STUDY AND 3D PRINTING OF AN ARTICULATED ARM ROBOT FOR SORTING PHARMACEUTICAL PRODUCTS

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Abstract: The research consists in developing a new system for an industrial robot manipulator with 5 degree of freedom that can sort color boxes using a color system sensor. The main goal of employing these systems is to sort products in the pharmaceutical field. The system can be developed by proposing various algorithms to achive the highest accuracy and precision. Examining, confirming, and naming colors are the typical stages of color perception. To detect a physical situation, sensors and microcontrollers play a crucial part in the automation system.
KEY WORDS: Design, 3D Printing, ANSYS, Witness

1. Introduction

The purpose of the research is to investigate, design, and manufacture a 3D-printed articulated arm automation system for classifying pharmaceutical products. The integration of robotics and 3D printing is an innovative method for improving the precision and efficacy of pharmaceutical classification processes. The approach will involve a comprehensive examination of the requirements and obstacles associated with the sorting of pharmaceutical products.

Using Ansys software one can observe the robot operation in a virtual environment, can determine the functional parameters (speeds, angles, accelerations) that can be further employed in programming and checking the operation of the kinematic joints, to assure a proper work of the robot.

2. State of art

The state of art in robot arms for color sorting incorporates advancements in several areas, as cameras and sensors with increased resolution and sensitivity enable precise color detection and sorting. In addition, sophisticated algorithms and Machine Learning techniques improve the capacity to recognize and distinguish subtle color variations. The end-effector of modern color-sorting robots can manipulate a wide variety of object sizes, dimensions, and materials [1]. They are designed to be adaptable and configurable to accommodate a variety of classification needs, making them suitable for industries such as food processing, recycling, and manufacturing [2].

The pharmaceutical industry handles a vast multitude of products that require precise classification based on specific criteria such as dosage, expiration dates, and packaging variations [3]. Manual classification processes are time-consuming and error-prone, resulting to potential production and distribution bottlenecks in the pharmaceutical industry. Implementing an automated sorting system can considerably boost productivity by decreasing sorting time and ensuring consistent, reliable results.

Based on conceptual design, the embodiment design of the product was perfromed using the following 5 systems (Fig. 1):

- Power supply - is responsible for supplying electrical energy
- Mechanical system - provides a strong and stable support structure.

- Sensor system - it provides the robot with the ability to make decisions based on that information
- Movement system - it is responsible for the robot's movement and manipulation of objects
- Task environment system - it defines the specific tasks and functions that the robot is designed to perform

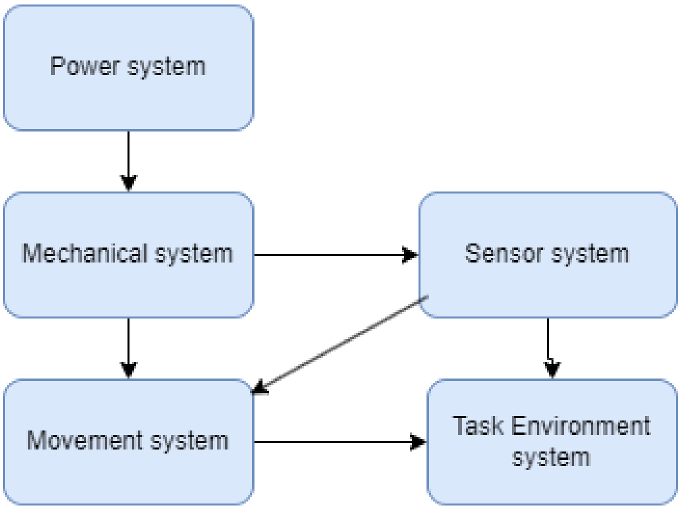


Fig. 1. Conceptual design

The parametric design was performed in Solidworks (Fig. 2). This software was chosen because it is highly efficient and can create a prototype by combining all the parts. It is a 5 degree of freedom Industrial Robot made by 6 parts: Base – has a significant role because provides stability; Waist – is essential because it maintains a balance and conduct specific actions; Arm1 - has the pliability to extend its working range by stretching and bending; Arm2 – because it has the ability to move in different directions and reach objects in different positions; Arm3 - is the connection between the arm and the gripper and is used for the pitch movement; Gripper support and End effector.

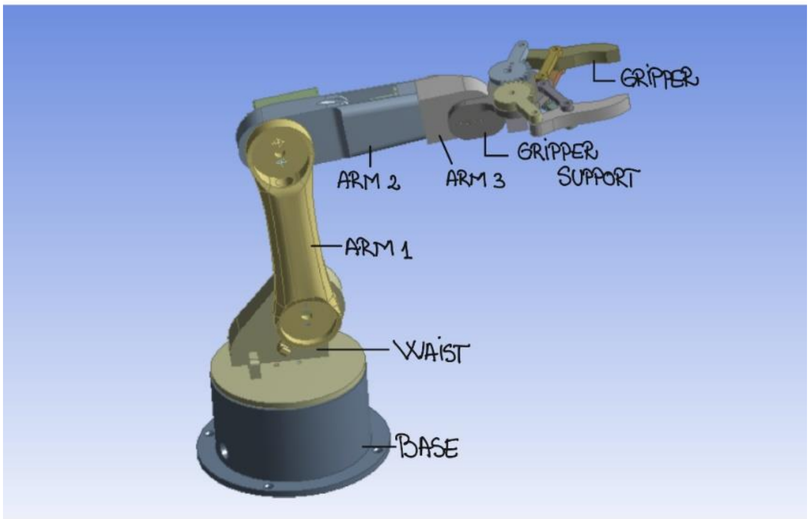


Fig. 2. Robot design in Solidworks

The material that has been employed both in the simulation and in the manufacturing stages of the product is PLA because it enables a high-quality printing, providing a good lamination and creates a clarity and gloss products. During the operations, one can check the behaviour of the materials through action. The characteristics of the material are illustrated in Table 1.

Tabel 1. Material properties

Density	1.28 g/cm3
Young’s Modulus	2270 Mpa
Poisson’s Modulus	0.35
Bulk Modulus	2.5222E+09 Pa
Shear Modulus	8.4074E+08 Pa
Specific heat	1.8 J/kg*K

Using Ansys simulation environment the constructive solutions were checked. For example stresses, strains and a comparison with robot performances like repeatability and optimization time were done.

The Transient Structural analysis (Fig. 3) proved that the safety factor is 2-2.5, often used in the mechanical field. The stresses are not high, therefore they can not cause problems in terms of structural stability and possible fatigue phenomena. If stability problems occur that means that it is a design problem that has to be solved. When running the simulation the „Stiffness Behavior” of the Arm1 component was set as flexible, to have a visible representation of the stress, strains and displacements during the simulation.

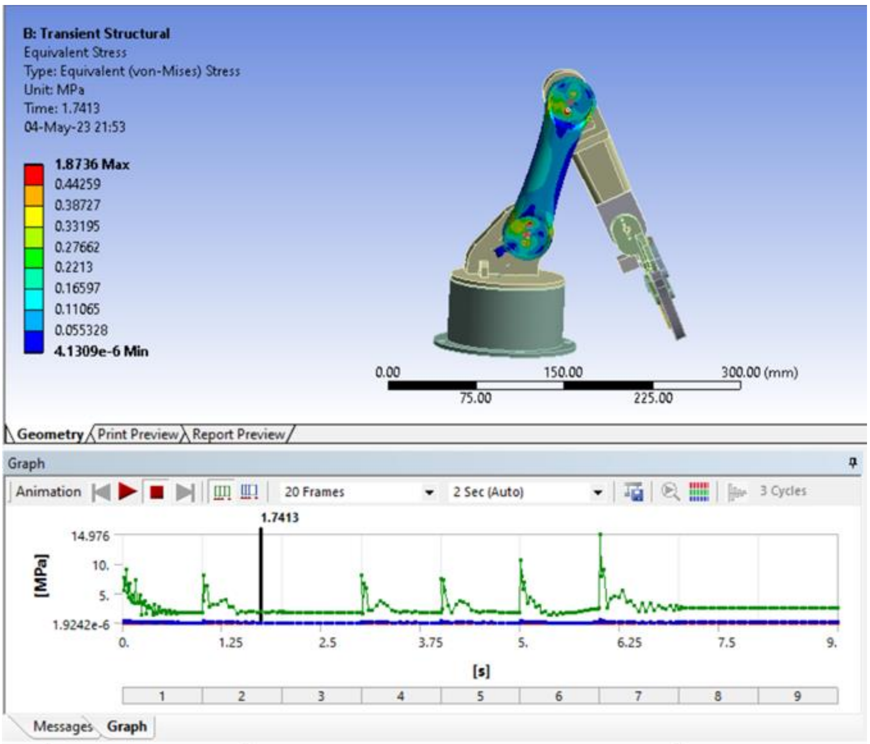


Fig. 3. Transient analysis of the robot

In order to determine the exact angles of action for the servomotors, the simulation environment was accessed (Fig. 4). The defined displacements and movements of the robot where simmilar to the real life behavior of the robot. Four rotational joints were defined, and with the simulation support, all the angles of the robot during operation were tuned with those employed in the programming stage of the robot.

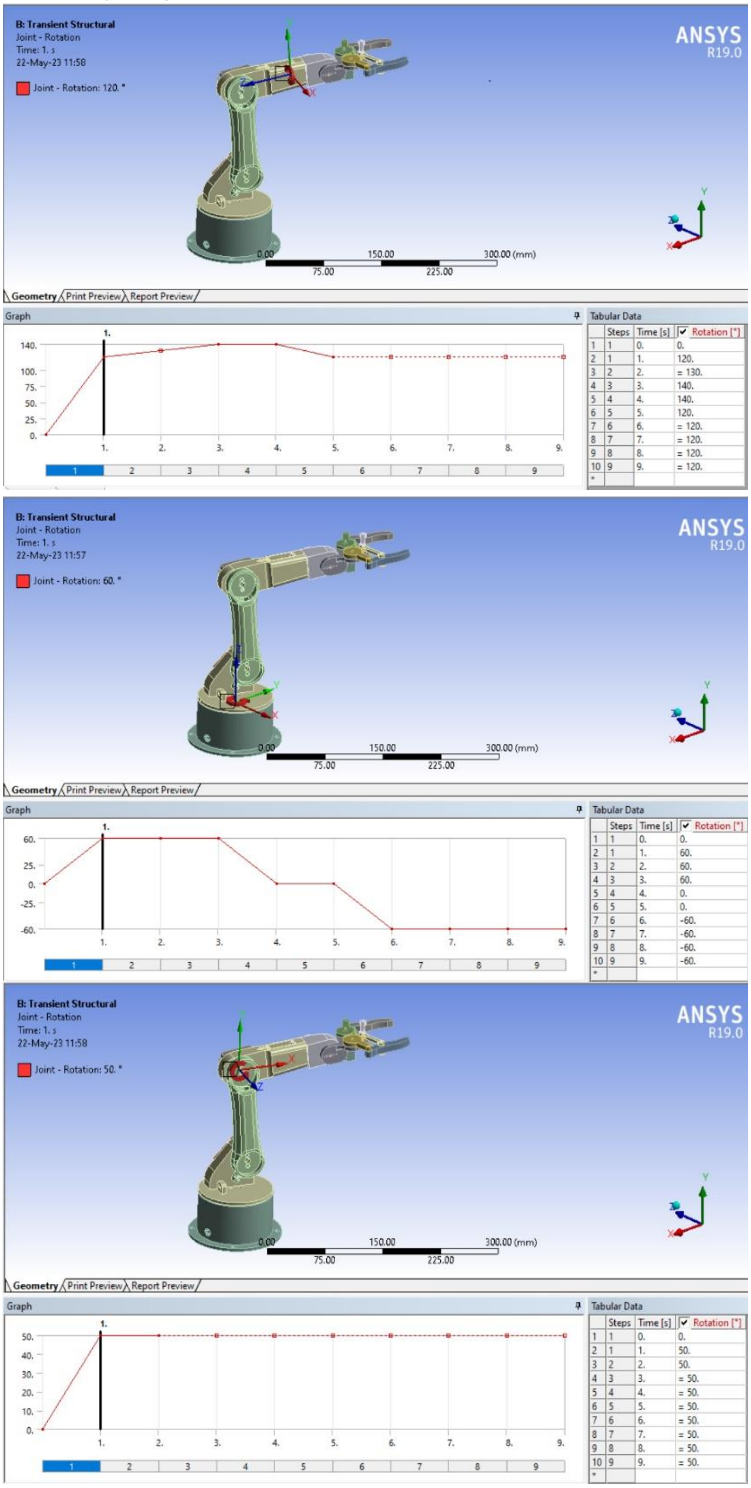


Fig. 4. Rigid Body analysis of the robot

Using Static Structural analysis (Fig. 5) the study proved that when the accelerations in the system are high and the acting forces are maximum, the structural deformability of the robot is small, the assembly is sufficiently rigid and does not affect the positioning accuracy and repeatability.

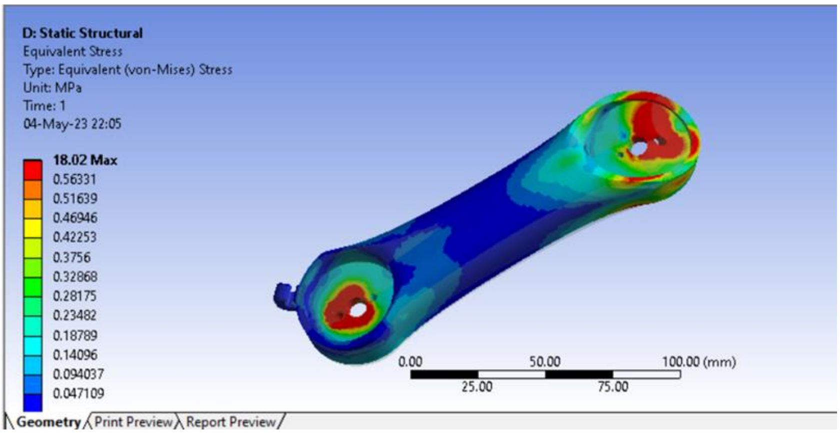


Fig. 5. Static analysis of the robot arm. The equivalent von Mises stress

For manufacturing the robot components Creality Ender 3 Pro printer was employed (Fig. 6), which is suitable for obtaining end product parts by directly importing them form the CAD system or software-created 3D design diagrams, figures and patterns [4]. The software employed to convert the 3D drawings in STP files for the 3D printed parts was CURA. One of the most important settings was to change the Infill Pattern from the Print settings [5]. The Gyroid pattern was chosen, because it provides a cubic symmetry, which in contrast to all other patterns is an almost isotropic structure. This means that it is equally resistant to forces acting from all directions [6]. Because all the pieces of the printed robot have largeg dimensions, this pattern is also useful to make the overall strongest structure.

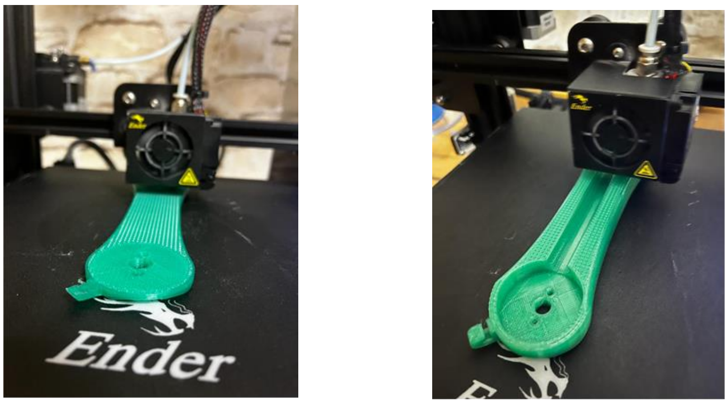


Fig. 6. 3D printed parts using Creality Ender 3 Pro printer

For programming the robot the Arduino UNO board was employed (Fig. 7), connected to five servo motors for the movements (3 are MG996 Servo Motors and 2 are SG90 Servo

Motors). A color sensor was also connected to the Arduino board and Python programming language was chosen to set the robot code.

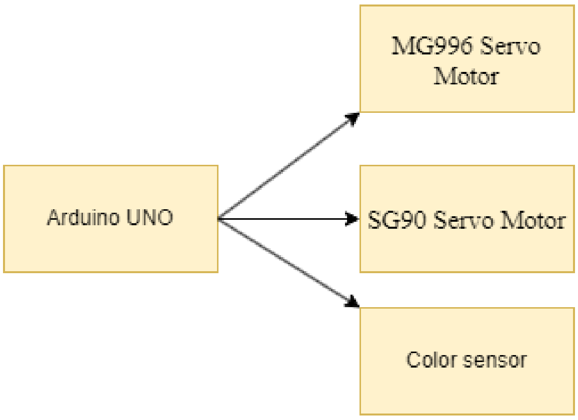
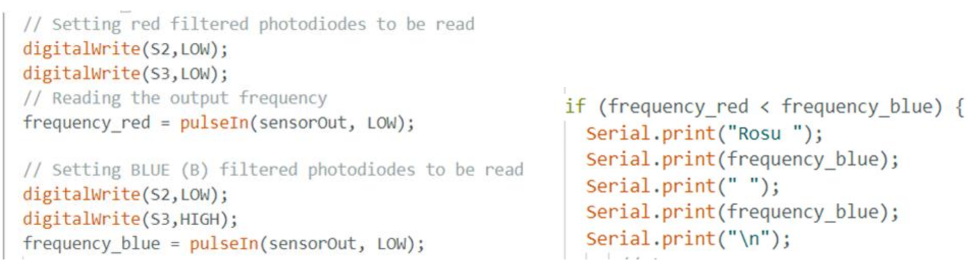


Fig. 7. Connection of the Arduino UNO system to the ServoMotors and the color sensor

An excerpt from the developed code is illustrated in Fig. 8.



```
// Setting red filtered photodiodes to be read
digitalWrite(S2,LOW);
digitalWrite(S3,LOW);
// Reading the output frequency
frequency_red = pulseIn(sensorOut, LOW);

// Setting BLUE (B) filtered photodiodes to be read
digitalWrite(S2,LOW);
digitalWrite(S3,HIGH);
frequency_blue = pulseIn(sensorOut, LOW);
```

```
if (frequency_red < frequency_blue) {
  Serial.print("Rosu ");
  Serial.print(frequency_blue);
  Serial.print(" ");
  Serial.print(frequency_blue);
  Serial.print("\n");
```

Fig. 8. Excerpt from the developed code

6. Conclusion

The research proved that the original robot produced by the 3D printing system provides low manufacturing costs and generates large revenues. It may meet the requirements for a high-quality prototype because of its good and accuracy and stability. Future work will focus on manufacturing additional parts on CNC machines to achive more stability and strength.

The CAE simulation provided the robot operability in a virtual environment and allowed the identification of the structural problems that were solved to increase the robot accuracy and scalability.

7. Bibliography

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