This project integrates INS and GPS technologies into a robust navigation system, enhancing accuracy and reliability across various applications.

By leveraging INS for high-frequency data and GPS for globally-referenced positioning, the system provides precise vehicle state estimation.

Key components include an Inertial Measurement Unit (IMU) for acceleration and orientation, along with GPS for speed and position calculations.

This integrated system offers cost-effective solutions for precise navigation and positioning needs, contributing to ongoing advancements in navigation technology.

## Specifications and Design Requirements

- The system includes a GPS module for location data, an IMU for position, velocity, and attitude (PVA) information, a microcontroller for data processing, a battery for power, and a display module for real-time visualization.
- Designed to operate continuously for 48 hours, the system must provide location data at a minimum frequency of 20 Hz, and the total weight should be under 1 kg for portability. The project balances cost, quality, and performance with affordable, high-quality components like the MPU-9250 IMU and GY-NEO6MV2 GPS.

The design ensures compatibility and ease of integration, with future upgrades like solar power and rugged enclosures for extended use.

## Solution Methodology

- For the mechanical solution, the MPU9250 was chosen for the 9-axis IMU, the NEO-6MV2 GPS was selected for its cost-effectiveness and ease of data processing, and the BMP180 pressure sensor was used to acquire altitude data. The Arduino Mega 2560 was chosen for its ample memory capacity, and an SD card was utilized for data recording. The Arduino IDE and C programming language were used for development.

- To process and compare the data obtained from the IMU with the data from the GPS, double integration and Kalman filters were employed. This approach allows for achieving low error rates and stable results. Additionally, the IMU data enables the measurement of angles, velocities, and accelerations in three axes, which are also included in the Kalman filtering process to minimize errors.

## Results and Discussion

- The table displays reflecting changes in yaw angle and the route direction, allowing the direction of magnetic north to be determined. However, it is not feasible to include all the data here. In addition to position and angle, the device accurately records angular velocity, angular acceleration, and altitude with low error margins. For instance, while the altitude of the route is between 880-890 meters, measurements were taken at 850-860 meters.

- The device records data at a minimum frequency of 30 Hz. Based on the current consumption, the used power bank provides an operational duration of 100 hours.

- Development Potential: The project could be further improved with a better GPS antenna, a custom-designed circuit board, and a 3D-printed enclosure tailored to the project. With a good budget, this project could deliver excellent results, and even in areas where GPS signals are weak, the IMU data alone could resolve positioning issues.

## References


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