Current Ergonomics Projects with Healthcare Focus

• Using virtual reality (VR) and haptic devices for surgical training simulations
• Using haptic devices for diagnostic testing and training of motor control ability
• Designing service robots for medicine delivery tasks
• Developing new computational algorithms for patient emotional state classification during healthcare operations
VR and Haptic Controls for Surgical Simulation

• Problem:
  – Resident training occurs by opportunity; focus on outpatient surgery constrains training time; use of minimally invasive surgery (MIS) reduces training opportunities.

• Research needs:
  – Create simulations that realistically model surgical tasks (tissue models) and facilitate motor skill training.
Surgical Simulation

• Method:
  – Develop prototype simulator based on task analysis with plastic surgeons.
  – Implement tissue modeling algorithm in VR (Lin, 2007).
  – Integrate haptic control device (Phantom) with simulation.
  – Conduct experiment to assess discrete movement and tracking task performance.
  – Determine if haptic device use conforms with established model of motor behavior (Fitts).
Surgical Simulation

• Outcomes:
  – Fitts’ Law explained haptic control behavior:
    • Move Time = $C_1 + C_2 \log_2 (D/W + 0.5)$
  – MT increased with system lag and task complexity (ID).
  – Cut accuracy decreased with greater lag and ID.
  – Surgeons survey:
    • Heterogeneous tissue model was perceived as realistic.
    • Haptic feedback was considered useful for training.
Haptic Device Use for Motor Rehabilitation

• Problem:
  – Standardized tests for diagnosing brain injuries (Rey-Osterrieth Figure) are performed and scored manually; test evaluation is time consuming; high variability in clinician assessments.

• Research needs:
  – Create computer-based diagnostic system for motor testing and automated scoring.
Haptic Devices for Motor Rehabilitation

• Method:
  – Develop haptic-based simulator.
  – Conduct experiment to:
    • compare haptic devices – low cost (Falcon) vs. high resolution (Phantom)
    • determine if hand control and muscle use are comparable to real drawing task behavior
  \[ M\dot{d} + K\ddot{d} = f_d(t) \]
  – Develop pattern-recognition algorithm for scoring test results
Haptic Devices for Motor Rehabilitation

- Outcomes:
  - Low cost device generates muscle forces comparable to real drawing.
  - Haptic devices produce task times different from real drawing (need training).
  - Scoring for high resolution device comparable to real drawing performance.
  - Subjects rated Phantom as being highly realistic (6.33 vs. 3.67).
Service Robot Design for Medicine Delivery Tasks

• Problem:
  – Projected nurse shortage of 340K by 2020; current high workload leading to overtime, fatigue and errors; medication errors compromise safety.
    • Medication delivery errors - 58%; 1 in every 5 doses; 7% are harmful (Barker et al., 2002)

• Research needs:
  – Consider use of technology (robots) to reduce nurse workload in medicine delivery, direct to patients.
  – Consider patient emotional response to robots and not just task performance.
Service Robots for Medicine Delivery

• Method:
  – Identify key feature for perceived humanness in robots (face, voice, interactivity).
  – Identify patient physiological variables for inferring emotional responses (cardiac, muscle activity).
  – Prototype service robot configurations.
  – Conduct experiment to assess effect of designs on patient response:
    • 24 seniors (63-91 yrs.) at assisted-living center
    • PeopleBot mobile robot platform
  • Collected HR, GSR, subjective ratings of arousal/pleasure, robot performance.
Service Robots for Medicine Delivery

• Outcomes:
  – People are sensitive to human features in robot design.
  – Humanlikeness increases arousal and pleasure in interaction in medicine delivery.
  – HR is strong predictor of pleasure and skin conductance is predictor of arousal.

• Survey:
  • 62.5% - would prefer human features in hospital robots.
  • 80% - Voice/speech is most critical feature followed by face.
New Algorithms for Patient Emotional State Classification

• Problems:
  – Patient emotional experiences may be related to perceptions of healthcare quality; current models of emotional state are qualitative; quantitative models do not exist for classifying states in real-time or to provide a basis for assessing/optimizing healthcare operations.

• Research needs:
  – Physiological responses are affected by emotions and can be collected in real-time; neural networks can be used to integrate physiological variable inputs and output specific patient emotional states classifications.
  – Create system to infer patient emotional states in real-time and provide basis for adapting nurse/robot behaviors to ensure perceived healthcare quality.
Patient Emotional State Classification

• Method:
  – Extraction of features from physiological signals (cardiac, skin conductance, EEG, EMG)
  – Signal de-noising using wavelet technology
  – Statistical-based selection of significant features for describing patient emotions
Patient Emotional State Classification

• More methods:
  – Development of non-linear models in physiological variables (HR, GSR) for predicting emotional states

• Future research:
  – Adaptation of robot behaviors in medicine delivery tasks to elicit specific emotions