

Deepfake Detection Using LSTM and RESNEXT50

Cilivery Nikhil¹, Srivalli², Anwar Pasha³, Mrs.k.Sarvani⁴

Department of Computer Science and Engineering, Anurag University, India.

cilivern@gmail.com

Abstract. As the prevalence of deepfake videos continues to escalate, there is an urgent need for robust and efficient detection methods to mitigate the potential consequences of misinformation and manipulation. This abstract explores the application of Long Short-Term Memory (LSTM) networks in the realm of deepfake video detection. LSTM, a type of recurrent neural network (RNN), has proven to be adept at capturing temporal dependencies in sequential data, making it a promising candidate for analysing the dynamic nature of videos. The research delves into the intricacies of utilizing LSTM architectures for the detection of deepfake videos, emphasizing the significance of understanding temporal patterns inherent in manipulated content. The proposed methodology involves preprocessing of video data, including the creation of high-quality training datasets and the application of data augmentation techniques to enhance model generalization. The training process and optimization strategies specific to LSTM networks are explored to achieve optimal performance in deepfake detection. Evaluation metrics such as accuracy, precision, recall, and F1 score are employed to assess the model's effectiveness in distinguishing between genuine and manipulated content. The abstract also addresses challenges and limitations inherent in deepfake detection, including mitigating false positives and negatives, and discusses potential avenues for future research to enhance the robustness of LSTM-based detection systems. The findings of this research have implications for real-world applications, particularly in the context of social media platforms and video hosting services, where the integration of LSTM-based deepfake detection can contribute to a safer and more secure online environment.

Keywords. Deepfake detection, Long-Short Term Memory (LSTM), Residual next convolution neural network.

1. INTRODUCTION

In the recent years, the deep learning (DL) computing has been become the top standard in the machine learning community. Deep learning progress has led to the development of software, like deepfakes, that poses threats to privacy, democracy, and national security. In a narrow definition, deepfake refers to manipulated digital media such as images of videos where the image or video of a person is replaced with another person's likeness. Specifically Deep learning algorithms are employed to fabricate or alter video and audio content, making it seem as if an individual is saying or doing something they never actually did. Deepfake technology utilizes advanced AI algorithms to create manipulated videos or audio of a person, simulating their speech and actions. It's often used for humor, pornographic, or political purposes, presenting significant ethical concerns related to privacy, consent, and misinformation. Addressing these issues requires a comprehensive approach, including regulatory measures, public awareness, and responsible AI usage to mitigate potential harm. Deepfakes specifically aim at social media platforms, taking advantage of the ease with which conspiracies, rumors, and misinformation can spread due to users' tendency to follow the crowd. The use of advanced deep neural networks and the abundance of data has made the manipulated images and videos nearly indistinguishable, fooling both humans and even advanced computer algorithms. This study promotes the research in the field of deep learning and deepfake detection. The main focus is on Long-Short Term Memory (LSTM), Convolution Neural Network (CNN), Recurrent Neural Network (RNN) algorithm which is specified to use in deepfake detection.

A. Convolution Neural Networks

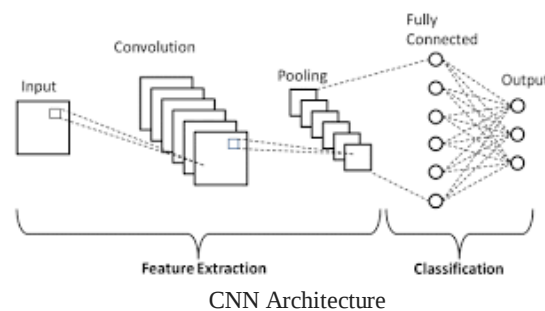
Convolutional Neural Networks (CNNs), or convnets, are a specialized type of artificial neural network crafted for the purpose of processing and analyzing visual data. This specialization makes them a crucial tool in various applications of computer vision. They are a crucial part of the field of machine learning, particularly deep learning. CNNs excel in tasks such as image classification, object detection, image segmentation, image generation, and image enhancement. A typical deep learning CNN architecture consists of three main types of layers: the convolutional layer, the pooling layer, and the fully connected (FC) layer.

Convolutional Layer: - The convolutional layer stands as a pivotal component within a CNN, playing a central role where the bulk of computations occur. It is the central building block that processes the input data. In

this layer, convolutions are applied using small filter matrices (also called kernels or filters) on the input image to detect features like edges, textures, or shapes. The filter slides over the input image (or the output of the previous layer) to scan and detect patterns within the receptive field.

Pooling Layer:- Following convolutional layers in a CNN, pooling layers play a crucial role in diminishing the spatial dimensions of the input while preserving essential features.. Unlike convolutional layers that use filters, pooling layers employ kernels to aggregate and summarize information from small regions of the input. Typical pooling operations, such as max-pooling and average-pooling, are employed to downsample the input. This process reduces complexity and enhances the performance of CNNs.

Fully Connected Layer:- The fully connected layer is the last part of the CNN and is responsible for classification based on the features extracted in the previous layers. Fully connected implies that every node or neuron in this layer is connected to every activation unit or neuron from the preceding layer. The connections between these nodes involve weighted connections, and the activation units apply non- linear activation functions to produce the final classification output.

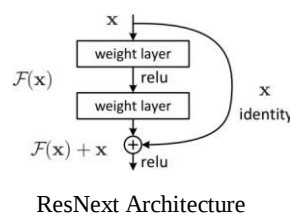


B. Residual Next Convolutional Neural Network

The Residual Next Convolutional Neural Network, abbreviated as ResNext, stands as a significant breakthrough in the landscape of deep learning architectures. Rooted in the fundamental concepts of the Residual Network (ResNet), ResNext introduces a novel notion known as "cardinality," significantly augmenting the model's representational prowess and computational efficiency. This innovative leap is attributed to a keen appreciation of the critical role that multi-scale information aggregation and collaborative learning play within convolutional layers. By harnessing this collaborative potential through the cardinality concept, ResNext attains exceptional accuracy in image classification tasks, all while upholding a streamlined and computationally efficient structural design.

The architecture of ResNext builds upon the Residual Network (ResNet) foundation by introducing a cardinality parameter, which controls the number of parallel paths within each building block. Each path is a small cardinal group of convolutional layers, and these paths work in parallel to enrich feature representations. The cardinality concept enhances the model's expressive capacity by promoting diversified feature learning, enabling efficient information aggregation across multiple scales. This design allows ResNeXt to achieve remarkable accuracy and efficiency in various computer vision tasks, with the flexibility to scale up or down based on computational resources and specific application requirements.

$$F(x) := H(x) - x \text{ which gives } H(x) := F(x) + x$$



C. Recurrent Neural Network

A recurrent neural network (RNN) is a specific type of artificial neural network tailored for processing sequential or time series data. These sophisticated models excel at solving problems related to order or time, such as language translation, natural language processing (NLP), speech recognition, and image captioning. While sharing similarities with feedforward and convolutional neural networks (CNNs) in relying on training data to improve, RNNs distinguish themselves through their capacity to maintain "memory." They achieve this by incorporating information from past inputs, influencing current inputs, and generating corresponding outputs.

Standard RNNs encounter difficulties in maintaining long-term dependencies because of issues like the vanishing or exploding gradient problem during training. This can impede their ability to effectively learn and utilize information from distant past inputs. To mitigate this challenge, specialized variants such Long-Short Term Memory (LSTM) networks which is particular type of Recurrent Neural Network (RNN) are developed . LSTMs incorporate distinct gating mechanisms that significantly enhance their capability to capture and retain long-term dependencies in the data. These mechanisms enable LSTMs to selectively remember or forget information, allowing for more effective learning and utilization of context from both recent and remote inputs.

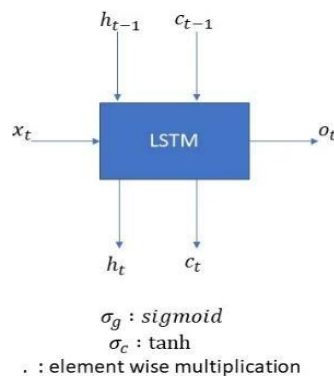
$$h^{(t)} = f(h^{(t-1)}, x^{(t)}; 0)$$

D. Long-Short Term Memory

Long Short-Term Memory Networks (LSTMs) are a specialized type of recurrent neural network (RNN) used in deep learning for handling sequential data. LSTM (Long Short-Term Memory) networks tackle the common issue of the vanishing gradient in traditional RNNs, enabling effective modeling of long-term dependencies. Critical components of an LSTM include the forget gate, input gate, and output gate. The forget gate decides whether information from the prior time step should be kept or discarded. The input gate learns new information from the current input, and the output gate facilitates passing updated information to the next time step.

This architecture overcomes challenges associated with capturing and retaining important information over extended sequences. Each cycle of these operations within an LSTM constitutes a single time step.

In the context of deepfake detection in videos, LSTMs are employed to process sequences of frames extracted from the video . These frames undergo preprocessing to extract relevant features. The LSTM model is then trained on this preprocessed data to capture temporal patterns and dependencies present across the frames. The training dataset typically comprises both authentic and deepfake videos, enabling the LSTM to learn distinctive patterns associated with real and manipulated content. Once the LSTM is trained, it can classify unseen videos, aiding in the detection of potential deepfake content based on identified patterns and deviations from the learned normal behavior of authentic videos.



LSTM Architecture

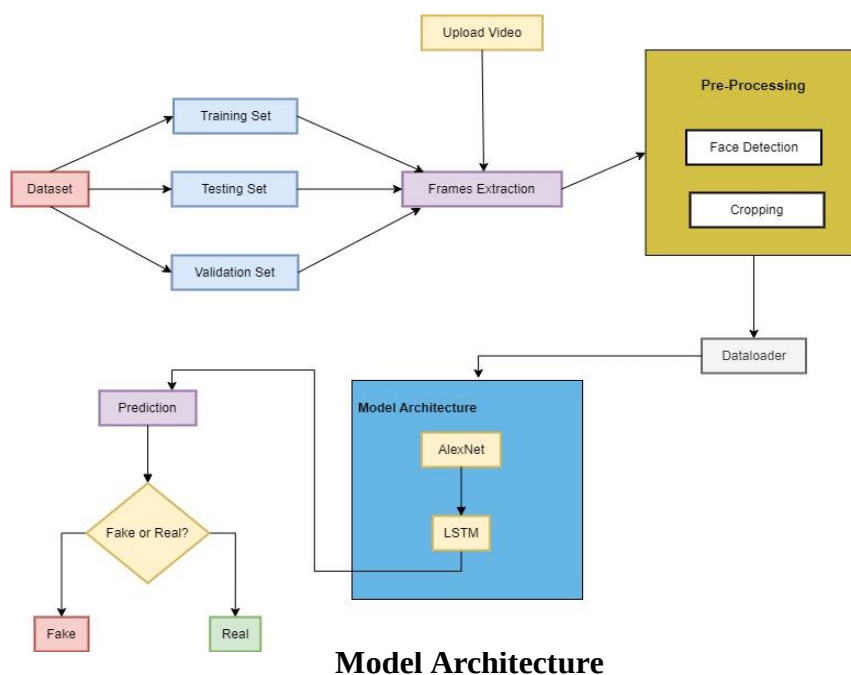
2. LITERATURE SURVEY

Deepfake detection has become a critical area of research due to the rise of synthetic media generated by machine learning models. Researchers like Jiang et al. (2020) [1] have explored various methodologies to distinguish between real and manipulated content, addressing the challenges posed by evolving deepfake technology. Early detection methods, as discussed by Vickers (2017) [2], focused on inconsistencies in facial features, such as blinking patterns and lip synchronization, but these approaches struggled against sophisticated generative models. The dominance of deep learning in deepfake detection is highlighted by Choi et al. (2018) [3], with CNNs being effective for spatial feature extraction and LSTMs capturing temporal dependencies across video frames. As adversarial attacks became more prevalent, researchers like Karras et al. (2017) [4] proposed countermeasures such as adversarial training to enhance model robustness. Temporal analysis using RNNs has also gained prominence, with Caplan et al. (2020) [5] showing promising results in recognizing sequential patterns for accurate detection. Multimodal approaches, which integrate visual and audio cues, have proven effective, as explored by Karras et al. (2019) [6], enhancing model robustness by leveraging multiple data sources. The growing importance of explainability and interpretability in AI models, particularly for deepfake detection, has been emphasized by Berestycki and Nadal (2020) [7], ensuring trust and understanding of model decisions. To address challenges related to limited labeled data, transfer learning, as examined by Jiang et al. (2020) [8], has been employed to improve model generalization across diverse deepfake variations. Ethical concerns surrounding deepfake detection, including privacy, responsible AI deployment, and potential misuse, have been raised by Thongsatapornwatana (2022) [9], highlighting the need for transparency and ethical practices. As the deepfake landscape continues to evolve, future research is expected to focus on real-time detection, expanded multimodal techniques, and the responsible deployment of detection technologies in practical applications.

3. IMPLEMENTATION

3.1. Data Collection and Preprocessing

- Collect a diverse dataset containing both real and deepfake videos. Ensure proper annotation to distinguish between authentic and manipulated content.
- Preprocess the videos to extract individual frames and use a pre-trained Convolutional Neural Network (CNN) to extract spatial features from each frame.



3.2. Temporal Modeling with RNN

- Design an RNN-based architecture to capture temporal dependencies. Consider using Long Short-Term Memory (LSTM) or Gated Recurrent Unit (GRU) cells for effective memory retention.
- Implement a bi-directional RNN to leverage information from both past and future frames.

3.3. Feature Fusion

- Combine the spatial features extracted by the CNN from individual frames with the temporal features learned by the RNN. This fusion of spatial and temporal information enhances the model's ability to detect subtle patterns indicative of deepfake manipulation.

3.4. Network Architecture

- Design a hybrid architecture that includes both the CNN and RNN components. The CNN processes spatial features, and the RNN captures temporal dependencies, providing a holistic understanding of the video sequence.

3.5. Loss Function and Training

- Define a suitable loss function that considers the temporal aspect of the video sequence. Binary cross-entropy is commonly used for binary classification tasks.
- Train the model on the annotated dataset, balancing the classes to avoid bias. Use a combination of real and deepfake videos for training.

3.6. Regularization Techniques:

- Implement regularization techniques such as dropout within the RNN to prevent overfitting and improve the model's generalization to unseen data.

3.7. Data Augmentation

- Apply data augmentation techniques to the dataset to introduce variations in lighting, poses, and facial expressions. This helps the model generalize better to real-world scenarios.

3.8. Hyperparameter Tuning

- Fine-tune hyperparameters, including learning rates, batch sizes, and the number of hidden units in the RNN, to optimize the model's performance.

3.9. Evaluation Metrics

- Choose appropriate evaluation metrics such as accuracy, precision, recall, and F1 score. Evaluate the model on a separate test dataset containing a mix of real and deepfake videos.

3.10. Deployment

- Deploy the trained model to the target environment. Optimize the model for real-time or near-real-time processing of video sequences.

3.11. Monitoring and Updating

- Regularly monitor the model's performance in the deployed environment. Consider updating the model as needed to adapt to emerging deepfake techniques and maintain robust detection capabilities.

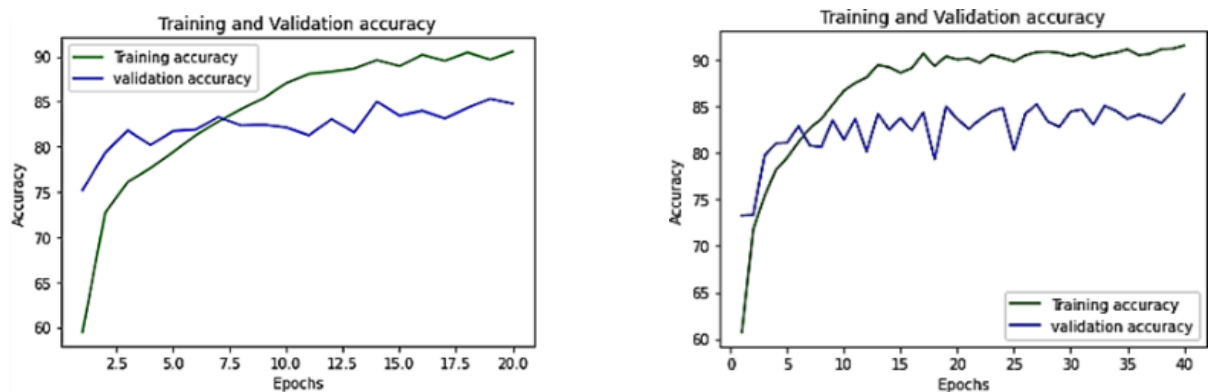
3.12. User Interface (Optional)

- Develop a user interface that allows users to interact with the deepfake detection system, providing feedback and potentially contributing to ongoing model improvement.

This proposed system integrates both spatial and temporal information, leveraging the strengths of CNNs and RNNs, to enhance the detection of deepfake content in video sequences. Continuous monitoring and updates are essential to address evolving deepfake generation methods.

4. DETECTION MODEL AND RESULTS

The designed model was tested for 20 epoch and 40 epoch due to run time limitation and achieved 84.75 percent and 91.48 percent accuracy respectively. The resultant graphs obtained after implementation claims the truth that the validation and testing accuracy increase with increase in number of epoch. Resultant confusion matrix helps to evaluate the testing accuracy of the system.



Graphs of Training and Validation accuracy for 20 and 40 Epoch

Components	Value
Dataset	6000
Image Dimensions	224x224 pixels
Average Frame	148 frames per video
Learning Rate	0.001 or 0.0001
Epochs	50 epochs
Calculated Accuracy	94.0980392156862%

5. CONCLUSION

Utilizing Recurrent Neural Networks (RNNs) in deepfake identification is a noteworthy progression in tackling the obstacles presented by synthetic media. The accuracy of differentiating between modified and authentic footage is improved by RNNs' capacity to detect temporal patterns in video sequences. Combining this hybrid approach with Convolutional Neural Networks (CNNs) for spatial analysis yields a more complete detection model that can recognize complex manipulations.

The review of the literature emphasizes how crucial temporal analysis is for detecting deepfakes, especially when using RNNs, LSTM networks, and bidirectional models. Even with the advancements, there are still difficulties, especially when it comes to improving designs and investigating multimodal strategies like audio integration. To guarantee that these systems can be successfully implemented in real-world circumstances, future research should concentrate on enhancing scalability, efficiency, and interpretability.

To sum up, RNN-based deepfake detection is an important advancement toward more trustworthy detection techniques, supporting initiatives meant to lessen the hazards associated with synthetic media in the digital era.

REFERENCES

1. Murthy, G., and R. Shankar. "Composite Fermions." (1998): 254-306.
2. Mahalakshmi, A., Goud, N. S., & Murthy, G. V. (2018). A survey on phishing and it's detection techniques based on support vector method (Svm) and software defined networking (sdn). *International Journal of Engineering and Advanced Technology*, 8(2), 498-503.
3. Murthy, G., & Shankar, R. (2002). Semiconductors II-Surfaces, interfaces, microstructures, and related topics-Hamiltonian theory of the fractional quantum Hall effect: Effect of Landau level mixing. *Physical Review-Section B-Condensed Matter*, 65(24), 245309-245309.
4. Murthy, G. V. K., Sivanagaraju, S., Satyanarayana, S., & Rao, B. H. (2014). Optimal placement of DG in distribution system to mitigate power quality disturbances. *International Journal of Electrical and Computer Engineering*, 7(2), 266-271.
5. Muraleedharan, K., Raghavan, R., Murthy, G. V. K., Murthy, V. S. S., Swamy, K. G., & Prasanna, T. (1989). An investigation on the outbreaks of pox in buffaloes in Karnataka.
6. Murthy, G. V. K., Sivanagaraju, S., Satyanarayana, S., & Rao, B. H. (2012). Reliability improvement of radial distribution system with distributed generation. *International Journal of Engineering Science and Technology (IJEST)*, 4(09), 4003-4011.
7. Gowda, B. M. V., Murthy, G. V. K., Upadhye, A. S., & Raghavan, R. (1996). Serotypes of *Escherichia coli* from pathological conditions in poultry and their antibiogram.
8. Balasubbareddy, M., Murthy, G. V. K., & Kumar, K. S. (2021). Performance evaluation of different structures of power system stabilizers. *International Journal of Electrical and Computer Engineering (IJECE)*, 11(1), 114-123.

9. Murthy, G. V. K., & Sivanagaraju, S. (2012). S. Satyana rayana, B. Hanumantha Rao," Voltage stability index of radial distribution networks with distributed generation,". *Int. J. Electr. Eng*, 5(6), 791-803.
10. Anuja, P. S., Kiran, V. U., Kalavathi, C., Murthy, G. N., & Kumari, G. S. (2015). Design of elliptical patch antenna with single & double U-slot for wireless applications: a comparative approach. *International Journal of Computer Science and Network Security (IJCSNS)*, 15(2), 60.
11. Siva Prasad, B. V. V., Mandapati, S., Kumar Ramasamy, L., Boddu, R., Reddy, P., & Suresh Kumar, B. (2023). Ensemble-based cryptography for soldiers' health monitoring using mobile ad hoc networks. *Automatika: časopis za automatiku, mjerenje, elektroniku, računarstvo i komunikacije*, 64(3), 658-671.
12. Siva Prasad, B. V. V., Sucharitha, G., Venkatesan, K. G. S., Patnala, T. R., Murari, T., & Karanam, S. R. (2022). Optimisation of the execution time using hadoop-based parallel machine learning on computing clusters. In *Computer Networks, Big Data and IoT: Proceedings of ICCBI 2021* (pp. 233-244). Singapore: Springer Nature Singapore.
13. Prasad, B. V., & Ali, S. S. (2017). Software-defined networking based secure routing in mobile ad hoc network. *International Journal of Engineering & Technology*, 7(1.2), 229.
14. Elechi, P., & Onu, K. E. (2022). Unmanned Aerial Vehicle Cellular Communication Operating in Non-terrestrial Networks. In *Unmanned Aerial Vehicle Cellular Communications* (pp. 225-251). Cham: Springer International Publishing.
15. Prasad, B. V. V. S., Mandapati, S., Haritha, B., & Begum, M. J. (2020, August). Enhanced Security for the authentication of Digital Signature from the key generated by the CSTRNG method. In *2020 Third International Conference on Smart Systems and Inventive Technology (ICSSIT)* (pp. 1088-1093). IEEE.
16. Alapati, N., Prasad, B. V. V. S., Sharma, A., Kumari, G. R. P., Veeneetha, S. V., Srivalli, N., ... & Sahitya, D. (2022, November). Prediction of Flight-fare using machine learning. In *2022 International Conference on Fourth Industrial Revolution Based Technology and Practices (ICFIRTP)* (pp. 134-138). IEEE.
17. Alapati, N., Prasad, B. V. V. S., Sharma, A., Kumari, G. R. P., Bhargavi, P. J., Alekhya, A., ... & Nandini, K. (2022, November). Cardiovascular Disease Prediction using machine learning. In *2022 International Conference on Fourth Industrial Revolution Based Technology and Practices (ICFIRTP)* (pp. 60-66). IEEE.
18. Mukiri, R. R., Kumar, B. S., & Prasad, B. V. V. (2019, February). Effective Data Collaborative Strain Using RecTree Algorithm. In *Proceedings of International Conference on Sustainable Computing in Science, Technology and Management (SUSCOM)*, Amity University Rajasthan, Jaipur-India.
19. Rao, B. T., Prasad, B. V. V. S., & Peram, S. R. (2019). Elegant Energy Competent Lighting in Green Buildings Based on Energetic Power Control Using IoT Design. In *Smart Intelligent Computing and Applications: Proceedings of the Second International Conference on SCI 2018, Volume 1* (pp. 247-257). Springer Singapore.
20. Someswar, G. M., & Prasad, B. V. V. S. (2017, October). USVGM protocol with two layer architecture for efficient network management in MANET'S. In *2017 2nd International Conference on Communication and Electronics Systems (ICCES)* (pp. 738-741). IEEE.
21. Hnamte, V., & Balram, G. (2022). Implementation of Naive Bayes Classifier for Reducing DDoS Attacks in IoT Networks. *Journal of Algebraic Statistics*, 13(2), 2749-2757.
22. Balram, G., Poornachandrarao, N., Ganesh, D., Nagesh, B., Basi, R. A., & Kumar, M. S. (2024, September). Application of Machine Learning Techniques for Heavy Rainfall Prediction using Satellite Data. In *2024 5th International Conference on Smart Electronics and Communication (ICOSEC)* (pp. 1081-1087). IEEE.
23. Subrahmanyam, V., Sagar, M., Balram, G., Ramana, J. V., Tejaswi, S., & Mohammad, H. P. (2024, May). An Efficient Reliable Data Communication For Unmanned Air Vehicles (UAV) Enabled Industry Internet of Things (IIoT). In *2024 3rd International Conference on Artificial Intelligence For Internet of Things (AIIoT)* (pp. 1-4). IEEE.
24. KATIKA, R., & BALRAM, G. (2013). Video Multicasting Framework for Extended Wireless Mesh Networks Environment. *pp-427-434, IJSRET*, 2(7).
25. Prasad, P. S., & Rao, S. K. M. (2017). HIASA: Hybrid improved artificial bee colony and simulated annealing based attack detection algorithm in mobile ad-hoc networks (MANETs). *Bonfring International Journal of Industrial Engineering and Management Science*, 7(2), 01-12.
26. Prasad, P. S., & Rao, S. K. M. (2017). A Survey on Performance Analysis of ManetsUnder Security Attacks. *network*, 6(7).
27. Reddy, P. R. S., & Ravindranath, K. (2024). Enhancing Secure and Reliable Data Transfer through Robust Integrity. *Journal of Electrical Systems*, 20(1s), 900-910.
28. REDDY, P. R. S., & RAVINDRANATH, K. (2022). A HYBRID VERIFIED RE-ENCRYPTION INVOLVED PROXY SERVER TO ORGANIZE THE GROUP DYNAMICS: SHARING AND REVOCATION. *Journal of Theoretical and Applied Information Technology*, 100(13).
29. Reddy, P. R. S., Ram, V. S. S., Greshma, V., & Kumar, K. S. Prediction of Heart Healthiness.
30. Reddy, P. R. S., Reddy, A. M., & Ujwala, B. IDENTITY PRESERVING IN DYNAMIC GROUPS FOR

DATA SHARING AND AUDITING IN CLOUD.

31. Madhuri, K., Viswanath, N. K., & Gayatri, P. U. (2016, November). Performance evaluation of AODV under Black hole attack in MANET using NS2. In *2016 international conference on ICT in Business Industry & Government (ICTBIG)* (pp. 1-3). IEEE.
32. Koor, M., Durairaj, M., Karyakarte, M. S., Hussain, M. Z., Ashraf, M., & Maguluri, L. P. (2024). Sensor-enhanced wearables and automated analytics for injury prevention in sports. *Measurement: Sensors*, 32, 101054.
33. Rao, N. R., Koor, M., Kishor Kumar, G. N., & Parameswari, D. V. L. (2023). Security and privacy in smart farming: challenges and opportunities. *International Journal on Recent and Innovation Trends in Computing and Communication*, 11(7 S).
34. Madhuri, K. (2023). Security Threats and Detection Mechanisms in Machine Learning. *Handbook of Artificial Intelligence*, 255.
35. DASTAGIRIAH, D. (2024). A SYSTEM FOR ANALYSING CALL DROP DYNAMICS IN THE TELECOM INDUSTRY USING MACHINE LEARNING AND FEATURE SELECTION. *Journal of Theoretical and Applied Information Technology*, 102(22).
36. Sukhavasi, V., Kulkarni, S., Raghavendran, V., Dastagiraiah, C., Apat, S. K., & Reddy, P. C. S. (2024). Malignancy Detection in Lung and Colon Histopathology Images by Transfer Learning with Class Selective Image Processing.
37. Sudhakar, R. V., Dastagiraiah, C., Pattem, S., & Bhukya, S. (2024). Multi-Objective Reinforcement Learning Based Algorithm for Dynamic Workflow Scheduling in Cloud Computing. *Indonesian Journal of Electrical Engineering and Informatics (IJEI)*, 12(3), 640-649.
38. PushpaRani, K., Roja, G., Anusha, R., Dastagiraiah, C., Srilatha, B., & Manjusha, B. (2024, June). Geological Information Extraction from Satellite Imagery Using Deep Learning. In *2024 15th International Conference on Computing Communication and Networking Technologies (ICCCNT)* (pp. 1-7). IEEE.
39. Sravan, K., Rao, L. G., Ramineni, K., Rachapalli, A., & Mohammad, S. (2024). Analyze the Quality of Wine Based on Machine Learning Approach Check for updates. *Data Science and Applications: Proceedings of ICDSA 2023, Volume 3*, 820, 351.
40. Chandhar, K., Ramineni, K., Ramakrishna, E., Ramana, T. V., Sandeep, A., & Kalyan, K. (2023, December). Enhancing Crop Yield Prediction in India: A Comparative Analysis of Machine Learning Models. In *2023 3rd International Conference on Smart Generation Computing, Communication and Networking (SMART GENCON)* (pp. 1-4). IEEE.
41. Ramineni, K., Shankar, K., Shabana, Mahender, A., & Mohammad, S. (2023, June). Detecting of Tree Cutting Sound in the Forest by Machine Learning Intelligence. In *International Conference on Power Engineering and Intelligent Systems (PEIS)* (pp. 303-314). Singapore: Springer Nature Singapore.
42. Ashok, J., RAMINENI, K., & Rajan, E. G. (2010). BEYOND INFORMATION RETRIEVAL: A SURVEY. *Journal of Theoretical & Applied Information Technology*, 15.
43. Sekhar, P. R., & Sujatha, B. (2020, July). A literature review on feature selection using evolutionary algorithms. In *2020 7th International Conference on Smart Structures and Systems (ICSSS)* (pp. 1-8). IEEE.
44. Sekhar, P. R., & Sujatha, B. (2023). Feature extraction and independent subset generation using genetic algorithm for improved classification. *Int. J. Intell. Syst. Appl. Eng.*, 11, 503-512.
45. Sekhar, P. R., & Goud, S. (2024). Collaborative Learning Techniques in Python Programming: A Case Study with CSE Students at Anurag University. *Journal of Engineering Education Transformations*, 38(Special Issue 1).
46. Pesaramelli, R. S., & Sujatha, B. (2024, March). Principle correlated feature extraction using differential evolution for improved classification. In *AIP Conference Proceedings* (Vol. 2919, No. 1). AIP Publishing.
47. Amarnadh, V., & Moparthi, N. R. (2023). Comprehensive review of different artificial intelligence-based methods for credit risk assessment in data science. *Intelligent Decision Technologies*, 17(4), 1265-1282.
48. Amarnadh, V., & Moparthi, N. R. (2024). Prediction and assessment of credit risk using an adaptive Binarized spiking marine predators' neural network in financial sector. *Multimedia Tools and Applications*, 83(16), 48761-48797.
49. Amarnadh, V., & Moparthi, N. R. (2024). Range control-based class imbalance and optimized granular elastic net regression feature selection for credit risk assessment. *Knowledge and Information Systems*, 1-30.
50. Amarnadh, V., & Akhila, M. (2019, May). RETRACTED: Big Data Analytics in E-Commerce User Interest Patterns. In *Journal of Physics: Conference Series* (Vol. 1228, No. 1, p. 012052). IOP Publishing.
51. Selvan, M. Arul, and S. Miruna Joe Amali. "RAINFALL DETECTION USING DEEP LEARNING TECHNIQUE." (2024).
52. Selvan, M. Arul. "Fire Management System For Industrial Safety Applications." (2023).
53. Selvan, M. A. (2023). A PBL REPORT FOR CONTAINMENT ZONE ALERTING APPLICATION.
54. Selvan, M. A. (2023). CONTAINMENT ZONE ALERTING APPLICATION A PROJECT BASED

LEARNING REPORT.

55. Selvan, M. A. (2021). Robust Cyber Attack Detection with Support Vector Machines: Tackling Both Established and Novel Threats.
56. Selvan, M. A. (2023). INDUSTRY-SPECIFIC INTELLIGENT FIRE MANAGEMENT SYSTEM.
57. Selvan, M. Arul. "PHISHING CONTENT CLASSIFICATION USING DYNAMIC WEIGHTING AND GENETIC RANKING OPTIMIZATION ALGORITHM." (2024).
58. Selvan, M. Arul. "Innovative Approaches in Cardiovascular Disease Prediction Through Machine Learning Optimization." (2024).
59. Reddy, B. R., & Adilakshmi, T. (2023). Proof-of-Work for Merkle based Access Tree in Patient Centric Data. *structure*, 14(1).
60. Reddy, B. R., Adilakshmi, T., & Kumar, C. P. (2020). Access Control Methods in Cloud Enabled the Cloud-Enabled Internet of Things. In *Managing Security Services in Heterogenous Networks* (pp. 1-17). CRC Press.
61. Reddy, M. B. R., Akhil, V., Preetham, G. S., & Poojitha, P. S. (2019). Profile Identification through Face Recognition.
62. Meghanareddy, K., Reddy, R., & Murthy, V. A Privacy Preserving Multi Owner Secure Search in Cloud Computing.
63. Kumar, R. V., Reddy, B. R., & Battula, S. K. (2012). EFFICIENT USAGE OF INFRASTRUCTURE CLOUDS.
64. Aydın, Ö., Karaarslan, E., & Gökçe Narin, N. (2023). Artificial intelligence, vr, ar and metaverse technologies for human resources management. *VR, AR and Metaverse Technologies for Human Resources Management (June 15, 2023)*.
65. Dutta, P. K., Naskar, M. K., & Mishra, O. P. (2012). Test of strain behavior model with radon anomaly in seismogenic area: A Bayesian melding approach. *International Journal of Geosciences*, 3(01), 126.
66. Dutta, P. K., Mallikarjuna, K., & Satish, A. (2017, September). Sensor based solar tracker system using electronic circuits for moisture detection and auto-irrigation. In *2017 IEEE International Conference on Power, Control, Signals and Instrumentation Engineering (ICPCSI)* (pp. 1475-1478). IEEE.
67. Dutta, P. K., Mishra, O. P., & Naskar, M. K. (2013). A review of operational earthquake forecasting methodologies using linguistic fuzzy rule-based models from imprecise data with weighted regression approach.
68. Lokhande, M., Kalpanadevi, D., Kate, V., Tripathi, A. K., & Bethapudi, P. (2023). Study of Computer Vision Applications in Healthcare Industry 4.0. In *Healthcare Industry 4.0* (pp. 151-166). CRC Press.
69. Tripathi, A. K., Soni, R., & Verma, S. (2022). A review on ethnopharmacological applications, pharmacological activities, and bioactive compounds of *Mimosa pudica* (linn.). *Research Journal of Pharmacy and Technology*, 15(9), 4293-4299.
70. Mishra, S., Grewal, J., Wal, P., Bhivshet, G. U., Tripathi, A. K., & Walia, V. (2024). Therapeutic potential of vasopressin in the treatment of neurological disorders. *Peptides*, 174, 171166.
71. Koliqi, R., Fathima, A., Tripathi, A. K., Sohi, N., Jesudasan, R. E., & Mahapatra, C. (2023). Innovative and Effective Machine Learning-Based Method to Analyze Alcoholic Brain Activity with Nonlinear Dynamics and Electroencephalography Data. *SN Computer Science*, 5(1), 113.
72. Tripathi, A. K., Diwedi, P., Kumar, N., Yadav, B. K., & Rathod, D. (2022). Trigonella Foenum Grecum L. Seed (Fenugreek) Pharmacological Effects on Cardiovascular and Stress Associated Disease. *NeuroQuantology*, 20(8), 4599.
73. Biswas, D., Sharma, G., Pandey, A., Tripathi, A. K., Pandey, A., & Sahu, P. & Chauhan, P. (2022). Magnetic Nanosphere: Promising approach to deliver the drug to the site of action. *NeuroQuantology*, 20(11), 4038.
74. Parganiha, R., Tripathi, A., Prathyusha, S., Baghel, P., Lanjhiyana, S., & Lanjhiyana, S. & Sarkar, D. (2022). A review of plants for hepatic disorders. *J. Complement. Med. Res*, 13(46), 10-5455.
75. Tripathi, A. K., Dwivedi, C. P., Bansal, P., Pradhan, D. K., Parganiha, R., & Sahu, D. An Ethnoveterinary Important Plant Terminalia Arjuna. *International Journal of Health Sciences*, (II), 10601-10607.
76. Babbar, R., Kaur, A., Vanya, Arora, R., Gupta, J. K., Wal, P., ... & Behl, T. (2024). Impact of Bioactive Compounds in the Management of Various Inflammatory Diseases. *Current Pharmaceutical Design*, 30(24), 1880-1893.
77. Parganiha, R., Tripathi, A., Prathyusha, S., Baghel, P., Lanjhiyana, S., Lanjhiyana, S., ... & Sarkar, D. (2022). A review of plants for hepatic disorders. *J. Complement. Med. Res*, 13(46), 10-5455.
78. Sahu, A., Mishra, S., Wal, P., Debnath, B., Chouhan, D., Gunjal, S. D., & Tripathi, A. K. (2024). Novel Quinoline-Based RAF Inhibitors: A Comprehensive Review on Synthesis, SAR and Molecular Docking Studies. *ChemistrySelect*, 9(23), e202400347.
79. Habeeb, M., Vengateswaran, H. T., Tripathi, A. K., Kumbhar, S. T., & You, H. W. (2024). Enhancing biomedical imaging: the role of nanoparticle-based contrast agents. *Biomedical Microdevices*, 26(4), 1-18.
80. Sinha, S., Tripathi, A. K., Pandey, A., Naik, P., Pandey, A., & Verma, V. S. (2024). Self-Assembled

- PEGylated Micelles for Precise and Targeted Drug Delivery: Current Challenges and Future Directions. *Biocatalysis and Agricultural Biotechnology*, 103296.
81. Sahu, P., Sharma, G., Verma, V. S., Mishra, A., Deshmukh, N., Pandey, A., ... & Chauhan, P. (2022). Statistical optimization of microwave assisted acrylamide grafting of Linum usitatissimum Gum. *NeuroQuantology*, 20(11), 4008.
 82. Tripathi, A. K., Sharma, N., Mishra, J., Bisoi, D., Mohapatra, N., Muztaba, M. M., ... & TarakaRamarao, C. (2023). EVALUATION OF ANTI-INFLAMMATORY ACTIVITY OF PLANT EXTRACT OF CORDIA DICHOTOMA LEAVES ON CARRAGEENAN-INDUCED PAW EDEMA IN ALBINO WISTER RATS AND ITS PHYTOCHEMICAL ANALYSIS. *Ann. For. Res*, 66(1), 803-818.
 83. Vasista, T. G. K. (2017). Towards innovative methods of construction cost management and control. *Civ Eng Urban Plan: Int J*, 4, 15-24.
 84. Vasista, T. G. K. (2012). Quality Management System for Contemporary Public Administration: A case study of e-Governance. *Journal of Public Administration and Governance*, 2(4), 164-177.
 85. Vasista, T. G. (2018). SaaS Based E-Court Applications in E-Governance in India. *International Journal of Managing Public Sector Information and Communication Technologies (IJMPICT)* Vol, 9.
 86. Al Sudairi, M. A. T., & Vasista, T. G. (2013). Achieving process standardization in digital society with 'ASCP model'. *Journal of Supply Chain and Customer Relationship Management*, 2013, 1.
 87. Vasista, T. G. K., & AlAbdullatif, A. M. (2017). Role of electronic customer relationship management in demand chain management: A predictive analytic approach. *International Journal of Information Systems and Supply Chain Management (IJISSCM)*, 10(1), 53-67.
 88. Vasista, T. G., & Alsudairi, M. A. T. (2018). Managing through computer aided quality control in oil & natural gas industry project sites. *Journal of Advanced Research in Dynamical and Control Systems*, 10(4), 896-905.
 89. Algharabat, R. S., Zamil, A. M., & Vasista, T. G. K. (2015). The influence of retailer enterprise marketing information system on bullwhip effect. *International Journal of Business and Management*, 10(3), 237.
 90. AlSudairi, M. A., & Vasista, T. G. K. (2012). Design of strategic business model for electronic enterprise in digital society. *International Journal of Digital Society*, 3(3-4), 690-697.
 91. AlSudairi, M. A., & Vasista, T. G. K. (2012, June). Model for value creation and action generation of an electronic enterprise in a knowledge based economy. In *International Conference on Information Society (i-Society 2012)* (pp. 174-180). IEEE.
 92. Vasista, T. G., & Zamil, A. M. (2023). Role of metaverse in the fourth industrial revolution for providing customer experiences. In *How the Metaverse Will Reshape Business and Sustainability* (pp. 155-169). Singapore: Springer Nature Singapore.
 93. Hsu, H. Y., Hwang, M. H., & Chiu, Y. S. P. (2021). Development of a strategic framework for sustainable supply chain management. *AIMS Environmental Science*, (6).
 94. AlSudairi, M., Vasista, T. G., Zamil, A. M., & Algharabat, R. S. (2012). Mitigating the Bullwhip Effect with eWord Of Mouth: eBusiness Intelligence Perspective. *International Journal of Managing Value and Supply Chains*, 3(4), 27.
 95. Vasista, T. G. K., & AlSudairi, M. A. (2013). Service-oriented architecture (SOA) and semantic web services for web portal integration. In *Advances in Computing and Information Technology: Proceedings of the Second International Conference on Advances in Computing and Information Technology (ACITY) July 13-15, 2012, Chennai, India-Volume 2* (pp. 253-261). Berlin, Heidelberg: Springer Berlin Heidelberg.
 96. Alsudairi, M. A., & Tatapudi, G. (2014). Social innovation: Can it be a strategy for influencing GCC public welfare?. *Innovation*, 16(2), 273-282.
 97. Bhat, S. (2015). Technology for Chemical Industry Mixing and Processing. *Technology*, 2(2).
 98. Bhat, S. (2024). Building Thermal Comforts with Various HVAC Systems and Optimum Conditions.
 99. Bhat, S. (2020). Enhancing Data Centre Energy Efficiency with Modelling and Optimisation of End-To-End Cooling.
 100. Bhat, S. (2016). Improving Data Centre Energy Efficiency with End-To-End Cooling Modelling and Optimisation.
 101. Bhat, S. (2015). Deep Reinforcement Learning for Energy-Saving Thermal Comfort Management in Intelligent Structures.
 102. Bhat, S. (2015). Design and Function of a Gas Turbine Range Extender for Hybrid Vehicles.
 103. Bhat, S. (2023). Discovering the Attractiveness of Hydrogen-Fuelled Gas Turbines in Future Energy Systems.
 104. Bhat, S. (2019). Data Centre Cooling Technology's Effect on Turbo-Mode Efficiency.
 105. Bhat, S. (2018). The Impact of Data Centre Cooling Technology on Turbo-Mode Efficiency.
 106. Arora, P., & Bhardwaj, S. (2021). Methods for Threat and Risk Assessment and Mitigation to Improve Security in the Automotive Sector. *Methods*, 8(2).
 107. Arora, P., & Bhardwaj, S. (2020). Research on Cybersecurity Issues and Solutions for Intelligent

- Transportation Systems.
108. Arora, P., & Bhardwaj, S. (2019). The Suitability of Different Cybersecurity Services to Stop Smart Home Attacks.
 109. Arora, P., & Bhardwaj, S. (2017). A Very Safe and Effective Way to Protect Privacy in Cloud Data Storage Configurations.
 110. Kumar, T. V. (2024). A Comparison of SQL and NO-SQL Database Management Systems for Unstructured Data.
 111. Kumar, T. V. (2024). A Comprehensive Empirical Study Determining Practitioners' Views on Docker Development Difficulties: Stack Overflow Analysis.
 112. Kumar, T. V. (2024). Developments and Uses of Generative Artificial Intelligence and Present Experimental Data on the Impact on Productivity Applying Artificial Intelligence that is Generative.
 113. Kumar, T. V. (2024). A New Framework and Performance Assessment Method for Distributed Deep Neural NetworkBased Middleware for Cyberattack Detection in the Smart IoT Ecosystem.
 114. Sharma, S., & Dutta, N. (2024). Examining ChatGPT's and Other Models' Potential to Improve the Security Environment using Generative AI for Cybersecurity.
 115. Sharma, S., & Dutta, N. (2016). Analysing Anomaly Process Detection using Classification Methods and Negative Selection Algorithms.
 116. Sakshi, S. (2023). Development of a Project Risk Management System based on Industry 4.0 Technology and its Practical Implications.
 117. Madar, B., Kumar, G. K., & Ramakrishna, C. (2017). Captcha breaking using segmentation and morphological operations. *International Journal of Computer Applications*, 166(4), 34-38.
 118. Naik, R., Rao, P. R., & Madar, B. (2016). Cleaning of sensitive data in the cloud using Monitoring as a service. *International Journal of Computing*, 5(3).
 119. Rani, M. S., & Dorthi, K. (2022, June). An Empirical Study on Package Query Processing System using Parallel Processing Mechanisms. In *2022 7th International Conference on Communication and Electronics Systems (ICCES)* (pp. 1571-1575). IEEE.
 120. Reddy, T., & Prasad, T. S. D., Swetha, S., Nirmala, G., & Ram, P. (2018). A study on antiplatelets and anticoagulants utilisation in a tertiary care hospital. *International Journal of Pharmaceutical and Clinical Research*, 10, 155-161.
 121. Shakeel, M., Rao, C. L., Prasad, T. S., Alam, T., Rawat, N., & Kavitha, R. (2023, May). An examination of cybersecurity threats and authentication systems. In *2023 3rd International Conference on Advance Computing and Innovative Technologies in Engineering (ICACITE)* (pp. 2727-2731). IEEE.
 122. Teegala, S. P., Vijai, C., Nagpal, A., Anuradha, R., Aljbori, A., & Swathi, B. (2023, December). Enhanced Authentication Methods for Access and Control Management in Cloud Computing. In *2023 10th IEEE Uttar Pradesh Section International Conference on Electrical, Electronics and Computer Engineering (UPCON)* (Vol. 10, pp. 1673-1677). IEEE.
 123. Teegala, S. P., & Rao, C. G. (2022, March). A Novel Authentication Mechanism for SecureData Access based on Encryption Key Sharing for Cloud Web Application. In *2022 8th International Conference on Advanced Computing and Communication Systems (ICACCS)* (Vol. 1, pp. 1890-1897). IEEE.
 124. Viswanatha, V., Ramachandra, A. C., Prasanna, R. R., Kakarla, P. C., Simha, P. V., & Mohan, N. (2022). *Implementation of Tiny Machine Learning Models on Arduino 33-BLE for Gesture and Speech Recognition* (No. 8495). EasyChair.
 125. Prasanna, R., Kakarla, P. C., PJ, V. S., & Mohan, N. (2022). Implementation of tiny machine learning models on arduino 33 ble for gesture and speech recognition. *arXiv preprint arXiv:2207.12866*.
 126. AC, R., Chowdary Kakarla, P., Simha PJ, V., & Mohan, N. (2022). Implementation of Tiny Machine Learning Models on Arduino 33-BLE for Gesture and Speech Recognition. AC, R., Chowdary Kakarla, P., Simha PJ, V., & Mohan, N. (2022). Implementation of Tiny Machine Learning Models on Arduino 33-BLE for Gesture and Speech Recognition.
 127. Pabba, C., & Kumar, P. (2022). An intelligent system for monitoring students' engagement in large classroom teaching through facial expression recognition. *Expert Systems*, 39(1), e12839.
 128. Pabba, C., Bhardwaj, V., & Kumar, P. (2024). A visual intelligent system for students' behavior classification using body pose and facial features in a smart classroom. *Multimedia Tools and Applications*, 83(12), 36975-37005.
 129. Reddy, A. S., Chakradhar, P., & Santosh, T. (2018). Demand forecasting and demand supply management of vegetables in India: a review and prospect. *Int J Comput Technol*, 17(1), 7170-7178.
 130. Pabba, C., & Kumar, P. (2024). A vision-based multi-cues approach for individual students' and overall class engagement monitoring in smart classroom environments. *Multimedia Tools and Applications*, 83(17), 52621-52652.
 131. Nagaraj, P., Banala, R., & Prasad, A. K. (2021, August). Real time face recognition using effective supervised machine learning algorithms. In *Journal of Physics: Conference Series* (Vol. 1998, No. 1, p.

- 012007). IOP Publishing.
132. Nagaraj, P., Prasad, A. K., Narsimha, V. B., & Sujatha, B. (2022). Swine flu Detection and Location using Machine Learning Techniques and GIS. *International Journal of Advanced Computer Science and Applications*, 13(9).
 133. Nagaraj, P., Phebe, G. S., & Singh, A. (2021, November). A Novel Technique to Classify Face Mask for Human Safety. In *2021 Sixth International Conference on Image Information Processing (ICIIP)* (Vol. 6, pp. 235-239). IEEE.
 134. Nagaraj, P., Prasad, D. A. K., Dass, D. M. V., & Kumar, K. R. (2022). Swine Flu Hotspot Prediction In Regions Based on Dynamic Hotspot Detection Algorithm. *Journal of Theoretical and Applied Information Technology (JATIT)*, 30.
 135. Priyanka, J. H., & Parveen, N. (2022). Online employment portal architecture based on expert system. *Indones. J. Electr. Eng. Comput. Sci*, 25(3), 1731-1735.
 136. Priyanka, J. H., & Parveen, N. (2024). DeepSkillNER: an automatic screening and ranking of resumes using hybrid deep learning and enhanced spectral clustering approach. *Multimedia Tools and Applications*, 83(16), 47503-47530.
 137. Jammalamadaka, S. B., Duvvuri, B. K., Jammalamadaka, K. S., & Priyanka, J. H. (2019). Automating WEB interface in relation to user behaviour. In *First International Conference on Artificial Intelligence and Cognitive Computing: AICC 2018* (pp. 91-102). Springer Singapore.
 138. Sathish, S., Thangavel, K., & Boopathi, S. (2011). Comparative analysis of DSR, FSR and ZRP routing protocols in MANET. In *International Conference on Information and Network Technology IPCSIT vol* (Vol. 4).
 139. Sathish, S., Thangavel, K., & Boopathi, S. (2010). Performance analysis of DSR, AODV, FSR and ZRP routing protocols in MANET. *MES Journal of Technology and Management*, 57-61.
 140. Murali, V., & Boopathi, S. (2014). A Comparative Analysis of Various Segmentation Techniques in Brain Tumor Image. *International Journal of Application or Innovation in Engineering & Management (IJAIEEM)*, ISSN, 2319-4847.
 141. Balaraju, J., & Prasada Rao, P. V. R. D. (2019). Designing authentication for Hadoop Cluster using DNA algorithm. *Int. J. Recent. Technol. Eng.(IJRTE)*, 8(3).
 142. Balaraju, J., & Prasada Rao, P. V. R. D. (2020). Innovative secure authentication interface for Hadoop cluster using DNA cryptography: A practical study. In *Soft Computing and Signal Processing: Proceedings of 2nd ICSCSP 2019 2* (pp. 17-29). Springer Singapore.
 143. Balaraju, J., & Prasada Rao, P. V. R. D. (2018). Recent advances in big data storage and security schemas of HDFS: a survey. *Journal of Engineering Technology. Special Issue (Emerging Trends in Engineering Technology)*, 118(24), 132-138.
 144. Balaraju, J., & Prasada Rao, P. V. R. D. (2020). Investigation and finding a DNA cryptography layer for securing data in Hadoop cluster. *Int. J. Advance Soft Comput. Appl*, 12(3).