ROBOTIC ARM FOR MINIMALLY INVASIVE SURGERY

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ABSTRACT

Minimally invasive surgery is a technique that has become an increasingly popular practice. This method is chosen because of the many advantages that it provides patients in comparison to traditional surgery. However, minimally invasive surgery is not suited for all operations because of the technical complexity and current instrumental limitations. Our goal was to design a lanthroscopic grasper, which imitates wrist motion and increases applications of the lanthroscopic grasper. To do this our design added an extra degree of freedom to the current lanthroscopic grasper model. The clamping of the graspers is controlled by a flip switch. The end of the shaft is capable of rotating vertically by the use of the trigger which can simultaneously rotate the shaft axially. The lanthroscopic grasper has been modified to imitate wrist motion, nevertheless further work and testing is necessary to insure its operation is safe and sanitary.

BACKGROUND

Two different devices are most commonly used in current minimally invasive surgery. Listed below are the main design components, advantages, and limitations of each device.

DaVinci Surgical System
- Robotic device
- Mimics motions of a human wrist
- Offers 7 degrees of motion
- Has motion scaling capabilities
- Bulky equipment limits patient access
- Costs approximately 2 million dollars

Figure 1: da Vinci II Surgical System


Figure 2: Laparoscopic Grasper

Laparoscopic Grasper
- Hand operable instrument
- Made in both disposable/reusable forms
- Cost is reasonable for small hospitals
- Offers only 2 degrees of motion
- Difficult to perform some tasks

PROBLEM SPECIFICATIONS

- Mimics wrist and hand movements
- Simultaneously rotates shaft in all directions
- Provides maximum tactile feedback
- Operable by single hand
- Diameter for surgical shaft < 5mm
- Materials used must be disposable or easily sterilized

PRELIMINARY DESIGN

The preliminary design compromised of two different mechanisms that controlled the movement of the graspers. In particular the trigger mechanism added the desired extra degree of freedom. Synchronized pulling and spinning of the trigger replicates movements of the human wrist with respect to the shaft.

Pen-click switch
- User operates switch with thumb
- Opens and closes the graspers
- Locks grapers in place

Figure 3: Pen Click Switch design with internal mechanism

Trigger Control
- User operates trigger with index finger
- Pulling back trigger rotates the instrument's shaft vertically
  - o Accelerator cable drives rotation
  - o Notches allow shaft to be set at various bent angles
  - o Extension spring returns trigger to initial position
- Spinning the trigger rotates the instrument's shaft axially
  - o Knurled trigger allows easy rotation

FINAL DESIGN

The final design for our laparoscopic grasper is compromised of two basic mechanisms that allow the user to move the shaft in all directions with the use of a single hand. The trigger mechanism is the component that adds the extra degree of freedom.

Spring loaded switch
- User operates with thumb
- Opens and close grasper
- Locks in the closed position
- Extension spring returns graspers to closed position


Figure 4: Rotation of knurled grip translates to shaft

Trigger Control
-User operates with index finger
-Pulling back trigger rotates the instrument's shaft vertically
  - o Extension spring holds trigger in forward position
  - o Torsion springs rotate end of shaft
-Spinning of the trigger rotates the shaft axially
  - o 90 degree beveled gears (1:1 ratio) translate the rotation of the trigger to the shaft
  - o Knurled grip allows for easy rotation


Figure 5: Rotating knurled grip translates bend of shaft end

FUTURE WORK

Improvements on our design must be done in the following areas to insure that our design is safe for use in surgical procedures.

Materials
- Prototype would be made of materials that are easily sterilized
- Prototype would be made of materials that are light
- Casing would surround the hinge
- Seals would be placed where appropriate

Design concentrations
- Work smoothly
- Ergonomic handle
- Downscaling of prototype

Testing
- Precision
- Accuracy
- Durability

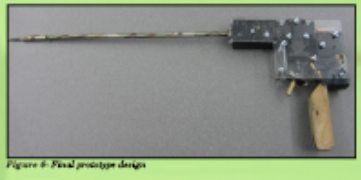
Figure 6: Final prototype design

ACKNOWLEDGEMENTS

Dr. Aimen Shaaban, Department of Surgery, University of Wisconsin - Madison Medical School

Professor Kreg Gruben, Department of Biomedical Engineering, Department of Kinesiology, University of Wisconsin - Madison

Professor Frank Fronczak, Department of Biomedical Engineering, Department of Mechanical Engineering, University of Wisconsin - Madison

Professor Willis Tompkins, Department of Biomedical Engineering, University of Wisconsin - Madison

Little Jon's Archery

Kevin Corcoran

Phil Michalski

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