DESIGNING AND MANUFACTURING OF AN ARTICULATED ROBOTIC ARM

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ABSTRACT: With the use of HIPS and PLA materials, FDM technology, an Arduino board, and four servo motors, this project seeks to design and create an articulated robotic arm. The prototype, which is based on the ABB IRB460, aims to be affordable, lightweight, and simple to manage and program, allowing small firms to automate their operations. Starting with a prototype, the goal is to develop a robot that can be used in factories for less money than conventional industrial robots. The design and production of the articulated robotic arm is the primary focus of the project.

KEY WORDS: Industrial Robot Arm, 3D Printing, Palletizing, Prototype, ABB IRB460

1. Introduction

Industrial robots are sophisticated equipment made to automate several production and manufacturing operations in sectors including automotive, electronics, food and beverage, pharmaceuticals, and more. These robots are an essential part of contemporary production processes since they are designed to carry out repetitive, dangerous, and complicated jobs with a high degree of accuracy and efficiency. Industrial robots can carry out a variety of tasks thanks to their numerous sensors, motors, and control systems, which come in a variety of sizes and forms. They may work around-the-clock without much supervision and are often programmed to carry out specialized activities like palletizing, welding, painting, assembling, and material handling. Industrial robots are getting smarter as technology develops, with the capacity to adapt to shifting situations and cooperate with people in the workplace. These innovations are revolutionizing the way we approach manufacturing, allowing businesses to increase productivity, quality, and safety while lowering costs and enhancing sustainability. Understanding the industrial robot design, development, and production processes, as well as the possible uses and advantages they provide, is crucial in this situation.

Palletizing is an essential part of modern manufacturing. The articulated palletizing robot has the advantages of small floor area, large action range, low operating cost, high efficiency, strong adaptability, and good stability. It is especially suitable for the working conditions of large batch, high repeatability, high temperature, dust, and other harsh working conditions. When the palletizing robot carries out the transportation task, the planning of the motion trajectory will directly affect the quality of the task. [Z01]

In automated production lines, palletizing is an important part to connect production and transport. It is a method to stack goods into a pile based on a certain pattern, to facilitate goods' storage, handling, loading transportation and other logistics activities. And palletizing robots are designed for palletizing. It is an essential packaging machinery in the production line. Its main function is to be able to better stack and ensure the normal packaging and handling of products, so that it can reduce labor costs. Since the Swedish ABB Company developed the world's first industrial robots IRB6 for the material handling and workpiece handling in 1974, along with the development of industrial robotics and industrial control technology, Japan, Germany, the United States, Sweden and other countries have made great breakthroughs in palletizing technology and design their own robots and automated robotic workstations. In China, more and more companies response to the national call "Machine Substitution" to develop relate technology and more and more palletizing robot workstations are applied to factory automation design. [Y01]

A robotic palletizer is a type of palletizer that employs a robotic arm to pick, orient, and place individual products and arrange them into a single stack of load. They are the next generation of palletizers, and they will supersede conventional palletizers. Their advantages, such as lower capital cost, versatility, and multi-tasking abilities, make them the preferred choice in select applications. However, their lack of speed, product dimension tolerance, and robustness limits them from completely replacing conventional palletizers. [Z02]

The aim of this project is to create a concept of an industrial robot arm with lightweight, low price, and high universality involves designing a robotic arm that can perform a wide range of tasks, is affordable, and is easy to deploy and operate is made. The key features of such a robot arm would include:

- Lightweight design: The robot arm would need to be lightweight to reduce its cost and increase its versatility. This would allow it to be easily moved and repositioned for different tasks.
- Low cost: The robot arm would need to be priced affordably to make it accessible to small and medium-sized businesses. This would require using low-cost materials and components in its construction.
- High universality: The robot arm would need to be able to perform a wide range of tasks to increase its usefulness in different industries.

To achieve these features, the robot arm is designed using lightweight materials such as carbon fiber or aluminum and using low-cost actuators and sensors. In addition, the robot arm is equipped with advanced software and sensors that enable it to perform tasks with precision and accuracy, such as object detection and manipulation. It is also designed with a user-friendly interface that makes it easy for operators to program and control the arm.

A prototype is an early version or sample of a product or system that is created to test and evaluate its design and functionality before mass production or implementation. The purpose of a prototype is to identify potential flaws or design issues and to make necessary improvements or modifications to the product or system before it is released or manufactured on a large scale.

Prototyping can be done using various methods such as 3D printing, computer simulations, or physical models, depending on the complexity of the product or system being developed. The prototype may be a complete or partial representation of the final product, but it should have enough functionality and features to test the critical aspects of the design.

Fused Deposition Modeling (FDM) 3D printing is a popular method for prototyping robotic parts and components due to its ability to produce complex geometries quickly and accurately. The prototyping of an industrial robot arm using FDM 3D printing typically involves the following steps:

- Design the parts: The first step in the prototyping process is to design the parts using CAD software. This involves creating 3D models of the parts and defining their dimensions and tolerances.
- Prepare the files: Once the parts have been designed, the CAD files need to be prepared for 3D printing. This involves converting the files to a format that is compatible with the 3D printer, for example STL.
- Set up the printer: The 3D printer needs to be set up with the appropriate materials and settings for the parts being printed. This includes selecting the right filament material, adjusting the temperature and speed settings, and calibrating the printer.
- Print the parts: Once the printer is set up, the parts can be printed. This typically involves loading the 3D files onto the printer, starting the printing process, and monitoring the printer to ensure that the parts are printing correctly.
- Post-processing: After the parts have been printed, they may require post-processing to remove any support structures, clean up any rough edges, and prepare them for assembly.

- Assemble the robotic arm: Once all the parts have been printed and post-processed, they can be assembled into the final robotic arm. This involves attaching motors and other components to the printed parts and wiring them together to create a functional robotic arm.

2. Functionality

2.1 Designed Product

SolidWorks, a computer-aided design program, was used to create this industrial robot arm. An Arduino Uno R3 microcontroller, a breadboard, four servo motors, and cables were used to put it together. The robot arm was designed using reverse engineering techniques starting from a 3D model found on Thingiverse (EEZYbotARM [Z03]) for the robotic arm, another 3D model also found on Thingiverse (Parallel Gripper for EEZYbotARM MK2 [Z04]) for the gripper assembly and also by designing my own parts in order to reduce the weight of the robot and the price by reducing the filament cost, which enabled testing and alterations before the arm was ever put together. The servomotors will be managed by the Arduino Uno R3 microprocessor, which will allow the arm to move. The cables and breadboard will be used to link the servomotors and microcontroller. Overall, the industrial robot arm was created using CAD software and microcontroller technology to provide a flexible and useful robotic tool for production and operations.
The list of components of the whole assembly for the designed robotic arm can be seen in Fig. 1, Fig. 2 and Fig. 3.

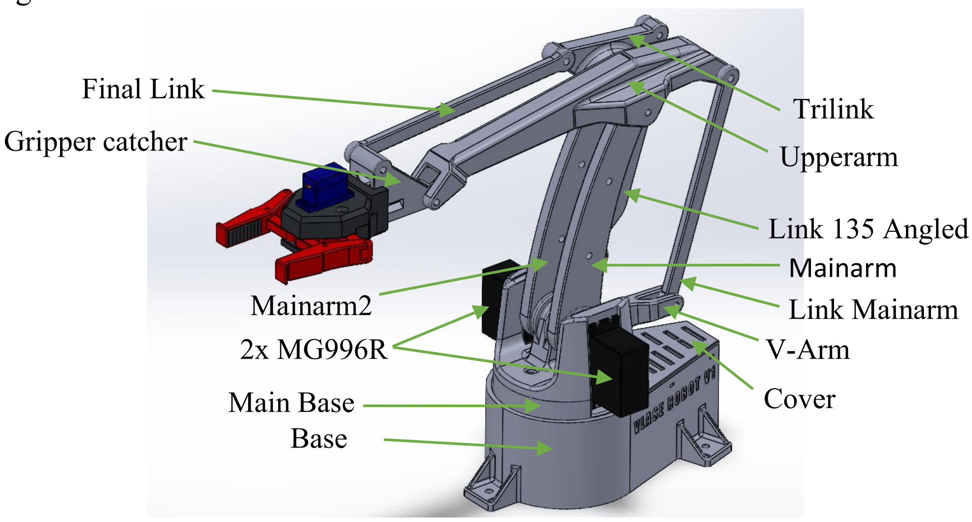


Fig. 1. Industrial robot arm assembly

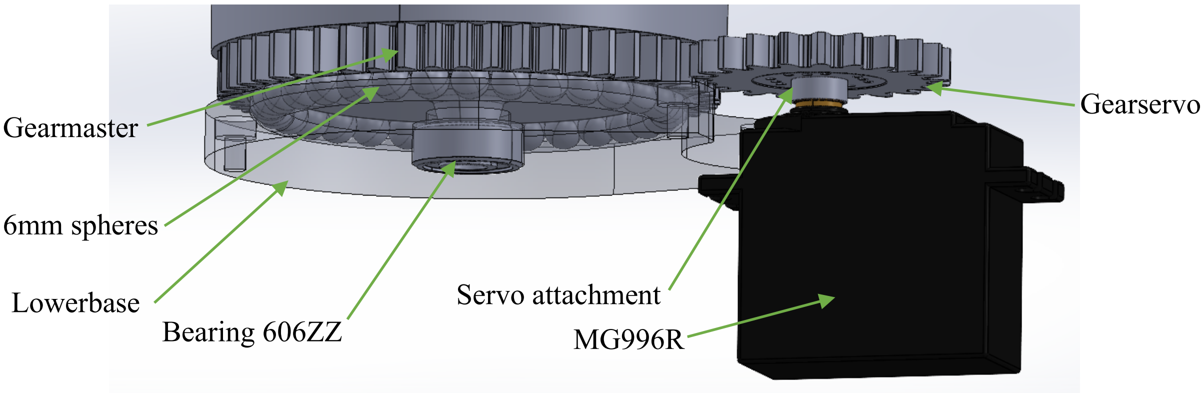


Fig. 2. Components inside the base of the robot

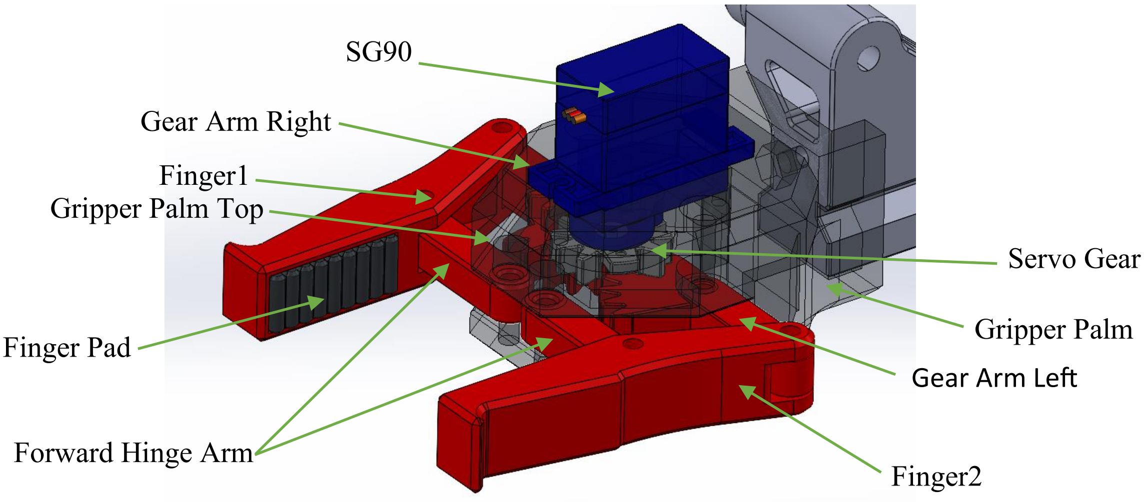
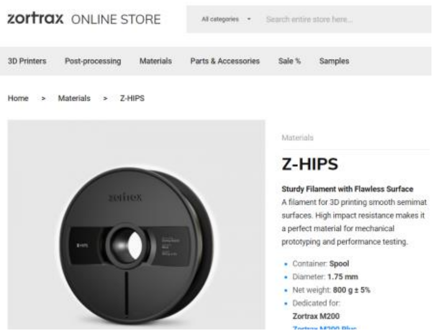


Fig. 3. Components inside the gripper assembly

From the point of view of the components that were necessary to be bought:

Component	Specifications	
	Brand Name	Tower Pro
	Model	SG90
	Weight	9g
	Torque	1.8kg/cm
	Speed	0.12s/60º (4.8V)
	Rotation angle	0º-180º
	Operating voltage	4.8 V
	Gear type	POM gear set
	Cable length	25cm
	Temperature range	0º C – 55º C
	Cost	3.03 USD
	Quantity	1
	Brand Name	Tower Pro
	Model	MG996R
	Weight	55g
	Torque	11kg/cm (6V)
	Speed	0.15s/60º (6V)
	Rotation angle	0º – 180º
	Operating voltage	4.8-6V
	Gear type	Metal
	Cable length	32mm

	Temperature range	0º C – 55º C
	Cost	6.64 USD
	Quantity	3
	Tensile strength	16.9MPa
	Breaking stress	13.02MPa
	Elong at max tens stress	1.87%
	Elong at break	7.75%
	Bending stress	29.30MPa
	Flexural Modulus	1.18GPa
	Glass transition temperature	98.68ºC
	Melt flow rate	7.14g/10min
	Specific density	1.136g/cm^3
	Shore hardness	73.2
	Cost	61.97 USD
	Quantity	1

2.2 Experimental stand

An experimental stand was made once the robot's components were all printed and put together to make its final form. Four legs were installed to each corner of a PAL with dimensions of 60x40x18mm once the PAL was purchased. This made it possible to secure the robot to the PAL without compromising the stability of the experimental stand. Three pallets were also constructed out of leftover wood and joined with wood glue. In order to simulate a real-world application, the robot will place and pick up cubes on these pallets.

The experimental stand can be seen in Fig. 4 in its final form.

The Thinkercad program was also used to build the electrical layout of the assembly, which is shown in Fig. 5.

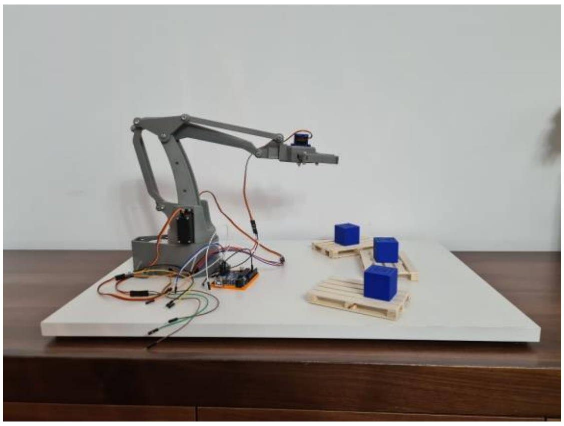


Fig.4 Experimental stand

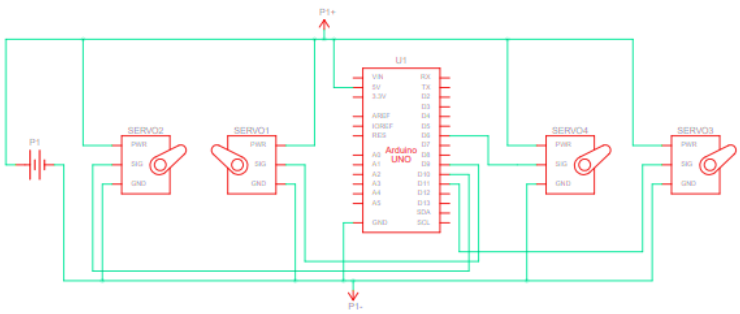


Fig. 5. Electrical scheme

3. Conclusions

The prototype of the design was also created using 3D printing FDM technology to see if there are some design issues that appear before launching the production in mass. Also, some parts may suffer some changes when they are sent to mass production because of the difficulty of manufacturing of some parts or the technologies needed to be used to keep the price of the product as low as possible, that way, we can help also small-medium businesses, as future users of the product, to automate their processes as well.

Original contributions are represented by the design of the industrial robot arm, with proposed optimization solutions such as the design of some parts in order to reduce the weight of the assembly and to reduce the cost of manufacturing and the adopted gripper.

Future research is to make the programming of the prototype using Arduino uno R3, a breadboard and wires to connect the motors to simulate its movements in a palletizing application and to make also a simulation in Witness Horizon to see how much a production line can be improved by adopting the proposed variant.

Overall, the development of an industrial robot arm with light weight, low price, and high universality represents an exciting opportunity for innovation and progress in the manufacturing and production industry. By continuing to explore new materials, manufacturing techniques, and design strategies, the capabilities and versatility of these robots can further enhanced, unlocking new possibilities for efficiency, productivity, and growth.

4. Bibliography

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