Robotic, Multi-Articulated Endoscopic Surgical Tools for Natural Orifice Translumenal Endoscopic Surgery

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Outline

• Background / Introduction to NOTES
• Current developments in the field
• Our approach
• Progress thus far
  – Problem characterization
  – Concept development
  – Prototyping
• Future work
What is NOTES?

- **Natural Orifice**: Tool insertion through the mouth, urethra, vagina, or anus.
- **Translumenal**: Accessing the abdominal cavity through an incision in the stomach, bladder, vagina, or colon.
- **Endoscopic Surgery**: Typically performed with a tool resembling a traditional endoscope.
NOTES Advantages

- Faster recovery time
- Less physical discomfort
- No visible scars

- These things may also lead to greater patient willingness to receive an important procedure.
Developing Technology

Important features include: Multiple tool channels
Tool articulation
Imaging, suction, and irrigation
Rigidity when necessary
Triangulation

USGI Medical

Olympus
Our Approach to the Problem

• Achieve teleoperated robotic control
• Produce all necessary device movements from within the tool end itself
• Device should be portable and field deployable (taking advantage of teleoperation)

Fluid Power
Why Fluid Power?

- Remotely located power source
- Can maintain force / torque with minimal energy consumption
- Precise control
- High power density
Problem Characterization

Diameter limitation of ~ 18 - 22 mm

Organ manipulation force requirements of ~ 1.5 - 4 N
Conceptual Development

Multi-directional articulation
  – Spherical joints (prototyped)
  – Cantilever beams

Need to be mobilized and modeled for controls
Conceptual Development (Cont.)

Force and displacement of articulation joint
- Need high force with limited space

Must balance the force requirement at the tool with the force input to the joint.
Conceptual Development (Cont.)

Fluid flow control

– Need to provide bi-direction flow control in small package
– Each actuator requires its own valve

MEMS
Microfluidic
Proportional
Control Valve
Conceptual Development (Cont.)

Force-Feedback Control Methods

– Provide tool load information to the surgeon
– Enable precise robotic control over tool position
Prototyping
Future Work

• Additional characterization of tool force requirements (e.g. suturing, biopsy, etc.)
• Experimental testing
  – Microfluidic valve
  – Articulation joint / Actuators / Controls
• Assembly of components into all-inclusive prototype
• Scaling
Summary

• NOTES as the next step in MIS
• Other devices currently under development
• Applying fluid power for compact solution
• Progress thus far
  – Identifying the problem
  – Concept development
  – Prototypes have been produced, more coming
• Future work in testing and prototyping


Thank You