Bincang Sains dan Teknologi (BST)
DOI: 10.56741/bst.v4i01.768

E-ISSN 2961-8746
P-ISSN 2961-8932

Graphical User Interface (GUI) For Face Detection Using Viola-Jones Algorithm

[1]Sabarudin Saputra*, [1]Muhammad Akbar, [2]Hamzarudin Hikmatiar
Corresponding Author: *sicoccinela@gmail.com
[1] Department of Information Technology, Tadulako University, Indonesia
[2] Department of Physics Education, Universitas Muhammadiyah Maumere, Indonesia

Article submitted:	Revised:	Accepted:
1 December 2024	3 January 2025	5 January 2025

Abstract

Face detection is an essential part of many applications, such as security systems, social networking platforms, and human-computer interaction. In order to detect human faces, this work investigates the application of the Viola-Jones algorithm in a graphical user interface (GUI) system created with Matlab. The Viola-Jones algorithm is a cutting-edge real-time face detection technique that uses AdaBoost learning to choose the most important features, Haar-like features, and an integral picture for quick feature computation. Fifteen randomly chosen photos from the internet with both single and numerous faces were used to test the system. The algorithm's efficacy in face detection is demonstrated by the results, which show an average accuracy of 89.86%. Nevertheless, other restrictions were noted, such as blocked faces, non-frontal facial angles, and subpar identification in dimly lit environments. These difficulties draw attention to how outside variables affect detection accuracy and point to possible areas for improvement, such using sophisticated preprocessing techniques or combining the algorithm with cutting-edge machine learning approaches. This study highlights the need for more research to increase the Viola-Jones algorithm's robustness in a variety of complicated circumstances while reaffirming its applicability.

Keywords: *Face Detection, Graphical User Interface, Matlab, Viola-Jones*

Introduction

Face detection is an essential part of many applications, such as social media platforms, security systems, and human-computer interfaces. In 2001, Paul Viola and Michael Jones developed the Viola-Jones algorithm, transforming face identification by offering a reliable, accurate, and real-time solution. This technique detects faces in photos with amazing speed and accuracy by using a machine learning approach that uses a cascade of classifiers trained with Haar-like features [1], [2]. The Viola-Jones algorithm is important not only because it is fundamental to face identification but also because it can be modified and enhanced to perform better in a variety of scenarios [3], [4].

The algorithm's architecture uses An integrated picture representation to process images rapidly, enabling speedy feature extraction. The AdaBoost learning algorithm complements this by choosing the most pertinent features from a big collection, hence improving the detection process [2], [5]. The Viola-Jones algorithm has become widely used in many applications due to its success, including surveillance systems, real-time video processing, and even mobile applications [4], [6]. In order to overcome the initial algorithm's shortcomings and broaden its scope, research is still being conducted to improve and develop it in response to the growing need for effective face detection [7], [8], [9].

The Viola-Jones algorithm has a large body of literature, which reflects its influence on computer vision. Its integration with other methods to increase detection speed and accuracy has been the subject of numerous studies. In order to increase performance in complex backdrops and different lighting circumstances, Maghraby et al. [7] presented a hybrid face detection system that integrates skin color detection with the Viola-Jones approach. This method emphasizes how crucial preprocessing methods are to raising the Viola-Jones algorithm's efficacy.

Kirana et al. [10] highlighted the method's adaptability in other scenarios beyond face detection by contrasting the original Viola-Jones approach with a Fisher Face-based variation for emotion recognition. According to their research, while the original algorithm works well for face detection in general, adjustments can produce superior results for certain uses, like emotion recognition. This flexibility is a common theme in the literature, with numerous academics suggesting improvements that take advantage of the Viola-Jones algorithm's fundamental ideas while resolving its drawbacks [3], [9].

Cho et al. [11] have also investigated the algorithm's hardware implementation, discussing how hardware optimization might speed up multi-view face identification. The algorithm's potential for real-time applications is highlighted by this study, especially in settings with constrained computational resources. Irgens et al.'s demonstration of the Viola-Jones algorithm's effective implementation on hardware platforms, including FPGAs, further confirms its applicability in real-world scenarios. Apart from hardware implementations, a number of studies have concentrated on enhancing the algorithm's resilience to changes in environmental factors and face orientation. As an illustration of the algorithm's versatility in various contexts, Oualla [12] presented a technique for identifying rotated faces by extending Haar-like features. In a similar vein, Dergachov et al. [5] stressed the value of adaptive algorithms in improving face detection systems' efficacy, especially in dynamic contexts.

Based on the description above, this study will discuss how an example of the implementation of the Viola-Jones algorithm in a graphical user interface (GUI) using Matlab. This study supports various previous findings and is tested on a system developed through Matlab. The purpose of this study is to provide an overview of how a face can be detected and how its weaknesses are in certain parts.

Material and Methods

The attentional cascade, the feature selection by Adaboost, and the integral image make up the core structure of the Viola-Jones method. The integral image makes it easier to quickly calculate Haar-like features, which are crucial for differentiating between non-facial and face parts in an image. Adaboost is used to pick the best features from a big collection, which greatly improves algorithm performance by concentrating on the most informative characteristics [13], [14]. The attentional cascade streamlines the detection process by arranging classifiers in a sequential fashion. Each stage is in charge of rejecting a sizable portion of negative samples, which makes it easier to detect faces under different circumstances [13], [15].

E-ISSN 2961-8746
P-ISSN 2961-8932

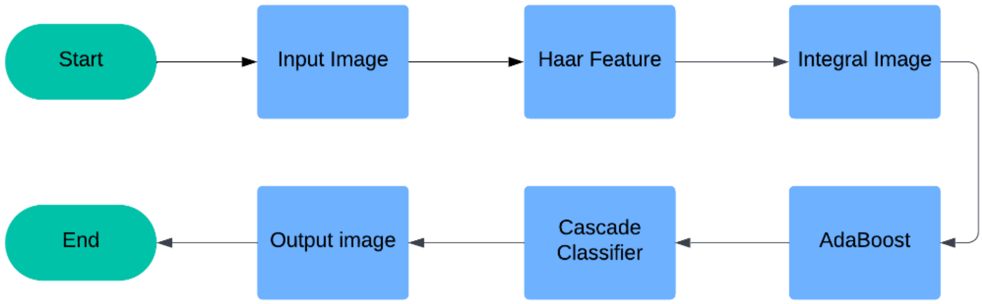


Fig. 1. Face detection process

Fig. 1 shows the face detection process using the Viola-Jones algorithm. This process utilizes Matlab by creating a graphical user interface (GUI) in Matlab. Then it can be explained that the Viola Jones algorithm utilizes images, Haar features, integral image, AdaBoost, and Cascade classifier. The image can be interpreted as a two-dimensional function $f(x, y)$, where x and y are coordinates and the function value f is the result of combining the coordinates (x, y). If f, x, y have vulnerabilities, then the image is a digital image (digital image). Images consist of elements, each of which has a location and a value called a pixel [16].

Image classification based on the value of a feature is carried out on the grounds that using features has a faster processing time than using pixels. There are 4 main processes in the Viola Jones algorithm, the first is the Haar Like Feature. This process uses 4 rectangles with 2 segmentations between the white and black segments [16] as in Fig. 2.

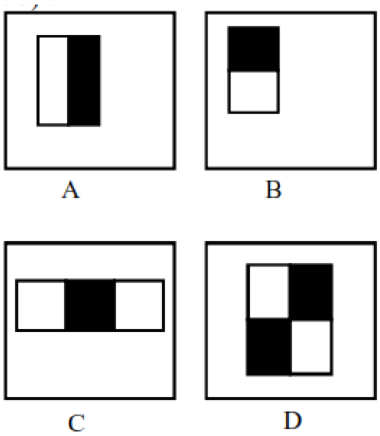


Fig. 2. Haar-like feature

Two rectangles with vertical and horizontal segmentation comprise features A and B, three rectangles with vertical segmentation and a black pixel in the center comprise feature C, and four rectangles with vertical and horizontal segmentation make up feature D, as seen in Figure 2. By subtracting the number of pixels in the black area from the number of pixels in the white area, one may determine the final value of this feature. The Viola-Jones algorithm uses Integral Image to expedite the computation process.

DOI: 10.56741/bst.v4i01.768
E-ISSN 2961-8746
P-ISSN 2961-8932

An integral image is the result of summing the values of the pixels from the top left to the desired point $f(x,y)$. Fig. 3a below illustrates how Integral Image is implemented.

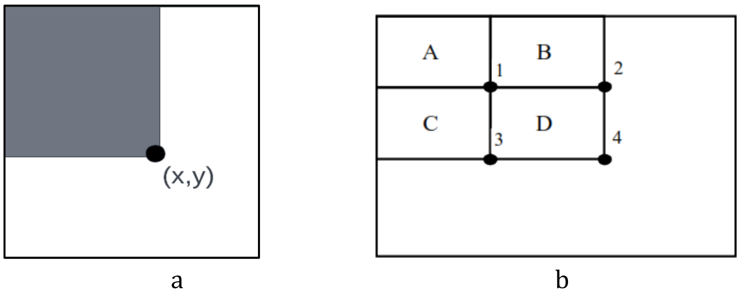


Fig. 3. a) $f(x,y)$ integral image, b) Calculate the features values

After that, the shaded region or subimage area's average pixel is computed. The computation of the integral picture in one of the shaded regions is shown in Fig. 3b. Using equation 1, the integral image's purpose is to determine the pixel values of multiple additional rectangles [16].

$$D = (A + B + C + D) - (A + B) - (A + C) + A \quad (1)$$

Viola Jones then use a technique known as AdaBoost Learning to choose particular facial features that will serve as the foundation for computations for determining threshold values. The aim assigned to AdaBoost is to combine multiple weak classifiers into a single, powerful classifier. When the classifier's filter simply receives fewer positive responses, it is said to be a weak classifier. A stronger classifier will be produced by connecting all of the weak classifiers into one. In order to create a powerful classifier, Adaboost Learning combines a number of weak classifiers and gives each one weight. As seen in Fig. 4, AdaBoost is also run more than once to determine whether the classifier is actually a strong classifier [16].

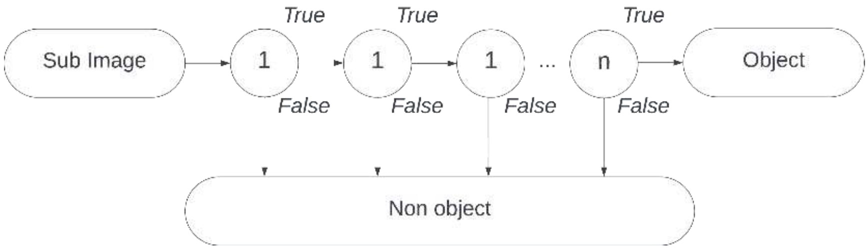


Fig. 4. Adaboost learning

Results and Discussions

The results of this research show the development of a GUI system using Matlab to detect human faces and the results of trials on several random images taken on the Internet. The GUI display for face detection is shown in Fig. 5.

DOI: 10.56741/bst.v4i01.768
E-ISSN 2961-8746
P-ISSN 2961-8932

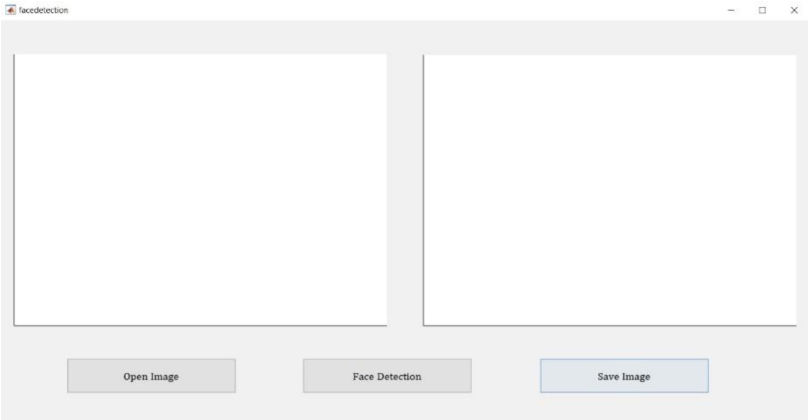


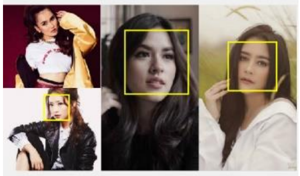
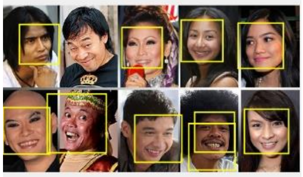
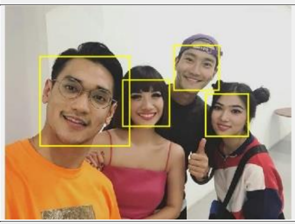
Fig. 5. GUI face detection system

Testing was carried out using 15 examples of images with many faces taken from the internet randomly. Testing will produce data on the number of images in which faces were detected correctly, the number of faces that were not detected and the number of detection errors that were not faces but were assumed by the algorithm to be faces.

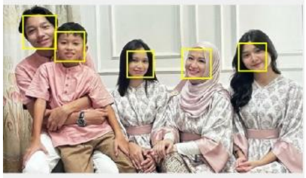
Table 1. Testing Result for 15 images

No	Image	Number of faces	Face detected	Face not detected	Percentage (%)
1		1	1	0	100
2		2	2	0	100
3		4	4	0	100
4		4	3	1	75

DOI: 10.56741/bst.v4i01.768
E-ISSN 2961-8746
P-ISSN 2961-8932

No	Image	Number of faces	Face detected	Face not detected	Percentage (%)
5		4	3	1	75
6		18	16	2	88.89
7		10	9	1	90
8		4	4	0	100
9		14	12	2	85.71
10		4	3	1	75
11		11	11	0	100
12		15	11	4	73.33

DOI: 10.56741/bst.v4i01.768
P-ISSN 2961-8932

No	Image	Number of faces	Face detected	Face not detected	Percentage (%)
13		20	17	3	85
14		4	4	0	100
15		5	5	0	100
	Average				**89.86**

Based on the results displayed in Table 1, it can be stated that the results of face detection using the Matlab GUI system based on the Viola-Jones algorithm are that the system can detect single and/or multiple faces facial images with an average accuracy value of 89.86%. Some faces were not optimally detected in images 4, 5, 6, 7, 9, 10, 12, and 13. Overall, there are several reasons why face detection in images is less than optimal, namely the lighting on the faces as shown in image 6; facial orientation factors as in images 5, 7, 9; the face does not look frontal like in images 4, 10; and finally, part or all of the face is covered as in images 12 and 13.

The accuracy of this investigation, which was 89.86%, indicates that the face detection process is significantly impacted by the implementation of AdaBoost learning. This is consistent with Yang et al.'s research [2], which uses AdaBoost learning to help choose the most pertinent face architecture traits. According to earlier studies, the lighting in image 6 has a significant impact on the face detection findings [7]. In this work [7], optimization was done to maximize skin color identification in order to get beyond the image's illumination limitations. According to research by Cho et al. [11], the results of face detection in images 12 and 13 demonstrate how the large number of faces in the image also affects the face detection process. Regarding the impact of face orientation on face detection in photos, as demonstrated by the findings of face detection in images 4, 5, 7, 9, and 10, this study is consistent with research by Oualla [12].

Conclusion

Using the Viola-Jones algorithm in Matlab, this study creates a graphical user interface (GUI) system for face detection and evaluates its functionality on fifteen randomly selected online images. According to the test findings, the system has an average accuracy level of 89.86% in detecting both single and multiple faces. However, there are a number of reasons why detection isn't always the best in some images, including bad lighting (like in image 6), a non-frontal face position (like in images 5, 7, 9, and 10), and partially or completely obscured faces (like in images 12 and 13). This demonstrates that even if the Viola-Jones method works quite well, outside influences might have an impact on the detection accuracy. Algorithm development or images preparation optimization are two possible directions for this research. In addition, its performance in face detection may be observed by combining it with different machine learning techniques. The development of application-based systems and the implementation of detection systems into several fields such as education, disaster, health, and security can be recommended for the sustainability of this research. The development of a more dynamic detection system for facial emotion analysis can also be a suggestion for future research. In general, the process of face detection in images needs optimization in terms of accuracy and efficiency and can be considered to be developed into a dynamic and real-time system.

References

[1] M. Da'san, A. Alqudah, and O. Debeir, "Face detection using Viola and Jones method and neural networks," in *2015 International Conference on Information and Communication Technology Research (ICTRC)*, IEEE, May 2015, pp. 40–43. doi: 10.1109/ICTRC.2015.7156416.

[2] Bin Yang, J. Yan, Z. Lei, and S. Z. Li, "Aggregate channel features for multi-view face detection," in *IEEE International Joint Conference on Biometrics*, IEEE, Sep. 2014, pp. 1–8. doi: 10.1109/BTAS.2014.6996284.

[3] M. Afifi, M. Nasser, M. Korashy, K. Rohde, and A. A. Mohamed, "Can we boost the power of the Viola–Jones face detector using preprocessing? An empirical study," *J Electron Imaging*, vol. 27, no. 04, p. 1, Jul. 2018, doi: 10.1117/1.JEI.27.4.043020.

[4] L.-B. Zhou, H. Wang, W. Mou, and Z.-C. Hu, "Robust face detection and tracking under natural conditions," in *2013 IEEE International Conference on Robotics and Biomimetics (ROBIO)*, IEEE, Dec. 2013, pp. 934–939. doi: 10.1109/ROBIO.2013.6739582.

[5] K. Dergachov, L. Krasnov, O. Cheliadin, and A. Zymovin, "Adaptive Algorithms Of Face Detection And Effectiveness Assessment Of Their Use," *Advanced Information Systems*, vol. 2, no. 3, pp. 10–18, Nov. 2018, doi: 10.20998/2522-9052.2018.3.02.

[6] J. Efendi, M. I. Zul, and W. Yunanto, "Real Time Face Recognition using Eigenface and Viola-Jones Face Detector," *JOIV : International Journal on Informatics Visualization*, vol. 1, no. 1, pp. 16–22, Mar. 2017, doi: 10.30630/joiv.1.1.15.

[7] A. ElMaghraby, M. Abdalla, O. Enany, and M. Y. El Nahas, "Hybrid Face Detection System using Combination of Viola - Jones Method and Skin Detection," *Int J Comput Appl*, vol. 71, no. 6, pp. 15–22, Jun. 2013, doi: 10.5120/12361-8681.

[8] N. A. C. Andryani, "Study of Viola Jones Face Detection on Color Image based on Skin Pigmentation Level," *Jurnal Elektro dan Mesin Terapan*, vol. 1, no. 1, pp. 44–52, May 2015, doi: 10.35143/elementer.v1i1.16.

[9] V. Mutneja and S. Singh, "Modified Viola–Jones algorithm with GPU accelerated training and parallelized skin color filtering-based face detection," *J Real Time Image Process*, vol. 16, no. 5, pp. 1573–1593, Oct. 2019, doi: 10.1007/s11554-017-0667-6.

[10] K. C. Kirana, S. Wibawanto, and H. W. Herwanto, "Emotion Recognition using Fisher Face-based Viola-Jones Algorithm," in *2018 5th International Conference on Electrical Engineering, Computer Science and Informatics (EECSI)*, IEEE, Oct. 2018, pp. 173–177. doi: 10.1109/EECSI.2018.8752783.

[11] P. Irgens, C. Bader, T. Lé, D. Saxena, and C. Ababei, "An efficient and cost effective FPGA based implementation of the Viola-Jones face detection algorithm," *HardwareX*, vol. 1, pp. 68–75, Apr. 2017, doi: 10.1016/j.ohx.2017.03.002.

[12] M. OUALLA, "The Fast Integration of a Rotated Haar-Like Feature for Face Detection," *International Journal of Advanced Trends in Computer Science and Engineering*, vol. 9, no. 3, pp. 4055–4062, Jun. 2020, doi: 10.30534/ijatcse/2020/232932020.

DOI: 10.56741/bst.v4i01.768

E-ISSN 2961-8746
P-ISSN 2961-8932

[13] Y.-Q. Wang, "An Analysis of the Viola-Jones Face Detection Algorithm," *Image Processing On Line*, vol. 4, pp. 128–148, Jun. 2014, doi: 10.5201/ipol.2014.104.

[14] V. V. Khryashchev, A. A. Lebedev, and A. L. Priorov, "Enhancement of Fast Face Detection Algorithm Based on A Cascade of Decision Trees," *The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences*, vol. XLII-2/W4, pp. 237–241, May 2017, doi: 10.5194/isprs-archives-XLII-2-W4-237-2017.

[15] D. M. Abdulhussien and L. J. Saud, "evaluation study of face detection by Viola-Jones algorithm," *Int J Health Sci (Qassim)*, pp. 4174–4182, Sep. 2022, doi: 10.53730/ijhs.v6nS8.13127.

[16] Mahmudi, M. Fatahillah, and Kusrini, "Implementasi Metode Viola Jones untuk Mendeteksi Wajah Manusia," vol. 5, pp. 2442–7942, 2019.

Authors

Sabarudin Saputra is a dedicated lecturer in the Informatics Engineering Program under the Department of Information Technology at Tadulako University, Indonesia. With a strong passion for advancing technology, his research primarily focuses on image processing and computer vision, areas that play a crucial role in developing innovative solutions across various industries. Through his academic contributions, he aims to enhance understanding and applications of these technologies, fostering growth in the field. Committed to both teaching and research, he strives to inspire and empower students to explore the vast potential of information technology. (email: sicoccinela@gmail.com).

Muhammad Akbar is a lecturer in the Informatics Engineering Program at the Department of Information Technology, Tadulako University, Indonesia. His research interests focus on embedded systems, networking, and the Internet of Things (IoT), where he explores innovative solutions to modern technological challenges. With a strong commitment to academic excellence, he actively contributes to the advancement of these fields through research, teaching, and collaborative projects. His work aims to bridge theoretical knowledge with practical applications, benefiting both academia and industry. Dedicated to fostering student growth, he inspires future professionals in technology. (email: akbar.stmikhdy@gmail.com).

Hamzarudin Hikmatiar is a lecturer at Universitas Muhammadiyah Maumere, where he plays a vital role in advancing knowledge and education. In addition to his teaching responsibilities, he is an active member of the Center for Astronomy Studies, contributing to the exploration and understanding of astronomical phenomena. His dedication to both academia and research reflects his commitment to fostering curiosity and innovation among students and colleagues. By combining his expertise in teaching with his passion for astronomy, he aims to inspire others to explore the wonders of science. (email: hamzarudinhikmatiar90@gmail.com).