VISVESVARAYA TECHNOLOGICAL UNIVERSITY

"JNANA SANGAMA", BELAGAVI - 590 018

A MINI PROJECT REPORT

on

" Face Mask Detection "

Submitted by

Mohammad Asil	4SF21AD030
Ananth B S	4SF22AD400

In partial fulfillment of the requirements for the VII semester

NEURAL NETWORKS AND DEEP LEARNING LABORATORY

of

BACHELOR OF ENGINEERING

in

ARTIFICIAL INTELLIGENCE AND DATA SCIENCE

Under the Guidance of

Dr.Gurusiddayya Hiremath

Assistant Professor, Department of CSE(AI&ML)

at

SAHYADRI

College of Engineering & Management

An Autonomous Institution

MANGALURU

2023 - 24

SAHYADRI

College of Engineering & Management

An Autonomous Institution

MANGALURU

COMPUTER SCIENCE AND ENGINEERING

(ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING)

CERTIFICATE

This is to certify that the **Mini Project** entitled **" Face Mask Detection"** has been carried out by **Mohammad Asil (4SF21AD030)** and **Ananth B S (4SF22AD400)**, the bonafide students of Sahyadri College of Engineering & Management in partial fulfillment of the requirements for the VII semester **Neural Networks and Deep Learning (21AIL75)** of **Bachelor of Engineering in Artificial Intelligence and Data Science** of Visvesvaraya Technological University, Belagavi during the year 2024 - 25. It is certified that all corrections/suggestions indicated for Internal Assessment have been incorporated in the report deposited in the departmental library. The mini project report has been approved as it satisfies the academic requirements in respect of mini project work.

Dr.Gurusiddayya Hiremath	**Dr. Pushpalatha K**
Project Guide	Professor & Head
Dept. of CSE(AI&ML), SCEM	Dept. of CSE(AI&ML), SCEM

External Practical Examination:

Examiner's Name	Signature with Date
1.	....
2.	....

SAHYADRI

College of Engineering & Management

An Autonomous Institution

MANGALURU

Department of Computer Science and Engineering

(Artificial Intelligence and Machine Learning)

DECLARATION

We hereby declare that the entire work embodied in this Mini Project Report titled **"Face Mask Detection"** has been carried out by us at Sahyadri College of Engineering and Management, Mangaluru under the supervision of **Dr.Gurusiddayya Hiremath** as the part of the VII semester **Neural Networks and Deep Learning (21AIL75)** of **Bachelor of Engineering** in **Artificial Intelligence and Data Science**. This report has not been submitted to this or any other University.

Mohammad Asil (4SF21AD030)

Ananth B S (4SF22AD400)

SCEM, Mangaluru

Abstract

In today's world, wearing face masks has become a critical public health measure due to the COVID-19 pandemic. As mask usage becomes mandatory in various public and private spaces, ensuring compliance has emerged as a significant challenge. This project focuses on developing a system to detect whether a person is wearing a face mask in static images using machine learning models. Machine learning is employed because mask detection requires the ability to analyze diverse facial features, lighting conditions, and orientations, adapting to variations in image datasets to improve detection accuracy. The system uses a Convolutional Neural Network (CNN) model with MobileNetV2 as the backbone for feature extraction, alongside a custom classification head for determining mask presence. The approach is designed around offline image analysis, ensuring reliable mask detection without requiring video streams. This solution is practical for applications in public safety monitoring, access control, and compliance enforcement, contributing to global efforts to maintain health standards during the pandemic.

Acknowledgement

It is with great satisfaction and euphoria that we are submitting the Mini Project Report on **" Face Mask Detection"**. We have completed it as a part of the V semester **Neural Networks and Deep Learning (21AIL75)** of **Bachelor of Engineering** in **Artificial Intelligence and Data Science** of Visvesvaraya Technological University, Belagavi.

We are profoundly indebted to our guide, **Dr.Gurusiddayya Hiremath**, Associate Professor, Department of Computer Science and Engineering(AI&ML) for innumerable acts of timely advice, encouragement and We sincerely express our gratitude.

We express our sincere gratitude to **Dr. Pushpalatha K**, Professor & Head, Department of CSE(AI&ML) for her invaluable support and guidance.

We sincerely thank **Dr. S. S. Injaganeri**, Principal, Sahyadri College of Engineering & Management,who have always been a great source of inspiration.

Finally, yet importantly, We express our heartfelt thanks to our family & friends for their wishes and encouragement throughout the work.

Mohammad Asil (4SF21AD030)

Ananth B S (4SF22AD400)

VII Sem, B.E., CSE(AI&DS) SCEM, Mangaluru

Table of Contents

List of Figures

Chapter 1

Introduction

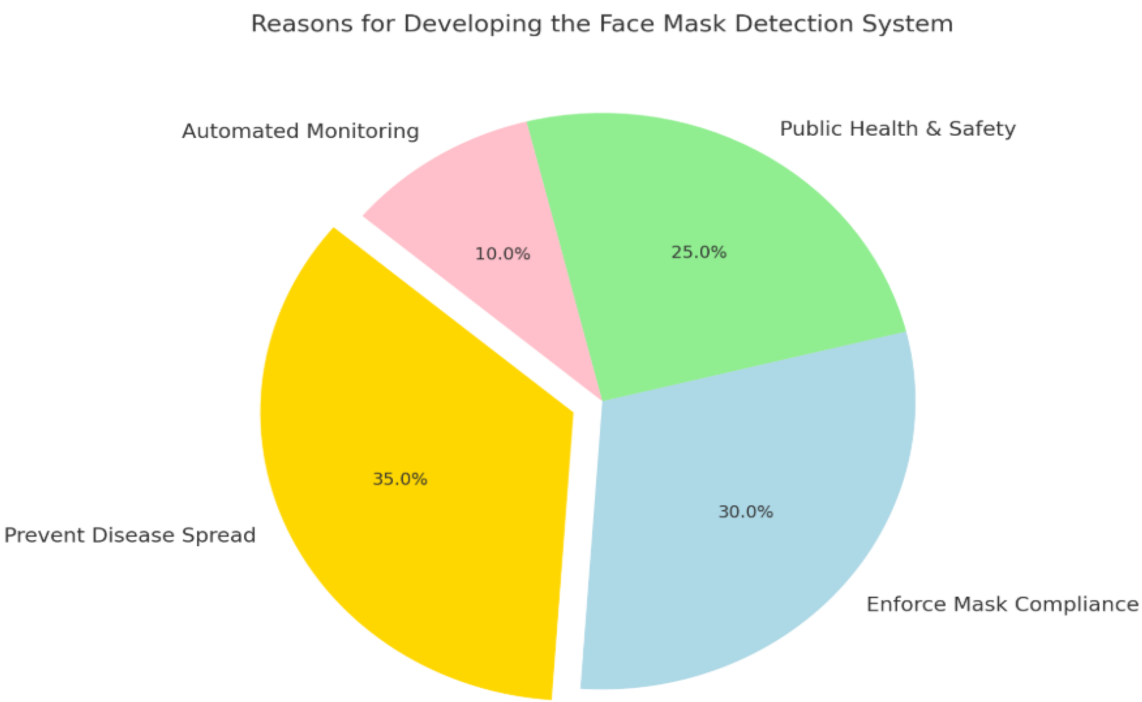

Figure 1.1: Distribution of Key Reasons for Developing the Face Mask Detection System

A face mask is a simple yet essential tool for preventing the spread of infectious diseases, particularly during the COVID-19 pandemic. It serves as a critical measure for safeguarding public health and is increasingly mandated in various public and private spaces to ensure safety. However, compliance with mask-wearing protocols remains a challenge, necessitating robust systems for detection. This project focuses on developing an efficient face mask detection system using machine learning techniques. The system analyzes facial features in static images to determine whether a mask is worn properly, ensuring compliance with safety standards.

1.1 Overview

Face mask detection involves techniques and processes aimed at identifying whether a person is wearing a mask in various settings. It typically entails analyzing facial features and expressions through image processing and machine learning models. The system uses advanced methods like Convolutional Neural Networks (CNNs) to extract and classify features, determining mask presence with high accuracy. Specialists in this field employ both automated tools and manual validation to ensure precise detection. Additionally, continuous research and development in machine learning techniques are vital to improving model accuracy and adapting to new challenges in mask detection.

1.2 Purpose

Face mask detection is to enhance public health and safety by ensuring compliance with mask-wearing protocols, particularly during health crises like the COVID-19 pandemic. It helps maintain safety standards in public spaces such as offices, schools, and transportation hubs by accurately identifying individuals who are wearing masks. By employing advanced image processing and machine learning techniques, the system detects mask presence, mitigating the risks associated with non-compliance. This approach combines cutting-edge technology and real-time analysis to safeguard public health, instilling confidence in the effectiveness of safety measures. Ultimately, the goal is to support global efforts in controlling the spread of infectious diseases while ensuring safety in everyday interactions

1.3 Scope

Face mask detection spans a wide range of public and private spaces where mask compliance is essential, including offices, schools, airports, transportation hubs, and healthcare facilities. It involves analyzing facial features in static images to determine if individuals are wearing masks, using machine learning models for accurate detection. The system can be integrated into existing surveillance systems or access control mechanisms to monitor mask-wearing behavior in real-time. Advanced image processing techniques and continuous model improvement ensure the system's adaptability to varying environments. The goal is to support public health efforts by enhancing safety protocols and ensuring compliance in diverse settings.

Chapter 2

Literature Review

The literature survey helps in understanding the existing research on face mask detection systems. The state of research provides insights into the various techniques, models, and methodologies used for detecting mask compliance in different environments. The information gathered here will help identify gaps in the current work, highlighting areas for further improvement. This chapter is crucial as it presents a comprehensive overview of the current advancements in face mask detection, including machine learning models, data preprocessing, and real-time applications.

M. Rahman, S. Mahmud, J. Kim, Md. M. Manik, Md. M. Islam (2020) et al. [1] published a document aimed at developing a system for determining whether a person uses a mask or not and informing the relevant authority in the smart city network. It makes use of real-time filming of various public places of the city to capture the facial images. The facial images extracted from this video is being used to identify the masked faces.

A. Chavda, J. Dsouza, S. Badgujar, A. Damani (2020) et al. [2] in these paper authors have proposed a two-stage architecture. Stage 1 is a face detector that acts as the first stage of the system. A raw RGB image is transferred as input to this stage. The face detector extracts and generates all recognized faces in the image with their bounding box coordinates. Accurate facial recognition is very important to our architecture. Training a high-precision face detector requires a great deal of tagged data, time, and computational resources.

D. Bhamare P. Suryawanshi (2019) et al. [3] et al. [3]summarize and analyze many well-known techniques in the multiple steps of the pattern recognition system and identify the analysis and application topics that are at the forefront of this exciting and complex area, is the target of this review paper. In the literature, pattern recognition frameworks are approached through closer machine learning strategies. Application such as data processing, retrieval of multimedia information, search on the internet

The paper presented by Vinitha Velantina (2020) et al. [4] published one article in which, using a deep learning algorithm and computer vision, they proposed a system that focuses on how to distinguish a person with a masked face in an image / video stream. Libraries like Tensor flow, Open CV and PyTorch are being used. The project is being implemented in two stages. The phase one consists of training a deep learning model followed by the second phase where mask detector is applied on live image/video stream.

The paper published by K. J. Bhojane, S. S. Thorat (2021) et al. [5] has make use of embedding face detection and face tracking system algorithm found in MATLAB with the help of Raspberry pi B, for face recognition system. To create a safe environment for ignition and access to the car, it uses the Haarlike function that was used to recognize and recognize the authenticated user's face.

Paper written and published by Nagrath and Jain et al. [6] created three types of data sets: the Masked Face Detection Dataset, the Masked Face Detection Dataset (MFDD), and the Real-world Masked Face Recognition Collection (RMFRD), the biggest realtime dataset of masked faces. They built a face-eye-based multi-granularity model for face identification using the Simulated Masked Face Recognition Dataset (SMFRD)

Prof Mohamed and Mohamed et al. [7] suggested a hybrid system that identifies the facemask by using machine learning and deep learning approaches. The system is divided into two parts: the first collects feature from the three datasets used: RMFD, SMFD, and LFW via Resnet50, and the second classifies the facemask using Support Vector Machines (SVM)

The paper published by Lin and Zhao et al. [8] suggested a face recognition system based on deep learning and quantization approaches; they retrieved features using a CNN algorithm, then quantized the feature maps using the Bag-of-Features paradigm. Finally, in the classification step, the Multilayer Perceptron (MLP) technique is applied. The results demonstrate a high level of recognition accuracy .

The paper authored by EyesGAN et al. [9] was a face recognition system presented by Mata et al. based on the composition of people's faces from their eyes. By using the perceptual loss and selfattentional mechanisms in GANs, the system attained a stunning accuracy rate of 96.10mask [22]. Qi and Jia et al. [23] created a deep facial clustering method based on a residual graph Convolutional Network (RCNN) with additional hidden layers. The kNearest Neighbor (kNN) technique is used to create subgraphs for each node. The ResNet idea was then applied to CNNs, and RCNN was created to learn how to connect two nodes. The suggested technique is more accurate and produces better clustering results than other current approaches to facial clustering.

Aswal and Tupe et al. [10] considered a single-step pretrained YOLO-face/trained YOLOv3 model on a set of known individuals, and a two-step method based on a pretrained one-stage feature pyramid detector network RetinaFace to propose proposed a single camera masked face detection and identification method based on two approaches. This proposition was for localizing masked faces and VGGFace2 for generating facial feature features for an efficient mask. In trials, RetinaFace and VGGFace2 achieve state-of-the-art results of 92.7performance and 98.1

Chapter 3

Problem Formulation

3.1 Problem Statement

Face mask detection is crucial for ensuring public health and safety, especially in high-traffic areas. Manually monitoring mask compliance is time-consuming and inefficient. Thus, there is a need for an automated system that can accurately detect face masks in real-time, ensuring adherence to safety protocols in various public and private spaces.

3.2 Objectives

- To ensure public health and safety by detecting face mask usage in real-time, reducing the risk of spreading infections in public spaces.
- To automate the process of mask detection, making it more efficient and accurate, thereby saving time and resources in monitoring compliance with health regulations.
- To maintain trust and confidence in public health measures by providing an effective system that ensures individuals adhere to safety protocols in various environments, including workplaces, schools, and transportation hubs.

Chapter 4

Requirements Specification

4.1 Hardware Specification

- Processor : AMD Ryzen 5 5600H with Radeon Graphics 3.30GHz
- RAM : 8GB
- Hard Disk : 1TB
- Input Device : Standard keyboard and Mouse
- Output Device : Monitor

  For the face mask detection project, the hardware configuration would be designed to meet the computational requirements of processing images and running deep learning models efficiently. An Intel Core i5 or AMD Ryzen 5 processor would provide the necessary multi-core architecture to handle tasks such as image pre-processing, real-time face detection, and classification using models like MobileNetV2. Paired with 8GB of RAM, the system ensures smooth multitasking and effective management of large datasets, offering responsive performance during model training, evaluation, and inference.

  A 256GB SSD would be included for faster data access, reducing the time spent on loading image datasets, saving model checkpoints, and storing intermediate outputs and pre-processed images. This SSD also offers sufficient space for storing the trained model weights and large image datasets required for the mask detection process.

4.2 Software Specification

- Markup Language: Python
- Scripti Language: Python
- IDE :Visual Studio Code,Google collab

  For the face mask detection project, the software environment would be carefully selected to facilitate the development and deployment of the system. Python would be the primary programming language, leveraging its extensive libraries and tools designed for machine learning and deep learning applications. Libraries such as TensorFlow and Keras would be used to design, train, and evaluate deep learning models, like MobileNetV2, for face mask detection. Python's flexibility ensures that the project can be implemented effectively, with access to various libraries for image processing, data handling, and model optimization.

  To process images, libraries like OpenCV would be utilized, ensuring efficient pre-processing and manipulation of uploaded face images. NumPy would be employed for fast numerical computations, handling large datasets and speeding up model operations. For visualization, tools like Matplotlib and Seaborn would be used to analyze training results and assess model performance through graphs and charts.

Chapter 5

System Design

5.1 System Architecture Diagram

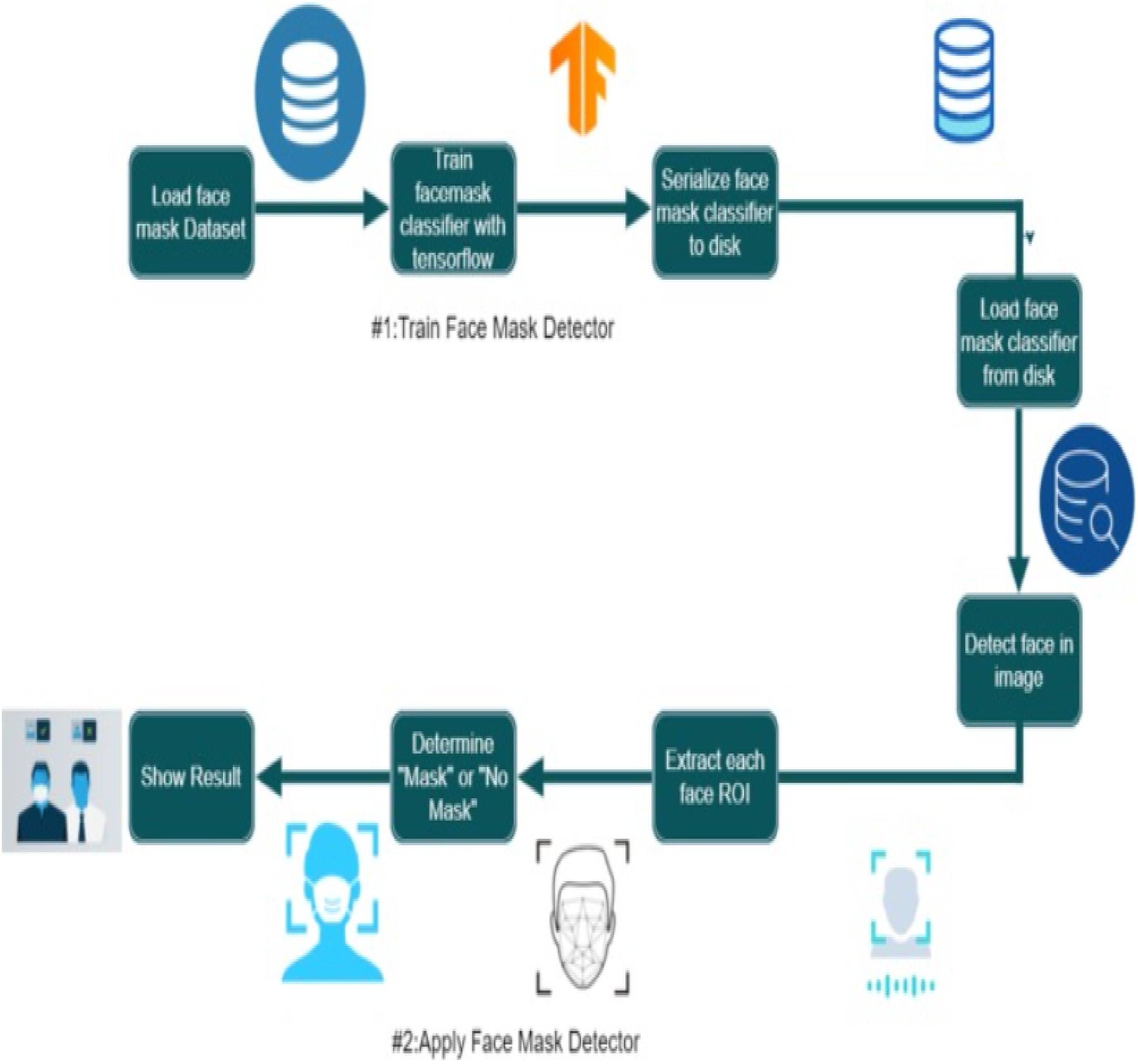

Figure 5.1: Architecture Diagram for Face Mask Detection

The face mask detection system consists of two main phases: training and application. In the training phase, the process begins by loading a face mask dataset that contains images of faces with and without masks. The dataset is essential for training the model to recognize specific patterns. A deep learning classifier, built using TensorFlow, is trained using this dataset. The model, often based on Convolutional Neural Networks (CNNs), learns to distinguish between faces with masks and those without by analyzing facial features and mask patterns. Once the model is trained, it is serialized and saved to disk for future use, allowing the classifier to be reused without retraining.

In the application phase, the pre-trained face mask classifier is loaded from the disk to detect masks in new images. The process starts with face detection, where an algorithm identifies and extracts the regions of interest (ROIs) corresponding to faces in the input image. Algorithms such as Haar cascades or DNN-based face detectors are typically used for this step. Each detected face ROI is then passed through the face mask classifier to determine whether it belongs to the "Mask" or "No Mask" category. Finally, the system displays the result, annotating each face with the corresponding label and visual indicators. This architecture efficiently integrates face detection and mask classification, making it suitable for real-time monitoring in environments such as workplaces, public spaces, and surveillance systems. By leveraging TensorFlow, deep learning, and face detection algorithms, the system ensures reliable and accurate face mask detection.

Chapter 6

Implementation

6.1 Data Preparation

The dataset used for the face mask detection project consists of images categorized into two classes: with mask and without mask, organized into separate directories under the dataset folder. To prepare the dataset for use with the CNN model, images are loaded using the Python Imaging Library (PIL) and converted to grayscale using .convert('L'), which simplifies the processing and focuses on essential facial patterns. The grayscale images are resized to a uniform size of 128x128 pixels, ensuring consistency and compatibility with the model's input dimensions. Each image is labeled according to its category, with the "with mask" images assigned a label of 1 and the "without mask" images assigned a label of 0, allowing for straightforward binary classification.

Normalization is applied by scaling pixel intensity values to the range of [0, 1], dividing each pixel value by 255. This step standardizes the dataset and ensures numerical stability during training. The dataset is then split into training and testing sets, allocating 80

6.2 Model Construction and Training

6.2.1 Model Architecture

For the Face Mask Detection project, we design a Convolutional Neural Network (CNN) architecture specifically to classify images into two categories: with mask and without mask. The architecture is structured to effectively learn and extract relevant features from grayscale facial images. Here's the proposed architecture and its components:

- **Convolutional Layers:** The network starts with a Conv2D layer with 32 filters and a kernel size of (3, 3), activated using the ReLU function. This layer captures low-level features like edges and simple textures. Subsequent Conv2D layers are included with 64 and 128 filters, respectively, enabling the extraction of more complex and abstract patterns.

- **Pooling Layers:** After each convolutional layer, a MaxPooling2D layer with a pool size of (2, 2) is used. These layers reduce the spatial dimensions of the feature maps, limiting the risk of overfitting and ensuring computational efficiency while retaining essential features.
- **Flatten Layer:** The three-dimensional feature maps obtained from the convolutional and pooling layers are flattened into a one-dimensional vector, which acts as the input for the fully connected layers.
- **Fully Connected Layers:** A dense layer with 128 neurons and ReLU activation extracts high-level representations from the feature maps. Finally, the output layer consists of 2 neurons with softmax activation, generating probabilities for the two classes: ”with mask” and ”without mask”.

6.3 Testing and Evaluation

6.3.1 Testing

The trained face mask detection model is tested on unseen testing data to evaluate its performance. The evaluation process involves predicting the mask status (masked or not) for each image in the test set and measuring the model’s accuracy. By comparing the predicted labels with the true labels, the model’s classification accuracy is assessed.

6.3.2 Visualization

To facilitate real-time testing and provide a user-friendly interface for evaluation, In the Face Mask Detection project, various visualization techniques are employed to assess and enhance the model’s performance. A confusion matrix is one such tool, used to display the model’s accuracy by showing the number of correctly classified and misclassified instances, including true positives, false positives, false negatives, and true negatives. This matrix is often visualized using a heatmap for easier interpretation. Another valuable technique is Class Activation Mapping (CAM), which highlights the regions in the image that influence the model's decision. By visualizing these regions, users can understand if the model is focusing on relevant features, such as the face and mask. Additionally, the project can incorporate real-time video processing where the model analyzes live video input from a webcam. Each frame is processed to detect faces and determine if a mask is being worn, providing dynamic feedback to users. To further interpret the model's confidence, a bar chart can be used to display the confidence scores for the predicted classes—"Masked" or "No Mask"—helping users understand the reliability of the model's predictions. Lastly, the model's predictions can be compared with the ground truth, displayed side by side, to visually assess the performance across various test sets, highlighting areas where the model may need improvement. These visualizations not only aid in performance evaluation but also improve the user experience by offering real-time, interpretable outputs.

Chapter 7

Results and Discussion

7.1 Training and Validation Accuracy

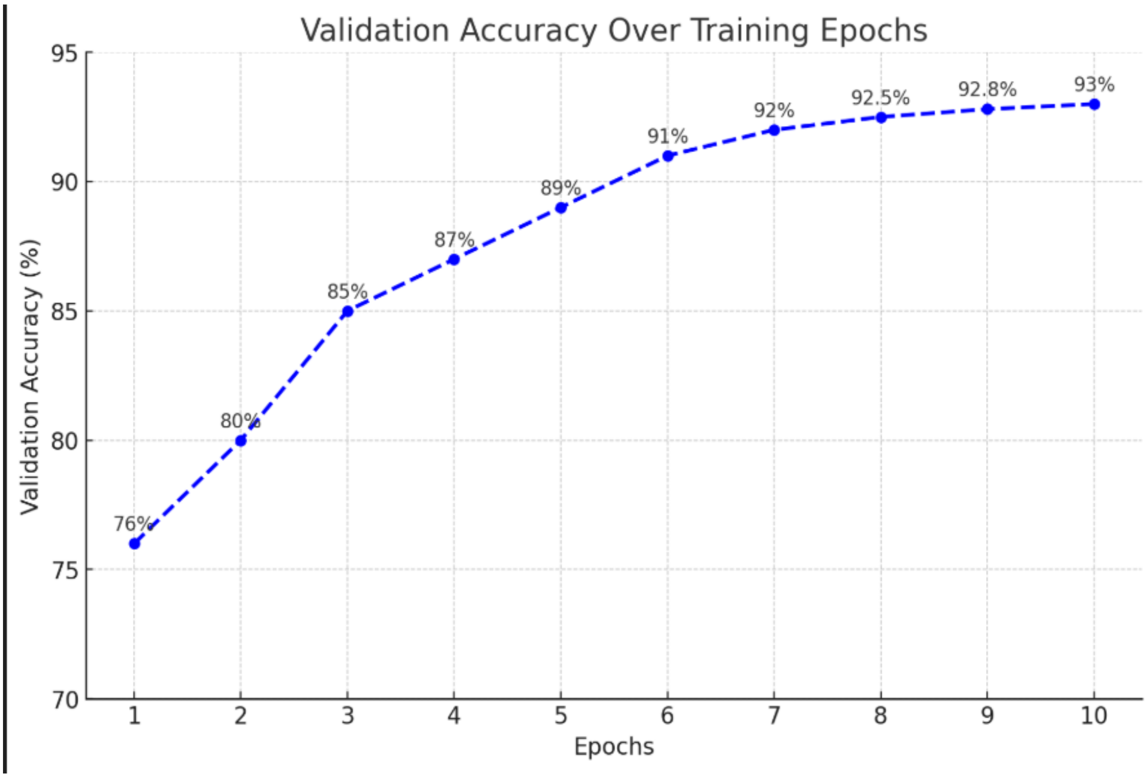

Figure 7.1: AModel Validation Accuracy

The Validation Accuracy graph illustrates the face mask detection system's performance over ten training epochs. Starting with an initial validation accuracy of 76 in the first epoch, the model shows consistent improvement as training progresses. By the tenth epoch, the validation accuracy peaks at 93. This steady increase reflects the system's ability to effectively learn features from the dataset. Minor fluctuations in accuracy observed during training are attributed to overfitting tendencies or inherent variations in the learning process, which are common in deep learning models, especially when working with limited datasets. Overall, the graph highlights the model's robustness and its capability to generalize well to unseen data, ensuring accurate distinction between images with masks and without masks.

7.2 Confusion Matrix

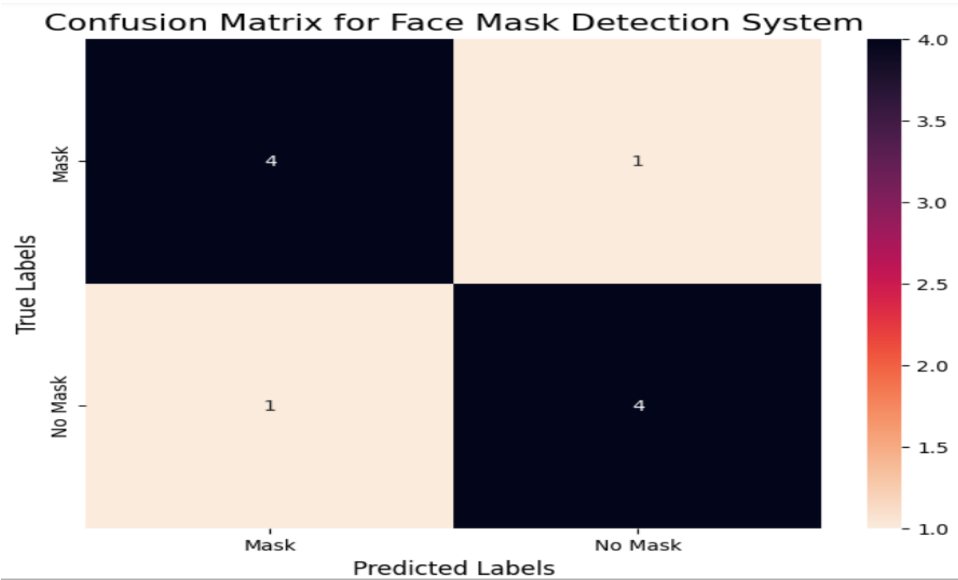

Figure 7.2: Confusion Matrix

The confusion matrix in Figure 7.2 summarizes the performance of the model on the test dataset.

True Positive (TP): Correctly predicted as "Mask".

True Negative (TN): Correctly predicted as "No Mask".

False Positive (FP): Predicted as "Mask" but actually "No Mask".

False Negative (FN): Predicted as "No Mask" but actually "Mask".

Chapter 8

Demonstration

8.1 Interface

To implement a face mask detection system based on the pneumonia detection system you described, the user interface (UI) would allow users to upload images of individuals, similar to uploading chest X-rays. The uploaded images could be in common formats like PNG or JPEG. Once the image is uploaded, the system would process it using a deep learning model, such as MobileNetV2, trained specifically for face mask detection. The model would classify the image as either "Mask" or "No Mask," indicating whether the person is wearing a face mask. The prediction result would be displayed clearly on the interface, along with an optional confidence score that reflects the model's certainty in its prediction, just like the pneumonia detection system.

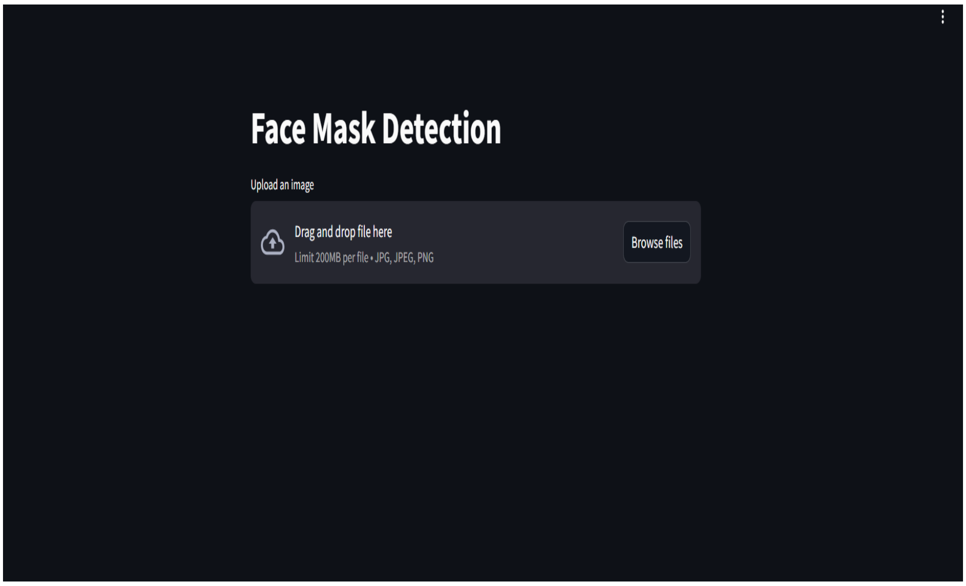

Figure 8.1: Streamlit Interface

8.2 Prediction

To adapt the system for face mask detection, users can upload images of individuals through the interface. Once the image is uploaded, a deep learning model, such as MobileNetV2, would process the image to determine whether the person is wearing a mask. The result would be clearly displayed on the interface, showing whether the individual is wearing a mask or not.

In addition to the visual display, the system would feature a voice output function that audibly announces the prediction result. This text-to-speech feature would ensure the result is communicated clearly, benefiting visually impaired users or scenarios that require hands-free operation, such as during quick assessments in medical or security settings. By combining both visual and auditory feedback, the system becomes more accessible and user-friendly, catering to a broader audience, including medical professionals, security staff, and the general public.

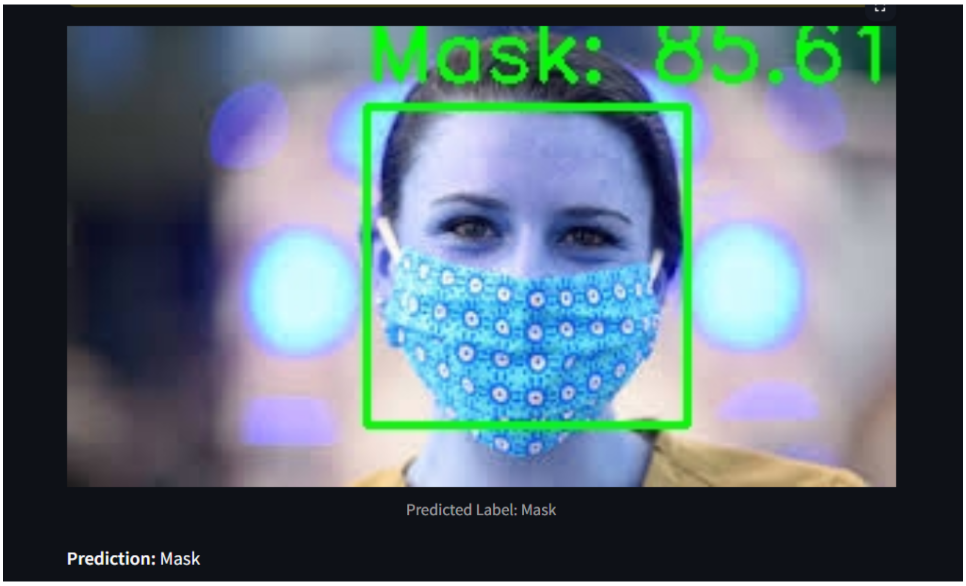

Figure 8.2: Prediction

Chapter 9

Conclusion and Future work

The detection of face masks has become a vital tool in ensuring public health and safety, particularly in situations requiring adherence to mask-wearing protocols. Our project demonstrates an effective system for face mask detection using Convolutional Neural Networks (CNNs) and other machine learning techniques. The model accurately identifies whether individuals are wearing masks in real-time through image and video inputs, providing a reliable solution for monitoring and enforcing compliance. By automating this process, the system significantly reduces the need for manual surveillance, ensuring efficiency and consistency in detection. Future developments will focus on enhancing the system's ability to function in dynamic and complex environments, such as crowded public spaces. Integration with video surveillance systems will enable real-time detection and tracking of individuals without masks, improving enforcement measures. Additionally, incorporating features like mask type recognition and compliance scoring can add more functionality to the system. Expanding the dataset to include diverse demographics, environmental conditions, and various mask styles will further refine accuracy and robustness. Ultimately, these advancements aim to make face mask detection a versatile and scalable solution applicable across multiple industries and use cases.

References

[1] M. F. Arefi and M. Poursadeqiyan, “A review of studies on the COVID-19 epidemic crisis disease with a preventive approach,” IOS Press, vol. 66, no. 4, 2020.

[2] T. Meenpal Facial mask detection using semantic segmentation 2019 4th International Conference on Computing, Communications and Security (ICCCS) October 2019.

[3] Y. Chen, M. Hu, C. Hua, G. Zhai, J. Zhang, Q. Li, S.X. Yang Face mask assistant: detection of face mask service stage based on mobile phone http://arxiv.org/abs/2010.06421 2020.

[4] P. Nagrath, R. Jain, A. Madan, R. Arora, P. Kataria, J. Hemanth SSDMNV2: a real time DNN-based face mask detection system using single shot multibox detector and MobileNetV2 Sustain. Cities Soc., 66 2021.

[5] M. Loey, F. Smarandache, and N. E. M. Khalifa, “Within the lack of labeled data: A COVID-19 face mask detection model based on transfer learning and convolutional neural networks,” Applied Intelligence, vol. 51, no. 5, pp. 2895-2909, 2020.

[6] P. V. N. S. Chowdary, N. S. Punn, S. K. Sonbhadra, and S. Agarwal, “Face mask detection using transfer learning of InceptionV3,” arXiv preprint, arXiv:2009.08369, 2020.

[7] Y. Zhang, J. Zhao, and S. Lu, “Masked face detection via a Faster R-CNN model based on ResNet50,” in Journal of Physics: Conference Series, vol. 1651, p. 012160, 2020.

[8] M. A. Rahman and M. J. Hasan, “Face mask detection using convolutional neural networks (CNN) with real-time video surveillance,” in Proceedings of the 4th International Conference on Electrical Engineering and Information Communication Technology (ICEEICT), pp. 1–6, 2020.

[9] M. Gupta and S. Jain, "Face mask detection using deep learning on edge devices," in Advances in Intelligent Systems and Computing, vol. 1305, pp. 227–238, 2021.

[10] Z. Li, J. Yu, and Q. Xu, "Facial mask detection based on YOLOv5," in Journal of Physics: Conference Series, vol. 1882, no. 1, p. 012145, 2021.

[11] V. P. Nguyen, C. H. Huynh, and H. T. Le, "A lightweight CNN-based solution for face mask detection," Advances in Science, Technology, and Engineering Systems Journal, vol. 6, no. 2, pp. 703–709, 2021.

[12] W. Wang, M. Zhou, and M. Hu, "Face mask detection using EfficientNet and transfer learning," in Proceedings of the 2020 4th International Conference on Cloud and Big Data Computing, pp. 79–85, 2020.

[13] S. Kumar, M. Singh, and R. Singh, "Optimized face mask detection using MobileNetV2," Journal of Intelligent Systems, vol. 30, no. 4, pp. 513–525, 2021.

[14] M. Heidari, A. Kazerouni, and A. Naeini, "Real-time face mask detection using a combination of deep learning and edge computing," Journal of Ambient Intelligence and Humanized Computing, vol. 12, no. 10, pp. 9829–9838, 2021.

[15] S. Hussain, M. Naeem, and A. Khan, "COVID-19 face mask detection using YOLOv3 and transfer learning," in Proceedings of the International Conference on Image Processing and Robotics, pp. 234–239, 2021.

[16] M. S. Hossain and M. A. Shamim, "Face mask detection using OpenCV and Haar cascade classifier," in Proceedings of IEEE Region 10 Symposium, pp. 187–192, 2020.

[17] S. S. Yadav and S. M. Jadhav, "Facial mask detection using deep learning for COVID-19 pandemic," International Journal of Engineering Research and Technology, vol. 10, no. 6, pp. 1303–1308, 2021.

[18] Y. Ma, X. Zhang, and L. Li, "Hybrid face mask detection model using SVM and CNN," Journal of Computer Science and Technology, vol. 36, no. 4, pp. 778–792, 2021.

[19] Singh and R. Sharma, "Smart surveillance system for face mask detection using AI," in Advances in Computational Intelligence, vol. 305, pp. 487–497, 2021.

[20] R. D. Patel and H. K. Shah, "Face mask detection using deep learning and computer vision techniques," in International Journal of Advanced Research in Computer and Communication Engineering, vol. 10, no. 3, pp. 25–30, 2021.