SERB Sponsored Research Internships (VRITIKA):

Title: Exploring Deep Neural Architectures in Healthcare Applications through Brain Computer Interface

Summary:

Human neural states can be measured by analysing and understanding EEG (Electroencephalogram) signal in various applications such as neuro-science, Brain-Computer Interfaces (BCI), etc. It is an important area of research where deep learning algorithms are used to develop tools through brain computer interface for early detection of neurological diseases.

The development of assistive tool will help in healthcare domain through understanding cognitive and social exercise. The technological advancement of assistive device will help medical practitioner to understand new treatments for a wide variety of diseases and disorders. This will bring an improvement both the standard and accessibility of care of patients and will enhance the patients' health outcomes. The aim of this research internship is to propose new methods for analyzing neural data for medical diagnosis and improvement of human health through brain computer interface.

The neural data analysis will also help in early diagnosis of medical disease through assistive tool. This research will deal with brain data for solving perceptual tasks of human being. An advance technology will be explored to investigate human's functional brain development while solving neural tasks. To this end, we will develop a Brain Computer Interface (BCI) for online analysis of patient's neurological data to produce encouraging results in detection of medical disorder.

Objectives:

1. Performance evaluation of different deep neural architectures for detection of neural states through brain computer interface.

2. The understanding of neural states on different mental disorder people through encouragement of different neural tasks using BCI.

3. A strong interpretation on motor neural skills of healthy and disorder patients for development of pathological tool through neural data analysis.

4. Neural State Classification using Hybrid Deep Learning Techniques and feature ensemble models.

5. Exploring Deep Learning techniques for computational brain modelling

6. Development of Brain Computer Interface Applications and Neurosimulations through EEG data analysis methods.

Importance of the proposed project in the context of current status:

Human cognitive analysis is an exciting area of research in health care domain. It has a great social impact through understanding the human cognition using Brain Computer Interface. It will help in healthcare application for producing the encouraging results on detection of medical diseases through intervention of BCI.

Methodology:

The modern deep learning (DL) algorithms can be used on large electroencephalogram (EEG) data set after applying the data augmentation process on them. We will apply the Deep Belief Network (DBN) model based on the Restricted Boltzmann Machine (RBM) for unsupervised feature learning of EEG signals to extract salient features. This DBN model provides an unsupervised taxonomy-based system without human intervention.

We plan to apply other DL methods such Recurrent Neural Network (RNN), Convolution Neural Network (CNN) and Long Short Term Memory (LSTM) before and after implementing data augmentation methods. We also plan to apply multivariate adaptive regression splines (MARS) model for early detection of neural diseases and provide therapeutic intervention with modern Brain Computer Interface (BCI) tool.

In this research, it is very much interesting to understand how the human brain processes perceptual tasks for different categories of people. The human brain is highly complex structure with each organ performed a particular computational task.

The statistical deep learning algorithms will be applied to extract most intrinsic information from neural data. Analysing and understanding this information will help for detection of disease through intervention of BCI.

In order to also understand their neural motor skills, different cognitive tests must be devised to capture their mental ability. A multi-channel EEG neuro headset will be used to capture the information from brain organ. This novel idea will be very effective in capturing perceptual tasks by exploiting cognitive information of human brain.

Applications and Research Outcomes:

This research has large impact in medical field for diagnosis of medical diseases through understanding different neural states. A BCI interface will be developed to make an intelligent decision on disease prediction through exploiting the knowledge of acquired cognitive skills.

Proposed Plan of Research Work for Research Interns

List of Research Interns	Nature of Work	Research Objectives	Timelines to complete research work	
			Dec 2020	**Jan 2021**
Research Intern 01	Analytical	Neural State Classification using Hybrid Deep Learning Techniques and feature ensemble models.	a). Data Analysis b) Ensemble models for feature extraction	a). Explore deep learning methods for classification b). Compare with state-of-the art techniques
Research Intern 02	Theoretical + Experimental	The understanding of neural states on different mental disorder people through encouragement of different neural tasks using BCI.	a). Computational Brain Modelling b) Examine simulation results on different neural states	a). Estimation of Neural states using deep statistical learning methods b) Performance evaluation with BCI devices.
Research Intern 03	Experimental	A strong interpretation on motor neural skills of healthy and disorder patients for development of pathological tool through neural data analysis.	a). Computational Data Analysis b). Understanding neural motor skills using cognitive tests	a). Machine Learning Algorithms for classification b). Pathological Tool development.