Design and Development of Hanging, Low-cost, Robotic-Assisted Laparoscope

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PROGRAM FOR UNDERGRADUATE RESEARCH

INTRODUCTION

•Laparoscopic surgery, also known as bandaid surgery is a surgical technique that is operated in the abdomen with the help of a camera through small incisions.

Figure 1. Laparoscopic Surgery [1]

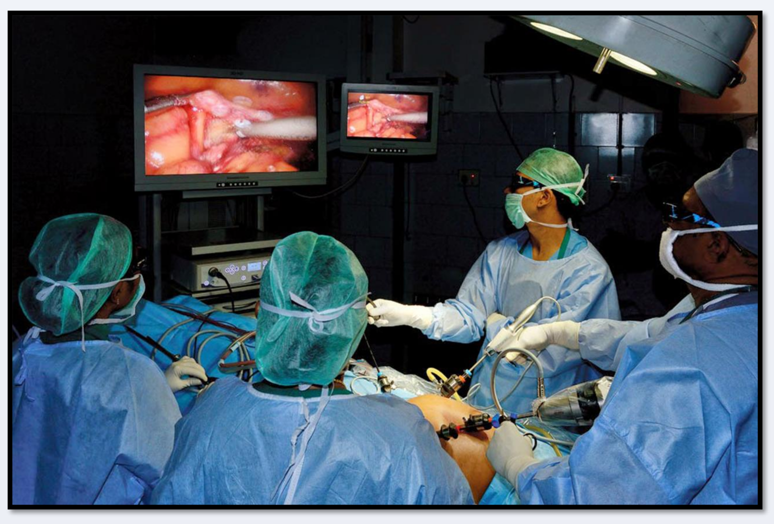


Figure 2. Laparoscopic Surgery [2]

•The duration of staying in hospital and recovery time for patients are significantly decreased (Gallagher, Mcclure, Mcguigan, Ritchie, & Sheehy, 1998). Although couple of advantages have been observed, a few remarkable disadvantages show up such as lack of space for surgeon during operation or the stability of the assistant during the surgery (Mirbagheri, Farahmand, Meghdari, & Karimian, 2011). There have been endeavors to turn these disadvantages into advantages by using more automated and multi-functional laparoscopic tools (Onal, Ersen, & Elitas, 2018).

• In this paper, a low-cost, and light robotic-assisted laparoscope which its control system is supplied by pedals is proposed as a solution. Our laparoscopic robot will make more space for surgeons to perform the surgery since the device is attached to the stable mechanism that takes place upside of the surgical area. Moreover, the assistant will not be required during the operation.

OBJECTIVE

- Designing a user-friendly, low-cost, automated, robotic-assisted laparoscope which gives more space to surgeon to perform the surgery and makes the surgery effective.

MATERIALS AND METHODS

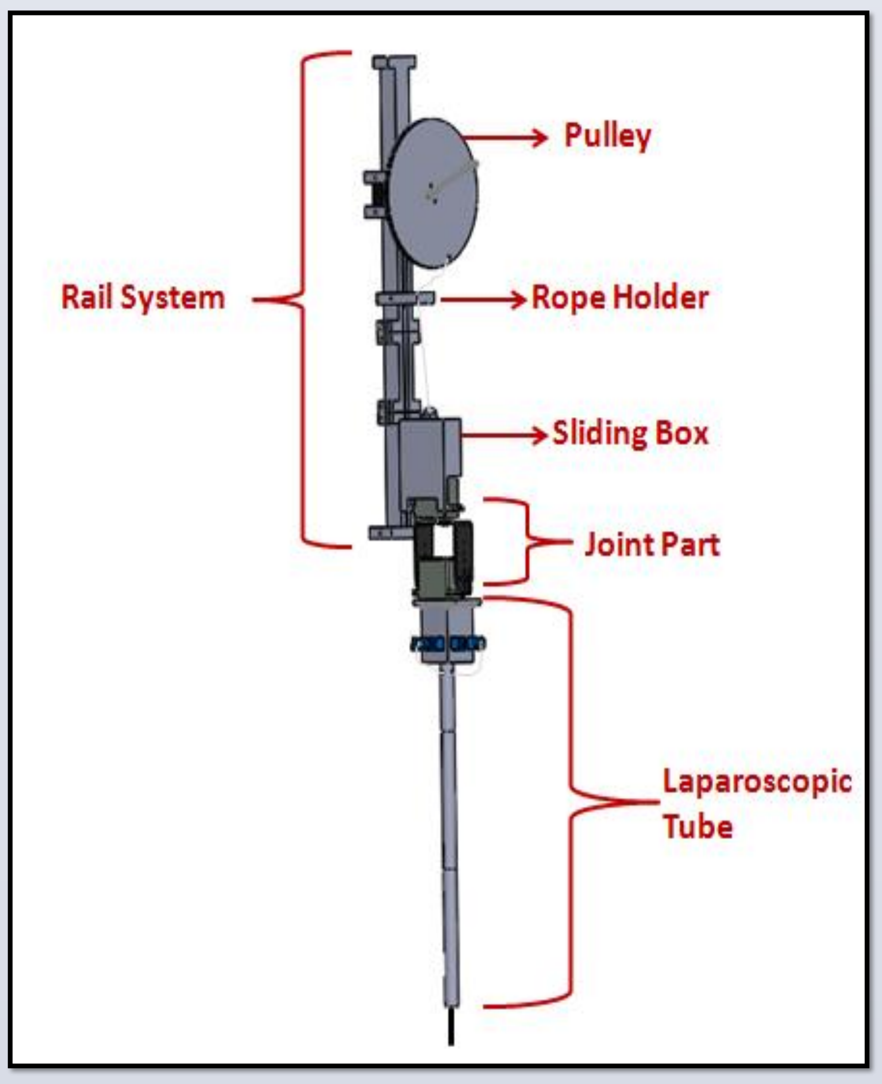


Figure 3. Robotic-assisted laparoscope

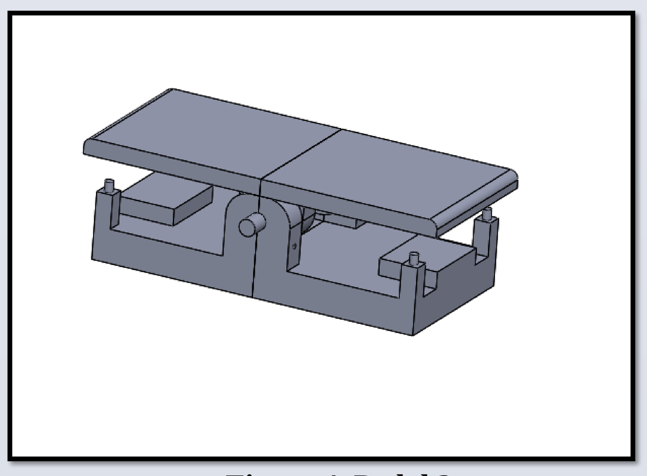


Figure 4. Pedal 2

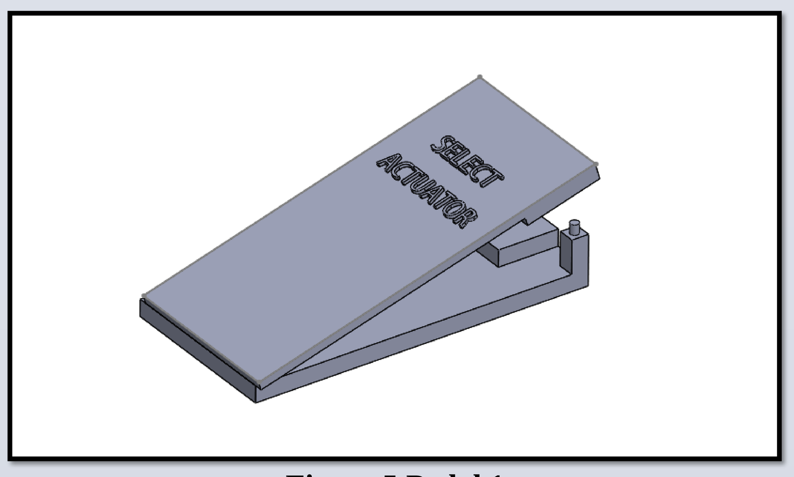


Figure 5.Pedal 1

SolidWorks 2015 Edition is used to design the robotic-assisted laparoscope. There are 2 main parts of the robotic-assisted laparoscope :

- ❑ *RAIL SYSTEM*
- ❑ *LAPAROSCOPIC TUBE*

- ❑ The rail system of the robotic-assisted laparoscope consists of a sliding box which contains a servo motor, 5 rails to keep the laparoscopic tube stable and create a special place to be able to move the sliding box, a pulley that is connected to a Servo Motor to pull the sliding box by providing movement for the laparoscopic tube, a rope holder to keep the fish line stable for a better motion and avoid shaking. There is a breadboard and Arduino Nano for providing movement to the motors, on the back side of the device.
- ❑ The laparoscopic tube comprises of 3 parts with lengths of 12 cm, 12 cm and 6 cm. Moreover, the laparoscopic tube has 4 small holes with diameter of 2 mm .The camera which has 5.5 mm diameter with 6 LED, 720P (SD), and IP67 waterproof feature is embedded into the center of the laparoscopic tube which has 6 mm diameter. Two servo motors are placed to the part of the laparoscopic tube which its length is 6 cm.

There are two pedals that controls the device. One of them is actuator selecting pedal. Second pedal works for moving the device.

MATERIALS AND METHODS

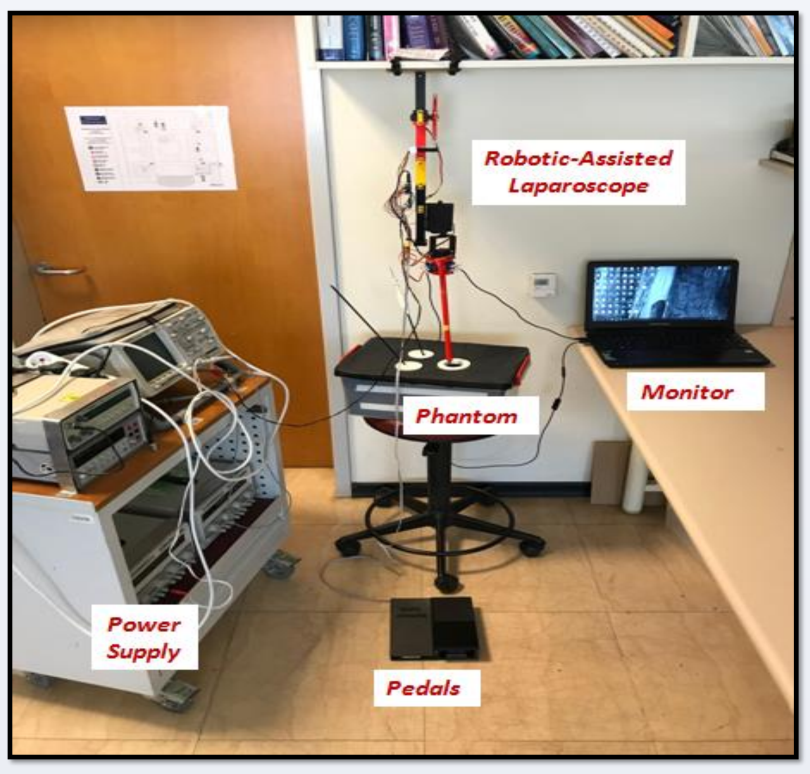


Figure 6. Setup of the experiment

All parts of the rail system and laparoscopic tube are made from the 3D printers which are in Collaboration space of Sabancı University.

TABLE 1
MAIN COMPONENTS AND THEIR FUNCTIONS

COMPONENT	FUNCTION
MG-996 Servomotor	Providing power to turn 180˚ of pulley to pull the sliding box. There are also 2 other servo motors inside the connector part to move the device 360̊
G-90 Servomotor	There are 2 of them on the laparoscopic tube. They are connected to fish lines that pulls and moves camera head 360̊
Phantom	The setup for the experiment that takes place for the human body
Camera	Getting vision from the human body
7 segment single digit display	Displaying which motor is in the use
Pedals	One of them works for switching the motors (Figure 5). The second one works for choosing which direction to move (Figure 4)
Rail System	Sustaining stability of laparoscope while it is moving up and down
Laparoscopic Tube	Special design for fish lines not to tangle and camera is going inside of it
Power Supply	Supplying power to the system approximately 5.9 V
Artificial Tissue	Taking place of human body

RESULTS AND DISCUSSION

TABLE 2
MOTOR FUNCTIONS

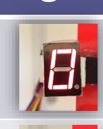
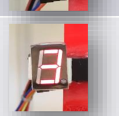
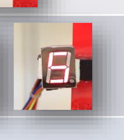
Seven Segment Single Digit Display	Motors	Motion
	Initial position	-
	Motor 1	180̊ on average 1.9 seconds
	Motor 2	180̊ on average 4.76 seconds
	Motor 3	180̊ on average 5.35 seconds.
 	Motor 4 - 5	180̊ on average 2.59 seconds

Figure 7. Tissue at +13 position

Figure 8. Tissue at +24 position

•In our experiments, we calculated what are the durations of the motors to perform their full actions shown in the first part of the result section. Then, we performed our experiment with artificial tissue and found out that our device moves 11 cm on average 1.30 seconds.
•As a future work, experiments can be done by a surgeon on a real animal tissue.

REFERENCES

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[1] Image Credit: Indiamart. [2] Image Credit: Surgeon2.