Device Control Using Gestures Sensed From EMG

Kevin R. Wheeler

NASA Ames Research Center

IEEE International Conference on

Soft Computing in Industrial Applications

Binghamton University, Binghamton, New York, June 23-25, 2003.

Presented by

Junaed Sattar

OUTLINE

- ☻ Terminology
  - What is an EMG?
  - How do we acquire EMG signals?
  - What Gestures are sensed?
- ☻ Applications
  - What can we do with this?
- ☻ Methodology
  - Steps of the algorithm including training and recognition
- ☻ Experiments
  - Virtual Joystick & Virtual Keyboard
  - Different validation methods
- ☻ Results
  - Presented as confusion matrices

ELECTROMYOGRAM (EMG)

- Test that is used to record the electrical activity of muscles
- Current is usually proportional to the level of the muscle activity
- Also referred to as a myogram
- Sensed by placing electrodes on (Surface EMG) or into (Intramuscular EMG) the muscles
- Any Muscle movement can be sensed; usually ease of electrode placement taken into consideration
- This experiment uses SEMG to sense current levels

APPLICATIONS

- Bioelectric interfaces
- Control of robotic arm or robotic exoskeleton
- Control of remote vehicles (UAV or Flight Simulators)

<u>METHODOLOGY</u>

- *Gesture Selection*

  What gestures are we trying to classify?
- *Electrode Application*

  How many required and where to place them?
- *Signal Acquisition, Filtering and Digitization*

  Improving quality and noise filtering
- *Feature formation*

  Separate signals enough for gestures to be distinguished by the moving average method
- *Pattern Recognition model training and testing*

  Used a pattern recognition module based on Hidden Markov Models (HMM)
- *Pattern Recognition application in interactive simulations*

  Simulation of operating a Joystick

  Simulation of typing in a numeric key pad

HIDDEN MARKOV MODELS

- Used mostly in speech recognition in response to the pattern recognition time-series problem
- Expressed as a triple (A,B,π) where,

  A=probability that the next state is q_j given that the current state is q_i;

  B=probability that the output is O_k given that the current state is q_i;

  π=A priori probabilities of individual states
- Trained using the standard Baum-Welch method

  -Finds HMM parameters which have maximum likelihood of generating the given sequence in the observation
- Uses *k-means clustering* for model initialization
- Recall performed using the Viterbi algorithm

  -An algorithm to compute the optimal (most likely) state sequence in an HMM given a sequence of observed outputs

EXPERIMENTS

- As mentioned before, focus' on two tasks

  Substitution of a joystick & a keyboard with bioelectric signals

- One HMM trained for each gesture in both tasks

  4 HMMs for joystick task & 11 HMMS for typing task

- Four different tests to validate the pattern recognition model

  1. Same Trial Acquisition and Testing

     -Test & Training data are different but of the same day

  2. Cross-Trial Acquisition and Testing

     -Test & Training data different and of different days

  3. Multi-Trial Acquisition and Testing

     -Trained on data subsamples across several days

     -Tested on another different sample from same data

  4. Best Trial Training and Real-Time Testing

     -Best performance training data taken

RESULTS

- Expressed in terms of confusion matrices
- Each gesture performed 50 times for Joystick data
- Keyboard task required entering the sequence 0-9-ENTER 51 times
- Live tests performed under high stress, imperfect electrode placements and participants are bombarded by questions and distractions

Gesture	Left	Right	Up	Down	Correct
Left	15	0	26	9	30%
Right	0	50	0	0	100%
Up	0	0	50	0	100%
Down	0	0	1	49	98%

Confusion Matrix for Cross-Trial Joystick Data

Gesture	Left	Right	Up	Down	Correct
Left	50	0	0	0	100%
Right	0	50	0	0	100%
Up	0	0	50	0	100%
Down	0	0	0	50	100%

Confusion Matrix for Multi-Trial Joystick Data

	1	2	3	4	5	6	7	8	9	%
1	46	0	0	4	0	0	1	0	0	90
2	0	48	0	0	0	0	0	3	0	94
3	0	0	49	0	0	1	1	0	0	96
4	11	0	0	38	2	0	0	0	0	75
5	1	3	0	5	36	1	3	2	0	71
6	0	1	6	0	0	42	0	0	2	82
7	0	0	0	0	0	0	51	0	0	100
8	0	0	0	0	2	1	3	44	1	86
9	0	0	0	0	0	0	0	0	51	100

Confusion Matrix for Multi-Trial Typing Data

DISCUSSIONS

1. Introduces an exciting area of pattern recognition applications; a quite recent advancement
2. Unique application areas; tested in several NASA projects (Extension of Human Senses)
3. Does not talk about details of the algorithm, skims over the techniques
4. No comparable framework discussed
5. No performance data provided as such
6. Somewhat unrealistic (too good!) lab results

REFERENCES

1. Michael Cohen's on line tutorial on HMMs http://screwdriver.bu.edu/cn760-lectures/l9n/l9.htm
2. Device Control Using Gestures Sensed From EMG; Kevin R. Wheeler; IEEE International Conference on Soft Computing in Industrial Applications, Binghamton University, Binghamton, New York, June 23-25, 2003.
3. Bioelectric Control of a 757 Class High Fidelity Aircraft Simulation Charles Jorgensen, Kevin Wheeler, Slawomir Stepniewski