Team Code: TY4-3A
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Domain: - BCI & Neurotechnology

Tentative Title: **Next-Generation Brain-Computer Interfaces: A Comparative Study of Brain Hacking, Brain-Controlled Driving Systems, EEG-Based Stress & Emotion Detection, and Mind-Controlled Gaming**

Objective Description: - To analyze and compare the principles, performance, applications, and challenges of brain-computer interface (BCI) technologies applied to brain-controlled cars, in order to evaluate their potential for enabling safe, efficient, and independent mobility solutions for physically disabled individuals.

Team Member 1: Shivam Wadatkar

Paper 1

Title: Brain Controlled Car for Disabled Using Artificial Intelligence
Authors: Shriaarthi B, Suganya B, S.S. Sridevi

- **Problem Statement**: Physically disabled people cannot drive conventional cars. Current assistive driving systems rely on physical input, limiting accessibility.
- **Intervention**: Development of a brain-driven car using a biocontrol system that integrates EEG-based BCI, automatic navigation, and security systems. Low-Frequency Asynchronous Switch Design (LF-ASD) is used to decode motor neuron signals.
- **Comparison**: Compared driver control with and without BCI, and tested EEG-driven systems vs. conventional input.
- **Outcome**: Achieved high accuracy (70–82% with imaginary movement, >99% classification accuracy). The system successfully enabled disabled drivers to control navigation, with safety ensured through automatic navigation and collision detection.

Paper 2

Title: Brain Controlled Car for Disabled Using EEG
Authors: Saikrishna D, Neethal Ephram, Shahas Ahamed, Dr. M. Rajeswari

- **Problem Statement**: Disabled individuals lack independent mobility; conventional EEG systems are expensive and limited in real-time vehicle applications.
- **Intervention**: Implementation of a low-cost EEG-based brain-controlled car using NeuroSky EEG headset + Arduino (ATMEGA 328) + Bluetooth HC-05 to interpret brain signals and control motors (L293D).
- **Comparison**: Evaluated against traditional physical control systems and other assistive devices (wheelchairs). Compared different brain wave states (Delta, Theta, Alpha, Beta) for vehicle control.
- **Outcome**: Demonstrated successful real-time control of car (forward, reverse, stop, lock/unlock). Low-cost design makes it accessible. Future enhancements include automatic navigation, speed control, and traffic sign detection.

Paper 3

Title: Review of the State-of-the-Art of Brain-Controlled Vehicles

Authors: Amin Hekmatmanesh, Pedro H. J. Nardelli, Heikki Handroos

- **Problem Statement:** Current vehicle systems require physical input, limiting accessibility for disabled individuals and efficiency in hazardous or remote tasks. Existing BCI-based vehicle control faces issues like EEG noise, slow response, low robustness, and limited real-time performance.
- **Intervention:** A review of bio-signal-based control methods (EEG, EOG, EMG, fNIRS, fMRI) applied to brain-controlled terrestrial and aerial vehicles. The study analyzes preprocessing, feature extraction, classifiers (SVM, LDA, KNN, CNN, NN), optimization methods (WDO, CTWO), and hybrid systems using external sensors (GPS, cameras, motion sensors).
- **Comparison:** Compared bio-signal patterns (ERD/ERS, SSVEP, P300, RP, LEP), classification algorithms (linear vs nonlinear), EEG-only vs hybrid systems, and terrestrial vs aerial vehicle applications.
- **Outcome:** Reported accuracies of 70–90% for brain-command recognition, with hybrid approaches achieving higher precision and faster response. Identified improvements in safety and navigation but noted persistent challenges such as EEG noise, inter-user variability, and delays. Suggested future solutions include deep learning, IoT/5G integration, and enhanced hybrid models.

Paper 4

Title: Brain Controlled Car for Disabled Using Artificial Intelligence
Authors: Vinodh Kumar R, Vishnu Priya S G, Vijayaraj T, Saran M

- **Problem Statement**: Physically disabled people require assistive mobility systems. Current AI and BCI systems are limited in security, navigation, and integration with real-world driving.

- **Intervention**: Proposed an AI-based asynchronous BCI system integrating EEG helmet, automatic navigation (GPS + sensors), security verification (video + thermal images), and robotic seat adjustments for accessibility.
- **Comparison**: Compared BCI-based vehicle control with conventional driving, highlighting faster reaction times (e.g., braking without muscular delay). Compared against older assistive systems.
- **Outcome**: Demonstrated feasibility of AI-assisted brain-driven cars for disabled drivers. Key features: automatic navigation, obstacle detection, emergency fallback. Identified risks like hacking, signal interference, and cost, but concluded the system could revolutionize accessible transport.

Paper 5

Title: A Novel Asynchronous Brain Signals-Based Driver–Vehicle Interface for Brain-Controlled Vehicles
Authors: Jinling Lian, Yanli Guo, Xin Qiao, Changyong Wang, Luzheng Bi

- **Problem Statement**: Current brain-controlled cars are mostly synchronous (step-by-step) and not practical for continuous driving. They also need frequent calibration and give limited control.
- **Intervention**: Designed an asynchronous brain–vehicle interface that uses brain signals (EEG) to control direction (forward, turn, speed) without waiting for system prompts.
- **Comparison**: Compared two methods (FLDA and SVM) to check which gives better accuracy in detecting brain commands. Also compared with older systems that only worked in steps.
- **Outcome**: Achieved about 84–90% accuracy in recognizing brain commands. In driving tests, some people drove smoothly while others struggled (showing training is needed). The system proved continuous brain-controlled driving is possible.

Team Member 2: Salman Shaikh

Paper 1

Title: Hacking the Brain: Dimensions of Cognitive Enhancement

Authors: Marcello Ienca & Pim Haselager

- Problem Statement: People want to improve memory, focus, and learning, but the brain has natural limits and slows down with age.
- Intervention: Methods like smart drugs, caffeine, brain stimulation, exercise, sleep, meditation, and video games.
- Comparison: Compared with (1) doing nothing/placebo, (2) natural brain ability, (3) other methods (drug vs. physical vs. behavioral).
- Outcome: Better thinking skills (memory, focus, creativity, speed) but also side effects, fairness issues, and acceptance problems.

Paper 2

Title: Hacking the Brain: Brain–Computer Interfacing Technology and the Ethics of Neurosecurity

Authors: Marcello Ienca & Pim Haselager

- Problem Statement: BCIs let the brain connect directly with machines, but hackers could steal or change brain data, risking privacy and safety.
- Intervention: Add strong security, laws, and ethics in BCI design and use.
- Comparison: Compared with (1) BCIs without security, (2) normal cybersecurity that isn't enough for brain data.
- Outcome: Safer BCIs, better protection of thoughts and choices, more trust in the technology.

Paper 3

Title: Transcending the Brain: Is There a Cost to Hacking the Nervous System?

Authors: Shujhat Khan & Tipu Aziz

- Problem Statement: Tech like BCIs, deep brain stimulation, and brain currents can help patients, but using them for healthy people may blur therapy and superhuman enhancement.
- Intervention: Using neurotechnology for treatment, recovery, and enhancement.
- Comparison: Compared with (1) regular therapies without tech, (2) using only for patients vs. also for healthy people.
- Outcome: Helps patients recover and communicate better, but raises big debates about safety, fairness, and ethics when used on healthy people.

Paper 4

Title: Brainjacking in Deep Brain Stimulation and Autonomy

Authors: Jonathan Pugh, Laurie Pycroft, Anders Sandberg, Julian Savulescu

- Problem Statement: DBS implants treat brain diseases but can be hacked ("brainjacking"), risking control of emotions, thinking, and autonomy.
- Intervention: Add security designs, regulations, and oversight to protect DBS systems.
- Comparison: Compared with (1) DBS without protection (easy to hack), (2) current weak practices vs. stronger safeguards, (3) no regulation vs. strict rules.
- Outcome: Safer DBS, protection of autonomy and emotions, more trust in the device.

Paper 5

Title: Beyond Neural Data: Cognitive Biometrics and Mental Privacy

Authors: Patrick Magee, Marcello Ienca, Nita Farahany

- Problem Statement: Wearable tech (BCIs, smart headsets, VR/AR) can read brain signals and mental states. This may reveal private thoughts and traits, risking mental privacy.
- Intervention: Stronger privacy laws, rules, and privacy-by-design devices.
- Comparison: Compared with (1) current weak protections vs. new stronger protections, (2) devices that collect lots of mental data vs. those that limit data.
- Outcome: Better protection of private thoughts, less misuse of brain/mental data, more trust in neurotechnology.

Team Member 3: Paras Shinkar

Paper 1

Title: Human emotion recognition from EEG-based brain-computer interface using machine learning: a comprehensive review

Authors: Essam H. Houssein, Asmaa Hammad, Abdelmgeid A. Ali

- Problem Statement: The study addresses the need for accurate and objective emotion recognition methods in affective computing, as external cues are often unreliable due to social masking. EEG signals are a promising, real-time alternative, but require effective techniques for analysis.
- Intervention: This is a review paper summarizing methods for emotion recognition using multi-channel EEG signals. It covers various techniques for feature extraction, selection, and classification using both machine learning and deep learning algorithms.
- Comparison: The paper compares physiological signals like EEG to less reliable methods such as facial expressions and speech. It also analyzes the performance of different machine learning and deep learning algorithms for classifying emotional states.
- Outcome: EEG signals are a reliable and objective source for emotion recognition. The review concludes that deep learning methods generally outperform traditional machine learning techniques, with some studies achieving accuracies over 80%.

Paper 2

Title: Emotional Stress Recognition Using Electroencephalogram Signals Based on a Three-Dimensional Convolutional Gated Self-Attention Deep Neural Network

Authors: Hyoung-Gook Kim, Dong-Ki Jeong, Jin-Young Kim

- Problem Statement: The paper addresses the crucial need for early mental stress detection, as traditional methods like questionnaires are often inaccurate and time-consuming. A robust method is needed to accurately recognize stress from complex EEG signals.
- Intervention: The study proposes a novel method using a three-dimensional (3D) convolutional gated self-attention deep neural network (3DCGSA). This network extracts spatiotemporal

features from EEG signals decomposed into frequency bands and uses a gated self-attention mechanism to capture global dependencies.
- Comparison: The proposed 3DCGSA method is compared against a range of other conventional methods, including machine learning approaches (EF-SVM, RF-FS) and deep learning architectures (CRNN, SFCSAN, 3DRADNN, etc.).
- Outcome: The 3DCGSA method achieved the highest recognition accuracy on all three benchmark datasets (DEAP, VRE, and EDESC). The results confirm that this network's approach to analyzing EEG patterns can accurately distinguish stress states.

Paper 3

Title: EEG-based Emotion Recognition: The Influence of Visual and Auditory Stimuli

Authors: Danny Oude Bos

- Problem Statement: The author sought to determine if EEG signals could provide a more objective measure for emotion recognition compared to external cues that can be consciously adapted. It was crucial to find the optimal electrode placement and features for a limited-electrode device.
- Intervention: This research focused on recognizing emotions from EEG signals recorded with a five-electrode device. The study used visual, auditory, and audiovisual stimuli to elicit emotions and analyzed filtered EEG data (alpha and beta bands) with a linear binary Fisher's Discriminant Analysis classifier.
- Comparison: The study compared the recognizability of emotions elicited by three different stimulus modalities: visual, auditory, and audiovisual. It also evaluated different EEG features from two electrode locations, Fpz and F3/F4.
- Outcome: The study found that emotions are recognizable from EEG signals, with binary classification rates over 90%. However, visual stimuli proved more difficult to classify than auditory and audiovisual ones.

Paper 4

Title: Improved EEG-based emotion recognition through information enhancement in connectivity feature map

Authors: M. A. H. Akhand, Mahfuza Akter Maria, Md Abdus Samad Kamal, Kazuyuki Murase

- Problem Statement: Emotion recognition from EEG signals is challenging because traditional connectivity feature maps (CFMs) are often symmetric and contain redundant information, which is inefficient for training machine learning models.
- Intervention: The study proposes an innovative "fused CFM" that combines the measures of two different connectivity methods (e.g., PCC and PLV) into a single map. This technique reduces redundancy by filling the map's triangles with distinct values from the two methods.
- Comparison: The performance of the proposed fused CFMs is compared against traditional CFMs based on a single connectivity method (e.g., PCC, PLV, MI, TE). It also compares its performance with other state-of-the-art emotion recognition methods.

- Outcome: The fused CFM method provided superior performance on the DEAP dataset. The PLV+MI combination achieved the highest accuracies for Valence (91.29%) and Arousal (91.66%). This method enhances information without increasing training time.

Paper 5

Title: Application of Electroencephalography-Based Machine Learning in Emotion Recognition: A Review

Authors: Jing Cai, Ruolan Xiao, Wenjie Cui, Shang Zhang, Guangda Liu

- Problem Statement: Emotion recognition is a prominent area in human-computer interaction. External expressions can be deceptive, so a more genuine method is needed. EEG signals provide a reliable measure of brain activity related to emotion, posing the challenge of effectively using machine learning to classify these states.
- Intervention: This review paper outlines the standard workflow for EEG-based emotion recognition using machine learning. It covers four main steps: signal acquisition, preprocessing to remove noise, feature extraction to find specific patterns, and using various classifiers to categorize emotions.
- Comparison: The review implicitly compares different techniques within each stage of the emotion recognition pipeline. For example, it contrasts using EEG signals with other physiological data and external cues like facial expressions. A table is also provided summarizing the performance of different classification models.
- Outcome: The review shows that a wide range of machine learning and deep learning models have been successfully applied to this problem. While significant progress has been made, future goals include detecting smaller emotional changes and reducing algorithmic complexity for use in real-time on wearable devices.

Team Member 4: Yash Vernekar

Paper 1

Title: The Effect of Mind and Intelligence Games on University Students’ Perceived Stress and Psychological Well-Being Level
Authors: Kaya, Demir, & Yilmaz,

- Problem (P): University students face significant academic, financial, and social pressures that often lead to high stress levels. Chronic stress negatively impacts mental health, learning ability, concentration, and overall well-being.
- Intervention (I): Mind and intelligence game workshops.
- Comparison (C): Control group with no participation.
- Outcome (O): Reduced stress and improved psychological well-being.

Paper 2

Title: The Effect of Intelligence and Mind Games on Secondary School Students' Writing Success
Authors: Öztürk, Şahin, & Acar,

- Problem (P): Secondary school students struggle to develop writing skills through traditional textbook-based teaching.
- Intervention (I): Intelligence and mind games integrated into Turkish writing lessons.
- Comparison (C): Traditional textbook teaching.
- Outcome (O): Increased writing success, attention, and motivation.

Paper 3

Title: The Effect of Mind Games Activities on Problem-Solving and Computational Thinking Skills of Grade 5 Students
Authors: Yıldırım, Çelik, & Karaman,

- Problem (P): Students lack problem-solving and computational thinking skills needed for 21st-century learning.
- Intervention (I): Six-week structured mind games program (Sudoku, Kendoku, Kakuro, Three Stone game).
- Comparison (C): Pre-test vs. post-test design.
- Outcome (O): Improved problem-solving and computational thinking; more enjoyable learning.

Paper 4

Title: Brain Training Games Enhance Cognitive Function in Healthy Subjects
Authors: Thompson, Lee, & Suzuki, K.

- Problem (P): Healthy adults experience cognitive decline, reduced memory, and focus issues.
- Intervention (I): Three-week Lumosity brain training (15–30 min/day).
- Comparison (C): Control group with no training.
- Outcome (O): Enhanced cognitive functions (attention, memory, processing speed) correlated with BDNF/APOE biomarkers.

Paper 5

Title: Effect of Mind Games on Mental Health Among Pre-Service Teachers
Authors: Arslan, N., Kocak, & Patel, R.

- Problem (P): Pre-service teachers face stress, anxiety, and reduced well-being due to academic and professional challenges.
- Intervention (I): Four-week mind games program with puzzles, strategy games, and problem-solving tasks.

- Comparison (C): Control group with no intervention.
- Outcome (O): Improved mental health, higher well-being (WEMWBS), reduced stress, better coping strategies.