School

of

Electronics and Communication Engineering

Mini Project Report

on

LOCALIZATION OF THE AUTONOMOUS VEHICLE USING IMU SENSOR

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SCHOOL OF ELECTRONICS AND COMMUNICATION ENGINEERING

CERTIFICATE

This is to certify that project entitled **LOCALIZATION OF THE AUTONOMOUS VEHICLE USING IMU SENSOR** is a bonafide work carried out by the student team of **"A C Sowjanya (01FE16BEC001), A Kavyashree (01FE16BEC002), Ajit Bijapur (01FE16BEC016),Akhil Kulkarni (01FE16BEC018)"** The project report has been approved as it satisfies the requirements with respect to the mini project work prescribed by the university curriculum for BE (V semester) in School of Electronics and CommunicationEngineering of KLE technological University for the academic year 2018-2019.

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ACKNOWLEDGMENT

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-The project team

ABSTRACT

Inertial measurement units (IMUs) are widely used in motion measurement. Across many years, the improvements and applications of IMU have increased through various areas such as manufacturing, navigation, and robotics. Recent trends of people bringing their own small electronic devices such as smart phones, GPS devices, and portable radios also have increased the demand of position sensors to determine their position live and update to the third party at the same time. The usage of IMU has been applied widely to determine their movements in terms of acceleration, angular velocity, and rotation. One of the major applications of the IMU sensors is dead reckoning where the accurate position of the vehicle is measured using the sensor. The magnetometer is combined with a three-axis accelerometer as a digital compass for orientation determination in static state by measuring the gravity and the earth's magnetic field vectors. A three-axis gyroscope is used to measure the orientation in dynamic state to complement the digital compass. Displacement determination is implemented using the accelerometer through double integration.

Contents

List of Tables

List of Figures

Chapter 1

Introduction

1.1 Motivation

There has been an increase in the market and the industry for autonomous vehicles. Although there are no fully functional units in the market for sale, the development in the last 4-5 years is tremendous. One of the most important aspects of an AEV is localization. Multiple solutions/technologies are available to tackle this problem, but the main aim of this project is to develop accurate and economic solution to make the end product safe and budget friendly

1.2 Objectives

The accurate positioning of autonomous vehicles is necessary for decision making path planning. High precision mapping is necessary for safety and robust driving of vehicles on lanes. This can be achieved by reducing the error percentage of location obtained through GPS and also by providing an alternative solution when the GPS fails.

1.3 Literature survey

1. **Dead reckoning and relative distance measurement using IMU.**
2. **Lane marking detection using computer vision.**
3. **GNSS sensors which gives the direct measurement of position.**
4. **LIDAR using 3D image processing and lane marking detection technique.**

1.4 Patent search

Patent 1:
The present invention relates to the field of vehicles running on a guideway, trains, and in particular to a vehicle location system using GNSS signals. Patent no:US8477067[1]
Patent 2:

A sensor node for a wireless sensor network is provided. The sensor node comprises a sensor module including one or more sensors, a data processor in operative communication with the sensor module, a radio frequency transceiver in operative communication with the data processor, and an inertial measurement unit in operative communication with the radio frequency transceiver. Patent no:US20080291042[2]
Dead reckoning and relative distance measurement using IMU. IMU sensor is the best suited solution because
An IMU can dead-reckon for a short period of time, meaning it can determine full position and attitude independently for a short while.
The IMU is a key dynamic sensor to steer the vehicle dynamically, and the IMU can maintain a better than 30cm accuracy level for short periods (up to 10 seconds) when other sensors go offline.
The IMU is also used in algorithms that can cross compare multiple ways to determine position/location and then assign a certainty to the overall localization estimate.
LIDAR localization and computations are expensive and not economic GPS/GNSS sensors do not provide high accuracy

1.5 Problem statement

To design a system which improves the positioning system and localization of an AEV and provides an alternative when the GPS fails. The system should:

- Be fully automated
- Be highly accurate
- Have easy interfacing with other devices
- Have low power dissipation

Chapter 2

System design

In this chapter, we list out the interfaces.

2.1 Functional block diagram

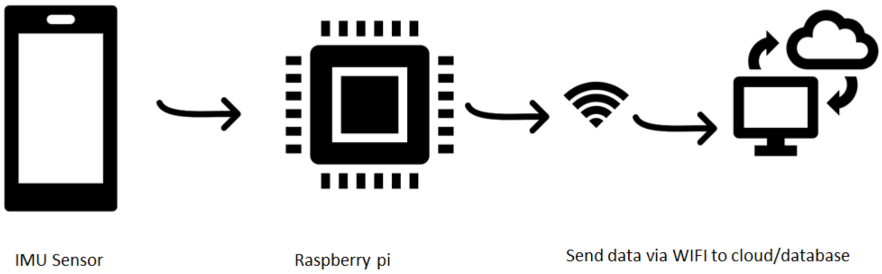

Figure 2.1: functional block diagram of IMU sensor

2.2 Morphological chart

Additional information on how to write tables is as shown in 2.1

Table 2.1: Morphological chart

PARAMETERS	**MPU 6000**	**MPU 9150**	**MPU9250**
ARM PROCESSORS	ARM7	ARM11	ARM CORTEX A53
communication protocol	I2C and SPI	digital motion sensor,SPI	SPI

2.3 Design alternatives

1. LIDAR using 3D image processing and lane marking detection technique. Generally

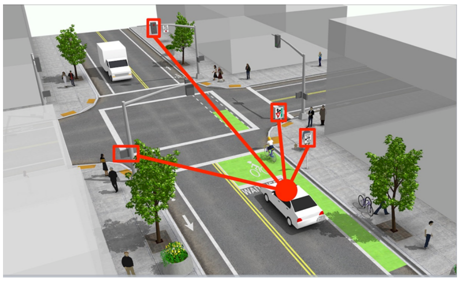

Figure 2.2: design alternative 1

path stamping information can be procured from various perspectives like utilizing visual cameras, GPS sensors, radar sensors and laser sensors. Every one of the technique has its own points of interest and confinements. path stamping identification can be one for the most part in three stages : catching and procuring the information from the preprocessed tasks, acquiring the genuine path checking from the related procedure and following the genuine area. There are a few impediments in building up this technique to the correct area. this technique utilizes laser heartbeats to quantify the reaches. The distinction in the laser return wavelength is utilized to make the 3D pictures.

2.GNSS sensors which gives the direct measurement of position. A satellite-based gadget

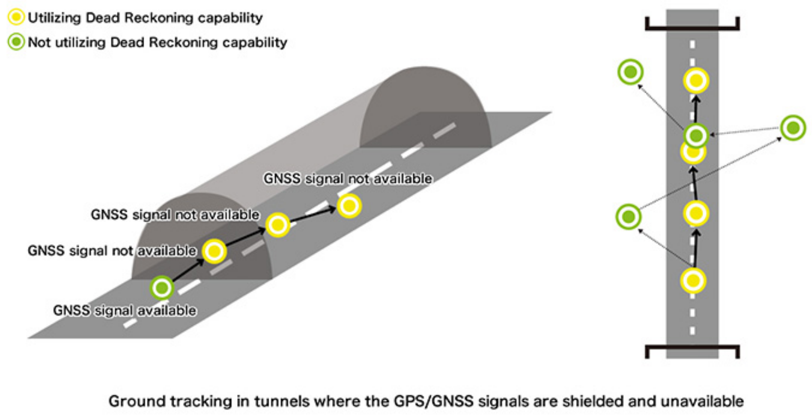

Figure 2.3: design alternative 2

gives most precise situating data to a self-sufficient vehicle . GPS beacon which utilizes just three satellite signs, to decide the area is less exact yet we can in any case get the situation of the vehicle. it is required to utilize four satellites to gauge the directions in 3D space (x,y,z). the GPS gadget is more exact inside three-meter scope of a wanderer . It is conceivable to obtain situating anyplace on the planet that GNSS satellite signs are accessible, whenever of day, High Precision Global Navigation Satellite System (GNSS) innovation gives the exactness, accessibility and unwavering quality that a vehicle requires to act naturally driving. This innovation is most as often as possible used to decide the area of an independent vehicle and furthermore to follow a question as for another protest. the GNSS utilizes two beneficiaries :a base stationary and wanderer recipient which are mounted on the vehicle, the base stationary collector tests information from satellite and transmits. Furthermore, alternate gets the transmitted information and both all in all decide the situation of the wanderer.

2.4 Final design

We select one of the optimal solutions based on its working and ease of the implementation.
Interfacing IMU 9250 with raspberry pi:

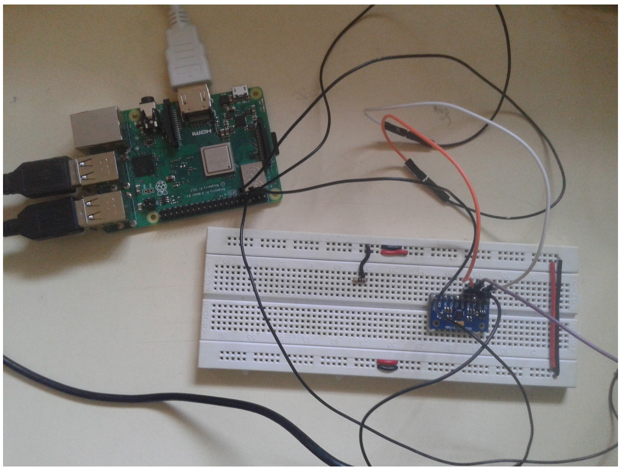

Figure 2.4: FINAL DESIGN

Chapter 3

Implementation details

Specifications and system architecture (White Box) MPU 9250 (Chosen IC for the project):

- 9 DOF
- 3 axis accelerometer
- Digital output
- Inbuilt 16 bit ADC
- Wake on motion interrupt for low power applications.
- 3 axis gyroscope
- Digital output
- Inbuilt16 bit ADC
- Factory calibrated sensitivity scale factor
- 3 axis magnetometer
- Inbuilt 16-bit ADC.
- I2C and SPI communication
- Digital output Temperature sensor
- I2C bus for third party sensors

Raspberry pi :

- SOC: Broadcom BCM2837B0 Cortex A53 64-bit SoC
- CPU : 1.4GHz 64-bit quadcore core ARM Cortex-A53 CPU
- RAM : 1GB LPDDR2 SDRAM
- WIFI : dual-band 802.11ac wireless Lan and Bluetooth 4.2

- Ethernet: Gigabit Ethernet over USB 2.0 (max 300 Mbps). Power-over-Ethernet support (with separate PoE HAT). Improved PXE network and USB mass-storage booting.
- Thermal management: Yes
- Video: Yes Video Core IV 3D. Full-size HDMI
- Audio: Yes
- USB 2.0: 4 ports
- GPIO: 40-pin
- Power: 5V/2.5A DC power input
- Operating system support: Linux and Unix

3.1 Specifications and final system architecture (White Box)

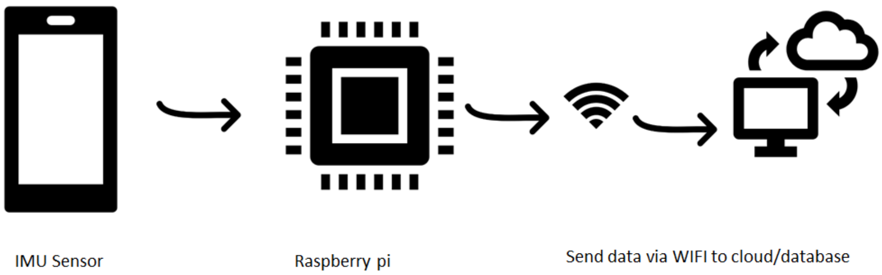

Figure 3.1: white box

3.2 Algorithm

Start
Configure the IMU sensor with raspberry pi
Check for I2C communication enabling
Once the communication is enabled, send data to IMU to set it up
Run the program and check for errors
If errors exist, debug them
Else
Read the raw values
Get usable data
Combine and reduce errors using filter
Get the orientation in space and then check for true north
Get the values of yaw, pitch and roll
Stop

3.3 Flowchart

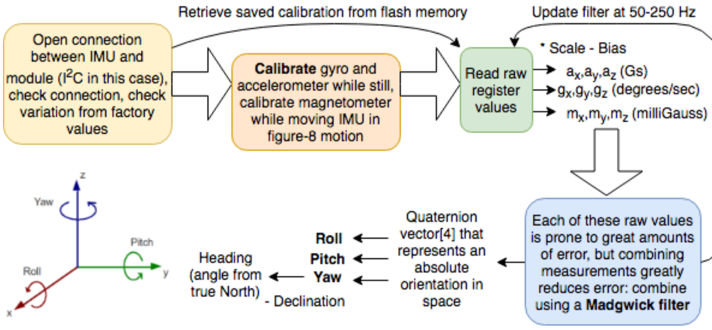

Figure 3.2: flow chart

Chapter 4

Optimization

4.1 Introduction to optimization

Optimization is a technique used by compilers in order to modify the program more efficiently by utilizing fewer resources, or making it execute faster, reduce complication/building time, reduces size, drawing lesser power, effective memory usage, etc. but all this happens without changing output or its side effects.

4.2 Types of Optimization

OOPS (Object Oriented programming) Call by value Expression simplification Inline functions Loop unrolling Data alignment, Structure padding, etc.

4.3 Selection and justification of optimization method

Depending upon the type of application we can select optimization techniques to save on time/memory and to reduce the size of the code. Most of the optimizations performed on the code involve a tradeoff between the execution speed and code size. Either the program can be faster or smaller but not both. Infact on improvement in one of these areas can have a negative impact on the other. For our project the optimization techniques which we used are OOPS, call by value and expression simplification.

OOPS: OOPS is one of the programming approach which is based on the concepts of classes and objects.OOPS also includes concepts like inheritance,encapsulation.Inheritance is mainly used by objects to derive the properties of other objects of other classes as well thereby saving memory and time. Call by value:

In call by value, different memory is allocated for actual and formal parameters since the value of the actual parameter is copied into the formal parameter. The actual parameter is the argument which is used in the function call whereas formal parameter is the argument which is used in the function definition.

Expression simplification: For a compiler to solve an expression it takes time, so instead of doing this we can solve this and add the simplified expression. By using call by value, we can reduce the time. And by simplifying the expressions and using OOPS we can save on memory.

Chapter 5

Results and discussions

From the above code we can conclude that it saves time and memory. By integrating the values of accelerometer, we get the displacement. And these values gives us the orientation and the position.

5.1 Result Analysis

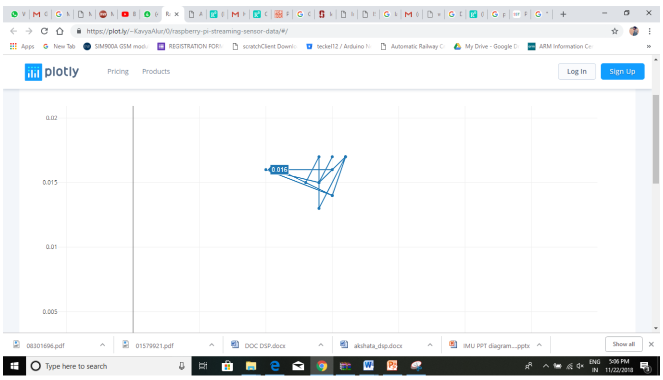

Figure 5.1: acceleration 2D

Discussion on optimization As we compare the optimized and unoptimized programs, in unoptimized code, memory and time utilization is more. By using the optimization techniques, we can reduce the time and memory utilization and the size of the code can be reduced.

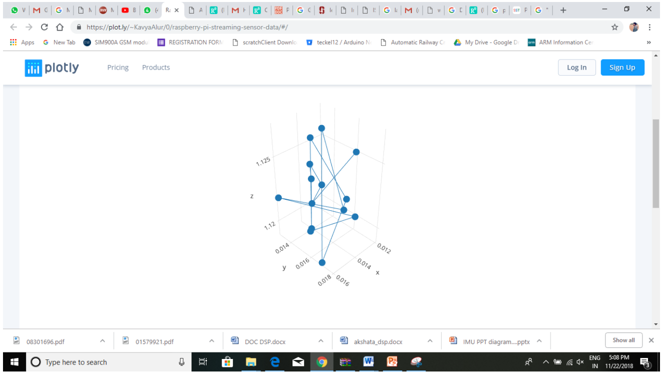

Figure 5.2: acceleration 3D

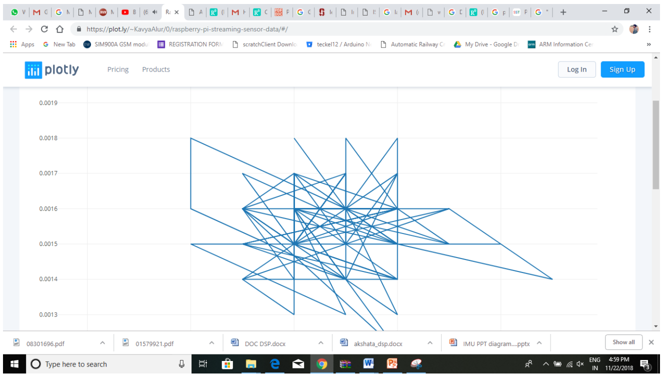

Figure 5.3: velocity 2D

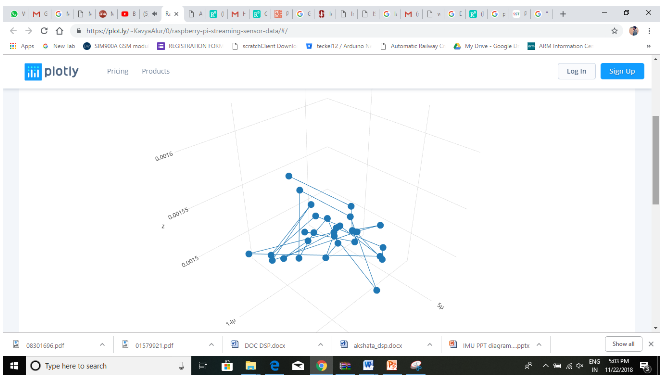

Figure 5.4: velocity 3D

Chapter 6

Conclusions and future scope

6.1 Conclusion

By combining the measurements of the accelerometer, gyroscope and magnetometer from the IMU sensor the orientation and position of the sensor is determined. Along with IMU, the readings from GPS can also be corrected by reducing the error percentage.

6.2 Future scope

The GUI for displaying the position can be improved and also the accuracy in position can be improved by designing efficient filter.

6.2.1 Application in the societal context

The IMUs can the equipped in various navigation systems such as in military vehicles, combat vehicles, aircrafts and also in various unmanned systems like UUVs and UAVs .This provides the system a dead reckoning capability and also enables user to gather accurate vehicle information such as speed and relative distance .These IMU based systems can also be used for traffic collision analysis using the sensor data.