3-DOF SELF STABILISING PLATFORM

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***Abstract*—The Gimbal system has been a sensation in our present generation as it improves the stabilisation of handheld footage. It uses sensors and motors to stabilize and support the camera. Our project is about a 3-DOF self-stabilizing platform. It is using PID and Kalman filter to obtain filtered values regarding the position of the accelerometer/gyroscope (MPU6050) as feedback which it then uses to remain in the calibrated position despite a displacement. Servo motors have been programmed to obey the microcontroller based on the feedback received from the gyroscope.**

***Index Terms*— Kalman filter, Gyroscope, Displacement, Feedback, Stablilized Platform.**

I. INTRODUCTION

Proportional, integral, and derivative (PID) control is a feedback control scheme widely used in engineering, science, and industry. The popularity of PID is largely due to its ease of implementation and effectiveness.

The motivation for the use of PID stems from its cost-efficiency: a PID controller is never an optimum controller but is good enough in most cases that the added cost and complexity of an optimum controller are not worth the marginal increase in performance. Furthermore, PID control does not require a deep understanding of the underlying workings of a process all that matters is that some measured process variables can be strongly influenced by some controlled variable. A PID controller is made up of three parts: the proportional part, which drives the output in proportion to the instantaneous error; the integral part, which drives the output in proportion to the accumulated error; and the derivative part, which drives the output in proportion to the instantaneous rate of change of the error. Each part has a weighted contribution to the total output signal of the controller. The process of establishing those weights in order to get the best response from the controller is known as tuning.

In statistics and control theory, Kalman filtering is referred to as linear quadratic estimation, which is an algorithm that uses a sequence of measurements observed over time, containing statistical noise, and other imprecision. It produces a measure of unknown variables that tend to be more precise than those supported by one measurement alone, by estimating a probability distribution over the variables for every timeframe. The Kalman filter is named after one of the first developers of its theory, Rudolf E. Kálmán. The Kalman filter has countless applications in technology. Kalman filters are also one of the topics within the field of robotic motion planning and control.

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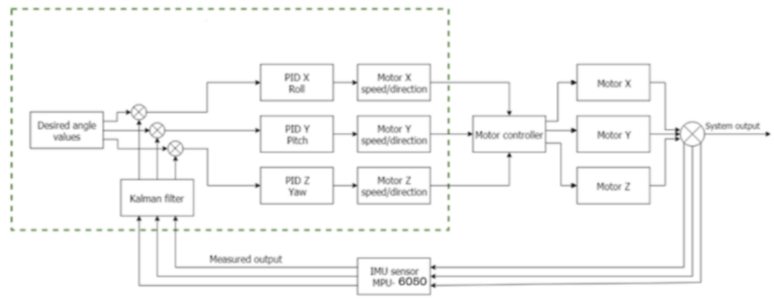
II. BLOCK DIAGRAM



Arduino Uno, Accelerometer and Gyroscope MPU6060, three servo motors and a platform which we needed to stabilise are needed to implement this project. The accelerometer gets the values of the orientation of the platform and with the assistance of the Arduino code of a PID controller and Kalman filter we see that the servo motors rotate such the platform remains at the stabilized level. IMU is an electronic device which can measure the force and speed of an object.

The operation Voltage of the "MPU-6050" is usually 3.3V, but some different models have regulators which allow it to connect up to 5V and it uses an I2C communication protocol. The accelerometer is used to calculate the acceleration. The IMU present in it also monitors the acceleration of gravity. This IMU performs with 8 bits registers. Each of the acceleration values monitored is stored in two registers which are low and high bits. The sum of these two registers gives us 16 bits of data. Therefore, the data will have two power times 16 value of acceleration value, including positive or negative signs when the IMU is perfectly aligned with any ground-level objects or floor. Then, the Z axis will be g=9.8 and the other two axis X and Y will be zero. When we rotate the IMU by 90 degrees, then the X-axis will be perpendicular to the floor, and thus it will have g=9.8.

The value of the gravitational force is 9.8m/s^2, and to calculate the three axes of the accelerometer, we can calculate the angle of inclination

III. EQUATIONS

The value of the gravitational force is 9.8m/s^2, and to calculate the three axes of the accelerometer, we can calculate the angle of inclination.

$$AngleY = atan\left(\frac{X}{\sqrt{Y^2 + Z^2}}\right)$$

$$AngleX = atan\left(\frac{Y}{\sqrt{X^2 + Z^2}}\right)$$

The MPU-6050 does not have a magnetometer. The gyroscope is used for measuring the angular velocity, so if we know the initial angle of IMU, then the gyroscope will add the value to know the new angle at each moment.

$$AngleY = PreviousAngleY + GyroDataY.elapsedTime$$

$$AngleX = PreviousAngleX + GyroDataX.elapsedTime$$

The values that we are obtaining from the gyroscope passes through the Kalman filter which analyze the info and normalizes it to offer an unruffled gradient of variation within the values of the gyroscope. This enables for adjustments to be supported the feedback during a much smoother and error-free method.

IV. RESULTS

The final outcome of the project is shown in the below Video link:

https://drive.google.com/file/d/1kS1Zib8g_DlNREd1BwJV5xk6mUHdbQtM/view?usp=share_link

V. HARDWARE MODULES

A. *ARDUINO UNO*

Arduino Uno is a microcontroller board based on the ATmega328P. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analogue inputs, a 16 MHz ceramic resonator (CSTCE16M0V53-R0), a USB connection, a power jack, an ICSP header and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with an AC-to-DC adapter or battery to get started.

B. *SERVO MOTOR*

A servo motor is a type of motor that can rotate with great precision. Normally this type of motor consists of a control circuit that provides feedback on the current position of the motor shaft, this feedback allows the servo motors to rotate with great precision. If you want to rotate an object at some specific angles or distance, then you use a servo motor. It is just made up of a simple motor which runs through a servo mechanism.
A servo motor usually comes with a gear arrangement that allows us to get a very high torque servo motor in small and lightweight packages. Servo motors are rated in kg/cm (kilogram per centimetre) most hobby servo motors are rated

TABLE I
MPU6050 DATASHEET

Part #	Gyro Full Scale Range	Gyro Sensitivity	Gyro Rate Noise	Accel Full Scale Range	Accel Sensitivity	Digital Output	Logic Supply Voltage	Operating Voltage Supply	Package Size
UNITS	(°/sec)	(LSB/°/sec)	mdps/√Hz	(g)	LSB/g		(V)	(V)	(mm)
MPU-6050	±250 ±500 ±1000 ±2000	131 65.5 32.8 16.4	0.005 0.005 0.005 0.005	±2 ±4 ±8 ±16	16384 8192 4096 2048	I²C	1.8V±5% or VDD	2.375V–3.46V	4x4x0.9

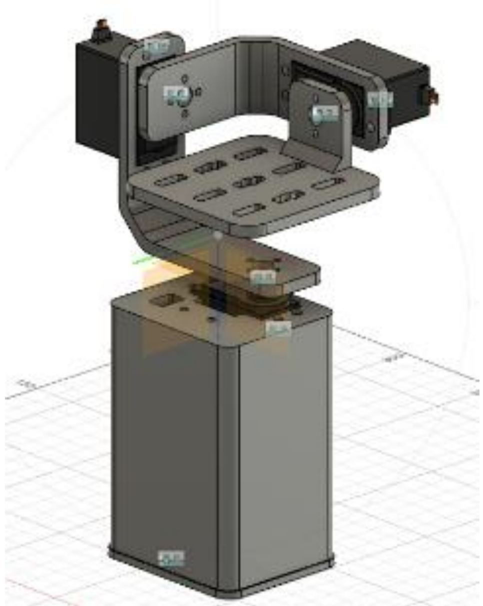
at 3kg/cm or 6kg/cm or 12kg/cm. This kg/cm tells you how much weight your servo motor can lift at a particular distance.

C. *INERTIAL MEASUREMENT UNIT (IMU)*

An Inertial Measurement Unit (IMU) is a device that typically consists of gyroscopes to measure and report angular rate and accelerometers to measure and report specific force.
An IMU typically consists of:

- Gyroscopes: providing a measure of angular rate
- Accelerometers: providing a measure of specific force/acceleration
- Magnetometers (optional): measurement of the magnetic field surrounding the system.

These electronic sensors are normally used to plan aircraft including UAVs, between several others, & spacecraft, comprising landers and satellites. Recent developments permit the manufacture of IMUbased GPS devices to function in an area where GPS signals are not available like tunnels or inside buildings. An IMU sensor unit working is often done by noticing linear acceleration with the assistance of 1 or additional accelerometers & rotational rate is often detected by using one or additional gyroscopes.



VI. CONCLUSION

We have concluded from this project that it involves smart implementation of statistical models and some basic components. In these modern days, the technology to assist people who are physically challenged has improved significantly. This project with today's technology can help people who are suffering from Parkinson's disease, which is a disorder that leads to handshaking and some difficulties with walking, so with the help of this self-stabilizing platform, it can reduce the shaking and help them to click nice pictures. It can also be used in several stabilization applications like camera stabilization in any moving platform.

ACKNOWLEDGMENT

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