Smart Lab Coat for the Dental Practitioner

Grace Olsen
Dr. Susan Brilliant
Dr. David Primeaux

October 10th 2007
Overview of Presentation

- Motivation
- Background – Ergonomics
- Background – Computer Science
- Prototype
- Early Data and Analysis
- Future Work
Motivation

- Needs of the VCU School of Dentistry
  - DentSim and Technology in VCU School of Dentistry
  - Current training given in conjunction with cavity preparation training
  - Instructor availability
  - Student perceptions
Background - Ergonomics

- Ergonomics and Dentistry
  - Work-related musculoskeletal disorders (WMSDs)
  - Causes of WMSDs in dentistry
    - Prolonged static postures
  - Costs of WMSDs
    - Medical costs and lost work
  - Changes in dentistry to alleviate WMSDs
    - Four-handed and seated dentistry
    - Chair design and layout of workspace
Ergonomics in Dentistry

- Ways to correct posture:
  - Holistic approach
    - Stretching
    - Taking breaks
    - Adjusting chair and patient’s chair
    - Core strength training
  - PAI System
  - Loupes
  - Dental chair design
  - Workspace environment

Posture Assessment Instrument
Traditional Ergonomics Methods:
- Qualitative approaches
  - Observation
  - Surveys and Questionnaires
- Quantitative approaches
  - Goniometers and image analysis
  - EMG recordings
Motivations for measuring human movement:
- Ergonomics / Posture
- Gait Analysis / Medical Applications
- Sports Analysis
- Animation

Methods of recording motion:
- EMG
- Video and Image Analysis
- Motion Capture
- On Body Sensors
Measuring Human Movement

1. Data Collection
2. Data Filtering
3. Data Analysis
4. Feedback to user(s)
On Body Sensors

- Accelerometers / Inclinometers
- Gyroscopes
- Pressure Sensors
- “Smart” Fabric
- Magnetometers
- Potentiometers

SCAT121T Series 2-Axis Inclinometer
Background - Filtering of Data

- Two Motivations:
  - Feature extraction
  - Noise reduction

- Methods of Filtering:
  - Fourier Transformation
  - Discrete Wavelet Transformation and Wavelet Packet Decomposition
  - Complementary Quaternion Filters
  - Discrete-time complementary Kalman filters
  - Combination of methods above
Background - Data Analysis

Classification of movement based on extracted features:

- Statistical Methods
- Neural networks
  - Clustering algorithms
- Combinations of existing machine learning techniques
Background -
User Interfaces

- Real time vs. non-real time systems
- Feedback to user vs. feedback to experts
- Feedback to correct movement or position vs. feedback to be further analysed by experts or other systems
- Feedback to system localized on user vs. feedback to a centralized source
A system to measure and classify posture

- Accurate
- Non-invasive
- Inexpensive
- Customized for each user
- Unobtrusive
- Real-time classification and feedback
Posture Measuring Prototype

- Hardware:
  - Multiple Inclinometer Sensors
  - Analog to Digital Converter
  - Pocket PC(?)
  - User Interface
Strategically placed inclinometers (sewn into a laboratory coat)

Analog-to-digital converter on a circuit board, connected to both the inclinometers and the Pocket PC (will also be attached to lab coat)

Headphones connected to Pocket PC for audio user interface

Pocket PC (connected to circuit board via serial cable) with software to filter and classify posture, and notify user if posture is harmful. Will reside in pocket of the lab coat.
Posture Measuring Prototype

Software:
- Interpreting changes in incline from inclinometers
- Calibration
- Filtering
- Classification
- Notification / User Interface
Initial Data Collection

• Data collected in one to three minute time intervals (approx. 1 reading per second)
• Five different positions recorded: nominally “good”, leaning left, leaning right, leaning forward, leaning back, slouching
• Trained on an ANN
## Initial Data – Trial 1

<table>
<thead>
<tr>
<th>Back X</th>
<th>Back Y</th>
<th>R. Shoulder X</th>
<th>R. Shoulder Y</th>
<th>L. Shoulder X</th>
<th>L. Shoulder Y</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.171°</td>
<td>55.256°</td>
<td>52.583°</td>
<td>35.972°</td>
<td>68.528°</td>
<td>-2.354°</td>
</tr>
</tbody>
</table>

### “Correct” Position – Actual Data

### Difference from “Correct” Position:

| Leaning Forward | 0.659° | 2.894° | 14.980° | -1.875° | 18.299° | -7.950° |
| Leaning Left    | 4.271° | -1.353°| 5.487°  | 9.972°  | 15.000° | -16.309°|
| Slouching       | -4.327°| -10.114°| 13.592° | -6.641° | 17.362° | -1.012° |
| Leaning Back    | -3.089°| -8.110° | -1.109° | 0.119°  | -1.493° | 4.436°  |
## Initial Data – Trial 2

<table>
<thead>
<tr>
<th>“Correct” Position – Actual Data</th>
<th>Back X</th>
<th>Back Y</th>
<th>R. Shoulder X</th>
<th>R. Shoulder Y</th>
<th>L. Shoulder X</th>
<th>L. Shoulder Y</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leaning Left</td>
<td>+6.165°</td>
<td>+1.994°</td>
<td>-0.146°</td>
<td>+16.022°</td>
<td>+7.603°</td>
<td>-14.928°</td>
</tr>
<tr>
<td>Slouching</td>
<td>-5.607°</td>
<td>-6.282°</td>
<td>+11.204°</td>
<td>+2.066°</td>
<td>+14.711°</td>
<td>-3.992°</td>
</tr>
</tbody>
</table>
# Initial Data – Trial 3

<table>
<thead>
<tr>
<th>“Correct” Position – Actual Data</th>
<th>Back X</th>
<th>Back Y</th>
<th>R. Shoulder X</th>
<th>R. Shoulder Y</th>
<th>L. Shoulder X</th>
<th>L. Shoulder Y</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leaning Forward</td>
<td>-3.23°</td>
<td>+6.15°</td>
<td>+13.76°</td>
<td>+3.31°</td>
<td>+15.97°</td>
<td>-2.93°</td>
</tr>
<tr>
<td>Leaning Left</td>
<td>+9.99°</td>
<td>+4.16°</td>
<td>+7.89°</td>
<td>-15.14°</td>
<td>+8.84°</td>
<td>-17.22°</td>
</tr>
<tr>
<td>Leaning Right</td>
<td>-14.25°</td>
<td>+2.84°</td>
<td>+12.07°</td>
<td>+25.29°</td>
<td>+10.97°</td>
<td>+26.4°</td>
</tr>
<tr>
<td>Slouching</td>
<td>-1.16°</td>
<td>-8.42°</td>
<td>+5.67°</td>
<td>+3.89°</td>
<td>+6.65°</td>
<td>+0.77°</td>
</tr>
<tr>
<td>Leaning Back</td>
<td>+1.28°</td>
<td>-1.69°</td>
<td>-2.55°</td>
<td>+1.21°</td>
<td>-4.74°</td>
<td>+4.75°</td>
</tr>
</tbody>
</table>
Initial Analysis

Initial Results:

- 77% of trained data classified correctly as “good”, 64% of test data classified correctly as “good”
- No false positives except leaning forward
  - 88% of all leaning forward test data was classified as “good”
- 99.8% of all other “poor” postures correctly identified as “poor”
- Data from another session has mixed accuracy
Future Work

- Portability – Pocket PC
- Filtering
- Analysis
- Real time testing of system
- User interface design
- Testing on dental students
Questions?
References

References


Images


