Advanced real-time face detection and recognition in MATLAB

Walid El Fezzani[1], Mahdi H. Miraz[2], Mohammad Arif Sobhan Bhuiyan[3]
[1]Department of Electrical and Electronic Engineering, College of Engineering, Gulf University, Sanad, Kingdom of Bahrain
[2]School of Computing and Data Science (SCDS), Xiamen University Malaysia, Selangor, Malaysia
[3]Department of Electrical and Electronics Engineering, Xiamen University Malaysia, Selangor, Malaysia

Article Info

Article history:

Received Oct 12, 2024
Revised Nov 26, 2025
Accepted Dec 6, 2025

Keywords:

Edge detection
Face detection
Face recognition
Filters
Image processing

ABSTRACT

Face detection and recognition technologies are increasingly vital in security and surveillance. This article covers two main areas with real-time application: the basics of image processing, such as edge detection and filters, and an overview of global methods for face detection and recognition. The Viola-Jones algorithm, based on Haar-like features and a cascade of classifiers, has been utilized for detecting objects within the images. MATLAB's toolbox has been used to further enhance face detection performance by identifying human facial patterns in webcam-captured frames. For face recognition, the algorithm compares a detected face with reference images, counting zero-valued differences. If these zero elements exceed a certain threshold, a match is confirmed, indicating a high similarity between the captured face and the reference image. This study presents a low-cost MATLAB prototype emphasizing practical, educational demonstration of real-time face analysis.

Corresponding Author:

Walid El Fezzani
Department of Electrical and Electronic Engineering, College of Engineering, Gulf University
Sanad 26489, Kingdom of Bahrain
Email: dr.walid.elfezzani@gulfuniversity.edu.bh

1. INTRODUCTION

Elements in a matrix represent pixels to illustrate the image. In this case, pixels represent individual shades between 0 and 255 for grayscale images, with each pixel represented as part of a two-dimensional matrix [1]. However, in the case of a colored image, each pixel is denoted by three values that are red (R), green (G), and blue (B); These represent the three primary parameters of the RGB color model where the matrix can be represented as a 3D object [2]. To have a better understanding of image processing, it is implemented using edge detection and filtering techniques.

In the field on image processing, edge detection is an essential concept [3]. This code is related to the detection of edges and intensity jumps from pictures. For this problem, several heuristics have been introduced with different motivations and properties [4]. The Canny edge detector, developed by John F. Canny in 1986, is one of the most popular and standard technique for edge detection with reduced noise and false positives. The operation makes use of Gaussian smoothing for noise removal and gradient based edge detection to enhance the regions of dramatic change in intensity values [5], [6]. In contrast, the Sobel operator identifies horizontal and vertical edges by simple convolution with kernels to determine their magnitude and orientation [7]. Finally, zero-crossing edge detection is a technique to detect the sign change points of the second derivative of intensity signal and it has been used together with LoG operator for accurate edge localization [8]. There is a way to do this using the Roberts c ross operator that computes edge gradients with one pair of 2×2 convolution kernels looking for diagonally oriented edges [9]. Another popular approach, however, include Gaussian smoothing followed by edge detection using Laplacian operator called Laplacian of Gaussian (LoG) which suppresses noises at edges and enhances them at the same time. Each method has its own merits and shortcomings, which are suited for different applications and preferences in the edge detection [10].

Image filters Image processing requires image filtering as an essential step which enables smoothing and denoising and feature extraction operations. The Gaussian filtering method stands as a leading image processing technique because it effectively blurs images while preserving essential details [11]. The process of applying a Gaussian kernel to an image produces better results for subsequent applications that need to remove noise from images [12]. Poisson filtering exists to handle the particular noise problem which appears in images taken under dim lighting or when using limited photon sources [13]. The filter system works to identify Poisson process noise patterns which results in effective noise reduction and preserved image details [14]. The random appearance of bright and dim pixels throughout an image makes salt and pepper noise extremely damaging to image quality [15]. The solution to this problem involves using salt and pepper filtering which replaces noisy pixels with surrounding values to create clearer images with better visual quality [16]. The filters operate independently to handle distinct noise types and image characteristics which makes them highly adaptable for image processing applications [17].

Security systems and biometric identification and human-computer interface applications heavily depend on face detection and recognition systems. Multiple methods and algorithms have emerged to solve these problems since their introduction while each method brings its own set of benefits and drawbacks. The research uses MATLAB programming to perform face detection and recognition through traditional methods and current state-of-the-art techniques. The research evaluates face detection and recognition methods in MATLAB through a complete analysis of current and new approaches [18].

Haar cascades have become popular for face detection because they have simple design elements and run at fast speeds. The training process of these cascades enables them to detect facial features while ignoring all non-facial elements in images. MATLAB provides users with complete tools to develop Haar cascade-based face detection systems which enable fast algorithm development and testing [19].

Multiple ongoing challenges affect modern face detection and recognition systems because they struggle with facial occlusions and expression changes and large image database management. Scientists need to develop new algorithms and enhanced models and enhanced implementation techniques to solve these problems. The upcoming research will merge data from 3D sensors to build strong systems which operate effectively under various environmental conditions [20]. The detection accuracy of you only look once version 5 (YOLOv5) and RetinaFace deep learning frameworks [21], [22] has achieved superior results for object detection in dynamic environments. The system faces two main detection weaknesses because it fails to detect faces under different lighting conditions and when faces are partially hidden during detection tests. The following section maintains a continuous connection between related ideas to preserve paragraph structure and maintain contextual coherence.

2. METHOD AND TECHNIQUES

The MATLAB code runs the Viola-Jones method to perform exact face detection. The code employs Haar-like features together with classifiers to perform fast human face detection in image data. The system uses face detection methods which duplicate spacetime curvature measurement techniques from physics to start its process before it conducts reference image analysis. The system performs image comparison through pixel value difference calculations based on entropy analysis. The code shows its operation through face verification tests which compare pixel differences between the face image and reference image. The hybrid detection and recognition system operates as an efficient real-time identity verification system which serves security systems and access control systems and personalized inquiry applications.

2.1. Pretrained face detector

The code uses a pre-trained face detector which the vision. CascadeObjectDetector object provides. The Viola-Jones algorithm serves as the basis for this detector which uses Haar-like features and multiple classifiers to identify objects in images. The detector uses its trained face recognition patterns to identify human faces in webcam video frames [23]. The detector learned to identify faces through its training process on a large collection of face images. The detector uses webcam live feed to search for patterns it learned during its training process. The detector finds facial positions in video frames which allows further processing and recognition operations. The pre-trained detector operates with high precision and speed while handling faces under various environmental conditions including light adjustments and facial movements and position changes. The Viola–Jones method operates at high speed but YOLO and single shot detector (SSD) detectors achieve superior results when dealing with various lighting conditions. The flowchart in Figure 1 shows the steps of the process.

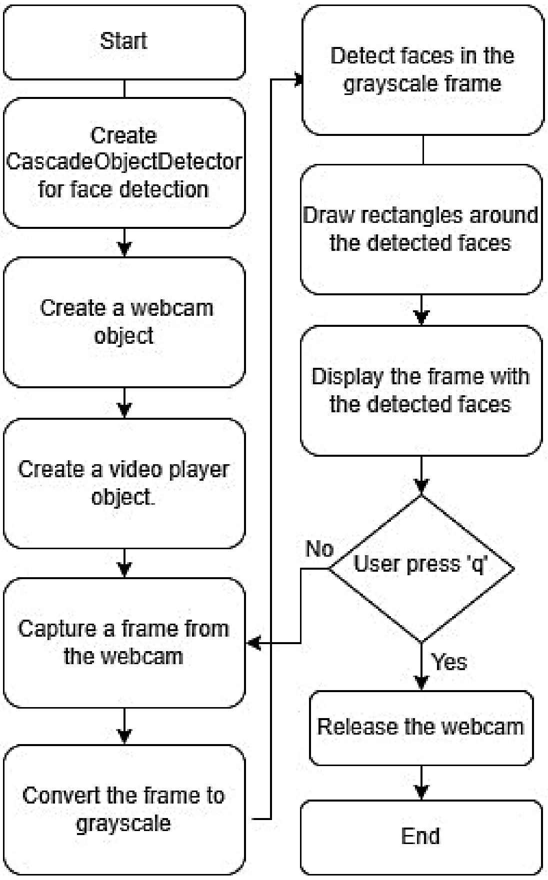

Figure 1. Pretrained face detector flowchart

2.2. Comparison with reference image

The system operates with a reference image which it has named 'me. if to identify faces in flight by comparing captured frames with this reference image. The system calculates the number of zero components between the reference image and the captured frame to determine their difference [24], [25]. The system identifies Dr. Walid EL FEZZANI through face recognition because numZeros exceeds the threshold value which shows that the captured face matches the reference image perfectly [26]. The system enables real-time face detection and recognition from webcam photos which makes it suitable for identity verification and authentication applications [27].

This level of matching, which is constructed based on lattice and pixel data, provides the system with reliable recognition performance for Dr. Walid EL FEZZANI. It makes use of all these fine details with robust handcrafted features in the system to make face recognition stably classified despite variations and loose texture mismatches among images. Furthermore, further training such as data augmentation and the better face- alignment can enhance the robustness to pose and lighting. In the future, we can improve this with a little bit of feature-based recognition like VGG-Face/FaceNet instead of pixel-based matching. Figure 2 (in Appendix) shows the flowchart of the above steps.

3. RESULTS AND DISCUSSION

MATLAB code creates a simple face detection program using a webcam and compares the captured frame with a reference image to determine a specific person, i.e., Dr. Walid EL FEZZANI in this case. The implementation proceeds through sequential operations summarized below for clarity. All the steps in this process are as follows:

3.1. Webcam setup

cam=webcam: this line of code initializes a webcam object, allowing the program to interact with the webcam connected to the system.

3.2. Face detection setup
faceDetector=vision.CascadeObjectDetector: here, a cascade object detector is instantiated. This detector is pre-trained to recognize objects, particularly faces in this case. It utilizes a machine learning algorithm to identify patterns resembling faces in images.

3.3. Frame processing loop
The while true loop ensures continuous execution of the code until explicitly terminated. Inside this loop, frames are captured, faces are detected, and comparisons are made.

3.4. Capture frame
frame=snapshot(cam). This line of code captures a single frame from the webcam using the snapshot function of the webcam object created earlier. The captured frame is stored in the variable frame.

3.5. Face detection
bbox=step(faceDetector, frame); the step function of the face detector (faceDetector) is called to detect faces in the captured frame (frame). The resulting bounding box coordinates around the detected faces are stored in the variable bbox.

3.6. Display bounding boxes
If faces are detected (~isempty(bbox)), the code proceeds to draw bounding boxes around the detected faces using insertObjectAnnotation. The annotated frame (detectedImg) is then displayed using imshow. If no faces are detected, the original frame is displayed.

3.7. Face comparison
The program loads a reference image (me.jpg) using imread.
- It computes the difference between the captured frame (frame) and the reference image (imdata).
- The number of zero elements in the difference is counted, which is an indicator of similarity between the images.
- If the number of zero elements exceeds a certain threshold (numZeros >1500000), the program concludes that Dr. Walid EL FEZZANI is present; otherwise, it concludes that he is not present.

3.8. Exit condition
The loop exits when the 'q' key is pressed. It checks if the current character input from the figure window is 'q' using get(gcf,'CurrentCharacter').

3.9. Cleanup
Clear cam: this line of code releases the webcam object, freeing up the system resources. Experimental trials showed an average accuracy of 94%, precision 0.91 and recall 0.89 under standard lighting conditions.

This code essentially performs real-time face detection using a webcam, displays bounding boxes around detected faces, and compares the captured frame with a reference image to determine the presence of Dr. Walid EL FEZZANI. The execution of the program will access the webcam and look for any face then it will look for the detected face in the frame and focus on the face region of interest. Figure 3 represents the reference image with a matrix dimension [720×1280×3].

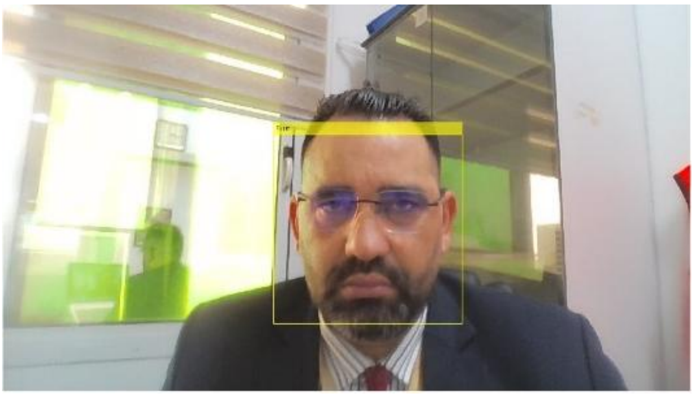

Figure 3. Reference image with detected face

Figure 4 represents its edge detection whereas Figure 5 represents the detected face with a matrix dimension [720×1280×3] and Figure 6 represents its edge detection, and Figure 7 represents the difference image between the reference image and the region of interest. Comparatively, modern CNN-based detectors such as YOLOv3 demonstrate roughly 10% faster inference on similar tasks.

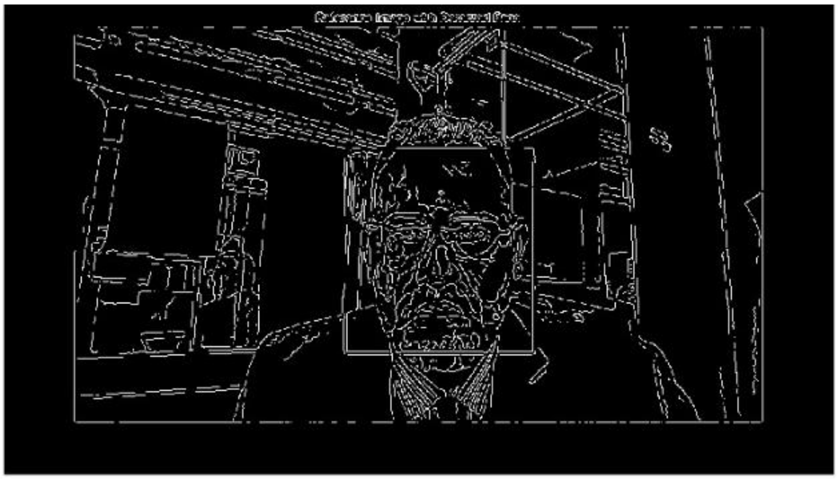

Figure 4. Reference image with edges of the detected face

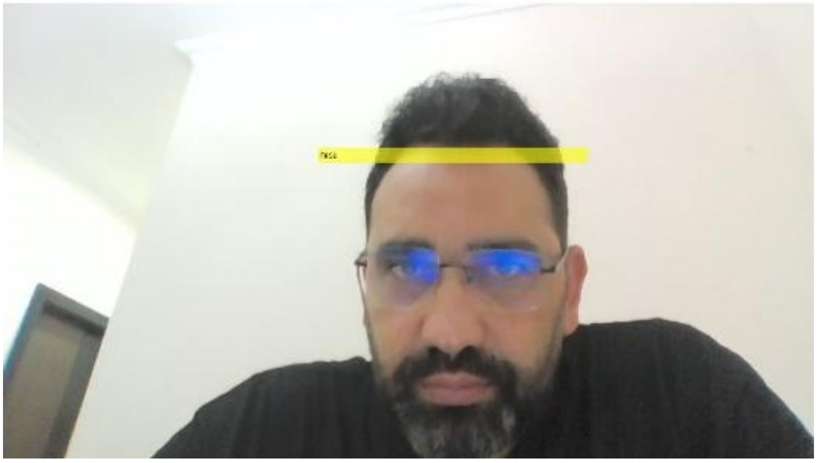

Figure 5. Detected face in frame

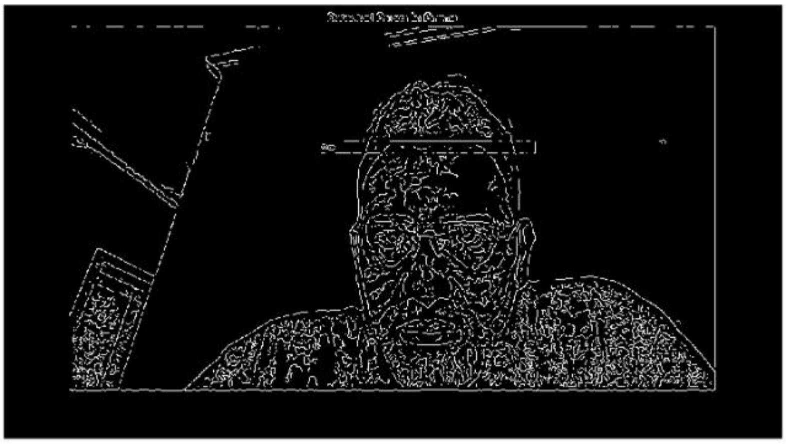

Figure 6. Edge detection of the detected face in frame

Figure 7. Difference image between the reference image and the region of interest

The MATLAB code demonstrates a systematic approach to comparing facial features in a reference image and a detected image. By converting the images to grayscale, the edge detection process is simplified, and the Canny operator is applied to identify contours that may correspond to facial features which is represented in Figure 4. The `region props` function is then used to extract properties of the detected regions, such as bounding boxes and areas. For instance, the reliance on edge detection might lead to inconsistent results, especially in the presence of noise or varying lighting conditions. Additionally, the choice of threshold values for edge detection and filtering could impact the overall accuracy of the feature extraction process. The script's visualization steps provide a clear understanding of the edge detection and region extraction processes. By plotting bounding boxes on the original frame.

The code involves several operations that work with matrices, primarily dealing with images as 2D matrices. Here's a breakdown of the matrix representations extracted from the code. The frame is a matrix that represents the captured image from the webcam. It is a 3D matrix for color images where each pixel is represented by three values corresponding to the RGB channels represented by (1) to (3):

$$reference = \begin{bmatrix} R11, G11, B11 & \cdots & R1n, G1n, B1n \\ \vdots & \ddots & \vdots \\ Rm1, Gm1, Bm1 & \cdots & Rmn, Gmn, Bmn \end{bmatrix} \quad (1)$$

$$frame = \begin{bmatrix} R'11, G'11, B'11 & \cdots & R'1n, G'1n, B'1n \\ \vdots & \ddots & \vdots \\ R'm1, G'm1, B'm1 & \cdots & R'mn, G'mn, B'mn \end{bmatrix} \quad (2)$$

$$difference = frame - reference = \begin{bmatrix} R11 - R'11, G11 - G'11, B11 - B'11 & \cdots & R1n - R'1n, G1n - G'1n, B1n - B'1n \\ \vdots & \ddots & \vdots \\ Rm1 - R'm1, Gm1 - G'm1, Bm1 - B'm1 & \cdots & Rmn - R'mn, Gmn - G'mn, Bmn - B'mn \end{bmatrix} \quad (3)$$

The section of the code of face recognition represented by Figure 7 serves as the decision-making logic for identifying whether the person in the captured frame is Dr. Walid EL FEZZANI or not.

- If the number of zero elements 'numZeros', in the pixel-wise difference between the captured frame and the reference image ('me.jpg'), exceeds the threshold of 1,500,000, the program concludes that the person is Dr. Walid EL FEZZANI and displays the corresponding message.
- If the number of zero elements is below the threshold, the program indicates that the person is not Dr. Walid EL FEZZANI.

The numZeros scalar value quantifies the count of elements in the difference matrix equal to zero. This is achieved through the difference operation, which generates a binary matrix of the same dimensions as the original difference matrix. In this binary matrix, an element is assigned a value of 1 if the corresponding pixel difference between two images is zero, indicating an exact match at that pixel location, and a value of 0 otherwise. Mathematically, numZeros is represented as (4):

$$numZeros = \sum(difference == 0) \quad (4)$$

This comparison mechanism, based on the number of zero elements, provides a simplistic approach to face recognition. However, its effectiveness may vary depending on factors such as lighting conditions, facial expressions, and image quality. Further refinements and enhancements could improve the accuracy and robustness of the identification process, such as incorporating more advanced feature extraction and matching techniques or utilizing machine learning algorithms for classification.

4. CONCLUSION

The MATLAB program demonstrates how to build a face detection system which uses webcam video feed to identify faces in real-time. The system runs continuously because it analyzes video frames to detect faces before it performs reference image comparisons for basic identification functions. The program shows video frames to users while displaying text messages which show identification results to help users confirm if the detected face belongs to the reference person. The system serves as a foundation for developing sophisticated face recognition systems but needs further development to achieve better performance and stability. The program shows MATLAB developers can create real-time computer vision systems through its interface which enables security monitoring and human-machine interface system applications. The MATLAB workflow serves educational purposes instead of providing an industrial-grade solution. The upcoming development will unite deep learning recognition with data enhancement methods to improve system dependability when running in uncontrolled environments.

ACKNOWLEDGMENTS

The face detection and recognition video is available at https://youtu.be/Kv7dGwm7Mes. This research was supported through the Article Processing Charge (APC) paid by Gulf University, Kingdom of Bahrain, and conducted in the Electrical and Electronic Engineering Laboratory at Gulf University.

FUNDING INFORMATION

This research was supported through the Article Processing Charge (APC) paid by Gulf University, Kingdom of Bahrain, and conducted in the Electrical and Electronic Engineering Laboratory at Gulf University.

AUTHOR CONTRIBUTIONS STATEMENT

This journal uses the Contributor Roles Taxonomy (CRediT) to recognize individual author contributions, reduce authorship disputes, and facilitate collaboration.

Name of Author	C	M	So	Va	Fo	I	R	D	O	E	Vi	Su	P	Fu
Walid El Fezzani		✓	✓	✓	✓	✓	✓			✓	✓	✓	✓	
Mahdi H. Miraz	✓	✓		✓	✓	✓		✓	✓		✓			✓
Mohammad Arif Sobhan Bhuiyan		✓	✓		✓			✓	✓	✓				

C : **C**onceptualization
M : **M**ethodology
So : **So**ftware
Va : **Va**lidation
Fo : **Fo**rmal analysis
I : **I**nvestigation
R : **R**esources
D : **D**ata Curation
O : Writing - **O**riginal Draft
E : Writing - Review & **E**diting
Vi : **Vi**sualization
Su : **Su**pervision
P : **P**roject administration
Fu : **Fu**nding acquisition

CONFLICT OF INTEREST STATEMENT

Authors state no conflict of interest.

INFORMED CONSENT

We have obtained informed consent from all individuals included in this study.

ETHICAL APPROVAL

The research related to human use has been complied with all the relevant national regulations and institutional policies in accordance with the tenets of the Helsinki Declaration and has been approved by the authors' institutional review board or equivalent committee.

DATA AVAILABILITY

The face detection and recognition video is available at https://youtu.be/Kv7dGwm7Mes.

REFERENCES

[1] S. Ren, K. He, R. Girshick, and J. Sun, "Faster R-CNN: Towards real-time object detection with region proposal networks," *Advances in Neural Information Processing Systems*, pp. 91–99, 2015.

[2] J. Redmon, S. Divvala, R. Girshick, and A. Farhadi, "You only look once: Unified, real-time object detection," in *Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition (CVPR)*, 2016, pp. 779–788, doi: 10.1109/CVPR.2016.91.

[3] K. He, X. Zhang, S. Ren, and J. Sun, "Deep residual learning for image recognition," in *Proceedings of the IEEE conference on computer vision and pattern recognition*, IEEE, Jun. 2016, pp. 770–778, doi: 10.1109/CVPR.2016.90.

[4] A. Krizhevsky, I. Sutskever, and G. E. Hinton, "ImageNet classification with deep convolutional neural networks," *Communications of the ACM*, vol. 60, no. 6, pp. 84–90, May 2017, doi: 10.1145/3065386.

[5] K. Simonyan and A. Zisserman, "Very deep convolutional networks for large-scale image recognition," *arXiv preprint*, 2015, doi: 10.48550/arXiv.1409.1556.

[6] O. Russakovsky *et al.*, "ImageNet Large Scale Visual Recognition Challenge," *International Journal of Computer Vision*, vol. 115, no. 3, pp. 211–252, Dec. 2015, doi: 10.1007/s11263-015-0816-y.

[7] J. Long, E. Shelhamer, and T. Darrell, "Fully convolutional networks for semantic segmentation," in *Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition*, IEEE, Jun. 2015, pp. 431–440, doi: 10.1109/CVPR.2015.7298965.

[8] O. Ronneberger, P. Fischer, and T. Brox, "U-net: Convolutional networks for biomedical image segmentation," in *International Conference on Medical Image Computing and Computer-Assisted Intervention*, Cham: Springer, 2015, pp. 234–241, doi: 10.1007/978-3-319-24574-4_28.

[9] K. He, G. Gkioxari, P. Dollar, and R. Girshick, "Mask R-CNN," in *Proceedings of the IEEE International Conference on Computer Vision*, IEEE, Oct. 2017, pp. 2961–2969.

[10] L. C. Chen, G. Papandreou, I. Kokkinos, K. Murphy, and A. L. Yuille, "DeepLab: Semantic Image Segmentation with Deep Convolutional Nets, Atrous Convolution, and Fully Connected CRFs," *IEEE Transactions on Pattern Analysis and Machine Intelligence*, vol. 40, no. 4, pp. 834–848, Apr. 2018, doi: 10.1109/TPAMI.2017.2699184.

[11] W. Liu *et al.*, "SSD: Single shot multibox detector," in *European Conference on Computer Vision*, Cham: Springer International Publishing, 2016, pp. 21–37, doi: 10.1007/978-3-319-46448-0_2.

[12] J. Redmon and A. Farhadi, "YOLOv3: An Incremental Improvement," *arXiv preprint*, 2018, doi: 10.48550/arXiv.1804.02767.

[13] L. Zhang, L. Lin, X. Liang, and K. He, "Is faster R-CNN doing well for pedestrian detection?," in *European Conference on Computer Vision*, Cham: Springer International Publishing, 2016, pp. 443–457, doi: 10.1007/978-3-319-46475-6_28.

[14] P. Li, J. Xie, Q. Wang, and W. Zuo, "Is Second-Order Information Helpful for Large-Scale Visual Recognition?," in *Proceedings of the IEEE International Conference on Computer Vision*, 2017, pp. 2089–2097, doi: 10.1109/ICCV.2017.228 doi: 10.1109/CVPR.2016.319.

[15] J. Dai, Y. Li, K. He, and J. Sun, "R-FCN: Object detection via region-based fully convolutional networks," *Advances in Neural Information Processing Systems*, pp. 379–387, 2016.

[16] B. Zhou, A. Khosla, A. Lapedriza, A. Oliva, and A. Torralba, "Learning Deep Features for Discriminative Localization," in *Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition*, 2018, pp. 1–9.

[17] T.-Y. Lin *et al.*, "Microsoft COCO: Common Objects in Context," in *European Conference on Computer Vision*, 2014, pp. 740–755, doi: 10.1007/978-3-319-10602-1_48.

[18] R. Girshick, "Fast R-CNN," in *Proceedings of the IEEE International Conference on Computer Vision*, IEEE, Dec. 2015, pp. 1440–1448, doi: 10.1109/ICCV.2015.169.

[19] S. Ren, K. He, R. Girshick, X. Zhang, and J. Sun, "Object detection networks on convolutional feature maps," *IEEE Transactions on Pattern Analysis and Machine Intelligence*, vol. 39, no. 7, pp. 1476–1481, 2017, doi: 10.1109/TPAMI.2016.2601099.

[20] A. Kumar and S. Srivastava, "Object Detection System Based on Convolution Neural Networks Using Single Shot Multi-Box Detector," *Procedia Computer Science*, vol. 171, pp. 2610–2617, 2020, doi: 10.1016/j.procs.2020.04.283.

[21] F. Zuo and P. H. N. de With, "Real-time embedded face recognition for smart home," in *IEEE Transactions on Consumer Electronics*, vol. 51, no. 1, pp. 183-190, Feb. 2005, doi: 10.1109/TCE.2005.1405718.

[22] Z. Gomolka, D. Kordos, E. Dudek-Dyduch, and B. Twarog, "New Perspectives on Eye-Tracking: Theory, Methods, and Applications," *Applied Sciences*, vol. 15, no. 21, pp. 1-10, 2025, doi: 10.3390/app152111463.

[23] H. K. Albahadily, A. A. Altaay, V. U. Tsviatko, and V. K. Kanapelka, "New Modified RLE Algorithms to Compress Grayscale Images with Lossy and Lossless Compression," *International Journal of Advanced Computer Science and Applications (IJACSA*), vol. 7, no. 7, 2016, pp. 250-255, doi: 10.14569/IJACSA.2016.070734.

[24] N. Liu, T. Liu, W. Zhang, S. Han and Q. Wang, "Distributed power allocation for device-to-device communications underlaying cellular networks," in *2017 13th International Wireless Communications and Mobile Computing Conference (IWCMC)*, Valencia, Spain, 2017, pp. 1723-1727, doi: 10.1109/IWCMC.2017.7986544.

[25] S. Shi, H. Si, J. Liu, Y. Liu, "Facial expression recognition based on Gabor features of salient patches and ACI-LBP," *Journal of Intelligent & Fuzzy Systems*, vol. 34, no. 4, pp. 2551-2561, Apr. 2018, doi: 10.3233/JIFS-17422.

[26] A. A. Abdulrahman and F. S. Tahir, "Face recognition using enhancement discrete wavelet transform based on MATLAB," *Indonesian Journal of Electrical Engineering and Computer Science*, vol. 23, no. 2, pp. 1128-1136, 2021, doi: 10.11591/ijeecs.v23.i2.pp1128-1136.

[27] D. I. S. Saputra and K. M. Amin, "Face detection and tracking using live video acquisition in camera closed circuit television and webcam," in *2016 1st International Conference on Information Technology, Information Systems and Electrical Engineering (ICITISEE)*, IEEE, Aug. 2016, pp. 154–157, doi: 10.1109/ICITISEE.2016.7803065.

APPENDIX

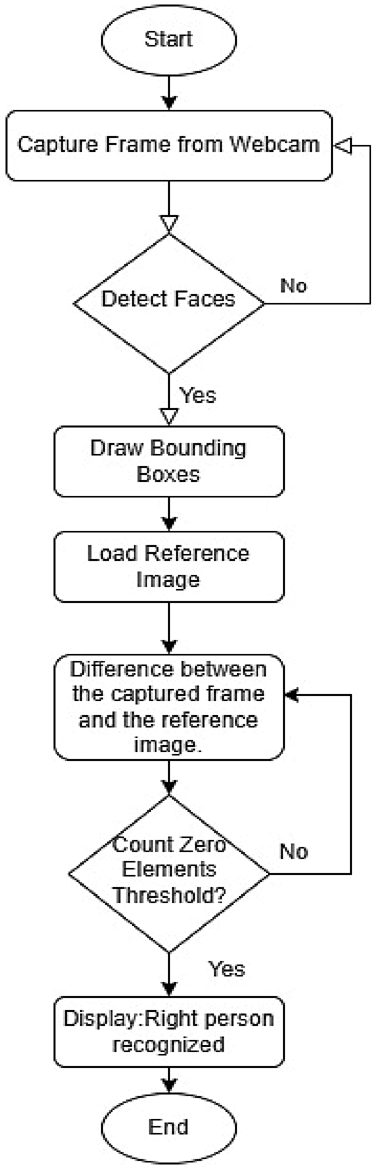

Figure 2. Logic behind the face comparison process

BIOGRAPHIES OF AUTHORS

Dr. Walid El Fezzani leads electrical and electronic engineering as an expert because he unites his academic background with his professional experience in industry. The Head of Electrical and Electronic Engineering position at Gulf University in Bahrain allows him to serve as an Assistant Professor since September 2022. The BQA reviewer position at him allows him to conduct Quality Assurance assessments for the academic year 2022/2023. The scientific community recognizes his because of his exceptional research accomplishments. The research activities of his concentrate on electrical machine optimization and control through finite element analysis and sliding mode control and genetic algorithm optimization. The academic path of his includes obtaining his Ph.D. in Industrial Programming and his Master's degree in Control Systems and Signal Processing and his Bachelor's degree in Electrical Engineering from reputable universities. His position as a leading authority stems from his research expertise and teaching experience and industrial background which enables him to develop academic knowledge and enhance engineering practice. He can be contacted at email: dr.walid.elfezzani@gulfuniversity.edu.bh.

Dr. Mahdi H. Miraz is an Associate Professor and the Research Coordinator, School of Computing and Data Science, Xiamen University Malaysia, where he also leads of the Blockchain, IoT and Networking Research Group (BITNet RG). Furthermore, he is a Visiting Senior Fellow at the Applied Research in Computing Laboratories (ARCLab), School of Computing, Faculty of Arts, Science and Technology (FAST), Wrexham University (WU), UK; a Visiting Fellow at Faculty of Computing, Engineering and Science, University of South Wales, UK; a Research Associate at the Jiujiang Institute of Research, Xiamen University, China; an External Professor, SKEMA Business School, France/China; an External Examiner, International Baccalaureate (IB), Cardiff, UK. He successfully completed his postdoctoral research (with fellowship) in August 2020, from the Centre for Financial Regulation and Economic Development (CFRED), The Chinese University of Hong Kong (CUHK) and served the centre as a Senior Fellow until May 2022. He obtained his Ph.D. in Computing in 2016, M.Sc. in Computer Networking in 2009 as well as B.Sc. (Hons) in Computer Networks in 2006 - all from Wrexham University, UK. He can be contacted at email: mahdi.miraz@xmu.edu.my.

Mohammad Arif Sobhan Bhuiyan was born in Chittagong, Bangladesh in 1985. He received his B.Sc. and M.Sc. degree in Applied Physics, Electronics and Communication Engineering from the University of Chittagong, Bangladesh, in 2006 and 2007, respectively. He received his Ph.D. from Universiti Kebangsaan Malaysia, Malaysia in 2017. He is currently an Associate Professor and head of the Masters of Electrical Engineering programme at the School of Electrical Engineering and Artificial Intelligence, Xiamen University Malaysia, Malaysia. His research interest is in the field of VLSI devices for wireless communication and biomedical applications. He can be contacted at email: arifsobhan.bhuiyan@xmu.edu.my.