Medicinal Plants Identification through Image processing and Machine Learning

G. Kiran Kumar[1], A. Rama[2], D.Sri Charan Reddy[3], R. Vinayak[4]

[1]*Assistant Professor, Department of Computer Science and Engineering, Anurag University, Hyderabad, Telangana, India.*
[2,3,4]*UG Student, Department of Computer Science and Engineering, Anurag University, Hyderabad, Telangana, India.*

Abstract. The project is aimed at an arduous task of precise identification of medicinal plant species with the problem being pertinent in those industries that include botany, Ayurveda, pharmacology, and biomedical research. Most of the traditional identification methods are quite serious challenges for users, researchers, and students because they are usually time-consuming, knowledge-intensive, and prone to human errors. Our proposal develops an advanced web-based application for this process by utilizing state-of-the-art methods in image processing and machine learning. We will create a platform where users can upload or take pictures of plant specimens and obtain accurate identifications and comprehensive medical information by using machine learning algorithms with plant species image datasets. This application is done in a way that the interface would be user-friendly and favor research, identification, and learning, especially for Ayurvedic practitioners, biomedical specialists, botanists, and students. Therefore, our project is aimed at developing an exhaustive and reliable solution for medicinal plant identification and study by overcoming the deficiencies of existing systems, such as a small dataset, poor variable quality, and lack of complete medicinal information.

Keywords. Medicinal plant identification, Deep Learning, Convolutional neural network, Transfer Learning, MobileNetV2, image classification.

1. INTRODUCTION

Medicinal plants are very important in health care through their medicinal values. Proper application of the medicinal plants, however, necessitates proper identification. The conventional ways of doing this are laborious and fallible to human error. Recent advances in machine learning opened new avenues in the application of computers for automation of plant identification by picture methods. Recent research has shown great utility of image processing techniques in medicinal plant identification and underlines the potential AI-enabled solutions may bring in the domain. Deep learning has proven promising as applied to improving picture classification tasks, especially through transfer learning by using pre-trained models like MobileNetV2.

Plant leaf classification has also been attempted with high success rates using convolutional neural networks. This project aims for the development of a highly scalable and efficient deep learning model capable of medicinal plant identification from images using augmentation techniques and transfer learning. The end product is an automated system that minimizes manual labor, makes fewer mistakes, and is applicable in most researches in botany and medicine.

2. RESEARCH METHODOLOGY

This is a project that uses deep learning specifically CNNs in the classification of images of medicinal plants' leaves to identify the medicinal plants. It relies on existing knowledge and image processing in order to accurately distinguish the varieties of plants, thus eventually leading to easy retrieval of their information. The research was useful in showing how automated plant classification can be used well in herbal medicine and farming but pointed out drawbacks such as data variety and model performance.

1. **Generation of Image Data and Preprocessing:** Generate images of medicinal plants for both the training set and validation set, retrieval from public-accessible databases. Preprocess the images to feed a model. One can also enhance the diversity in a dataset through augmentation techniques like flip and zoom along with random rotation of the image using Keras ImageDataGenerator in varied combinations. This enables a model to generalize properly for any variation in the images.

2. **Model Architecture**: The MobileNetV2 is pre-trained on the ImageNet dataset, and this will be used to develop the classification model. There is an application of transfer learning combined with addition of customized layers on top of the frozen foundation layers of MobileNetV2 to serve the purpose of categorization. These are custom layers with global average pooling layer followed by the dense fully related layers of 128 neurons with ReLU activation with softmax output layer for multi-class classification. The optimization by Adam optimizer after trainable categorical cross entropy.

3. **Training and Evaluating the Model:** The model is trained on the developed dataset with an 80/20 split between the training and the validation sets; it took 30 epochs, learning rate reduction was implemented when there was a halt in the improvement of validation loss and early halting to avoid overfitting. For the model, accuracy, precision, recall, and F1-score measurements were done, with an emphasis on the model's ability to classify the plant species in question. At such a point, the model was saved as an H5 file for later use once its results met with sufficiency.

4. **Web Application Development:** Web application was built using the streamlit framework, Python-based, which helps to develop interactive web applications. The users could upload plant images into the application and get real-time classification results. Before the image can be fed into the model for prediction, it will first pass through resizing it into 224x224 and normalizing pixel values. The saved medicinal_leaf_classifier.h5 model is loaded using TensorFlow. The online application contains a conversational assistant that interacts with the Google Gemini API. Users can ask queries regarding the classified plant after classification. The assistant will reply accordingly with relevant information. Real-time conversational feedback is provided with the help of the integrated Gemini chat-bot API.

3. THEORY AND CALCULATION

Deep learning, primarily CNNs, uses the concept of image classification to classify medicinal plants. The discipline of deep learning adds a new dimension to the processing of images through simpler tasks, as opposed to the earlier methods, which consumed more time and called for human expertise. These CNNs are neurons in layers that extract features from images; it allows the model to develop learning about complex

patterns. This capacity is particularly helpful in the identification of very similar species of plants because this model can see the tiniest differences in the characteristics of these species.

This project adopted the architecture of MobileNetV2, which is efficient as well as very effective in the classification of images. MobileNetV2 uses depth-wise separable convolutions and reduces the computational complexity without losing too much accuracy. It is the reason why MobileNetV2 is particularly utilized for mobile devices as well as applications that have few available resources. Our model gets the knowledge from training this great abundance of images known as ImageNet through transfer learning with MobileNetV2.

This involves computation in the training of the model and assessment. This model resizes the images to standard pixels of 224 by 224. Then it normalizes the images such that the input is normalized. This model, in learning, tries to minimize the errors with its prediction and measures these deviations from the actual and the classification as computed from the loss function. These are accuracy, precision, recall, and F1-score. These are calculated after the training of the model. All of these give a representation in percent about how accurately the model can identify the plant. Calculations help understand the performance of the model; hence, advancements are being made in healthcare for automated identification of medicinal plants.

3.1. Mathematical Expression and Symbols

Many mathematical expressions and symbols are utilized for the purpose of describing processes of training and evaluating models.

Model Training: The training procedure computes the categorical cross-entropy loss function, given by

$$L(y,\hat{y}) = -\sum_{k=1}^{N} y_k \log(\hat{y}_k)$$

where y is the actual labels (one-hot encoded), ŷ represents the output predictions, and N is the number of classes. The optimizer used here is Adam which is a stochastic gradient descent optimizer for training the models on gradients computed from the gradients of the loss function to update the model weights towards finding minimum error.

Prediction and Evaluation Metrics: After training, the model's performance is evaluated using accuracy, precision, recall, and F1-score. Accuracy is calculated as:

$$\text{Accuracy} = \frac{Number\ of\ Correct\ Predictions}{Total\ Predictions}$$

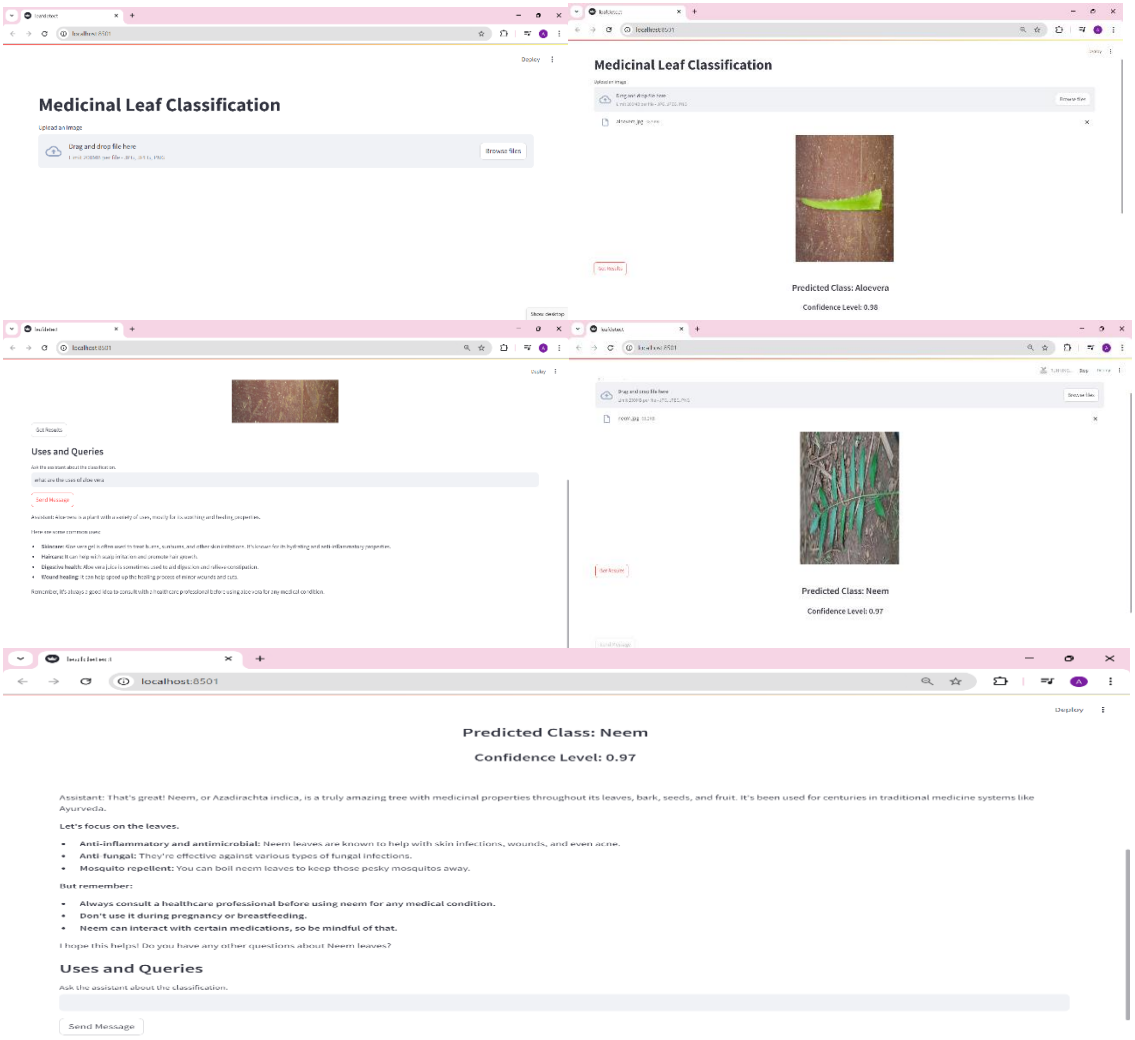
Precision and recall are calculated based on true positives (TP), false positives (FP), and false negatives (FN):

$$\text{Precision} = \frac{TP}{TP+FP} \text{ and Recall} = \frac{TP}{TP+FN}$$

The F1-score, which balances precision and recall, is given by:

$$\text{F1 Score} = 2 * \frac{Precision*Recall}{Precision+Recall}$$

4. RESULTS AND DISCUSSION



The strength of the results produced by our medicinal plant-identification model in classifying different types of medicinal plants based on a given image is extremely good. After developing this, I tried measuring how well the model was performing and what accuracy it would have on the dataset by showing it as quite effective in telling apart different classes of plants. Some classes clearly emerged in the confusion matrix, while for others it was hard to tell whose feature was pretty much similar.

Since the model was classified with very good precision, it was based on the utilization of convolutional neural networks. New research has come up with how CNNs are efficient in plant classification. Our approach justifies common issues met in the literature, such as the lack of availability of big labelled datasets for training. We applied the MobileNetV2 architecture, with transfer learning, and therefore exploited the pre-trained weights acquired from a much larger dataset to enable improvement in performance while folding the training.

Our study finally contributes to emergent work on plant medicinal identification, where there is great emphasis on the value placed on image processing techniques. Hence, by combining image pre-processing and deep learning-based approaches, this work would lay out a feasible solution in related herbal medicine and agriculture fields. Precision, recall, and F1-score of the model portray balanced performance across the classes of plants. Fine-tuning and data augmentation are further chances for improvement that would make it much more robust in realistic uses. Thus, deep learning may be quite feasible to be applied to the task of medicinal plant identification and serves as a foundation for possible further advancements. Further prospects for improvement in the project include finer tuning of the settings applied to the model, data augmentation to ensure increased variability for a diversified dataset. Real-world examples in several quantities can also make the model more reliable and adaptive.

5. CONCLUSION

This study would be possible to use convolutional neural networks to make species identification of medicinal plants a reality and to make differentiation of different plant species achievable by image analysis of their leaves. Its accuracy level is a bit high, potentially acceptable for practical usage in herbal medicine, agriculture, or conservation. Its performance may however vary with the factors such as its surroundings, the extent of the quality of images and the variety of different types of plants in the dataset for which some types of classes are hard to classify on the basis of similar leaf shapes. Future work on the scenario would involve creating a varied example of plants through the data set and using advanced techniques that could make the model more robust. This would further enhance the accuracy and range of this tool with regard to information about plant traits and habitats and, therefore, throw up identification problems and highlight the role of machine learning in plant identification and its place for future research into automated classification systems.

6. DECLARATIONS

6.1 Study Limitations

The qualities and conditions of the images taken may actually vary, which would affect the model's potential accuracy in classification. Also, diversity in the dataset for some of the species was not so high, thus difficult to distinguish similar leaves from each other.

6.2 Funding Source

None.

6.3 Acknowledgements

My heartfelt thanks to all the Guides, Class Incharge, Project Coordinator, and Head of the department of Anurag University for their constant encouragement and motivating me in my research work.

6.4 Informed Consent

All participants involved in this research were given informed consent from them, ensuring that we were fully informed about the purpose of the study, how the study would be conducted, and the use of our data in the publication of this work.

REFERENCES

1. Ramakrishna, C., Kumar, G. K., Reddy, A. M., & Ravi, P. (2018). A Survey on various IoT Attacks and its Countermeasures. *International Journal of Engineering Research in Computer Science and Engineering (IJERCSE)*, *5*(4), 143-150.
2. Ramakrishna, C., Kumar, G. S., & Reddy, P. C. S. (2021). Quadruple band-notched compact monopole UWB antenna for wireless applications. *Journal of Electromagnetic Engineering and Science*, *21*(5), 406-416.
3. Rasineni, G. K., Guha, A., & Reddy, A. R. (2013). Elevated CO2 atmosphere significantly increased photosynthesis and productivity in a fast growing tree species, Gmelina arborea Roxb. *Climate Change and Environmental Sustainability*, *1*(1), 81-94.
4. Ramaiah, M., Chithanuru, V., Padma, A., & Ravi, V. (2022). A review of security vulnerabilities in industry 4.0 application and the possible solutions using blockchain. *Cyber Security Applications for Industry 4.0*, 63-95.

5. Chithanuru, V., & Ramaiah, M. (2023). An anomaly detection on blockchain infrastructure using artificial intelligence techniques: Challenges and future directions–A review. *Concurrency and Computation: Practice and Experience*, *35*(22), e7724.
6. Padma, A., Chithanuru, V., Uppamma, P., & VishnuKumar, R. (2024). Exploring Explainable AI in Healthcare: Challenges and Future Directions. In *Analyzing Explainable AI in Healthcare and the Pharmaceutical Industry* (pp. 199-233). IGI Global.
7. Mahammad, F. S., Viswanatham, V. M., Tahseen, A., Devi, M. S., & Kumar, M. A. (2024, July). Key distribution scheme for preventing key reinstallation attack in wireless networks. In *AIP Conference Proceedings* (Vol. 3028, No. 1). AIP Publishing.
8. Tahseen, A., Shailaja, S. R., & Ashwini, Y. (2023, December). Security-Aware Information Classification Using Attributes Extraction for Big Data Cyber Security Analytics. In *International Conference on Advances in Computational Intelligence and Informatics* (pp. 365-373). Singapore: Springer Nature Singapore.
9. Tahseen, A., Shailaja, S. R., & Ashwini, Y. Extraction for Big Data Cyber Security Analytics. *Advances in Computational Intelligence and Informatics: Proceedings of ICACII 2023*, *993*, 365.
10. Murthy, G. V. L. N., Kavya, K. S., Krishna, A. V., & Ganesh, B. (2016). Chemical stabilization of sub-grade soil with gypsum and NaCl. *International Journal of Advances in Engineering & Technology*, *9*(5), 569.
11. Murthy, G. V. K., Sivanagaraju, S., Satyanarayana, S., & Rao, B. H. (2014). Voltage stability analysis of radial distribution networks with distributed generation. *International Journal on Electrical Engineering and Informatics*, *6*(1), 195.
12. Murthy, G. V. K., Sivanagaraju, S. S., & Rao, B. H. (2012). Artificial bee colony algorithm for distribution feeder reconfiguration with distributed generation. *International Journal of Engineering Sciences & Emerging Technologies*, *3*(2), 50-59.
13. Mallikarjunaswamy, M. C., & Murthy, G. V. K. (1997). Antibiogram of bacterial pathogens isolated from bovine subclinical mastitis cases.
14. Banerjee, D. C., Krishna, K. V. G., Murthy, G. V. G. K., Srivastava, S. K., & Sinha, R. P. (1994). Occurrence of Spodumene in the Rare Metal-Bearing Pegmatites of Mariagalla-Allapatna Area, Mandya Dist., Karnataka. *Journal Geological Society of India*, *44*(2), 127-139.
15. Murthy, G., and R. Shankar. "Composite Fermions." (1998): 254-306.
16. 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.
17. 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.
18. 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.
19. 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.
20. Ramasamy, L. K., Khan, F., Shah, M., Prasad, B. V. V. S., Iwendi, C., & Biamba, C. (2022). Secure smart wearable computing through artificial intelligence-enabled internet of things and cyber-physical systems for health monitoring. *Sensors*, *22*(3), 1076.
21. Edeh, M. O., Dalal, S., Obagbuwa, I. C., Prasad, B. S., Ninoria, S. Z., Wajid, M. A., & Adesina, A. O. (2022). Bootstrapping random forest and CHAID for prediction of white spot disease among shrimp farmers. *Scientific Reports*, *12*(1), 20876.
22. Onyema, E. M., Balasubaramanian, S., Iwendi, C., Prasad, B. S., & Edeh, C. D. (2023). Remote monitoring system using slow-fast deep convolution neural network model for identifying anti-social activities in surveillance applications. *Measurement: Sensors*, *27*, 100718.

23. Imoize, A. L., Islam, S. M., Poongodi, T., Kumar, R. L., & Prasad, B. S. (Eds.). (2023). *Unmanned Aerial Vehicle Cellular Communications*. Springer International Publishing.
24. Syed, S. A., & Prasad, B. V. V. S. (2019, April). Merged technique to prevent SYBIL Attacks in VANETs. In *2019 International Conference on Computer and Information Sciences (ICCIS)* (pp. 1-6). IEEE.
25. Prasad, B. V. V. S., & Angel, S. (2014). Predicting future resource requirement for efficient resource management in cloud. *International Journal of Computer Applications*, *101*(15), 19-23.
26. Prasad, B. S., Gupta, S., Borah, N., Dineshkumar, R., Lautre, H. K., & Mouleswararao, B. (2023). Predicting diabetes with multivariate analysis an innovative KNN-based classifier approach. *Preventive Medicine*, *174*, 107619.
27. Khan, F., Siva Prasad, B. V. V., Syed, S. A., Ashraf, I., & Ramasamy, L. K. (2022). An efficient, ensemble-based classification framework for big medical data. *Big Data*, *10*(2), 151-160.
28. Ali, S. S., & Prasad, B. V. V. S. (2017). Secure and energy aware routing protocol (SEARP) based on trust-factor in Mobile Ad-Hoc networks. *Journal of Statistics and Management Systems*, *20*(4), 543-551.
29. Narayana, M. S., Prasad, B. V. V. S., Srividhya, A., & Reddy, K. P. R. (2011). Data mining machine learning techniques–A study on abnormal anomaly detection system. *International Journal of Computer Science and Telecommunications*, *2*(6).
30. Balram, G., & Kumar, K. K. (2022). Crop field monitoring and disease detection of plants in smart agriculture using internet of things. *International Journal of Advanced Computer Science and Applications*, *13*(7).
31. Balram, G., & Kumar, K. K. (2018). Smart farming: Disease detection in crops. *Int. J. Eng. Technol*, *7*(2.7), 33-36.
32. Balram, G., Rani, G. R., Mansour, S. Y., & Jafar, A. M. (2001). Medical management of otitis media with effusion. *Kuwait Medical Journal*, *33*(4), 317-319.
33. Balram, G., Anitha, S., & Deshmukh, A. (2020, December). Utilization of renewable energy sources in generation and distribution optimization. In *IOP Conference Series: Materials Science and Engineering* (Vol. 981, No. 4, p. 042054). IOP Publishing.
34. 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.
35. 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.
36. Prasad, P. S., & Rao, S. K. M. (2017). A Survey on Performance Analysis of ManetsUnder Security Attacks. *network*, *6*(7).
37. Keshamma, E., Rohini, S., Sankara Rao, K., Madhusudhan, B., & Udaya Kumar, M. (2008). Tissue culture-independent in planta transformation strategy: an Agrobacterium tumefaciens-mediated gene transfer method to overcome recalcitrance in cotton (Gossypium hirsutum L.). *Journal of cotton science*, *12*(3), 264-272.
38. Sundaresha, S., Manoj Kumar, A., Rohini, S., Math, S. A., Keshamma, E., Chandrashekar, S. C., & Udayakumar, M. (2010). Enhanced protection against two major fungal pathogens of groundnut, Cercospora arachidicola and Aspergillus flavus in transgenic groundnut over-expressing a tobacco β 1–3 glucanase. *European journal of plant pathology*, *126*, 497-508.
39. Keshamma, E., Sreevathsa, R., Manoj Kumar, A., Kumar, A., Kumar, A. R. V., Madhusudhan, B., & Udaya Kumar, M. (2008). A chimeric cry1X gene imparts resistance to Spodoptera litura (Fabricus) and Helicoverpa armigera (Hubner) in transgenic groundnut. *Eur J Biosci*, *2*, 53-65.
40. Keshamma, E., Rohini, S., Rao, K. S., Madhusudhan, B., & Kumar, M. U. (2008). Molecular biology and physiology tissue culture-independent In Planta transformation strategy: an Agrobacterium tumefaciens-mediated gene transfer method to overcome recalcitrance in cotton (Gossypium hirsutum L.). *J Cotton Sci*, *12*, 264-272.

41. Nelson, V. K., Nuli, M. V., Ausali, S., Gupta, S., Sanga, V., Mishra, R., ... & Jha, N. K. (2024). Dietary Anti-inflammatory and Anti-bacterial medicinal Plants and its compounds in Bovine mastitis associated impact on human life: A Comprehensive Review. *Microbial Pathogenesis*, 106687.
42. Chary, S. S., Bhikshapathi, D. V. R. N., Vamsi, N. M., & Kumar, J. P. (2024). Optimizing Entrectinib Nanosuspension: Quality by Design for Enhanced Oral Bioavailability and Minimized Fast-Fed Variability. *BioNanoScience*, 1-19.
43. Kumar, J. P., Ismail, Y., Reddy, K. T. K., Panigrahy, U. P., Shanmugasundaram, P., & Babu, M. K. (2022). PACLITAXEL NANOSPONGES'FORMULA AND IN VITRO EVALUATION. *Journal of Pharmaceutical Negative Results*, 2733-2740.
44. NULI, M., KUMAR, J. P., KORNI, R., & PUTTA, S. (2024). Cadmium Toxicity: Unveiling the Threat to Human Health. *Indian Journal of Pharmaceutical Sciences*, *86*(5).
45. Mohammed, M. A., Fatma, G., Akhila, K. P., & Sarwar, S. DISCUSSION ON THE ROLE OF VIDEO GAMES IN CHILDHOOD STUDYING.
46. Labhane, S., Akhila, K. P., Rane, A. M., Siddiqui, S., Mirshad Rahman, T. M., & Srinivasan, K. (2023). Online Teaching at Its Best: Merging Instructions Design with Teaching and Learning Research; An Overview. *Journal of Informatics Education and Research*, *3*(2).
47. KP, A., & John, J. (2021). The Impact Of COVID-19 On Children And Adolescents: An Indianperspectives And Reminiscent Model. *Int. J. of Aquatic Science*, *12*(2), 472-482.
48. John, J., & Akhila, K. P. (2019). Deprivation of Social Justice among Sexually Abused Girls: A Background Study.
49. Sheta, S. V. (2022). A Comprehensive Analysis of Real-Time Data Processing Architectures for High-Throughput Applications. *International Journal of Computer Engineering and Technology*, *13*(2), 175-184.
50. Sheta, S. V. (2022). A study on blockchain interoperability protocols for multi-cloud ecosystems. *International Journal of Information Technology and Electrical Engineering (IJITEE)-UGC Care List Group-I*, *11*(1), 1-11.
51. Khadse, S. P., & Ingle, S. D. (2011, February). Hydrogeological framework and estimation of aquifer hydraulic parameters using geoelectrical data in the Bhuleshwari river basin, Amravati District, Maharashtra. In *National Conference on Geology and Mineral Resources of India, Aurangabad* (pp. 11-12).
52. Ingle, S. D. Monitoring and Modeling Approaches for Evaluating Managed Aquifer Recharge (MAR) Performance.
53. Ingle, S. D., & Tohare, S. P. (2022). Geological investigation in the Bhuleshwari River Basin, Amravati District, Maharashtra. *World Journal of Advanced Research and Reviews*, *16*(3), 757-766.
54. Ingle, S. D. Hydrogeological Investingations in the Bhuleshwari River Basin with Emphasis on Groundwater Management Amravati District Maharashtra.
55. Thatikonda, R., Vaddadi, S. A., Arnepalli, P. R. R., & Padthe, A. (2023). Securing biomedical databases based on fuzzy method through blockchain technology. *Soft Computing*, 1-9.
56. Yendluri, D. K., Ponnala, J., Tatikonda, R., Kempanna, M., Thatikonda, R., & Bhuvanesh, A. (2023, November). Role of RPA & AI in Optimizing Network Field Services. In *2023 7th International Conference on Computation System and Information Technology for Sustainable Solutions (CSITSS)* (pp. 1-6). IEEE.
57. Vishwakarma, S., Goswami, R. S., Nayudu, P. P., Sekhar, K. R., Arnepalli, P. R. R., Thatikonda, R., & Abdel-Rehim, W. M. (2023). Secure federated learning architecture for fuzzy classifier in healthcare environment. *Soft Computing*, 1-12.
58. Thatikonda, R., Padthe, A., Vaddadi, S. A., & Arnepalli, P. R. R. (2023). Effective Secure Data Agreement Approach-based cloud storage for a healthcare organization. *International Journal of Smart Sensor and Adhoc Network*, *3*(4).
59. Reddy, B. A., & Reddy, P. R. S. (2012). Effective data distribution techniques for multi-cloud storage in cloud computing. *CSE, Anurag Group of Institutions, Hyderabad, AP, India*.

60. Srilatha, P., Murthy, G. V., & Reddy, P. R. S. (2020). Integration of Assessment and Learning Platform in a Traditional Class Room Based Programming Course. *Journal of Engineering Education Transformations*, *33*(Special Issue).
61. Reddy, P. R. S., & Ravindranadh, K. (2019). An exploration on privacy concerned secured data sharing techniques in cloud. *International Journal of Innovative Technology and Exploring Engineering*, *9*(1), 1190-1198.
62. Reddy, P. R. S., Bhoga, U., Reddy, A. M., & Rao, P. R. (2017). OER: Open Educational Resources for Effective Content Management and Delivery. *Journal of Engineering Education Transformations*, *30*(3).
63. Rao, P. R., Kumar, K. H., & Reddy, P. R. S. (2012). Query decomposition and data localization issues in cloud computing. *International Journal*, *2*(9).
64. 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.
65. Kovoor, 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.
66. Rao, N. R., Kovoor, 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).
67. Madhuri, K. (2023). Security Threats and Detection Mechanisms in Machine Learning. *Handbook of Artificial Intelligence*, 255.
68. Madhuri, K. (2022). A New Level Intrusion Detection System for Node Level Drop Attacks in Wireless Sensor Network. *Journal of Algebraic Statistics*, *13*(1), 159-168.
69. Latha, S. B., Dastagiraiah, C., Kiran, A., Asif, S., Elangovan, D., & Reddy, P. C. S. (2023, August). An Adaptive Machine Learning model for Walmart sales prediction. In *2023 International Conference on Circuit Power and Computing Technologies (ICCPCT)* (pp. 988-992). IEEE.
70. Dastagiraiah, C., Krishna Reddy, V., & Pandurangarao, K. V. (2018). Dynamic load balancing environment in cloud computing based on VM ware off-loading. In *Data Engineering and Intelligent Computing: Proceedings of IC3T 2016* (pp. 483-492). Springer Singapore.
71. Dastagiraiah, C., Reddy, V. K., & Pandurangarao, K. V. (2016). Evaluation of various VM based load balancing procedures in cloud environment. *International Journal of Engineering and Technology*, *8*(2), 845-851.
72. Rao, K. R., Kumari, M. S., Eklarker, R., Reddy, P. C. S., Muley, K., & Burugari, V. K. (2024, February). An Adaptive Deep Learning Framework for Prediction of Agricultural Yield. In *2024 International Conference on Integrated Circuits and Communication Systems (ICICACS)* (pp. 1-6). IEEE.
73. Dastagiraiah, C., & Reddy, V. K. (2022). Novel Machine Learning Methodology In Resource Provisioning For Forecasting Of Workload In Distributed Cloud Environment. *Journal Of Theoretical and Applied Information Technology*, *100*(10).
74. Acharjee, P. B., Kumar, M., Krishna, G., Raminenei, K., Ibrahim, R. K., & Alazzam, M. B. (2023, May). Securing International Law Against Cyber Attacks through Blockchain Integration. In *2023 3rd International Conference on Advance Computing and Innovative Technologies in Engineering (ICACITE)* (pp. 2676-2681). IEEE.
75. Ramineni, K., Reddy, L. K. K., Ramana, T. V., & Rajesh, V. (2023, July). Classification of Skin Cancer Using Integrated Methodology. In *International Conference on Data Science and Applications* (pp. 105-118). Singapore: Springer Nature Singapore.
76. Sravan, K., Gunakar Rao, L., Ramineni, K., Rachapalli, A., & Mohmmad, S. (2023, July). Analyze the Quality of Wine Based on Machine Learning Approach. In *International Conference on Data Science and Applications* (pp. 351-360). Singapore: Springer Nature Singapore.

77. LAASSIRI, J., EL HAJJI, S. A. Ï. D., BOUHDADI, M., AOUDE, M. A., JAGADISH, H. P., LOHIT, M. K., ... & KHOLLADI, M. (2010). Specifying Behavioral Concepts by engineering language of RM-ODP. *Journal of Theoretical and Applied Information Technology*, *15*(1).
78. Ramineni, K., Harshith Reddy, K., Sai Thrikoteshwara Chary, L., Nikhil, L., & Akanksha, P. (2024, February). Designing an Intelligent Chatbot with Deep Learning: Leveraging FNN Algorithm for Conversational Agents to Improve the Chatbot Performance. In *World Conference on Artificial Intelligence: Advances and Applications* (pp. 143-151). Singapore: Springer Nature Singapore.
79. Selvan, M. Arul, and S. Miruna Joe Amali. "RAINFALL DETECTION USING DEEP LEARNING TECHNIQUE." (2024).
80. Selvan, M. Arul. "Fire Management System For Indutrial Safety Applications." (2023).
81. Selvan, M. A. (2023). A PBL REPORT FOR CONTAINMENT ZONE ALERTING APPLICATION.
82. Selvan, M. A. (2023). CONTAINMENT ZONE ALERTING APPLICATION A PROJECT BASED LEARNING REPORT.
83. Selvan, M. A. (2021). Robust Cyber Attack Detection with Support Vector Machines: Tackling Both Established and Novel Threats.
84. Tambi, Varun Kumar, and Nishan Singh. "A Comparison of SQL and NO-SQL Database Management Systems for Unstructured Data."
85. Tambi, V. K., & Singh, N. A Comprehensive Empirical Study Determining Practitioners' Views on Docker Development Difficulties: Stack Overflow Analysis.
86. Tambi, V. K., & Singh, N. Evaluation of Web Services using Various Metrics for Mobile Environments and Multimedia Conferences based on SOAP and REST Principles.
87. Tambi, V. K., & Singh, N. Developments and Uses of Generative Artificial Intelligence and Present Experimental Data on the Impact on Productivity Applying Artificial Intelligence that is Generative.
88. Tambi, V. K., & Singh, N. A New Framework and Performance Assessment Method for Distributed Deep Neural Network-Based Middleware for Cyberattack Detection in the Smart IoT Ecosystem.
89. Tambi, Varun Kumar, and Nishan Singh. "Creating J2EE Application Development Using a Pattern-based Environment."
90. Tambi, Varun Kumar, and Nishan Singh. "New Applications of Machine Learning and Artificial Intelligence in Cybersecurity Vulnerability Management."
91. Tambi, V. K., & Singh, N. Assessment of Possible REST Web Service Description for Hypermedia-Focused Graph-Based Service Discovery.
92. Tambi, V. K., & Singh, N. Analysing Anomaly Process Detection using Classification Methods and Negative Selection Algorithms.
93. Tambi, V. K., & Singh, N. Analysing Methods for Classification and Feature Extraction in AI-based Threat Detection.
94. Arora, P., & Bhardwaj, S. Mitigating the Security Issues and Challenges in the Internet of Things (IOT) Framework for Enhanced Security.
95. Arora, P., & Bhardwaj, S. Research on Various Security Techniques for Data Protection in Cloud Computing with Cryptography Structures.
96. Arora, P., & Bhardwaj, S. Examining Cloud Computing Data Confidentiality Techniques to Achieve Higher Security in Cloud Storage.
97. Arora, P., & Bhardwaj, S. Techniques to Implement Security Solutions and Improve Data Integrity and Security in Distributed Cloud Computing.
98. Arora, P., & Bhardwaj, S. Integrating Wireless Sensor Networks and the Internet of Things: A Hierarchical and Security-based Analysis.
99. Arora, P., & Bhardwaj, S. Using Knowledge Discovery and Data Mining Techniques in Cloud Computing to Advance Security.
100. Arora, P., & Bhardwaj, S. (2021). Methods for Threat and Risk Assessment and Mitigation to Improve Security in the Automotive Sector. *Methods*, *8*(2).
101. Arora, P., & Bhardwaj, S. A Thorough Examination of Privacy Issues using Self-Service Paradigms in the Cloud Computing Context.

102. Arora, P., & Bhardwaj, S. (2020). Research on Cybersecurity Issues and Solutions for Intelligent Transportation Systems.
103. Arora, P., & Bhardwaj, S. (2019). The Suitability of Different Cybersecurity Services to Stop Smart Home Attacks.
104. Khan, A. (2020). Formulation and Evaluation of Flurbiprofen Solid Dispersions using Novel Carriers for Enhancement of Solubility. *Asian Journal of Pharmaceutics (AJP)*, *14*(03).
105. Shaik, R. (2023). Anti-Parkinsonian Effect Of Momordica Dioica On Haloperidol Induced Parkinsonism In Wistar Rats. *Journal of Pharmaceutical Negative Results*, 69-81.
106. Selvan, M. A. (2023). INDUSTRY-SPECIFIC INTELLIGENT FIRE MANAGEMENT SYSTEM.
107. Selvan, M. Arul. "PHISHING CONTENT CLASSIFICATION USING DYNAMIC WEIGHTING AND GENETIC RANKING OPTIMIZATION ALGORITHM." (2024).
108. Selvan, M. Arul. "Innovative Approaches in Cardiovascular Disease Prediction Through Machine Learning Optimization." (2024).
109. FELIX, ARUL SELVAN M. Mr D., and XAVIER DHAS Mr S. KALAIVANAN. "Averting Eavesdrop Intrusion in Industrial Wireless Sensor Networks."
110. 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.
111. 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.
112. 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).
113. 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.
114. 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.
115. 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.
116. 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.
117. 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.
118. Amarnadh, V., & Moparthi, N. (2023). Data Science in Banking Sector: Comprehensive Review of Advanced Learning Methods for Credit Risk Assessment. *International Journal of Computing and Digital Systems*, *14*(1), 1-xx.