

Smart Lab Coat for the Dental Practitioner

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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



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

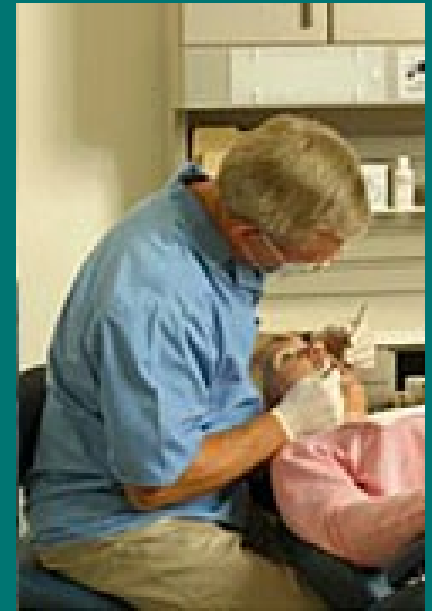
- Real time vs. non-real time systems
- Feedback to user vs. feedback to experts
- Feedback to correct movement or position vs. feedback to be further analysed by experts or other systems
- Feedback to system localized on user vs. feedback to a centralized source

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

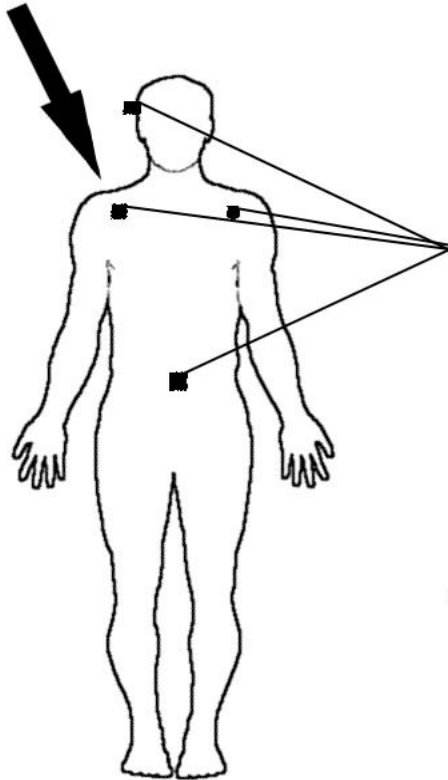


Poor Posture

Posture Measuring Prototype

- Hardware:
 - Multiple Inclinator 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.*

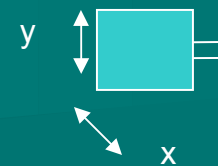
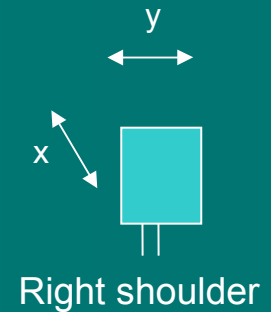
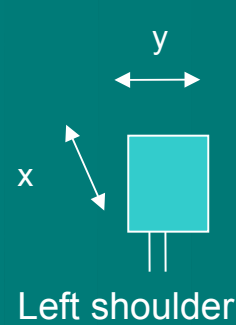
Posture Measuring Prototype

■ 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



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	1.171°	55.256°	52.583°	35.972°	68.528°	-2.354°
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°
Leaning Right	-8.929°	-4.388°	+18.465°	-17.434°	+20.988°	+12.169°
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

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

Initial Data – Trial 3

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

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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