EEG-Based Stress Detection Using Deep Learning Techniques : A Survey

Perera K.M.S.
Student
Dept of Computer Engineering
University of Peredeniya
Sri Lanka
milindaperera14996@mail.com

Moda malisha
Student
Dept of Computer Engineering
University of Peredeniya
Sri Lanka
milindaperera14996@mail.com

Moda nadeeka
Student
Dept of Computer Engineering
University of Peredeniya
Sri Lanka
milindaperera14996@mail.com

***Abstract*—Distinguishing between simple physiological arousal and the maladaptive state of true stress is crucial. This harmful condition arises when environmental demands exceed an organism's coping capacity, impairing physiological recovery. Due to its widespread negative impact, early and accurate detection of maladaptive stress is vital for protecting personal, social, and economic wellbeing in today's fast-paced world. Electroencephalography (EEG), as a primary method for monitoring neural activity, has shown significant promise in identifying the distinct brain states associated with this stress. Modern deep learning architectures provide a powerful approach by automatically extracting meaningful patterns and hierarchical features from complex EEG data. This comprehensive survey offers researchers, practitioners, and technology enthusiasts a definitive overview of current advancements and highlights the future directions of EEG-based stress detection using deep learning.**

***Index Terms*—component, formatting, style, styling, insert.**

I. Introduction

Stress [1] is any intrinsic or extrinsic stimulus that evokes a biological response, and it can be a triggering or aggravating factor for many pathological conditions [THE IMPACT OF STRESS ON BODY FUNCTION: A REVIEW]. This response is broadly categorized as acute stress, which results from the demands and pressures of the recent past or near future, or chronic stress, which is caused by long-standing pressures [A Survey of Affective Computing for Stress Detection]. If a stressor is overwhelming and cannot be resolved, it becomes chronic, leaving neuroendocrine parameters altered and compromising the immune system [The effects of chronic stress on health: new insights into the molecular mechanisms of brain–body communication]. This chronic state is linked to a wide range of serious illnesses, including cardiovascular dysfunctions, diabetes, cancer, and mental illnesses like depression [The effects of chronic stress on health: new insights into the molecular mechanisms of brain–body communication]. Furthermore, chronic stress can lead to macroscopic structural changes in the brain, such as atrophy, which in turn can cause significant disorders related to cognition and memory [THE IMPACT OF STRESS ON BODY FUNCTION: A REVIEW].To objectively identify stress, research has moved beyond subjective questionnaires to focus on measurable physiological signals ****. The most common methods capture the body's autonomic response, primarily by analyzing Heart Rate Variability (HRV) from Electrocardiography (ECG) signals ****. Other validated approaches include measuring Galvanic Skin Response (GSR), which tracks changes in sweat gland activity ****, and using infrared thermography to detect the rapid drop in skin temperature caused by peripheral vasoconstriction ****. While these peripheral signals are effective, another line of inquiry targets the source of the stress response itself: the electrical activity of the brain.This makes Electroencephalogram (EEG) signals a prime candidate, as they offer a non-invasive method to directly observe the brain's electrical activity and explore the intricacies of neural activity in response to stimuli. EEG is particularly valuable as it allows for the estimation of a person's stress in real-time due to its high temporal resolution. In fact, numerous studies utilizing traditional machine learning (ML) frameworks have already demonstrated significant success in this area. Classic algorithms, particularly the Support Vector Machine (SVM), have proven to be highly effective, with multiple studies achieving impressive classification accuracies well over 90% in detecting stress from EEG signals.While traditional ML has shown promise, it is often limited by a dependency on manual, time-consuming feature extraction [Deep Learning Approaches for Stress Detection: A Survey; A review on evaluating mental stress by deep learning using EEG signals]. This process requires expert knowledge and may not generalize well across different domains [Deep Learning Approaches for Stress Detection: A Survey]. Deep Learning (DL) architectures have emerged as a powerful alternative, as their key advantage is the ability to automatically learn representative and hierarchical features directly from high-dimensional, heterogeneous data [Deep Learning Approaches for Stress Detection: A Survey; Deep learning for electroencephalogram (EEG) classification tasks: a review]. This end-to-end learning capability is particularly well-suited for the complex, non-stationary, and low signal-to-noise ratio nature of EEG signals, eliminating the need for hand-crafted feature selection [A novel technique for stress detection from EEG signal using hybrid deep learning model; EEG classification of

Identify applicable funding agency here. If none, delete this.

driver mental states by deep learning; A review on evaluating mental stress by deep learning using EEG signals]. Within this domain, specific DL models have shown exceptional promise: Convolutional Neural Networks (CNNs) excel at extracting relevant spatial features [A review on evaluating mental stress by deep learning using EEG signals; Deep learning for electroencephalogram (EEG) classification tasks: a review], while Long Short-Term Memory (LSTM) networks are adept at capturing the crucial temporal dependencies in sequential data [A review on evaluating mental stress by deep learning using EEG signals; A novel technique for stress detection from EEG signal using hybrid deep learning model]. Furthermore, hybrid models combining CNNs and LSTMs are increasingly achieving high classification accuracies by leveraging the strengths of both architectures [A novel technique for stress detection from EEG signal using hybrid deep learning model; A review on evaluating mental stress by deep learning using EEG signals].

II. BACKGROUND

A. Stress

Stress is a psychophysiological response of the human body to internal or external stressors, manifesting in physical, mental, or emotional forms. It is triggered when an individual perceives a situation as challenging, threatening, or demanding. Stressors may be biological, developmental, psychological, socio-cultural, or environmental, and even positive events can disrupt homeostasis, the body's internal balance. Stress is generally classified into two main categories: short-term (episodic) and long-term stress (chronic). Short-term stress arises from specific tasks or situations such as examinations, deadlines, or sudden pressures. Repeated exposure to such stressors may result in episodic stress, often linked to anxiety and hypertension [2]. Prolonged exposure leads to chronic stress, which can cause depression, psychological disorders, and severe physical illnesses. Chronic stress disrupts the nervous system, impairs functional capacity, and adversely affects daily life [2].

Assessing stress is difficult because people react differently to the same stressor, and the same individual may react differently at different times. Clinical and psychological tools such as the Perceived Stress Scale are used for evaluation, but these survey-based methods are better suited for long-term psychological conditions and may not capture real-time stress fluctuations [3]. In addition, physiological methods use bio-signals like ECG-based HRV, speech patterns, and galvanic skin response, all of which change with mental stress. More recently, EEG has gained attention as a non-invasive and reliable signal for detecting stress-related brain activity, making it a key focus in deep-learning-based stress detection research.

Today, stress has become a major public health concern, intensified by fast-paced lifestyles, heavy workloads, and increasing academic pressure on students. Prolonged or unmanaged stress is linked to serious consequences such as depression, cardiovascular disease, weakened immunity, violent behavior, and even suicidal tendencies. These risks highlight the growing need for early detection, continuous monitoring, and timely intervention. Establishing reliable and efficient stress-detection frameworks can greatly improve overall well-being by helping individuals manage stress more effectively. Such systems can contribute to better academic performance, enhanced workplace productivity, and more responsive medical care, making stress detection an essential component of modern health monitoring solutions.

B. Units

- Use either SI (MKS) or CGS as primary units. (SI units are encouraged.) English units may be used as secondary units (in parentheses). An exception would be the use of English units as identifiers in trade, such as "3.5-inch disk drive".
- Avoid combining SI and CGS units, such as current in amperes and magnetic field in oersteds. This often leads to confusion because equations do not balance dimensionally. If you must use mixed units, clearly state the units for each quantity that you use in an equation.
- Do not mix complete spellings and abbreviations of units: "$\mathrm{Wb/m^2}$" or "webers per square meter", not "$\mathrm{webers/m^2}$". Spell out units when they appear in text: ". . . a few henries", not ". . . a few H".
- Use a zero before decimal points: "0.25", not ".25". Use "$\mathrm{cm^3}$", not "cc".)

C. Equations

Number equations consecutively. To make your equations more compact, you may use the solidus (/), the exp function, or appropriate exponents. Italicize Roman symbols for quantities and variables, but not Greek symbols. Use a long dash rather than a hyphen for a minus sign. Punctuate equations with commas or periods when they are part of a sentence, as in:

$$a + b = \gamma \tag{1}$$

Be sure that the symbols in your equation have been defined before or immediately following the equation. Use "(1)", not "Eq. (1)" or "equation (1)", except at the beginning of a sentence: "Equation (1) is . . ."

D. LaTeX-Specific Advice

Please use "soft" (e.g., `\eqref{Eq}`) cross references instead of "hard" references (e.g., `(1)`). That will make it possible to combine sections, add equations, or change the order of figures or citations without having to go through the file line by line.

Please don't use the `{eqnarray}` equation environment. Use `{align}` or `{IEEEeqnarray}` instead. The `{eqnarray}` environment leaves unsightly spaces around relation symbols.

Please note that the `{subequations}` environment in LaTeX will increment the main equation counter even when there are no equation numbers displayed. If you forget that, you might write an article in which the equation numbers skip from (17) to (20), causing the copy editors to wonder if you've discovered a new method of counting.

BibTeX does not work by magic. It doesn't get the bibliographic data from thin air but from .bib files. If you use BibTeX to produce a bibliography you must send the .bib files.

LaTeX can't read your mind. If you assign the same label to a subsubsection and a table, you might find that Table I has been cross referenced as Table IV-B3.

LaTeX does not have precognitive abilities. If you put a `\label` command before the command that updates the counter it's supposed to be using, the label will pick up the last counter to be cross referenced instead. In particular, a `\label` command should not go before the caption of a figure or a table.

Do not use `\nonumber` inside the `{array}` environment. It will not stop equation numbers inside `{array}` (there won't be any anyway) and it might stop a wanted equation number in the surrounding equation.

E. Some Common Mistakes

- The word "data" is plural, not singular.
- The subscript for the permeability of vacuum μ_0, and other common scientific constants, is zero with subscript formatting, not a lowercase letter "o".
- In American English, commas, semicolons, periods, question and exclamation marks are located within quotation marks only when a complete thought or name is cited, such as a title or full quotation. When quotation marks are used, instead of a bold or italic typeface, to highlight a word or phrase, punctuation should appear outside of the quotation marks. A parenthetical phrase or statement at the end of a sentence is punctuated outside of the closing parenthesis (like this). (A parenthetical sentence is punctuated within the parentheses.)
- A graph within a graph is an "inset", not an "insert". The word alternatively is preferred to the word "alternately" (unless you really mean something that alternates).
- Do not use the word "essentially" to mean "approximately" or "effectively".
- In your paper title, if the words "that uses" can accurately replace the word "using", capitalize the "u"; if not, keep using lower-cased.
- Be aware of the different meanings of the homophones "affect" and "effect", "complement" and "compliment", "discreet" and "discrete", "principal" and "principle".
- Do not confuse "imply" and "infer".
- The prefix "non" is not a word; it should be joined to the word it modifies, usually without a hyphen.
- There is no period after the "et" in the Latin abbreviation "et al.".
- The abbreviation "i.e." means "that is", and the abbreviation "e.g." means "for example".

An excellent style manual for science writers is [**?**].

F. Authors and Affiliations

The class file is designed for, but not limited to, six authors. A minimum of one author is required for all conference articles. Author names should be listed starting from left to right and then moving down to the next line. This is the author sequence that will be used in future citations and by indexing services. Names should not be listed in columns nor group by affiliation. Please keep your affiliations as succinct as possible (for example, do not differentiate among departments of the same organization).

G. Identify the Headings

Headings, or heads, are organizational devices that guide the reader through your paper. There are two types: component heads and text heads.

Component heads identify the different components of your paper and are not topically subordinate to each other. Examples include Acknowledgments and References and, for these, the correct style to use is "Heading 5". Use "figure caption" for your Figure captions, and "table head" for your table title. Run-in heads, such as "Abstract", will require you to apply a style (in this case, italic) in addition to the style provided by the drop down menu to differentiate the head from the text.

Text heads organize the topics on a relational, hierarchical basis. For example, the paper title is the primary text head because all subsequent material relates and elaborates on this one topic. If there are two or more sub-topics, the next level head (uppercase Roman numerals) should be used and, conversely, if there are not at least two sub-topics, then no subheads should be introduced.

H. Figures and Tables

a) Positioning Figures and Tables: Place figures and tables at the top and bottom of columns. Avoid placing them in the middle of columns. Large figures and tables may span across both columns. Figure captions should be below the figures; table heads should appear above the tables. Insert figures and tables after they are cited in the text. Use the abbreviation "Fig. 1", even at the beginning of a sentence.

TABLE I
TABLE TYPE STYLES

Table Head	**Table Column Head**		
	Table column subhead	***Subhead***	***Subhead***
copy	More table copy[a]		

[a]Sample of a Table footnote.

Figure Labels: Use 8 point Times New Roman for Figure labels. Use words rather than symbols or abbreviations when writing Figure axis labels to avoid confusing the reader. As an example, write the quantity "Magnetization", or "Magnetization, M", not just "M". If including units in the label, present them within parentheses. Do not label axes only with units. In the example, write "Magnetization (A/m)" or "Magnetization {A[m(1)]}", not just "A/m". Do not label axes with a ratio of

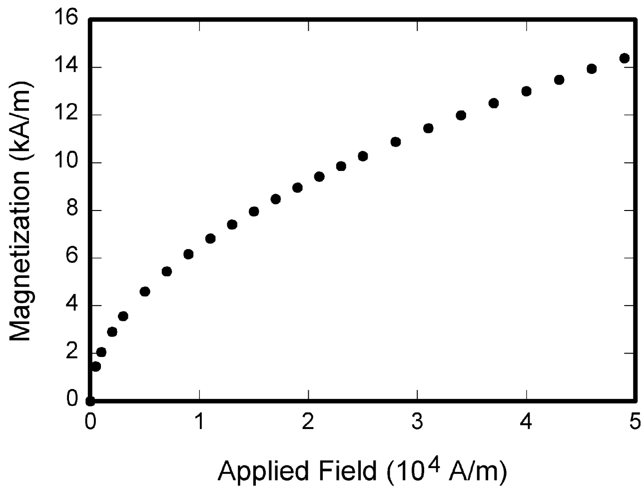

Fig. 1. Example of a figure caption.

quantities and units. For example, write "Temperature (K)", not "Temperature/K".

ACKNOWLEDGMENT

The preferred spelling of the word "acknowledgment" in America is without an "e" after the "g". Avoid the stilted expression "one of us (R. B. G.) thanks . . .". Instead, try "R. B. G. thanks. . .". Put sponsor acknowledgments in the unnumbered footnote on the first page.

REFERENCES

Please number citations consecutively within brackets [**?**]. The sentence punctuation follows the bracket [**?**]. Refer simply to the reference number, as in [**?**]—do not use "Ref. [**?**]" or "reference [**?**]" except at the beginning of a sentence: "Reference [**?**] was the first . . ."

Number footnotes separately in superscripts. Place the actual footnote at the bottom of the column in which it was cited. Do not put footnotes in the abstract or reference list. Use letters for table footnotes.

Unless there are six authors or more give all authors' names; do not use "et al.". Papers that have not been published, even if they have been submitted for publication, should be cited as "unpublished" [**?**]. Papers that have been accepted for publication should be cited as "in press" [**?**]. Capitalize only the first word in a paper title, except for proper nouns and element symbols.

For papers published in translation journals, please give the English citation first, followed by the original foreign-language citation [**?**].

REFERENCES

[1] H. Yaribeygi, Y. Panahi, H. Sahraei, T. P. Johnston, and A. Sahebkar, "The impact of stress on body function: A review," *EXCLI journal*, vol. 16, p. 1057, 2017.

[2] M. Kyrou, I. Kompatsiaris, and P. C. Petrantonakis, "Deep learning approaches for stress detection: A survey," *IEEE Transactions on Affective Computing*, vol. 16, no. 2, pp. 499–517, 2024.

[3] M. A. Hafeez and S. Shakil, "Eeg-based stress identification and classification using deep learning," *Multimedia Tools and Applications*, vol. 83, no. 14, pp. 42 703–42 719, 2024.

IEEE conference templates contain guidance text for composing and formatting conference papers. Please ensure that all template text is removed from your conference paper prior to submission to the conference. Failure to remove the template text from your paper may result in your paper not being published.