Design Analysis of parallel robot for Surgical applications

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Abstract

Laparoscopic surgery also referred to as minimally invasive surgery(MIS) describes the performance of surgical procedures with the assistance of a video camera and several thin instruments. During the surgical procedure, small incisions of up to half an inch are made and plastic tubes called ports are placed through these incisions. The camera and the instruments are then introduced through the ports which allow access to the inside of the patient The camera transmits an image of the organs inside the abdomen onto a television monitor. The surgeon is not able to see directly into the patient without the traditional large incision. The video camera becomes a surgeon's eyes in laparoscopy surgery, since the surgeon uses the image from the video camera positioned inside the patient's body to perform the procedure. In the common mode of operation in laparoscopic surgery, the surgeon holds in his right hand the laparoscope and in his left hand the surgical tool. In some cases, the surgeon works with a human assistant who holds the laparoscopic camera in a desired orientation. This arrangement is far from being satisfactory because of the fact that one of the surgeon's hands is occupied in manipulating the laparoscope. In addition, the requirement for steadily holding the laparoscope camera for long time is physically demanding, thus, consuming unnecessary effort from the surgeon. Incorporating a robotic assistant for steadily holding the laparoscope camera reduces the workload of the surgeons, and in many procedures eliminates the necessity for a second one.The project aim to design a parallel robot/serial robot for steady holding of camera

Keywords*:*
parallelrobot ,laproscopicsurgery

1. Introduction to Robots for Medical Applications

Robotic–assisted surgery is a new trend in medicine, which aims to help the surgeon by taking advantage of robots' high accuracy and accessibility[1]. Introducing a robotic assistant as an integral part of the surgical tool array provides the surgeon with several advantages. These advantages include off-loading of the routine tasks and reduction of the number of human assistants in the operating room. In addition, by using the capabilities of the robot, the surgeon can complement his own skills with the accuracy, motion steadiness, and repeatability of the robot. The experimental comparison, presented in journal by Kavoussi, et al., 1996,**[12]** compared the performance of a human assistant and a robotic assistant in manipulating a laparoscope. The results of this comparison emphasized the superiority of the robot in terms of motion steadiness. Another work by Kazanzides, et al., 1995,[13] presented experimental results comparing the cross sections of a manually broached implant cavities and cross sections of robot milled cavities for hip replacement surgery. The comparison resulted in clear preeminence of the robot in performing accurate milling of the implant cavities. Noticing these features of the robot, several researchers invested efforts in assimilating the robot in the surgical arena

2)Approaches to robot assisted surgery.

1)Active execution approach,
2) semi-active approach
3) passive approach.

2.1)Active execution approach:

In the active execution approach, the robot actively performs surgical procedures such as bone cutting and milling as in the works presented by Kazanzides, et al., 1995;.[13] In the first example, a serial robot performed milling of the femur bone to suite the implant in a knee surgery, and in the second one**,** a Stewart platform robot is used for hip surgery**.**

2.2)semi-active execution approach:

In the semi-active execution approach, the robot is used as an aiding tool during surgery for tasks such as precise guidance of the surgical cuts without actually performing them. In this mode of operation, the robot holds the surgical tool while the surgeon moves the tool. The task of the robot is to prevent the surgeon from moving the tool out of the desired regions. Examples for this semi-active approach were presented in journel by Harris, et al., 1997[8] in total kn ee replacement surgery

2.3)passive approach:

In the third approach, the passive approach, the robot is merely a tool moved directly by the surgeon in remote manipulation mode as in [Grace, et al., 1993; Jensen, et al., 1994] [10]that used a parallel six degrees of freedom robot in the field of ophthalmic surgery

.Most of the works listed above use serial robots. Some use special purpose serial robots like in [Taylor, et al., 1995][9]. These robots suffer from all the disadvantages of the serial architectures; thus, these designs result in large and heavy robots.

3)The fundamental requirements of a medical robot

The following discussion is limited to formulating the fundamental requirements from the robotic architecture only..In order to insure the success of a medical robot, four fundamental requirements must be fulfilled. The first and most crucial requirement is safety. The following seven criteria constitute the safety requirement.[1]

1) Effective control: The robot must allow, in all configurations, effective control of the tool with both speed and force control schemes implemented
2) Limited Workspace: The robot must have limited workspace in order to prevent hazardous collisions between its moving parts and the medical staff or the patient.
3) Limited Forces or Force feedback: In applications where the robot is active in performing surgical procedures that include tactile tasks, the force applied by the tool must be limited.
4) Immunity against magnetic interference of other surgical tools.
5) Full control option: In applications where the robot performs automated tasks, the control program must allow the surgeon, in any stage in the task, to interrupt the automatic execution process and take over the control to his hands.
6) Fail safe features: The most reliable systems will inevitably fail in some stage of their service. Based on this premise the robot must support a fail-safe mode. This includes keeping the position of the tool when the power supply is lost, electrical limiting of the end effector's speed and force even when the control program fails.
7) Safe behavior near singular configurations: The path planning of the robot should avoid passing near singular configurations. However, in the cases where the robot acts as a slave, the surgeon might manipulate it into singular configurations. Therefore, the architecture of the robot must provide signals for the surgeon that warn him from approaching singularity

4) Advantages of parallel robots in medical applications

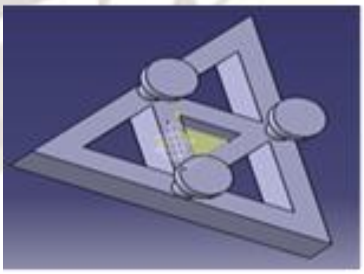
From the two robot architectures, i.e., the serial and parallel ones, the one most compliant with the fundamental requirements is the parallel architecture. In contrast with the bulky serial architecture, the compact and lightweight parallel architectures simplify the relocation of the robot in the operating room, save necessary space, and allow easy sterilization by covering the robot with a closed drape. The relatively small work volume of the parallel robots, if correctly designed, can introduce an important safety feature. In addition, parallel robots behave safely near singularity. When the robot traces a path towards a singular configuration, the required forces from the actuators reach high values. Consequently, monitoring the electrical current of the actuator motors gives a reliable warning against approaching singular configurations. In serial robots, singular configurations are associated with very high values of joint velocities and this introduces a hazardous element.
The parallel robots provide accuracy with lower price when compared to similar serial robots with the same accuracy level. Some accuracy levels may not be achieved with serial robots. These high levels of accuracy are important for eye surgery Based on the above arguments, we may conclude that the parallel architecture is better than the serial one for medical applications that require a suitable workspace for reasonable robot design.

5).Designing of Double Circular double triangle parallel robot using 3d softwares

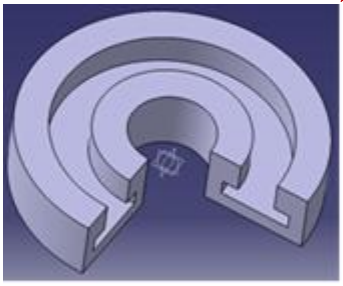
This structure is composed of two 3 DOF planar mechanisms. These planar mechanisms are different from regular mechanism, Since they use a circular-triangular combination rather than triangular- triangular one, thus providing much higher orientation capability (theoretically unlimited)[7]

Various parts:
Triangle

A moving triangle which is connected to the circle by three passive sliders as shown in 3d figure.

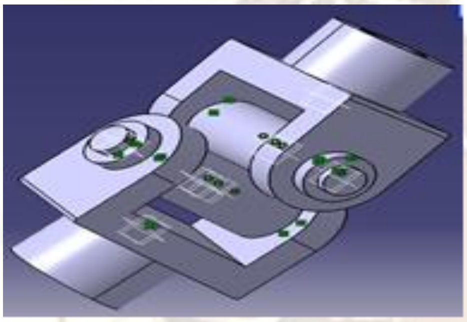


Circle:
The robot has two similar planar mechanisms each one consists of a stationary circle. These are the circles where both the triangles were supposed to move

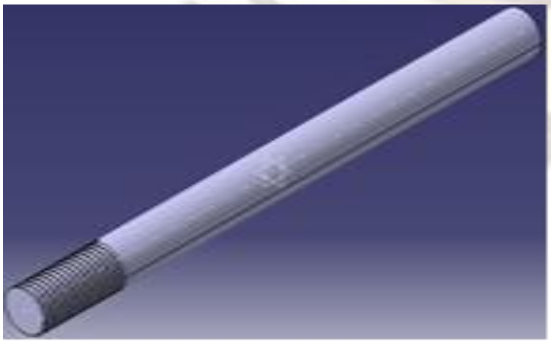


Universal coupling (U – joint):

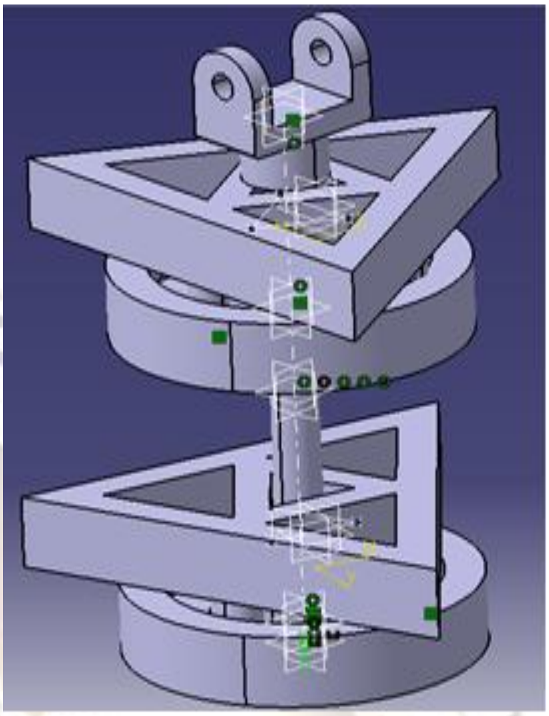
Each triangle's center contains a U- joint and is connected to the output link at one triangle's center through a prismatic joint and at the other through a helical joint (nut and a lead screwfriction After the assembly of both circle and triangle this U- Joint was assembled at the centre of both the triangles which leads to another two degrees of freedom at every link i.e. totally four degrees of freedom.



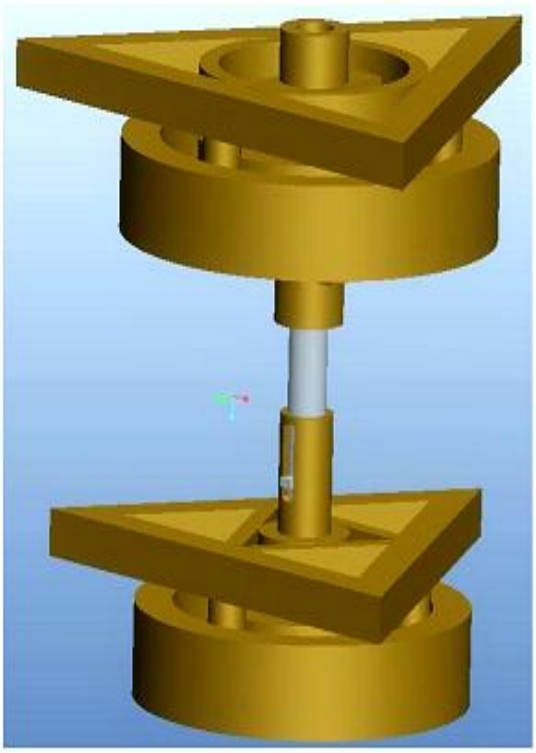
Lead screw:
Two sets of this structure are used to construct a six-DOF robot. Each structure contributes three-DOF, namely, moves the triangle in a plane and rotates the triangle about an axis normal to this plane. With two such sets, a line connecting the triangle's centers is actuated in four-DOF. The output link is located along this line and the additional two-DOFs are obtained by controlling the rotational motion of the moveable triangles.



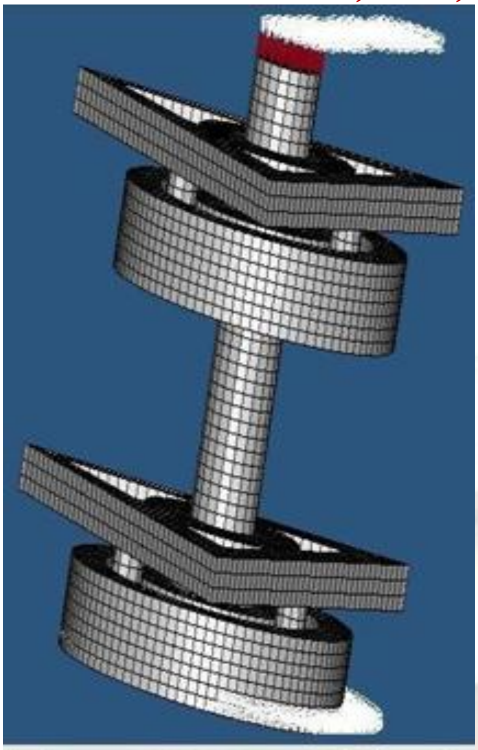
Assembeled parallel robot using catia software



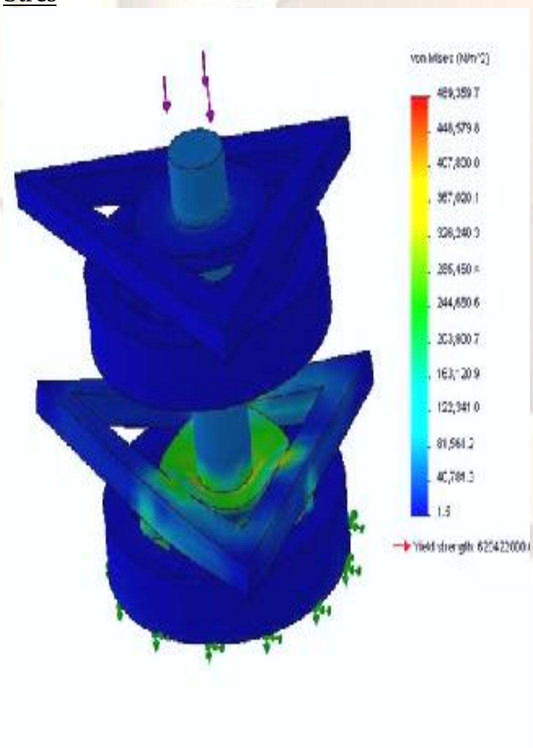
Assembled parallel robot using pro/e software



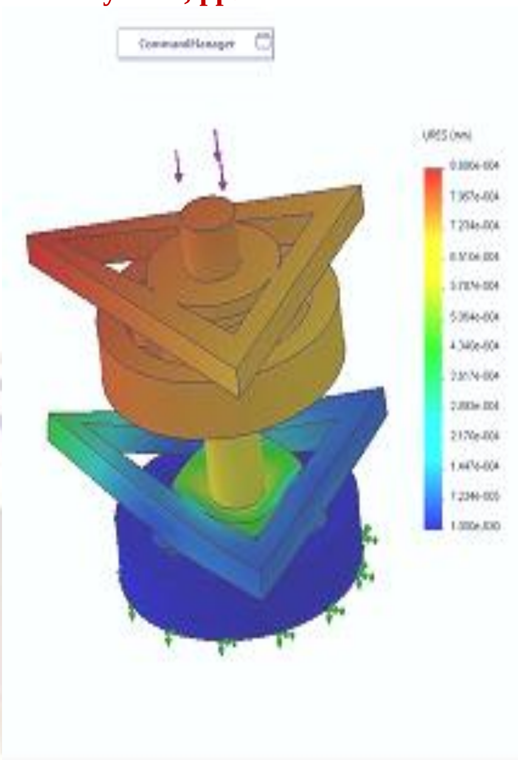
.3D Meshing Using Altair Hyper Works:



5.Analysis using Solid Works For Steel: CONTOUR PLOT – Von Misses Stres



CONTOUR PLOT – DISPLACEMENT OF THE REQUIRED PART



7. Conclusion

From the complex analysis process it is observed that the maximum stress in the mechanism is far less than its yield strength. And displacement is very small to consider .hence structure can with stand the load that is laproscopic camera / applied force.future scope of this project is to find work volume of the parallel robot and to design a flexible parallel robot for laproscopic surgery.

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