SISTEKINFO
JURNAL SISTEM DAN TEKNOLOGI INFORMASI

e-ISSN : 3109 6522

Volume 2 • Number 2 • September 2025 • 1 - 5

A Literature Study on Deep Learning Approaches for Face Mask Detection in Air Pollution Mitigation

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Received: September 24, 2025 Accepted: September 27, 2025 Published: September 29, 2025

Abstract

Air pollution ranks among the most significant environmental health issues, especially in cities with elevated pollution levels. Face masks act as an easy but effective way to limit the intake of harmful pollutants like particulate matter (PM2.5), carbon monoxide, and various atmospheric substances. Nonetheless, the efficacy of maks is significantly infuluced by regular use among the public. In this scenario, progeress in deep learning and computer vision creates a change to create automated systems for detecting face maks. This study analyzes current literature on deep learning techniques for mask detection, emphasizing their significance in minimizing air pollution. The method uses a systematic literature review through databases such as Scopus, IEEE Xplore, MDPI, and ScienceDirect, encompassing works from 2020 to 2025. Articles ware examined according to architecture, datasets, and perfomace outcomes. Results indicate that YOLOv3 and MobileNetV2 models based on CNN achieve high precision (95-99%) in detecting masks, although the majority of studies concentrate on COVID-19 scenarios. Research gaps consist of the lack of specific datasets for pollution, restricted outdoor evaluations, absence of lightweight models for edge devices, and poor integration with air quality monitoring. This research emphasizes innovation by transitioning from pandemic sotuations to enduring air pollution, palceing AI-based mask detection as a viable public health approach

Keywords: Face Mask Detection, Air Pollution, Deep Learning, Public Health, Computer Vision

INTRODUCTION

Air pollution has emerged as one of the most significant global environmental health issues with the World Healt Organization (WHO) estimating that more than seven million early deaths are associated wirh air pollution annualy. Particulate matter (PM2.5), nitrogen oxides (NOx), sulfur dioxide (SO2), and volatile organic compounds (VOCs) are some of the most dangerous pollutants, particularly in cities with significant industrial operations and heavy vehicular congestion. Donning protective masks has been shown to greatly decrease personal exposure to these hazardous airbone contaminants

Though mask-wearing became universally common during the COVID-19 pandemic, the majorty of technological advancements inf face mask detection were driven by the need to implement public health strategies to curb viral spread (Das et al., 2020). Computer vision and deep learning techniques were widely developed to eversee compliance in public areas, especially using surveillance cameras connected to real-time monitoring systems. Nevertheless, studies indivate that despite significant cuts in emissions during the COVID-19 lockdowns, unanticipated pollution levels remained due to meteorological an atmospheric chemical element. This emphasiezes the necessity of ongoing monitoring systems outside of pandemic situantions.

Medical masks do not truly represent the efficacy of respirators, cloth masks, or industrial-quality filters essential for protection against pollution. Moreover, outdoor factors like haze, poor visibility, and smog are seldom represented in the datasets, diminishing the reliability of current models for pollution reduction. Advancement is still constrained in developing lightweight models that can function effectively on edge devices, crucial for implementation at a smart city level. Moreover, current systems often function in isolation, without integration with air quality monitoring platforms, which restricts their capacity to provide comprehensive insights for urban health initiatives (Tsokov et al., 2022). By transitioning the focus from pandemic usage to persistent air pollution challenges, face mask detection technologies can evolve from temporary enforcement tactics into sustainable, scalable solutions for protecting public health.

METHODS

This study employs a systematic literature rivew methodology, gathering pertinent articles from esteemed databases such as Scopus, IEEE Xplore, MDPI, and ScienceDirect, selected for their extensive coverage of computer science, healt, and environmental studies. The search procedure esed different keyword combinations like deeo learning, face mask detection, computer vision, smart city, air pollution, YOLO and CNN. To ensure the quality and relevance of the selected studies, the inclusion criteria stated that research employed deep learning techniques for mask detection, yielded quantitative results such as accuracy, precision, recall, or inference speed, and was published between 2020 and 2025. At the same time, exclusion criteria were applied to discard articles without empirical evaluation, opinion-based writings, or studies limited solely to COVID-19 issues with no broader significance for air pollution mitigation. The chosen studies were subsequently examined and categorized according to deep learning framework (Like CNN, YOLO, MobileNet, or ResNet)., dataset features (type of mask, indoor or outdoor settings), and performance matrics such as accuracy, spped of processing, and resilience. This methodological framework gurantees the study's reproducibility and enebles future researchers to expand on the findings by integrating new datasets or upcoming publications

FINDINGS AND DISCUSSION

Most research utilized CNN based models because of their demonstrated effectiveness in image recognition. (Das et al., 2020) showcased a CNN oriented approach built with TensorFlow and keras, attaining 96% accuracy for detecting face masks in real time. Likewise, YOLOv3 and MobileNetV2 were emphasized as efficient options, reaching accuracy rates of 95-99% on benchmark datasests (Nowrin et al., 2021). YOLO models are particularly appreciated for their rapid detection speed, essential for urban scale implementation where numerous surveillance channels need to be processed at once.

A major limitation noted in the literature is the dependence on datasets created mainly for COVID-19. These datasets generally include surgical masks in indoor, regulated lighting settings. In pollution related situations, the variety of masks should be broadened to encompass respirators, industrial masks, and multilayer fabric masks. Additionally, datasets seldom replicate environmental obstacles like smog, reduced visibility, or intense backlighting, which are typical in heavily polluted urban areas. Lacking this realism, existing models may struggle to perform adequately in outdoor situations.

An additional problem is that AI-driven mask detection systems are still mostly isolated. Few research efforts combine them with environmental monitioring systems or Internet of Things (IoT) networks that monitor air quality in real time. According to (Tsokov et al., 2022), frameworks for smart cities are progressively dependent on integrated sensors and analytics powered by AI. Incorporating mask detection into ehsse frameworks would allow officials to link air quality information with mask adherence, offering a comprehensive perspective on safeguariding public health in contaminated areas.

In general, the examined literature consistently demonstrates strong effectiveness of deep learning models but underscores the insufficient attention given to pollution reduction. By tackling dataset constraints, creating efficient architectures, and merging detection with smart city systems, AI-driven mask detection can transform nto a lasting solution beyond pandemic scenarios

Integration of mask detection and environmental monitoring

Recent research ephasizes the necessity of broadening mask detection studies beyond the scope of pandemic situations to include long-term uses related to air pollution. (Militante & Dionisio, 2020) showed that a CNN based system, when combined with a Raspberry Pi, can reach an accuracy of up to 96% in real time mask detection, along with an alarm system designed to improve public adherence. This discovery demonstrates that deep learning models are not only efficient in regulated settings but can also be implemented in affordable, scalable systems for wider public health efforts.

Simultaneously, (Le et al., 2020) highlighted that even with a significant 90% decrease in emissions during the COVID-19 lockdowns in China, pollution levels continued to evelevated due to meteorological influences such as humidity, air stagnation, and atmospheric checimal interactions. These findings emphasize the intricacy of pollution monitoring and the importance of merging AI based mask detection with real time air quality information. Such a marger could offer more thorough solutions for protecting urban populations in areas with severe pollutions.

This subsection indicates that upcoming research should focus on lingking mask setection systems with environmental monitoring platforms, thus facilitating comprehensive strategies that integrate individual protection with city wide pollution management.

CONCLUSION

This literature riview shows that deep learning methods like CNN, YOLO, and MobileNet attain high precision in tasks relate to face mask detection. Nonetheless, existing studies mainly concentrate on COVID-19 scenarios and ignore long-term strategies for pollution reduction. This paper's innovation consists of redefining mask detection as a tool for environmental health.

Future research should concentrate on creating pollution specific datasets that encompass various mask types and outdoor conditions, as these factors are crucial for guaranteeing reability in actual polluted settings. Equally significant is the enhancement of lighweight deep learning models that can operate efficiently on edge devices, essential for large scale, real time applications in smart city environments. Additionally, combining platforms would enable authorities to monitior mask compliance as well as link it directly to environmental factors.

By following these paths, face mask detection can evolve from a temporary pandemic response mechanism to a sustainable apporoach for reducing air pollution and protecting public health

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