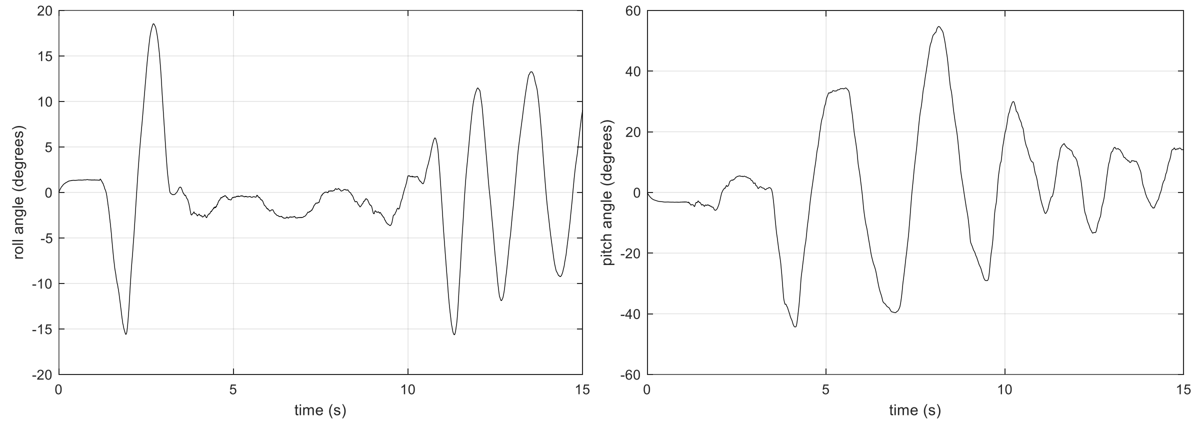
Bölüm: Kendi kendini dengeleyen robotun açısının bulunması

Arduino Kodu:

```
#include <Wire.h>

const int MPU = 0x68; // MPU6050 I2C address
float AccX, AccY, AccZ, GyroX, GyroY, GyroZ;
float accAngleX, accAngleY, gyroAngleX, gyroAngleY, angleX, angleY;
float AccErrorX, AccErrorY, GyroErrorX, GyroErrorY;
float elapsedTime, currentTime, previousTime;
int c = 0;
struct IMU {
  float angleX, angleY;
  unsigned long timeStamp;
};
IMU imu;

void setup() {
  Serial.begin(57600);
  initialize_MPU6050();
  // Call this function if you need to get the IMU error values for your
module
  //calculate_IMU_error();
}

void loop() {
  read_IMU();
  //Serial.print(imu.angleX); Serial.print(' '); Serial.print(imu.angleY);
Serial.print(' '); Serial.println(imu.timeStamp);;
  Serial.write('h'); Serial.write((byte*)(&imu), sizeof(imu));
}

void initialize_MPU6050() {
  Wire.begin();                      // Initialize comunication
  Wire.beginTransmission(MPU);       // Start communication with MPU6050 //
MPU=0x68
  Wire.write(0x6B);                  // Talk to the register 6B
  Wire.write(0x00);                  // Make reset - place a 0 into the 6B
register
  Wire.endTransmission(true);        //end the transmission
  // Configure Accelerometer
  Wire.beginTransmission(MPU);
  Wire.write(0x1C);                  //Talk to the ACCEL_CONFIG register
  Wire.write(0x10);                  //Set the register bits as 00010000
(+/- 8g full scale range)
  Wire.endTransmission(true);
  // Configure Gyro
  Wire.beginTransmission(MPU);
  Wire.write(0x1B);                   // Talk to the GYRO_CONFIG register
(1B hex)
  Wire.write(0x10);                   // Set the register bits as 00010000
(1000dps full scale)
  Wire.endTransmission(true);
}

void calculate_IMU_error() {
  // We can call this funtion in the setup section to calculate the
accelerometer and gury data error. From here we will get the error values
used in the above equations printed on the Serial Monitor.
```

```
  // Note that we should place the IMU flat in order to get the proper
values, so that we then can the correct values
  // Read accelerometer values 200 times
  while (c < 200) {
    Wire.beginTransmission(MPU);
    Wire.write(0x3B);
    Wire.endTransmission(false);
    Wire.requestFrom(MPU, 6, true);
    AccX = (Wire.read() << 8 | Wire.read()) / 4096.0 ;
    AccY = (Wire.read() << 8 | Wire.read()) / 4096.0 ;
    AccZ = (Wire.read() << 8 | Wire.read()) / 4096.0 ;
    // Sum all readings
    AccErrorX = AccErrorX + ((atan((AccY) / sqrt(pow((AccX), 2) +
pow((AccZ), 2))) * 180 / PI));
    AccErrorY = AccErrorY + ((atan(-1 * (AccX) / sqrt(pow((AccY), 2) +
pow((AccZ), 2))) * 180 / PI));
    c++;
  }
  //Divide the sum by 200 to get the error value
  AccErrorX = AccErrorX / 200;
  AccErrorY = AccErrorY / 200;
  c = 0;
  // Read gyro values 200 times
  while (c < 200) {
    Wire.beginTransmission(MPU);
    Wire.write(0x43);
    Wire.endTransmission(false);
    Wire.requestFrom(MPU, 4, true);
    GyroX = Wire.read() << 8 | Wire.read();
    GyroY = Wire.read() << 8 | Wire.read();
    // Sum all readings
    GyroErrorX = GyroErrorX + (GyroX / 32.8);
    GyroErrorY = GyroErrorY + (GyroY / 32.8);
    c++;
  }
  //Divide the sum by 200 to get the error value
  GyroErrorX = GyroErrorX / 200;
  GyroErrorY = GyroErrorY / 200;
  // Print the error values on the Serial Monitor
  Serial.print("AccErrorX: ");
  Serial.println(AccErrorX);
  Serial.print("AccErrorY: ");
  Serial.println(AccErrorY);
  Serial.print("GyroErrorX: ");
  Serial.println(GyroErrorX);
  Serial.print("GyroErrorY: ");
  Serial.println(GyroErrorY);
}

void read_IMU() {
  // === Read acceleromter data === //
  Wire.beginTransmission(MPU);
  Wire.write(0x3B); // Start with register 0x3B (ACCEL_XOUT_H)
  Wire.endTransmission(false);
  Wire.requestFrom(MPU, 6, true); // Read 6 registers total, each axis
value is stored in 2 registers
  //For a range of +-8g, we need to divide the raw values by 4096,
according to the datasheet
  AccX = (Wire.read() << 8 | Wire.read()) / 4096.0; // X-axis value
  AccY = (Wire.read() << 8 | Wire.read()) / 4096.0; // Y-axis value
  AccZ = (Wire.read() << 8 | Wire.read()) / 4096.0; // Z-axis value
  // Calculating angle values using
  accAngleX = (atan(AccY / sqrt(pow(AccX, 2) + pow(AccZ, 2))) * 180 / PI) +
1.15; // AccErrorX ~(-1.15) See the calculate_IMU_error()custom function
for more details
  accAngleY = (atan(-1 * AccX / sqrt(pow(AccY, 2) + pow(AccZ, 2))) * 180 /
PI) - 0.52; // AccErrorX ~(0.5)

  // === Read gyro data === //
  previousTime = currentTime;        // Previous time is stored before the
actual time read
  imu.timeStamp = millis();            // Current time actual time read
  currentTime = float(imu.timeStamp);
  elapsedTime = (currentTime - previousTime) / 1000;   // Divide by 1000 to
get seconds
  Wire.beginTransmission(MPU);
  Wire.write(0x43); // Gyro data first register address 0x43
  Wire.endTransmission(false);
  Wire.requestFrom(MPU, 4, true); // Read 4 registers total, each axis
value is stored in 2 registers
  GyroX = (Wire.read() << 8 | Wire.read()) / 32.8; // For a 1000dps range
we have to divide first the raw value by 32.8, according to the datasheet
  GyroY = (Wire.read() << 8 | Wire.read()) / 32.8;
  GyroX = GyroX + 1.85; //// GyroErrorX ~(-1.85)
  GyroY = GyroY - 0.15; // GyroErrorY ~(0.15)
  // Currently the raw values are in degrees per seconds, deg/s, so we need
to multiply by sendonds (s) to get the angle in degrees
  gyroAngleX = GyroX * elapsedTime;
  gyroAngleY = GyroY * elapsedTime;

  // Complementary filter - combine acceleromter and gyro angle values
  imu.angleX = 0.98 * (imu.angleX + gyroAngleX) + 0.02 * accAngleX;
  imu.angleY = 0.98 * (imu.angleY + gyroAngleY) + 0.02 * accAngleY;
}
```



Şekil 1: MPU6050 hareket sensöründen gelen verilerle Arduino üzerinde iki açıyı bulduktan sonra Arduino’dan MATLAB’a seri port aracılığıyla hesaplanan iki açıyı ve zaman verisini yolladık.