Computer Engineering Department

Robotics Laboratory

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Research Theme

A Dexterous Robotic Surgery Tool for MIS Procedures

Motivation

- A high-dexterity miniature robotic structures
- Application to a variety of applications including Minimally Invasive Surgery (MIS) like throat with specific shape, length, and complexity:
  - Thin structure for insertion as endoscopes with multiple long tools through a narrow laryngoscope like suturing vocal fold tissue, or
  - A low diameter surgery tool to be inserted in the patient body (of the chest and abdomen) through a pivoting point.
- Minimal kinematic constraints to ease the passage through fixed entry ports
- Dexterous tools with ease of manipulation to permit common surgical subtasks.
- Easily scalable to small sizes, simple to manufacture, and can be used with multiple detachable surgical tools.
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Approach

- A light, miniature, back-drivable, transmission mechanism for robotic surgery
- A master-slave arrangement, each is 3-dof, revolute, with a pivoting point.
- A functional and ergonomic interface of master arm to surgeon hand and fingers
- A tight mechanical interfacing between master and slave arms
- Bilateral structure and back-drivable with reflected force (haptic) feedback
- Allow remote operation of 2-3 tools with high tip dexterity to enable suturing and soft-tissue manipulation by the surgeon
- New wire-poley attachment to eliminates slippage, one steel transmission rope per dof, and pre-tensioning independently for each loop
- Effective mechanisms, transparency, compactness, and low cost.

1. ***Phase 1:*** **Snake-Like Multi-Layered Mechanism**
   - Snake-like distal dexterity mater-slave unit based on Samaan's design (2004)
   - Multi-backbone snakelike mechanism
   - A snake-like multi-layered mechanism using a flexible backbone
   - Actuation redundancy resolution to allow further downsize scalability while reducing the risk of buckling of the primary backbone
   - Extended to a symmetric Master-Slave mechanism
   - Absence of standard miniature joints
   - Reduced complexity and manufacturing costs

2. Phase 2: A distal Snake-like Master-Slave System (10 mm D)

- A snake-like (Simaan et al., 2004) multi-layered mechanism using a flexible backbone
- Extended to a symmetric Master-Slave mechanism
- Uses four 0.6 mm Steel flexible ropes connecting the layers of master and slave mechanisms
- 25 cm distance from master to slave mechanism
- Inexpensive due to absence of joints
- Reduce the manufacturing costs
- Reduced size due to the small number of moving parts

3. Phase 3: A 14 MM 3-DOF Master-Slave Surgery Tool

- Articulated, revolute, 3 dof, wire-based miniature manipulator arm (14mm D)
- Extended to a symmetric master-slave mechanism
- Interface to surgeon hand and fingers (Pending Patent)
- Three 0.6 mm steel ropes for one-to-one connection of the 3 dof of master and slave arms
- Master and slave can be extended to arbitrary distance using small motors and servos
- Offers a total of 6 dof to its terminal using body position (3 dof) rotation (1 dof)