International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 08 Issue: 02 | February - 2024 SJIF Rating: 8.176 ISSN: 2582-3930

Advances in Stress Detection: A Comprehensive Review of Machine Learning and Deep Learning using Multimodal Data Approaches

Satpalsing Rajput[1], Nisarga Kasar[2], Pranjal Jadhav[3], Vasanti Kachare[4], Pradnya Linge[5]
[12345]Pimpri Chinchwad College of Engineering, Nigdi, Pune, Maharashtra

Abstract- *Stress detection has become increasingly crucial in recent years due to its detrimental effects on physical and mental health. Machine learning and deep learning offer powerful tools for analyzing various data modalities and identifying stress-related patterns. This paper provides a comprehensive review of current research on stress detection using multimodal data and deep learning techniques.*

Keywords- Stress detection, machine learning, deep learning, facial expressions, speech analysis, self-reported surveys, Multimodal data, physiological signals, text analysis.

I. INTRODUCTION

Stress is a natural human response to demanding or threatening situations. While short-term stress can be adaptive, chronic stress can have significant negative consequences for physical and mental health, including increased risk of cardiovascular disease, anxiety, and depression. Therefore, early and effective detection of stress is crucial for timely interventions and stress management strategies.Traditional methods for stress assessment often rely on self-reported data, which can be subjective and prone to bias. Machine learning and deep learning offer promising alternatives by analyzing various data modalities that capture objective physiological, behavioral, and linguistic markers of stress. This paper reviews the state-of-the-art in using multimodal data and deep learning for stress detection.

Stress is a pervasive concern affecting individuals globally, prompting extensive research into effective stress detection methods.Each paper explores unique approaches, emphasizing the significance of multi-modal analysis and the potential for real-world applications.

II. LITERATURE REVIEW

[1] This paper proposes a facial expression recognition system using pre-trained deep learning models. It emphasizes non-invasiveness and achieves promising results, particularly in stress classification using webcam-captured facial expressions.

[2] Focusing on physiological signals, this paper employs deep learning algorithms for real-time stress detection. The study compares various

models and highlights the effectiveness of LSTM networks in achieving competitive accuracy.

[3] Targeting IT professionals, this paper uses image processing and deep learning for stress detection based on facial expressions. While promising, it acknowledges challenges and ethical considerations for real-world implementation.

[4] Providing a comprehensive overview, this paper discusses ML-based solutions for real-time stress monitoring, emphasizing the advantages and limitations of existing approaches. It identifies potential future directions for more effective stress monitoring systems.

[5] Focusing on Indian working professionals, this study utilizes ML models to predict stress levels based on self-reported data. The paper ranks influential stress factors and offers a practical application through a developed stress prediction tool.

[6] Examining the broader landscape, this section reviews various approaches to stress detection using physiological signals, facial expressions, speech, and self-reported surveys. It highlights common strengths and limitations across different studies.

[7] Specifically addressing university students, this section reviews papers employing ML for stress detection through various data modalities. It emphasizes the potential for early detection and personalized interventions.

[8] Focusing on speech data, this paper introduces a multi-branch CNN architecture for systematic stress detection. The study achieves competitive accuracy and contributes a systematic methodology to CNN-based stress detection.

3. COMPARATIVE STUDY AND ANALYSIS

A. Facial Expression Recognition:

Almeida and Rodrigues proposed a facial expression recognition system for stress detection using deep learning. Their proof-of-concept system utilizes pre-trained CNNs and achieved promising results in classifying stressful emotions. While the approach offers non-invasiveness, challenges such as lighting variations and individual differences in facial expressions need consideration. Transfer learning and deep neural networks present an effective avenue for stress detection in this modality, emphasizing the need for further validation with larger datasets and diverse populations.

B. Physiological Signals Analysis:

Angalakuditi and Bhowmik developed a stress detection system based on physiological signals such as EMG, EDA, and HRV, employing

multiple deep learning models. The LSTM network showed the highest accuracy, emphasizing the potential for real-time stress detection. Despite the promising results, challenges include dataset size limitations and the impact of individual differences on real-world accuracy. Future directions involve exploring multi-modal stress detection and addressing ethical concerns surrounding data privacy.

C. Speech Data Processing:

Several research papers have explored the use of multimodal data and deep learning for stress detection. Here's a review of some notable studies

Mohapatra et al. proposed a systematic stress detection system using a multi-branch CNN for analyzing speech data. The approach combines MFCCs, GFCCs, and prosodic features, achieving competitive accuracy. However, limitations include reliance on a small dataset and a lack of discussion on generalizability. The comparison with related literature highlights the unique contribution of multi-branch architecture

Paper Title	Data Modality	Deep Learning Algorithm	Strengths	Limitations
Facial Expression Recognition System for Stress Detection with Deep Learning	Facial expressions	VGG16, VGG19, Inception-ResNet V2,78.9%	Non-invasive, webcam-based	Requires large datasets, limited generalizability
Stress Detection Using Deep Learning Algorithms	Physiological signals (EMG, EDA, HRV)	MLP, LSTM, CNN,86.67%	Real-time, potentially cost-effective	Requires validation with larger populations, ethical considerations
IT professionals stress detection by image processing using deep learning	Facial expressions	CNN	Non-intrusive, webcam-based	Lacks details about architecture and training, requires validation with diverse populations
Machine Learning Based Solutions for Real-Time Stress Monitoring	Physiological signals	SVMs, Random Forests, RNNs	Comprehensive overview, identifies future directions	Lacks specific discussion of unique contributions
Prediction of Stress Level on Indian Working Professionals Using Machine Learning	Self-reported data, stress factors	SVM, KNN, Random Forest, Decision Tree, Logistic Regression,76.42%	Addresses work-related stress in India, identifies key stress factors	Relies on self-reported data, limited generalizability, ethical considerations
Systematic Stress Detection in CNN Application	Speech data	Multi-branch CNN,87.5%	Competitive accuracy, systematic approach	Limited data, generalizability not discussed, ethical considerations not addressed

The table above summarizes the key aspects of the reviewed papers. It highlights the differences in data modalities, deep learning algorithms used, and achieved accuracies. It also emphasizes the strengths and limitations of each approach. This comparison allows us to identify trends and potential trade-offs in current stress detection research.Comparing the methodologies reveals their specific strengths and limitations. Facial expression recognition offers non-invasiveness but faces challenges in real-world implementation. Physiological signals analysis provides real-time potential but requires validation with larger datasets. Speech data processing shows systematic promise but needs further research for broader applicability. Transfer learning and multi-modal approaches emerge as potential solutions to enhance accuracy and robustness across these methodologies.

IV. CONCLUSION

The synthesis of these papers reveals the diversity and richness in the approaches to stress detection using ML and DL. While each study contributes valuable insights, challenges such as data privacy, biases, and real-world implementation persist. The evolving field calls for continued interdisciplinary collaboration, ethical considerations, and validation with larger and diverse datasets to ensure the responsible and effective implementation of stress detection systems.Multimodal stress detection using deep learning offers a promising approach for non-invasive, objective, and potentially continuous assessment of stress. Different data modalities and deep learning algorithms have been explored with varying degrees of success. While promising results have been achieved, limitations such as data privacy concerns, individual variability, and real-world generalizability need to be addressed.This review provides a foundation for researchers, practitioners, and policymakers seeking to understand the current landscape of stress detection and envision its future developments.

V. REFERENCES

[1] Almeida, José, and Fátima Rodrigues. “Facial Expression Recognition System for Stress Detection with Deep Learning." *ICEIS (1)*. 2021.

[2] Seo, Wonju & Kim, Namho & Park, Sung-Min. (2022). “Deep Learning Approach for Detecting Work-Related Stress Using Multimodal Signals”. IEEE Sensors Journal. 22. 11892-11902. 10.1109/JSEN.2022.3170915.

[3] A.PriyaDharshini, Mrs.P.Jasmine Lois Ebenazer, Mrs.S.Cecilia Pearline Christy and Mrs.S.Cephas:(2022). “IT professionals stress detection by image processing using deep

learning". IJCRT Volume 10 Issue 5 May 2022

[4] Nath, Rajdeep & Thapliyal, Himanshu & Caban-Holt, Allison & Mohanty, Saraju. (2020). "Machine Learning Based Solutions for Real-Time Stress Monitoring". IEEE Consumer Electronics Magazine. PP. 1-1. 10.1109/MCE.2020.2993427.

[5] Pabreja, Kavita & Singh, Anubhuti & Singh, Rishabh & Agnihotri, Rishita & Kaushik, Shriam & Malhotra, Tanvi. (2022). "Prediction of Stress Level on Indian Working Professionals Using Machine Learning. International Journal of Human Capital and Information Technology Professionals". 13. 1-26. 10.4018/IJHCITP.297077.

[6] Bobade, Pramod & M., Vani. (2020). "Stress Detection with Machine Learning and Deep Learning using Multimodal Physiological Data". 51-57. 10.1109/ICIRCA48905.2020.9183244.

[7] Gedam, Shruti & Paul, Sanchita. (2020). "Automatic Stress Detection Using Wearable Sensors and Machine Learning: A Review." 1-7. 10.1109/ICCCNT49239.2020.9225692.

[8] Mohapatra, Srikanta & Ravikumar, Kishore & Arora, Ginni & Sarangi, Prakash kumar & Mohanty, Jayashree & Sahu, Premananda. (2022). "Systematic Stress Detection in CNN Application". 1-4. 10.1109/ICRITO56286.2022.9964761.