Thinking about Security

Analysis of Brain-Waves and Other Bio-Feedback Signals

- **Name of Research Program**: TRUST, SPRING 2011
- **Faculty Mentor**: John Chuang, School of Information
- **Undergraduate Researcher**: Charles Wang, Hamilton Nguyen

- **Abstract**: Biometric authentication is a field that has seen great progress in recent years. This multidisciplinary research project tackles yet another biometric medium: the brain. We design and develop systems to efficiently measure brain-waves of subjects performing security tasks. Our aim is to provide a secure and practical method of user identification based on our analysis of these signals.

Overview

- We perform signal processing and analysis of individual brainwave patterns in the application of identification, authentication, and security.

Project Approach

- Began by proposing different experimental tasks, each designed to exercise a particular mode of neural activity (e.g. relaxation, focus, visualization, excitation, etc)
- Conducted the experiments, evaluating each on feasibility and effectiveness. Then narrowed the scope of experimentation to a small number of security tasks
- Analyzed data and drafted a pattern matching algorithm designed to match signals with subjects
- Developed an accuracy metric to evaluate effectiveness of our algorithm

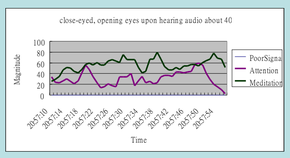
Objectives

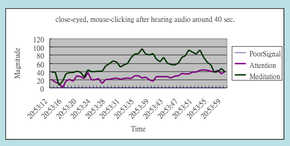
- Recognize individual brainwave pattern in specified experimental setting
- Compare patterns among research group and seek to differentiate one from another
- Improve authentication process by maximizing accuracy and optimizing efficiency of performing security tasks

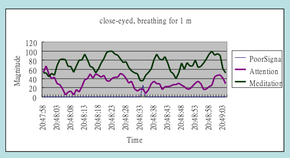
Problem Formulation

- How to use brainwave in aspect of security?
- How to design our experiments?
- How many prototypes/targets are enough?
- What should we choose as accuracy metric?
- What are the results we expect?

Experiment Result 1

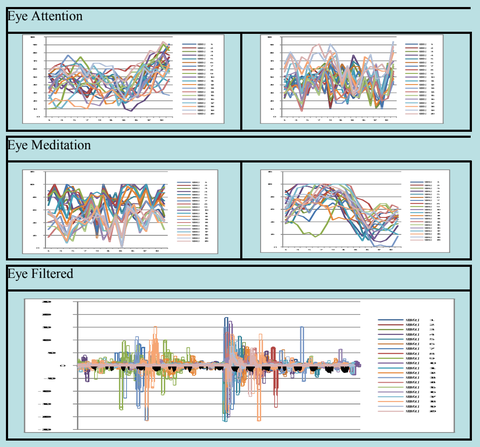




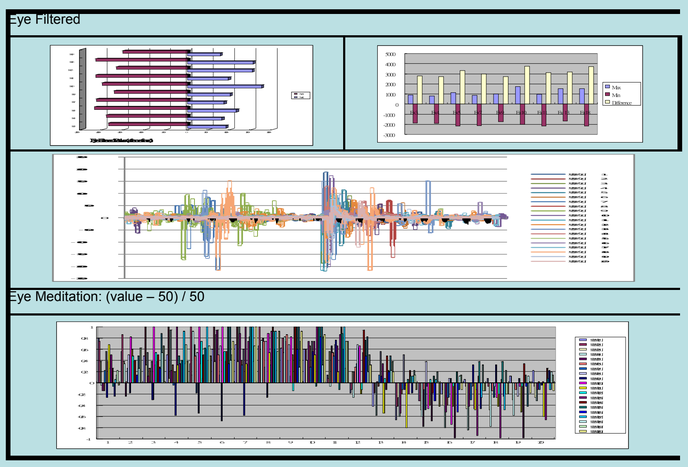


- Meditation tasks consistently have stronger readings
- One specific experiment – auditory stimulus during eye-closed meditation – showed meditation and attention levels coinciding, a feature that was consistent throughout all subjects

Experiment Result 2



Experiment Result 3



Data Analysis

- Using template matching approach to pattern recognition (wherein we match prototypes to tests)
- Search the database for the reference pattern most similar to the given test pattern

Current implementation uses the Sakoe-Chiba method to compute matching costs

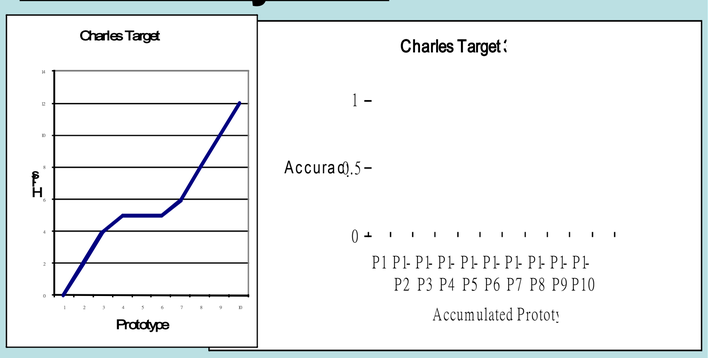
Data Analysis 1

5 test samples from 3 subjects were matched against iterations of 1, 2, … 10 prototypes

After computing matching costs against a complete iteration of prototypes, algorithm outputs a single decision for each test sample

Decisions are then evaluated for their correctness

Data Analysis 2



Number of hits correlates near-linearly with number of prototypes
Proportion of correct guesses is roughly uniform for 9 and fewer prototypes

Discussion & Expectation

- Peak values for filtered signal is not consistent for individual, making it difficult to normalize signals across different experiment sessions
- Based on what accuracy metric is used, accuracy rate ranges from 47% to 72%
- Ongoing project, next immediate goal is to establish relationship between accuracy and number of prototypes

References

- "Introduction to Pattern Recognition- A Matlab Approach"-Sergios Theodoridis
- NeuroSky MindWave Headset Manual
- Pattern Recognition articles on Web