The Effect of Haptic Feedback in a Remote Grasping Situation

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Motivation

• Man-machine interfaces are everywhere
• Haptic feedback is especially important
• But there are some problems
Solution

An air bladder based haptic feedback glove
Complete PHIG Apparatus

1. Simulink grasping simulation
2. Telemetric Glove
3. Satellite Board
4. Main Board
5. Fill Valves
6. Drain Valves
Mechanical

- Consists of
  - Pneumatic piping
  - Pneumatic on/off valves
  - Rubber bladders sealed with a primer and cyanoacrylate
    - A telemetric glove
  - Pressurized air supply
Electronics

• Based around a Xilinx Spartan 2 series FPGA
• Includes:
  – Basic I/O
  – RS-232 serial communication
  – High current, inductive load drivers
  – Offboard connectors for the ADCs
• The ADCs are on “satellite” circuit boards
  – 12 bits of available accuracy
Results I: Force Control Correlated to Feedback
Results II: Feedback Aids Grasping Success

Damaging force exerted…

at any time.  

at end of trial.

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**Cumulative Success**

- Not Grasped: 8 trials
- Grasped: 11 and 12 trials
- Damaged: 8 and 13 trials

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**Final Success**

- Not Grasped: 8 trials
- Grasped: 14 and 16 trials
- Damaged: 5 and 9 trials
Data Analysis I: Force Control

- Threshold for significance of 0.05
- Force control data was analyzed with a 2-tailed, paired t-test yielding 0.0365
- On average, subjects ability to control force increased 205%
Data Analysis II: Grasping Success

- Chi-squared test with 5% probable threshold for significance
- Haptic feedback increases grasped and damaged for cumulative success, test result of 0.0211
- Haptic feedback increases grasped and damaged for final grasping success, test result of 0.0185
Disappointment

- A mistake in the experimental protocol
  - Subjects were not told that they were under any time pressure
Current Status

- Improved controller for the pressure control system
- More experiments, focused on time to grasp
- Rectify the error in testing protocol
Contributions

• Designed, constructed, and tested an innovative, economical, and portable haptic feedback system
• Demonstrated a significant change in grasping success
• Demonstrated an improvement in a user’s ability to control grasping force
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Questions?
Appendices

- Data collection
- Testing procedure
- Grasping time analysis
Data Collection

- **Raw Data**
  - Time
  - Linear position of thumb and pointer fingers
- **Data was trimmed to eliminate calibration data**
- **Timing data was unfortunately not useful due to the testing procedure**
Testing Procedure

Explanation of Equipment → Explanation of Task → Training:
- Interact with the model
  - 3 minutes with haptic feedback
  - 3 minutes without haptic feedback

Perform Trials:
- 6 order randomized trials
  - 3 with haptic feedback
  - 3 without haptic feedback
- Distance of blocks from cylinders is also varied

Proctor starts simulation
- Calibration routine
- Return fingers to rest
- Start grasping action
- Subject stops simulation
Data Analysis: Grasping Time

• Threshold for significance of 0.05
• Time data was analyzed with a 2-tailed, paired t-test
  – Null hypothesis: Feedback does not affect grasping time
  – Result of t-test was 0.4995, greater than the threshold
    • Null hypothesis is not disproved