Interfacing APL Snake End Effector with the LARS

600.446: Computer-Integrated Surgery II

Project Proposal

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Aim of The Project: The main and static aim of our project is to interface the APL Snake end effector to the LARS and achieve end-point control of the same. The APL snake is a standalone medical device which can used to reach potentially inaccessible parts of body during the course of a surgery, easily. Attaching it to the LARS would enable automation of guidance of the Snake to the intended end points.

Motivation and Significance:

The main and static aim of our project is to interface the APL Snake end effector to the LARS. The APL Snake is a surgical manipulator intended to be used in hip osteolysis removal surgery. However, since development its potential has been realized and it is being constantly upgraded to be a self sustained surgical tool. Initially, it was controlled through mouse and keyboard only. Intuitive control interface for the manipulator, has since, been designed and integrated with the snake using PHANTOM® Premium haptic controller. The desire to further reduce human intervention for its operation and make the setup fully automated still remains. The Laparoscopic - Assisted Robot System (LARS) is an ideal platform for achieving the same due to its mobility, dexterity, and versatility of use with various end-effectors. End point control of the Snake is to be achieved following the inverse kinematics of LARS with the manipulator. The demonstration of the level of achievement of the same is planned to be shown on cardboard, solid model(s) after registration and finally on cadavers; chronologically.

Background:

LARS - The Laparoscopic - Assisted Robot System (LARS) was developed in the early 90's as a joint study between IBM Research and the JHU Medical School. More recently, in the summer of 2008, the LARS underwent some level of rehabilitation where it was re-wired and outfitted with new electronic hardware, including new encoders and a Galil motor controller / amplifier.

APL Snake - The APL Snake was initially developed with an intention of use in hip osteolysis removal surgery. Various potential applications have been thought of, since development, such as use in heart surgeries etc. It is being constantly being upgraded to be a self sustained surgical tool. Intuitive control interface for the manipulator, has since, been designed and integrated with the snake using PHANTOM® Premium haptic controller. Our Mentors are also working on development of APL Snake.

Technical Approach:

- Understanding 'Galil Suite' and DMX Controller of the LARS.
- Develop understanding of CISST Library.
- Repair the LARS and get it up and working.
- Calculate the inverse kinematics equations of the LARS.
- Simulate the above on MATLAB.
- Implement end-point control using a dummy snake.
- Achieve 3D registration and alignment with the insertion axis.
- Come up to terms with Snake Robot control software.
- Configure snake in desirable positions.

The control system which we aim to achieve is represented in block diagram below:

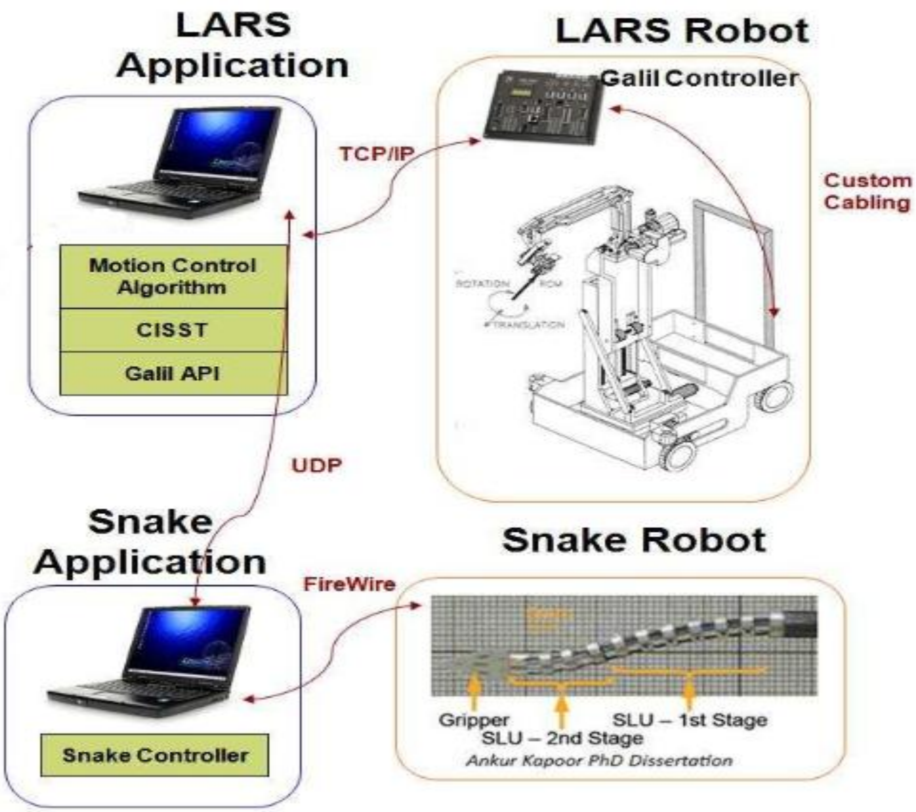


Image courtesy: H. Tutkun Şen

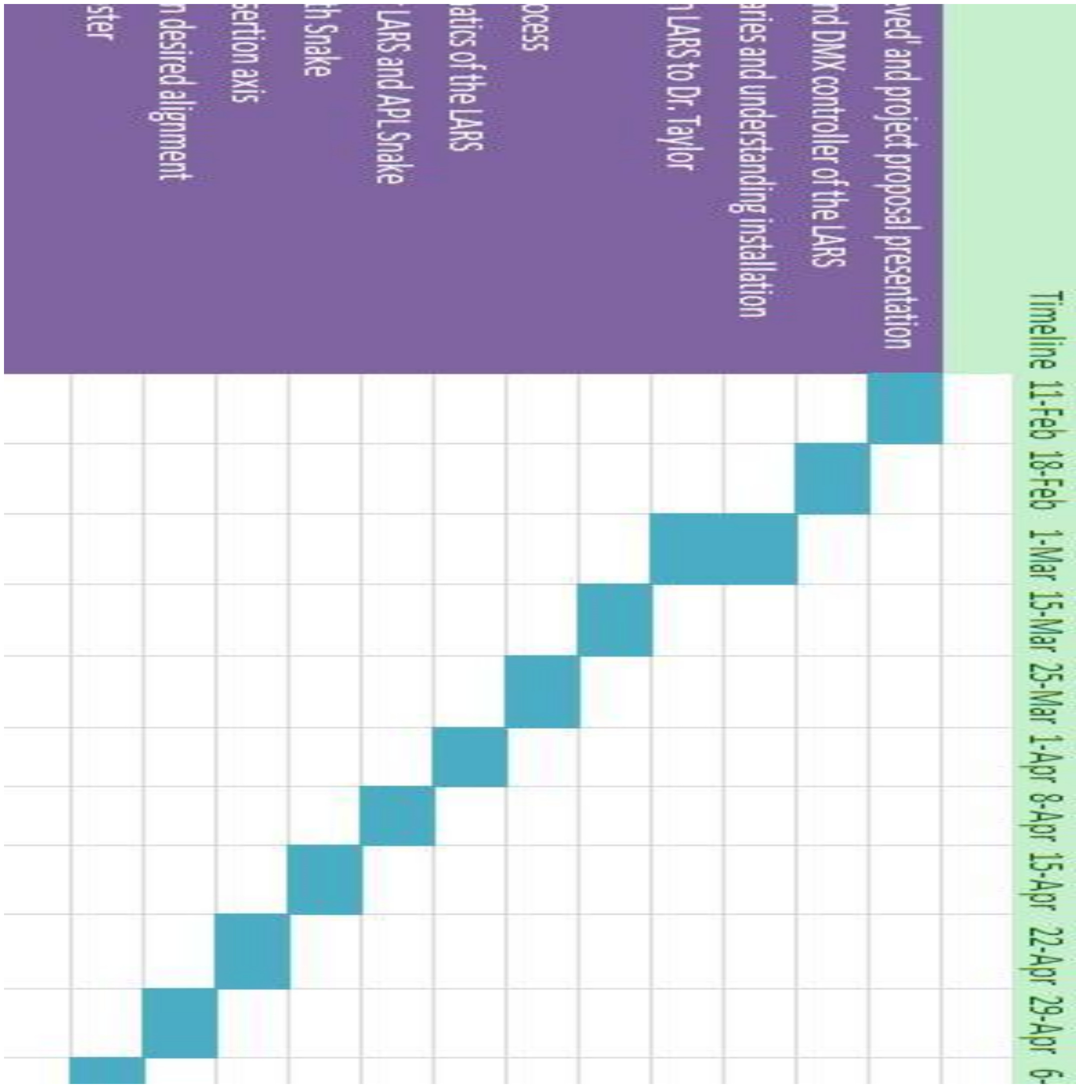
Snake controller is an Ubuntu based software system which provides a standalone environment for control of the APL Snake. LARS is controlled by the Galil Suite which is available only for Windows systems as of now. Hence, the controllers are also to be integrated over a platform.

Another issue in our hands is that the LARS we are expected to work upon has some technical problems in the existing wirings and gearboxes of motors. We also expect ourselves to get the LARS working to its capabilities as soon as possible.

List of Deliverables:
Minimum: (Expected by ___?)
Fix the LARS________________________________ (Mar 15th)
End-point control_____________________________ (Apr 15th)
Expected:
3D Registration and alignment with insertion axis____ (Apr 22nd)
Maximum:
Configure the Snake in any desirable alignment_____ (May 6th)
Demonstration of the same on cadaver____________ (*)
*after the end of EN.600.446 timeline Prof. Armand expects us to demonstrate application on a cadaver and record video of the same.

Dependencies:
• **Requirement of parts/tools for replacement in the LARS.**
Prof. Taylor will be notified about the same by 1st March, 2013. We hope to have the items with us within the following two weeks. We can carry out the repairs with the resources, already available, till then.
• **Working platform/software with the snake.**
We hope to have a working platform/software which can control the snake's precision by 18th April 2013. This will allow us to implement accurate control of snake after mounting it on the LARS.

Project Timeline



Management Plan

•Regular meeting with mentor(s) to summarize the developments on Wednesdays, every week.

•Updating the wiki by every weekend to reflect the work (thus updating the TA and Prof Taylor about our work).

•Maintaining a collection of literature review of publications in related field at the rate of at least two papers per week.

•Team meetings every Monday to update each other on the progress.

Reading List

1. J. Funda, R. Taylor, B. Eldridge, S. Gomory, and K. Gruben, "Constrained Cartesian motion control for teleoperated surgical robots," IEEE Transactions on Robotics and Automation, vol. 12, pp. 453-466, 1996.

2. Galil Motion Control, Inc. *DCM-40x0 User Manual*, Rev. 1.0c. Dec, 2008. www.galilmc.com
3. Galil Motion Control, Inc. *DCM-40x0 Command Reference*, Rev. 1.0d. Dec, 2008. www.galilmc.com
4. G. Hamlin and A. Sanderson, *A Novel Concentric Multilink Spherical Joint with Parallel Robotics Applications*. IEEE, pp. 1267-1272. 1994.
5. A. Kapoor, M. Li, and R. Taylor, *Constrained Control for Surgical Assistant Robots*. IEEE Int'l Conf. on Robotics and Automation. pp. 231-236. May 2006.
6. A. Kapoor. *Motion Constrained Control of Robots for Dexterous Surgical Tasks*. Johns Hopkins University Ph.D. Thesis. Sept, 2007.
7. P. Marayong, et. al. *Spatial Motion Constraints: Theory and Demonstrations for Robot Guidance Using Virtual Fixtures*. IEEE Int'l Conf. on Robotics & Automation. pp. 1954-1959. Sept. 14-19, 2003.
8. R. Taylor, et. al. *A Telerobotic Assistant for Laparoscopic Surgery*. IEEE Engineering in Medicine and Biology. pp. 279-288. May/June 1995