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Computational Sensing + Robotics

Project Background Reading Presentation on

"A Dexterous System for Laryngeal Surgery "

Nabil Simaan, Prof. Russell Taylor (Johns Hopkins University-ERC-CISST) and Paul Flint (Johns Hopkins School of Medicine)

Proceedings of the 2004 IEEE International Conference on Robotics & Automation, New Orleans, LA • April 2004

Interfacing APL Snake End Effector to LARS

Group 3 **Ashish Kumar**

Statement of Our 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.

- Maximum deliverable is placing of the snake robot in any desirable configuration.

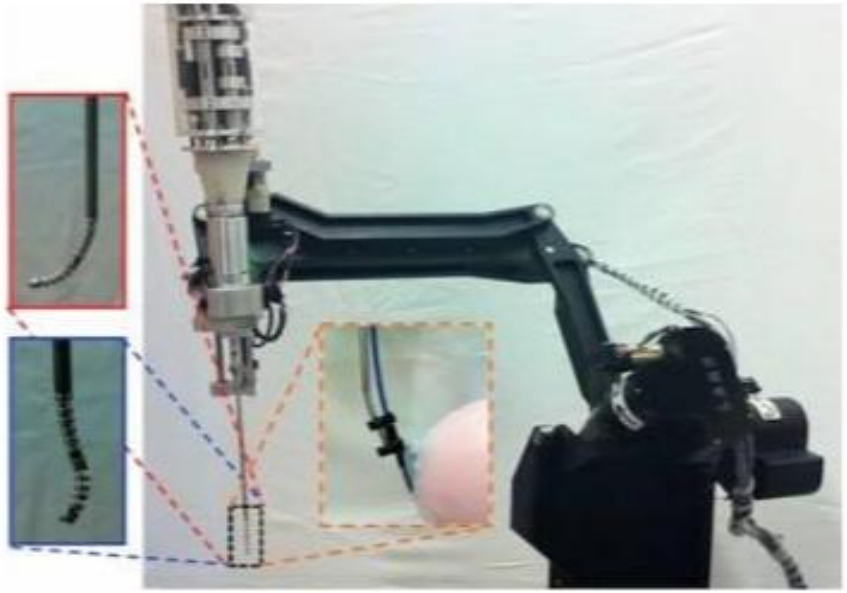

Image from: Tutkun Şen: *Elastography with LARSnake Robot*

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Paper Selected

- A Dexterous System for Laryngeal Surgery - Nabil Simaan, Prof. Russell Taylor (Johns Hopkins University-ERC-CISST) and Paul Flint (Johns Hopkins School of Medicine) - Proceedings of the 2004 IEEE International Conference on Robotics & Automation, New Orleans, LA • April 2004

Reason for Selection of the Paper for Today's Presentation.

- Discussed a system which is equipped with 3 snake–like distal dexterity units(DDU) and further discussed the design and kinematic analysis of the 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
- System designed in this paper is to be used for minimally invasive surgery (MIS) of the throat where motion is highly constrained
- Described a novel idea as how to use Snake Like Units for holding and manipulating of surgical tools

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Summary of the Problem

- 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.

- A fundamental challenge was the kinematic constraint imposed by the passage of surgical tools through fixed entry ports into the patient's body

Key Result

Designing a high dexterity tele-operated 3 armed robotic system capable of performing a MIS of the throat with carrying out actions like suturing of vocals folds and functional reconstruction.

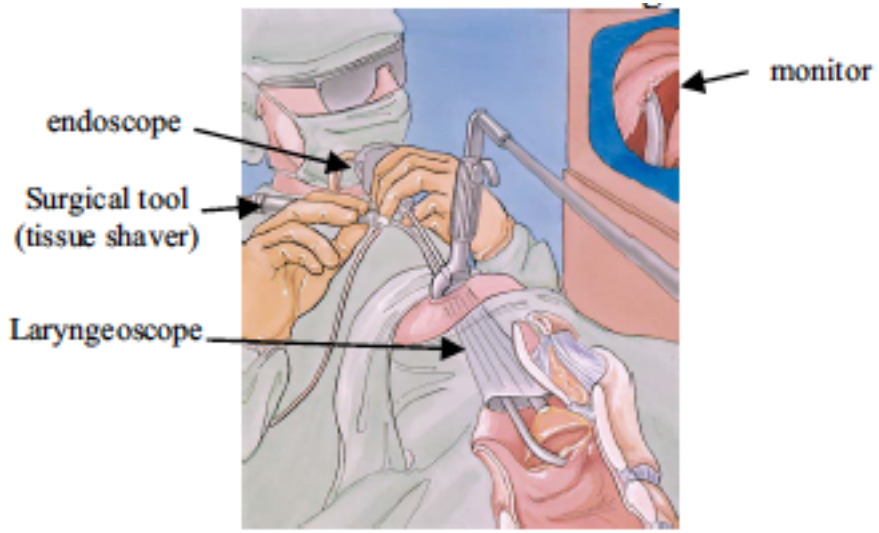
Significance of Key Result

- Designed a new 3 armed robotic system which is capable of carrying out sub surgical tasks like sewing and functional reconstruction in the MIS of the throat. This was extremely difficult task until then. The system is designed to be remotely operated.

- Since the robot had 3 arms it can manipulate three surgical tools simultaneously.

Necessary Background

- Human larynx/voice box – Responsible for breathing, airway protection during swallowing, and producing voice.
- Is subject to various benign and malignant growth which require surgical procedures to be removed
- MIS procedures require an array of long tools to be inserted into the patient's mouth using a laryngoscope which itself is placed in the patient's mouth. These tools are manipulated by the surgeon.



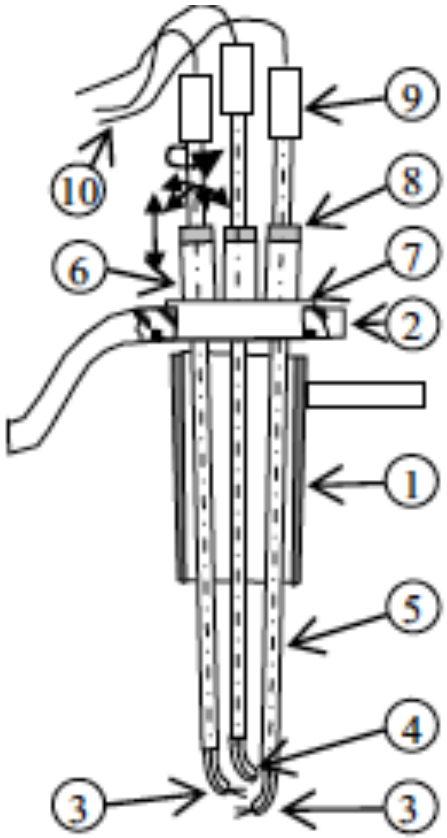
(Image Courtesy: Nabil Simaan, Russell Taylor, Paul Flint)

Necessary Background(cont…)

- MIS tools available at the time of this paper did not provide the required tip dexterity to carry out tissue flap rotation or sewing of vocal tissues.

What the authors did

Overall System Architecture



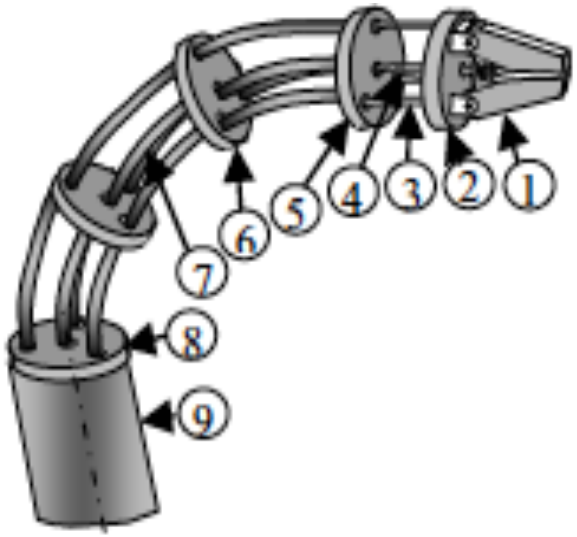
1 laryngoscope
2 base link
3 Distal dexterity unit
4 suction snake
5 DDU holder
6 4 DoF tool manipulation unit (TMU)
7 rotating base
8 fast clamping device
9 DDU actuation unit
10 electrical supply /data

(Image Courtesy: Nabil Simaan, Russell Taylor, Paul Flint)

What the authors did(cont…)

The multi-backbone snake like unit

- Provides 2-DOF



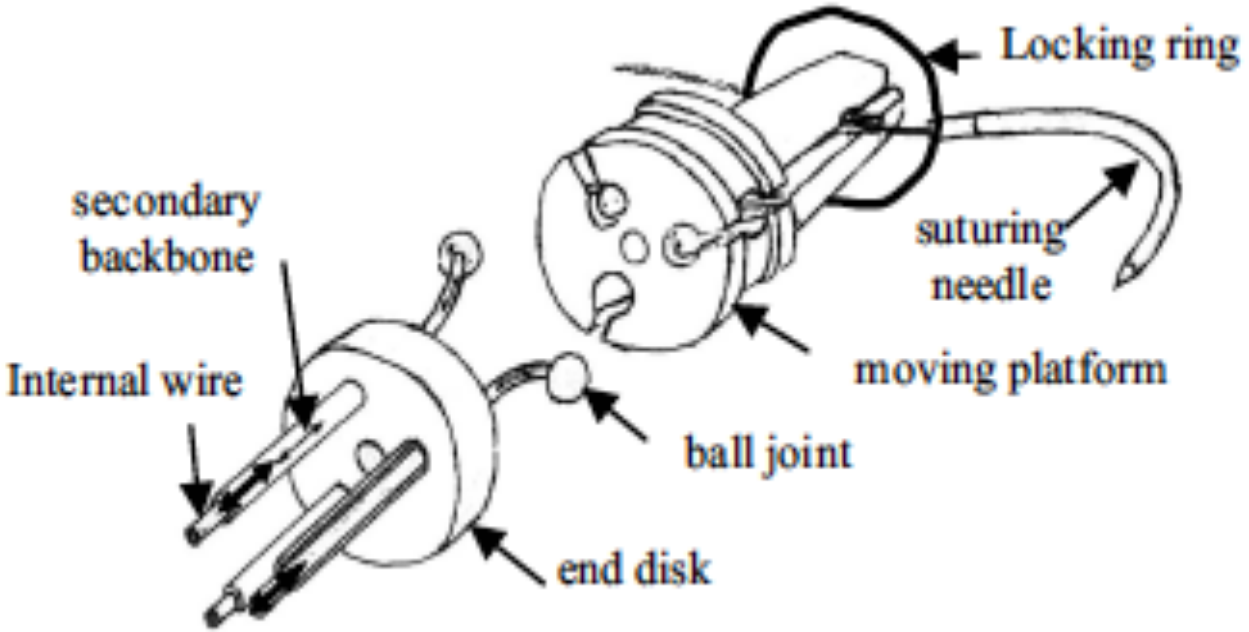
1 gripper
2 moving platform
3 parallel stage wires
4 gripper wire
5 end disk
6 spacer disk
7 central backbone tube
8 base disk
9 DDU holder

(Image Courtesy: Nabil Simaan, Russell Taylor, Paul Flint)

What the authors did(cont…)

The detachable milli parallel unit

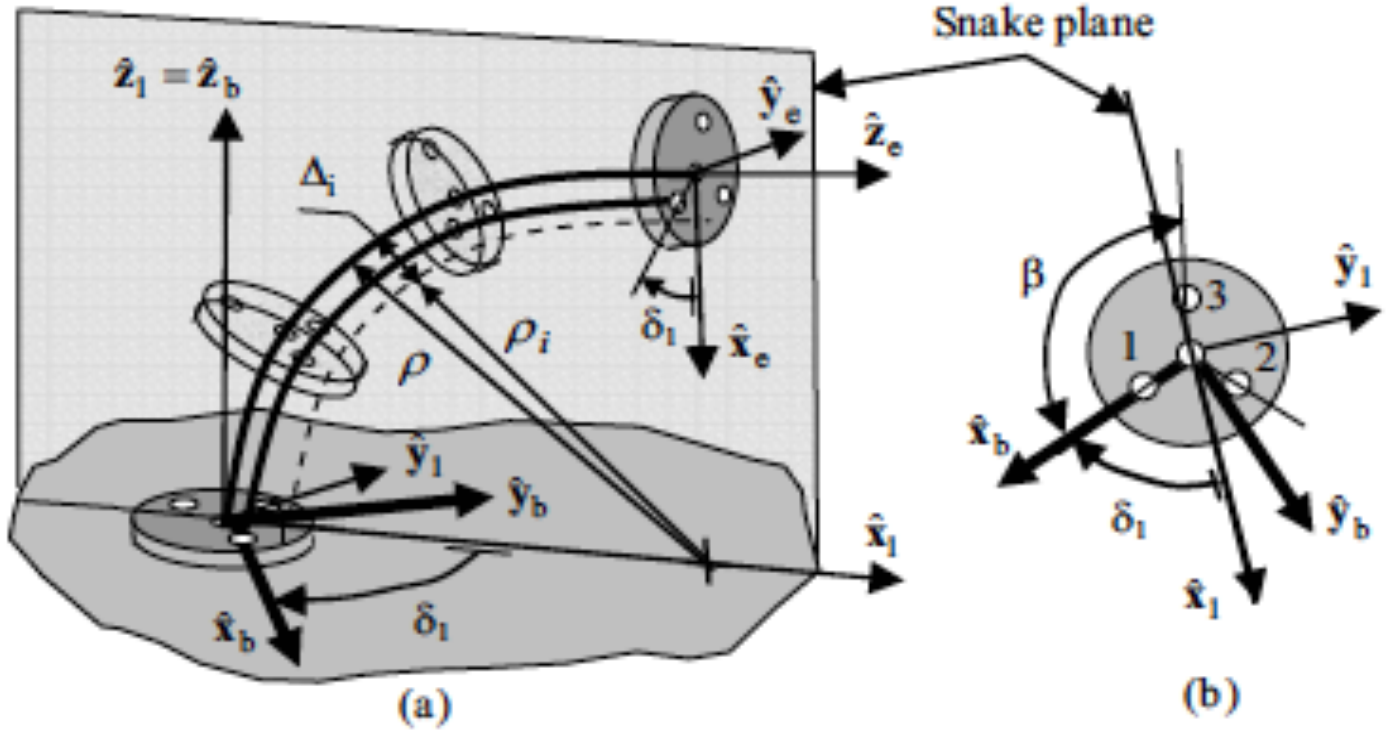
- Provides an additional 3-DOFs for delicate and accurate motion control in confined spaces
- Provides tool detachability



(Image Courtesy: Nabil Simaan, Russell Taylor, Paul Flint)

What the authors did(cont…)

Kinematics of the Snake Like Units

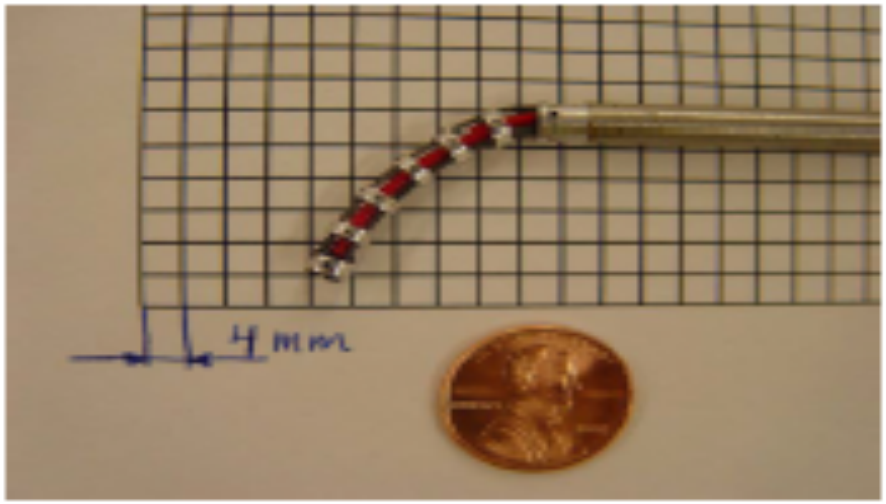


(Image Courtesy: Nabil Simaan, Russell Taylor, Paul Flint)

What the authors did(cont…)

Prototype Experiment

- The authors did a prototype experiment using the snake shown in the figure below



- The primary and the secondary backbones were made using NiTi elastic tubes

Assessment Of The Work

Strength(s)

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

Assessment Of The Work (cont…)

Weakness(s)

- The section dealing with the kinematics of the SLUs was somewhat hard to comprehend; a few more detailed pictorial depictions would have been helpful

- 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.

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Conclusion

- 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.

THANK YOU!

Questions?