Smart Lab Coat for the Dental Practitioner

Grace Olsen
Dr. Susan Brilliant
Dr. David Primeaux
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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

DentSim Simulator

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

Background - Ergonomics

- Traditional Ergonomics Methods:
  - Qualitative approaches
    - Observation
    - Surveys and Questionnaires
  - Quantitative approaches
    - Goniometers and image analysis
    - EMG recordings

Goniometer

Background - Engineering

- Motivations for measuring human movement
  - Ergonomics / Posture
  - Gait Analysis / Medical Applications
  - Sports Analysis
  - Animation

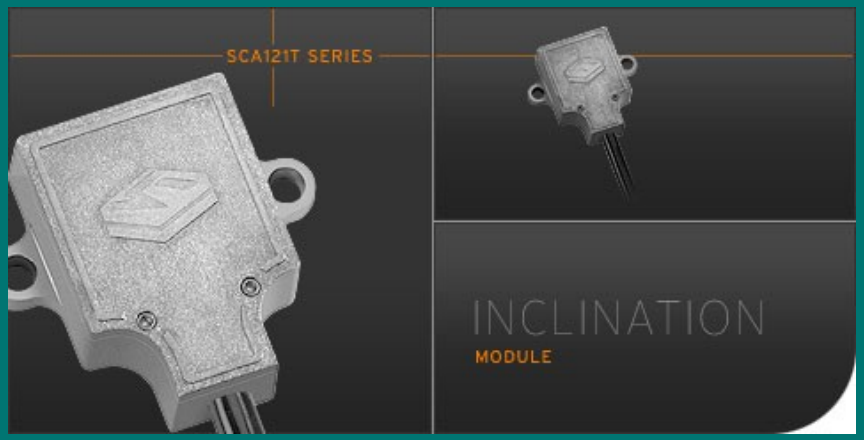
- Methods of recording motion:
  - EMG
  - Video and Image Analysis
  - Motion Capture
  - On Body Sensors

Background - Measuring Human Movement

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

Background - Data Collection: Sensors

- 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

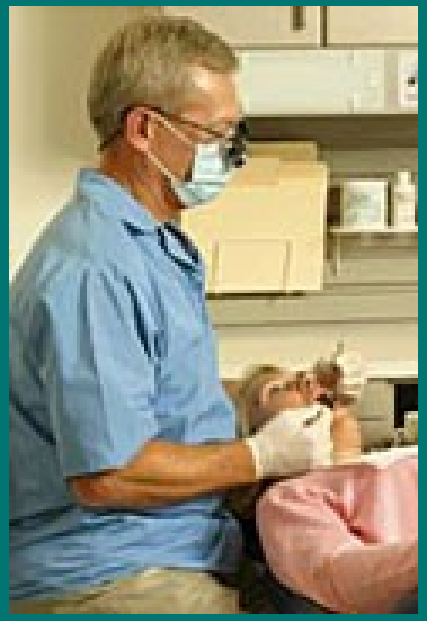
- Classification of movement based on extracted features:
  - Statistical Methods
  - Neural networks
    - Clustering algorithms
  - Combinations of existing machine learning techniques

Background - User Interfaces

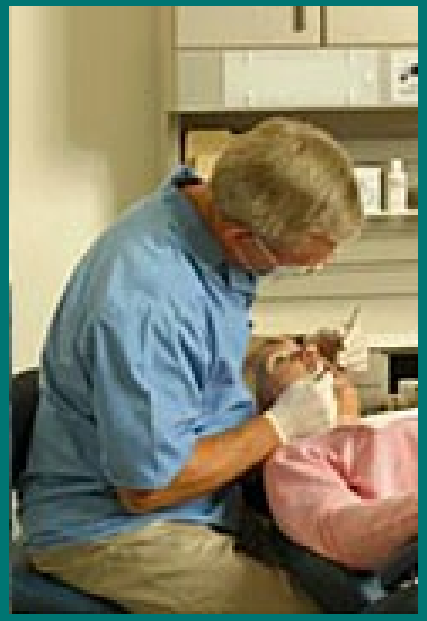
- Real time vs. non-real time systems
- Feedback to user vs. feedback to experts
- Feedback to correct movement or position vs. feedback to be further analysed by experts or other systems
- Feedback to system localized on user vs. feedback to a centralized source

Posture Measuring Prototype

- A system to measure and classify posture
  - Accurate
  - Non-invasive
  - Inexpensive
  - Customized for each user
  - Unobtrusive
  - Real-time classification and feedback



Good Posture

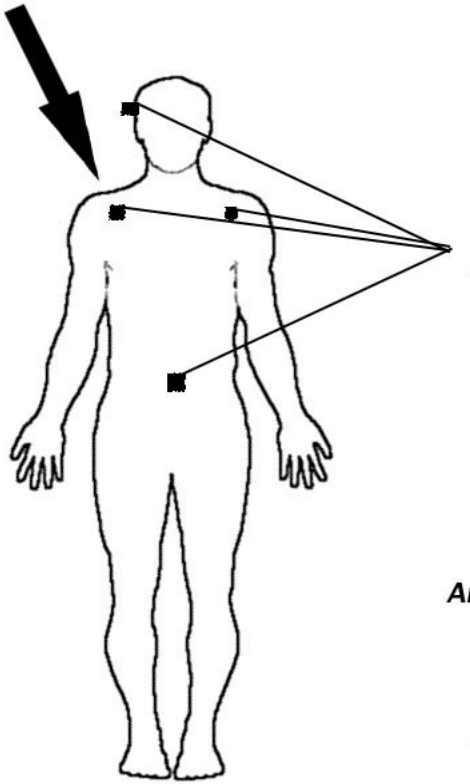


Poor Posture

Posture Measuring Prototype

- Hardware:
  - Multiple Inclinometer Sensors
  - Analog to Digital Converter
  - Pocket PC(?)
  - User Interface

Strategically placed inclinometers (sewn into a laboratory coat)



Headphones connected to Pocket PC for audio user interface

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

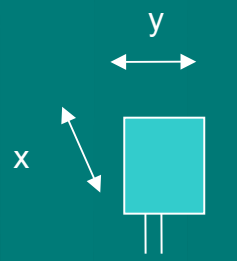
Pocket PC (connected to circuit board via serial cable) with software to filter and classify posture, and notify user if posture is harmful. Will reside in pocket of the lab coat.

Posture Measuring Prototype

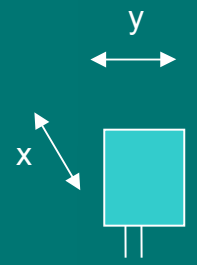
- Software:
  - Interpreting changes in incline from inclinometers
  - Calibration
  - Filtering
  - Classification
  - Notification / User Interface

Initial Data Collection

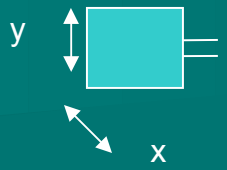
- Data collected in one to three minute time intervals (approx. 1 reading per second)
- Five different positions recorded: nominally "good", leaning left, leaning right, leaning forward, leaning back, slouching
- Trained on an ANN



Left shoulder



Right shoulder



Middle of lower back

Initial Data – Trial 1

	Back X	Back Y	R. Shoulder X	R. Shoulder Y	L. Shoulder X	L. Shoulder Y
"Correct" Position – Actual Data	1.171º	55.256º	52.583º	35.972º	68.528º	-2.354º
Difference from "Correct" Position:						
Leaning Forward	+0.659º	+2.894º	+14.980º	-1.875º	+18.299º	-7.950º
Leaning Left	+4.271º	-1.353º	+5.487º	+9.972º	+15.000º	-16.309º
Leaning Right	-8.929º	-4.388º	+18.465º	-17.434º	+20.988º	+12.169º
Slouching	-4.327º	-10.114º	+13.592º	-6.641º	+17.362º	-1.012º
Leaning Back	-3.089º	-8.110º	-1.109º	+0.119º	-1.493º	+4.436º

Initial Data – Trial 2

	Back X	Back Y	R. Shoulder X	R. Shoulder Y	L. Shoulder X	L. Shoulder Y
"Correct" Position – Actual Data	5.081º	57.987º	45.784º	33.318º	51.881º	0.974º
Difference from "Correct" Position:						
Leaning Forward	+2.068º	+9.426º	+17.502º	+4.636º	+20.702º	-8.663º
Leaning Left	+6.165º	+1.994º	-0.146º	+16.022º	+7.603º	-14.928º
Leaning Right	-14.227º	+6.284º	+19.181º	-18.589º	+18.775º	+18.208º
Slouching	-5.607º	-6.282º	+11.204º	+2.066º	+14.711º	-3.992º
Leaning Back	-6.628º	-2.053º	-13.858º	+4.577º	-11.799º	+6.807º

Initial Data – Trial 3

	Back X	Back Y	R. Shoulder X	R. Shoulder Y	L. Shoulder X	L. Shoulder Y
"Correct" Position – Actual Data	-11.05º	19.19º	34.31º	-11.7º	32.33º	-7.06º
Difference from "Correct" Position:						
Leaning Forward	-3.23º	+6.15º	+13.76º	+3.31º	+15.97º	-2.93º
Leaning Left	+9.99º	+4.16º	+7.89º	-15.14º	+8.84º	-17.22º
Leaning Right	-14.25º	+2.84º	+12.07º	+25.29º	+10.97º	+26.4º
Slouching	-1.16º	-8.42º	+5.67º	+3.89º	+6.65º	+0.77º
Leaning Back	+1.28º	-1.69º	-2.55º	+1.21º	-4.74º	+4.75º

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?

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Images

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