Brain Waves as a Biometric Property

Brain waves

⊗   Gamma waves (38 TO 42 HZ)
-     Peak mental state
⊗   Beta waves (13 TO 32 HZ)
-     Thinking, calculating, learning
⊗   Alpha waves (8 TO 13 HZ)
-     Relaxation: music, sleeping, yoga
⊗   Theta waves (4 TO 13 HZ)
-     Automatic relaxed activity: sleeping, daydreaming, washing teeth
⊗   Delta waves (0.5 TO 4 HZ)
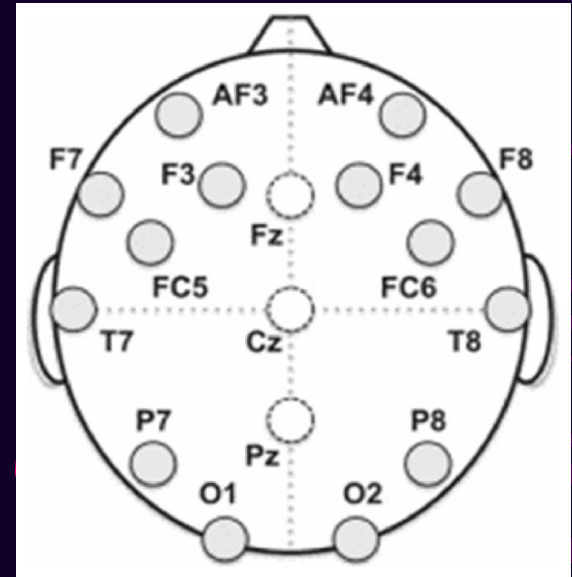-   Complete rest: sleep
⊗   ERPs

ERPs

ERPs stand for Event-related potentials, they are small voltages generated in the brain structure in response to specific events or stimuli.s

EEG

An electroencephalogram (**EEG**) is a test that detects electrical activity in your brain using small, metal discs (electrodes) attached to your scalp

Authentication

Authentication

Identification

Collecting brain waves response through Stimuli

Authentication

Recognizing brain waves through recreating the Stumli

Identification

Signal acquisition

EEG signals are often recorded with the Emotiv EPOC headset which uses integrated sensors located at standard positions

Pre-Processing

Pre-processing is applied to improve the resolution of brain signals, since the raw EEG signals are noisy.

The feature extraction

The brain patterns used are characterized by certain features. Describing the signals by a few relevant value

The feature extraction

Frequency Domain

power spectral density (PSD)

$$S_x(f) = (\frac{1}{N}) \sum_{i=1}^{N} |X(f)|^2$$

channel spectral power

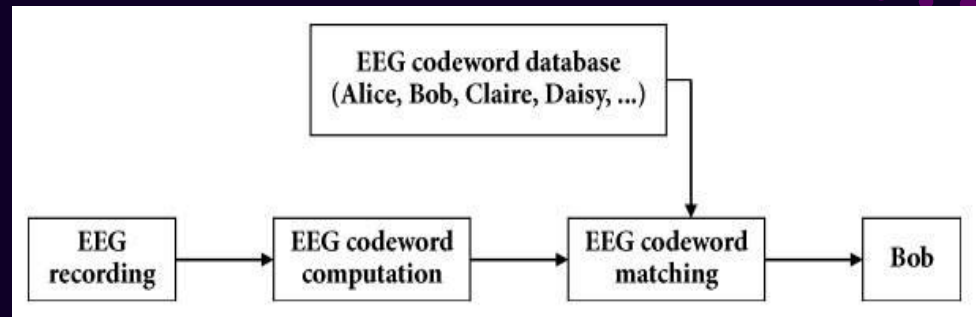$$P_{f_1 f_2} = \int_{f1}^{f2} S_x(f) df$$

Time Domain

Mean

Median

Variance

Authentication

Classification

The obtained feature vector is compared against a previously stored feature vector for that subject, using Euclidean Distance for template matching.

Experiment

Overview

Experiment

Person Authentication using Brainwaves (EEG) and Maximum A Posteriori Model Adaptation.

S´ebastien Marcel

Jos´e del R. Mill´an

Dataset

9 normal subjects during 12 non-feedback sessions over 3 days (4 sessions per day).

DATA Acquisition

Tasks

- ⊗ The imagination of repetitive self-paced left-hand movements, (left).

- ⊗ The imagination of repetitive self-paced right-hand movements, (right).

- ⊗ Generation of words beginning with the same random letter, (word).

Protocols

person	session	Kfold 1			Kfold 2			Kfold 3		
		T	V	E	T	V	E	T	V	E
1	1	C			C				I	
	2		C/I			C/I			I	
	3			C/I			C/I			I
	4			C/I			C/I			I
2	1	C				I		C		
	2		C/I			I			C/I	
	3			C/I			I			C/I
	4			C/I			I			C/I
3	1		I		C			C		
	2		I			C/I			C/I	
	3			I			C/I			C/I
	4			I			C/I			C/I

T = EER
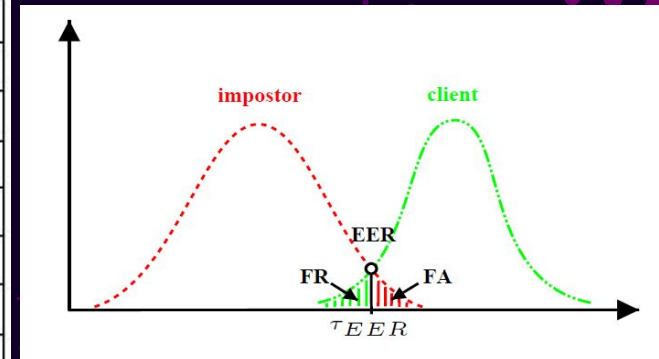
Incremental Learning

person	session	P2			P3			P4		
		T	V	E	T	V	E	T	V	E
clients (2, 3, 4, 5, 7, 8)	1	C			C			C		
	2	C			C			C		
	3		C/I			C/I			C/I	
	4			C/I		C/I				C/I
	5			C/I	C			C^{d+1}		
	6			C/I	C					C/I
	7			C/I		C/I				C/I
	8			C/I		C/I				C/I
	9			C/I			C/I	C^{d+2}		
	10			C/I			C/I			C/I
	11			C/I			C/I			C/I
	12			C/I			C/I			C/I
impostor 1	1		I			I			I	
	2		I			I			I	
impostors 6, 9	1			I			I			I
	2			I			I			I

Results

HTER = (FAR + FRR) /2

Number of Gaussians	Protocol								
	P4-d1			P4-d2			P4-d3		
	FAR	FRR	HTER	FAR	FRR	HTER	FAR	FRR	HTER
4	15.1	17.2	16.1	20.0	50.5	**35.3**	24.7	46.8	**35.7**
32	5.7	8.5	**7.1**	7.3	82.7	45.0	8.3	96.0	52.1
	Protocol								
	$P4^{d+1}$-d2			$P4^{d+1}$-d3			$P4^{d+2}$-d3		
	FAR	FRR	HTER	FAR	FRR	HTER	FAR	FRR	HTER
4	24.9	2.7	13.8	29.4	10.6	20.0	29.3	1.2	15.25
32	16.0	0.2	**8.1**	17.8	28.3	**23.0**	24.5	0.02	**12.3**

Biometrics

Universality

Everyone has a brain

Distinctiveness

Permanence

Circumvention

Collectability

Easy to collect through EEG headset and tools

Performance

Acceptability

Controversial at it's best

Biometrics

Permanence

HTER: 7.1 -> 36.2
TAR: 94.60%
83.64%
78.20%

Distinctiveness

100% Recognition across all subjects

Twins could possibly inherit similar brain waves

Biometrics

Performance

Accuracy can reach 100%
Speed 5-10 mins

Circumvention

Friendly privacy

Cancelability

Future Promises

Less Electrodes

4-8 electrodes

Multi-Tasking

Combined tasks

More time (178 days)

Ear-EEG

Outer ear electrodes

Multimodal

Combined biometrics

More complicated

PRESENTATION FINISHED !!

ANY QUESTIONS ?