**Eye detection using EEG signal: ensemble forest structure classifier**



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# 1 Introduction

1.1 Background introduction

Eye state detection is the task of predicting the state of eye whether it is open or closed, or simply called eye blink detection. This detection has been widely used, for instance, eye blink is a direct signal to monitor driver’s fatigue and drowsiness in autonomous driving [1], as well as to help person impaired in movement capability to make some decisions and communicate with the world in medical assistance [2].

Usually there are two main methods for eye blink detection. The first is vision-based method, which integrate computer vision and machine learning techniques. A large amount of researchs have been conducted in this area. Talal Bin Noman et al (2018) [3]devised a Mobile-based blink detection system on Android Platform by using both haar classifier and Normalized Summation of Square of Difference template-matching method, Nassr Alsaeedi\* et al(2019)[1] achieved real-time eye blink detection by analyzing eyeblink phases, Aleksandra Królak et al (2012) [2]estimated eyeblink using IR spectrum of eye images. However, vision-based method still encounters many problems, such as easily-effected by illumination, image scale, glasses etc.

Another way to estimate eye blink is using brain activity signals by the mean of electroencephalography (EEG) measures, even this method has been implemented for decades, there still has much studies needed to be explored. S. Rihana et al(2013)[4] implemented a probabilistic neural network to accomplish binary classification for eye blink. Rajesh Kanna. K et al(2015) [5]designed a decision tree with C4.5 algorithm to estimate eye states. Ali Al-Taei(2017) [6]devised an ensemble classifier to predict the state of eyes.

In this paper, we will introduce a forest structure to tackle this classification problem, which is not much like a normal ensemble decision tree structure, we will devise a new feature extractor to form the training dataset. The training and testing data is supported by Rösler and Suendermann[7], which has been published on Kaggle.

1.2 Source of data

<https://www.kaggle.com/c/compomicssummer2018/overview>

1.3 Data description

An Emotiv headset device with 14 sensors has been used to record brain signals. The duration time of each recording was 117 seconds. Then, the different eye states observed during each recording were manually added. Each data point consists of 14 EEG features and an eye-state class (either 0 for open, or 1 for closed).

1.4 Question addressed by machine learning

According to the data set, we want to do eye blinking prediction based on multi-dimensional data and machine learning techniques. There are only 2 states of eye blinking which are open and closed, so basically we should construct a binary classifier to predict eye blinking.

1.5 Programming language

MATLAB and Python

# 2 Research design and method

**2.1 Feature extractor**

Usually EEG signal comes from several sensors on the brain. Directly using all the data maybe not the best way for training process, because the eye blink behavior is not much related to all EEG signals. In order to diminish effect on training process of useless data, we will separate the EEG signal into different parts as the training feature, using a slide window to form a spatial relationship between the sensor, as illustrated in figure1, sliding window will scan all the original measurements and then to generate several sequences of new feature for the training process.

A screenshot of a cell phone

Description automatically generated

Figure 1 illustrates the feature exaction process

**2.2 Ensemble forest**

After the feature exaction, every new sequence feature will be trained using a single decision tree, and finally all the single tree will form a forest structure. Here because we can define different size of the sliding window, then we can generate different types of forests, this diversity is very important to ensemble algorithm. Figure 2 illustrates the algorithm structure.

A close up of text on a black background

Description automatically generated

Figure 2 illustrates ensemble forest structure

# 3 Expected results

By using this methods we hope the new ensemble forest structure can perform best among all the tested method, which means a lowest error rate of the testing data.

# 4 Reference

1. Nassr Alsaeedi\* and Dieter Wloka “Real-Time Eyeblink Detector and Eye State Classifier for Virtual Reality (VR) Headsets (Head-Mounted Displays, HMDs)” [Sensors (Basel)](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6427357/). 2019 Mar; 19(5): 1121.
2. Królak, A. & Strumiłło, P. Univ Access Inf Soc (2012) 11: 409. https://doi.org/10.1007/s10209-011-0256-6
3. Noman, Md, et al. "Mobile-based Eye-Blink Detection Performance Analysis on Android Platform." Frontiers in ICT 5 (2018): 4.
4. Rihana, S., P. Damien, and T. Moujaess. "EEG-Eye blink detection system for brain computer interface." *Converging Clinical and Engineering Research on Neurorehabilitation*. Springer, Berlin, Heidelberg, 2013. 603-608.
5. S. Vachiravel, Eye State Prediction using EEG Signal and C4.5 Decision tree algorithm, March 2016.
6. Al-Taei, Ali. "Ensemble Classifier for Eye State Classification using EEG Signals." *arXiv preprint arXiv:1709.08590* (2017).
7. Jain, Neha, et al. "Eye state prediction using EEG by supervised learning." *International Journal of Science, Engineering and Technology* 10 (2015).