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Design of a Robotic Arm

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***Abstract:** Cancer and tumor detection is a very important field in today's medical profession. The medical procedures such as radiology, biopsy, surgeries, etc. require paramount precision. Technologies such as robotic arms have come into play these days to minimize the pain, post-operation and also to make the surgeries and procedures much more cost-effective. A robotic arm has been experimentally designed that takes the coordinates as input and reach the target point. The main aim of this project was to increase the precision and accuracy of the robotic arm that has been experimentally designed. The objective of the project was to find the deviation of the end needle caused due to the functioning of the robot and due to its self-weight. Designing of the robotic arm was done in Solid works and analysis was carried out in ANSYS. The results for stress and strain were obtained for static structural analysis. The vibrational analysis was done in comparison to the previous model.*

***Keywords:** Robotic arm, Vibration and structural analysis, LabVIEW, MyRIO.*

I. INTRODUCTION

Robots have been used extensively since the last century after it has been invented. They are widely used in the fields of medicine, industry, automation, etc. Industries have used robots to automate most of their processes that were done by humans previously. In the field of medicine, robots help doctors to operate on the patients. Though robots have come into play in the medical field, intensive research work is being carried out to make them more user-friendly. In the medical profession, perfection and precision play a very crucial role. This is where robotic arms can be very helpful as they are programmable and can be controlled mechanically, thus reducing the chances of errors in the part of the doctor. Many robots are being currently used in the medical field for the detection of diseases, disinfection, and sanitation, telepresence robots, surgical assistance, and diagnostics. Diagnosis of a disease is one of the most important processes that precedes treatment especially in diseases like cancer and tumor. Extensive research is being done in the field of technology to help the human population.

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The collaboration of the medical field with robots has undergone many advancements. In the research paper by Chen Yanhong et. al., a sub frame of a truck was subjected to stress analysis in ANSYS. Analysis was carried out to find the maximum stress in the beam of the frame [1]. In another paper by Guohua Wang et. al., end effector for automatic harvesting by robots were designed. Analysis of the force and material characteristics were done to increase the working rate of the end effector [2]. Ningbin Zhang et. al. in their paper discussed about the design and carried out kinematic analysis and singular configurations were identified [3]. In a paper by Marco Lionesio et. al., they performed a vibrational analysis of a robotic milling machine. The cutting capability of an industrial robot was studied in their paper [4]. Liangwen Wang et. al. in their research paper, optimized the parameters of a robot for better motion trajectory [5]. Liang Jie et. al., in their research paper put forward a study of the end effector. Analysis of stiffness, payload, mounting operations and technological processes were carried out on the end effector of the modelled robot [6].

II. METHODOLOGIES

A. CAD Design

The modeling of the robotic arm was done in SOLIDWORKS 2016. Simulation of the 5-axis open linkage mechanism has been done in SOLIDWORKS 2016. There is a fixed base. The first actuator is the first joint. The Bioloids that is linked to the first stepper motor is the first link. The first joint provides a rotary motion to link 1. The second joint is the second actuator that starts from link 1 and is connected to link 2. The second joint provides rotary motion to the second link. The plane containing the motion of the second joint is perpendicular to the plane of the motion of the first joint. The third actuator is the third joint and the link connected to it is the third link. In parallel planes of motion, the second, third, fourth and fifth joint rotates along with which the link rotates. The dimensions of the actuator have been taken from the datasheet provided by the manufacturer. The links have one degree of freedom and can rotate a complete 360 degrees. The CAD model can be seen in figure 1.

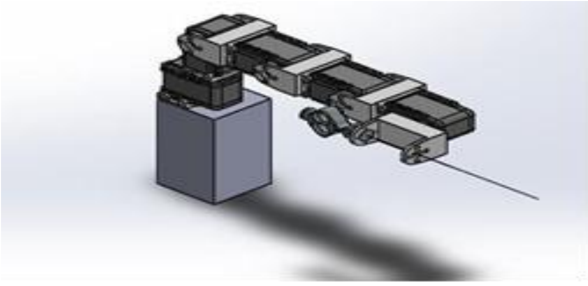


Fig. 1: CAD model of the robotic arm

An actual working model of the robotic arm has been designed to check its accuracy and working. It has been portrayed in figure 2

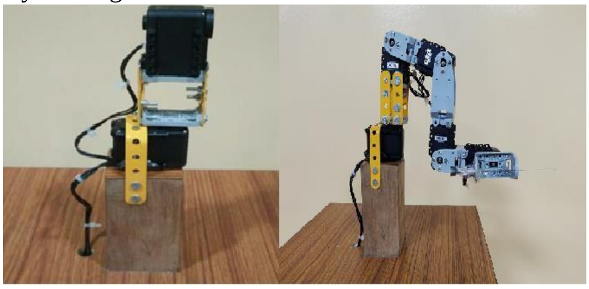


Fig. 2: Working model

Table 1 shows all the properties of material used in robotic arm

TABLE 1: PROPERTIES OF THE MATERIAL

Material	Aluminum alloy	Stainless steel
Parts	links	Shafts, bolts and nuts
Density	2770kg/m3	7750kg/m3
Young's Modulus	7.1E+10 Pa	1.93E+11 Pa
Compressive yield strength	2.8E+8 Pa	2.07E+8 Pa
Tensile Ultimate Strength	3.1E+8 Pa	5.8E+8 Pa
Specific Heat	875kg/JC	480kg/JC

III. RESULT AND DISCUSSION

A. Static analysis

Static analysis for the 5 axis robotic arm model was performed in ANSYS V15. The robotic arm has been analyzed for von-mises stress and strain. Von-mises stress and strain analysis performs the task of predicting yielding of a material during the multiaxial loading condition. Manufacturer provided the material data of actuators used, at the time of performing the analysis of the robotic arm, those data were taken into account. The wooden base of the motor was taken to be fixed along with a joint one. Standard earth gravity was applied to the model to calculate the stress-strain and deformation of the robotic arm. Meshing and finite element analysis were done with the help of ANSYS V15. The total deformation when the robotic arm was subjected to only its own weight could be seen in figure 4. The stress and strain along with axial deformations are also given below.

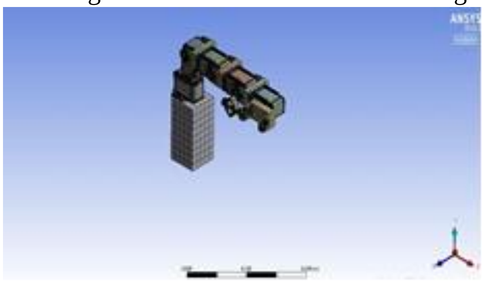
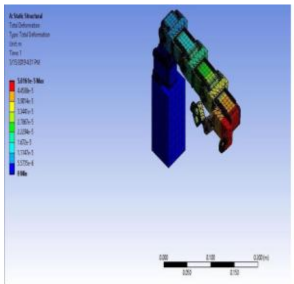


Fig. 3: Meshing of the robotic arm model

Mesh of the robotic arm model is done with standard parameters in ANSYS.



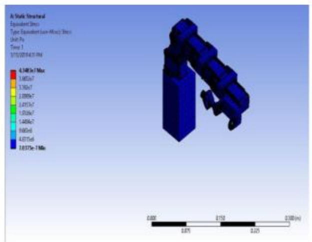


Fig.4 Total deformation Fig.5. Equivalent Stress

B. Comparison of result of Vibrational analysis

PMOD ACL sensor which is used to measure acceleration in X, Y and Z direction, is attached with a MyRio controller using LabView. From MyRio vibrational amplitude data were transcribed directly in real-time. A feed of 90 degrees was given to each link and the end of each link was attached by accelerometer sensor to measure the maximum vibration due to the movement in all the joints.

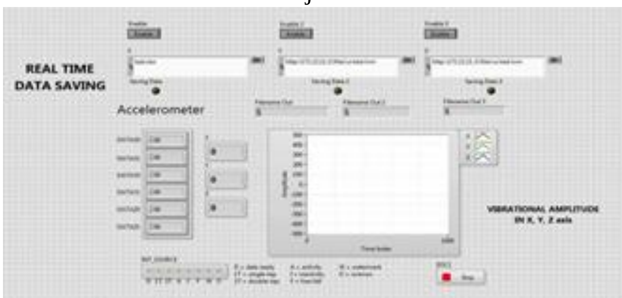


Fig. 6: VI designed in LabVIEW.

This VI is designed in LabView, it controls MyRio to read the vibration data obtained in sensor.

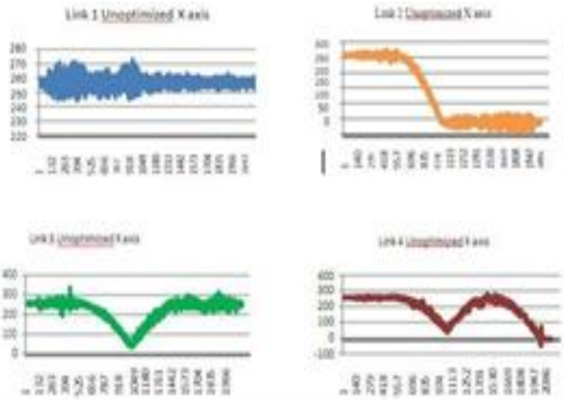


Fig. 7 Vibrational amplitude of links in X-axis.

IV. CONCLUSION

Technology and the field of medicine when tangled, they can help future generations to come in a better way by providing advance health care. In this project, the analysis of the robotic arm gave a clear picture of the deformation that can cause the robotic arm to function inaccurately. The structural analysis is done by using ANSYS V15 on the robotic arm and the deformation is very less which can be in accepted level. vibrational analysis is done by using accelerometer and shown in Fig.6 and Fig.7.

The most susceptible point in the robotic arm was found to be the shaft of the first actuator and the second link.

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