DESIGNING AND MANUFACTURING A DELTA ROBOT FOR PICK AND PLACE APPLICATIONS

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Abstract: *In this paper it is presented in brief the design and manufacturing for a Delta robot with 3 degrees of freedom. Fusion 360 software was used to design the robotic system, and with the help of a 3D printer, the components of the robotic system were built. With the help of the ideaMaker program 3D printing was done. After assembling the robotic system and create control for this robot, the servo motors on the robot base were actuated for the final tests. With the help of these tests, the performance of the robotic system was validated.*

Key words: *Delta robotic system, degree of freedom, design, 3D printer, pick and place, manufacture.*

1. INTRODUCTION

In practice a robot it is controlled by a computer or microcontroller and is usually an electro-mechanical machine. In the control of the robot, a program is used that controls the actions of the robot, providing information on the tasks that the robot must perform [1]. The categories in which the robots can fit are manual, semiautonomous and autonomous, and can also be controlled remotely being used in many tasks. Two different kinds of robots are the most used, namely: service and industrial robots. The industrial robot was defined by the ISO standard as a manipulator that is automatically controlled, programmable and can have multiple axes. Sensors as well as communication interfaces are required for a robot to perform its tasks. Industrial robots are designed to move tools, parts and materials. Service robot, on the other hand is a robot that operates semi or fully autonomously to perform services useful to the well-being of humans [2]. To build robots we need to have knowledge of mechanical engineering, electrical engineering [3], systems and industrial engineering, computer science, economics, and mathematics [4].

Research in the area of robotics can be done on the kinematics, dynamic and control side, being a rich area of research. In modelling the mechanical configuration of the robot, the dynamic modelling of a robot is an important step to be analyzed. The symbolic computation deals with symbolic objects, the input data being symbolic while the output data are algebraic expressions. In symbolic computation of the robot dynamic modelling consist in direct generation of the symbolic form of the equations of the generalized forces and obtained data are useful to generate the simulation of the dynamic behavior [5]. Also, kinematics in the field of robotics it has a very important role. 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 that modeling the kinematic behavior for any mechanical structure [6]. For robots two types of kinematic structures are used: serial, parallel. A serial robot has an open loop chain and consists of several links that are joined in series. One edge of the robot is free to move in space and the other edge is attached to the ground. The free end where a gripper is attached is called the end effector and the fixed link is called base. For the robot to perform a task, it is necessary to establish at the beginning the location of the final effector in relation to the

base. Serial robots are used in applications that require repetitive task over period of time. The parallel robot can be defined as a combination of cinematic chains with a closed loop. For this kind of robot, the gripper is connected to the fixed base by more than one kinematic chain independent. Parallel structures have been used in applications like machining centers, walking machines, mining machines, adjustable articulated trusses, airplane simulators, etc. [7].

2. DESIGNING OF THE COMPONENTS OF THE DELTA ROBOT

The Delta robotic structure (figure 1) is designed in the Fusion 360 program and this structure has 3 degrees of freedom. The Fusion 360 program is designed by Autodesk being a complex program that can be used both for modeling 3D objects and for finite element analysis. Also, with the help of this program can be done manufacturing, animation and rendering. With this program we can edit components without starting from scratch even if the specifications change, giving the designer a very good editing tool [8].
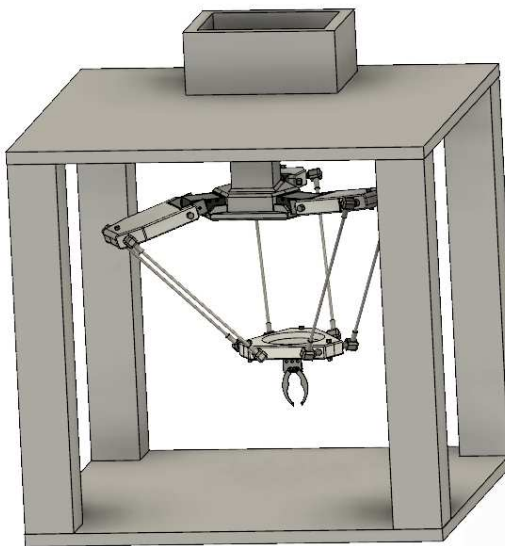

Fig. 1 CAD model

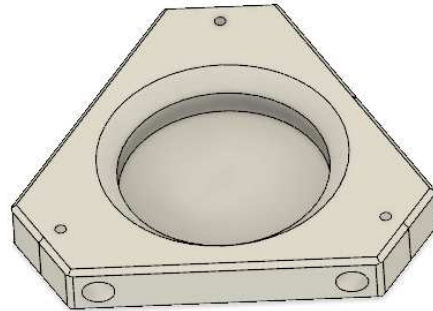The robotic structure is made up of the following main components:

- Mobile base

Fig. 2 Mobile base

On this mobile base of the robotic structure is attached six arms and a gripper. The mobile base of the robotic structure can be controlled with the help of the six arms, and with the help of the gripper can take small objects.
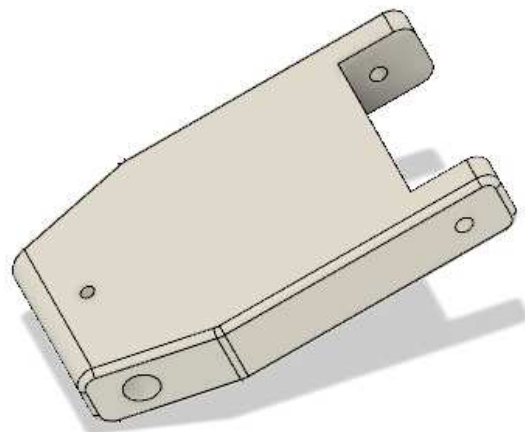
- Support for arms

Fig. 3 Support for arms

Through this support the arms that control the mobile platform of the Delta robotic structure are attached. The actuators are also mounted at the end of this support.
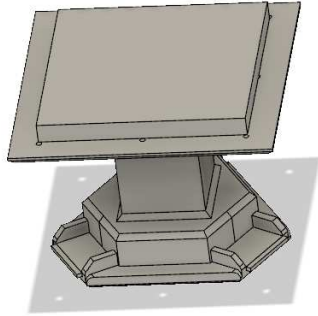
- Fixed base

Fig. 4 Fixed base

To this base three servo motors are attached.

3. MANUFACTURING AND ASSEMBLING OF THE PARTS

3.1 Introducing the CAD components of the Delta robot structure into ideaMaker printer software

After the components of the Delta robotic structure were designed in the Fusion 360 software, these components needed to be saved in the stl. Extension (figure 5) so they can be imported into the IdeaMaker slicing engine software, which is illustrated in figure 6.
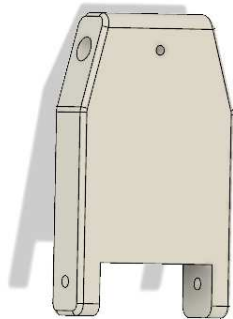

Fig. 5 Component saved with stl. extension

IdeaMaker is one of many slicing platforms, but what distinguishes it is its sleek compatibility with highly customizable print settings, provide limitless customization for advanced users. This

software is available for Windows, Linux, and Mac operating systems (OS). Slicing with ideaMaker is fast, efficient, and completely free because this software is open source. A program with free license can be used for commercial purpose, because commercial is not like that 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 [9].

The main features for ideaMaker software are [10]:

- remote monitoring and print job management;
- the parts in assemblies can be separated automatically;
- as an input it accepts the 3MF / OBJ / STL format, and as output is the G code format;
- generate automatic support structures;
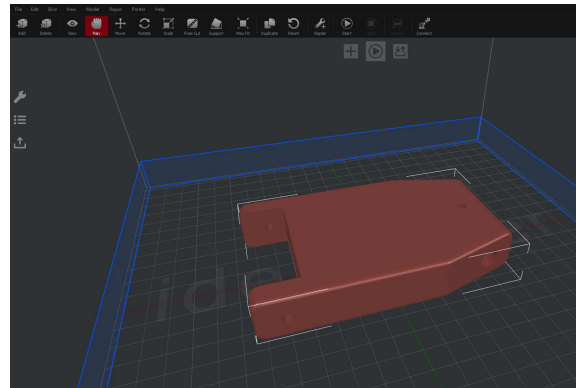- view cross-sections of models.

Fig. 6 ideaMaker slicing engine software

3.2 Creating and assembling components

In order to create the components of the Delta robotic structure, a 3D printer was used. Additive processes are used for 3D printing, under the control of a computer control are laid down successive layers of material. The prototyping stage advances to the manufacture of the final product in this process, being usable in various fields. [11]. The plastic parts resulted from additive can be improved by processing them on machine tools with numerical control for the improvement of the quality on the whole

surface [12]. Was made a choice of the materials with which 3D printing has been made before components have been created for the delta robotic structure. There are two types of dominant material, namely Acrylonitrile Butadiene Styrene (ABS) and Polylactic Acid (PLA). They are called as thermoplastics, at a normal temperature these materials are solid and when are heated they become soft and shapeable, and this process can be repeated many times. These materials are widespread because of their ability to melt and can be processed again.

General characteristics for PLA and ABS

PLA - is biodegradable and are made through two different processes: condensation and polymerization. The users who print are attracted by a wide range of colors and a translucencies and glossy sensation. Many users prefer the semi-sweet smell and the plant-based origins rather than ABS. The PLA material under proper cooling conditions gives the impression that it has higher printing speeds, clearer corners and lower layer heights. This is a popular plastic used more for the hobbyists, having a low deformation of the pieces.

ABS - is a common thermoplastic well known in the injection molding industry. The natural ABS material has a beige color before adding colorants. With this material due to the flexibility can be created interlocking pieces or pieces connected with pin [13].
We chose the PLA material for 3D printing after we analyzed the two materials (PLA and ABS).
In the following images we can see components of the Delta structure that were created by 3D printing.
After the appropriate 3D print settings have been made in the ideaMaker environment, 3D printing has been released. In figure 7 we can see the main components of the Delta robotic system that were made with the 3D printer.

Fig. 7 Main components of the Delta robotic system

Assembling the robot

After the pieces of the Delta system were created using the 3D printer, various devices were attached to these components as follows:

- Fixed base

  On the fixed base of the robotic system, three servo motors were attached (figure 8). These servo motors control the Delta robotic system.

Fig. 8 Fixed base

- Mobile base

On the mobile base of the robotic system are attached six threaded rods from metal

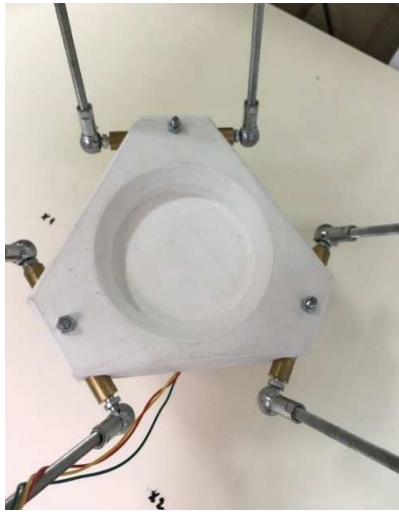material (figure 9), through which this base can be positioned at different angles.

Fig. 9 Mobile base

- Arm

On each arm that is built using the 3D printer are attached two long beam. (figure 10). This long beam is made of the threaded rod that enters in the spherical joints of the parallel robot. The threaded rod was purchased at a longer length and then cut to the desired size.
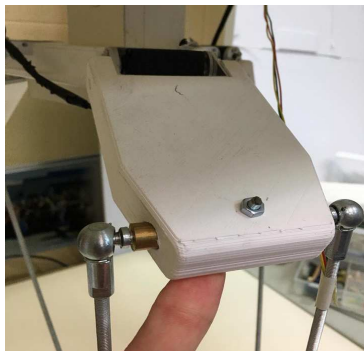

Fig. 10 Arm

After attaching the necessary devices to the components of the robotic system, it went to the next stage, namely, to assemble the entire Delta robotic system (figure 11). This robotic system is designed for pick and place applications, and via a gripper this robot can handle small-sized objects.

Fig. 11 The Delta robotic system

4. CONCLUSIONS

The paper presents design and manufacturing of a Delta robotic structure. The components of this structure were first designed in Fusion 360 program, after which they were manufactured using the 3D printer technology. After manufacturing the components, the robotic structure has been assembled and tests have been made for its functionality by actuating the servo motors. Performed tests have validated the robotic system performances.

ACKNOWLEDGMENT

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PROIECTAREA SI FABRICAREA UNUI ROBOT DELTA PENTRU APLICATII DE PICK AND PLACE

Rezumat: Lucrarea prezintă proiectarea şi fabricarea unui sistem robotizat Delta, cu trei grade de libertate. Sistemul robotic a fost proiectat folosind programul Fusion 360, apoi componentele sistemului robotic au fost fabricate folosind imprimanta 3D. Pentru mediul de imprimare 3D a fost folosit programul ideaMaker. După asamblarea sistemului robotic şi crearea controlului pentru acest robot, s-au efectuat teste pentru funcţionalitate prin acţionarea servomotoarelor ataşate pe baza fixă. Aceste teste au validat performanţele sistemului robotic.

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