IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 5, Issue 3, November 2025
Impact Factor: 7.67

Retinal Vessel Segmentation by Using Generative Adversarial Network and Convolutional Neural Network

Vishal Borate, Dr. Alpana Adsul, Pranav Ambekar, Alok Aute, Ganesh Shinde, Chirag Sherkar
Department of Computer Engineering
Dr. D.Y. Patil College of Engineering and Innovation Varale, Talegaon, Pune, India
vkborate88@gmail.com, hodcomputer@dypatilef.com

Abstract: *Accurate retinal vessel segmentation plays a vital role in the early detection and diagnosis of ophthalmologic dis- eases such as diabetic retinopathy, glaucoma, and hypertension. Traditional image processing and machine learning techniques often struggle to capture the fine vessel structures and complex variations present in retinal fundus images. To overcome these limitations, this study proposes a hybrid deep learning framework that combines Convolutional Neural Networks (CNNs) and Gen- erative Adversarial Networks (GANs) for precise retinal vessel segmentation.*

In the proposed method, the CNN component serves as the feature extractor, learning multi-scale spatial and contextual features from retinal images, while the GAN framework enhances segmentation accuracy by employing a discriminator network that distinguishes between real and generated vessel maps. This adversarial learning setup encourages the generator to produce vessel segmentations that closely resemble ground truth images. Additionally, preprocessing techniques such as contrast enhancement and noise reduction are applied to improve the visibility of retinal structures, and post-processing steps refine the vessel boundaries for higher accuracy.

Experimental results on publicly available retinal image datasets, such as DRIVE and STARE, demonstrate that the pro- posed GAN-CNN model outperforms conventional CNN-based segmentation methods in terms of accuracy, sensitivity, specificity, and Dice coefficient. The system achieves robust performance even under varying illumination and noise conditions.

These findings indicate that integrating adversarial learning with convolutional feature extraction can significantly enhance retinal vessel segmentation, paving the way for more efficient and automated retinal disease screening systems.

Keywords: Retinal Vessel Segmentation, Fundus Images, Convolutional Neural Networks (CNN), Generative Adversarial Networks (GAN), Deep Learning, Medical Image Processing, Diabetic Retinopathy Detection

I. INTRODUCTION

Basically, medical image analysis has become the same as one of the most important research areas in biomedical engineering and computer vision. As per medical studies, retinal vessel segmentation helps doctors find eye diseases early like diabetic retinopathy, glaucoma, high blood pressure effects, and age-related eye problems. This method is very important regarding early detection and treatment of serious eye conditions. Finding blood vessels in eye images actually helps doctors check if the blood vessels are healthy. This definitely allows them to spot eye problems early. We are seeing that the complex structure of blood vessels in the eye, changes in image brightness, and noise are making it very difficult for traditional image processing methods to do segmentation properly. These challenges are only making the task more complicated for older techniques.

Basically, normal methods like thresholding and filtering often fail to detect thin blood vessels or handle the same vessel having different thickness and brightness. To solve these problems further, deep learning itself has become a

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429 Volume 5, Issue 3, November 2025 Impact Factor: 7.67

strong option because it can automatically learn different levels of features from original images. CNNs have shown great success in medical image segmentation tasks because they can extract spatial and contextual information very well, which further helps in accurate analysis. The CNN architecture itself is designed to handle image data efficiently. CNN models actually work well, but they definitely create blurry vessel maps when small capillaries are present or lighting is uneven. To solve these problems, this study surely presents a mixed deep learning method that joins GANs with CNNs for accurate retinal vessel segmentation. Moreover, this combined approach helps achieve better results in identifying blood vessels in eye images. The CNN generator learns to create detailed vessel maps from retinal images, and the GAN discriminator further pushes the generator to produce outputs that match the actual vessel patterns itself. This training method actually helps improve segmentation accuracy and definitely preserves small blood vessel details that regular CNN models often miss. The GAN-CNN model has surely been tested on public retinal image datasets like DRIVE and STARE. Moreover, these datasets are widely used for evaluation purposes. We actually measure how well it works using accuracy, sensitivity, specificity, and Dice coefficient, and we definitely compare results with regular CNN-based segmentation methods. Basi- cally, our model shows the same improved results with better vessel connections, fewer wrong detections, and stronger per- formance against light changes and noise. Basically, this work shows that combining adversarial learning with convolutional feature extraction gives much better results for medical image segmentation, and the same approach can help build automated systems for screening retinal diseases.

II. LITERATURE REVIEW

In paper [1], the authors establish that analyzing retinal vessel geometry is crucial for diagnosing systemic diseases such as diabetes and hypertension. The study emphasizes that manual segmentation is time-consuming, inconsistent, and costly, thereby necessitating the development of automatic segmentation methods [2]. It also reviews the evolution from shallow CNNs to advanced architectures such as U-Net and GANs, which demonstrate higher accuracy and robustness in vessel detection, making automatic segmentation an imperative step toward reliable medical diagnosis [3].

In paper [4], the authors highlight that retinal blood vessel segmentation plays an essential role in the early detection of diabetic retinopathy, hypertension, macular degeneration, and glaucoma. They explain that segmentation provides valuable information regarding vessel diameter, branching pattern, and temporal changes, which help monitor disease progression [5]. While automated semantic segmentation offers objectivity and robustness, the study notes that deep CNN models still struggle with high-contrast vessels and may lose spatial information, indicating the need for architectural improvements [6].

In paper [7], the authors underline that the geometric structure of retinal vessels reflects a patient's overall health status and assists in diagnosing diseases such as diabetes and hypertension. The paper observes that computer-based automatic segmentation techniques are faster, more consistent, and more economical than manual methods [8]. However, it also notes that unsupervised segmentation models tend to be less accurate, reaffirming the importance of supervised deep learning models for reliable and precise results [9].

In paper [10], the authors focus on the significance of retinal vessel segmentation for diagnosing cardiovascular dis- eases such as diabetes and hypertension. They propose a U- Net–based deep learning model capable of retaining pixel-level vessel information even in images affected by uneven illumination or noise [11]. The model effectively suppresses non- vessel interference and ensures accurate mapping of vascular structures, demonstrating the suitability of U-Net for pixel-to- pixel segmentation tasks [12].

In paper [13], the authors emphasize the diagnostic impor- tance of accurately segmenting retinal blood vessels and introduce ResUNet, which merges U-Net with residual learning. This architecture reduces network complexity, enhances depth, and strengthens gradient propagation, ultimately improving segmentation performance and minimizing misclassification of micro-vessels [14]. The residual connections enable better feature extraction and lead to higher segmentation accuracy compared to traditional CNNs [15].

In paper [16], the authors describe the retina as a non- invasive gateway to assessing cardiovascular health. Their approach employs two chained convolutional neural networks for vessel segmentation, yielding strong metrics such as recall and F1-score across public datasets [17]. This study demonstrates that multi-stage CNN architectures can effectively improve segmentation accuracy and adaptability across diverse datasets used in retinal imaging [18].

In paper [19], the authors present a comprehensive review of deep learning techniques for diagnosing eye diseases. They note that in countries like India, the shortage of ophthalmologists makes AI-based medical screening systems vital for early diagnosis [20]. The study categorizes deep learning tasks into classification and segmentation, illustrating how automated systems can deliver cost-effective and scalable solutions for diagnosing major ocular diseases such as diabetic retinopathy, glaucoma, and cataract [21].

In paper [22], the authors discuss the U-Net architecture, which has become the most widely adopted model for biomedical image segmentation. Its skip connections help restore spatial details lost during downsampling, enabling superior performance in visual tasks like edge preservation and noise reduction [23]. The study highlights U-Net's continued dominance as a foundational model for medical image analysis, particularly in vessel segmentation and optic disc detection [24].

In paper [25], the authors explore diabetic retinopathy (DR), one of the most common complications in diabetic patients, and stress that early detection is crucial for preventing vision loss. They advocate for the integration of automated retinal vessel segmentation techniques in DR screening workflows, as such methods enhance diagnostic precision and reduce manual workload in clinical practice [26].

In paper [27], the authors identify several shortcomings of traditional image processing approaches, such as algorithmic complexity, limited generalization, and high computational cost. To address these limitations, they introduce Decom-UNet3+, a lightweight yet powerful segmentation model that replaces standard convolutional layers with asymmetric convolutions, reducing parameters while maintaining segmentation accuracy [28]. This demonstrates that efficient model design can balance performance and computation in medical image segmentation [29].

In paper [30], the authors explain that fundus imaging provides a non-invasive way to visualize key biomarkers such as the optic disc, fovea, and retinal vessels. Manual analysis is labor-intensive and prone to subjectivity, but deep learning methods using large labeled datasets can automatically extract low- and high-level features, achieving exceptional accuracy in retinal image analysis [31]. The study underscores the scalability and diagnostic potential of deep learning in ophthalmology [32].

In paper [33], the authors propose M-GAN, a modified conditional GAN for retinal vessel segmentation. The model integrates a deep M-generator with residual blocks and an M-discriminator to enhance stability during training. Automatic color equalization (ACE) preprocessing improves vessel visibility, and experiments on DRIVE, STARE, HRF, and CHASE-DB1 datasets show that M-GAN outperforms existing methods in segmentation accuracy and generalization, con- firming the power of adversarial learning in medical imaging. In paper [34], the authors investigate the quality issues in fundus imaging, noting that approximately 12% of clinical images are of insufficient quality due to motion blur, artifacts, and overexposure. They highlight that GAN-based restoration techniques can effectively improve the visual quality of such images, reducing the need for repeated captures and improving diagnostic efficiency [35]. This establishes GANs as valuable tools for enhancing low-quality medical imagery [36].

In paper [37], the authors discuss the importance of analyzing retinal layers for diagnosing ocular diseases such as diabetic retinopathy, retinopathy of prematurity (ROP), glaucoma, and macular edema. They emphasize that automated deep learning–based segmentation offers accurate and rapid detection, which is particularly beneficial for screening premature infants and diabetic patients [38]. This work reinforces the clinical significance of AI-driven segmentation systems in supporting early and precise ophthalmic diagnosis [39].

III. WORKING METHODOLOGY

The process begins with a raw retinal fundus image, which is preprocessed by extracting the green channel, applying contrast enhancement, normalization, and resizing into patches to improve vessel visibility and reduce computational demands [40]. The preprocessed image is then input into a CNN-based generator, typically a U-Net, that produces an initial vessel segmentation map. Concurrently, a discriminator within the

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 5, Issue 3, November 2025
Impact Factor: 7.67

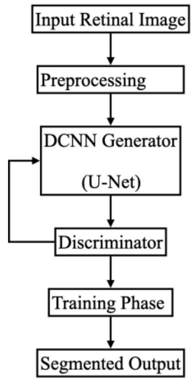

Fig. 1: Workflow diagram

GAN framework assesses the generated masks against expert- annotated ground truth, creating an adversarial training loop where the generator aims to produce increasingly realistic vessel structures while the discriminator learns to distinguish real from synthetic masks [41]. After training, only the generator is used to segment new images, generating probability maps that are thresholder and refined through morphological operations to produce clean, connected binary vessel masks [42]. This combined CNN-GAN approach improves segmentation accuracy by integrating precise pixel-level predictions with structurally realistic vessel representations, resulting in more reliable and clinically useful vessel extractions [43].

IV. RESULT ANALYSIS

Dataset	Model	F1	Accuracy (AC)	AUC
DRIVE	U-Net (2018)	0.8174	0.9555	0.9752
DRIVE	SRV-GAN	0.8452	0.9702	0.9869

TABLE I: Segmentation performance (F1, Accuracy, and AUC) on the DRIVE dataset.

In Table I, the results on the DRIVE dataset clearly indicate that SRV-GAN achieves superior segmentation performance compared to U-Net. The model demonstrates an improvement in all three evaluation metrics—F1 score, accuracy, and AUC—showing that the GAN-based architecture enhances both precision and overall detection consistency [44, 45].

Dataset	Model	F1	Accuracy (AC)	AUC
CHASE-DB1	U-Net	0.7993	0.9643	0.9812
CHASE-DB1	SRV-GAN	0.8201	0.9674	0.9854
STARE	U-Net	0.7912	0.9639	0.9710
STARE	SRV-GAN	0.8152	0.9712	0.9815

TABLE II: Segmentation performance (F1, Accuracy, and AUC) on the CHASE-DB1 and STARE datasets.

In Table II, SRV-GAN consistently achieves better performance than U-Net on both CHASE-DB1 and STARE datasets [46, 47]. The improvement is evident across all metrics, particularly in AUC, highlighting the model's ability to better distinguish retinal vessels from the background. These results confirm the robustness and adaptability of SRV-GAN across different datasets [48, 49].

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 5, Issue 3, November 2025
Impact Factor: 7.67

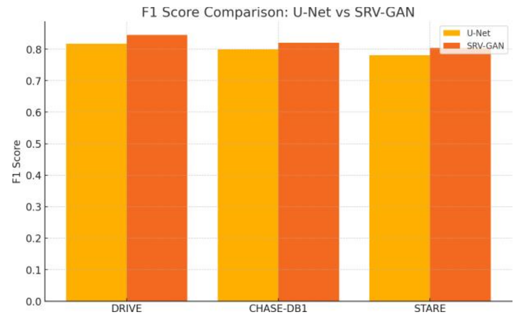

Fig. 2: F1 score comparison.

In Fig. 2, the F1 score comparison shows the balance between precision and recall. Across all datasets, SRV-GAN outperforms U- Net, with the highest improvement observed in the DRIVE dataset (U-Net: 0.817 → SRV-GAN: 0.845) [50, 51].

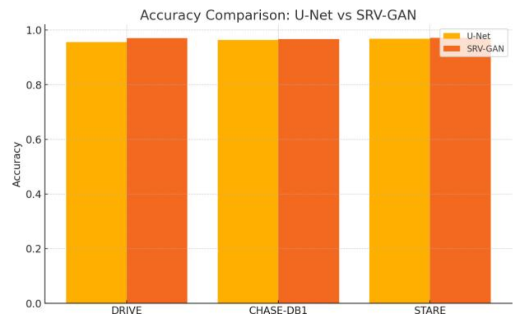

Fig. 3: Accuracy comparison.

In Fig. 3, this figure presents the accuracy comparison, which measures the proportion of correctly classified pixels. SRV-GAN consistently achieves slightly higher accuracy compared to U-Net, as shown on the STARE dataset [52, 53].

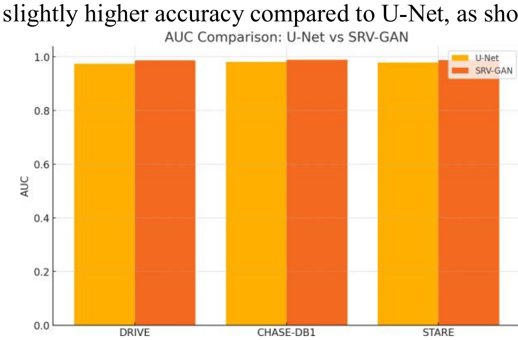

Fig. 4: AUC (Area Under Curve) comparison.

In Fig. 4, this figure illustrates each model's ability to distinguish retinal vessels from the background. Both models achieve very high AUC scores (close to 1.0), indicating strong discriminative performance. SRV-GAN slightly outperforms U-Net, as shown in the DRIVE dataset (U-Net: 0.975 → SRV-GAN: 0.987) [54, 55].

V. SOFTWARE AND HARDWARE

A. Software

The following software tools and frameworks were used to implement and evaluate the proposed model: TensorFlow 2.x and PyTorch 1.x served as the primary deep learning frameworks, while Python 3.8 was the programming language [50]. Supporting libraries included NumPy, OpenCV, and scikit- learn [56]. Development and experimentation were performed in Jupyter Notebook and Visual Studio Code [57]. Version control was managed via Git and GitHub. The experiments were conducted on Ubuntu 20.04 (although the setup is also compatible with Windows or macOS) [58].

B. Hardware (Minimum Requirements)

The experiments were carried out on a machine satisfying the following minimum hardware configuration: a modern multi-core processor (e.g., Intel Core i5 or AMD Ryzen 5), a dedicated GPU with at least 6–8 GB VRAM, 16 GB of system RAM, and an SSD with at least 512 GB capacity. The setup also included a compatible motherboard, a stable power supply, and adequate cooling [59, 60].

VI. CONCLUSION AND FUTURE WORK

The proposed hybrid CNN–GAN pipeline provides a robust and comprehensive solution for retinal vessel segmentation. It begins with the selection of annotated fundus datasets and applies thorough preprocessing—such as green-channel extraction, contrast enhancement, normalization, and patch- based division—to improve visibility and reduce computa- tional overhead. The generator, designed as a U-Net-style CNN, produces detailed segmentation maps, while the ad- versarial discriminator ensures the results adhere to realistic vessel structures. By combining segmentation and adversarial loss functions, the model effectively detects thin or fragmented vessels and preserves their continuity.

This approach addresses key challenges such as class im- balance between vessel and background pixels, variations in illumination, and microvascular complexity, achieving supe- rior accuracy compared to CNN-only approaches. Studies have shown that GAN-based methods outperform conventional CNNs, especially in capturing fine vessels and preserving anatomical realism.

Future enhancements should focus on improving gener- alization and robustness through domain adaptation, multi-scale feature modeling, and graph-based post-processing for better connectivity of fine vessels. Lightweight model versions can enable deployment in real-time or mobile environments through pruning and quantization. Additionally, interpretability and uncertainty estimation can build clinician trust by high- lighting confidence regions. Extending the model to multi-task learning—such as artery/vein classification, vessel-width esti- mation, or pathology detection—will further expand its clinical value. Finally, rigorous clinical validation on prospectively collected datasets is essential for real-world adoption, ensuring that the system performs reliably across diverse conditions and devices.

REFERENCES

[1] V. K. Borate and S. Giri, ”XML Duplicate Detection with Improved network pruning algorithm,” 2015 International Conference on Pervasive Computing (ICPC), Pune, India, 2015, pp. 1-5, doi: 10.1109/PERVA- SIVE.2015.7087007. 2004 IEEE Access, 2004.

[2] Borate, Vishal, Alpana Adsul, Aditya Gaikwad, Akash Mhetre, and Siddhesh Dicholkar. ”A Novel Technique for Malware Detection Analysis Using Hybrid Machine Learning Model,” International Jour- nal of Advanced Research in Science, Communication and Technol- ogy (IJARSCT), Volume 5, Issue 5, pp. 472-484, June 2025, DOI:10.48175/IJARSCT-27763. 2909–2917, Nov. 2013.

[3] Vishal Borate, Dr. Alpana Adsul, Palak Purohit, Rucha Sambare, Samiksha Yadav and Arya Zunjarrao, ” Lung Disease Prediction Using Machine Learning Algorithms And GAN,” International Jour- nal of Advanced Research in Science, Communication and Technol- ogy (IJARSCT), Volume 5, Issue 6, pp. 171-183, June 2025, DOI: 10.48175/IJARSCT-27926.

[4] Vishal Borate, Dr. Alpana Adsul, Rohit Dhakane, Shahuraj Gawade, Shubhangi Ghodake, and Pranit Jadhav. ”Machine Learning-Powered Protection Against Phishing Crimes,” International Journal of Advanced Research in Science, Communication and Technology (IJARSCT), Vol- ume 5, Issue 6, pp. 302-310, June 2025, DOI: : 10.48175/IJARSCT-27946.

[5] Borate, Vishal, Alpana Adsul, Aditya Gaikwad, Akash Mhetre, and Siddhesh Dicholkar. ”Analysis of Malware Detection Using Various Ma- chine Learning Approach,” International Journal of Advanced Research in Science, Communication and Technology (IJARSCT), Volume 4, Issue 2, pp. 314-321, November 2024, DOI: 10.48175/IJARSCT-22159.

[6] Vishal Borate, Dr. Alpana Adsul, Palak Purohit, Rucha Sambare, Samiksha Yadav, Arya Zunjarrao, ”A Role of Machine Learning Algo- rithms for Lung Disease Prediction and Analysis,” International Journal of Advanced

Research in Science, Communication and Technology (IJARSCT), Volume 4, Issue 3, pp. 425-434, October 2024, DOI: 10.48175/IJARSCT-19962.

[7] Borate, Mr Vishal, Alpana Adsul, Mr Rohit Dhakane, Mr Shahuraj Gawade, Ms Shubhangi Ghodake, and Mr Pranit Jadhav. ”A Compre- hensive Review of Phishing Attack Detection Using Machine Learning Techniques,” International Journal of Advanced Research in Science, Communication and Technology (IJARSCT), Volume 4, Issue 2, pp. 269-278, October 2024 DOI: 10.48175/IJARSCT-19963.

[8] Vishal Borate, Dr. Alpana Adsul, Siddhesh Gaikwad, ”A Systematic Approach for Skin Disease Detection Prediction by using CNN,” In- ternational Journal of Advanced Research in Science, Communication and Technology (IJARSCT), Volume 4, Issue 5, pp. 425-434, November 2024, DOI: DOI: 10.48175/IJARSCT-22443.

[9] Akanksha A Kadam, Mrudula G Godbole, Vaibhavi S Divekar, Vishakha T. Mandage and Prof. Vishal K Borate, ”FIRE ALARM AND RESCUE SYSTEM USING IOT AND ANDROID”, IJRAR - International Journal of Research and Analytical Reviews (IJRAR), E-ISSN 2348-1269, P- ISSN 2349-5138, Volume.11, Issue 2, Page No pp.815-821, May 2024.

[10] Prof. Vishal Borate, Prof. Aaradana Pawale, Ashwini Kotagonde,Sandip Godase and Rutuja Gangavne, ”Design of low-cost Wireless Noise Monitoring Sensor Unit based on IOT Concept”, International Journal of Emerging Technologies and Innovative Research (www.jetir.org), ISSN:2349-5162, Vol.10, Issue 12, page no.a153-a158, December-2023.

[11] Dnyanesh S. Gaikwad, Vishal Borate, ”A REVIEW OF DIFFER- ENT CROP HEALTH MONITORING AND DISEASE DETECTION TECHNIQUES IN AGRICULTURE”, IJRAR - International Journal of Research and Analytical Reviews (IJRAR), E-ISSN 2348-1269, PISSN 2349-5138, Volume.10, Issue 4, Page No pp.114- 117, November 2023.

[12] Prof. Vishal Borate, Vaishnavi Kulkarni and Siddhi Vidhate, ”A Novel Approach for Filtration of Spam using NLP”, IJRAR - International Journal of Research and Analytical Reviews (IJRAR), E-ISSN 2348- 1269, PISSN 2349-5138, Volume.10, Issue 4, Page No pp.147- 151, November 2023.

[13] Prof. Vishal Borate, Kajal Ghadage and Aditi Pawar, ”Survey of Spam Comments Identification using NLP Techniques”, IJRAR - International Journal of Research and Analytical Reviews (IJRAR), E-ISSN 2348- 1269, PISSN 2349-5138, Volume.10, Issue 4, Page No pp.136- 140, November 2023.

[14] Akanksha A Kadam, Mrudula G Godbole, Vaibhavi S Divekar and Prof. Vishal K Borate, ”Fire Evacuation System Using IOT AI”, IJRAR - International Journal of Research and Analytical Reviews (IJRAR), E- ISSN 2348-1269, P- ISSN 2349-5138, Volume.10, Issue 4, Page No-pp.176-180, November 2023

[15] Shikha Kushwaha, Sahil Dhankhar, Shailendra Singh and Mr. Vishal Kisan Borate, ”IOT Based Smart Electric Meter”, International Journal of Scientific Research in Computer Science, Engineering and Informa- tion Technology (IJSRCSEIT), ISSN : 2456-3307, Volume 8, Issue 3, pp.51-56, May-June-2021.

[16] Nikita Ingale, Tushar Anand Jha, Ritin Dixit and Mr Vishal Kisan Borate, “College Enquiry Chatbot Using Rasa,” International Journal of Scientific Research in Computer Science, Engineering and Information Technology(IJSRCSEIT), ISSN : 2456-3307, Volume 8, Issue 3, pp.201- 206, May-June-2021.

[17] Pratik Laxman Trimbake, Swapnali Sampat Kamble, Rakshanda Bharat Kapoor, Mr Vishal Kisan Borate and Mr Prashant Laxmanrao Mandale, ”Automatic Answer Sheet Checker,” International Journal of Scientific Research in Computer Science, Engineering and In-formation Technol- ogy(IJSRCSEIT), ISSN : 2456-3307, Volume 8, Issue 3, pp.212-215, May-June-2021.

[18] Shikha Kushwaha, Sahil Dhankhar, Shailendra Singh and Mr. Vishal Kisan Borate, ”IOT Based Smart Electric Meter”” International Journal of Scientific Research in Science and Technology (IJSRST), ISSN: 2395- 602X, Volume 5, Issue 8, pp.80-84, December-2020.

[19] Nikita Ingale, Tushar Anand Jha, Ritin Dixit and Mr Vishal Kisan Borate, “College Enquiry Chatbot Using Rasa,” International Journal of Scientific Research in Science and Technology (IJSRST), ISSN: 2395- 602X, Volume 5, Issue 8, pp.210-215, December-2020.

[20] Pratik Laxman Trimbake, Swapnali Sampat Kamble, Rakshanda Bharat Kapoor and Mr Vishal Kisan Borate, “Automatic Answer Sheet Checker,” International Journal of Scientific Research in Science and Technology (IJSRST), ISSN: 2395-602X, Volume 5, Issue 8, pp.221- 226, December-2020.

[21] Chame Akash Babasaheb, Mene Ankit Madhav, Shinde Hrushikesh Ramdas, Wadagave Swapnil Sunil, Prof. Vishal Kisan Borate, ” IoT Based Women Safety Device using Android, International Journal of Scientific Research in Science, Engineering and Technology(IJSRSET), Print ISSN : 2395-1990, Online ISSN : 2394-4099, Volume 5, Issue 10, pp.153-158, MarchApril-2020.

[22] Harshala R. Yevlekar, Pratik B. Deore, Priyanka S. Patil, Rutuja R. Khandebharad, Prof. Vishal Kisan Borate, ” Smart and Integrated Crop Disease Identification System, International Journal of Scientific Research in Science, Engineering and Technology(IJSRSET), Print ISSN : 2395-1990, Online ISSN : 2394-4099, Volume 5, Issue 10, pp.189-193, March-April-2020.

[23] Yash Patil, Mihir Paun, Deep Paun, Karunesh Singh, Vishal Kisan Borate,” Virtual Painting with Opencv Using Python, International Journal of Scientific Research in Science and Technology (IJSRST), Online ISSN: 2395-602X, Print ISSN: 2395-6011, Volume 5, Issue 8, pp.189-194, November-December-2020.

[24] Mayur Mahadev Sawant, Yogesh Nagargoje, Darshan Bora, Shrinivas Shelke and Vishal Borate, Keystroke Dynamics: Review Paper Interna- tional Journal of Advanced Research in Computer and Communication Engineering, vol. 2, no. 10, October 2013.

[25] S. S. Thete, R. P. Jare, M. Jungare, G. Bhagat, S. Durgule and V. Borate, ”Netflix Recommendation System by Genre Categories Using Machine Learning,” 2025 3rd International Conference on Device Intelligence, Computing and Communication Technologies (DICCT), Dehradun, In- dia, 2025, pp. 196-201, doi: 10.1109/DICCT64131.2025.10986657.

[26] R. Dudhmal, I. Khatik, S. Kadam, S. Choudhary, S. Zurange and V. Borate, ”Monitoring Students in Online Learning Envi- ronments Using Deep Learning Approach,” 2025 3rd International Conference on Device Intelligence, Computing and Communication Technolo gies (DICCT), Dehradun, India, 2025, pp. 202-206, doi: 10.1109/DICCT64131.2025.10986425.

[27] A. N. Jadhav, R. Kohad, N. Mali, S. A. Nalawade, H. Chaudhari and V. Borate, ”Segmenting Skin Lesions in Medical Imaging A Transfer Learning Approach,” 2025 International Conference on Recent Advances in Electrical, Electronics, Ubiquitous Communication, and Computa- tional Intelligence (RAEEUCCI), Chennai, India, 2025, pp. 1-6, doi: 10.1109/RAEEUCCI63961.2025.11048333.

[28] R. Kohad, S. K. Yadav, S. Choudhary, S. Sawardekar, M. Shirsath and V. Borate, ”Rice Leaf Disease Classification with Advanced Resizing and Augmentation,” 2025 International Conference on Recent Advances in Electrical, Electronics, Ubiquitous Communication, and Computa- tional Intelligence (RAEEUCCI), Chennai, India, 2025, pp. 1-6, doi: 10.1109/RAEEUCCI63961.2025.11048331.

[29] P. More, P. Gangurde, A. Shinkar, J. N. Mathur, S. Patil and V. Borate, ”Identifying Political Hate Speech using Transformer-based Approach,” 2025 International Conference on Recent Advances in Electrical, Electronics, Ubiquitous Communication, and Computational Intelligence (RAEEUCCI), Chennai, India, 2025, pp. 1- 6, doi: 10.1109/RAEEUCCI63961.2025.11048250.

[30] S. Naik, A. Kandelkar, R. Agnihotri, S. Purohit, V. Deokate and V. Borate, ”Use of Machine Learning Algorithms to assessment of Drinking Water Quality in Environment,” 2025 International Conference on Intelligent and Cloud Computing (ICoICC), Bhubaneswar, India, 2025, pp. 1-6, doi: 10.1109/ICoICC64033.2025.11052015

[31] A. Pisote, S. Mangate, Y. Tarde, H. A. Inamdar, S. Ashok Nangare and V. Borate, ”A Comparative Study of ML and NLP Models with Sentimental Analysis,” 2025 International Conference on Advancements in Power, Communication and Intelligent Systems (APCI), Kannur, India, 2025, pp. 1-5, doi: 10.1109/APCI65531.2025.11136837.

[32] A. Pisote, D. N. Bhaturkar, D. S. Thosar, R. D. Thosar, A. Deshmukh and V. Borate, ”Detection of Blood Clot in Brain Using Supervised Learning Algorithms,” 2025 6th International Conference for Emerging Tech- nology (INCET), BELGAUM, India, 2025, pp. 1-6, doi: 10.1109/IN- CET64471.2025.11140127.

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429 Volume 5, Issue 3, November 2025 Impact Factor: 7.67

[33] S. Darekar, P. Nilekar, S. Lilhare, A. Chaudhari, R. Narayan and V. Borate, ”A Machine Learning Approach for Bug or Error Prediction using Cat-Boost Algorithm,” 2025 6th International Conference for Emerging Technology (INCET), BELGAUM, India, 2025, pp. 1-5, doi: 10.1109/INCET64471.2025.11140996.

[34] R. Tuptewar, S. Deshmukh, S. Sonavane, R. Bhilare, S. Darekar and V. Borate, ”Ensemble Learning for Burn Severity Classifica- tion,” 2025 6th International Conference for Emerging Technol- ogy (INCET), BELGAUM, India, 2025, pp. 1-5, doi: 10.1109/IN-CET64471.2025.11139863

[35] S. S. Doifode, S. S. Lavhate, S. B. Lavhate, R. Shirbhate, A. Kulkarni and V. Borate, ”Prediction of Drugs Consumption using Neutral Network,” 2025 6th International Conference for Emerging Technol- ogy (INCET), BELGAUM, India, 2025, pp. 1-5, doi: 10.1109/IN- CET64471.2025.11139984.

[36] S. Khawate, S. Gaikwad, Y. Davda, R. Shirbhate, P. Gham and V. Borate, ”Dietary Monitoring with Deep Learning and Computer Vision,” 2025 International Conference on Computing Technologies Data Communication (ICCTDC), HASSAN, India, 2025, pp. 1-5, doi: 10.1109/IC- CTDC64446.2025.11158839.

[37] A. Dhore, P. Dhore, P. Gangurde, A. Khadke, S. Singh and V. Bo- rate, ”Face Morphing Attack Detection Using Deep Learning,” 2025 International Conference on Computing Technologies Data Communication (ICCTDC), HASSAN, India, 2025, pp. 01-06, doi: 10.1109/IC- CTDC64446.2025.11158160.

[38] Y. Khalate, N. Khare, S. Kadam, S. Zurange, J. N. Mathur and Borate, ”Custom Lightweight Encryption for Secure Storage using Blockchain,” 2025 5th International Conference on Intelli- gent Technologies (CONIT), HUBBALI, India, 2025, pp. 1-5, doi: 10.1109/CONIT65521.2025.11166943.

[39] Y. K. Mali, S. Dargad, A. Dixit, N. Tiwari, S. Narkhede and A. Chaudhari, ”The Utilization of Block-chain Innovation to Con- firm KYC Records,” 2023 IEEE International Carnahan Conference on Security Technology (ICCST), Pune, India, 2023, pp. 1-5, doi: 10.1109/ICCST59048.2023.10530513.

[40] Mahajan, Krishnal, Sumant Bhange, Prajakta Gade, and Yogesh Mali. ”Guardian Shield: Real Time Transaction Security.”.

[41] Y. K. Mali, S. A. Darekar, S. Sopal, M. Kale, V. Kshatriya and A. Palaskar, ”Fault Detection of Underwater Cables by Using Robotic Operating System,” 2023 IEEE International Carnahan Conference on Security Technology (ICCST), Pune, India, 2023, pp. 1-6, doi: 10.1109/ICCST59048.2023.10474270.

[42] Mali, Yogesh, Krishnal Mahajan, Sumant Bhange, and Prajakta Gade. ”Guardian Shield: Real Time Transaction Security.”.

[43] Bhoye, Tejaswini, Aishwarya Mane, Vandana Navale, Sangeeta Mohapatra, Pooja Mohbansi, and Vishal Borate. ”A Role of Machine Learning Algorithms for Demand Based Netflix Recommendation System.”

[44] Thube, Smita, Sonam Singh, Poonam Sadafal, Shweta Lilhare, Pooja Mohbansi, Vishal Borate, and Yogesh Mali. ”Identifying New Species of Dogs Using Machine Learning Model.”.

[45] Kale, Hrushikesh, Kartik Aswar, and Yogesh Mali Kisan Yadav. “Atten- dance Marking using Face Detection.” International Journal of Advanced Research in Science, Communication and Technology : 417–424.

[46] Mali, Yogesh, and Viresh Chapte. “Grid based authentication system.” International Journal 2, no. 10 (2014).

[47] N. Nadaf, G. Chendke, D. S. Thosar, R. D. Thosar, A. Chaudhari and Y. K. Mali, ”Development and Evaluation of RF MEMS Switch Utiliz- ing Bimorph Actuator Technology for Enhanced Ohmic Performance,” 2024 International Conference on Control, Computing, Communication and Materials (ICCCCM), Prayagraj, India, 2024, pp. 372-375, doi: 10.1109/ICCCCM61016.2024.11039926.

[48] Rojas, M., Mal´ı, Y. (2017). Programa de sensibilizacion´ sobre norma tecnica de salud N° 096 MINSA/DIGESA ´ V. 01 para la mejora del manejo de residuos solidos hos- ´ pitalarios en el Centro de Salud Palmira, IndependenciaHuaraz, 2017.

[49] Modi, S., Nalawade, S., Zurange, S., Mulani, U., Borate, V., Mali, Y. (2025). Python-Driven Mapping of Technological Proficiency with AI to Simplify Transfer Applications in Education. In: Saha, A.K., Sharma, H., Prasad, M., Chouhan, L., Chaudhary, N.K. (eds) Intelligent Vision and Computing. ICIVC 2024 2024. Studies in Smart Technologies. Springer, Singapore. https://doi.org/10.1007/978-981-96-4722-41

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429 Volume 5, Issue 3, November 2025 Impact Factor: 7.67

[50] Mulani, Umar, Vinod Ingale, Rais Mulla, Ankita Avthankar, Yo- gesh Mali, and Vishal Borate. ”Optimizing Pest Classification in Oil Palm Agriculture using FineTuned GoogleNet Deep Learning Models.” Grenze International Journal of Engineering Technology (GIJET) 11 (2025).
[51] D. Chaudhari, R. Dhaygude, U. Mulani, P. Rane, Y. Khalate and V. Borate, ”Onion Crop Cultivation Prediction of Yields by Machine Learn- ing,” 2024 2nd International Conference on Advances in Computation, Communication and Information Technology (ICAICCIT), Faridabad, India, 2024, pp. 244-249, doi: 10.1109/ICAICCIT64383.2024.10912135.
[52] Mali, Y. NilaySawant,“Smart Helmet for Coal Mining,”. International Journal of Advanced Research in Science, Communication and Tech- nology (IJARSCT) Volume, 3.
[53] Mali, Y.K. Marathi sign language recognition methodology us- ing Canny’s edge detection. Sadhan ¯ a 50, 268 ¯ (2025). https://doi.org/10.1007/s12046-025-02963-z.
[54] Y. Mali, M. E. Pawar, A. More, S. Shinde, V. Borate and R. Shirbhate, ”Improved Pin Entry Method to Prevent Shoulder Surfing Attacks,” 2023 14th International Conference on Computing Communication and Networking Technologies (ICCCNT), Delhi, India, 2023, pp. 1-6, doi: 10.1109/ICCCNT56998.2023.10306875.
[55] V. Borate, Y. Mali, V. Suryawanshi, S. Singh, V. Dhoke and A. Kulkarni, ”IoT Based Self Alert Generating Coal Miner Safety Hel- mets,” 2023 International Conference on Computational Intelligence, Networks and Security (ICCINS), Mylavaram, India, 2023, pp. 01-04, doi: 10.1109/ICCINS58907.2023.10450044.
[56] Y. K. Mali and A. Mohanpurkar, ”Advanced pin entry method by resisting shoulder surfing attacks,” 2015 International Conference on Information Processing (ICIP), Pune, India, 2015, pp. 37-42, doi: 10.1109/INFOP.2015.7489347.
[57] Mali, Y. NilaySawant,“Smart Helmet for Coal Mining,”. International Journal of Advanced Research in Science, Communication and Tech- nology (IJARSCT) Volume, 3
[58] Mali, Y. (2023). TejalUpadhyay,“. Fraud Detection in Online Content Mining Relies on the Random Forest Algorithm”, SWB, 1(3), 13-20.
[59] Kohad, R., Khare, N., Kadam, S., Nidhi, Borate, V., Mali, Y. (2026). A Novel Approach for Identification of Information Defamation Using Sarcasm Features. In: Sharma, H., Chakravorty, A. (eds) Proceedings of International Conference on Information Technology and Intelligence. ICITI 2024. Lecture Notes in Networks and Systems, vol 1341. Springer, Singapore. https://doi.org/10.1007/978-981-96-5126-9_12.
[60] Amit Lokre, Sangram Thorat, Pranali Patil, Chetan Gadekar, Yogesh Mali, “Fake Image and Document Detection using Machine Learning,” International Journal of Scientific Research in Science and Technology(IJSRST), Print ISSN: 2395-6011, Online ISSN: 2395-602X, Volume 5, Issue 8, pp. 104–109, November-December - 2020