Resting State EEG-Based Biometrics for Individual Identification Using Convolutional Neural Networks

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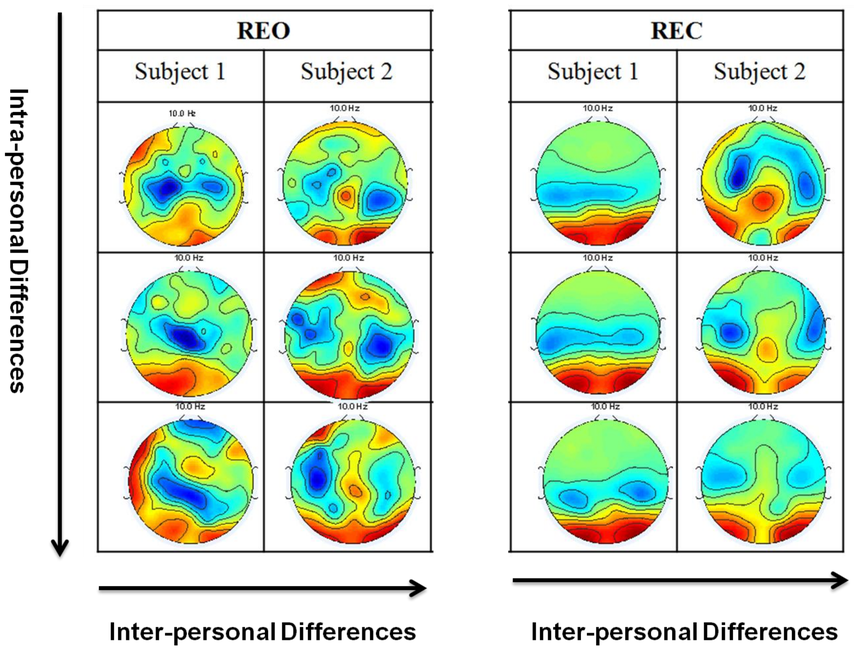
Abstract

Biometrics is a growing field, which permits identification of individuals by means of unique physical features. Electroencephalography (EEG)-based biometrics utilizes small intra-personal differences and large inter-personal differences between individuals' brainwave patterns. We use convolutional neural networks (CNN) to automatically extract an individual's best and most unique neural features and conduct classification, using EEG data derived from both Resting State with Open Eyes (REO) and Resting State with Closed Eyes (REC). Results indicate that this System yields a high degree of **accuracy of identification (88%) for 10-class classification**. Furthermore, rich inter-personal difference can be found using a very low frequency band (0-2Hz). Additionally, results suggest that the temporal portions over which subjects can be individualized is less than 200 ms.

Proposed Method

The Bases of EEG Biometric Systems

- Small Intra-personal Differences
- Large Inter-personal Differences

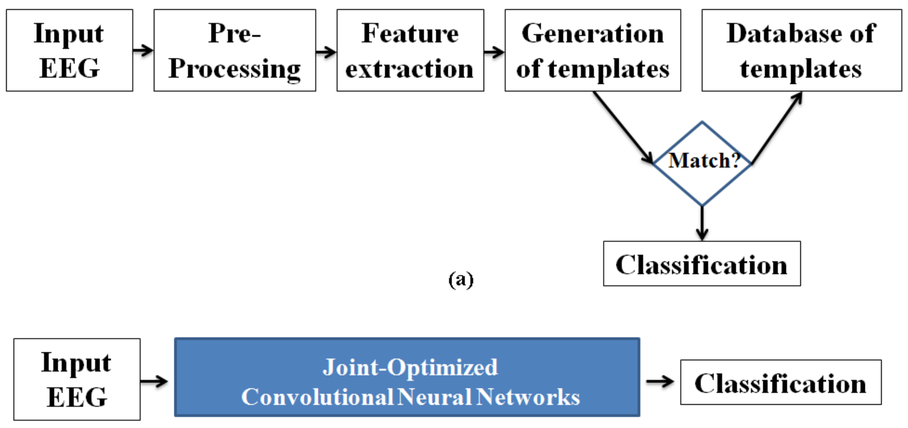


Two subject' three 10-Hz spectrum-topographies under resting state with eyes open, (REO) and under resting state with eyes close (REC) conditions. Illustrates small intra-personal differences and large interpersonal differences. Each spectrum-topography is analyzed in 10-second duration.

The paradigms of EEG based Biometric Systems

- **Task based EEG**
  - ✓ High accuracy
  - ✗ Certain tasks cannot be performed by certain group of people. e.g., Attention Deficit Disorder (ADD) or handicapped patients.
- **Resting-state EEG**
  - ✓ Evidence indicates that electrical activities' resting state organizes and coordinates neuronal functions.
  - ✗ Much Lower accuracy than using task based EEG.
  - ✗ Commonly use non-optimized, handcrafted features.
- **We propose:**
  - •Convolutional Neural Networks for the purpose of automatically extracting resting-state EEG features and conducting classification.
  - •The whole procedure is then joint-optimized based on gradient descent.

Framework of The EEG-based Biometric Systems



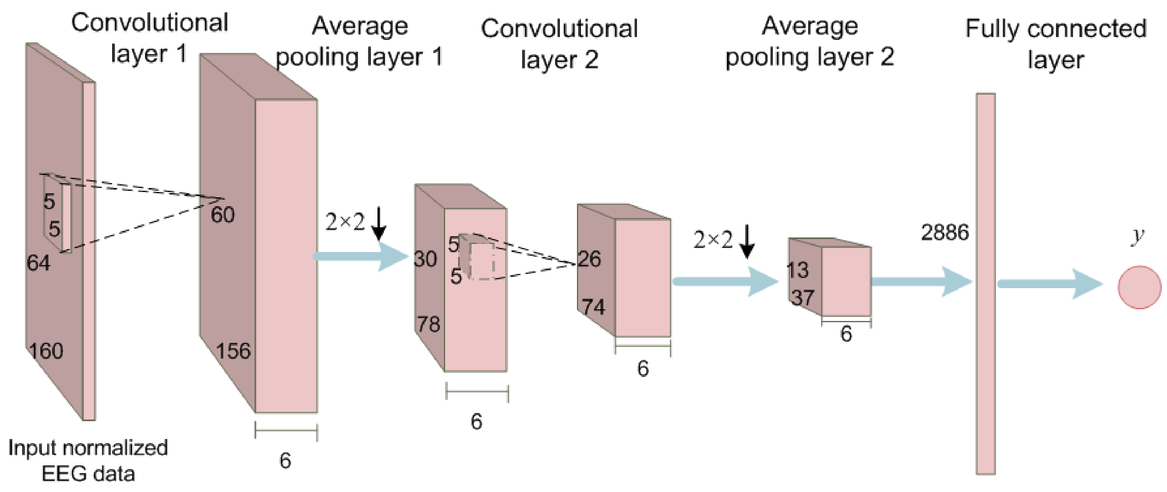
(a) Common framework of the EEG-based Biometric Systems

(b) The framework of our joint-optimized CNN-based EEG Biometric Systems

Dataset [1]

- 10 Subjects' REO and REC data (Sampling rate: 160; Electrodes number:64). Both conditions using 55 seconds for each single condition in time.
- The 55-second dataset was divided into 55 1-second sub-datasets; 50 of these sub-datasets were used for training the networks and 5 of them for testing.
- Each subject's dataset has the structure as: 64*160
  - •50 for training, 10 subjects have 500 samples. (64*160*500)
  - •5 for test, 10 subjects have 50 samples (64*160*50)

The Topology of Five-Layer Convolutional Neural Network (CNN) [2]



Experiment Results

The Accuracy of the Full Data Set

- Resting state with eyes open, (REO)
- Resting state with eyes close, (REC)

	Individual Identification (10-class)		
	REO	REC	REO+REC
Accuracy	88%	86%	82%

The Accuracy of the Filtered Data Set

- The frequency bands started from a very low range (0-2 Hz) and become progressively wider, ultimately reaching 0- 80Hz.

	REO	REC
0Hz-2Hz	68%	64%
0Hz-4Hz	72%	64%
0Hz-6Hz	72%	70%
0Hz-8Hz	74%	72%
0Hz-10Hz	74%	74%
0Hz-20Hz	78%	76%
0Hz-30Hz	82%	78%
0Hz-40Hz	84%	80%
0Hz-50Hz	84%	82%
0Hz-60Hz	84%	86%
0Hz-70Hz	88%	86%
0Hz-80Hz	88%	86%

The Accuracy of the Divided Temporal-Structure Data Set

- We divided each 1-s REO EEG signal into various smaller portions (from 6.25ms-1000ms) and then performed random permutations.

	6.25ms	12.5ms	25ms	50ms	62.5ms
REO	34%	44%	54%	64%	76%
	100ms	200ms	500ms	800ms	1000ms
REO	78%	88%	88%	88%	88%

[1] Goldberger A L, Amaral L A N, Glass L, et al. Physiobank, physiotoolkit, and physionet components of a new research resource for complex physiologic signals[J]. Circulation, 2000, 101(23): e215- e220.
[2] Ciresan D C, Meier U, Masci J, et al. Flexible, high performance convolutional neural networks for image classification[C]//IJCAI Proceedings-International Joint Conference on Artificial Intelligence. 2011, 22(1): 1237.