

Satellite Surgery and Assembly through Assisted Teleoperation and Mechatronic Design

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INTRODUCTION

The Laboratory for Computational Sensing and Robotics (LCSR) is a not-for-profit interdisciplinary academic center for engineering, research and development and was founded as a principal locus for robotics research at one of the worlds premier research institutions, Johns Hopkins University (JHU). Comprised of personnel from The Whiting School of Engineering (WSE), the JHU School of Medicine (SOM), Kreiger School of Arts and Sciences, and the JHU Applied Physics Laboratory (APL) working in collaboration with universities, corporations, and other research organizations worldwide, the Center aims to further scientific and engineering advances by encouraging interdisciplinary cooperation and the free flow of ideas. It is in this spirit that members of the LCSR community have formed a partnership in which we can combine our expertise in order to develop solutions for developing and demonstrating technologies to cooperatively harvest and re-use valuable components from retired, nonworking satellites in GEO and demonstrate the ability to create new space systems at greatly reduced cost, as per the DARPA Phoenix initiative.

TELESURGERY

The Johns Hopkins University has a long history of developing telerobotic systems for surgical applications. In addition to a full mock operating room with a commercial Intuitive Surgical da Vinci S system, we also have a da Vinci Classic system with completely custom written software, meant as a research platform. The master console of this research da Vinci can be used in arbitrary telemanipulation applications. With the commercial da Vinci system, we have worked extensively on augmenting the users capabilities through the use of easy to use tools. An example tool is a measuring system that allows the surgeon to see the distance between two marked points in 3D space, or the length of a 3D path. Such tools can be accessed using a *Masters as Mice* system where the master interface can be disengaged from the robot and used to interact with menus or other additional functionality. The overlay of information to assist in difficult tasks has also been explored. On the commercial da Vinci, preoperative imagery (such as CT or MRI scans) that has been registered to the patient can be shown transparently in the surgeons view port, allowing the surgeon to "see inside" the patient's internal structures.

ASSISTED TELEOPERATION

We are also investigating sophisticated methods for performing dexterous tele-manipulations and tele-operations in remote environments that involve various communication delays, bandwidth and inherent uncertainty. Our approach will address these challenges by developing controllers and planners that will operate at the remote site. For a human operator perspective, these systems will present a various level of assistance and autonomy as a continuous function over the amount of time delay, bandwidth and uncertainty perceived by the remote systems for the execution of a task. Thus, for long time delays and a task involving manageable uncertainties, the remote system will provide greater assistance to the human operator. This could involve executing a task, or components of a task, with little or no human intervention. In contrast, for a task with short communication delays and large uncertainty, the remote system would require greater human intervention to guide the operation along the variables involving larger risk.

MECHATRONIC DESIGN FOR ASSEMBLY

The final research domain which is brought to bear on this challenge is the study of robot and protein kinematics and self-x design. Using concepts from Lie Group mathematics, geometrical symmetries and stochastic modeling, this work can be used to develop metrics and algorithms associated with configurations of rigid bodies, motion planning strategies and part assembly. These tools are then used for improved motion planning, strategies for efficient assembly processes and error diagnosis. We then seek to create novel strategies and designs to enable improved robustness and reliability for manipulation procedures. Not only will this significantly increase the odds of a task being performed successfully, but it expands the range of components that can be accurately manipulated. We express these algorithms and designs in the construction of modular robotic systems for self-reconfiguration, replication and repair towards the goal of improving machine autonomy, sustainability and longevity. Of particular importance are the design methodologies that we have developed to allow for machine performed assembly and disassembly.