Stabilizing Glove

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Abstract

Parkinson's disease and essential tremors are two conditions characterized by hand and arm tremors. This greatly affects the daily life of millions of patients worldwide. The solution investigated here is a stabilizing glove using a gyroscope controlled through an accelerometer sensor and a microcontroller. The achieved momentum of the gyroscope is approximately 4.4 times larger than that of a hand tremor.

Introduction

Parkinson's disease (PD) and essential tremor (ET) are two medical conditions which affect the motor system. PD affects more than 10 million people worldwide and ET is eight times more common [1,2]. These conditions lead to uncontrollable movements, with hand and arm tremors being the predominant symptoms [3]. While great improvements are being made in treating these conditions, they remain far from cured. In the meantime, external technical aids are utilized to lessen or overcome the symptoms. However, many of these aids are purpose-specific, meaning they are designed for a certain task. One example of such is the stabilizing spoon [4]. This leads to every patient having to own a large number of different aids. The advantage of a stabilizing glove would thus be that it can make several other aids obsolete.

The concept of a stabilizing glove using a gyroscope already exists on the market, for example the GyroGlove™ [5,6]. The purpose of this project was therefore to further develop the idea by integrating smart steering of the stabilizing system through a sensor indicating when the stabilization is actually necessary and then turn the gyroscope on or off. By doing this, it would be possible to save battery power, which can have several positive outcomes, for example on the environment. It would also facilitate comfortable use when the tremor is less active.

Design

The stabilizing glove consists of an accelerometer that detects the tremor and communicates through a microcontroller to turn on or turn off the gyroscope. The gyroscopic effect is achieved using a brushless motor and is powered by a DC Lab power supply. However, it should be changed to a battery to make the glove mobile. The gyroscope is located in the middle of the hand and the accelerometer sensor just above the gyroscope. The intention is for the battery to be mounted along the forearm to not limit the movement of the hand. The specific models used can be found in table 1.

Table 1: List of components

Component	Function
DX2205 2600KV- 4S Brushless Motor	Gyroscope
Accelerometer MPU 9265	Detects tremors
Arduino nano	Central control unit
ESC - Hobbywing SkyWalker 30A	Speed controller
DC Lab Power Supply or 2S LiPo Battery	Power source

Mechanical design

To achieve a stabilizing effect, it is necessary that the gyroscopic momentum is greater than the momentum of hand tremors. The main controllable factor for the gyroscopic momentum is the rotations per minute or RPM, which depend on the voltage of the power source. For the DX2205 motor, a voltage of 7.4 V would lead to approximately 20 000 RPM, i.e. an angular velocity ω of 2094.4 rad/s. The motor has a radius r of 1.5 cm and a mass m of 28 g. The momentum can thus be calculated:

$$\text{Linear velocity } v = r \cdot \omega = 0.015 \cdot 2094.4 = 31.42 \text{ m/s}$$

$$\text{Momentum } p = m \cdot v = 0.028 \cdot 31.42 = 0.88 \text{ kgm/s}$$

Note that it is possible to secure a weight to the top of the motor, thus increasing the mass and in turn, the momentum. The calculations can be compared to the momentum of a hand tremor. The average hand weighs 460 g [7], and a tremor has the approximate linear velocity of 2 m/s, leading to a momentum of 0.92 kgm/s.

Electronic design

The microcontroller is connected to the gyroscope through an electronic speed controller and to the accelerometer, see figures 1. The microcontroller was programmed using the Arduino IDE. It takes in information from the accelerometer and reads the acceleration value caused by moving the sensor. The code for this was based on the library MPU9250_asukiaaa and its associated code made by Asuki Kono [8]. The values are then made into a vector that is sampled twice with a delay in between after which the second value is subtracted from the first. The value that is obtained is essentially the derivative and that shows how fast the hand is moving. The derivative is then integrated and added to 90 % of the previous integrated derivative. The integration is used so that fast, intentional movements (i.e. not tremors) do not increase the value so much that the motor is turned on. Multiplying with 0.9 is important so the value can start decreasing when the tremor stops and the motor can turn off. This value is then sent to a function that decides the speed of the motor.

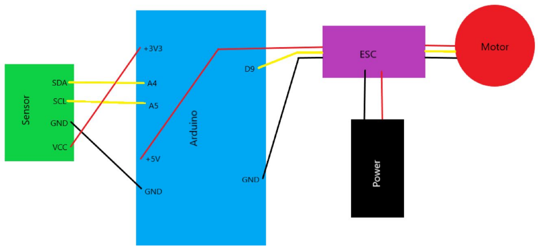

Figure 1: Schematic of electronic connection. Red lines for power, black lines for ground, yellow lines for signals.

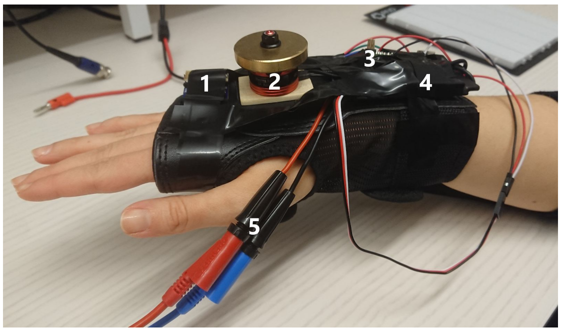

Figure 2: Prototype of glove: 1. Sensor 2. Motor with weight 3. Arduino 4. ESC 5. Power Source

The gyroscope is also controlled by the microcontroller, using the standard Servo library in the Arduino IDE for control of motors [9]. It was programmed to start when the tremors reached above a threshold value.

Evaluation

The prototype glove can be seen in figure 2. The preferable method of evaluation would have been for someone with PD or ET to try the glove. Unfortunately, this was not possible. For someone without these conditions to simulate tremors also proved difficult as it becomes natural to fight the dampening effect, making it impossible to calculate how strong the dampening actually is. However, a brass plate with a mass of 75.6 g and radius 40 mm was attached to the motor. The gyroscopic momentum thus becomes 4.05 kgm/s. This is 4.4 times stronger than the momentum of a hand tremor, and the gyroscopic effect can clearly be felt while wearing the glove.

At the moment the glove gets its power from a DC lab Power Supply rather than the battery. One of the first steps in improvements would be to adjust the connectors to fit a battery rather than the power supply.

The original plan for the code was to use a high pass filter to remove fast, intentional movements while keeping the tremors. It is possible that it would work better than the current system of derivation and integration, but requires more time and research to implement.

The current glove is only a first prototype and several other improvements are necessary. The components need to be covered, both for the safety of the user and to protect the electronics. The motor needs a cooling system as it becomes warm when on for a longer period of time. There is also an issue when the motor is first turned on as it immediately reaches quite a high velocity, making it feel jumpy. This could potentially be solved by designing our own ESC.

Conclusion

A prototype of a stabilizing glove using gyroscopic momentum and smart steering through an accelerometer was made. It is able to detect active tremors and turn the gyroscope on or off depending on the accelerometer data.

References

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