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Masked Face Recognition for Smart City Utilization

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Abstract

Recent international projects to create smart cities that maintain sustainability have significantly improved humanity. Incorporating deep learning and facial recognition in intelligent cities guarantees security in public places. If facial recognition is accurate, it can hasten such activities, enhancing their convenience and adding intelligence to city life. Numerous facial recognition tasks now face significant challenges due to the increasing use of face masks. A thorough surveillance is necessary due to the widespread usage of face masks in many communities, as multiple security evaluations suggest that face masks may be used to hide identities. Consequently, using the uncovered region of the masked face for facial recognition in smart cities has become essential. In the area of intelligent city surveillance, biometrics, smart cards, law enforcement, and security information, this technology is widely used. Therefore, this work proposes a framework for developing a face recognition system for masked face images in intelligent cities. A transfer learning approach has been employed to train the Facemask Detection dataset by integrating YOLOv8 with the HOG algorithm. Furthermore, an examination of the YOLOv8 algorithm's performance compared to other algorithms has been provided. The simulated results confirm that the system is robust when identifying individuals in masked face images. Additionally, on the dataset, the YOLOv8 algorithm obtains a mAP50 of 99.5%, improves the precision of 99.9%, and achieves an accuracy of 99.3% for face recognition. Furthermore, the YOLOv8 algorithm offers sufficient speed and accuracy on small faces.

Keywords: Maskedface Detection; Face Recognition; YOLOv8 Algorithm; HOG; Deep Learning; Smart City.

1 | Introduction

In this era, where urbanization is happening faster and more advanced technologies are within reach, the concept of smart cities has been established to herald the dawn of creativity and competence. Within a smart city's infrastructure, facial recognition is one of its core technologies that is equally significant for the destiny of urban areas worldwide. Facial recognition software determines whether someone's facial features match a database of known faces. Increased use of face-covering during this period has necessitated masked individuals based on their location, for example, national security installations officers, university students as well as other learners, as well as passengers in any transport (trains, buses, or subways), staff in various research labs and other organizations [1, 2]. It plays different roles in smart cities, focusing on enhancing public safety. Figure 1 presents the applications of facial recognition systems in smart cities.

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Figure 1. Applications of Face Recognition System.

Surveillance cameras with face recognition capabilities are now used in smart cities to monitor public areas. Thanks to this cutting-edge technology, authorities can more efficiently respond to disasters and emergencies by identifying and following masked individuals of interest. Figure 2 illustrates the process of facial recognition in smart cities.

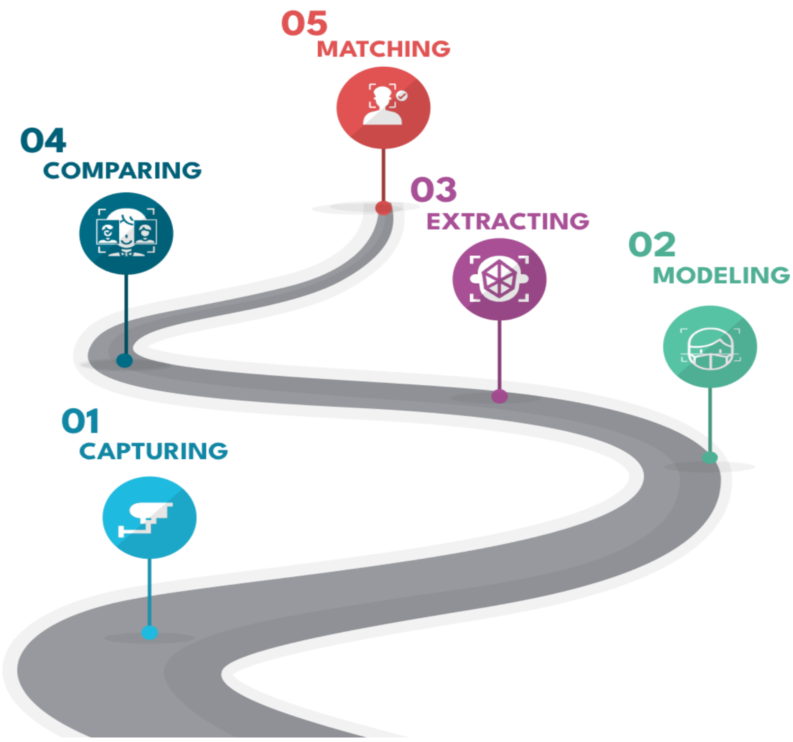

Figure 2. The process of facial recognition in a smart city.

In emergencies or natural calamities, face recognition is used to quickly locate survivors and first responders. Accessibility control supported by this technology ensures a reduction in the risks from insecurity and breaches of health-protection measures by denying unauthorized individuals access. Nowadays, a lot of smart cities have implemented community policing programs into place. In these programs, police officers interact with people and actively handle safety problems using mobile devices equipped with face recognition technology.

These elements include looking for potential threats and interpersonal crimes in public areas, educational institutions, businesses, and other work environments, among other places [3]. As a result, it is essential to create a highly secure facial recognition system to recognize people who wear face masks and improve the surveillance system.

Feature extraction-based facial recognition algorithms aim to get stable and differentiating characteristics, capturing every person's distinctiveness. Some methods such as Local Binary Patterns (LBP) [4], Histogram of Oriented Gradients (HOG) [5], Convolutional Neural Networks (CNNs), FaceNet [6], VG-GFace [7], DeepFace [8], and others deep learning architectures have been used so far to improve face recognition performance. Face recognition algorithms frequently face challenges when handling occlusion, illumination, expression, and position differences.

The occlusion problem is processed in the present work by combining facial detection and recognition. This approach uses YOLOv8 to detect the uncovered portion in masked face images and the HOG algorithm to match the detected face with the dataset images to recognize it.

The contributions of this paper include the following:

- The main objective is to find and recognize those with partially covered faces in intelligent cities.
- Improved Performance in Masked Situations.
- Decreases the privacy dangers that come with full-face images.
- YOLOv8 produced faster and more accurate results when identifying the exposed portion of the face.
- The proposed system is superior to the existing methods.

The rest of this paper is structured as follows. Section 2 presents the literature review of face recognition. After that, Section 3 provides the proposed methodology. Section 4 discusses the dataset, experimental platform, parameter settings, and experimental results. Finally, the concluding remarks are presented in Section 5.

2 | Literature Review

Closed-circuit television cameras [9] are the foundation of many facial recognition systems, as they gather images from different points of view. Subsequently, advanced methods [10] are employed to track individuals, automatically detect irregularities, and immediately recognize potential dangers. A facial recognition (FR) system using deep convolutional neural networks (DCNN) to extract face characteristics and transfer learning in fog and cloud computing is proposed by Salama AbdELminaam et al. [11]. When tested using three datasets and the Decision Tree, K Nearest Neighbour, and Support Vector Machine algorithms with the most fantastic accuracy of 99.06%, the recommended technique performed better than the other algorithms.

One of the early attempts to detect and identify faces using a Raspberry Pi [12] was demonstrated. The system employed the Raspberry Pi, the Haar detection algorithm, and Principal Component Analysis (PCA) to recognize people's faces. A real-time face recognition system for those with visual impairments was designed using the Haar feature-based cascade classifier and a Raspberry Pi [13]. The system incorporated a camera module to take images and identify faces instantly.

Rahman et al.'s work [14] suggested a method for preventing the transmission of COVID-19 in smart city systems, where closed-circuit television (CCTV) cameras monitor all public areas by finding and recognizing facial masks, which would be done to reduce the number of people who could come into exposure to the virus. When someone is not wearing a mask, the appropriate authorities are notified via the city network. A Smart Screening and Disinfection Walkthrough Gate (SSDWG) based on the Internet of Things (IoT) was proposed by Sanjaya and Rakhmawan [15]. The SSDWG was created to perform quick screening. It does this by taking the subject's temperature using a sensor that doesn't require physical contact and recording the person who raises suspicions for later observation and control. Real-time deep learning techniques have been integrated into their proposed screening tool to enable face mask identification and classification.

Das et al. [16] used the ResNet-50 deep transfer learning algorithm to build a key component of the feature extraction technique to detect masks in images of medical face masks. Additionally, Vijitkunsawat and Chantngarm [17] showed the detection accuracy of three deep learning-based face mask detection techniques: Max pooling, Average pooling, and MobileNetV2.

3 | The Proposed Model

Researchers in computer vision have been trying to integrate face recognition algorithms into smart cities. The strategy has been used for security systems, access control, monitoring, and other relevant fields. In the proposed method, the face recognition system of the masked face is applied in smart cities. This approach uses YOLOv8 to detect the part uncovered in masked face images and the HOG algorithm to match the detected face with the dataset images to recognize it. The model is trained on the Face mask Detection Dataset. Even when people put on masks, a typical scene in urban areas because of health and safety measures, we ensured our suggested method could perform excellent recognition. Figure 3 shows the steps of our proposed method.

Figure 3. Steps of the proposed method.

4 | Results and Discussion

4.1 | Dataset

The "facemask detection dataset"[18], made available online via Kaggle, is the data source used in the study. There are 20,000 images total, with 10,000 including faces covered in masks and 10,000 without. Standardizing each image to 224 by 224 grayscale pixels results in a compact representation that can be used in various computer vision applications. The masked facial image dataset's uncovered portion is labeled using Roboflow. After annotating them and the associated class, it is simple to transform the images into the trainable YOLOv8 format. Figure 4 shows sample images from the dataset.

Figure 4. Sample images from the online Facemask Detection dataset.

4.2 | Experimental platform and parameter settings

Experiments were conducted using Python on a PC with a Windows 11 operating system, OM3PDP3-AD NVMe KDI 512GB, and AMD Ryzen 7 with 16 GB RAM. This work also utilized Visual Studio 2022 and T4 GPU.

The parameter settings considered during the training stage are as follows: the batch size is 16, the number of images is 422, and the image size is 640 × 640. For YOLOv8, the training process runs up to 100 epochs. The training process took approximately 0.339 hours on T4 GPU for YOLOv8. Table 1 shows the performance metrics that were used in this work.

Table 1. Performance Metrics.

Metric	Equation
Accuracy	(TP+TN)/(TP+TN+ FP+FN)
Precision	TP/(TP+FP)
Recall	(TP/(TP+FN)

Where TP refers to the number of samples the model accurately determines to be positive, TN refers to the number of samples the model correctly identified as harmful. The number of samples the model mistakenly identifies as positive when they are dangerous is known as FP. FN represents the number of samples the model mistakenly identifies as unfavorable when they are positive.

4.3 | Numerical Results and Analysis

This section comprehensively analyzes our face recognition for masked faces created in smart cities. The result is compared with other methods shown in Table 2. Our method achieved the following results: 99.3% accuracy, 99.9% precision, and 100% recall. These results show that our method can ensure a firm ability to recognize masked faces in the presence of masks. When compared to existing models, our approach significantly outperforms others. In precision, accuracy, and recall metrics, the DCNN method demonstrates strong performance and high results across all metrics, but our approach outperforms it. From the results, the HOG with SVM approach also performs well after the DCNN approach, but our algorithm also outperforms it. The comparisons show that the combination of YOLOv8 and HOG will be effective as compared to other methods that exist so far. This combination, however, improves the adaptability of masked face recognition, which is critically needed in smart cities. This method highlights the potential to improve safety and operation efficiency with technology, providing a robust solution to modern urban challenges. The superiority of our method establishes it as a leading approach in the domain of masked face recognition, which is crucial for the evolving landscape of smart cities.

Table 2. Comparison between facial recognition algorithms.

Metric Work Ref.	Accuracy	Precision	Recall
DCNN [11]	99.06%	99.12%	99.07%
LR-HGBC-CNN [19]	88%	86%	90%
HOG + GSO-CNN[20]	83.6%	72.2%	82.8%
HOG + SVM [21]	95%	95%	95%
CNN [22]	94%	96%	93%
The proposed	99.3%	99.9%	100%

5 | Conclusion

In the proposed method, the face recognition system uses uncovered facial features for application in smart cities, offering a new way to maintain high accuracy in cases where individuals are partially masked. The application of YOLOv8 in detecting visible face sections covered with masks and subsequent comparison of these identified attributes by the Histogram of Oriented Gradients (HOG) algorithm with collected images of human datasets addresses the security requirements and real-world challenges imposed by wearing the mask. This approach shows essential capability for helping to enhance the infrastructure of smart cities. Thus, the method guarantees strong security while monitoring effectively and with robust accuracy, and it even works when masked individuals are involved. With an accuracy of 99.3%, our facial recognition system was the most accurate. Overall, the face recognition system described is an effective method suitable for the smart city that balances increased safety rates and usual lifestyle features.

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Author Contributions

All authors contributed equally to this work.

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Data Availability

The datasets generated during and/or analyzed during the current study are not publicly available due to the privacy-preserving nature of the data but are available from the corresponding author upon reasonable request.

Conflicts of Interest

The authors declare that there is no conflict of interest in the research.

Ethical Approval

This article does not contain any studies with human participants or animals performed by any of the authors.

References

[1] Fischer EP, Fischer MC, and G. D. et al., "Low-cost measurement of face mask efficacy for filtering expelled droplets during speech," 2020

[2] M. Klompas, C. A. Morris, J. Sinclair, M. Pearson, and E. S. Shenoy, "Universal masking in hospitals in the Covid-19 era," New England Journal of Medicine, vol. 382, p. e63, 2020.

[3] S. Feng, C. Shen, N. Xia, W. Song, M. Fan, and B. J. Cowling, "Rational use of face masks in the COVID-19 pandemic," The Lancet Respiratory Medicine, vol. 8, pp. 434-436, 2020.\

[4] T. Ojala, M. Pietikainen, and D. Harwood, "Performance evaluation of texture measures with classification based on Kullback discrimination of distributions," in Proceedings of 12th International Conference on Pattern Recognition, 1994, pp. 582-585 vol.1.

[5] R. K. McConnell, "Method of and apparatus for pattern recognition," 1986.

[6] F. Schroff, D. Kalenichenko, and J. Philbin, "Facenet: A unified embedding for face recognition and clustering," in Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition, 2015, pp. 815-823.

[7] O. Parkhi, A. Vedaldi, and A. Zisserman, "Deep face recognition," in BMVC 2015-Proceedings of the British Machine Vision Conference 2015, 2015.

[8] Y. Taigman, M. Yang, M. A. Ranzato, and L. Wolf, "Deepface: Closing the gap to human-level performance in face verification," in Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition, 2014, pp. 1701-1708.

[9] A. C. Davies and S. A. Velastin, "A progress review of intelligent CCTV surveillance systems," Proc. IEEE IDAACS, pp. 417-423, 2005.

[10] Sreenu G and S. D. M. A., "Intelligent video surveillance: a review through deep learning techniques for crowd analysis," 2019.

[11] D. Salama AbdELminaam, A. M. Almansori, M. Taha, and E. Badr, "A deep facial recognition system using computational intelligent algorithms," Plos one, vol. 15, p. e0242269, 2020.

[12] I. Gupta, V. Patil, C. Kadam, and S. Dumbre, "Face detection and recognition using Raspberry Pi," in 2016 IEEE International WIE conference on electrical and computer engineering (WIECON-ECE), 2016, pp. 83-86.

[13] M. T. Islam, M. Ahmad, and A. S. Bappy, "Real-time family member recognition using Raspberry Pi for visually impaired people," in 2020 IEEE Region 10 Symposium (TENSYMP), 2020, pp. 78-81.

[14] M.M. Rahman, M.M.H. Manik, M.M. Islam, and S. M. a. J. H. Kim, "An Automated System to Limit COVID-19 Using Facial Mask Detection in Smart City Network," 2020.

[15] S. A. Sanjaya and S. A. Rakhmawan, "Face mask detection using MobileNetV2 in the era of COVID-19 pandemic," in 2020 International Conference on Data Analytics for Business and Industry: Way Towards a Sustainable Economy (ICDABI), 2020, pp. 1-5.

[16] A. Das, M. W. Ansari, and R. Basak, "Covid-19 face mask detection using TensorFlow, Keras, and OpenCV," in 2020 IEEE 17th India Council International Conference (INDICON), 2020, pp. 1-5.

[17] W. Vijitkunsawat and P. Chantngarm, "Study of the performance of machine learning algorithms for face mask detection," in 2020-5th International Conference on Information Technology (InCIT), 2020, pp. 39-43.

[18] https://www.kaggle.com/datasets/luka77/facemask-detection-dataset-20000-images.

[19] A. Rahim, Y. Zhong, T. Ahmad, S. Ahmad, P. Plawiak, and M. Hammad, "Enhancing Smart Home Security: Anomaly Detection and Face Recognition in Smart Home IoT Devices Using Logit-Boosted CNN Models," Sensors (Basel), vol. 23, Aug 6, 2023.

[20] R. H. Al-Abboodi and A. A. Al-Ani, "A Novel Technique for Facial Recognition Based on the GSO-CNN Deep Learning Algorithm," Journal of Electrical and Computer Engineering, vol. 2024, pp. 1-21, 2024.

[21] M. DR, M. El Akmal, M. Ula, and I. Sahputra, "Facial-Based Autism Classification Using Support Vector Machine Method," International Journal of Computing and Digital Systems, vol. 16, pp. 875-886, 2024.

[22] S. S. Beulah Benslet and P. Parameswari, "Enhancement of Criminal Facial Image Using Multistage Progressive V-Net for Facial Recognition by Pixel Restoration," ICST Transactions on Scalable Information Systems, 2024.