of obstacles to give high accuracy in localization as shown in the simulation results. Orientation or direction degree with 0.1 accuracy is obtained in the unit. Step taken by the person sensed using highly sensitive touch sensor interfaced with barometer produces a vivid trajectory path in the monitoring panel. Effective creation of indoor maps is challenging and exact location of a person inside the building and path tracking are difficult. In future the system can be enhanced with camera incorporated IMU module and highly sophisticated image processing units. This will reduce the necessity of indoor maps to localize a person as the effective creation of indoor maps is still a challenge.

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AUTHOR BIOGRAPHY

P.D.Saravanan is currently pursuing his master's degree with specialization in embedded system technologies at Vel Tech Dr.RR & Dr.SR.Technical University, Chennai, India. He received his bachelor's degree with specialization in Electronics and Communication Engineering from Anna University Chennai. His research area includes Microcontrollers, Embedded system designs and its application.

S.Baskar was born in Cuddalore, India on February 3, 1974. He received his B.E (Electrical & Electronics) from Annamalai University and M.Tech (Power Electronics) from Vellore Institute of Technology, India. He has completed his Ph.D in the area of FACTS controllers from Annamalai University. He is currently working as Professor in the Department of Electrical and Electronics Engineering, at Veltech Rangarajan Dr.Sagunthala R&D Institute of Science and Technology, Vel Tech Dr. Rr & Dr. Sr Technical University, Avadi, Chennai India. His research interests include Power Electronics, Control and Modeling of FACTS Controllers and its application to power system.