9 (2) July 2023 1-8 ISSN 2502-3357 (online) | ISSN 2503-0477 (print)
Register: *Jurnal Ilmiah Teknologi Sistem Informasi*

Contents lists available at www.journal.unipdu.ac.id

Register

Journal Page is available to www.journal.unipdu.ac.id/index.php/register

Research article

Facemask Detection using the YOLO-v5 Algorithm: Assessing Dataset Variation and Resolutions

Fachrul Kurniawan [a,*], *I Nyoman Gede Arya Astawa* [b], *I Wayan Budi Sentana* [c], *I Made Ari Dwi Suta Atmaja* [d], *Aji Prasetya Wibawa* [e]

[a] *Department of Informatics Engineering, Universitas Islam Negeri Maulana Malik Ibrahim Malang, Jl. Gajayana No.50 Lowokwaru, Malang, 65144, Indonesia*
[b,c] *Department of Electrical Engineering, Politeknik Negeri Bali, Jl. Raya Uluwatu No. 45 Jimbaran, Badung, 80364, Indonesia*
[d] *Department of Computing, Macquarie University, Balaclava Rd, Macquarie Park NSW 2109, Sydney, Australia*
[e] *Department of Electrical Engineering, Universitas Negeri Malang, Jl. Semarang 5, Malang, 65145, Indonesia.*
email: [a*] fachrulk@ti.uin-malang.ac.id, [b] arya_kng@pnb.ac.id, [c] i-wayan-budi.sentana@hdr.mq.edu.au, [d] arisuta@pnb.ac.id, [e] aji.prasetya.ft@um.ac.id
* *Correspondence*

ARTICLE INFO

Article history:
Received 29 December 2022
Revised 30 January 2023
Accepted 4 July 2023
Available online 28 July 2023

Keywords:
Face Detection;
Mask;
Dataset;
YOLO-v5;

Please cite this article in IEEE style as:
F. Kurniawan, I. N. G. A. Astawa, I. W. B. Sentana, I. M. A. D. S. Atmaja, and A. P. Wibawa, "Facemask Detection using the YOLO-v5 Algorithm: Assessing Dataset Variation and Resolutions," *Register: Jurnal Ilmiah Teknologi Sistem Informasi*, vol. 9, no. 2, pp. 1-8, 2023.

ABSTRACT

The Covid-19 pandemic has made it imperative to prioritize health standards in companies and public areas with a large number of people. Typically, officers oversee the usage of masks in public spaces; however, computer vision can be employed to facilitate this process. This study focuses on the detection of facemask usage utilizing the YOLO-v5 algorithm across various datasets and resolutions. Three datasets were employed: the face with mask dataset (M dataset), the synthetic dataset (S dataset), and the combined dataset (G dataset), with image resolutions of 320 pixels and 640 pixels, respectively. The objective of this study is to assess the accuracy of the YOLO-v5 algorithm in detecting whether an individual is wearing a mask or not. In addition, the algorithm was tested on a dataset comprising individuals wearing masks and a synthetic dataset. The training results indicate that higher resolutions lead to longer training times, but yield excellent prediction outcomes. The system test results demonstrate that face image detection using the YOLO-v5 method performs exceptionally well at a resolution of 640 pixels, achieving a detection rate of 99.2 percent for the G dataset, 98.5 percent for the S dataset, and 98.9 percent for the M dataset. These test results provide evidence that the YOLO-v5 algorithm is highly recommended for accurate detection of facemask usage.

1. Introduction

As a consequence of the Covid-19 outbreak, wearing masks has become mandatory [1]. Given the extensive range of community interactions, companies and public venues employing a large number of people must prioritize health procedures [2, 3]. This requirement extends to the supervision of mask usage in public spaces. However, relying solely on manual supervision, such as deploying officers in airports or shopping centers to monitor mask-wearing compliance, proves to be inefficient and increases the risk of virus transmission. Therefore, it is crucial to conduct research on face detection while individuals are wearing masks. Computer vision offers a viable solution by enabling surveillance technology, particularly object detection [4, 5].

The utilization of computer vision has witnessed substantial growth in recent years, leading to the development of advanced applications and automation systems capable of real-time object detection, distinction, and localization in images and videos [4, 6, 7]. Detection, unlike classification, is a more intricate process. While classification can identify objects in an image, it fails to determine their precise location within the image [8]. Moreover, in scenarios where an image contains multiple objects

ISSN 2502-3357 (online) | ISSN 2503-0477 (print)
9 (1) July 2023 1-8

[9], the combination of feature extraction methods and a classifier for face detection may not yield optimal results [10].

Researchers have extensively explored real-time object detection, particularly face detection, in public settings [11-13]. Various methods have been employed, including the Viola-Jones method [11], Holistic Matching Methods [14], Local Binary Pattern [13], CNN [1], and others. Several face detection methods rely on features such as eyes, nose, and mouth [15, 16]. However, recognizing faces entails overcoming numerous challenges [3, 17, 18], such as variations in lighting, face position, noise, and other factors. The difficulty increases when individuals wear accessories like masks [1, 7]. Deep learning-based approaches have been employed in investigations to detect faces while individuals are wearing masks. For example, researchers [5] utilized the YOLO-v5 method with datasets from the AIZOOTe team's FaceMaskDetection. In another study, researchers [19] employed the YOLO-v3 approach with a faster R-CNN to achieve improved results in face detection with masks. Additionally, researchers [19] combined the YOLO-v3, DBSCAN, DFSD, and MobileNetv2 algorithms to detect individuals wearing masks on their faces. The choice of method is crucial for effective face detection with masks [20], and acquiring datasets for training poses a challenge [21] as face datasets with masks are not widely available.

This study presents a face detection method using the YOLO-v5 algorithm to address the challenge of mask detection. The unified model created by this deep learning approach enhances efficiency by providing a bounding box that represents the recognized face and a corresponding label indicating mask usage. What sets this research apart is the utilization of generated datasets. By generating synthetic datasets that transition from unmasked faces to masked faces, the system can effectively identify the presence of masks. To evaluate the system's accuracy, three distinct datasets will be tested: the face dataset with masks (M dataset), the synthetic dataset (S dataset), and the combined dataset (G dataset), each at different resolutions. Computer vision researchers will find the proposed synthetic dataset in this study particularly valuable. The primary objective of this research is to assess the accuracy of the YOLO-v5 algorithm in detecting mask usage. Additionally, the algorithm was tested on datasets comprising individuals wearing masks, as well as synthetic datasets.

2. Materials and Methods

Typically, a detection system utilizes a classifier or localizer to detect objects by applying the model at various locations and scales within an image [22]. The YOLO method, however, takes a distinct approach by applying a single neural network to the entire image [23]. This approach involves dividing the image into regions, predicting bounding boxes and probabilities. Each bounding box provides a prediction of object classification, allowing for identification of objects within the image. The highest probability within a bounding box is selected as the object separator, while the lowest value is disregarded. With its straightforward architecture and convolutional layers, the YOLO algorithm achieves real-time object detection. It is a powerful neural network for real-time object detection [19]. The YOLO algorithm was developed by Redmon et al. [24], who claims that it can achieve high accuracy and reliable prediction results.

The YOLO algorithm can accurately predict objects by providing bounding boxes for images [25]. It operates by labeling each grid in the image and applying image classification and object localization algorithms to these labeled grids, as described earlier. This algorithm analyzes each grid independently, marking labels that contain objects and bounding boxes within each grid. The R-CNN and YOLO algorithms share similar characteristics. Utilizing convolutional features [24], each grid cell generates a hypothetical bounding box and scores it based on the proposal. In Blaschko and Lampert's study, the bounding box approach (Bounding) is employed for object localization to overcome the limitations of the sliding window method [26]. The sliding window method is based on the CNN approach, which involves partitioning the image into windows of the same size, resulting in multiple cut areas containing various objects, classes, and object bounding boxes [19]. These objects are then combined to form a unified object. CNNs play a crucial role in pattern recognition related to computer vision due to their improved spatial feature extraction capabilities and cost-effective processing [1]. CNNs have made significant advancements in facial recognition technology by leveraging feature learning and transformation invariant components.

ISSN 2502-3357 (online) | ISSN 2503-0477 (print)
9 (2) July 2023 1-8

Numerous studies propose innovative approaches for detecting faces obscured by masks, with most of them treating the problem as a binary classification task using a simple CNN algorithm. However, when it comes to face detection while wearing masks, it requires employing an object detection model to identify a large number of individuals and provide bounding boxes. These bounding boxes are then assigned a specific color based on whether the person is wearing a mask or not, allowing for an analysis of the mask-wearing ratio using the YOLO-v5 method. The YOLO-v5 algorithm, an evolution of YOLO-v4.5, is adopted as the object recognition algorithm due to its impressive speed of 140 frames per second [5]. YOLO-v5 effectively handles the challenge of detecting faces at different scales, although it may struggle with smaller objects. This capability alleviates the difficulties associated with varying face sizes and improves overall face detection performance.

Several studies have focused on masked face detection using the YOLO-v5 algorithm. For instance, Kannan et al. [27] has successfully detected and differentiated between masked and non-masked individuals under complex environmental conditions using the YOLO-v5 algorithm. Shetty et al. [28] developed a model that accurately recognizes people with or without masks and also determines whether the mask properly covers the nose and mouth. Additionally, Fauzi et al. [29] created the YOLO-v5s model, achieving a high accuracy of 90.37% in identifying mask usage. Based on these studies' outcomes, the YOLO-v5 algorithm proves effective in detecting masked and non-masked faces, and its performance has been evaluated on various datasets.

In this paper, the methodology involves a concise three-step approach. The first step is dataset creation, followed by model training in the second step, and finally, testing the trained model in the last step. To accomplish this, NumPy, PyTorch, and OpenCV were utilized as tools in this study.

2.1. Dataset Preparation Process

The dataset utilized in this study consists of three components: the M dataset, the S dataset, and the G dataset. The M dataset comprises face images of individuals wearing masks and was obtained from Larxel [30]. The S dataset is a synthetic dataset and the G dataset is a combined dataset. The synthetic dataset was created by employing a machine learning algorithm to generate face images wearing masks from a collection of face images without masks. The process of generating the synthetic dataset is depicted in Figure 1, where face images without masks were captured using a smartphone camera.

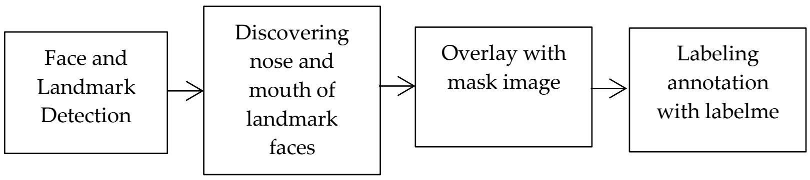

Fig. 1. Dataset Synthesizing Process

Figure 1 illustrates the step-by-step process involved in creating a synthetic dataset. The process begins by preparing a face image without a mask, followed by face and landmark detection. The next objective is to accurately determine the positioning of the nose, mouth, and chin relative to the detected facial landmarks. Subsequently, the face image is overlaid with the mask's picture, but this can only be achieved if the face is captured in a frontal orientation facing the camera. Lastly, the annotation process, in which a label for an image is produced, is performed using the labelme program, resulting in data in the form of xml files that include bounding boxes and corresponding labels. Figure 2 below showcases the annotation process, which involves assigning labels to images by specifying bounding boxes and class names for the objects present in the image.

http://doi.org/10.26594/register.v9i2.3249

ISSN 2502-3357 (online) | ISSN 2503-0477 (print)
9 (1) July 2023 1-8

Fig. 2. The application of a mask to a face image

Figure 2 illustrates the difference between two images based on the presence or absence of a mask, showcasing the left column without a mask and the right column with a mask. These results emphasize the importance of testing and evaluating the accuracy of mask detection, along with its suitability for various scenarios [20]. The YOLO-v5 method is an advanced algorithm known for its effectiveness in object detection [27], making it highly suitable for detecting masked faces in public spaces as a preventive measure against the spread of COVID-19 [31].

2.2. Training

The training process is presented in Figure 3. Three datasets were utilized for this study. The face image dataset consisted of 853 images depicting faces with masks. The synthetic dataset comprised 262 facial photos, and the merged dataset contained 1,115 photos in total. Each dataset was supplemented with 192 additional face photos without masks. Prior to training, the image dataset was divided into two folders: one for the training set and the other for the validation set, with an 80% and 20% split, respectively. The face images with masks were converted to Darknet format, as were the images without masks. The labeling of the face images involved assigning symbol 0 to indicate faces wearing masks and symbol 1 for faces without masks. The YOLO-v5 algorithm was employed for training. Consequently, a comprehensive database of faces wearing and not wearing masks was created through this training process.

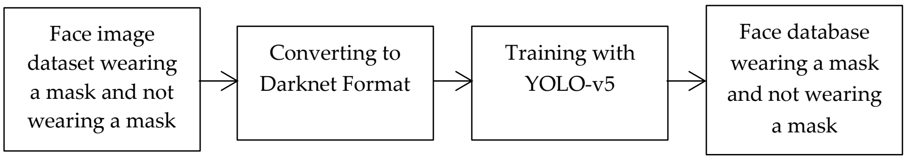

Fig. 3. The training process using YOLO-v5

The training process in this study was carried out using OpenCV (Open Source Computer Vision Library) and NumPy. Each dataset and pixel were trained separately, resulting in the creation of three databases: M, S, and G.

2.3. Testing

In this study, tests were conducted to develop a system using the PyTorch tool and then its performance was evaluated on multiple databases. The objective was to determine face detection while wearing masks. To achieve this, the study proposed a face detection procedure utilizing two models. The first model was designed to detect faces in the image, while the second model assessed the presence or

 http://doi.org/10.26594/register.v9i2.3249

ISSN 2502-3357 (online) | ISSN 2503-0477 (print)
9 (2) July 2023 1-8

absence of masks within the discovered bounding boxes. The evaluation involved analyzing various facial photos, both with and without masks.

3. Results and Discussion

Following the training procedure depicted in Figure 3, computational training was conducted on each dataset using a GPU with the YOLO-v5 algorithm on the Google Colab server. The training utilized pre-trained weight values with epoch 30, batch size 16, and a threshold ranging from 0.5 to 0.95. The images were trained at resolutions of 320 pixels and 640 pixels, and the outcomes are presented in Table 1.

Table 1. Training outcomes for the three datasets

No	Dataset Type	Number of face images wearing masks (pieces)	Image resolution (pixel)	Training time (hour)	mAP@ 0.5	mAP@ 0.5:.95	Prediction
1	Dataset M	853	320	0.080	0.583	0.343	0.9
2	Dataset M	853	640	0.145	0.613	0.389	0.932
3	Dataset S	262	320	0.126	0.986	0.625	0.955
4	Dataset S	262	640	0.204	0.986	0.694	0.964
5	Dataset G	1115	320	0.104	0.604	0.392	0.929
6	Dataset G	1115	640	0.275	0.634	0.44	0.965

Table 1 provides a summary of the training outcomes for the three datasets. It can be observed that training with higher-resolution images takes a longer time. The prediction value shows fairly good results, as evidenced by the accuracy of the predictions across various datasets and resolutions, which indicates good performance. The prediction value represents the ratio of true positive predictions to the overall positive projections, which is a significant measure of prediction performance. The mean Average Precision (mAP), an evaluation parameter for object detection, is calculated as the average value of Average Precision (AP). The obtained mAP values with a threshold of 0.5 to 0.95 are quite good. Increasing the threshold leads to a reduction in false positives. However, setting the threshold too high may result in missed detections and lower confidence in correct predictions. The assessment ratings obtained during the training process indicate highly precise and successful training. These training results align with a previous study by Larxel [30] that highlights the influence of image resolution on training time and predictions. It is also observed that Google Colab is a favorable platform for training with large datasets and achieving fast results. Furthermore, the mAP value is strongly dependent on the chosen threshold. Therefore, the analysis confirms that mAP can serve as an effective evaluation parameter for assessing object detection performance [32].

3.1. System testing results

Following the successful training, the developed system was tested using the training result database. The implementation of the system focuses on detecting face images. Once a face is recognized, the system generates a new image displaying a bounding box around the detected face. Additionally, a file is provided that includes the coordinates of the bounding box along with the estimated probability of the face wearing or not wearing a mask.

The testing phase involves evaluating the system's performance on single or multiple faces in public places. Figure 4 illustrates the results obtained from the testing process, showcasing the outcomes of the system's detection capabilities. As depicted in Figure 4, the system constructed with YOLO-v5 demonstrates accurate prediction of faces wearing masks and faces without masks. The utilization of the YOLO-v5 approach yields excellent results for face detection with masks, as the trained object detector effectively detects the bounding box and associated label. The bounding box visually represents the recognized faces, while the label indicates whether the individual is wearing a mask or not. The system is designed to perform real-time testing on both 2D images and videos. The test results reveal precise face detection within bounding boxes, accompanied by probability information. In this study, the system was evaluated using a test dataset consisting of 475 face images, encompassing both masked and unmasked faces. The findings of this research align with Kannan et al.'s study [27], highlighting the YOLO method's proficiency in object detection and probability estimation. Consequently, the results of this analysis establish that the utilization of the YOLO method in this study is highly suitable for detecting whether a face is wearing a mask or not [30].

ISSN 2502-3357 (online) | ISSN 2503-0477 (print)
9 (1) July 2023 1-8

Fig. 4. Training System test results with predictive probabilities

Table 2. The results of face detection wearing masks on different datasets and resolutions

Dataset Type	Image resolution (pixel)	Detection results
Dataset M	320	97,8%
Dataset M	640	98,9%
Dataset S	320	97,4%
Dataset S	640	98,5%
Dataset G	320	98,2%
Dataset G	640	99,2%

Table 2 showcases the test results, revealing an impressive average accuracy of 98.3 percent across various datasets and resolutions. Notably, the G dataset demonstrates the highest efficacy in detecting masked faces. The YOLO-v5 algorithm, employed in this study for face detection with masks across different datasets, proves to be highly recommended based on the test results. These findings align with the research conducted by Javed et al. [31], affirming the YOLO-v5 method's remarkable accuracy in detecting masked faces.

With such accurate results, this method holds great potential in aiding the prevention of virus and germ transmission by enabling anticipation and monitoring of the presence or absence of face masks in public areas.

4. Conclusion

This study focuses on face detection when individuals are wearing masks, accomplished through the analysis of various datasets: a dataset of faces wearing masks (dataset M), synthetic datasets (dataset S), and combined datasets (dataset G). The research has yielded three significant findings. Firstly, it has been observed that time and prediction performance are strongly influenced by image resolution. The system was developed using the YOLO-v5 algorithm, and tests were conducted on multi-face photos encompassing diverse datasets and resolutions. The highest detection rates were achieved at a resolution of 640 pixels, with dataset M achieving 98.9 percent accuracy, dataset S achieving 98.5 percent accuracy, and dataset G achieving 99.2 percent accuracy. Secondly, the YOLO-v5 method has demonstrated remarkable capabilities in object detection and probability estimation. The average face detection rate when wearing masks reached 98.3 percent. Thirdly, the YOLO-v5 method showcased consistent accuracy across various datasets, reaffirming its effectiveness. As a result of these consistent findings, our recommendations for face detection while wearing masks are applicable to all datasets studied. The test results strongly advocate for the utilization of the YOLO-v5 algorithm as a highly recommended approach for detecting faces using masks. While this research significantly contributes to the accuracy of mask-based face detection, it also has limitations. Future investigations should explore real-time masked face detection and consider the incorporation of facial temperature detection as an additional component.

References

[1] Oumina, A., N.E. Makhfi, and M. Hamdi, "Control The COVID-19 Pandemic: Face Mask Detection Using Transfer Learning". in *2020 IEEE 2nd International Conference on Electronics, Control, Optimization and Computer Science (ICECOCS)*. 2020.

[2] Donthu, N. and A. Gustafsson, "Effects of COVID-19 on business and research". *Journal of business research*, 2020. 117: p. 284-289.

[3] Charoenpong, T., C. Nuthong, and U. Watchareeruetai, "A new method for occluded face detection from single viewpoint of head". in *2014 11th International Conference on Electrical Engineering/Electronics, Computer, Telecommunications and Information Technology (ECTI-CON)*. 2014.

[4] Khan, A.I. and S. Al-Habsi, "Machine Learning in Computer Vision". *Procedia Computer Science*, 2020. 167: p. 1444-1451.

[5] Yang, G., et al., "Face Mask Recognition System with YOLOV5 Based on Image Recognition". in *2020 IEEE 6th International Conference on Computer and Communications (ICCC)*. 2020.

[6] Neethu, N. and B. Anoop, "Role of Computer Vision in Automatic Inspection Systems". *International Journal of Computer Applications*, 2015. 123: p. 28-31.

[7] Bhuiyan, M.R., S.A. Khushbu, and M.S. Islam, "A Deep Learning Based Assistive System to Classify COVID-19 Face Mask for Human Safety with YOLOv3". in *2020 11th International Conference on Computing, Communication and Networking Technologies (ICCCNT)*. 2020.

[8] Qiang, B., et al., "Convolutional Neural Networks-Based Object Detection Algorithm by Jointing Semantic Segmentation for Images". *Sensors*, 2020. 20(18): p. 5080.

[9] Murtaza, G., et al., "Deep learning-based breast cancer classification through medical imaging modalities: state of the art and research challenges". *Artificial Intelligence Review*, 2020. 53(3): p. 1655-1720.

[10] Cheng, W.-C., H.-C. Hsiao, and D.-W. Lee, "Face recognition system with feature normalization". *International Journal of Applied Science and Engineering*, 2021. 18(1): p. 1-9.

[11] Mahdi, F.P., et al., "Face recognition-based real-time system for surveillance". *Intelligent Decision Technologies*, 2017. 11(1): p. 79-92.

[12] Hitoshi, I., "Video Face Recognition System Enabling Real-time Surveillance". *NEC Technical Journal*, 2016. 11(1): p. 36-39.

[13] Kranthikiran, B. and P. Pulicherla, "Face Detection and Recognition for use in Campus Surveillance". *International Journal of Innovative Technology and Exploring Engineering (IJITEE*, 2020. 9(3).

[14] Parmar, D.N. and B.B. Mehta, "Face Recognition Methods & Applications". *International Journal Computer and Applications*, 2013. 4(1): p. 84-86.

[15] Wang, L., H. Zhang, and Z. Wang, "Component based representation for face recognition". in *2015 12th IEEE International Conference on Electronic Measurement & Instruments (ICEMI)*. 2015.

[16] Singh, Y.K. and V. Hruaia, "Detecting face region in binary image". in *2015 IEEE Recent Advances in Intelligent Computational Systems (RAICS)*. 2015.

[17] Mekami, H. and S. Benabderrahmane, "Towards a new approach for real time face detection and normalization". in *2010 International Conference on Machine and Web Intelligence*. 2010.

[18] Khadatkar, A., R. Khedgaonkar, and K.S. Patnaik, "Occlusion invariant face recognition system". in *2016 World Conference on Futuristic Trends in Research and Innovation for Social Welfare (Startup Conclave)*. 2016.

[19] Srinivasan, S., et al., "COVID-19 Monitoring System using Social Distancing and Face Mask Detection on Surveillance video datasets". in *2021 International Conference on Emerging Smart Computing and Informatics (ESCI)*. 2021.

ISSN 2502-3357 (online) | ISSN 2503-0477 (print)
9 (1) July 2023 1-8

[20] Susanto, S., et al., "The Face Mask Detection For Preventing the Spread of COVID-19 at Politeknik Negeri Batam". in *2020 3rd International Conference on Applied Engineering (ICAE)*. 2020.

[21] Abbasi, S., H. Abdi, and A. Ahmadi, "A Face-Mask Detection Approach based on YOLO Applied for a New Collected Dataset". in *2021 26th International Computer Conference, Computer Society of Iran (CSICC)*. 2021.

[22] Sermanet;, P., et al., "OverFeat: Integrated Recognition, Localization and Detection using Convolutional Networks". *arXiv:1312.6229*, 2014. 4.

[23] Srivastava, S., et al., "Comparative analysis of deep learning image detection algorithms". *Journal of Big Data*, 2021. 8(1): p. 66.

[24] Redmon, J., et al., "You Only Look Once : Unified, Real-Time Object Detection", in *The IEEE Conference on Computer Vision and Pattern Recognition (CVPR),*2016. p. 779-788.

[25] Geethapriya. S, N. Duraimurugan, and S.P. Chokkalingam, "Real-Time Object Detection with Yolo". *International Journal of Engineering and Advanced Technology (IJEAT)*, 2019. 8(3S): p. 578-581.

[26] Blaschko, M.B. and C.H. Lampert, "Learning to Localize Objects with Structured Output Regression". in *Computer Vision – ECCV 2008*. 2008. *Berlin, Heidelberg*: Springer Berlin Heidelberg.

[27] Kannan, A., et al., "Face Mask Detection Using Yolo V5". *International Journal of Novel Research and Development (IJNRD)*, 2022. 7(5): p. 390-395.

[28] Shetty, R.U., et al., "Real Time Face Mask Detectionusing Yolov5 and OpenCv". *International Journal for Research in Applied Science & Engineering Technology (IJRASET)*, 2022. 10(VI): p. 1925-1931.

[29] Fauzi, A., et al., "Development of Health Mask Identification Using YOLOv5 Architecture". *International Journal Of Artificial Intelegence Research*, 2022. 6(1): p. 1-8.

[30] Larxel, A., "Face Mask Detection". 2020 [cited 2021 May 27]; Available from: https://www.kaggle.com/andrewmvd/face-mask-detection.

[31] Javed, I., et al., "Face mask detection and social distance monitoring system for COVID-19 pandemic". *Multimedia Tools and Applications*, 2023. 82(9): p. 14135-14152.

[32] Muhamad, M. and T. Wan Sen, "Real-Time Detection of Face Masked & Face Shield Using YOLO Algorithm with Pre-Trained Model and Darknet". *Indonesian Journal of Artificial Intelligence and Data Mining*, 2021. 4(2): p. 97-107.

 http://doi.org/10.26594/register.v9i2.3249