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A Face Mask Detection Method in the Era of the COVID-19 Pandemic Based on GLCM and YOLO

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Abstract:

In recent decades, the identification of faces with and without masks from visual data, such as video and still images, has become a captivating research subject. This is primarily due to the global spread of the Corona pandemic, which has altered the appearance of the world and necessitated the use of masks as a vital measure for epidemic prevention. Intellectual development based on artificial intelligence and computers plays a decisive role in the issue of epidemic safety, as the topic of facial recognition and identifying individuals who wear masks or not was most prominent in the introduction and in-depth education. This research proposes the creation of an advanced system capable of accurately identifying faces, both with and without masks. The suggested system incorporates a multi-layer neural network (CNN) and a gray-level co-occurrence matrix (GLCM). It also uses techniques for preparing and preprocessing data. These additions aim to enhance the efficiency and accuracy of the system's identification algorithm. The YOLO5 neural network algorithm was utilized in the post-processing phase, with the addition of a new layer consisting of six phases. We formed this layer by integrating two algorithms, GLCM and CNN. The algorithm has become effective for real-time object recognition. The obtained accuracy results showed that the proposed system successfully combined the face mask (0.975) and face datasets. (0.925).

Keywords: Face, Mask, Artificial Intelligence, Deep Learning, Face mask, co-occurrence matrix.

طريقة للكشف عن قناع الوجه في عصر جائحة كوفيد-19 استنادًا إلى GLCM و YOLO

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الخلاصة

كان تحديد الوجه الذي يرتدي قناعًا مقابل عدم ارتداء قناع من البيانات المرئية مثل الفيديو والصور الثابتة موضوعًا بحثيًا رائعًا في العقود الأخيرة بسبب انتشار جائحة كورونا التي غيرت مظهر العالم بأكمله وأجبرت الناس على ذلك ارتداء الأقنعة كوسيلة للوقاية من الأوبئة، والتي لعبت فيها دورًا حاسمًا. ويلعب التطوير الفكري المبني على الذكاء الاصطناعي وأجهزة الحاسوب دورا حاسما في مسألة السلامة من الوباء، حيث كان موضوع التعرف على الوجه وتحديد الأفراد الذين يرتدون الأقنعة أو لا يرتدونها، أبرز ما في المقدمة والتعليم المتعمق. يقترح في هذا البحث تطوير نظام ذكي للتعرف بشكل صحيح على الوجوه التي ترتدي قناعًا والوجوه التي لا ترتدي قناعًا. يعتمد النظام المقترح المطور على إعداد البيانات ومعالجتها مسبقا وإضافة شبكة عصبية متعددة الطبقات (CNN)ومصفوفة التواجد المشترك ذات المستوى الرمادي (GLCM) قبل استخراج خوارزمية الكشف لتحسين كفاءة ودقة النظام. في مرحلة ما بعد المعالجة، تم استعمال خوارزمية الشبكة العصبية YOLO5، والتي أضيفت إليها طبقة جديدة من ست مراحل تم إنشاؤها من دمج خوارزميتين (GLCM وCNN). أصبحت الخوارزمية فعالة للتعرف على الكائنات في الوقت الفعلي. أظهرت نتائج الدقة التي تم الحصول عليها أن النظام المقترح نجح في الجمع بين قناع الوجه (0.975) ومجموعات بيانات الوجه. (0.925).

1. Introduction

In December 2019, China declared a pandemic crisis called Corona Virus Infection Disease 2019 (COVID-19). The World Health Organization (WHO) proclaimed a global pandemic on 11 March, 2020, similar to the SARS-CoV-2 virus. Throughout history, humanity has experienced numerous pandemics, such as African obesity and flu pandemics. [1][2]. Humanity is currently facing a critical point in their battle against an imperceptible adversary, the coronavirus. The virus has spread to millions of individuals worldwide, resulting in a significant number of fatalities. In January 2020, a number of people in Wuhan City reported experiencing pneumonia with an unclear cause. The COVID-19 epidemic's rapid spread poses significant challenges to its control [3] [4]. With the alarming rise of the Corona virus infection disease, the world is searching for a way to stop its spread. New restrictions have emerged in daily life, such as quarantine, social isolation, wearing masks, constant hand washing, and determining the number of people in enclosed spaces. Government entities have enacted numerous biosafety regulations to reduce contamination [5] and [6]. Among them is the mandatory use of masks, as they have been demonstrated to protect people and those in their vicinity [7] [8]. As a result of its vital function in preventing infection with the coronavirus, the mask has become an indispensable component that individuals cannot do without. Are individuals permitted entry if they don a mask [9] [10]?

2. Problem Statement

The accurate detection of face masks in real-time is crucial for various applications, including access control, public safety, and healthcare. Existing methods often struggle with accuracy, particularly in challenging environments with varying lighting conditions, occlusions, and face poses. This study aims to develop a robust and accurate face mask detection system that addresses these limitations.

3. Related Work

Several studies have focused on face mask detection, particularly in response to the COVID-19 pandemic. These studies have explored various approaches, including:

- **Mall Access Control:** systems that utilize cameras to capture images and identify masked individuals, granting access based on mask detection [11].

- **Store Entry Recognition:** Systems that employ YOLOV5-based methods to recognize masked and unmasked faces, automate entry control, and reduce human intervention.
- **Multi-Scale Detection:** Algorithms like SSDv2 are designed to detect concealed and small targets wearing masks, enabling effective identification in diverse environments [12].
- **Face Detection and Classification:** Systems that combine face detection and mask categorization, leveraging efficient algorithms like MobileNetV11.0 for training.
- **Public Area Monitoring:** Systems that integrate mask detection with temperature monitoring for public safety, using predefined models to identify faces and facial features [13].
- **Lightweight and High-Performance Detection:** Systems based on YOLOv5, incorporating technologies like Shuffle CANet and BiFPN for efficient feature extraction and semantic combination [14][15].

4. Proposed System

Identifying the dataset and the established environment crucial for the suggested method is essential, as discussed in the following sections.

4.1 Data Acquisition:

The system utilizes two datasets, AIZOO [16] and MoLa RGB CovSurv [17], to ensure a comprehensive and balanced training set. These datasets contain a wide range of face images with varying sizes, illumination, scale, makeup, pose, expression, and occlusion, providing a robust foundation for training the detection model.

4.1.1 AIZOO Dataset:

The AIZOO dataset consists of 815 images, with 984 images in the training set and 446 images in the test set [18]. The dataset consistently labels (annotates), providing information on the object box's upper left corner coordinates, lower right corner coordinates, and face class.

4.1.2 MoLa RGB CovSurv Dataset:

The MoLa RGB CovSurv dataset provides a diverse collection of face images, further enhancing the training data's representativeness [19].

4.2 Methodology

The proposed face mask detection system can work offline (from images), restrict access to certain areas, and determine whether individuals are wearing face masks [20] [21]. (At present). The user's text does not contain any information. The system possesses capabilities that enable it to operate on devices with restricted computational capacity, has a reduced price, and is simpler to deploy with security cameras compared to existing models. The suggested system possesses practical applications in real-world scenarios. The suggested system has three stages: data production, preprocessing, and the integration of a convolutional neural network (CNN) with a gray-level co-occurrence matrix (GLCM). This system merges the YOLOv5s method with the GLCM and CNN algorithms [22]. Figure 1 displays the total block and block diagrams of the proposed face mask detection system [23] and [24].

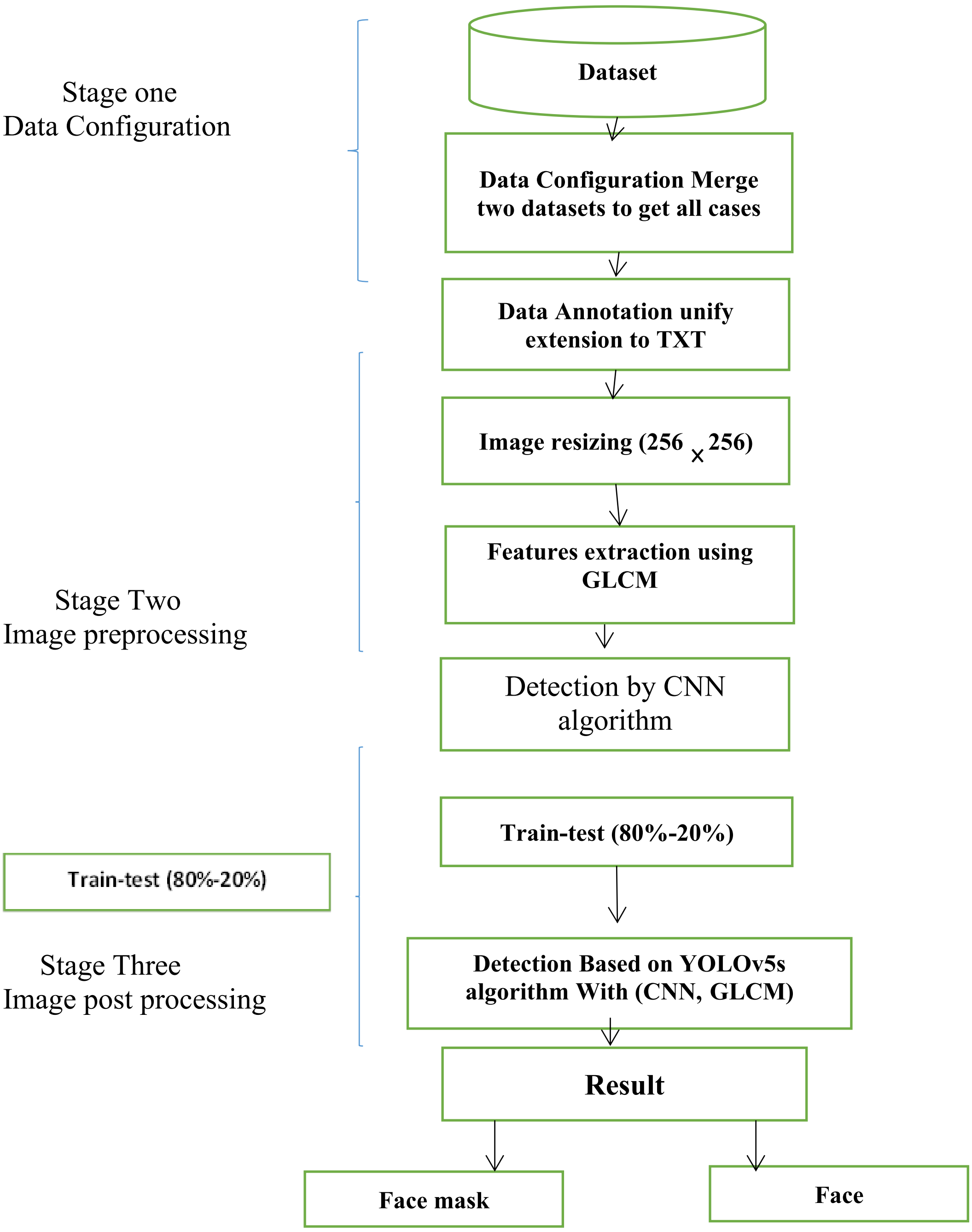

Figure 1: System diagram**.**

4.2.1 Data Configuration

Most types of datasets dedicated to detecting faces and face masks suffer from image imbalance, where either the number of face masks is low or the number of faces is high, resulting in inadequate system training [25]. From this perspective, researchers selected the two most well-known datasets for face and face mask detection, AIZOO and MoLa RGB CovSurv, and combined them into a single dataset to leverage the largest number of images and create a comprehensive dataset that encompasses all image scenarios, known as the merged dataset. The merged dataset contains a wide range of variations in different images, depending on factors such as face size, illumination, scale, makeup, pose, expression, and occlusion, among others [26] [27] [28]. Figure (2) shows face and face mask numbers in AIZOO, MoLa RGB CovSurv, and the merged dataset.

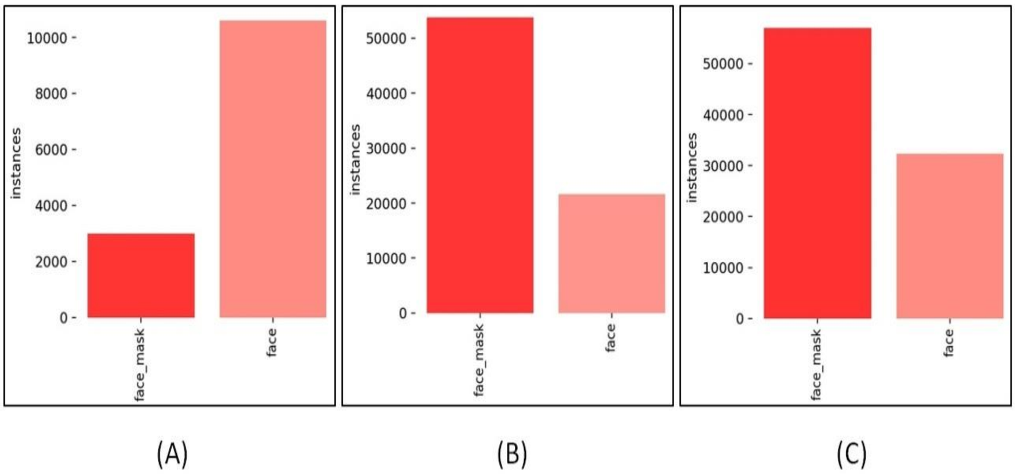

Figure 2: numbers of the Face and Face mask in (A) AIZOO dataset, (B) MoLa and CovSurv dataset, and (C) Merged dataset

4.2.2 Image pre-processing

The pre-processing stage involves:

- **Data Annotation Conversion:** Converting annotation formats from XML to TXT for compatibility with the YOLOv5s algorithm.
- **Image Resizing:** Resizing all images to 245 × 245 pixels to ensure consistency and reduce computational complexity.

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4.2.2.1 Convert Data Annotation

The YOLOv5s algorithm must be trained on a dataset that includes images containing a label (data annotation) in which the coordinates of the bounding squares are mentioned [29] and [30]. It is very difficult to manually draw a bounding box for all the images that the algorithm will be trained on; for this must use a dataset that contains an annotation that includes complete information. The annotations in the ALZOO dataset are in XML format, whereas those in the MoLa RGB CovSurv dataset are in TXT format. The YOLOv5s algorithm requires annotations with a TXT extension, but some images in the dataset had a different XML extension. Additionally, some images in the dataset had incorrect or incomplete annotations, necessitating their processing before the algorithm could use them. This research addressed the issues related to annotation [31] and [32].

4.2.2.2 Image Resizing (245 × 245**)**

The basic idea is to unify the image sizes to reduce the fluctuation in the data set between images of small sizes and images of large sizes. After the experiment, it was found that the image size of 245 × 245 is the appropriate size to achieve a balance between the proposed system's speed and accuracy [33].

4.2.3 Add New Layer & YOLOv5s algorithm

There are 24 network base levels in the YOLOv5s algorithm. The first layer sequence begins with a value of 0. After adding a layer in sequence 8, the proposed system has 25 primary levels and 275 sub-layers. The new layer has six sub-layers: CNN and GLCM algorithms. If there is a significant change in the value of the matrix, GLCM is considered the best approach. GLCM is the best way to classify pixels by pixel values [34, 35]. The gray-level co-occurrence value is utilized. The GLCM algorithm utilizes the principle of texture categorization. The homogeneity value determines the texture classification. A smoothing value is computed for every pixel that is rendered in the image. Upon completion of the smoothing calculations, a matrix of values is generated. The GLCM value is calculated when there is a change in the smoothing value of the given pixel [36]. in the pictures. In an input layer, the tensor (image data) from the last layer is entered in four dimensions (1×245×8×8) and exited in one dimension to flatten it. Flattening data accelerates processing. There are two layers of ReLU activation functions that eliminate unnecessary data [37]. The output layer restores data. (four dimensions) [38][39]. Because the YOLOv5s algorithm processes four-dimensional data, it is put into a CNN or GLCM network [40]. Based on training results, the proposed system's detection accuracy increased considerably after adding the new layer [41, 42]. In the proposed system, the model using YOLOv5s was chosen because increasing the model's size will not increase its efficiency; instead, it will increase its complexity and detection speed. Since the model's goal is to discover only two distinct categories (with or without a mask), the smallest, least complex, and fastest model is the best choice, especially given the reassuring fact that increasing the model's size will not increase its efficiency. Thorough proofreading of the manuscript is essential to rectifying grammatical errors and enhancing overall clarity and coherence in the text.

5. Post-processing with CNN and GLCM Layer:

The post-processing stage utilizes the YOLOv5s algorithm, augmented with a new layer consisting of six sub-layers that integrate the CNN and GLCM algorithms [43]. This integration enhances the system's ability to detect subtle changes in texture and improves the accuracy of face mask detection.

5.1 Work Steps of The YOLOv5s Algorithm

The YOLOv5s algorithm operates on the entire image, simultaneously predicting bounding boxes and object classes. It employs a grid of cells (8 × 8 in this case) to predict bounding boxes (anchor boxes) for different object sizes. The algorithm utilizes IoU (intersection over union) to evaluate the accuracy of bounding box predictions, selecting the box with the highest IoU score. Each bounding box also generates confidence scores, signifying the certainty of the predicted object class [44]. The GLCM function extracts texture features by analyzing pixel pairs and their spatial relationships, providing additional information for object classification [45] and [46].

5.2 Intersection over Union (IoU):

IoU is a commonly used metric in object detection tasks to measure the overlap between the predicted bounding box and the ground truth bounding box [47]. It is calculated as the ratio of the area of intersection between the two boxes to the area of their union [48].

6. Results and Discussion

The system was trained on both AIZOO and MoLa RGB CovSurv datasets, achieving high accuracy in detecting masked and unmasked faces. The training results show a consistent improvement in accuracy with increasing epochs, reaching a plateau after 120 epochs. The proposed system demonstrates its effectiveness in real-time object recognition, offering a practical solution for face mask detection in various applications.

6.1 Training Parameters:

The training process involved optimizing various hyperparameters, including learning rate, batch size, and optimizer selection. These parameters were carefully tuned to achieve optimal performance.

Table 1: Best results of training the model in different epochs

Epoch Number	train/ box_loss	train/ obj_loss	train/ cls_loss	metrics/ mAP_0.5	metrics/ recall
10	0.032288	0.010821	0.002108	0.94122	0.90985
30	0.031088	0.01056	0.0015883	0.94235	0.91478
120	0.029613	0.010171	0.0013873	0.94437	0.91884
200	0.025171	0.008765	0.0007539	0.94449	0.92705

Table 1 shows a consistent improvement in training results as the number of epochs increases. It was observed that the outcomes after 120 epochs closely resemble those after 200 epochs. This implies that extending the number of epochs beyond 200 will not result in an improvement in the model's accuracy. Therefore, the training was halted at 120 epochs.
MoLa RGB CovSurv dataset

Table 2: Best results of training the model in different epochs Merged dataset

Epoch Number	train/ box	train/ obj	train/ cls	metrics/ mAP_0.5	metrics/ recall
10	0.024579	0.0099776	0.0021446	0.83998	0.78899
70	0.020067	0.0089954	0.0016331	0.851108	0.81110
190	0.021181	0.008665	0.00076225	0.95665	0.93997
230	0.032334	0.010907	0.00181110	0.95589	0.96889

The results improved when we trained the model to the third period's limit. Still, as in figure (2) below, during the attempt to train the model for 800 epochs, the YOLOv5s algorithm terminated training at epoch 230. The algorithm made this decision after observing that the model's performance did not significantly improve with additional epochs.

Table 3: Best results of training the model in different epochs

Epoch Number	train/ box_loss	train/ obj_loss	train/ cls_loss	metrics/ mAP_0.5	metrics/ recall
10	0.048966	0.015848	0.0074704	0.87332	0.80215
60	0.037971	0.012472	0.0034581	0.92765	0.88934
80	0.033379	0.011386	0.002293	0.97212	0.94914
100	0.033284	0.011197	0.002248	0.97744	0.95495

As indicated in Table 3, after 100 epochs, the system attained outstanding outcomes, rendering it unnecessary to further augment the number of training epochs. The previous sections have demonstrated that the suggested method has achieved a high level of efficiency in detecting faces and face masks using two distinct datasets. The following points will elucidate the justifications for those accomplishments:

1. The YOLOv5s algorithm was used for real-time detection because it balances execution time and accuracy and adapts well to various image sizes [18] [19] [20]. The YOLOv5s algorithm's new layer (CNN, GLCM network) improved image target spotting in face and face mask images. It improves target image feature recognition and tracking. Results indicate
2. Increasing the dataset's image number and variety improves model accuracy.
3. The YOLOv5s algorithm reduces training time by automatically stopping training if the model does not change.

Table 4: compares our proposed method's detection accuracy to prior studies using multiple datasets. Our solution outperforms others, according to the data.

RF.	Year	Methods And Type	dataset	Result
[6]	2020	YOLOV5 (real-time)	AIZOO	**mAP** 97.90%
[7]	2021	SDDv2 (no- real-time)	AIZOO	**mAP** 72.79%
[8]	2021	pipeline (real-time)	-AIZOO -Moxa 3K	**AIZOO mAP** 93.80% **Moxa3k mAP** 69.18%
[9]	2022	YOLOV5 (No- real-time)	Mola RGB Covsury	**mAP** 82.38%
[10]	2022	YOLOv5 (real-time)	AIZOO	**mAP** 95.2%
Proposed system	2022	YOLOv5 (real-time) and offline	AIZOO	**mAP** 99.4%
			Mola RGB Covsury	**mAP** 92.2%
			Merged	**mAP** 93.5%

Table 4: Compare the final result with other studies

7. Detection Object in Proposed System

Object detection is widely favored in computer vision models for its exceptional adaptability. Mask and non-mask object detection approaches aim to recognize and categorize related objects in images into two distinct groups. Additionally, they train an object identification model capable of accurately identifying all forms of face recognition, regardless of whether the things are being worn or not. The model has the capability to identify both the face and the face mask in various scenarios, including real-time, photos, videos, directories of images, and streams. The proposed model has successfully addressed numerous challenges in face detection, including variations in face orientations, occlusion caused by non-mask objects, blurred faces, different types of masks, small faces, and faces wearing masks. Figure (3) demonstrates the system's proficiency in accurately identifying the majority of images that provide difficulties. Thorough proofreading of the manuscript is essential to rectifying grammatical errors and enhancing overall clarity and coherence in the text.

Figure 3: The planned system overcame many obstacles [27].

Figure 4 shows the system's ability to correctly detect most images containing a small face and face mask.

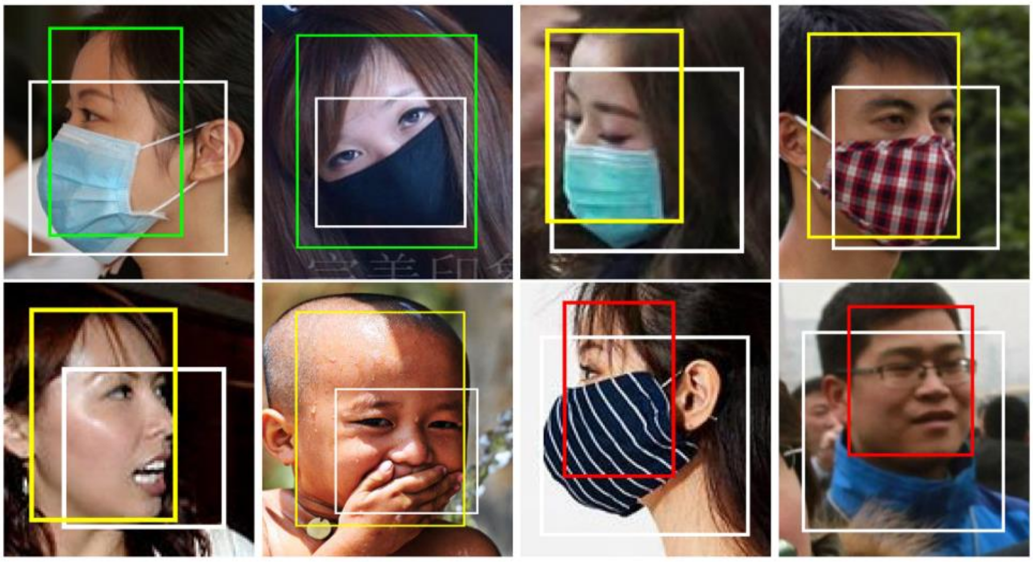

Figure 4: detection of the small Face and face mask [44].

8.Conclusion:

This study presents a novel face mask detection system that leverages the combined strengths of GLCM and CNN algorithms integrated into the YOLOv5s framework. The system demonstrates high accuracy and efficiency in detecting face masks, showcasing its potential for practical deployment in various settings [49]. Future work will focus on further enhancing the system's robustness by exploring different dataset combinations and optimizing hyperparameters.

9. Limitations:

- **Dataset Bias:** The system's performance may vary depending on the specific dataset used for training.

- **Lighting Conditions:** Variations in lighting conditions can affect the system's accuracy.
- **Occlusion:** When objects partially obscure faces, the system may have trouble detecting them.

10. Future Directions:

- **Dataset Expansion:** Expanding the training dataset with more diverse images, including different face poses, lighting conditions, and mask types, can improve the system's generalizability.
- **Hyperparameter Optimization:** Optimizing hyperparameters, such as learning rate and batch size, can improve the model's performance.
- **Real-Time Deployment:** Exploring real-time deployment strategies, such as integration with security cameras or mobile devices, can facilitate practical applications.

This research contributes to the advancement of face mask detection technology, offering a promising solution for promoting public health and safety during the ongoing pandemic and beyond.

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Conflicts Of Interest
The author declares no conflict of interest.

References

[1] T. M. K. a. B. F. C. Shorten, "Deep Learning applications for COVID-19," J. Big Data, vol. 8, no. 1, 2021. doi: 10.1186/s40537-020-00392-9.

[2] A. A. M. S. M. F. Abdul-Jabbar S.S., "Fast 128-bit Multi-Pass Stream Ciphering Method," Iraqi Journal of Science, vol. 64, no. 5, pp. 2589-2600, 2023.

[3] K. K. e. al, "Biosafety Concerns During the Collection, Transportation, and Processing of COVID-19 Samples for Diagnosis," Arch. Med. Res, vol. 51, no. 7, p. 623–630, 2020. doi: 10.1016/j.arcmed.2020.08.007.

[4] A. S. M. S. Mohammed F.G., "Disc damage likelihood scale recognition for Glaucoma detection," Journal of Physics: Conference Series, vol. 2114, no. 1, 2021.

[5] M. M. a. E. A. A.-Z. Mijwil, "Medical image classification for coronavirus disease (COVID-19) using convolutional neural networks," Iraqi Journal of Science, vol. 62, no. 8, pp. 2740-2747, 2021.

[6] A.-J. S. M. F. Mohammed S.G., "Art Image Compression Based on Lossless LZW Hashing Ciphering Algorithm," Journal of Physics: Conference Series, vol. 2114, no. 1, p. 012080, 2021.

[7] J. B. P. C. a. J. V.-A. J. S. Talahua, "Facial recognition system for people with and without face mask in times of the covid-19 pandemic," Sustain, vol. 13, no. 12, pp. 19-1, 2021. doi: 10.3390/su13126900.

[8] S. S. S. I. A. A. M. M. Hoobi, "Enhanced Multistage RSA Encryption Model," 2nd International Scientific Conference of Al-Ayen University (ISCAU), p. 455, 2020.

[9] S. N. C. a. S. Y. J. Ieamsaard, "Deep Learning-based Face Mask Detection Using YoloV5," iEECON, p. 428–431, 2021. doi: 10.1109/iEECON51072.2021.9440346.

[10] F. A. S. Mohammed, "Disc damage likelihood scale recognition for Glaucoma detection," Journal of Physics: Conference Series, vol. 2114, no. 1, p. 012005, 2021.

[11] G. Y. e. al, "Face Mask Recognition System with YOLOV5 Based on Image Recognition," ieee 6th Int. Conf. Comput. Commun, vol. 3, p. 1398–1404, 2021. doi:

10.1109/ICCC51575.2020.9345042.

[12] W. K. L. Y. a. L. J. Z. Shanshan, "Face Mask Detection Based on SSDv2 Network," Assoc. Adv. Artif. Intell, vol. 3, no. 422, 2021.

[13] M. M. e. a. Salih, "Benchmarking Framework for COVID-19 Classification Machine Learning Method Based on Fuzzy Decision by Opinion Score Method," Iraqi Journal of Science, pp. 922-943, 2023.

[14] S. D. J. C. F. A. H. J. M. a. J. B. C. Melo, "Ai based monitoring of different risk levels in covid19 context," Sensors, vol. 22, no. 1, p. 1–18, 2022. doi: 10.3390/s22010298.

[15] S. Xu, "An Improved Lightweight YOLOv5 Model Based on Attention Mechanism for Face Mask Detection," arXiv, vol. 2, no. 2203, p. 1–12, 2022.

[16] Chiang., "AIZOO | Kaggle," 2020.

[17] L. M. a. H. M. A. Alhelfi, "Using Persistence Barcode to Show the Impact of Data Complexity on the Neural Network Architecture," Iraqi Journal of Science, vol. 63, no. 5, pp. 2262–2278, May 2022, doi: 10.24996/ijs.2022.63.5.37

[18] J. Q. J. Z. H. S. J. Y. a. X. L. J. Yao, "A real-time detection algorithm for kiwifruit defects based on yolov5," Electron, vol. 10, no. 14, 2021.

[19] M. M. A. a. M. A. M. M. L. Francies, "A robust multiclass 3D object recognition based on modern YOLO deep learning algorithms," Concurr. Comput. Pract. Exp, vol. 34, no. 1, p. 1–24, 2022.

[20] D. E. F. L. Y. C. a. B. M. P. Jiang, "A Review of Yolo Algorithm Developments," Procedia Comput. Sci., vol. 199, p. 1066–1073, 2021. doi: 10.1016/j.procs.2022.01.135.

[21] R. X. L. a. X. T. Xu, "A model for face mask detection through deep learning," Computers, and Software Engineering , vol. 12787, pp. 390-395, 2023.

[22] F. G. Z. F. Z. X. W. H. L. P. L. a. Y. C. Yu, "Improved YOLO-v5 model for boosting face mask recognition accuracy on heterogeneous IoT computing platforms," Internet of Things, p. 100881, 2023.

[23] A. B. P. D. T. N. V. S. J. P. S. L. A. A. E. E. E. S. H. a. N. K. Khazalah, " Khazalah, Ali, Boppana Prasanthi, Dheniesh Thomas, Nishathinee Vello, Suhanya Jayaprakasam, Putra Sumari, Image processing identification for sapodilla using convolution neural," springer, pp. 107-127, 2022.

[24] X. X. F. Y. D. a. H. H. Fan, "COVID-19 CT image recognition algorithm based on transformer and CNN," Displays, vol. 72, 2022.

[25] H. K. V. K. R. D. M. R. a. C. N. P. Dey, "An integrated gene network analysis to decode the multi-drug resistance mechanism in Klebsiella pneumoniae," Microbial Pathogenesis , vol. 173, 2022.

[26] M. a. S. E. Kang, "Novel regenerator design for caloric cycles using artificial neural network—Genetic algorithm method and additive manufacturing," Energy Reports, vol. 9, pp. 4257-4274, 2023.

[27] f. a. m. a. mohammed s h al-tammi, "face mask detection based on algorithm yolov5," IJNAA, vol. 14, pp. 676-697, 2023.

[28] X. W. H. J. L. G. W. a. H. R. Dong, "Effect of laser parameters on melting ratio and temperature distribution in dissimilar laser welding of brass," laser application, vol. 33, no. 3, 2021.

[29] C. S. D. J. C. F. A. H. M. a. J. B. Melo, "AI based monitoring of different risk levels in COVID-19 context," Sensors , vol. 22, no. 1, p. 298, 2021.

[30] N. O. A. M. a. B. E.-H. Mohamed Mokhtar, "Improving Smart Infrastructure Monitoring System as a Response to Prevalent Pandemic," Port-Said Engineering Research, 2023.

[31] J. F. C. Y. L. Y. S. a. T. M. Xue, "Detection of farmland obstacles based on an improved YOLOv5s algorithm by using CIoU and anchor box scale clustering," Sensors, vol. 22, no. 5, 2022.

[32] J. Tang, S. Liu, B. Zheng, J. Zhang, B. Wang and M. Yang, "Smoking Behavior Detection Based On Improved YOLOv5s Algorithm," *2021 9th International Symposium on Next Generation Electronics (ISNE)*, Changsha, China, 2021, pp. 1-4, doi: 10.1109/ISNE48910.2021.9493637.

[33] Y. M. M. R. M. F. I. A. a. R. K. Watanobe, "Identifying algorithm in program code based on structural features using CNN classification model," Applied Intelligence, vol. 53, no. 10, pp. 12210-12236, 2023.

[34] P. P. S. a. L. G. Mohanaiah, "Image texture feature extraction using GLCM approach," International journal of scientific and research publications , vol. 3, no. 5, 2013.

[35] Ş. a. B. A. Öztürk, "Application of feature extraction and classification methods for histopathological image using GLCM, LBP, LBGLCM, GLRLM and SFTA," Procedia computer science, vol. 132, 2018.

[36] C. I. a. N. W. Ossai, "GLCM and statistical features extraction technique with Extra-Tree Classifier in Macular Oedema risk diagnosis," Biomedical Signal Processing and Control, vol. 73, 2022.

[37] N. a. K. S. Suganthi, "Feature extraction based on glcm and glrm methods on covid-19 dataset," Springer, pp. 271-279, 2021.

[38] L. K. a. B. N. J. Kumari, "A Robust Feature Extraction Technique for Breast Cancer Detection using Digital Mammograms based on Advanced GLCM Approach," EAI Endorsed Transactions on Pervasive Health and Technology, vol. 8, no. 30, 2022.

[39] M. N. Alfa Farah, W. Hayyin Suristiyanti, S. Ibad, R. A. Pramunendar and G. Fajar Shidik, "GLCM Feature Extraction and PCA for Tuberculosis Detection with Neural Network," *2022 International Seminar on Application for Technology of Information and Communication (iSemantic)*, Semarang, Indonesia, 2022, pp. 314-318, doi: 10.1109/iSemantic55962.2022.9920478.

[40] N. a. K. S. Suganthi, "Feature extraction based on glcm and glrm methods on covid-19 dataset," Springer, pp. 271-279, 2021.

[41] H.-S. S.-H. P. a. T.-H. I. Jeon, "Grid-Based Low Computation Image Processing Algorithm of Maritime Object Detection for Navigation Aids," Electronics, vol. 12, no. 9, 2023.

[42] S. a. A. S. Avidan, "Seam carving for content-aware image resizing," Seminal Graphics Papers: Pushing the Boundaries, vol. 2, pp. 609-617, 2023.

[43] S. S. S. C. a. V. K. Katoch, "A review on genetic algorithm: past, present, and future," Multimedia tools and applications, vol. 80, pp. 8091-8126, 2021.

[44] p. p. b.,. b. ales jaklic, "deep image semantic segmentation and recognition," applied sciences, vol. 12, no. 6, 2021.

[45] J. P. J. A. Z. X. C. a. W. H. Zhou, "Ship target detection algorithm based on improved YOLOv5," Journal of Marine Science and Engineering, vol. 9, no. 8, 2021.

[46] J. F. C. Y. L. Y. S. a. T. M. Xue, "Detection of farmland obstacles based on an improved YOLOv5s algorithm by using CIoU and anchor box scale clustering," Sensors, vol. 22, no. 5, p. 1790, 2022.

[47] Y.-Q. Wang, "An analysis of the Viola-Jones face detection algorithm," Image Processing On Line, vol. 4, pp. 128-148, 2014.

[48] D. Meena and R. Sharan, "An approach to face detection and recognition," *2016 International Conference on Recent Advances and Innovations in Engineering (ICRAIE)*, Jaipur, India, 2016, pp. 1-6, doi: 10.1109/ICRAIE.2016.7939462.

[49] G. Yang *et al*., "Face Mask Recognition System with YOLOV5 Based on Image Recognition," *2020 IEEE 6th International Conference on Computer and Communications (ICCC)*, Chengdu, China, 2020, pp. 1398-1404, doi: 10.1109/ICCC51575.2020.9345042.