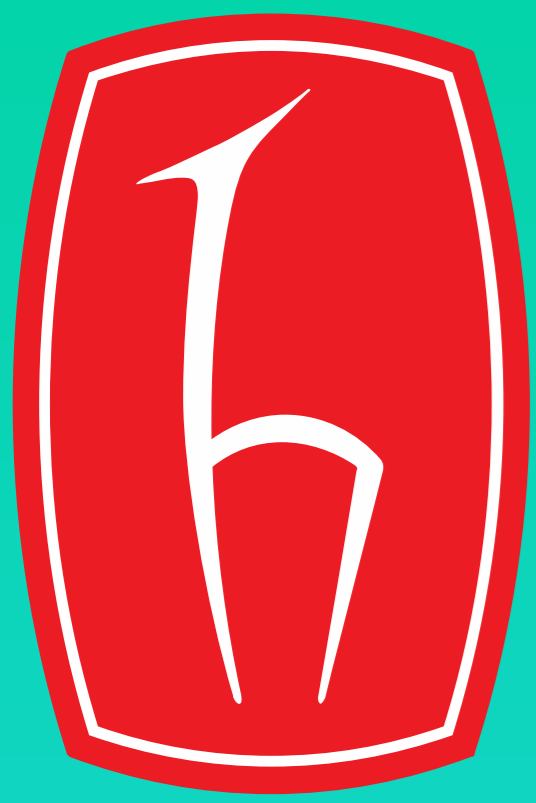# Design of Attitude Heading and Reference System (AHRS)

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Introduction

❖ With the beginning of the history locating and orientation became very important for human generation. People invented and discovered many things such as map, compass etc. And one of the inventions is Attitude and Heading Reference System(AHRS).

❖ At World War 2 AHRS' s are developed for navigating rockets. Direction of the vehicle is the basic information for navigation, because position depends on the movement direction of the vehicle. An attitude and heading reference system consists of sensors on three axes that provide attitude information including roll, pitch and yaw for a device.

❖ This project aims to design and implementation of an integrated AHRS real-time system. We will get signal's from sensors then analyse, process and feedback control them at MCU unit. After fusion algorithms Euler angles will display the navigation at screen. For this purpose both hardware and software solutions are implemented.

Specifications and Design Requirements

❖ Complete AHRS will be a portable equipment (together with rechargable batteries) weiging less than 1Kg.
❖ Complete AHRS will be able to display data (1Hz update) for at least 48 hours.

Solution Methodology

❖ First of all, I researched the necessary hardware equipment. I decided that one 9 DOF IMU sensor, one microcontroller unit, one LCD display and power supply would be sufficient. I chose MPU9250 as IMU and Arduino UNO as microcontroller.

MPU9255
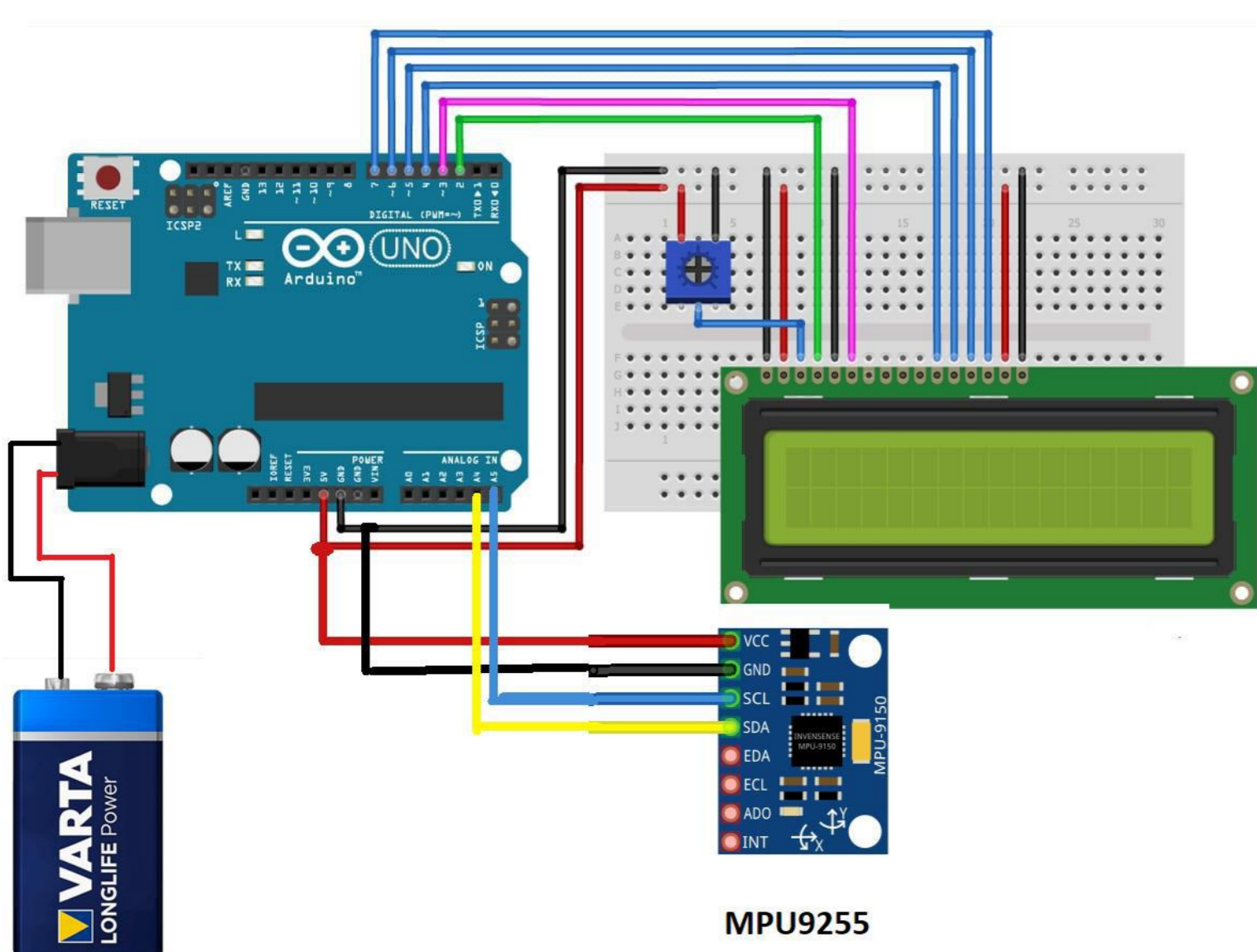
❖ Gymball, which gave the roll and pitch angles used in the old days, was useless because it was too heavy and big. Instead, MEMS-based IMUs began to be used. But since these sensors contain a lot of noise, we cannot use the received data in its raw unprocessed form. At this point, it is necessary to do something software-wise. I learned that Kalman and Madgwicks filters would be useful for this purpose. Although the Kalman filter algorithm gave successful results, it required a lot of complex operations and required high memory. Then I saw that Madgwick's filter, which is one of the complementary filters, gives results close to the Kalman filter. In addition, Madgwick had less transaction complexity and was easier to implement. And it was less tiring for the microcontroller I was using.

Right figure shows that Madgwicks Filter block diagram.
- Step 1: Obtain sensor measurements
- Step 2 (a) : Orientation increment from Acc and Mag and Gyro
- Step 3: Fuse Measurements
Repeat steps 1 to 3 for every time instant.
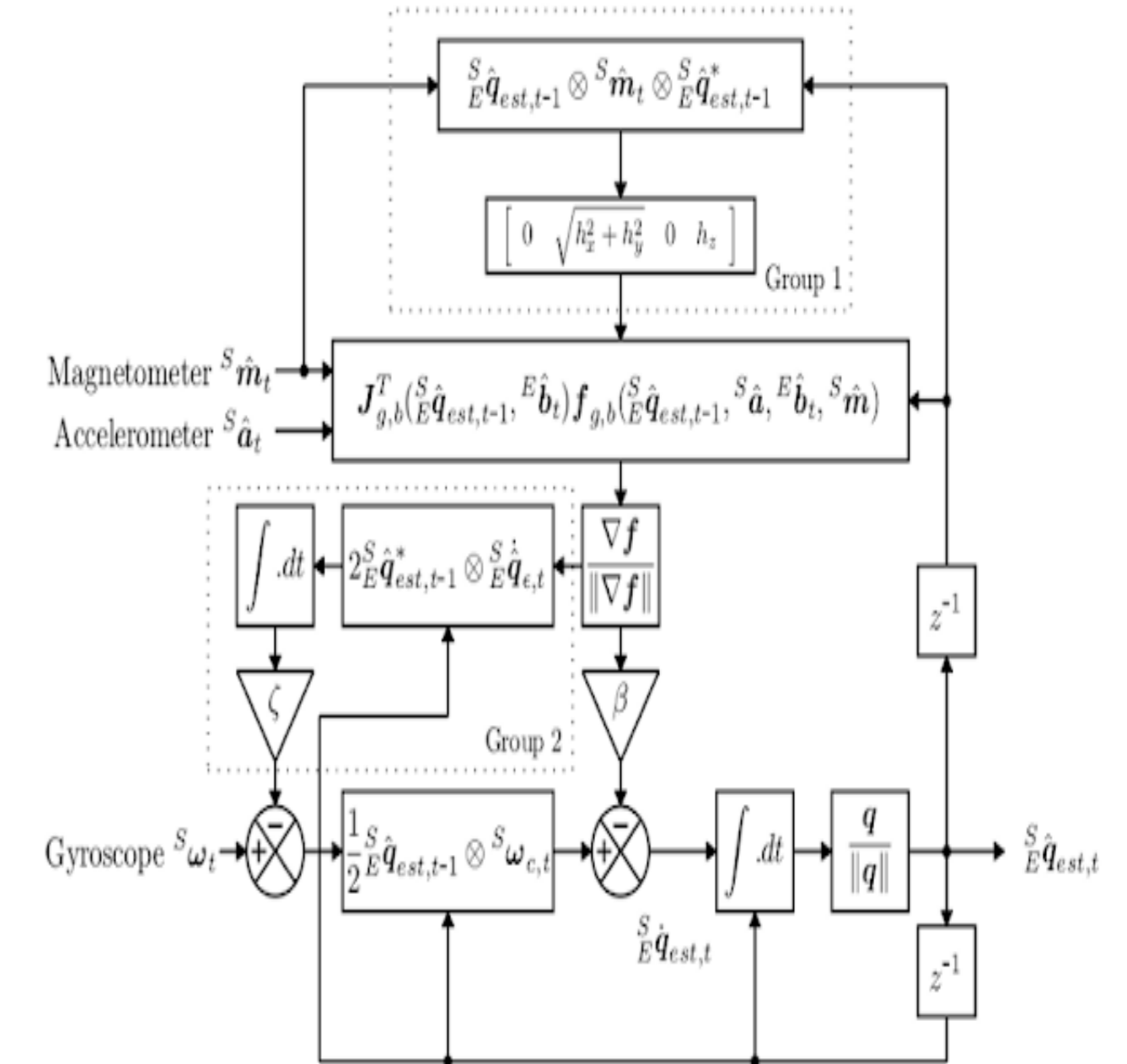
Application Areas

❖ Application area spread out Navigating Rockets, marine, aerospace, land systems, smart cell phones and virtual reality glasses etc.

Results and Discussion

❖ As a result, angular velocity, acceleration and magnetic field insity data come from the IMU.
❖ However, since the data we receive are measurements of noise parameters and errors, a few calibration and filtering processes are required. For example, while the magnetometer measures the earth's magnetic field intensity, it requires magnetometer calibration as it is affected by metals in the measuring device and other magnetic field generators in the environment.
❖ The most important problem affecting gyroscope measurement is bias and drift. And the accelerometer also gives noisy data. A filtering algorithm is required to eliminate them. Madgwick's filter is used in this project. Finaly , Euler angles calculated by MCU.

❖ In order to develop this project, a program that can make 3D modeling in terms of euler can be written and a more understandable output can be obtained for people.

```
AccelX: -0.019853   AccelY: 0.041670   AccelZ: 0.192507
GyroX: -0.019445   GyroY: -0.022870   GyroZ: 0.013512
MagX: 0.624524   MagY: 0.780515   MagZ: 0.027664
ROLL: -0.964750   PITCH: -1.375823   YAW: -0.209397
```

References

- OZKAN ,OBEN. SENSÖR FÜZYONU ALGORİTMALARI İLE AÇISAL KONUM REFERANS SİSTEMİ TASARIMI. YÜKSEK LİSANS TEZİ, YILDIZ TEKNİK ÜNİVERSİTESİ , 2019.
- http://www.ee.hacettepe.edu.tr
- https://github.com/arduino-libraries/MadgwickAHRS/blob/master/src/MadgwickAHRS.cpp

Acknowledgements