The Effect of Visual Force Feedback on Applied Forces during a Complex Laparoscopic Procedure

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Background and Motivation

Minimally Invasive Surgery (MIS)

- The fulcrum effect at the entry point:
  - Reverses hand motion
  - Increases friction
  - Significantly reduces dexterity
  - Considerably degrades the sense of touch
  - These limitations result in new perceptual-motor relationships that require training to overcome.

Minimally Invasive Surgery (MIS)

- Up to 7,000 deaths occur in Canada every year due to preventable surgical errors.
- Simulator training is effective if learning feedback is provided.
- Current performance measures rely on time and/or instrument or hand motion.
- It is difficult to relate these measures to execution and safety.

Experimental Methods

A complex procedure composed of 5 tasks was performed:

- Task 1: Palpation
- Task 2: Cutting
- Task 3: Manipulation
- Task 4: Suturing
- Task 5: Tying a surgeon’s knot: one double knot followed by two single knots.

Visual force feedback was provided as force bars that increased in size and changed colour (green, yellow, orange, and red).

Feedback was randomly provided in four levels:
1. None
2. Grasping force only
3. Cartesian force only
4. Both grasping and Cartesian forces.

The forces felt at the hand during MIS are different from the forces acting on the tissue.

A set of sensorized laparoscopic instruments was developed that are capable of measuring positions and tool–tissue forces in all directions.

Experimental Design

Hypothesis:
Providing visual force feedback to surgeons performing a complex laparoscopic procedure allows them to be gentler and reduces the application of excessive forces

- Experiments were performed using the sensorized instruments in a laparoscopic training box.
- A computer was used to display, calibrate and record the force and position data.
- 30 subjects performed the experiments a total of 4 times (17 novices, 13 experts).

The experiment was designed as a repeated measures study with feedback (2 factors at 2 levels) as a within-subjects factor and experience level as a between-subjects factor.

Conclusions and Future Work

- Real-time measurement of force allows visual force feedback to be presented to the surgeon.
- Visual force feedback was able to reduce the high grasping ratio and the maximum grasping forces.
- Future work will evaluate whether training on the use of feedback causes subjects to react appropriately.

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