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A Comprehensive Review on Fuzzy Logic-Based Models for Stress Detection

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Abstract: *Individuals naturally experience stress on a regular basis. It causes the production of hormones that assist to handle any circumstances, however long-term stress has adverse impacts on wellness and may cause symptoms such as headaches, insomnia and depression. For this reason, early identification of stress is crucial to preventing these negative impacts. This paper provides a comprehensive review on various fuzzy Inference Systems (FIS) models for stress detection. The scholarly articles which have been published from 2022 to 2026 are considered in this work. Moreover, this paper mainly focused on those stress detection models which have been developed by using fuzzy logic. A comparison study of existing best fuzzy logic-based systems is offered after a comprehensive literature review. This paper reviewed publications which used psychological, behavioural and physiological inputs to investigate conventional and mixed fuzzy system. The work investigated how well fuzzy models, like Mamdani, handle non-linear stress variables. During this study, it is analyzed that fuzzy logic offers excellent performance for the identification of stress at its early phases. Moreover, the discussion concludes by outlining the present issues, limits and opportunities for further stress detection research using fuzzy logic.*

Keywords: *Stress Detection, Artificial Intelligence, Machine Learning, Fuzzy Logic, Fuzzy Inference Systems, Disease detection, comprehensive review, comparative analysis*

I. INTRODUCTION

In current times, stress has emerged as a medical problem that affects both elderly and adults [1]. It is linked to a number of illnesses, including diabetes, heart disorders, psychological disorders and orthopaedic difficulties [2]. This condition is a well-explained as well as intricate series of reactions that are triggered while a person experiences stress [3-5]. Raised hypertension, heartrate, sweating and breathing rate are all consequences of this illness. Stress is a complicated mental process that can lead to several conditions, including heart rhythm disorder, depression and irregular heartbeats [6-8]. It is difficult to prevent stress as well as stressful circumstances in everyday life. Experts discovered that extreme and continuous stress must be handled as soon as signs manifest to avoid permanent harm [9]. By recognizing and controlling stress in its initial phase, investigators and healthcare professionals helped in creating novel approaches to mitigate the adverse consequences of a persistent stress state. The creation of sophisticated and trustworthy stress identification methods has emerged as a crucial area of AI research due to its rising incidence of illnesses associated with stress [10]. Despite their strength, traditional methods for stress detection using DL and ML sometimes demands enormous and labelled data sets and functions as opaque frameworks, which restricts their readability as well as practical application in delicate fields like medicine [11].

On the other aspect, fuzzy logic approaches, which are founded on the basis of concept of approximation rationality, offer a clear and comprehensible structure to assist in managing the lack of clarity and ambiguity present in stress-driven data [12-13]. Mental stress, galvanic skin reaction and heartbeat fluctuations are examples of physical and mental stress signs that are intrinsically ambiguous and frequently mix among different categories of stress. This uncertainty is successfully modelled by FIS which uses rule-driven rationality and linguistic factors [14]. Figure I shows the fundamental structure of FIS in which the fuzzifier component uses membership functions to transform the input into fuzzy variables [15]. Utilizing the knowledge base, these fuzzy variables are further presented to the fuzzy inference component to produce outcomes. The knowledge base contains information and rules which are utilized in the derivation of

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conclusions [16]. Furthermore, the defuzzifier makes it possible to adjust the received variables to the appropriate frequency to provide results [17].

While there are many publications on stress detection systems developed by using AI methods, however, fuzzy logic as an unique and specific framework is rarely discussed in the majority of review publications, which mostly involves DL and ML methods. In order to close this gap, this work offers a thorough and targeted analysis of stress detection models developed by using traditional fuzzy logic and hybrid fuzzy logic. Hence, this study will help investigators in comprehending the way unpredictability in physical and emotional datasets is efficiently handled by using FIS techniques by offering a comprehensive and organized review of stress detection models developed by using fuzzy logic. Additionally, it provides a comparison of prevailing methodologies, making it simpler to identify research gaps and directing the advancement of higher-quality, comprehensible and rapid models for identification of stress for next investigators and real-world uses. The following are the paper's main contributions:

- An organized and thorough analysis of current systems for stress detection developed by using fuzzy logic
- To ensure that the evaluation covers current advances, approaches and new developments in stress detection models using fuzzy logic, this analysis only takes into account and evaluates new scientific articles issues from 2022 to 2026.
- Establishing comparative table that unifies assessment indicators including findings of publications, type of FIS, objective, input format.
- Investigation of new developments like DL incorporation and IoT-connected stress detection.

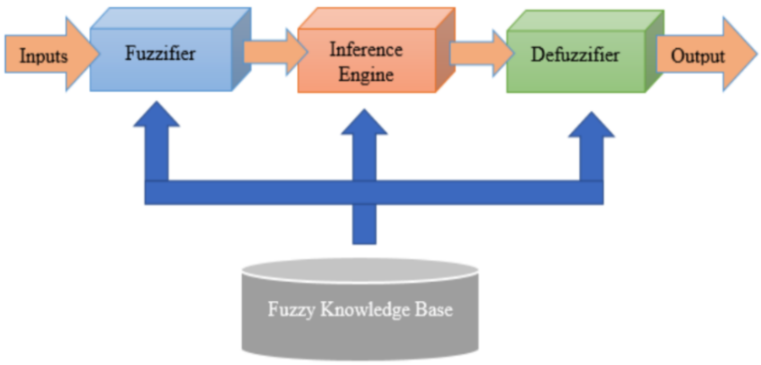

Fig. I. Fundamental Structure of FIS [15]

II. LITERATURE REVIEW

With an emphasis on current development, approaches and practical areas, this section provides an organized study of a collection of studies on models of stress detection using fuzzy logic. To demonstrate the manner in which FIS methods were used to simulate ambiguity in mental and physical stress parameters, this section of study thoroughly evaluates existing publications issues from 2022 to 2026. Table I provides a comparative analysis of existing publications based on objective, database, type of FIS, input format and findings.

In a study presented by Bülbül (2022) [18], four distinct fuzzy logic frameworks were implemented to categorize stress in human via sleep. The data set related to the stress identification in human during sleep and from sleep was acquired from Kaggle and further utilized in the constructed frameworks. Respiratory rate and blood oxygen level are two main symptoms which were used as input to the fuzzy logic designs, and stress was classified appropriately. Employing several membership functions in four distinct frameworks, their effectiveness in determining the type of sleep stress was assessed. With 85% accuracy, the framework developed using the

Generalized Bell membership function outperform different approaches in classifying stress.

Abdullah et al. (2023) [19] suggested a model using Fuzzy Logic method to identify stress based on two physical signals. These inputs are skin conductance and heart rate. The Mamdani FIS is supplied to MATLAB software during the construction of suggested model. The developed model has 9 rules, and it helps in determining whether the condition indicating stress is "not stress" or "stress". There is no available data set used in this study; rather it depends on information collection from individuals under stress and physical data obtained through experimentation. According to the findings of this research work, the developed model can identify stress with an accuracy of 87.5 percent, making it a dependable method.

Ogunbiyi et al. (2023) [20] showed the development of fuzzy logic framework for identifying human distress. 3 crucial factors such as activity, sound and proximity, can describe a distressing scenario including assaults physically were fed into the framework and the responses of the system was recreated. Random sample of the data parameters were used in research to assess the framework's performance. The approach consistently demonstrated anticipated results and attained excellent accuracy, the framework's mean accuracy was 95.45 percent at 100 records, 95.24 percent at 60 input cases, 96.67 percent at 40 input cases and 94.44 percent at 20 input cases as observed.

In the research work of Fajrin et al. (2024) [21], a stress identification system was developed utilizing the fuzzy logic technique, leveraging blood pressure and body temperature measurements as markers to assess an individual's level of stress. The instrument employed an Arduino Uno as a processor for processing data, MPX5100GP sensor to measure blood pressure and the LM35DZ sensor to measure temperature of the body. Additionally, a mental stress test, stress scale 42, anxiety and depression are assessed in relation to levels of stress indicated on this detecting device. The mean conformance level is 74 percent, according to developed model's evaluation tests using a survey.

Melinda et al. (2024) [22] created an instrument to track skin conductance, temperature of body and heart rate in order to identify stress indicators. The Fuzzy Logic approach is then used as a decision-making system to analyze the experimental data. Specifically, the authors employed sixty-four rules using membership functions for every variable. The state of stress will be shown utilizing a label widget and the variable values will be shown utilizing a Gauge widget. The outcomes can be seen directly via standard android gadgets and shown on the Blynk app in conjunction with IoT platforms. With 93.75 percent for skin conductance sensors, 97.7 percent for body temperature sensors and 95.01 percent for heart rate sensors, the developed gadget shows excellent accuracy in identifying stress.

FIS, Bidirectional Long Short-term Memory and CNN are all integrated by Deepakraj et al. (2025) [23] and proposed a mixed approach that combines fuzzy logic and deep learning to enhance ability to interpretation as well as effectiveness. This research provides colleges and universities with a comprehensive way to track stress among students in a timely manner, enabling prompt responses and improvements in educational performance. Physical data such as ECG signals, electrodermal activity and heartrate variability were employed in training phase of the system with 0.995 AUCROC score, 98.1 percent recall, 97.8 percent precision and 98.7 percent accuracy, outcomes of experiments show a significant improvement in the classification of stress levels. When tested against basic frameworks like random forest and SVM, the proposed method shows improved performance in discriminating levels of stress and offers conclusions that are understandable by humans.

Reddy et al. (2025) [24] introduced an integrated AI system that combines SVM and fuzzy logic to enhance educational risk assessment and identification of stress in college students impacted by social media use. Educational achievement markers, social and mental attributes and social network involvement behaviour are among the multimodal inputs used by the developed approach. To manage ambiguity and produce preliminary stress evaluation, a Mamdani FIS is employed. The results are then input into a classifier based on SVM for the result projection. Instead of using traditional metrics, the data set is built on questionnaire and organizational student data. The

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selection limits of conventional SVM are altered by polyhedral pyramidal membership functions. By utilizing ambiguity more effectively, this increases generalizability. The proposed fuzzy-SVM outperformed conventional SVM in terms of accuracy and dependability if examined on benchmarking data sets. The experiment outcomes are extremely outstanding, with 95.25 percent accuracy, 93.76 percent precision, 95.69 percent F1 score and 91.17 percent recall.

Irhamsyah et al. (2025) [25] designed a reliable model for early identification that uses physical as well as mental bodily markers to predict elevated stress in adults. The markers data was acquired by using different sensors such as digital tensiometer for blood pressure, pulse oximeter for SpO2, heart rate, GSR sensor for skin conductance and DS18B20 sensor for body temperature. All 5 of these variables are included in the online platform and provide data that is remotely transmitted to a data base and evaluated on an internet-based server utilizing fuzzy logic technique. Moreover, mental stress is measured using the Perceived Stress Scale tool. This solution achieves 100 percent accuracy by sending, processing and displaying the ultimate data finding derived from two features of the website.

Applying Statistical Observation Data (SOD), Duan (2026) [26] offered a fuzzy predictive model (FPM) to enhance student's physical reactions to stress. The suggested framework extracts unique compositional properties by utilizing time-specific monitoring data. These characteristics are linked to the psychological disorder and stress that student encounter in various contexts. In contrast to general fuzzy algorithms, the proposed method explicitly incorporates situation-based data from observations to enhance context understanding for psychological wellness diagnosis. The Kaggle database is used to extract a dataset named as "Student Stress Factor", containing multi-sectional responses from students on mental, educational and behavioural attributes has been utilized in this study, with an F1 score of 0.91 and an overall accuracy of classification higher than 93 percent, the suggested model demonstrated a satisfactory equilibrium among precision and sensitivity in detecting standardized psychological risk factors.

Swapna et al. (2026) [27] leveraged fuzzy classification to forecast worker stress with respect to face detection. Webcams installed on the workplace screen that supply picture data to the proposed approach. Fuzzy logic is used to build fuzzy classifier, which simulates how human make choices by taking into consideration a variety of probabilities around "No" and "Yes". The prominent individual face attributes such as lips and eyes are first recognized by the Gabor filter. The software is going to then retrieve the data related to motion. The worker's levels of stress are then computed. This main goals of this framework are managing stress, fostering a relaxed and comfortable workplace for staff members and optimizing their output throughout normal hours of operation. The performance has been assessed using true positive rate, false positive rate, precision and classification accuracy. The stated psychological wellness assessment framework for workers is superior as compared to alternative methods with 99 percent precision, 3 percent false positive rate, 97 percent true positive rate and 98 percent accuracy.

TABLE I. COMPARION TABLE OF CONSIDERED PUBLICATIONS

References	Objective	Database	Type of FIS	Input Format	Findings
Bülbül (2022) [18]	To implement four different fuzzy logic frameworks using different membership functions for classifying stress in human using sleep data	Kaggle sleep stress	Mamdani	Quantitative physiological signals	Generalized Bell membership function achieved highest accuracy i.e., 85%
Abdullah et al. (2023) [19]	To identify stress based on two physical signals using fuzzy logic	Experimental data	Mamdani	Physical signals	Developed model achieved 87.5% accuracy
Ogunbiyi et al. (2023) [20]	To develop fuzzy logic framework for identifying human distress	Sample data parameters were generated randomly	Mamdani	Behavioural or environmental indicators	Mean accuracy achieved are 95.45% at 100 records, 95.24% at

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					60 input cases, 96.67% at 40 input cases and 94.44% at 20 input cases as observed
Fajrin et al. (2024) [21]	To develop a stress identification system using fuzzy logic technique	Self-collected	Mamdani	Number inputs derived from physical sensors	The mean conformance level is 74%
Melinda et al. (2024) [22]	To create an instrument for tracking indictors of stress using fuzzy logic and display real-time output on app and device	Small scale experimental	Mamdani	Crisp numeric values from senor data	93.75% accuracy for skin conductance sensors, 97.7% accuracy for body temperature sensors and 95.01% accuracy for heart rate sensors
Deepakraj et al. (2025) [23]	To propose a mixed system for stress detection in university students by combining fuzzy logic and deep learning	Physical signal data based on instances of educational stress	Mamdani	Quantitative inputs derived from physical sensors	Proposed system achieved 0.995 AUCROC score, 98.1 percent recall, 97.8 percent precision and 98.7 percent accuracy
Reddy et al. (2025) [24]	To introduce an integrated system for identifying stress in students at universities impacted by social media using fuzzy logic and SVM	University student's actual academic data	Mamdani	Numerical values	The introduced approach achieved 95.25% accuracy, 93.76% precision, 95.69% F1 score and 91.17% recall.
Irhamsyah et al. (2025) [25]	To design a model for early identification of stress in final year adults using fuzzy logic	Student academic data	Mamdani	Numeric values	The designed model achieved 100% accuracy
Duan (2026) [26]	To offer a fuzzy predictive system to enhance student physical response to stress	Kaggle's Student Stress Factor data	Mamdani	Numerical and tabular data	The offered model achieves 0.91 F1 score and up to 93% classification accuracy.
Swapna et al. (2026) [27]	To forecast worker's stress with respect to face detection using fuzzy classifier	Pictures of workers	Mamdani	Image data	The proposed method achieved 99% precision, 3% false positive rate, 97% true positive rate and 98% accuracy.

III. DISCUSSION

This study effectively analyzed the existing studies published from 2022 to 2026 mainly focused on fuzzy logic-based stress detection systems. According to the comparative analysis conducted in above section, it is observed that, study [25] achieved 100% accuracy by acquiring data from sensors and employing fuzzy logic for classification task. However, it has some limitation like generalizability. Moreover, in the classification task of stress identification, hybrid techniques frequently function better than independent fuzzy logic algorithms. Outstanding results are shown by research works like [23] and [24], which achieve accuracy over 95% and good F1 score and AUC. The main cause of this increase is the combination of fuzzy logic and standard ML methods like DL and SVM, which assist in detection of patterns, acquiring attributes and promote generalization. As a result, relative to traditional Mamdani-inspired fuzzy algorithms, hybrid systems offer superior strength and dependable stress analysis. The evaluated investigations have a number of drawbacks regardless their encouraging outcomes, several approaches are limited in relevance to everyday circumstances because they depend on manufactured, simulated or very small dataset. Specific comparisons between research are also difficult due to the absence of defined data sets and consistent indicators of assessment. Additionally, some investigations claim incredibly high accuracy rate, like 100 percent, this could be sign of inadequate evaluation or overfitting. In addition, such stress identification technologies' ability to be generalized is diminished by their inadequate examination of varied groups. There are some restrictions on the presented review work as well. It mostly concentrates in current work that has been released since 2022, probably leaving out previous fundamental findings of stress identification using fuzzy logic. Furthermore, sophisticated fuzzy variants and Sugeno type fuzzy receive relatively lesser amount of coverage in this work than Mamdani type fuzzy models. Selection bias may be introduced because the screening of research is restricted to papers that are easily available and open access.

IV. CONCLUSION

The significance of fuzzy logic in identifying stress is highlighted in this paper, especially its capacity to manage ambiguity and offer comprehensible decisions in physical, mental and behavioural fields. Mamdani-type methods are the most popular because of their ease of use, however hybrid approaches that incorporate ML performed better. Nonetheless, issues like conflicting indicators of assessment and unstructured data sets continue to exist. All things considered, fuzzy logic is still a useful strategy, with new developments focusing on the interdisciplinary data fusion and integration for increased stress identification efficiency. For practical stress identification methods, future investigations must concentrate on investigating sophisticated mixed fuzzy algorithms and creating consistent data sets.

REFERENCES

1. Y. Bhole, “Stress Detection using AI and Machine Learning,” *International Journal of Engineering Research & Technology (IJERT)*, vol. 13, no. 08, pp. 326–332, Aug. 2024.
2. Vaccarino and J. D. Bremner, “Stress and cardiovascular disease: An update,” *Nature Reviews Cardiology*, vol. 21, no. 9, pp. 603–616, May 2024. doi:10.1038/s41569-024-01024-y
3. U. Srinivasarao *et al.*, “A novel and efficient personalized stress detection technique using a deep learning model,” *Scientific Reports*, vol. 15, no. 1, Aug. 2025. doi:10.1038/s41598-025-16642-w
4. C. Chatzaki and M. Tsiknakis, “An overview of stress analysis based on physiological signals: Systematic review of open datasets and current trends,” *Sensors*, vol. 25, no. 23, p. 7108, Nov. 2025. doi:10.3390/s25237108
5. F. Ghasemi, D. Q. Beversdorf, and K. C. Herman, “Stress and stress responses: A narrative literature review from physiological mechanisms to intervention approaches,” *Journal of Pacific Rim Psychology*, vol. 18, Jan. 2024. doi:10.1177/18344909241289222
6. D. G. Leo *et al.*, “At the heart of the matter: How mental stress and negative emotions affect atrial fibrillation,” *Frontiers in Cardiovascular Medicine*, vol. 10, Jun. 2023. doi:10.3389/fcvm.2023.1171647
7. G. N. Levine, “Psychological stress and heart disease: Fact or folklore?,” *The American Journal of Medicine*, vol. 135, no. 6, pp. 688–696, Jun. 2022. doi:10.1016/j.amjmed.2022.01.053
8. Pereira-Figueiredo and E. H. Umeoka, “Stress: Influences and determinants of psychopathology,” *Encyclopedia*, vol. 4, no. 2, pp. 1026–1043, Jun. 2024. doi:10.3390/encyclopedia4020066
9. F. Liu, Q. Ju, Q. Zheng, and Y. Peng, “Artificial Intelligence in mental health: Innovations brought by artificial intelligence techniques in stress detection and interventions of building resilience,” *Current Opinion in Behavioral Sciences*, vol. 60, p. 101452, Dec. 2024. doi:10.1016/j.cobeha.2024.101452
10. F. Zafar *et al.*, “The role of artificial intelligence in identifying depression and anxiety: A comprehensive literature review,” *Cureus*, Mar. 2024. doi:10.7759/cureus.56472

Economic Sciences
https://economic-sciences.com
ES(2026) 22, (2), 342-348 | ISSN:1505-4683

11. M. Ali, S. Ali, Q. Abbas, Z. Abbas, and S. W. Lee, "Artificial Intelligence for Mental Health: A narrative review of applications, challenges, and future directions in Digital Health," *DIGITAL HEALTH*, vol. 11, May 2025. doi:10.1177/20552076251395548
12. J. Cao *et al.*, "Fuzzy inference system with interpretable fuzzy rules: Advancing Explainable Artificial Intelligence for Disease Diagnosis—a comprehensive review," *Information Sciences*, vol. 662, p. 120212, Mar. 2024. doi:10.1016/j.ins.2024.120212
13. N. Shoaip, S. El-Sappagh, T. Abuhmed, and M. Elmogy, "A dynamic fuzzy rule-based inference system using fuzzy inference with Semantic Reasoning," *Scientific Reports*, vol. 14, no. 1, Feb. 2024. doi:10.1038/s41598-024-54065-1
14. G. D'Aniello, "Fuzzy logic for situation awareness: A systematic review," *Journal of Ambient Intelligence and Humanized Computing*, vol. 14, pp. 4419–4438, Feb. 2023. doi:10.1007/s12652-023-04560-6 K. Uyar, I. A. Ozkan, and S. Tasdemir, "The analysis and optimization of CNN hyperparameters with Fuzzy Tree model for Image Classification," *Turkish Journal of Electrical Engineering & Computer Science*, vol. 30, pp. 961–977, 2022. doi:10.3906/elk-2107-130
15. F. Camastra, A. Ciaramella, G. Salvi, S. Sposato, and A. Staiano, "On the interpretability of Fuzzy Knowledge Base Systems," *PeerJ Computer Science*, vol. 10, Dec. 2024. doi:10.7717/peerj-cs.2558

A. Romanov, A. A. Filippov, and N. G. Yarushkina, "An approach to generating fuzzy rules for a fuzzy controller based on the Decision Tree Interpretation," *Axioms*, vol. 14, no. 3, p. 196, Mar. 2025. doi:10.3390/axioms14030196

16. M. A. Bülbül, "Performance of different membership functions in stress classification with fuzzy logic," *Journal of Science and Technology*, vol. 12, no. 2, pp. 60–63, 2022.
17. L. B. Abdullah, A. S. Ali, Z. Tukiran, and S. Mohamad, "Implementation of fuzzy logic technique for physiological based stress detection," *AIP Conference Proceedings*, vol. 2956, p. 030010, 2023. doi:10.1063/5.0123078
18. D. Ogunbiyi, I. Ogundoyin, and C. Akanbi, "A fuzzy logic model for human distress detection," *Journal of Engineering Studies and Research*, vol. 29, no. 3, pp. 49–56, Jan. 2023. doi:10.29081/jesr.v29i3.005
19. H. R. Fajrin, S. Sasmeri, L. Riski Prilia, B. Untara, and M. Ahdan Fawwaz Nurkholid, "Fuzzy logic method-based stress detector with blood pressure and body temperature parameters," *International Journal of Electrical and Computer Engineering (IJECE)*, vol. 14, no. 2, pp. 2156–2166, Apr. 2024. doi:10.11591/ijece.v14i2.pp2156-2166
20. M. Melinda, V. Setiawan, Y. Yunidar, G. Sakarkar, and N. Basir, "Portable stress detection system for autistic children using Fuzzy Logic," *Jurnal Nasional Teknik Elektro*, pp. 60–68, Jul. 2024. doi:10.25077/jnte.v13n2.1203.2024
21. J. Deepakraj *et al.*, "Fuzzy logic and deep learning hybrid model for physiological stress detection in higher education," *2025 5th International Conference on Intelligent Technologies (CONIT)*, pp. 1–7, Jun. 2025. doi:10.1109/conit65521.2025.11167821
22. L. J. Reddy *et al.*, "Fuzzy logic–SVM framework for stress detection and academic risk prediction among social media-affected students in Higher Education," *2025 IEEE 2nd International Conference for Women in Computing (InCoWoCo)*, pp. 1–6, Nov. 2025. doi:10.1109/incowoco68239.2025.11406956
23. M. Irhamsyah *et al.*, "A fuzzy logic-based stress recognition system for final-year students using PSS-10 neuropsychological measures," *International Journal on Advanced Science, Engineering and Information Technology*, vol. 15, no. 5, pp. 1663–1671, Oct. 2025. doi:10.18517/ijaseit.15.5.20941
24. D. Duan, "Using a predictive model based on fuzzy logic methods to test the mental health of students," *Discover Computing*, vol. 29, no. 1, Mar. 2026. doi:10.1007/s10791-026-09962-6
25. N. Swapna, V. Ahmed, M. H. Khan, M. A. W. Rubaas, and F. H. Khan, "Facial Recognition based Prediction of Employee Stress using Fuzzy Classification," *International Conference on Multidisciplinary Perspectives in Advanced Computing and Technology (IMPACT 2026)*, vol. 1, pp. 386–397, 2026.