HUMAN RELIABILITY ESTIMATION

Metrics and Modalities to evaluate the Human Performance-

1. Workload ( EEG)
2. Attention (EEG + Video)
3. Vigilance levels (EEG + EMG + ECG + Video)
4. Mental Fatigue (EEG)
5. Anxiety (EEG)
6. Working Memory (EEG)
7. Relaxation (EEG)
8. ErRP (EEG + ECG)
9. Drowsiness ( EEG + Video)

**a. ANXIETY-**

**Informal Definition:**

Anxiety is the natural response of the body to a stressful scenario. Anxiety originates due to factors that are persistent and continues to exist even after the stressful situation is over.

**Formal Definition:** Anxiety is an emotion characterized by feelings of tension, worried thoughts and physical changes like increased blood pressure. People with anxiety disorders usually have recurring intrusive thoughts or concerns. (<https://www.apa.org/topics/anxiety#:~:text=Anxiety%20is%20an%20emotion%20characterized,recurring%20intrusive%20thoughts%20or%20concerns>. )

Anxiety can be categorized into two main types i.e., state anxiety and trait anxiety. State anxiety echoes the psychological and physiological response of a person to a particular situation at hand whereas, on the contrary, trait anxiety describes the personality trait of an individual. Human trait anxiety is commonly measured using rest state recording whereas, state anxiety is an instant form of anxiety and is generally measured in response to some stimulus which instigates mental strain.

**Existing Approaches:**

1. **EEG‐Based Anxious States Classification Using Affective BCI‐Based Closed Neurofeedback System  
   (**[**https://link.springer.com/article/10.1007/s40846-020-00596-7**](https://link.springer.com/article/10.1007/s40846-020-00596-7) **)  
     
   Idea:** This study designed a closed neurofeedback experiment that contains three experimental stages to adjust subjects’ mental state. The EEG resting state signal was recorded from thirty-four subjects in the first and third stages while EEG-based mindfulness recording was recorded in the second stage. At the end of each stage, the subjects were asked to fill a Visual Analogue Scale (VAS). According to their VAS score, the subjects were classified into three groups: non-anxiety, moderate or severe anxiety groups.  
     
   **Pros:**  Through ten times tenfold cross-validation, classification results demonstrated that the average classification accuracy of Gaussian + one-vs-one is 92.30 ± 1.31%, the average accuracy of Gaussian + one- vs-rest is 92.48 ± 1.20%.  
     
   **Cons:** Other modalities such as heartbeat and blodd pressure could also have been incorporated.

**b.WORKING MEMORY-**

**Informal:**

Working memory is the small amount of information that can be held in mind and used in the execution of cognitive tasks, in contrast with long-term memory, the vast amount of information saved in one’s life. It has often been connected or related to intelligence, information processing, executive function, comprehension, problem-solving, and learning,.

**Formal:**

Our work­ing memory is one of the central brain structures, which starts to develop in early childhood, and is mainly located in the prefrontal cortex (PFC), enabling us to process and temporally store task­relevant informa­tion and is, therefore, crucial to keep things in mind while performing complex tasks.  
(<https://link.springer.com/article/10.1007/s00702-011-0660-3> ).

Therefore, the working memory represents a central cognitive function and is assumed to operate whenever information has to be retained and manipulated over brief periods to guide an immediate response.

**Existing Approaches:**

1. **Characterizing Focused Attention and Working Memory Using EEG:**(<https://www.mdpi.com/1424-8220/18/11/3743> )  
     
   **Idea** - In this paper, an approach for the prediction of focused attention and working memory using EEG is proposed. EEG signals were recorded while the subjects undertook a cognitive test that stimulated these cognitive skills. The collected EEG signals were analyzed in the time and frequency domains to extract a set of 280 features, which were then used to train different classifiers.  
     
   **Pros-**  The proposed models provide generalizable and consistent results since they were obtained using a relatively-large sample size. In addition, the best obtained classification accuracies were 77% and 83%, respectively, using SVM binary classifiers.  
     
   **Cons-** Various Deep Learning Techniqueds using CNNs and RNNs could also been used.

**c.DROWSINESS-**

**Informal:**

A [tired](https://dictionary.cambridge.org/dictionary/english/tired) [state](https://dictionary.cambridge.org/dictionary/english/state), between [sleeping](https://dictionary.cambridge.org/dictionary/english/sleeping) and being [awake](https://dictionary.cambridge.org/dictionary/english/awake).

**Formal:**

Drowsiness is a transition of psychophysiological state from alert towards sleep causing degradation in concentration, thereby increasing the response time.

(<https://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=8833866&tag=1> )

**d) VIGILANCE-**

**Informal definition:**

Sustained attention, or vigilance, as it is more often called, refers to the state in which attention must be maintained over time.

**Formal** **definition:**

In modern psychology, vigilance, also termed sustained concentration, is defined as the ability to maintain concentrated attention over prolonged periods of time. During this time, the person attempts to detect the appearance of a particular target stimulus. The individual watches for a signal stimulus that may occur at an unknown time.

**Existing Approaches:**

1. **Automation in Construction  
   (**[**https://www.sciencedirect.com/science/article/pii/S0926580518307507**](https://www.sciencedirect.com/science/article/pii/S0926580518307507) **)  
     
   Idea-** Researchers proposed to implement electroencephalograph (EEG) to measure construction workers’ perceived risks based on their vigilance status. This paper adopts the Wavelet Packet Transform (WPT) to decompose hybrid kinematic-EEG signals into sub-bands to construct vigilance indicators for construction workers.  
     
   **Pros-** Compared with the results of NASA-TXL survey and the vigiance stage model (<https://brainclinics.com/eeg-vigilance-models-and-theory/> ), three indices shown high consistency and reliability. Hence, the approach can be developed further for the quantitative vigilance level measurement.  
     
   **Cons-** Real Time video was used for the purposes of event tagging only. Techniques such as eye tracking accompanied with the ECG signals can also bes used to determine vigilance levels.

**e.MENTAL WORKLOAD:**

**Informal-**

Mental workload reflects the amount of mental resources required to perform a set of concurrent tasks. Sustained high mental workload will cause mental fatigue, decreased performance, and even detrimental health effects in the long run.

**Formal-**

Workload is thought of as a mental construct, a latent variable, or perhaps an “intervening variable” (Gopher and Donchin 1986, p. 41-4), reflecting the interaction of mental demands imposed on operators by tasks they attend to. The capabilities and effort of the operators in the context of specific situations all moderate the workload experienced by the operator.

Workload can be characterized as a mental construct that reflects the mental strain resulting from performing a task under specific environmental and operational conditions, coupled with the capability of the operator to respond to those demands.

**Existing Approaches:**

**1.Recognition of the Mental Workloads of Pilots in the Cockpit Using EEG Signals**

**Idea:** A convolutional neural network is used to classify EEG features across different mental workloads in a continuous performance task. Results show that between the two models, projecting convolutional feature channels achieved higher performance, with 76.25% sensitivity and 87.81% specificity in WL detection in n-back-test leave-one-out subject evaluation and good task transfer with the detected WL increasing with the number of interruptions.

**Pros:** Achieved good accuracy for workload level measurement.  
  
**Cons**: Can also include other metrics such as ECG, EMG and eye tracking.

**f.ATTENTION:**

**Informal:**

In its most generic form, attention could be described as merely an overall level of alertness or ability to engage with surroundings.Attention is the ability to actively process specific information in the environment while tuning out other details.

**Formal:**

In his 1890 book “The Principles of Psychology,” psychologist and philosopher [William James](https://www.verywellmind.com/william-james-biography-1842-1910-2795545) wrote that attention is, “It is the taking possession by the mind, in clear and vivid form, of one out of what seem several simultaneously possible objects or trains of thought. Focalization, concentration, of consciousness are of its essence. It implies withdrawal from some things in order to deal effectively with others, and is a condition which has a real opposite in the confused, dazed, scatterbrained state.”.

**Existing Approaches:**

1. **EEG‐Based Detection Model for Evaluating and Improving Learning Attention-  
   (**[**https://link.springer.com/article/10.1007/s40846-017-0344-z**](https://link.springer.com/article/10.1007/s40846-017-0344-z) **)**

**Idea-** To measure a student’s attention level precisely, and how to provide an effective attention recovery method for are topics worth attention in the field of learning. The study also observes the relationship between brain wave changes and varying attention levels during learning, and provides attention recovery methods that can help students restore attention and improve their learning efficiency.

**Pros-** This research integrated singular value decomposition, the Fourier transform, the minimum entropy principle, and an associative Petri net to develop an attention evaluation technique. The level of accuracy achieved by this technique (> 90%) is higher than that of the other techniques. It also concluded that napping can help all participants recover their

Focus.  
  
**Cons-** No video tracking methods such as eye tracking or blinking count were used.

**g.MENTAL FATIGUE:**

**Informal:**

Mental fatigue refers to a feeling of tiredness or exhaustion, and a disengagement from the task at hand.

**Formal:**

Mental fatigue is associated with excessive demands on neural and cognitive systems. Mental fatigue can lead to suboptimal functioning of the cognitive systems that involve attention, planning, and adaptively changing strategies in the face of negative outcomes. From a behavioral standpoint, mental fatigue manifests itself as deteriorated performance, which is typically seen in target-detection failure, escalating reaction times, and the subjective experience of fatigue.

**(**[**https://www.sciencedirect.com/science/article/pii/S2095809918304958#:~:text=Heuristically%2C%20mental%20fatigue%20refers%20to,impaired%20cognitive%20and%20behavioral%20performance**](https://www.sciencedirect.com/science/article/pii/S2095809918304958#:~:text=Heuristically%2C%20mental%20fatigue%20refers%20to,impaired%20cognitive%20and%20behavioral%20performance)**. )**

**Existing Approaches:**

1. **Using EEG for Mental Fatigue Assessment: A Comprehensive Look Into the Current State of the Art (**[**https://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=8827306**](https://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=8827306) **)  
     
   Pros-** Various approaches in time, frequency, and time–frequency domains were discussed.  
     
   **Cons-** The deep learning models are currently not emphasized till date.

**h.RELAXATION:**

**Informal:**

Relaxation in [psychology](https://en.wikipedia.org/wiki/Psychology) is the [emotional state](https://en.wikipedia.org/wiki/Emotional_state) of a living being, of low tension, in which there is an absence of [arousal](https://en.wikipedia.org/wiki/Arousal), particularly from negative sources such as [anger](https://en.wikipedia.org/wiki/Anger), [anxiety](https://en.wikipedia.org/wiki/Anxiety), or [fear](https://en.wikipedia.org/wiki/Fear).

**Formal:**

**i.ERROR RELATED POTENTIALS:**

**Informal:**

When a person recognizes an error during a task, an error-related potential (ErrP) can be measured as response. It has been shown that ErrPs can be automatically detected in tasks with time-discrete feedback, which is widely applied in the field of Brain-Computer Interfaces (BCIs) for error correction or adaptation.

**Formal:**

Error-related potentials (ErrPs) are neurophysiological signals associated with error processing. They are generated when wrong actions are perceived. They has appeared in different contexts like when a subject perceives that he/she has committed an error and recognizes it immediately (‘response ErrP’), when a subject receives the feedback of a previous choice without knowing whether it was wrong (‘feedback ErrP’), when observing mistakes of another person or agent (‘observation ErrP’)’ or during the interaction with a brain-computer interface (BCI) when the feedback is not the expected one (‘interaction ErrP’).

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