Entropy Feature Extraction of EEG Signals for Automatic Person Identification

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Dinh Van Phung

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Summary of Thesis

The use of human brain electroencephalography (EEG) signals for automatic person identification has been investigated for a decade. It has been found that the performance of an EEG-based person identification system highly depends on what feature to be extracted from multi-channel EEG signals. Linear methods such as Power Spectral Density and Autoregressive Model have been used to extract EEG features. However these methods assumed that EEG signals are stationary. In fact, EEG signals are complex, non-linear, non-stationary, and random in nature. In addition, other factors such as brain condition or human characteristics may have impacts on the performance, however these factors have not been investigated and evaluated in previous studies.

It has been found in the literature that entropy is used to measure the randomness of non-linear time series data. Entropy is also used to measure the level of chaos of brain-computer interface systems. Therefore, this thesis proposes to study the role of entropy in non-linear analysis of EEG signals to discover new features for EEG-based person identification. Five different entropy methods including Shannon Entropy, Approximate Entropy, Sample Entropy, Spectral Entropy, and Conditional Entropy have been proposed to extract entropy features that are used to evaluate the performance of EEG-based person identification systems and the impacts of epilepsy, alcohol, age and gender characteristics on these systems.

Experiments were performed on the Australian EEG and Alcoholism datasets. Experimental results have shown that, in most cases, the proposed entropy features yield very fast person identification, yet with compatible accuracy because the feature dimension is low. In real life security operation, timely response is critical. The experimental results have also shown that epilepsy, alcohol, age and gender characteristics have impacts on the EEG-based person identification systems.

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Abbreviations

AD	Alzheimer's Disease
AEEG	Autralian Electroncephalogram Dataset
AIC	Akaike Information Criterion
ANN	Artificial Neural Network
ApEn	Approximate Entropy
AR	Auto Regressive
AR6	Auto Regressive, order 6
AR14	Auto Regressive, order 14
BCI	Brain-Computer Interface
BSS	Blind Source Separation
CC	Cross Correlation
CD	Correlation Dimension
CAD	Computer Aided Diagnostic
CEn	Conditional Entropy
CFS	Correlation-based Feature Selection
DFT	Discrete Fourier Transform
DTFT	Discrete Time Fourier Transform
DWT	Discrete Wavelet Transform
EEG	Electroencephalogram
EP	Evoked Potential
ERP	Event-related Potential
ESD	Energy Spectrum Density
FFT	Fast Fourier Transform

fMRI	functional Magnetic Resonance Imaging
FT	Fourier Transform
HC	Healthy Control Groups
HOS	High Order Spectra
ICA	Independent Component Analysis
K	KolmogorovSinai Entropy
KEn	Kolmogorov Entropy
k-NN	K-Nearest Neighbor
LC	Linear Complexity
LDA	Linear Discriminant Analysis
MAR	Multivariate Autoregressive model
MI	Mutual Information
MCI	Mild Cognitive Impared
MEG	Magnetoencephalogram
MPEn	Multi-Scale Permutation Entropy
MSEn	Multi-Scale Entropy
NN	Neural Network
PCA	Component Analysis
PEn	Permutation Entropy
PET	Positron Emission Tomography
PLV	Phase Locking Value
PSD	Power Spectral Density
REn	Renyis Entropy
SampEn	Sample Entropy
SEn	Shannon Entropy
STFT	Short-Time Fourier Transform
SOM	Self-organizing Map
SpEn	Spectral Entropy
SVM	Support Vector Machine
VEP	Visual Evoked Potentials
WEn	Wavelet Entropy
WT	Wavelet Transform
WPD	Wavelet Packet Decomposition