Oculomotor Plant Biometrics: Person-Specific Features in Eye Movements

Sampath Jayarathna\(^1\), Oleg Komogortsev\(^1\), Cecilia Aragon\(^2\), and Mechehoul Mahmoud\(^1\)
\(^1\)Texas State University – San Marcos, \(^2\)Lawrence Berkeley National Laboratory

**Abstract**
This study presents a new biometric approach that involves an estimation of the unique oculomotor plant (OP) or eye globe muscle parameters from an eye movement trace. It includes both behavioral and physiological human attributes, is difficult to counterfeit, non-invasive, and could easily be incorporated into existing biometric systems to provide an extra layer of security.

**Background**

**Biometric**: Refers to methods for uniquely recognizing humans based upon one or more intrinsic physical or behavioral traits. There are two major categories of biometric identification: Physiological and Behavioral

**Physiological**
Related to the shape of the human body.

• Hand and palm prints and geometry
• Fingerprints
• Vascular (vein) patterns
• Facial
• Voice
• Odor Scents
• DNA

**Behavioral**
Related to the behavior of a person.

• Brain waves
• Voice
• Typing rhythm, handwriting, and signature
• Gait analysis (human locomotion)

**Oculomotor Plant Biometrics**
Most popular biometric identification methods such as fingerprint verification or iris recognition are based on physiological properties of the human body.

However, physiological properties are vulnerable to forging and may be used to identify an unconscious or even a dead person.

Eye Movements combine both physiological (muscle) and behavioral (brain) aspects.

Eye movement based identification uses information mostly produced by the brain, and so far impossible to imitate.


**Eye Movement Classification Algorithms**: Velocity Threshold (VVT), Hidden Markov Model (HMM), Kalman Filter (KF), Minimum Spanning Tree (MST), Dispersion Threshold (D-Threshold)

**Experimental Methodology**

**Apparatus**: The experiments were conducted with a Tobii x120 eye tracker.

**Eye Movement Innovation Tasks**: The stimulus was presented as a ‘jumping point’ with vertical coordinate fixed to the middle of the screen.

**Participants**: The test data consisted of 68 student volunteers ages 18-25 with an average age of 21.2 and standard deviation of 3.2, 24 males and 44 females, with normal or corrected-to-normal vision. Only 41 subject records passed the selection criteria, resulting in mean accuracy of 1.25º (SD=0.77) and a mean invalid data percentage of 12.43% (SD=17.22%). Only saccades with amplitudes of 17-22º were employed for biometric identification.

**Performance evaluation metrics**

- False Acceptance Rate (FAR) – The ratio of the number of imposter samples classified as authentic to the total number of all the imposter samples.
- False Rejection Rate (FRR) – The ratio of the number of authentic samples classified as imposters to the number of all the authentic samples.

**Results**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>KNN</th>
<th>Decision Trees (S2)</th>
<th>C4.5</th>
<th>SVM</th>
<th>Bagging (S2)</th>
<th>AdaBoost (M1)</th>
<th>NM-S1</th>
<th>NM-S2</th>
</tr>
</thead>
<tbody>
<tr>
<td>FAR (%)</td>
<td>26.3%</td>
<td>26.3%</td>
<td>5.3%</td>
<td>26.3%</td>
<td>21.1%</td>
<td>36.8%</td>
<td>26.3%</td>
<td>26.3%</td>
</tr>
<tr>
<td>FRR (%)</td>
<td>73.3%</td>
<td>76.7%</td>
<td>70%</td>
<td>63.3%</td>
<td>80%</td>
<td>73.3%</td>
<td>76.7%</td>
<td>70%</td>
</tr>
</tbody>
</table>

We conducted the classification with both the KNN (top value) and C4.5 algorithms on each of the OPMN parameters, and determined that the best results were obtained with KNN utilizing the TR algorithm with optimization strategy 1 for the length tension coefficient. These results improve on previous work in the field by Kasprowski (Kasprowski 2006).

**Discussion, Conclusion and Further Work**

We have introduced a novel method of biometric identification based on the utilization of Oculomotor Plant Mathematical Model parameters from horizontal positive saccadic eye movements.

Via our tests, we demonstrated the potential to distinguish authorized users from imposters with this technique.

This new method could also be easily combined with existing biometric identification systems that incorporate digital cameras to scan the face or iris, to provide an additional layer of security.

However, further testing with larger subject pools and different statistical classification algorithms is needed to improve on the accuracy rates of our method.

**References**


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**Contacts**

Sampath Jayarathna, Texas State University – San Marcos, Email: sampath@txstate.edu, Tel: 1-512-465-6293