Utility of a Semi-Autonomous Tissue Retraction Robot in Simulated Pacemaker Implantation Surgery

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Abstract

Anatomical retraction of tissue is an important aspect of many surgical procedures including pacemaker implantation. These procedures are often performed by members of the healthcare team, however, due to current healthcare staff shortages innovative solutions are in high demand. E.R.R.S.E.L.A. (ETIC Research Robot for Student Engagement & Learning Activities) is part of a research and student engagement program created by the NYIT College of Engineering & Computing Sciences and Entrepreneurship & Technology Innovation Center (ETIC). The purpose of this project is to alleviate healthcare workers of the tedious task of tissue retraction during pacemaker implantation surgery through using a semi-autonomous robotic retraction system using E.R.R.S.E.L.A. This study aims to assess the ability of E.R.R.S.E.L.A. to move autonomously about a simulated surgical environment and perform simulated surgical retraction for pacemaker implantation surgery through use of attached linear actuators and retractors. This project is a collaboration between the NYIT College of Osteopathic Medicine and College of Engineering & Computing Sciences.

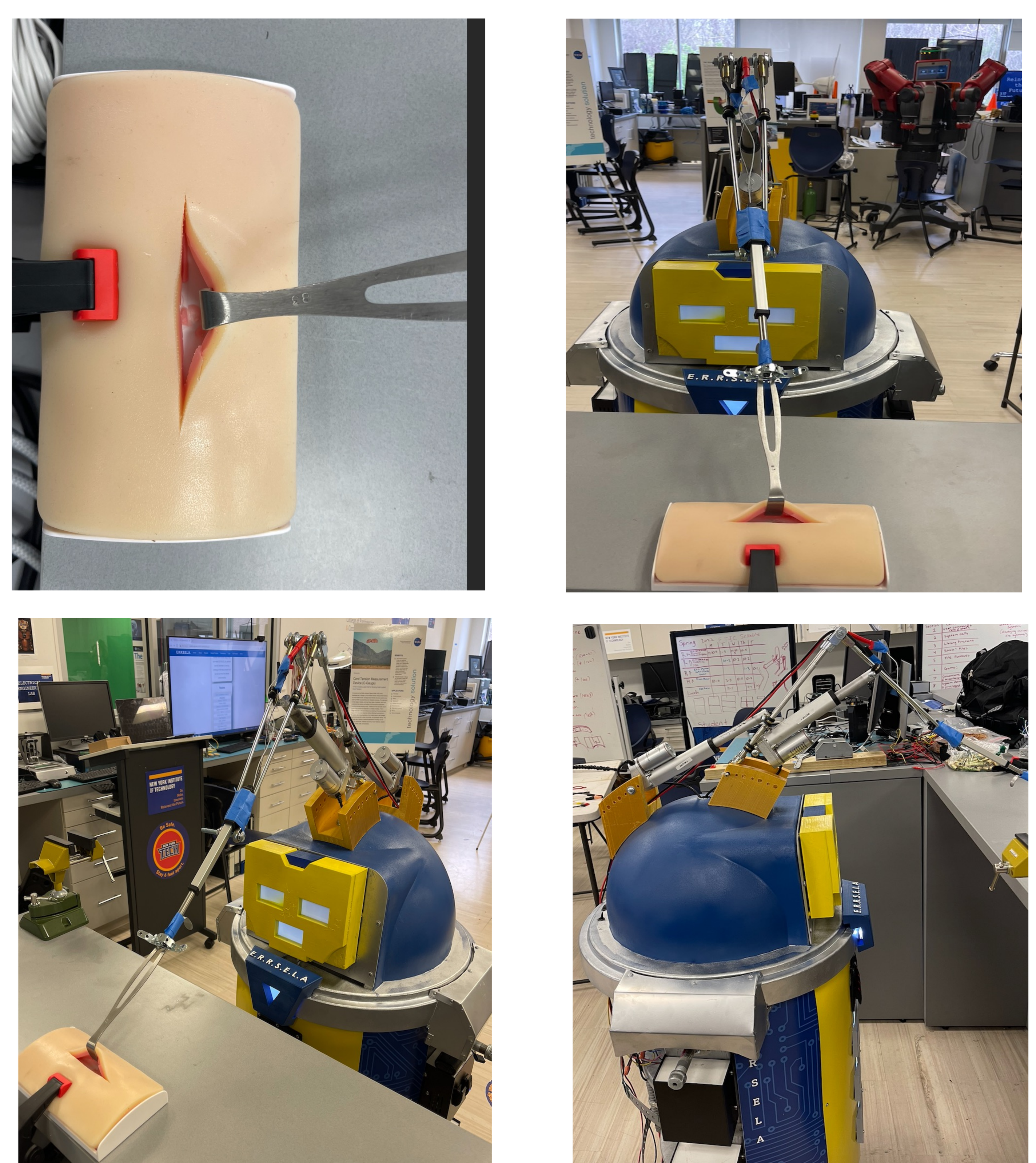
Introduction

Anatomical retraction of tissue is an important component of many surgeries. Very often this task is performed by a member of the healthcare team however with the current shortage of healthcare professionals, this may be inefficient. Robotic surgical systems in laparoscopic surgery and other minimally invasive surgeries are increasingly being used and are becoming more cost effective and efficient [1,2]. The use of robotic technology in surgery may thus alleviate the burden of staff shortages in operating rooms. Pacemaker implantation is a surgery where the use of retractors is commonplace. A simulation of pacemaker implantation surgery is utilized here as a model to test the feasibility of a semi-autonomous robotic system for tissue retraction.

Methodology

E.R.R.S.E.L.A. (ETIC Research Robot for Student Engagement & Learning Activities) is part of a research and student engagement program created by the NYIT College of Engineering & Computing Sciences and Entrepreneurship & Technology Innovation Center (ETIC). E.R.R.S.E.L.A. was developed to enrich student creativity by allowing students to develop custom-designed tools and routines for the robot. The robot consists of a chassy (metal and wood), battery powered Rasberry Pi computer, and electric motor which allows wireless internet control of the robot through custom pre-programmed routines. The robot is capable of rolling forward on the horizontal plane and turning either side 180 degrees. An arm was constructed using two linear actuators attached to the robot using two 3-D printed rack mounts. An Army-Navy retractor was mounted onto the end of a third linear actuator that was placed onto the end of the arm. Two switches on the side of the robot were used to manually control the motion of the actuators which were capable of extending and lowering the retractor into place. The experiment consisted of using preprogrammed motion routines to move the robot in front of a lab table with a mounted rubber skin model (OneHalf Design Co. ,LTD). The skin model was cut to the approximate length of a pacemaker in order to simulate the formation of a pocket in surgery. The retractor arm was then moved into place using the manual switches on the robot and was inserted into the skin by the operator. A manual switch was then used to activate the linear actuator directly attached to the retractor and retract to the appropriate amount. The switches were then used to extend the retractor and replace it back to normal. The robot then autonomously moved to its original position based on the pre-programmed routine.

Figure 1. Robotic system and simulated skin



Results

The dimensions of the robot and specifications of the parts are listed in table 1. After two trials the robot successfully moved into place in front of the simulated skin and retracted the appropriate amount in the horizontal plane (the arm was angled downwards). The first trial experienced issues due to an inappropriate estimation of the distance required to reach the skin in the pre-programmed routine activated by the operator on a computer. The retraction force is reported as the max force capable of being applied by the small linear actuator that directly moves the retractor. Figure 1 includes images of the robot and simulated skin. A video is available upon request.

Table 1. Measurements of the Robot

Measurement	Value	Unit
Robot Height	1.17	m
Robot Diameter	0.64	m
Arm Length (fully extended)	0.59	m
Retractor arm force	22.24	N

DISCUSSION AND CONCLUSION

This semi-autonomous robotic retraction system successfully completed the task of retraction with some limitations. The robot was able to move to the operating table, extend the retractor, retract, and return however the only autonomous action it could perform was maneuvering to the table. The average retraction force used during surgery is 2.49 N., thus this system (retraction force 22.24 N) can provide adequate retraction force. The system is also capable of maneuvering in multiple directions thus can be used in various positions around the operating table. The limitations of this experiment include the robot's inability to retract, extend, and insert without being controlled by the operator through switches, inability to move in reverse, the use of simulated instead of real skin, and the use of a lab table instead of an operating table. Future efforts will be focused on integrating the linear actuator arm system into the robot's computer for the creation of pre-programmed routines for the arm to perform true autonomous retraction as well as allowing motion in reverse. Voice commands will also be explored as a means of activating the robot to completely eliminate the use of an operator at a computer to activate the robot's routines. The aim for the final prototype is the ability to move into place and retract without pre-programmed routines and test in an operating room with real surgeries.

References

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