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Real-Time Iris Detection and Recognition System Using You Only Look Once Version 8

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Abstract: ***The model which is used in real time object detection which has high speed and accuracy which processes the images in a single pass is the You Look Only Once model. This project mainly the focus on the application of YOLOv8 or You Look Only Once version 8 model for iris detection and recognition in biometric systems, focusing on high-security and accuracy. to improve the performance of model under various lighting conditions it was trained under various customized datasets. To improve the generalization of the model advanced image augmentation techniques like flips, rotation and brightness adjustments were done . The model yielded 95% average precision on the validation set which was trained using pytorch framework with optimized hyperparameters which shows the effectiveness of YOLOv8 in real time iris recognition and detection.***

Keywords: ***Iris Recognition System, Image Augmentation, Pytorch Framework, Hyper Parameter, Generalization***

I. INTRODUCTION

In Today's World the Biometric System plays a crucial role in identification and authorization due to their accuracy. The iris detection uses the stable iris pattern which is unique to every individual for identification which is deployed in various applications to enhance security. The iris recognition and the detection model is done using YOLOv8 or You Look Only Once version 8 deep learning model which performs the best for real time object detection which can be used in various real time monitoring environments.

The latest iteration YOLOv8 is being used which enhances the speed and accuracy. This project fine tunes the YOLOv8 model using custom image dataset and image augmentation techniques to improve generalization across various lighting conditions and changes. The goal is to tackle the variability of the dataset and utilize the efficiency of the YOLOv8 model to provide a more accurate and efficient biometric system.

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To design the model specifically for iris recognition advanced image augmentation is employed.

To create a rich and varied dataset various image processing techniques were used and then employ the YOLOv8 model to accurately detect and identify objects. To improve model generalization capability this approach uses multiple image filters and effects such as RGB (Red, Green, Blue), CMY (Cyan, Magenta, Yellow), grayscale, black and white thresholding. To address challenges like limited data availability, variation in lighting conditions and model overfitting the dataset set is expanded using augmentation.

The process begins with a series of images to augment by applying a range of filters and effects and for efficient storage and processing images are stored in a compressed format. The YOLOv8 model is trained using the augmented dataset. It is trained using customizable training parameters like selectable epoch and validation splits making it effective for future enhancement. To ensure real time monitoring and analysis of model's progress the performance metrics like loss and mean Average Precision (MAP) is continuously tracked. This end to end process shows an organized pipeline which paves way for highly accurate iris detection systems for real world applications.

II. LITERATURE SURVEY

Significant efforts have been taken in iris detection and recognition using deep learning and machine learning D.

P. Benalcazar, D. A. Benalcazar and A. Valenzuela has done Artificial Pupil Dilation for Data Augmentation Iris Semantic Segmentation: mainly focuses on data augmentation technique by applying fast geometric transformations to adjust pupil dilation in images [1] Al-Waisy and Rami Qahwaji proposed a multi-biometric iris recognition system based on deep learning approach utilizing deep learning to improve the accuracy under different challenging conditions including pupil dilation and noise. Very useful data augmentation techniques such as fast geometric transformations are applied that will adjust the dilation of the pupil in the images [2]. Hokchhay Tann presented an embedded iris recognition system that is resource efficient based on Fully Convolutional Networks to overcome all the issues with computation requirements and this system makes use of Fully Convolutional Networks (FCN). This system integrates the segmentation with the Field Programmable Gate Arrays (FPGA) hardware acceleration and three step co-design methodology [3].

Meenakshi Choudhary presented an system which mainly deals with the challenge of how other people may try to present part of their system, in this case an image of the eye, in order to perform an iris recognition. The novelty of their research is the proposition of a strong robust presentation attack detection design, powered by the machine learning model composed of diversified datasets [4]. Shouwu He and Xiaoying Li presented a Enhance DeepIris Model for Iris Recognition Applications presents a Enhance DeepIris model, which integrates CNN feature extraction with ordinal metric modeling and dual network structures [5]. Diego R. Lucio Presented a Simultaneous Iris and Periocular Region Detection Using Coarse Annotations where it explores the coarse annotations with You Look Only Once version 2 and faster Region Based Convolutional Neural Network [6].

Naseem Ahmad depicted a two stage architecture based model for accurate estimation of iris center in photos of facial images. In order to overcome the challenges, such as pose, scale, and illumination, this model employs a cascaded deep learning architecture for iris center localization in facial images [7].Gabriela Yukari presented a classification of Convolutional neural network Hyperparameter tuning applied not to iris liveness but for the purpose of differentiating between live and spoofed iris images. This system employs an architecture that includes a cascaded SpoofNet framework integrated with Convolutional Neural networks layers [8]. Nada Alay presents a Deep Learning Approach for Multimodal Biometric Recognition System Based On Fusion Of Iris to fuse the recognition of face, iris and finger vein recognition with Convolutional Neural Network models [9].

Shervin Minaee presented a Deep Iris Recognition system that addresses limitations in unimodal biometric systems,

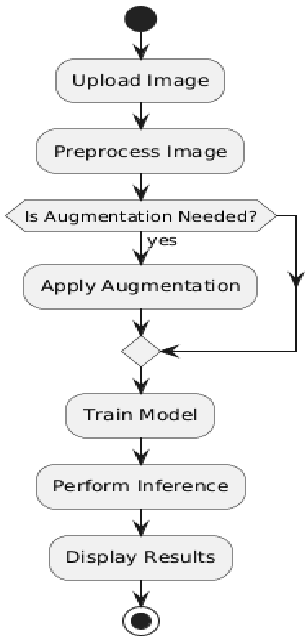
such as susceptibility to spoofing and noise [10], by developing a robust multimodal iris recognition system Andrey Kuehlkamp presented system which combines Binary Statistical Image Features (BSIF) with lightweight Convolutional Neural Network to tackle iris presentation attack detection [11]. The method enhances detection accuracy by employing multi-view learning and meta–fusion techniques Muthana H presented a system which utilizes a Fourier descriptors and Principal Component Analysis (PCA) for feature extraction and this presents a reliable iris recognition system [12].

Naseem Ahmad presented integrated approach towards detection and development of Iris tracking using deep learning This system combines Tiny-You Look Only Once (YOLO)version 3 for eye detection [13], segmentation Network and Kanade-Lucas-Tomasi algorithm for tracking Jorge

E. Zambrano presented a system to overcome the traditional limitations like image distortions from aliasing and head movement this system uses an enhanced residual network (ResNet50) backbone with anti-aliasing filters and a novel encoding method [14]. Renu Sharma introduced a dependable and precise biometric system for iris recognition who made use of intelligent algorithms to improve security features on the system as the system employs DenseNet121 (Dense Convolutional Network) augmented by t-SNE (t-distributed Stochastic Neighbor Embedding),Grad-CAM (Gradient-weighted Class Activation Mapping) as well as frequency and analyse for enhance understanding [15].

Leyuan Wang presented a assessment of quality in the Feature Space this system proposes a deep learning based quality assessment method which utilizes attention- based pooling and feature space embeddings to address challenges in low quality iris images affecting recognition performance [16]. Sohaib Ahmad presented a system which uses triple-based CNN (Convolutional Neural Network) for iris recognition which omits normalization using ResNet-50(Residual Network) and batch -hard triplet loss to optimize class separation [17]. Daniel Kerrigan & Mateusz Trokielewicz & Adam Czajka & Kevin W. Bowyer presented a Iris Recognition with Image Segmentation Employing Retrained Off-the-Shelf-Deep Neural Network: This system uses a restrained deep neural networks(Visual Geometry Group, Dilated Residual Network, Segmentation Network) for accurate iris segmentation. To improve Gabor-based recognition without manual annotations irregular segmentation masks are used which enhance segmentation accuracy [18].

Juan E [19]. Tapia & Sebastian Gonzalez & Daniel Benalcazar presented a On the Feasibility of Creating Iris Periocular Morphed Images [20]: To enhance the biometric recognition system this method uses deep learning and attention -based pooling to assess quality of iris images [21]. Zhaoyuan Fang presented a system that uses a Raspberry Pi, NIR (Near infrared) camera and custom python software presenting an open source iris recognition system [22]. S. Senthil Pandi, presented a system that mainly focuses to enhance the classification accuracy of machine learning algorithms [23]. Kumar P, V. K. S, P. L and S. Senthil Pandi (2023), "Enhancing Face Mask Detection Using Data Augmentation Techniques," [24]. This mainly focuses on increasing the detection accuracy using data augmentation [25]. R. K. Mahendran, R. Aishwarya, R. Abinaya priya and P. Kumar, "Deep Transfer Learning Based Diagnosis of Multiple Neurodegenerative Disorders," [26]. It mainly focuses on detecting neurogenetic disorders which explores the use of deep learning by leveraging pre-trained models to identify disease specific patterns [27].



[Fig.1: Flow Diagram]

III. PROPOSED SYSTEM

The advanced object detection model YOLOv8 Or You Look Only Once version 8 is used for its speed, accuracy and efficiency. It Extracts the images features through a backbone network like darknet-53 or CSP (Cross Stage Partial network) darknet. that flows through convolutional layers to produce feature maps for object detection. To predict the bounding boxes and confidence scores convolutional layers with multiple anchor boxes are used .

The Multi-scale approach which uses feature pyramid network (FPNs) to detect object of varying sizes while retaining high speed is the key innovation in YOLOV8 or You Look Only Once version8 Model. To further enhance the robustness of the model optimization techniques like focal loss and multi scale training are done. To predict the object location effectively the model is refined during training from the predefined anchor boxes from various sizes and aspect ratios. Based on anchor Boxes the model adjusts the bounding boxes to predict the confidence score and class probabilities making it ideal for real time applications.

IV. METHODOLOGY

A. Dataset Description

The Project utilizes dataset from the Chinese Academy of Science Institution and Automation (CASIA). It is one of the well suited dataset for iris based research . The dataset contains around 10,000 images under different lighting conditions, iris patterns and distances. The iris segmentation ground truth (bounding boxes and mask) is included.

B. System Design and Implementation

The Model initializes its process with a preprocessing of images by resizing, normalizing, enhancing features to standardize inputs for YOLOv8 or You Look Only Once version 8. Employs a number of approaches including variation in rotation, scaling, flipping of the images in order to increase the robustness of the system. In order to make the model more suitable for iris detection one can set up several parameters in the YOLO or You Once version 8 model in the configuration settings. The enhanced images or data is passed to the model to increase iris detection efficiency through multiple epochs and when the count is over the model is tested on in-sample data and standard evaluation metrics are evaluated

C. Requirement Specifications

The requirement specification for iris recognition and detection based on YOLOv8 or You Look Only Once version-8 gives a comprehensive roadmap to the components that are required to design and create a diagnostic tool. The key purpose of requirement analysis is to give a complete view of the elements that are necessary to build an accurate and reliable system that aims at detection and recognition of iris.

i. Libraries and Framework:

Ultralytics YOLO: This is the main library used for implementing the YOLOv8 or You Look Only Once version8 model .

penCV: This is primarily used for image processing and handling video Streams.

Numpy: It Is essential for numerical computations and handling arrays.

Pandas : It is used for data Manipulation and analysis Mat Plotlib: It is used for plotting and visualizing results.

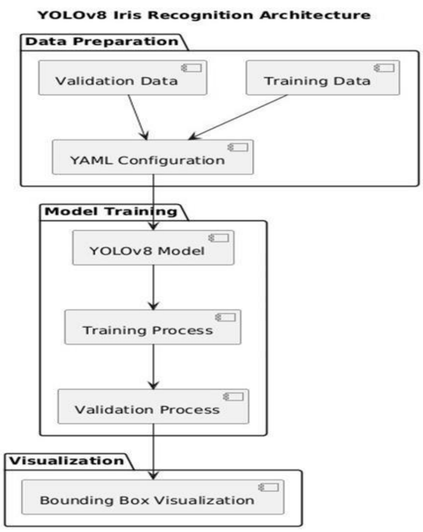
Tensorflow or Pytorch: The suitable deep learning framework like tensorflow, pytorch is used as they provide comprehensive tools and API Or Application Programming Interface for deep Learning tasks including model development and optimization.

ii. Algorithm Used:

The latest iteration of the YOLO is the YOLOv8 known for its fast and high accuracy in object detection. Due to the fact that the image is processed in a single go, this model is appropriate for real time applications such as a biometric system . The iris area detection is completed and the iris is classified with the help of the YOLOv8 model which is operating in the present context.

The key feature of the YOLO model is the enhanced loss function that balances accuracy and speed by anchor boxes and localization precision is improved by anchor boxes by adjusting to object shapes. The Yolo enhances the performance even on limited hardware by reducing the computational load. The flexibility of the YOLOv8 model for custom hyperparameter tuning makes the model perform optimally in iris detection and recognition tasks.

V. MODULE DESIGN



[Fig.2: Architecture Diagram]

A. Dataset Preprocessing

At the start, the process consists of gathering the entire dataset that is divided into the training set and the validation set in the ratio of 80:20. The image annotation is done with bounding boxes around the irises. To develop a robust model which is capable of accurate predictions in various scenarios the quality and diversity of the dataset is maintained.

B. Image Augmentation

Image Augmentation is mainly applied to transform original images in ways which

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can mimic different viewing conditions. This mainly includes flipping the images horizontally and vertically to generate different angles of observation. Brightness and contrast adjustments were also done to perform well on varying lighting conditions. Random rotation of images up to 90 degrees were also performed and to ensure consistency during training all images were normalized.

C. YOLOv8 Model Selection and Customization

The YOLOv8(You Look Only Once) is used as it has high efficiency in real time object detection. The model is customized and fine-tuned for iris detection to specialize the model for iris detection the default classes were replaced with custom iris labels. To balance between memory usage and performance the batch size was adjusted to 16. These customizations helped the YOLOv8(You Look Only Once) model to handle unique challenges in iris detection.

D. Model Training

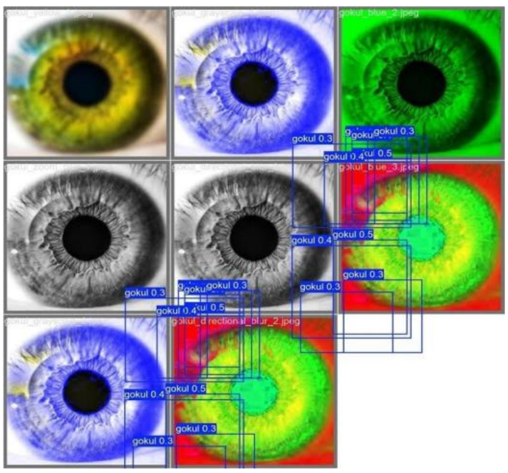
The Stochastic Gradient Descent (SGD) optimizer was chosen due to its ability in training deep learning models effectively. The model was given enough time to learn the hidden patterns in data without overfitting and the number of epochs was chosen. The YOLO (You Look Only Once) model was run for 50 epochs with a stochastic gradient optimizer.

E. Performance Evaluation

Performance metrics such as precision and recall as well as average precision were derived using a separated validation set. The performance measures of precision and recall depict the model's efficiency in identifying true irises without making too many false errors. Results have shown average Precision was responsible for providing a complete picture of model performance across different condition thresholds.

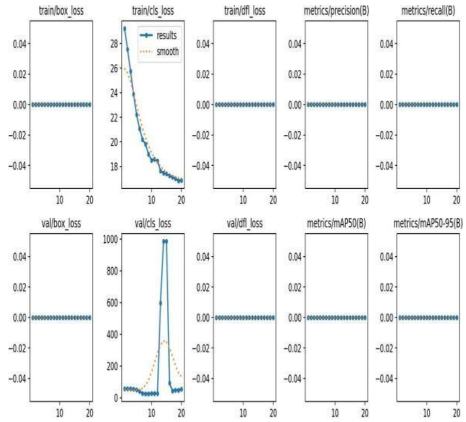
VI. VII RESULT AND DISCUSSION

The YOLOv8 or You Look Only Once version 8 model yielded promising results after being trained on the dataset achieving a high accuracy in various scenarios. The model attained an average precision of 95% in the validation set which indicates that it has remarkable consistency in detecting irises.



[Fig.3: Annotation]

The Performance metrics that were observed included precision, recall and F1 Score. Recall in this context is particularly relevant as the proportion of actual positives that were correctly identified. The Precision reached 94 percent which represents the proportion of correctly identified true positives to all positive detections. About the recall was approximately 96% which too the ratio of the true positives to the number of all relevant instances meg with retriever model. The F1-score was scored 95% which is the balance in overall performance providing the model sufficient capability to identify true positives while retaining an exceptionally low false positive rate to avoid detection blemishes.



[Fig.4: Model Precision, Recall, Loss Graph]

The advance image augmentation techniques like random flips, rotations and brightness adjustments significantly enhance the model generalization ability. These augmentation techniques helped the model learn to recognize irises in various conditions such as changes in lighting, different viewing angles and partial occlusions. The model performed well on less than ideal conditions and the robustness of the model under various conditions makes the model best suitable for real world applications.

VII.CONCLUSION AND FUTURESCOPE

The YOLOv8 (You Look Only Once) model achieved high accuracy with an average precision of 95% on the validation dataset. The Model generalization was significantly increased using advanced image augmentation techniques. The Project also faces and overcome challenges related to dataset diversity, occlusions and varying lighting conditions.

The future Work should primarily focus on creating an user friendly user interface where users can feed images or live video streams which can be integrated into real world applications. Also expanding the diversity of the dataset incorporating a broader range of iris images under various conditions such as differing lighting, angles and occlusions which will enhance the models robustness

DECLARATION STATEMENT

After aggregating input from all authors, I must verify the accuracy of the following information as the article's author.

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REFERENCES

1. D. P. Benalcazar, D. A. Benalcazar and A. Valenzuela, "Artificial Pupil Dilation for Data Augmentation in Iris Semantic Segmentation," 2022 IEEE Sixth Ecuador Technical Chapters Meeting (ETCM), Quito, Ecuador, 2022. DOI: http://dx.doi.org/10.1109/ETCM56276.2022.9935749
2. Al-Waist, A.S., Qahwaji, R., Ipson, S. et al. A multi- biometric iris recognition system based on a deep learning approach. Pattern Anal Applic 21, 783–802 (2018). DOI: http://dx.doi.org/10.1007/s10044-017-0656-1
3. Tann, Hokchhay, Heng Zhao, and Sherief Reda. "A resource-efficient embedded iris recognition system using fully convolutional networks." ACM Journal on Emerging Technologies in Computing Systems (JETC) 16.1 (2019). DOI: http://dx.doi.org/10.48550/arXiv.1909.03385
4. Choudhary, M., Tiwari, V. & Uduthalapally, V. Iris presentation attack detection based on best-k feature selection from YOLO inspired RoI. Neural Comput & Applic 33, 5609– 5629 (2021). DOI: https://doi.org/10.1007/s00521-020-05342-3
5. S. He and X. Li, "EnhanceDeepIris Model for Iris Recognition Applications," in IEEE Access, vol. 12, pp. 66809- 66821, 2024. DOI: https://dx.doi.org/10.1109/ACCESS.2024.3388169
6. D. R. Lucio, R. Laroca, L. A. Zanlorenzi, G. Moreira and Menotti, "Simultaneous Iris and Periocular Region Detection Using Coarse Annotations," 2019 32nd SIBGRAPI Conference on Graphics, Patterns and Images (SIBGRAPI), Rio de Janeiro, Brazil, 2019. DOI: http://dx.doi.org/10.48550/arXiv.1908.00069
7. Ahmad, Naseem, Muhammad Ghulam, Kuldeep Singh Yadav, Rabul Hussain Laskar, Ashraf Hossain and Zulfiqar Ali. “A cascaded deep learning framework for iris center localization in facial image(2023). DOI: http://dx.doi.org/10.1111/exsy.13483
8. Kimura, Gabriela Y., Diego R. Lucio, Alceu S. Britto Jr, and David Menotti. "CNN hyperparameter tuning applied to iris liveness detection." arXiv preprint arXiv:2003.00833 (2020). DOI: http://dx.doi.org/10.48550/arXiv.2003.00833
9. Alay, N.; Al-Baity, H.H. Deep Learning Approach for Multimodal Biometric Recognition System Based on Fusion of Iris, Face, and Finger Vein Traits. Sensors 2020. DOI: http://dx.doi.org/10.3390/s20195523
10. Minaee, Shervin, and Amirali Abdolrashidi. "Deepiris: Iris recognition using a deep learning approach." arXiv preprint arXiv:1907.09380 (2019). DOI: http://dx.doi.org/10.48550/arXiv.1907.09380
11. A. Kuehlkamp, A. Pinto, A. Rocha, K. W. Bowyer and Czajka, "Ensemble of Multi-View Learning Classifiers for Cross-Domain Iris Presentation Attack Detection," in IEEE Transactions on Information Forensics and Security, vol. 14, no. 6, pp. 1419-1431, June 2019. DOI: http://dx.doi.org/10.1109/TIFS.2018.2878542
12. Hamd, Muthana H. and Samah K. Ahmed. “Biometric System Design for Iris Recognition Using Intelligent Algorithms.” International Journal of Modern Education and Computer Science 10 (2018). DOI: http://dx.doi.org/10.5815/ijmecs.2018.03.02
13. Ahmad, Naseem, Kuldeep Singh Yadav, Anish Monsley Kirupakaran, Saharul Alom Barlaskar, Rabul Hussain Laskar and Ashraf Hossain. “Design and development of an integrated approach towards detection and tracking of iris using deep learning.” Multim. Tools Appl. 83 (2023). DOI: http://dx.doi.org/10.1007/s11042-023-17433-z
14. J. E. Zambrano, J. I. Pilataxi, C. A. Perez and K. W. Bowyer, "Iris Recognition Using an Enhanced Pre-Trained Backbone Based on Anti-Aliased CNNs," in IEEE Access, vol. 12, pp. 94570-94583, 2024. DOI: http://dx.doi.org/10.1109/ACCESS.2024.3425648
15. L. Wang, K. Zhang, M. Ren, Y. Wang and Z. Sun, "Recognition Oriented Iris Image Quality Assessment in the Feature Space," 2020 IEEE International Joint Conference on Biometrics (IJCB), Houston, TX, USA, 2020. DOI: http://dx.doi.org/10.1109/IJCB48548.2020.9304896
16. S. Ahmad and B. Fuller, "ThirdEye: Triplet Based Iris Recognition without Normalization," 2019 IEEE 10th International Conference on Biometrics Theory, Applications and Systems (BTAS), Tampa, FL, USA, 2019. DOI: http://dx.doi.org/10.1109/BTAS46853.2019.9185998
17. D. Kerrigan, M. Trokielewicz, A. Czajka and K. W. Bowyer, "Iris Recognition with Image Segmentation Employing Retrained Off-the-Shelf Deep Neural Networks," 2019 International Conference on Biometrics (ICB), Crete, Greece, 2019. DOI: http://dx.doi.org/10.1016/j.imavis.2019.103866
18. Tapia, Juan E., Sebastian Gonzalez, Daniel Benalcazar, and Christoph Busch. "On the Feasibility of Creating Iris Periocular Morphed Images." arXiv preprint arXiv:2408.13496 (2024). DOI: http://dx.doi.org/10.48550/arXiv.2408.13496
19. Fang, Zhaoyuan, and Adam Czajka. "Open source iris recognition hardware and software with presentation attack detection." 2020 IEEE International Joint Conference on Biometrics (IJCB). IEEE, 2020. DOI: http://dx.doi.org/10.1109/IJCB48548.2020.9304869
20. S. Senthil Pandi, V. R. Chiranjeevi, K. T and Kumar P, Improvement of Classification Accuracy in Machine Learning Algorithm by Hyper-Parameter Optimization(2023), 2023 International Conference on Research Methodologies in Knowledge Management, Artificial Intelligence and Telecommunication Engineering (RMKMATE), Chennai, India, 2023. DOI: http://dx.doi.org/10.1109/RMKMATE59243.2023.10369177
21. Kumar P, V. K. S, P. L and S. SenthilPandi(2023), "Enhancing Face Mask Detection Using Data Augmentation Techniques," 2023 International Conference on Recent Advances in Science and Engineering Technology (ICRASET), B G NAGARA, India, 2023, pp. 1-5, DOI: https://doi.org/10.1109/ICRASET59632.2023.10420361.
22. R. K. Mahendran, R. Aishwarya, R. Abinayapriya and P. Kumar, "Deep Transfer Learning Based Diagnosis of Multiple Neurodegenerative Disorders," 2024 International Conference on Emerging Smart Computing and Informatics (ESCI), Pune, India, 2024. DOI: https://doi.org/10.1109/ESCI59607.2024.10497320
23. A., O., & O, B. (2020). An Iris Recognition and Detection System Implementation. In International Journal of Inventive Engineering and Sciences (Vol. 5, Issue 8, pp. 8–10). DOI: https://doi.org/10.35940/ijies.h0958.025820
24. Harini, K., Yamuna, Dr. G., & Santhiya, V. (2020). Biometric Iris Recognition System using Multiscale Feature Extraction Method. In International Journal of Recent Technology and Engineering (IJRTE) (Vol. 8, Issue 6, pp. 2298–2303). DOI: https://doi.org/10.35940/ijrte.f8016.038620
25. Bankar, R., & Salankar, S. (2020). Face Tracking Performance in Head Gesture Recognition System. In International Journal of Engineering and Advanced Technology (Vol. 9, Issue 5, pp. 1096–1099). DOI: https://doi.org/10.35940/ijeat.e1043.069520
26. Singh, S., Gupta, A. K., & Singh, T. (2019). Sign Language Recognition using Hybrid Neural Networks. In International Journal of Innovative Technology and Exploring Engineering (Vol. 9, Issue 2, pp. 1092–1098). DOI: https://doi.org/10.35940/ijitee.l3349.129219
27. Rathore, R., & Shrivastava, Dr. N. (2023). Network Anomaly Detection System using Deep Learning with Feature Selection Through PSO. In International Journal of Emerging Science and Engineering (Vol. 11, Issue 5, pp. 1–6). DOI: https://doi.org/10.35940/ijese.f2531.0411523