Design of GNSS Aided Inertial Navigation System

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INTRODUCTION

Navigation refers to the method of determining aspects such as position, speed, and direction during travel. In the pre-modern era, direction and position were determined using an altazimuth, a compass, and a map; These are now considered primitive forms of navigation. As a result of modern developments in science and technology, exact positions and speeds are determined using equipment such as artificial satellites, global navigation satellite system (GNSS), inertial navigation systems (INS). In the modern sense, navigation is mechanical devices equipped in ground vehicles, ships, and aircraft to determine their positions.

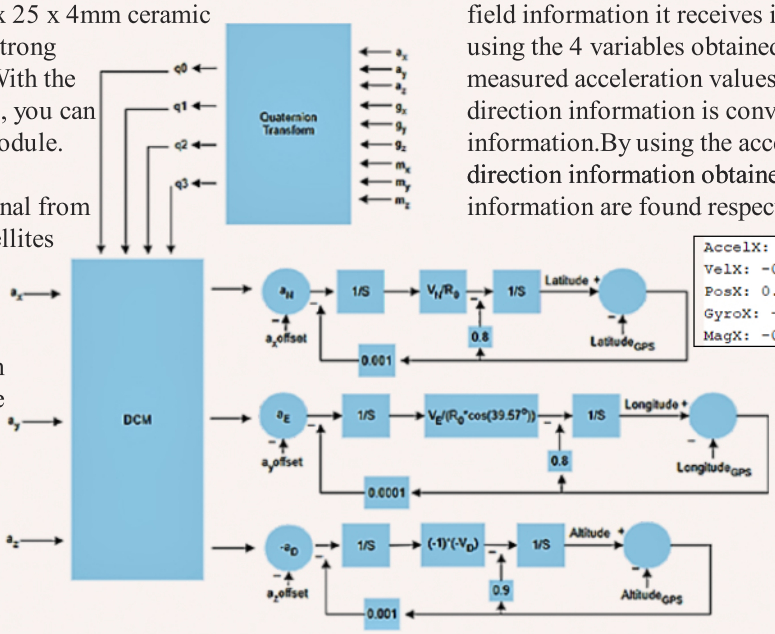
This project aims to design GNSS/INS navigation system, GNSS system uses signals from orbiting satellites to compute position, time and velocity, Inertial Navigation System (INS) uses rotation and acceleration information from an Inertial Measurement Unit (IMU) to compute a relative position over time. For this purpose, both hardware and software solutions are implemented.

GNSS SYSTEM

A satellite navigation device, colloquially called a GPS receiver, or simply a GPS, is a device that is capable of receiving information from GNSS satellites and then calculate the device's geographical position (Latitude, Longitude and Altitude). Using suitable software, the device may display the position on a map, and it may offer routing directions.

The NEO-6M GPS module is a well-performing complete GPS receiver with a built-in 25 x 25 x 4mm ceramic antenna, which provides a strong satellite search capability. With the power and signal indicators, you can monitor the status of the module.

The GPS receiver gets a signal from each GPS satellite. The satellites transmit the exact time the signals are sent. By subtracting the time the signal was transmitted from the time it was received, the GPS can tellhow far it is from each satellite.

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Latitude   = 39.796943
Longitude  = 32.799915
Altitude   = 997 meters
Speed      = 0 kmph
Course     = 0
Time (GMT) : 13:30:44
Date       : 30/8/2021
Satellites = 8
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INS SYSTEM

First, the Mpu9250 was decided to use as an IMU sensor. With Mpu9250, acceleration, gyro and magnetic field values were measured in all 3 axes. The acceleration and gyro values needed to show 0 when the chipset was stationary on a flat surface. That's why, a function was written to automatically average the first 2000 values and find the offset values. After, these 9 values were first inserted into the Madgwick quaternion transform. This transformation converts the acceleration, gyro and magnetic field information it receives into 4 variables. Converted to DCM using the 4 variables obtained. By multiplying the continuously measured acceleration values with this DCM, the x, y and z direction information is converted to the global direction information.By using the acceleration values with the new direction information obtained, latitude, longitude and altitude information are found respectively.

```
AccelX: 0.003679  AccelY: -0.005220  AccelZ: 0.002252
VelX: -0.002668  VelY: -0.003283  VelZ: 0.016771
PosX: 0.117376  PosY: 0.010042  PosZ: 997.100097
GyroX: -0.020802  GyroY: -0.049314  GyroZ: 0.019243
MagX: -0.554094  MagY: 0.704357  MagZ: 0.443691
```

RESULT

The latitude, longitude and altitude values obtained from the INS system were fed back with the values obtained from the GNSS system because a more precise result is desired. The microSD card module, which is the third part of this project, is required for the data saving part. Location information is written to the SD card continuously for 24 hours. The full system is supposed to work continuously for 24 hours, so in order to implement this feature, one of 7.4v 2000mah Li-Ion battery should be used as power supply of the system.

For the final version of the project, a pcb design was made and printed in Hacettepe Printed Circuit Laboratory, and all parts of the project were placed in the box that was printed on a 3D printer with 90 x 90 mm dimensions.