شبكة المعلومات الجامعية

بسم الله الرحمن الرحيم

HOSSAM MAGHRABY

شبكة المعلومات الجامعية

شبكة المعلومات الجامعية

التوثيق الالكتروني والميكروفيلم

HOSSAM MAGHRABY

شبكة المعلومات الجامعية

جامعة عين شمس

التوثيق الإلكتروني والميكروفيلم

قسم

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HOSSAM MAGHRABY

AIN SHAMS UNIVERSITY

FACULTY OF ENGINEERING

Computer and Systems Engineering

Deep Learning Approaches for Motor Imagery Brain-Computer Interfaces

A Thesis submitted in partial fulfilment of the requirements of the degree of

Master of Science in Electrical Engineering

(Computer and Systems Engineering)

by

Raghda Hassan Mohamed

Bachelor of Science in Electrical Engineering

(Computer and Systems Engineering)

Faculty of Engineering, Ain Shams University, 2014

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Date: 25 May 2021

Statement

This thesis is submitted as a partial fulfilment of Master of Science in Electrical Engineering, Faculty of Engineering, Ain shams University.

The author carried out the work included in this thesis, and no part of it has been submitted for a degree or a qualification at any other scientific entity.

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Abstract

Motor imagery represents one Brain-Computer Interface (BCI) paradigm that has been utilized in developing applications to assist subjects with motor disability. Such paradigm relies on analyzing brain electroencephalography (EEG) activity to identify the intended movement direction. Existing motor imagery feature extraction techniques are focused on utilizing traditional signal processing and machine learning techniques. Recent advances in the deep learning field has inspired the development of few methods for motor imagery classification that achieved further performance improvement. This thesis introduces a deep neural network approach for motor imagery classification using Long Short-Term Memory (LSTM) combined with Autoencoders based on a sequence-to-sequence architecture. The proposed network extracts features from the frequency-domain representation of EEG signals. This network is trained to obtain low-dimensional representation of EEG features that are then fed into a multi-layer perceptron of 3 layers for classification. Systematic and extensive examinations have been carried out by applying the approach to public benchmark EEG datasets. The obtained results outperform classical state–of-the-art methods employing standard frequency-domain features and common spatial patterns, and comparative results to methods such as filter bank common spatial pattern and its variants. Our results indicate the efficacy of the proposed LSTM autoencoder approach in EEG motor imagery classification.

Keywords: Motor imagery, deep learning, long short-term memory, brain computer interface, EEG

Summary

A Brain-Computer Interface (BCI) system aims at processing brain signals to recognize human intention that is subsequently used to control an external device. BCI systems are based on monitoring and analyzing electroencephalography (EEG) brain activity. EEG activity is a non-invasive signal that can be include different patterns such as P300 evoked potentials, steady-state visual evoked potentials (SSVEP) and motor imagery (MI) rhythms. MI signals are evoked during the imagination of movement without performing the actual action. In this thesis, a deep learning approach based on Long-Short-Term-Memory and Autoencoder has been developed and introduced to solve Motor imagery classification problem competing with state-of-the-art methods.

The chapters of this thesis are divided into 5 chapters, which are as follows:

Chapter 1 provides an introduction to the thesis outlining the research scope, objectives and contributions.

Chapter 2 gives a literature review of brain computer interface, electroencephalography, motor imagery and machine learning.

Chapter 3 introduces the proposed approach along with a detailed description of the methods developed and the training process.

Chapter 4 demonstrates the achieved results and comparisons of our experiments and proposed approach to other approaches.

Chapter 5 gives the conclusions and future work.

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