Course Title: *Brain Computer Interaction (BCI)* L-T-P-C- 3-1-0-4 Institute Elective

Course Description:

This course will give an introductory idea of how the brain works in accordance with computers and how we can use that knowledge to develop various medical and non medical applications.

Course Objective:

This BCI course will provide the foundational knowledge on brain, BCI devices as well as the emerging frontiers of brain interface technologies. Armed with this knowledge, the students may explore careers in the field of cognitive engineering, from engaging in deep discovery, coming up with inventions, helping solve some human health problems, or identify problems that may lead to discoveries about the interaction mechanisms.

Syllabus:

Module I: Introduction to Brain Computer Interface

- Definition and overview of BCI.
- History of BCI.
- Synapses, neurons and working of the brain and its various lobes.
- Neural mechanisms, transfer of neuronal information.
- Brain computer interface types - Invasive, Semi-invasive, Non-invasive.
- An Introduction to Non Invasive Acquisition approaches - EEG, MEG, fNIRS, fMRI.
- Application of BCI in medical and non medical fields.

Module II: EEG based BCI

- EEG and Why EEG?
- EEG Hardwares, EEG electrode systems.
- EEG Data Acquisition approaches, Experimental setups, EEG Recording and analysis softwares
- Neural Potentials- ERP, P300, SSVEP, ASSR, SCP, Motor Imagery
- Biological artifacts

Module III: Signal processing and Data Analysis

- Signal Pre-processing: Epoching and noise removal
- Filtering techniques
- Feature Engineering- Feature extraction, reduction and optimization
- Classification and Clustering

Module IV: BCI Applications I

- Cognitive Engineering
- Probing mind
- Vigilance detection using EEG signals
- Mental workload and Cognitive load estimation

- BCI in consumer marketing
- BCI for lie detection

Module V: BCI Applications II

- Understanding EEG dataset
- Segmentation of EEG data into epochs
- Filtering the data using band-pass, low-pass and high-pass filters
- Applying existing algorithms to remove artifacts
- Extracting features from EEG epochs and Finding redundant and irrelevant features
- Training and testing with classifiers and Quantitative analysis

Tentative teaching Plan:

Module 1-> 2 weeks
Module 2-> 2 weeks
Module 3-> 4 weeks
Module 4-> 2 weeks
Module 5-> 2 weeks

Course Assessment or Evaluation:

Examination: 50%
Mid Semester Exam: 20%
End Semester Exam: 30%

Research work and home assignments: 30%

Class Participation: 10%

Scheduled Quizzes: 10%

Textbook:

Brain-Computer Interfacing: An Introduction, Rajesh P. N. Rao, Cambridge university press, 2019

References:

1. Brain-Computer Interfaces: Principles and Practice, Jonathan Wolpaw (editor), Oxford university Press, 2012
2. Cognition, Brain, and Consciousness: Introduction to Cognitive Neuroscience, Second Edition, Bernard J. Baars, Nicole M. Gage, Academic Press, 2010
3. Bishop, Christopher M. Pattern recognition and machine learning. springer, 2006.
4. Satish Kumar, Neural networks: A classroom approach, Tata McGraw Hill, 2011.
5. J. S. R. Lang, C. T. Sun and E. Mizutaju, Neuro-fuzzy and soft computing, Pearson Education, 1996.

6. David E. Goldberg , Genetic Algorithms in Search, Optimization, and Machine Learning, Addison-Wesley, 1989

Web references:

1. **https://sccn.ucsd.edu/wiki/Introduction_To_Modern_Brain-Computer_Interface_Design**