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DEVELOPMENT AND IMPLEMEMTATION OF A ROBOTIC HAND FOR DEMONSTRATION IN MECHATRONICS LABORATORIES OF NIGERIA HIGHER INSTITUTIONS

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Abstract – For many decades, Nigeria's manufacturing industry has been plagued by a shortage of genuine products. Aside from that, they face globalization issues (such as the use of artificial intelligence tools in the manufacturing process).To address this and other related issues, our higher education institutions have recently begun studying mechatronics. This paper describes the creation of a small robotic hand that can be used as a learning aid in our mechatronic laboratories. The system is made up of tendons (cables) and fingers that work together in an open and closed manner to manipulate objects in the same way that human hands do. When fully operational, the robotic hand can handle a 100g product in approx. 17 seconds seconds. The system is intended to operate with a voltage supply from a battery. The robotic system also includes a battery overcharge protector to address the technical issue of voltage supply from a public or private electric power supply. To protect the developed robotic hand, it was housed in a transparent composite material (Teflon).When compared to imported ones used in our many mechatronic laboratories of higher institutions of learning in Nigeria, the fabricated robotic hand performed well in terms of efficiency and functionality.

Key words: Keywords: Manufacturing, globalization, robotic hand, robotic system

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Introduction

The word "robota" originates in Czech and refers to forced labor in 1920 (Ravikumar et al., 2015).When it comes to accomplishing different robotic tasks, the robotic hand is especially important, especially when it comes to differentiating tasks that require grasping (Xizhe et al,2023).Depending on consumer demand, robots are being employed in a variety of human endeavours, including industrial and educational settings. According to Rang et al. (2014), it arises from deficiencies in either insulin action or secretion. In schools, educational robots are widely used for both extracurricular and classroom purposes.

Robots intended for educational purposes are typically mobile in nature, using actuators exclusively for their motors and display components like lights, speakers, or screens (Robots,2023).Pre-assembled mobile robots, robotic kits, robotic arms, and robotic hands are a few examples of the kinds of robots that are frequently utilized in educational settings. However, many industrial robots, especially those with robotic arms or hands, impact the surroundings through end effectors, which are typically grippers or related instruments (Fig. 1).Robotic hands often have built-in pressure sensors that alert the computer when the hand is gripping the object securely enough.

Educational robots are widely used in schools, both in the classroom and for extracurricular activities. Educational robots are typically mobile robots with actuators as motors and display devices such as lights, sounds, or a screen (Robots,2023). Robots commonly used in educational institutions include pre-assembled mobile robots, robotics kits, robotic arms, and robotic hands. Despite this, many industrial robots, particularly robotic arms (or robotic hands), have an impact on the environment via end effectors, which are typically grippers or similar tools (Fig. 1). Robotic hand frequently features inbuilt Robotic hand frequently features inbuilt pressure sensors that tell the computer when it is gripping with the right amount of strength.

In Nigeria, several studies on the design and fabrication of small robots have been conducted.Daniel et al. (1993) created a low-cost, modular, cable-driven, anthropomorphic robotic hand.It was done with models that help to mimic both the form and mechanical features of the human hand.The system produces a highly dexterous, 26 degree of freedom anthropomorphic robotic hand that captures all of the degree of freedom in the human hand and wrist. The tool's aggregated information serves as a foundation for existing tool studies and new tool and wood product development. Adesoji et al. (2022) highlighted hand learning to avoid butter finger. Ibrahim et al. (2022) designed and prototyped a robotic hand for sign language using locally sourced materials.

Princewill (2023) develops and implements a wireless-controlled robotic arm with six degrees of freedom (DOF) for lifting applications. The robot was developed from the working principle to the development of the kinematic equations, as well as CAD modeling and component selection. In training institutions, the system could be a valuable learning tool for experimenting with robotics. However, many of these robots are designed for industrial use rather than educational or training purposes. The goal of this work was to create a low-cost, high-performance robotic hand for demonstrating robotic applications in industry.

The study design is worth considering because it had a better effect on robotics learning in Nigeria. Electric-powered robots required for industrial applications have been developed in the country, but literature on developing a prototype of robotic hand for use in Nigeria laboratories using locally sourced materials such as DC. motor in developing countries is scarce. This research seeks to design and test a simple robotic hand jack made from locally sourced materials, with the goal of saving money and improving the economy.

2. MATERIALS AND METHODS

2.1 Basic concept of the machine

The robotic hand was designed and built with the following goals in mind: safe operation, general maintenance and servicing, low initial and operating costs, and efficient and effective performance, among others. The hand is designed for grasping an object with an irregular shape (or a soft object with a regular shape, such as bread).

2.3. Designing of the robotic hand

Designing a good robotic hand or arm is more of an art than a technique (BR,2007). The work begins with a sketch of how the robot hand will look. The robot was developed from the working principle to the development of the kinematic equations, as well as CAD modeling and component selection. In training institutions, the system could be a valuable learning tool for experimenting with robotics. The robotic arm is controlled by a computer by rotating step motors connected to individual joints.

Freehand sketching was used to create the design for the robot. The sketch was improved using Auto-CAD software at the mechatronic laboratory, Department of Mechanical Engineering technology Federal Polytechnic, Ede, and the plant was documented. All fingers move in the same way that tendons in the human hand do. The mechanical design of the robotic hand consists primarily of claws (fingers) that function similarly to tendons in the human hand, controllers, drives, sensors, and the robotic hand's arm.

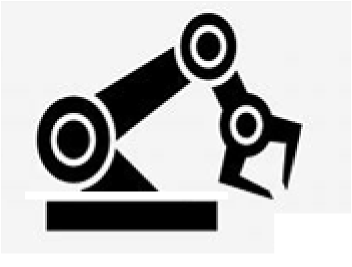


Fig.1: Model of robotic hand using Auto Cad

2.1.1 Drives

Drives are the motors located between joints that control movement and maneuvering. They typically use belts similar to those found in automobile engines. Motor drives are used to propel the machine. The drives are attached to the joints of a robot to control movement and maneuvering between the joints. The rotating motion is then transmitted to a joint via a shaft attached to the joint to increase bevel gears. The hand is based on a motor-direct-driven mechanism, a structure that positions the motors with respect to the joints to drive the joint, either directly or indirectly via gear.

2.1.2 Power Supply

The working power of the robot is supplied by batteries, hydraulic, solar, or pneumatic power sources.

2.1.3 **Claws**

The robotic hand, also known as the end-effect or grip and lift object, uses claws that are usually two or three in number to grip the object to lift. The claws are attached to the hand's end. The hand claws are connected to the chain's end.

2.1.4 Controllers

Controllers are the main processors and brains of robotic arms. Because the robotic hand serves as its brain, controllers are required to control it. They can either operate automatically as programmed or manually by outputting instructions directly from a technician. Manual control entails connecting to a computer and receiving instructions. When a task is to be performed on the robotic hand, a message is sent to it via a controller.

2.1.5 Arms

An actuator is required to convert energy within an electronic component. Actuators are energy conversion devices used inside robots; their primary function is to convert energy into movement. The actuator used to drive the robotic hand must take into account several important parameters such as size, motor type, torque, efficiency, and so on (Intel,2023) .

2.1.6 Controllers

They are essentially the control consoles for the robotic arms and come in a variety of styles depending on the amount of processing power required. Some controllers in large factories are complex computer systems, whereas others, such as those found in science project kits, are simple joysticks.A robotic controller assists in the rotation of each joint's associated motor.

2.2. Designing of the robotic hand

Designing a good robotic hand or arm is more of an art than a technique (BR,2007). The robot was developed in this work from the working principle to the development of the kinematic equations, as well as CAD modeling and component selection. In training institutions, the system could be a valuable learning tool for experimenting with robotics. The robotic arm is controlled by a computer by rotating step motors connected to individual joints. A larger robotic arm uses pneumatic or hydraulic control) development and implementation of a wireless controlled robotic arm for lifting applications with 6 degrees of freedom (DOF).Because the step motors move in increments, the computer can move the arm precisely and perform the same movement repeatedly (Techman,2023).

2.2 Basic Calculation

2.2.1 Kinetic Analysis of the robotic hand

To analyze the kinematic and dynamic behavior of a human finger, the coordinate system is assigned to each joint using the DH parameter rules. As shown in Figure 2 and Table 1, each joint has three coordinate systems, with one at the finger tip. The following table defines the DH parameters of the finger under consideration.

θ is angle of rotation about the joint axis
β is angle about common normal, from old z axis to new z-axis
ρ is offset along previous z to the common normal
l is length of the common normal (link length)

Table 1: DH parameters

θ	B	ρ	l(mm)
θ_1	0	0	24
θ_2	0	0	24
θ_3	0	0	14

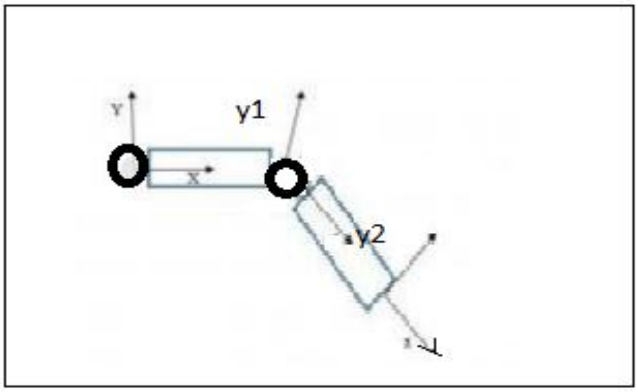


Fig.2: Links and the coordinate system obtain using DH parameter rule

2.2.1 Relationship between torque and applied motor

As a result, it is necessary to understand the relationship between joint torque and motor torque, as well as the relationship between joint displacement and motor rotation.As a result, it is critical to understand the relationship between joint torque and motor torque, as well as the relationship between joint displacement and motor rotation.

Let τ_1 be the torque at the finger joint and τ_2 be the torque at the motor, then due to design considerations,

$$\frac{\tau 1}{\tau 2} = \frac{r2}{r1} \qquad \text{Eq. (1)}$$

Where, r_1 = radius of the pulley at the finger joint and r_2 = half of the horn length of the motor as shown in the figure,

Similarly, Let, $\theta 1$ be the joint displacement of the finger and $\theta 2$ be the rotation made by the motor, then

$$\frac{\theta 1}{\theta 2} = \frac{r2}{r1} \qquad \text{Eq. (1)}$$

2.2 Assembly of Robotic hand

Robotic hand parts are assembled as shown in the AutoCAD CAD model (Fig). This is a prototyping process in which all of the required components of the robotic hand are assembled in an orderly manner, and the final output is shown in Figures 2 and 3.The prototype assembly began with the arm assembly and progressed to other components.

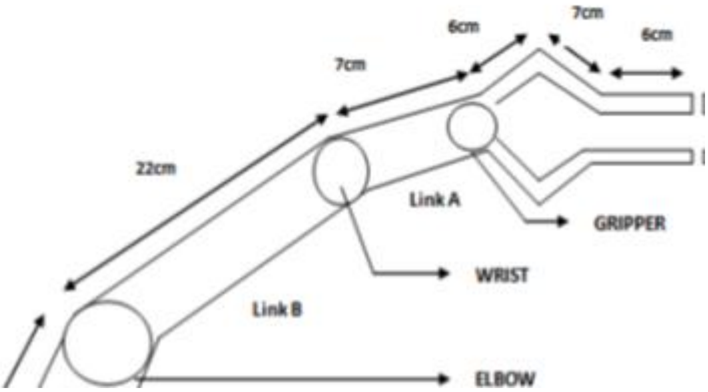


Figure 2. The Robotic hand Schematic Diagram

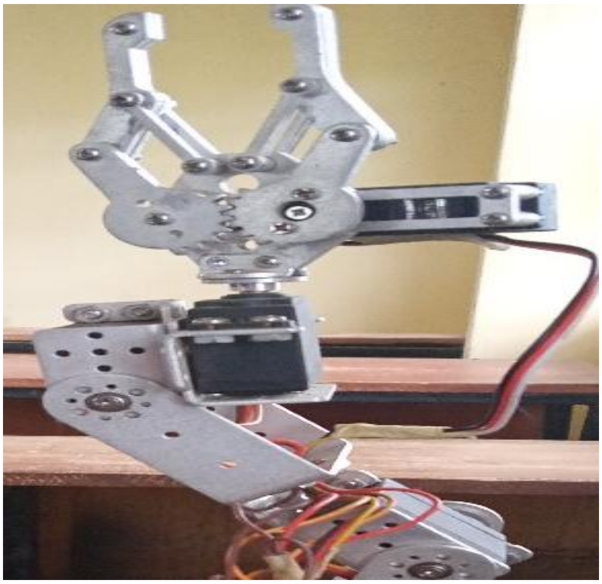


Figure 2. A picture of assembledrobotic hand

2.4Experimental procedure

A simple, easy to maintain and table top robotic hand was developed, constructed and tested and shown in Figure 1 above. The robot is on a table to ensure easy movement during demonstration. To test the gripping and lifting capability of the equipment, five different materials as shown in table 1, as shown in table 2 below.

Table 2: The materials used for performance test of the robotic hand

S/N	Object	Body weight(gram)
1.	Vegetable	20
2.	Bees brood comb	40
3.	Bread	60
4.	Solid Sulphur	80

5.	Pounded yam	100

Table 3: Cost implication/Budget

Serial No.	Component name	Quality	Total cost**(₦)**
1.	Servo motor	3	18,000.00
2.	Servo Motor Drivers	3	12.000.00
3.	Servo Mounts	3	6,000.00
4.	Supporting Frame	-	3,000.00
5.	Resistors LED	-	2,000.00
6.	Transformer/Adapter	-	6,000.00
7.	Capacitors (of various capacity)	-	4,000.00
8.	Transistors	-	4,200.00
9	PIC Microcontroller	-	22,000.00
10	Cables and Connectors	-	3,000.00
11.	Diodes	-	3,000.00
12.	IC Sockets	-	3,800.00
13.	Gripper Claws		5.000.00
14.	Robotic arm carcass	1	5,000.00
15.	18f2550 microcontroller	1	7,000.00
16.	Voltage regulator (Im2576)	3	5,000.00
17	Capacitors of various sizes	10	5,000.00
18.	Programming expenses	-	15,000.00
19.	12v deep cycle battery	-	10,000.00
20.	Push ButtonsSwitch	2	800.00
21.	Base Frame	-	1000.00

22.	Workmanship	-	10,000.00
23.	Miscellaneous	-	7,000.00
	Total		

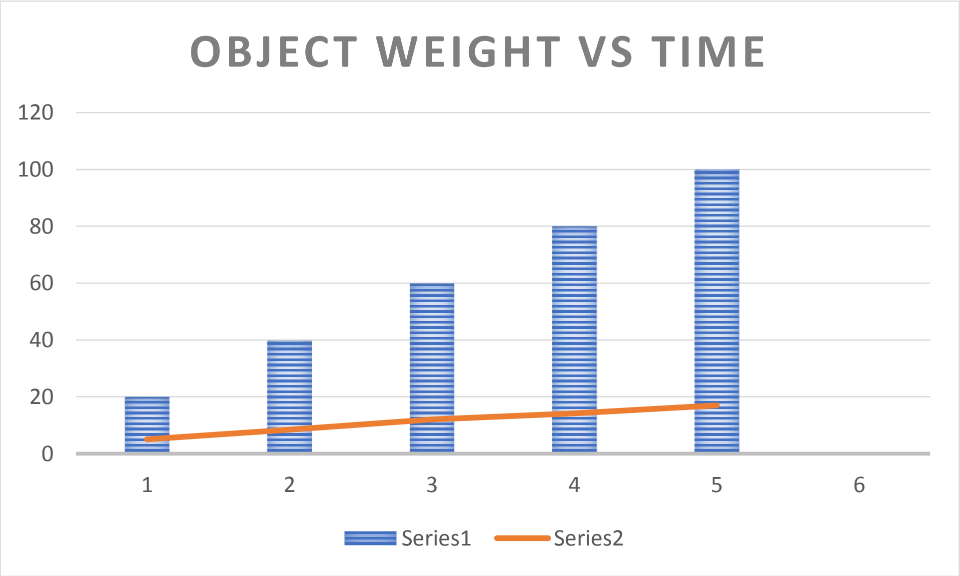
3.0Result and Discussion

Table 3 was used to design, build, and test a robotic hand. The robot was designed to grasp any irregularly shaped object. manual effort, allowing an object to be lifted from the ground to the maximum height the robot can move. Furthermore, the system is made up of five main components: a drive, a power supply, a controller, arms, and the Claws. These components are easily obtained from the local market.

The capacity of the automatic hydraulic jack is 2 tons. Objects of various weights were used to evaluate the device's performance, as shown in Table1.Figure 9 depicts the outcome of the performance test for the five different objects considered. The minimum time required to lift a car with the jack was 5.06 seconds, while the maximum time was 17.03 seconds.

Efficiency tends to decrease as weight increases, and lifting time increases as weight decreases. As a result, efficiency and speed have an inverse relationship, and the percentage seed damage has a direct relationship with operating speed. It was also discovered that as the weight increased, so did the time spent lifting. This is because more energy is available for lifting heavier objects and striking them more effectively against the robot's dead weight. The recommended weight of the car to be lifted for efficient and smooth operation of the machine was discovered to be between 100 and 120 grams.

S/N	Weight (grams)	Duration (second)
1.	20	5.06
2.	40	8.40
3.	60	12.00
4.	80	14.20
5.	100	17.03



4.0 Conclusion

A simple robotic hand had been fabricated for practical use.A 12-volt lead-cell battery can power the robot. This is based on inexpensive, readily available materials, and we proposed a simple design that can deliver a productive, efficient, and reliable robot for practical use in higher education laboratories. The robot also requires little upkeep, making it both user-friendly and cost-effective. Its design is straightforward, requiring little effort to operate and maintain. The system is simple to use and can be lifted with little effort. This equipment can adequately replace imported demonstration robots used in our higher education learning areas, which are typically purchased at a high cost from overseas countries. Several recommendations were made, including the use of sensors to Several recommendations were made, including the use of sensors to improve its performance. To protect the developed robotic hand, it was housed in a transparent composite material (Teflon), but better material can be used so as its interaction can be improved. Also to make the system sensitive and artifical intelligence (AI)compliance, a sensor can be incorporated with the system.

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