

Smart Lab Coat for the Dental Practitioner

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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

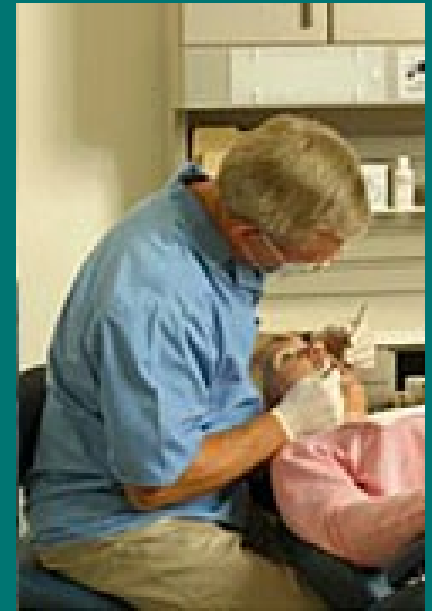
- Real time vs. non-real time systems
- Feedback to user vs. feedback to experts
- Feedback to correct movement or position vs. feedback to be further analysed by experts or other systems
- Feedback to system localized on user vs. feedback to a centralized source

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 Inclinator Sensors
 - Analog to Digital Converter
 - Pocket PC(?)
 - User Interface

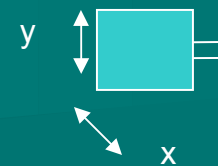
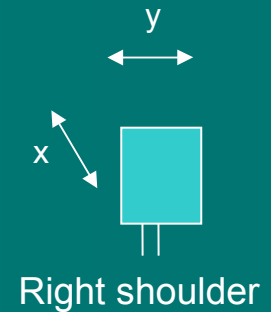
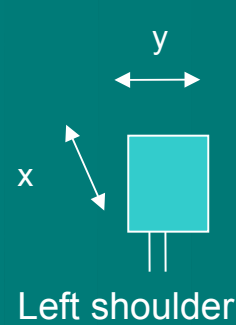
Posture Measuring Prototype

■ 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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Images

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