Critical Review of a Research Paper

"A Dexterous System for Laryngeal Surgery"

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As a part of EN.600.446 CIS II, I am currently working on a project titled "*Interfacing the APL Snake End Effector with LARS",* with my project partner Piyush Routray, under the guidance of our mentors Prof.Mehran Armand, Ryan Murphy and Michael Kutzer.

The main aim of the project is to interface the APL Snake end effector to the LARS and achieve end-point control. On top of this one of our maximum deliverables of this project is the placing of the snake in any desirable configuration.

The image presented below is a close representation of the work we aim to achieve. The image is from the CIS II report of H.T. Sen who worked on similar project in 2010.

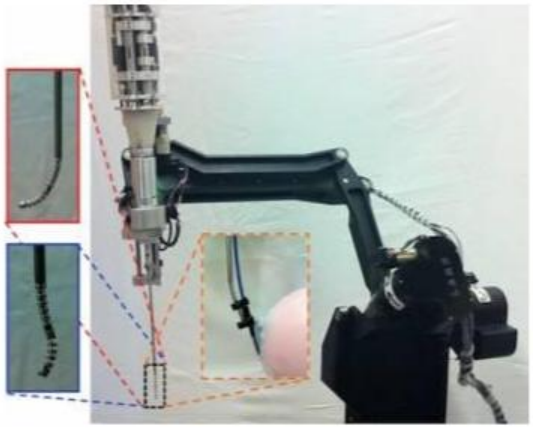

Image from: Tutkun Şen: *Elastography with LARSnake Robot*

Reason for selection of the paper:

The paper discusses a system which is equipped with 3 snake–like distal dexterity units(DDU) for surgical tool manipulation. The paper describes not only the manufacture and design of these DDUs but discusses the kinematics of these Snake Like Units(SLUs).

The snake is a key component of my project and this paper helped me get familiarized with other similar end effectors, their actuation control mechanism and their kinematic analysis. We will have to work on similar issues when we will work on configuring our snake in any desired position. Also, the system designed in this paper is to be used for minimally invasive surgery (MIS) of the throat where motion is highly constrained. We aim of achieve similar results with the snake of our project.

Furthermore, this paper describes a novel idea as how to use Snake Like Units for holding and manipulating of surgical tools. If all the goals of our project is met in a timely fashion we can maybe start exploring in this direction.

Problem Statement:

Until 2004, the systems for performing a MIS of the throat were hard to manipulate and lacked sufficient dexterity to carry out tasks like suturing of vocal fold tissues. The authors have discussed a tele-operated three-armed robotic system capable of carrying out surgical subtasks like suturing and other tissue manipulation activities.

Key Result:

The primary goal that the authors have achieved is designing a high dexterity system capable of performing a MIS of the throat with carrying out actions like suturing of vocals folds which until now was almost impossible task in minimally invasive approaches. Furthermore, the system is capable of simultaneously manipulating 3 surgical instruments.

Flow of the paper:

The authors begin with stating the shortcomings of the current MIS throat surgeries and then propose designing a system, which will overcome these shortcomings. Then they give a brief description of the overall system and after that describe in detail the primary component of this system namely the snake-like distal dexterity unit. Furthermore, they describe, the kinematics of the SLUs. The authors conclude the paper by using a prototype snake unit and demonstrating the its actuation using 2 backbone tubes within the constraint limit of the tubes.

Strengths of the paper:

- The paper describes a novel system, which can be used for surgical subtasks in MIS throat surgeries, which until now were considered extremely difficult.

- The flow and structure of the paper was very smooth which made it easy to understand the concept of the paper.

- The description of the snake-like DDUs has been given in a very clear and detailed manner.

Weaknesses of the paper:

- The section dealing with the kinematics of the SLUs is not as lucid; a few more detailed pictorial depictions would have been helpful
- Furthermore, while calculating the dynamics of the SLU, the authors have made a number of assumptions mainly about the forces acting on the SLU for example, it has been assumed that weight of the Snake will be zero hence eliminating the gravitational force on the same. However, this will not be the case in actual real life scenarios.

- In the prototype experiment, described in the paper , the snake used is actuated by 2 secondary backbones whereas in the paper the SLU have been described as having 3 secondary backbones. A

demonstration with a SLU same as the one described in the paper would have been better.

Possible next Steps for this work:

The authors have designed this system keeping in the mind the laryngeal surgery. A possible next step in this work could be expanding the use of this system for MIS in other parts of the body like the chest or the abdomen.

Conclusion:

The paper describes a novel system to carry out sub operational tasks like suturing of the vocal folds in MIS of the throat in a very lucid and detailed fashion and the techniques developed can be extended in other MIS surgeries.

This paper has indeed helped us get familiarized with the actuation mechanisms of SLUs which will definitely help us in our efforts for achieving the control of the snake in our project.