MINIATURE IN VIVO SURGICAL ROBOT FOR SPACE APPLICATIONS

E. J. Markvicka[1], T. P. Frederick[1], K. M. Lackas[1], W. Bircher[1], E. Greene[1], S. M. Farritor[1], and D. Oleynikov[2]
[1]University of Nebraska-Lincoln, Department of Mechanical and Materials Engineering, [2]University of Nebraska Medical Center, Department of Surgery

This paper presents work to develop miniature in vivo robots for remote surgical applications including long duration space flight and exploration. The robotic platform consists of a miniature in vivo robot and a remote surgeon interface. The robot design is comprised of a torso and two independent arms. Each robotic arm has a two degree of freedom rotational shoulder and elbow joint. The forearms are fitted with specialized end effectors, such as a grasper, cautery, or monopolar scissors, depending on the surgical task being performed. Each joint is powered by a DC electric motor with on board dedicated control hardware. The control hardware is receives commands over serial from a Linux machine running ROS (Robot Operating System) which is housed within the user interface. The surgeon interface is comprised of two Phantom Omni® haptic devices, a monitor, and foot pedals. The haptic device provides a haptic boundary, preventing the user from exceeding the extent of the workspace. The haptic interface also allows the surgeon to control the robotic device from a remote location. The monitor provides high definition visual feedback and the foot pedals allow the surgeon to clutch or brake each individual arm. This device has been developed specifically for general surgery. The device is introduced into an insufflated abdominal cavity through a single incision using a specialized port. The specialized port allows the irregular shaped robotic device to be inserted without loss of insufflation. To simplify the process, the entire device is inserted at once, unlike previous devices, reducing the complexity and time of insertion [1]. When the surgical procedure is completed, the device can be removed along with any specimens. This platform provides improved dexterity and visualization in comparison to standard laparoscopic techniques. Robotic-assisted laparoscopic surgery also increases precision while reducing trauma to the patient. Preliminary prototypes have been developed and tested in multiple non-survival porcine procedures. The robot can facilitate minimally invasive surgical resection of abdominal emergencies. This includes emergency appendectomies, emergency cholecystectomies, emergency perforation of gastric ulcers, and intra-abdominal bleeding due to trauma. Although the likelihood of these accidents is low, it has been reported on other remote locations including North Pole expeditions and submarine service. Because of its small size, this robotic platform is advantageous to medical emergencies during long duration space flight and exploration. While this work is in an early phase, the minimal invasiveness of this approach could enable its use in remote locations such as on a moon or Mars colony.

A surgical suite for long term space flight and exploration is currently being developed based on workstations on the International Space Station (ISS), Figure 1. The surgeon user interface and miniature in vivo robot will be tested on a parabolic flight early next year. The surgeon user interface will be comprised of haptic devices based on previous success of other researchers, a monitor to provide visual feedback, and push buttons instead of foot pedals. The feet of the user will be constrained to foot straps. Two surgical devices will be tested. Both prototypes will be based on previous research. The first device will be able to withstand all forces that will be experienced throughout the flight. The second miniaturized device will only be able to operate within a reduced gravity environment.

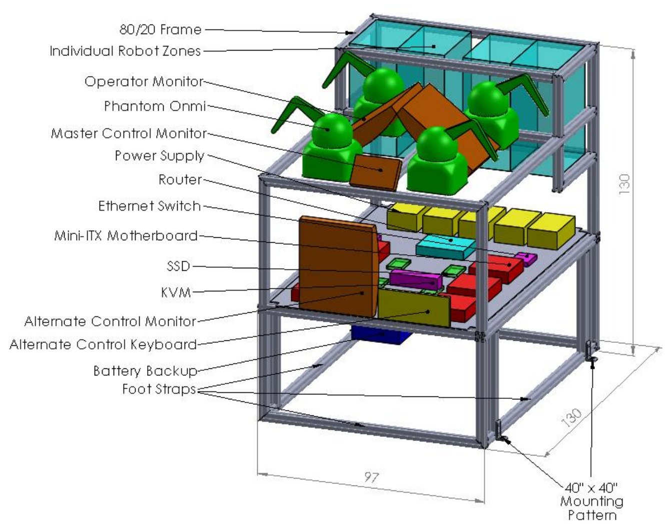

Figure 1: Preliminary Surgical Suite Test Setup for Parabolic Flight.

REFERENCES

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