

DESIGN OF STEPPER MOTOR APPLICATION AS ARCHERY DRAWER

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ABSTRACT

The presence of various manuals and instructions on approaching archery is easily attainable. Existing archery manuals and instructions lack practicality in real-time applications. To address this issue, an archery drawer project is proposed, serving as a training partner for users to understand the required draw length and its impact on arrow power. The project is designed to benefit both beginners and professional archers seeking to improve their skills and reduce the risk of injury caused by prolonged training to determine optimal draw length. By allowing users to determine the draw length and observe its impact on arrow power, the project enhances understanding and skill development in archery. The utilization of a stepper motor, Arduino, and servo enables precise control over the bow's draw length, contributing to a safer training environment and reducing the risk of injury caused by prolonged training to determine optimal draw length. The project's use of low-cost materials ensures affordability while maintaining a high-quality machine. It was also able to get the highest efficiency of shooting of 96.7% at draw length of 22 cm. Overall, this archery drawer project offers a user-friendly and accessible solution for archers of all skill levels to enhance their performance and training experience.

Keywords: Archery, Arduino and stepper motor

1.0 INTRODUCTION

Design of stepper motor application as archery drawer is a combination between an Arduino software and the hardware of an archery drawer. This project mainly designs an automatic bow drawer utilizing a stepper motor and Arduino. In many cultures, the art of shooting arrows using a bow, the archery, has advanced to another higher level. Archery has been practised by aboriginal peoples throughout North America since pre-Columbian times. In Japanese word for archery, which is Kyudo, is more to a mental sport that uses longbow and more straightforward gear than standard European archery [1]. Existing archery manuals and instructions lack practicality when

applied in real-time scenarios. The information provided in these manuals may not effectively translate into practical archery skills and techniques. Besides that, Archers often struggle to determine the optimal draw length that would result in the desired power and accuracy of their arrows. This process of trial and error can be time-consuming and may lead to increased risk of injury due to prolonged training sessions. The component of the system, mainly the stepper motor, plays an essential part in how the project works. Electrical energy is converted into mechanical energy by a bipolar stepper motor. The stepper motor with a 12V power source is the most powerful and efficient. The signal sequence is managed by this stepper motor, which rotates step by step [3]. The use of the stepper motor in this system is also supported by the fact that the stepper motor is one of the greatest forms of motor for controlling sensitive applications like as micro-surgical motors, aircraft take-off detective devices, printers, scanners, disc drives, and many more acute and accurate daily industrial uses [5]. In many industrial applications, stepper motors are frequently used, particularly when a highly precise control position is required. Most applications that call for discrete movement use stepper motors [2] – [4].

In addition to the stepper motor, the servo motor also works in the system. The servo motor is a useful technology in remote control and robotics. Because these motors are specifically designed to perch in a precise position, they play an important function in the robotics sector. Servo motors are self-contained electric devices that precisely spin or push machine elements. A tiny mechanical device comprising an output shaft is called a servo. This shaft can be moved to certain angular positions by transmitting a coded signal to the servo. For as long as the coded signal is present on the input line, the servo will preserve the shaft's angular position. When the coded signal changes, the shaft's angular position changes [6]. Because archery requires bi-manual coordination, these two pieces of equipment are the most critical in this archery project. It is possible to execute it with leisurely arm movements and small torques and forces. It also necessitates the use of externally affecting tools (bow and arrow) (target). It is a great job for assessing different learning algorithms and learning features because the reward is effectively provided by the high-level description of the task aim. Finally, it combines image processing, motor control, and learning components in a single job [7]. The draw length of the archery drawer can be adjusted by the user, and this previous project has succeeded in meeting its goal of being a useful training tool for the archery industry. The use of a stepper motor capable of performing the archery motion of drawing and releasing the string will help to reduce the energy-consuming act. To hit the target, the traditional method of archery, drawing the bow and arrow, requires strength, energy, and pin point accuracy. A stepper motor archery drawer is used to improve current conditions by programming a stepper motor to draw the bow at a consistent length. As a result, the stepper motor must be equipped with an Arduino that can be programmed to draw the bow at various draw lengths for any type of bow.

An Arduino Uno is inserted into the system for the programming because of its affordable price. Various machineries are available, however they come at a high price that a small-scale firm may not be able to afford [8]. The access to affordable archery training tools is limited, especially for small-scale firms or individuals who cannot afford expensive machinery and equipment commonly used in archery automation. Hence, the goal is to use G-codes and a microcontroller to automate an existing machine setup. This method lowers the cost of automation while also allowing for customisation through programming [9]. The Arduino UNO is a gadget that may be programmed to conduct a series of events using the C++ programming language. It controls the state of input devices and sends a signal to control the state of output

devices. It has 20 input and output pins in total. PWM outputs are available on six pins, while analogue inputs are available on six more [10]. It can complete data collecting, analysis, processing, and body control with all those characteristics [11].

The primary purpose of this project is to reduce the workload of archery, resembling the creation of a humanoid archery robot that can do the act of archery consistently and not have to expend energy [12][13]. This project seeks to recreate an archer's motions, with each shot cycle being broken down into phases: The archer lifts the bow while on the firing line, pulls the bowstring, points the arrow at the target, and release the arrow [14]. The elastic forces of a bow and a limb at varying degrees of draw as well as the vibration of a bow after firing were examined by researchers to better understand the mechanical characteristics of a bow and limb. It was found that the elastic force and pulling distance were nonlinear. Although the middle range of pull was minor, it was noticeable in the final range of pull because the early rate of elastic force rise had been quite large. In terms of draw strength, they also found differences in the elastic force patterns between the bow's upper and lower limbs. The difference occurred when the limbs were dragged more deeply, causing the shapes of the middle and end regions of the arms to differ slightly [15]. This sequence is often done by archers when in practice. This can be overused, leading to injuries to the muscles. The upper limb muscles are activated in a coordinated manner to produce each of these actions. Bowstring tugging involved the posterior deltoid and trapezius muscles, according to electromyographic (EMG) research [16], in order to stabilise the scapula, the lower trapezius muscle is used. [17]. Scapular muscles (deltoid, trapezius) on the bow side are responsible for regulating humeral tremor and improving aiming precision [18]. Therefore, this project mitigates the risk of injuries associated with archery training.

Archery, in theoretically, is defined as the act of a particle that is launched obliquely toward the surface of the earth, it travels along a curved path while accelerating continuously in the direction of the earth's natural center. Such a particle's motion is known as projectile motion, and its path is referred to as a projectile [19]. Research is made about the following topics, and it is founded that an archery robot 53-DOF humanoid robot iCub [7], developed by the Italian Institute of Technology, which shoots arrows using a bow. These two-research works focused on projectile motion, the type of arrows used, and the algorithm used to shoot the arrows [20]. There are also other examples such as a Japanese educational system where a college called College of Technology has gathered students such 62 college from 15 to 20 years under the Department of System and Control Engineering to train them integrate like mechatronics systems for them to fully understand the basic interface technology from integrated and systematic viewpoints. One of the contests that was held during 1999 was creating Horseback archery robots. The following robot can move along the white line written on the floor and take arrows that will shoot to the prescribed positions [21].

In term of assuring the launcher to aim and hit a target as accordingly planned, angle of the launcher and the distance of the target from the launcher. Determining the projectile impact points is important as it will be set to be used throughout the experiment activities. Conventionally, seismic waves are used to localized to test the projectile placement. However, the surface deviation characteristics, greatly affects the accuracy of the positioning by the seismic wave transmission. Therefore, in order to expeditiously and accurately determine the specific location of the projectile impact point, Di Chang'an proposed and acoustic projectile impact point localization model based on the double right-angled pyramid configuration [22].

2.0 METHODOLOGY

The design of the prototype as in Figure 1 is separated into three parts which is the stepper motor, Arduino, and servo motor as inputs. The Arduino UNO is employed as the key component in the construction of this system to regulate the input and output states. The TB6600 Stepper Motor Driver is then employed as the main component to regulate the stepper motor's speed and current. A MG996R Servo motor is also connected to the Arduino to control the releasing process of the bow. This project uses a 24v power supply to power all the components.



Figure 1: Archery drawer prototype

The design of the archery drawer requires a connection between all the components. Figure 2 shows the schematic diagram of the archery drawer.

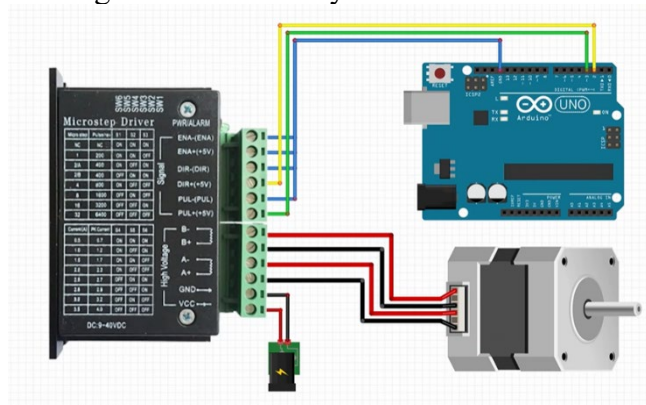


Figure 2: Archery drawer schematic diagram

Figure 3 below shows the flowchart of the archery drawer. First, the Arduino is turned on, and the coding from the Arduino is transferred to the stepper motor, where the motor pulls the bow and arrow back a certain distance. When the motor has reached the distance set, the servo attached will be alerted and release the arrow from the bow to complete the cycle of the system.

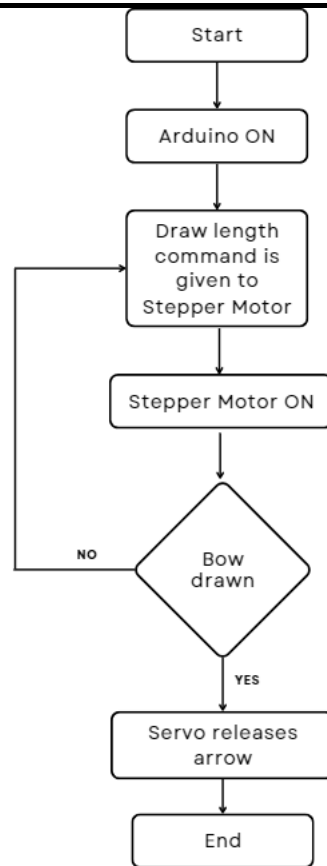


Figure 3: Flowchart of the archery drawer programming

3.0 RESULTS AND DISCUSSION

As a result, the bow draw length is set between 12 to 24 cm using the setting of steps per revolution as in Table 3. After reaching the desired draw length, the stepper motor stops, and the servo motor is alerted to release the bow together with the arrow. The point in which the arrow hit the target is recorded. This project provides the user with the flexibility to set the speed at which the motor moves and the bow's draw length. This can be used to replicate the traditional motion of a typical archer, which is the drawing and releasing action.

Based on the data presented in Table 3, the steps per revolution value of 5500 provides the most efficient outcome for the projectile launcher. This optimal performance is achieved when maintaining a draw distance of 22 cm between the stepper motor and the servo motor, resulting in an average value of 9.7 as highlighted in the table. These findings indicate that 5500 steps per revolution offer superior performance compared to other tested values. The stepper motor plays a crucial role in controlling the draw length distance, allowing for precise adjustments in the force and trajectory of the projectile launch. It provides fine-tuning capabilities, ensuring accurate and controlled propulsion. In contrast, the servo motor controls the release mechanism, ensuring precise timing and synchronization for accurate launches. The combined operation of these motors enables controlled and accurate projectile propulsion, enhancing overall performance and efficiency.

Table 3: Average and efficiency for different lengths of bow drawn.

Steps Per Revolutions	Draw length (cm)	Arrow Points			Total	Average (Total/3)	Efficiency (Average/100) %
		Arrow 1	Arrow 2	Arrow 3			
3000	12	M	M	M	0	0	0
3500	14	M	7	M	7	2.3	23
4000	16	M	M	7	7	2.3	23
4500	18	7	8	8	23	7.7	77
5000	20	9	9	9	27	9	90
5500	22	9	10	10	29	9.7	97
6000	24	10	8	9	27	9	90

M = Miss of target

To ensure smooth and efficient operation, it is important to consider the weight of the motor and the materials used to connect it to the aluminium profile. The motor should be compatible with the load-bearing capacity of the profile to maintain stability. Additionally, utilizing sturdy brackets or mounting plates made from high-quality, durable materials is crucial to withstand forces and vibrations. The materials used to build the base are aluminium and M3 brackets. The aluminium profile was used as the mainframe of the project because it is sturdy and light. By selecting appropriate materials, a secure and reliable connection can be established between the motor and the aluminium profile. M3 brackets are used to connect the aluminium profile. The stepper motor is used together with a TB6600 stepper motor driver for the main components. The TB6600 stepper motor driver's purpose is to control the speed and current at which the stepper motor runs. An Arduino is implemented for programming purposes so that the user can predetermine the intended draw length. These components, combined with the servo motor that is used to release the arrow, make a working archery drawer, as stated in this paper.

4.0 CONCLUSION

In conclusion, this project has achieved the objective set which is that the archery drawer can allow the user to set the draw length and be useful in the archery industry such as a training tool. It is also found that for this bow and arrow, the optimum draw length is 22 cm. Using a stepper motor that can execute the archery motion of drawing and releasing the string will help reduce the energy-consuming act. The traditional way of archery, drawing the bow and arrow, requires strength, energy, and pinpoint accuracy to hit the target. Addressing these issues, a stepper motor archery drawer is used to improve the current conditions by programming a stepper motor to draw the bow at a consistent length. Therefore, the stepper motor needs to be fitted with an Arduino, which can be programmed to draw the bow at different draw lengths for any type of bow or arrow.

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