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ABSTRACT

A smartphone is a device that has been widely used by people as taking photos or selfies in everyday life. The addition of a gimbal system can reduce the reduction in out-of-focus results produced by the human handgrip to the smartphone holder. In this study, control was carried out using an Arduino Uno microcontroller with the help of servo. The result of the research is that the movement of the servo is proportional to the given input value. There is a significant error value generated in the roll movement to the left due to low sensor readings and the lack of implementation of PID control on the system.

Key words: Smartphone, Gimbal, Focus, Roll, Holder

1. INTRODUCTION

A smartphone is a mobile phone with advanced features and has functionality beyond the functionality of previous mobile phones [1-5]. Smartphones can take pictures or videos, depending on the user's needs [6-10]. Taking photographs or videos done via smartphones still depends on the user's expertise in taking pictures or videos. Seeing the need for a gimbal system to make it easier for users who are less skilled in taking pictures or videos, a gimbal system can be created that stabilizes the smartphone when taking pictures or videos by moving the bracket from the smartphone in the opposite direction of the user's movement so that the smartphone can be stable in the shooting process or video taking process.

The gimbal is a mechanical device that is mounted on a specific axis to maintain the stability of an object or tool in a certain position [11-12]. Nowadays, gimbals are widely used in various fields, one of which is in the process of photography and videography [13-17]. DSLR cameras have used the help of gimbals for shooting and video, especially in the realm of film. The main benefit of the gimbal system is that it reduces the shock that occurs caused by the human hand, holding the weight of the object.

This study discusses the design of a gimbal system for smartphone stabilization using the help of the Arduino Uno microcontroller and servo to assist in taking pictures and videos on smartphones.

The gimbal is a mechanical device that is mounted on a certain axis to maintain the stability of an object or tool in a certain position [6]. The gimbal works by providing input to the motor or servo that works on the system to move in the opposite direction from the user's hand movement. The mathematical model of gimbal movement for 2 types of axes, namely roll and pitch, is as follows:

Rotation matrix for the roll axis

$$R1 = \begin{pmatrix} 1 & 0 & 0 \\ 0 & \text{Cos}\,\theta & -\text{Sin}\,\theta \\ 0 & \text{Sin}\,\theta & \text{Cos}\,\theta \end{pmatrix} \quad (1)$$

Rotation matrix for the pitch axis

$$R2 = \begin{pmatrix} \text{Cos}\,\theta & 0 & \text{Sin}\,\theta \\ 0 & 1 & 0 \\ -\text{Sin}\,\theta & 0 & \text{Cos}\,\theta \end{pmatrix} \quad (2)$$

The MPU6050 sensor is used to read the movement of the bracket so that it can provide control of the Arduino. The MPU6050 sensor is a gyro sensor, this sensor functions as a reader of the roll, pitch, and yaw angle movements. In this research, it will only be used to read the roll angle and pitch. Then the error value of the servo rotation movement can later be notated as follows

$$\varepsilon 1 = \alpha 1 - \alpha 1_c \quad (3)$$
$$\varepsilon 2 = \alpha 2 - \alpha 2_c \quad (4)$$

where $\varepsilon 1, \varepsilon 2$ shows the error value of the servo movement, and alpha 1 and 2 are the desired movement values and alpha 1 zero and alpha 2 zero are the reading values from the sensor.

2. MATERIALS AND METHODS

In the research conducted, several research methodologies were used, namely:

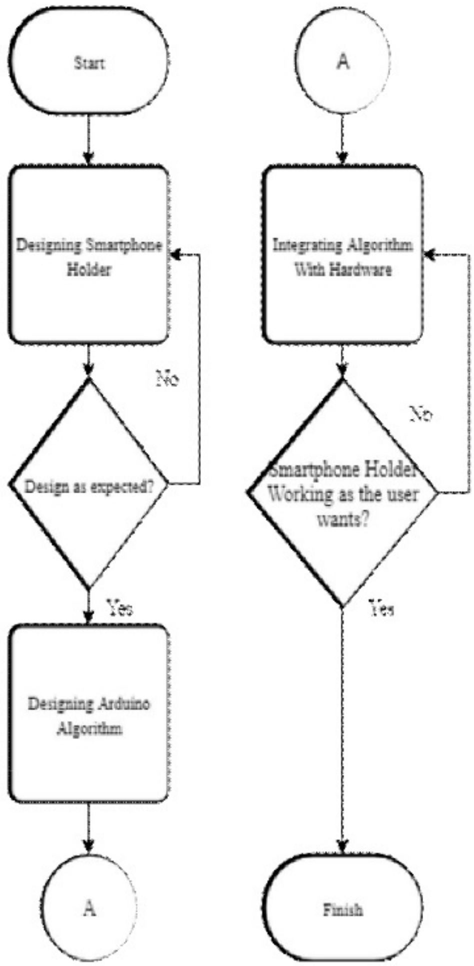

Figure 1: Research Flowchart

In Figure 1, it can be seen that the research flow is taking place with a literature study which is then followed by the design of a smartphone holder device using a smartphone holder or commonly known as "selfie stick" which is removed from the existing bracket so that it can be replaced with a new servo and bracket. Then the stick is attached first to a plywood board that has been affixed with a breadboard.

This plywood will later be used to hold the kinds of electronics used in this study.

The next stage is to design an electronic circuit on a breadboard on a plywood. First, plug the Arduino Uno and the MPU6050 Gyro sensor into the breadboard. Where the connection between the sensor and Arduino can be seen in the Table 1 below.

Table 1: Arduino Cable Connection with Sensor

Arduino	MPU6050
5Volt	VCC
Ground	Ground
A5	SCL
A4	SDA

After connecting Arduino with the MPU6050 sensor, then place it on a breadboard that has been attached to the selfie stick.

Next, select the servo to connect with bracket. At the beginning of the study, the first trials were carried out with a stickless prototype using the TowePro SG90 servo, where the specifications can be seen in Table 2 below.

Table 2: SG90 Servo Specifications

SG90 Servo Specifications	
Modulation	Analog
Torque	1.8 Kg at 4.8 Volt
Speed	0.12 to 60 degrees
Dimension Length	23 mm
Width Dimension	12.2 mm
Dimension Height	29 mm
Gear type	Plastic

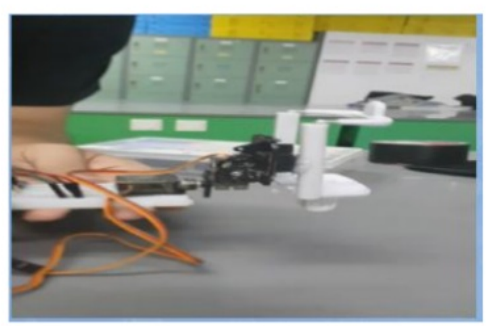

Figure 2: Smartphone Holder Prototype Trial with a gimbal system

It can be seen in Table 2 above that the servo can withstand a load of 1.8 kilograms, which can move the prototype bracket but not enough to move the final raft with the smartphone attached. Therefore, the servo used for the final stage is the MG996R servo with a torque of 9 to 11 kilograms which will be installed on the roll axis and also the pitch.

At the initial prototype-making stage, a trial was carried out, as shown in Figure 2. It can be seen in the picture above with the SG90 servo, testing is carried out only with the end bracket of the smartphone to analyze whether the algorithm used is as desired.

Table 3. MG996R Servo Specifications

MG996R Servo Specifications	
Modulation	Digital
Torque	9.4 Kg at 4.8 Volt
Speed	0.19 s / 60 degrees
Dimension Length	40.7 mm
Width Dimension	19.7 mm
Dimension Height	42.9 mm
Gear type	Metal

Table 3 above is the MG996R servo specification. The MG996R's lack of servo compared to the SG90 servo is the larger and heavier dimensions that make the stick holder smartphone heavier.

After installing the servo on the axis roll and pitch, attach the servo to the bracket as in Figure 3 and then use tape to attach the servo to the stick that has been attached with plywood.

The next step is to create an algorithm to give to Arduino, the algorithm must be made can move the servo so that it provides a movement that is opposite to the user's hand motion, that way the servo will stabilize the smartphone bracket on the end of the stick.

3. RESULTS AND DISCUSSION

In the study, measurements were made using an arc and saw the results of the bracket movement that had been placed on the smartphone, as shown in Figure 3.

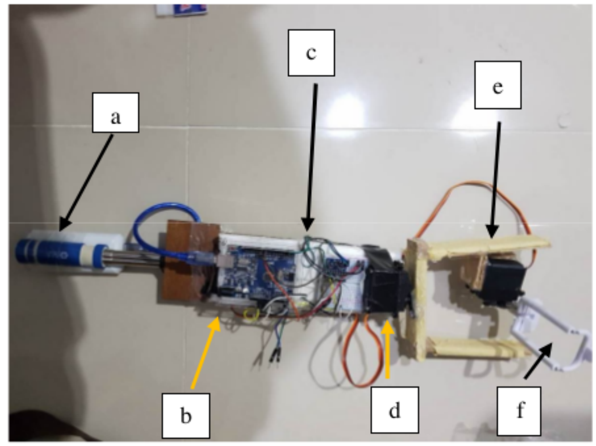

Figure 3: The Final result of the smartphone holder tool with gimbal system (a) The stick and the power bank as the power provider for the Arduino, (b) Arduino Uno location, (c) MPU6050 Gyro Sensor Location, (d) Roll axis servo location, (e) Servo drive location the pitch axis, (f) The bracket where the smartphone is placed

In Figure 3 it can be seen that the result of a Smartphone Holder Tool Raft that has been implemented by the gimbal system. At the bottom of the stick at point (a) is placed a power bank as a power supply for the Arduino Uno, then at point (b) is the location of the Arduino Uno which is connected to the breadboard and plywood so that it can settle on the top of the stick. At point (c) is the location of the MPU6050 sensor which will read the movement of the roll and pitch axis rotation made by the user. At point (d) is the servo location which will control the movement of the roll axis, the servo will provide the opposite movement of the user's movement.

Servo axis roll requires a large enough torque because it will hold the whole bracket as shown and reinforced adhesion with bracket with the help of the glue gun provided. However, at the beginning of the trial, the glue gun was not strong enough to withstand the overall load bracket, so that a bolt is given to connect the servo to the back of the plywood bracket.

Point (e) is the location of the servo, which controls the movement of the axis pitch. This servo will move the bracket, which is directly related to a smartphone so the load borne by the servo is not as heavy as the servo at point (d). Point (f) is the location bracket who will be in direct contact with a smartphone. Part of the initial selfie stick before modification. After testing the resistance of the tool by lifting the stick that had been placed smartphone. The next stage is to test the gimbal system, and the results of the data obtained are presented in Table 4 and Table 5.

Table 4: Results of research data for roll axis

Hand Movement	Reference Angle (Degree)	Reading Angle (Degrees)
Rotate Right 45 Degree	Turn Left 45	Turn Left 43
Rotate Left 45 Degree	Turn Right 45	Turn Right 44
Rotate Right 90 Degrees	Turn left 90	Turn Left 88

Table 5: Results of research data for the pitch axis

Hand Movement	Reference Angle (Degree)	Reading Angle (Degrees)
Move Up 45 Degree	Move Down 45	Moving Down 46
Move Down 45 Degree	Move Up 45	Moving Up 43
Move Up 90 Degrees	Move Down 90	Move Down 75
Move Down 90 Degrees	Move Up 90	Moving Up 73

In the data table above, it can be seen that the movement of the roll axis is close to the reference value except for moving to the left by 90 degrees, this is because the sensors used are still relatively cheap so there are still errors in the sensor, and there is still a lack of implementation of PID control to control servo in order to produce more accurate data. For the results of the pitch axis data, it can be seen that the rotation of the bracket movement is quite precise except for above 75 degrees, this is due to the movement of the servo and the size of the bracket which are large enough to cause movement obstruction above 75 degrees.

Error can be reduced in further research by using a lighter but stronger material to withstand the weight of a smartphone and also implementing PID control on the system to get more accurate results in gimbal control.

4. CONCLUSION

The conclusion obtained from the research is that the addition of a gimbal system on a smartphone holder stick can help users to take pictures or videos that are more stable and do not cause blur. However, this research tool still needs more development to reduce the errors generated, because it can be seen for the roll movement to the left still causes a significant error value. It is necessary to add a control system to reduce the resulting errors.

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