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DESIGNING AND BUILDING A SERIAL ROBOTIC ARM WITH FOUR DEGREES OF FREEDOM

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Abstract: *The paper presents the design and manufacturing process for a 4 degrees of freedom robotic arm. The robotic arm was designed using the Fusion 360 program, after which the components of the robotic arm were manufactured using 3D printer. For the 3D printing environment, the ideaMaker printer software was used. After assembling the robotic arm, tests for functionality were performed by actuating the stepper motors that are attached to the robot arm.*

Key words: *degree of freedom, robotic arm, CAD model, design, 3D printer*

1. INTRODUCTION

Industrial robot is officially defined by ISO as an automatically controlled and multipurpose manipulator programmable in three or more axis [1]. For an operation, most robots are set up by the teach-and-repeat technique. A trained operator (programmer), in this mode typically uses a portable control device (a teach pendant) to teach a robot its task manually. During these programming robot speeds in these sessions are slow. Robotics is a rich area of research, in terms of their kinematics, dynamics and control. Kinematics plays a significant role in robotics and especially for the study of industrial manipulators' behavior. Therefore, a decisive step in any robotics system is the analysis and modeling of the manipulator kinematics. There are multiple methods according to dedicated literature to establish the expressions for the kinematic behavior for any mechanical structure [2]. This paper briefly provides a description of the building of a 4 degree of freedom robotic arm. This robotic arm version was chosen to sort small objects by color and shape, actuation it's made with stepper motors. The next stage is to attach a video camera on the robotic arm that will detect the shape and color of the objects. Also to detect shape and color with this video camera, we need to create a software for image processing.

The paper is organized as follow: Section 2 presents mechanical design of the serial robotic arm. Section 3 presents creating the serial robot components with help of the 3D printer, followed by conclusions and references.

2. MECHANICAL DESIGN OF THE SERIAL ROBOTIC ARM

The mechanical design of the robot arm is based on a robot manipulator with similar functions to a human arm. The links of the robot are connected by joints allowing rotational motion and the links of the robot is considered to form a kinematic chain. In figure 1 we can see the free body diagram for mechanical design of the robotic arm.

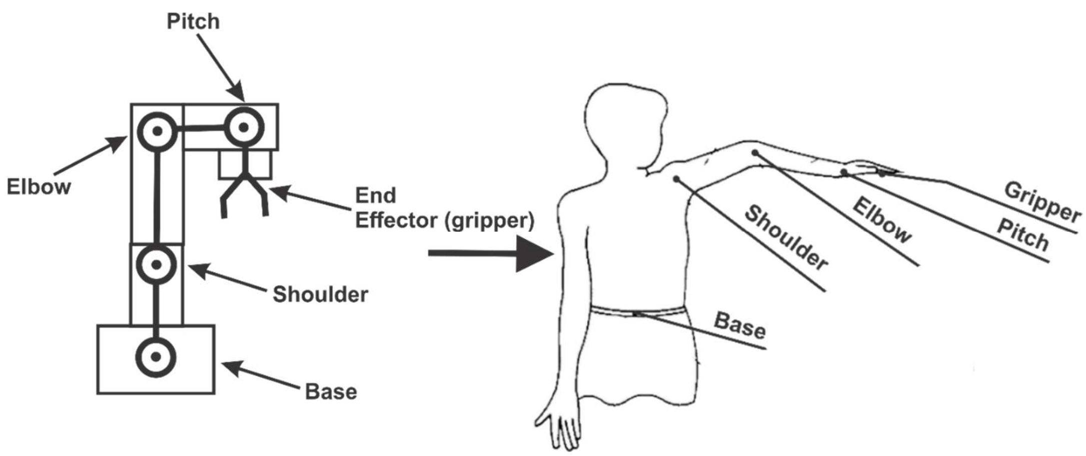

Fig. 1 Free body diagram of the robot arm

Work region of the robotic arm is shows in figure 2. The workspace of a robot is defined by the range of the movement on each joint, and the shape and the dimensions of the workspace of a robot are generally given by the number of joints [3]. Workspace of a robot arm with four degree of freedom (4 DOF) is typical for this kind of robot.

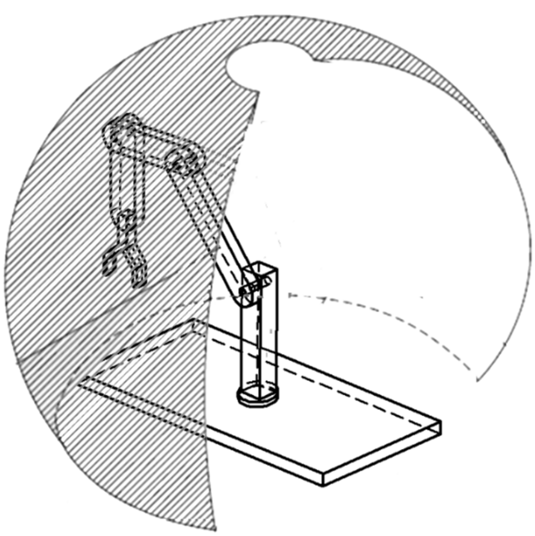

Fig. 2 Work region of the robot

In Fusion 360 we designed a 4 degrees of freedom robotic arm (figure 3). Fusion 360 is a complete parametric CAD tool developed by Autodesk (the AutoCAD editors). It is considered by many as a combination with the best tools of cutting-edge programs like Rhino, Inventor, SolidWorks, Vault, and AutoCAD [4].

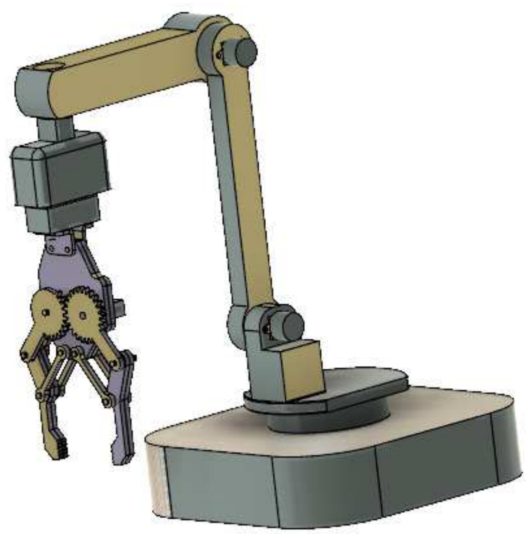

Fig. 3 CAD model

The robotic system is made up of the following main components:

- The base of the robot

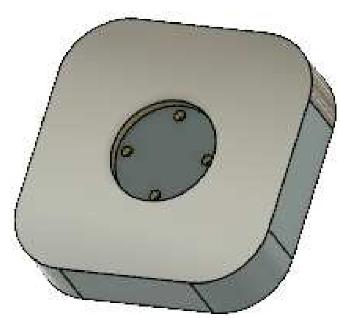

Fig. 4 The base of the robot

This is the base for the first joint. It is attached to the base of the whole robot with 4 screws. We tried to design this component in such a way that the robot would have a good stability and it can be easily fix to any surface.

- Structure for clamping the first joint of the robotic arm

Fig. 5 Clamping structure for the first join

On this structure we have attached the first joint of the robotic arm. On the structure is a hole for introduction of a stepper motor, and the joint from figure 6 is attached to the shaft of stepper motor.

- The first joint of the robotic arm

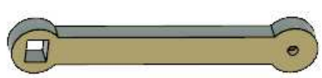

Fig. 6 The first joint of the robotic arm

Figure 6 shows the first joint that is used for the robotic arm. At the ends of the joint are two holes for attaching two stepper motors.

- The second joint of the robotic arm

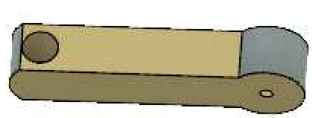

Fig. 10 The second joint of the robotic arm

This joint is caught by the first joint (figure 6) and the holder to hold the gripper.

- Support for fixing the gripper

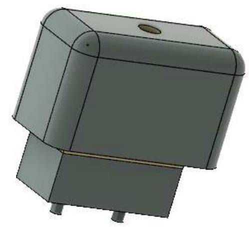

Fig. 7 Support for attached the gripper

On this support is caught the robotic arm gripper, figure 8.

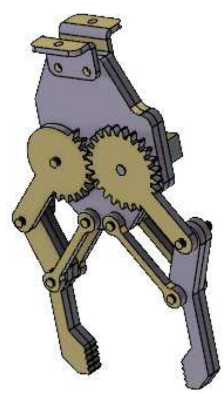

Fig. 8 Gripper

With this gripper, the robotic arm can catch small objects for manipulation.

3. CREATING THE SERIAL ROBOT COMPONENTS WITH THE 3D PRINTER

3.1 Introducing the CAD components of the robotic arm into the ideaMaker printer software

After the serial robot components were designed in Fusion 360 CAD environment, these components were saved with the stl. extension, in order to can be imported into the ideaMaker 3D printer software [5], illustrated in figure 9.

After the file was prepared for printing with ideaMaker software, the file was imported in ideaMaker for slicing (figure 9).

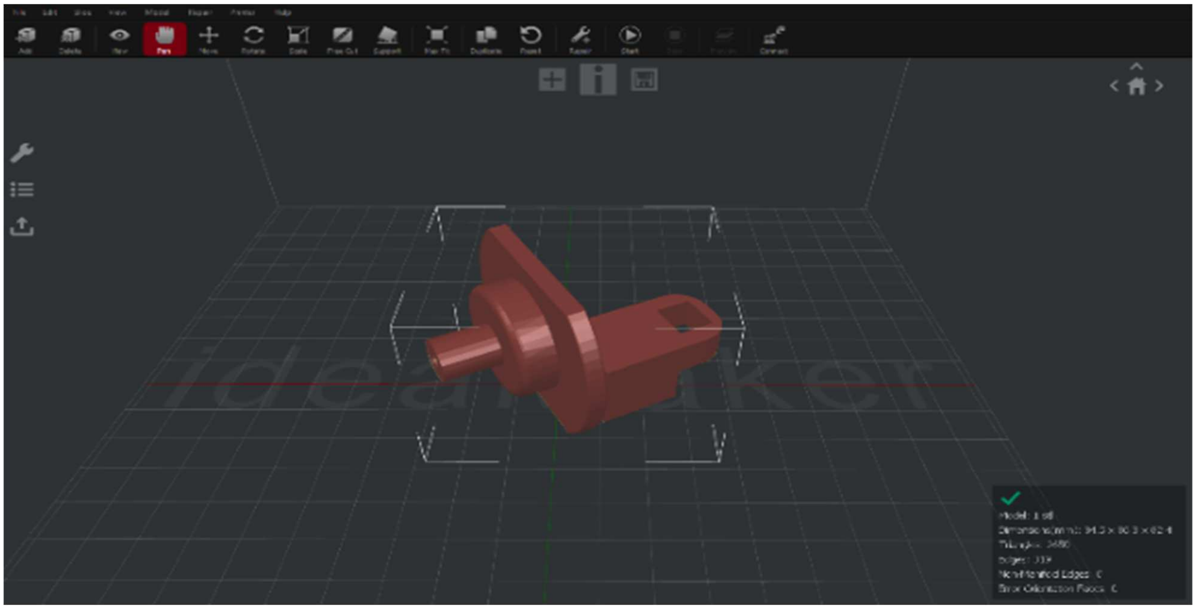

Fig. 9 IdeaMaker 3D printer software

IdeaMaker is user friendly, slicing with ideaMaker is fast, efficient, and completely free, because this software is open source. An open source software can be used for commercial purpose, because commercial is not the same as proprietary, as they are based on different rules. The list of open source software is a wide one, covering a wide range of domains, like networking and internet, games, educational, media, artificial intelligence (robotics), programming, security and so on [6].

The main features for ideaMaker software are:

- automate the separation of parts in assemblies;
- comprehensive repair features for repairing poor-quality models;
- generate automatic support structures.

3.2 Creating components using the 3D printer

The additive manufacturing process known as 3D printing is usable in various fields advancing the state from prototyping stage to end-product manufacturing [7]. Additive manufacturing technology has improved significantly in terms of equipment's and plastic parts resulted from additive manufacturing have different shapes and in order to improve their quality over the entire surfaces milling equipment is used [8].

Before creating the components for the robotic arm, was made a choice of the materials with which 3D printing has been made. Are many materials that are being explored for 3D printing, however we found that the two dominant plastics are ABS and PLA. For a material to prove viable for 3D printing, it must pass three different tests as follows: initial extrusion into plastic filament, second extrusion and trace-binding during the 3D printing process, then finally appropriateness for the end use application as a 3D printed part / object.

The first test, that of production from base plastic resin into top-notch plastic filament such as what we carry is a strict and carefully monitored process. It is a battle of wits and engineering that takes the plastic from a pile of pellets to a uniformly dense, bubble free, consistently sized, round rod. Both ABS and PLA do best if, before use or when stored long term, they are sealed off from the atmosphere to prevent the absorption of moisture from the air.

ABS - Moisture laden ABS will tend to bubble and spurt from the tip of the nozzle when printing, reducing the visual quality of the part, part accuracy, strength and introducing the risk of a stripping or clogging in the nozzle. ABS can be easily dried using a source of hot (preferably dry) air such as a food dehydrator.

PLA - responds somewhat differently to moisture, in addition to bubbles or spurting at the nozzle, you may see discoloration and a reduction in 3D printed part properties as PLA can react with water at high temperatures and undergo de-polymerization. While PLA can also be dried using something as simple as a food dehydrator, it is important to note that this can alter the crystallinity ratio in the PLA and will possibly lead to changes in extrusion temperature and other extrusion characteristics. For many 3D printers, this need not be of much concern.

After analysis we chose the PLA material to use for the building of the robotic arm.

In the following are some images of the robotic arm components 3D printing process.

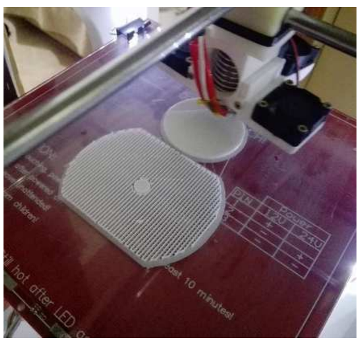

Fig. 10 Beginning of the 3D printing process

After the appropriate 3D print settings have been made in the IdeaMaker environment, 3D printing has been released. Figure 10 shows the beginning of 3D printing, the first layer deposited for the future piece on the bottom of the 3D printer.

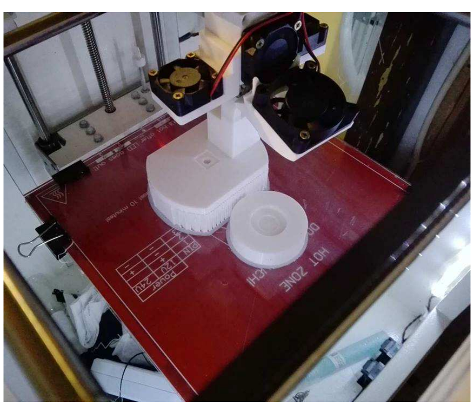

Fig. 11 Intermediate process

In figure 11 we can see an intermediate process of creating the proposed part in the 3D printer after multiple layers have been deposited.

Fig. 12 Components obtained after 3D printing

After all the parts for the robotic arm have been created (figure 12), the next step was to assemble the robotic arm.

Fig. 13 Assembling the gripper

We started with the assembly of the gripper (figure 13), the gripper parts of the robotic arm were fastened via screws.

3.3 Assembling the robot

The next stage was assembling the entire robotic arm (figure 14). Also, in this stage, the stepper motors were mounted on structure, as we can be seen on the figure 14.

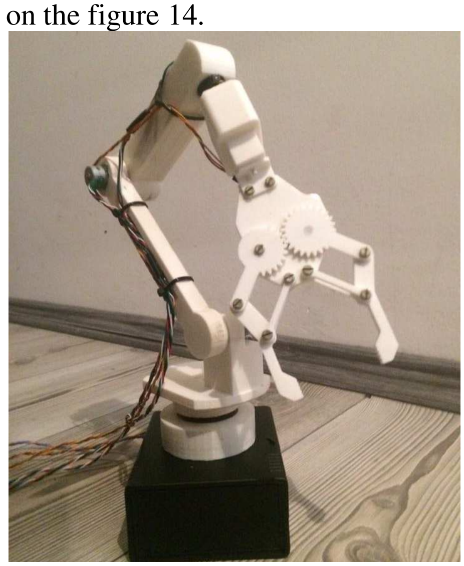

Fig. 14 The final assembling

4. CONCLUSIONS

The paper presents design and manufacturing of a 4 degree of freedom robotic arm. The components of this robotic arm were first designed in Fusion 360 program, after which they were manufactured using the 3D printer. After manufacturing the components, the robotic arm has been assembled and tests have been made for its functionality by actuating the stepper motors.

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PROIECTAREA ȘI CREAREA UNUI BRAȚ ROBOTIC SERIAL CU PATRU GRADE DE LIBERTATE

Rezumat: Lucrarea prezintă proiectarea şi procesul de fabricaţie pentru un braţ robotic cu 4 grade de libertate. Bratul robotic a fost proiectat cu ajutorul programului Fusion 360, după care componentele braţului robotic au fost fabricate cu ajutorul unei imprimante 3D. După asamblarea braţului robotic s-au făcut teste pentru funcţionalitate prin acţionarea motoarelor pas cu pas care sunt ataşate braţului robotului.

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