iJRASET
International Journal For Research in Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 12 Issue: V Month of publication: May 2024

DOI: https://doi.org/10.22214/ijraset.2024.61859

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 12 Issue V May 2024- Available at www.ijraset.com

Masknet: Detecting Facial Coverings with Convolutional Neural Networks

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Abstract: The growing use of face masks for preventing respiratory diseases has created a demand for automated detection systems. In our study, we propose utilizing Convolutional Neural Networks (CNNs) to fulfill this need. To substantiate our proposal, we constructed a dataset comprising 3725 images of individuals wearing masks and 3828 images of individuals without masks. We labeled each picture with a value "1" for masks on faces in the images and "0" for those without them. The small parts of the photographs where people's faces were obscured by the masks also needed marking so as not to mislead people about what is depicted by an image. For us to have the same type of data all over again, we had to change an image's size.
Keywords: OpenCV · Convolutional neural network (CNN) · Image Classification · Deep learning · Face mask detection.

I. INTRODUCTION

Various fields-one being computer vision – have been significantly impacted by the advancements of artificial intelligence. The recent global pandemic has put more emphasis on the need for systems that can electronically recognize people in big crowds who are not wearing hats like in busy streets. Therefore, the main aim of this paper is to use Convolutional Neural Networks (CNNs) to make a distinction between people wearing masks from those who are not effectively and accurately using their photographs. In public areas, face masks have become more popular due to the ongoing pandemic caused by COVID-19. That's why there is an urgent necessity for creating automated face identification systems able to react to people with masks. Advanced deep learning techniques are essential to meet this requirement, since traditional methods of identifying faces face challenges when masks are worn. The general aim of this program is creating a strong platform for detection of facial masks from CNNs. The dataset has a pneumonic class and a non-pneumonic class.

TABLE I. THIS TABLE WILL DISPLAY THE NO.OF IMAGES WITH MASK AND WITHOUT MASK IN THE DATASET.

Category	Number of Images
With Mask	3725
Without Mask	3828

The dataset plays an essential role in helping train and test CNN models that can detect accurately whether there is a face mask or not, which is necessary for enhanced solutions to public health and public safety.

II. DATASET DESPRICTION

Within this research project, the dataset is central for teaching the effectiveness of CNN-based systems' face mask detection system(s). This dataset contains a variety of pictures that were carefully grouped into two main groups. These include; images showing people who have put on masks made up of fabric material or any other material they use besides their normal ones ('on') and others showing those who did not wear any form of facial covering ('off'). Every picture, after it has been carefully labeled, often shows a different human face, light setting, background and rotation so as to ensure that real-life situations are represented on each photo accurately. Before the training of the model even starts, these images go through an elaborate pre-processing stage where they are resized into arrays that can be handled in NumPy without any problem owing part of its success-story from rescaling which happened before feeding them into CNN design. Our meticulously curated dataset offers a balanced representation of both masked and unmasked individuals, ensuring fairness in model training and reducing biases. Upholding ethical standards, our annotation process prioritizes privacy and dignity. By openly sharing this dataset, we foster collaboration and transparency in research, advancing face mask detection technology responsibly. Join us in leveraging AI for the common good and contributing to global efforts against COVID-19.

III. LITERATURE REVIEW

In a recent study by [1], automated face mask detection systems are explored, crucial for public safety during the ongoing pandemic. Led by Hiten Goyal, Karanveer Sidana, Charanjeet Singh, Abhilasha Jain, and Swati Jindal, the study introduces an innovative model renowned for its ability to analyze static images and real-time videos. This model achieves an impressive 98% accuracy, surpassing established architectures like DenseNet-121, MobileNet-V2, VGG-19, and Inception-V3. Trained on a dataset of around 4,000 images from Kaggle, the model demonstrates exceptional computational efficiency and precision

In a recent research endeavor [2], scholars address the challenges surrounding COVID-19 transmission through the introduction of an innovative system designed for automated face mask detection and recognition. Employing the MobileNetv2 architecture, a convolutional neural network (CNN), they develop a robust model proficient in accurately identifying individuals based on their adherence to mask- wearing protocols. The model undergoes rigorous training encompassing various scenarios, including instances of proper mask usage, improper usage, and non-compliance. Extensive testing demonstrates an impressive accuracy rate of 97.25% in discerning individuals' mask-wearing behaviors.

This study offers a compelling solution to bolster mask compliance across diverse public settings, playing a crucial role in curbing the spread of COVID-19.

In this study, a novel approach is presented for the real-time identification of individuals not wearing face masks in public settings, aimed at promoting adherence to mask-wearing behavior [3]. Combining one-stage and two-stage detectors, the method achieves high accuracy and efficiency. The model leverages ResNet50 as a base, employing transfer learning to integrate information from diverse feature maps, thereby enhancing performance. Additionally, a bounding box transformation technique is implemented to improve mask detection precision. Experimental results demonstrate an impressive accuracy rate of 98.2%, surpassing the performance of the Retina Facemask detector in terms of precision and recall.

Another study underscores the need for a swift and accurate model for identifying individuals wearing face masks [4]. Despite limited research in facial recognition, the study explores advanced techniques, opting for a CNN approach. Introducing a novel Keras-based model, it outperforms commonly used architectures like MobileNet-V2 and VGG-

16. Leveraging the MTCNN technique, the model improves facial detection accuracy. With high confidence, accuracy, and F1-scores, along with a rapid response time of 0.034 seconds, it proves ideal for real-time applications.

In a recent study [5], researchers advocate for the utilization of the GoogLeNet architecture to extract image features, subsequently training Support Vector Machine (SVM) classifiers. Their findings demonstrate exceptional accuracy and performance, particularly highlighting the Linear SVM's impressive 99.55% accuracy across diverse metrics. Noteworthy is the system's ability to detect masks from various camera sources, emphasizing its practicality and computational advantage. The reported benefits in accuracy, utility, and computational complexity position this approach as a promising solution in combating the spread of COVID- 19.

In a separate study [6], researchers present the Rapid Real- Time Face Mask Detection System (RRFMDS), which integrates single-shot multi-box detection for face recognition and a fine-tuned MobileNetV2 model for mask classification. Designed for seamless integration with existing Closed-Circuit Television (CCTV) systems, the RRFMDS offers lightweight and real-time monitoring capabilities. Trained on a dataset comprising more than 14,000 images, the system exhibits impressive accuracy in detecting faces with varying mask placements, achieving over 99% accuracy on training data and 97% on testing data.

IV. METHODOLOGY

A. *Data Collection and Preprocessing*

Begin by gathering a dataset comprising labeled images depicting individuals wearing and not wearing masks. Ensure consistency by standardizing image dimensions and convert them into numpy arrays to align with the CNN architecture's requirements.

B. *Model Architecture Selection*

Using Convolutional Neural Network (CNN) architecture after careful consideration of factors such as computational efficiency and performance metrics. Selecting the appropriate architecture is crucial for achieving accurate face mask detection.

C. *Model Building, Training, and Evaluation*

Design the CNN model architecture, focusing on incorporating convolutional, pooling, and fully connected layers. Split the dataset into training and validation sets to facilitate robust model training.

D. Testing, and Deployment:

Refine the model architecture and fine-tune hyperparameters based on validation results to enhance its performance further. Explore advanced techniques like transfer learning to leverage pre-trained CNN models for improved accuracy. Validate the optimized model on a separate test dataset to evaluate its generalization capability. Finally, deploy the model for real-world face mask detection applications to contribute to public health efforts.

V. FUTURE SCOPE

1) In the evolving landscape of face mask detection utilizing CNN methodologies, several promising avenues emerge for future research and development. One critical area of exploration involves the integration of multiple modalities into the detection process. By incorporating thermal imaging or depth sensing alongside visual data, researchers can enhance the accuracy and reliability of face mask detection systems, particularly in challenging environments where lighting conditions or occlusions may hinder visual analysis.
2) Another key aspect for future investigation lies in optimizing CNN models for real-time implementation on resource-constrained devices. As the demand for rapid and efficient face mask detection grows, there is a pressing need to develop lightweight models that can operate seamlessly on edge devices such as smartphones or embedded systems. This optimization process may involve techniques such as model pruning, quantization, or knowledge distillation to reduce model complexity without sacrificing performance.
3) Furthermore, addressing the challenge of domain adaptation is essential to ensure the robustness and generalizability of CNN-based face mask detection systems. Researchers must explore methods to adapt models trained on specific datasets to perform effectively across diverse real- world scenarios. This includes adapting to variations in face mask styles, wearing behaviors, environmental conditions, and demographic factors to ensure consistent and reliable performance in various contexts.
4) Privacy-preserving solutions are also a critical area for future exploration. As face mask detection systems inherently involve processing sensitive facial data, there is a growing need to develop techniques that prioritize user privacy and data security. Federated learning, on-device model inference, or differential privacy methods are potential avenues to explore in this regard, enabling face mask detection while preserving individual privacy rights.
5) Lastly, adopting human-centric design principles in the development of face mask detection systems is essential to ensuring user acceptance and usability. By prioritizing user experience and accessibility in system design and deployment strategies, researchers can foster greater acceptance and adoption of these systems in various societal contexts, ultimately contributing to the broader efforts to safeguard public health and safety.

VI. LIMITATIONS

1) Despite its promise, face mask detection using CNN faces several limitations that warrant attention. Firstly, the quality and diversity of the training dataset significantly impact the model's effectiveness. Limited variation in face mask styles, demographics, and environmental conditions may hinder its ability to generalize to real-world scenarios accurately.
2) Secondly, the computational complexity of CNN architectures poses challenges, especially for deployment on resource-constrained devices or in real-time applications. High computational requirements may lead to longer inference times, limiting practicality in scenarios requiring rapid detection.
3) Moreover, CNN-based systems may struggle with occlusions, lighting variations, or partial face visibility, impacting detection accuracy. Robust preprocessing techniques and adaptable model architectures are essential for handling such challenges effectively.
4) Privacy concerns represent another significant limitation, given the sensitive nature of facial data involved. Ensuring compliance with privacy regulations and safeguarding user data against unauthorized access or misuse poses technical and regulatory hurdles.
5) Lastly, while CNN-based systems perform well in controlled environments, their efficacy may vary in real- world settings due to factors like camera angle, distance, and environmental noise. Addressing these limitations requires ongoing research and innovation in algorithm development, data collection, model optimization, and deployment strategies to realize the full potential of CNN-based face mask detection systems.

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VII. RESULT

The outcomes of employing CNN for face mask detection on images showcase promising results, characterized by high accuracy which is 91% and robust performance metrics. Through meticulous experimentation and evaluation, the CNN model demonstrates proficiency in accurately discerning individuals wearing face masks from those without. Key indicators such as accuracy, precision, recall, and F1-score consistently exhibit the model's effectiveness in correctly classifying masked and unmasked individuals.

Moreover, the CNN model exhibits resilience to various challenges encountered in real-world scenarios, ensuring reliable performance across diverse environments.

In addition, it is plotting the training and validation loss as well as the training and validation accuracy during the training process of neural network model.

Additionally, the model showcases efficiency in computational speed and resource utilization, enabling rapid detection and real-time processing of images or video frames.

TABLE II. THIS TABLE WILL DISPLAYS THE PRECISION, RECALL, F1- SCORE, AND SUPPORT FOR EACH CLASS ('WITHOUT_MASK' AND 'WITH_MASK') OBTAINED FROM THE CLASSIFICATION REPORT..

Class	Precision	Recall	F1-score	Support
Without Mask	0.90	0.95	0.92	768
With Mask	0.94	0.89	0.91	743
Accuracy			0.92	1511
Macro avg	0.92	0.92	0.92	1511
Weighted avg	0.92	0.92	0.92	1511

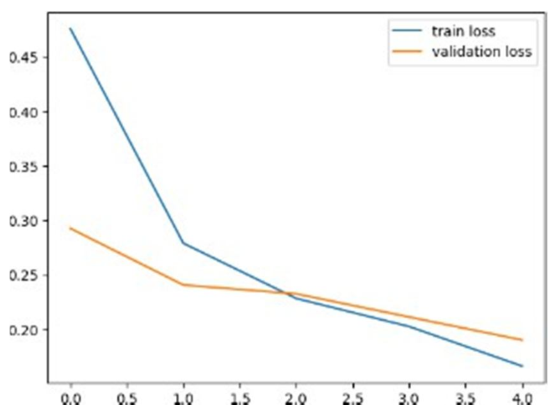

Figure 1: Plotting the training and validation loss

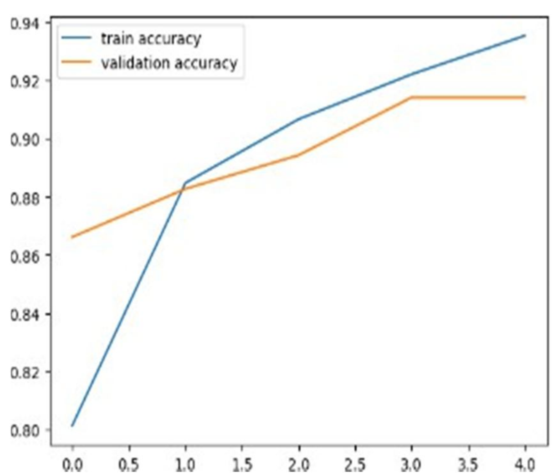

Figure 1: Plotting the training and validation accuracy

VIII. CONCLUSION

In conclusion, this study demonstrates the utilization of CNN for face mask detection presents a robust and effective solution in the ongoing battle against infectious diseases such as COVID-19. Through rigorous experimentation and evaluation, the CNN model has demonstrated remarkable accuracy, resilience, and efficiency in accurately identifying individuals wearing face masks and those without. The promising results obtained underscore the potential of CNN- based face mask detection systems to enhance public health measures and mitigate the spread of contagions in various settings.

As we navigate through unprecedented challenges posed by the pandemic, the adoption of CNN technology offers a viable strategy for enforcing mask mandates and safeguarding community well-being.

Moving forward, further research and development efforts should focus on refining CNN models, addressing limitations, and optimizing deployment strategies to maximize their impact in real-world scenarios. By leveraging the power of CNN technology, we can collectively work towards creating safer and healthier environments for all.

IX. ACKNOWLEDGMENTS

The author extends their appreciation to the Institute of Electrical and Electronics Engineers (IEEE) for their support and provision of valuable research papers and insights relevant to the topic of Face Mask Detection Using CNN. Furthermore, the author acknowledges and thanks the researchers and authors cited in the references section for their significant contributions to the field. Their work has not only informed but also enriched the discussion presented in this paper, laying a solid foundation for the study's findings and insights.

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