



Face Mask Detection Using Deep Learning

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Abstract

The COVID-19 pandemic emphasized the importance of automated systems for monitoring public health regulations, particularly face mask usage in public environments. Manual inspection methods are inefficient, subjective, and difficult to scale. This graduation project presents a comprehensive study and planning phase for developing a face mask detection system using deep learning and computer vision techniques. The project reviews the theoretical foundations of artificial intelligence, deep learning, and convolutional neural networks, analyzes related research, identifies suitable datasets, and defines a structured methodology for system development. The outcomes of this project provide a strong academic and technical foundation for implementation and experimentation in Graduation Project 2.

Keywords: Face Mask Detection, Deep Learning, Computer Vision, Convolutional Neural Networks, COVID-19

Chapter1: Introduction

Artificial Intelligence (AI) has become one of the most influential technological fields in recent decades. AI systems are designed to simulate human intelligence by performing tasks such as learning, reasoning, perception, and decision-making. One of the most impactful subfields of AI is computer vision, which enables machines to analyze and interpret visual data such as images and videos. Face analysis is a critical application of computer vision. It includes tasks such as face detection, face recognition, emotion recognition, and facial attribute classification. These technologies are widely applied

in security systems, biometric authentication, surveillance, smart cities, and human–computer interaction.

The outbreak of the COVID-19 pandemic created unprecedented challenges for healthcare systems and governments worldwide. Health organizations emphasized the importance of wearing face masks as an effective preventive measure to reduce virus transmission. As a result, monitoring compliance with mask-wearing policies became a significant concern.

Traditional manual monitoring methods rely heavily on human supervision, which is costly, time-consuming, and prone to error, particularly in crowded environments such as airports, hospitals, shopping malls, and universities. These limitations highlighted the need for automated and intelligent monitoring solutions.

Deep learning techniques, especially convolutional neural networks (CNNs), have demonstrated outstanding performance in image classification and object detection tasks. By leveraging these techniques, automated face mask detection systems can be developed to analyze images and video streams accurately and efficiently.

This graduation project focuses on the study, analysis, and planning of a deep learning-based face mask detection system. Graduation Project 1 emphasizes understanding the problem domain, reviewing existing literature, selecting appropriate datasets, and defining a structured methodology for system development.

The scientific contribution of this project lies in providing a comprehensive academic review of face mask detection approaches, identifying current limitations, and proposing a robust framework suitable for real-world deployment.

This chapter also outlines the objectives, scope, and organization of the report, serving as a foundation for the subsequent chapters.

Chapter 3: Overview

This chapter presents the theoretical background required for understanding the proposed face mask detection system. It introduces the fundamental concepts of artificial intelligence, machine learning, and deep learning.

Artificial Intelligence refers to the capability of machines to perform tasks that typically require human intelligence. AI applications include expert systems, recommendation systems, robotics, and computer vision.

Machine Learning is a subset of AI that enables systems to learn patterns from data without explicit programming. Supervised learning is widely used in image classification tasks where labeled datasets are available.

Deep learning is an advanced form of machine learning based on artificial neural networks with multiple hidden layers. Deep learning models automatically extract hierarchical features from raw data, making them highly effective for visual tasks.

Artificial Neural Networks are inspired by the biological structure of the human brain. They consist of interconnected neurons organized into layers, each applying mathematical operations to input data.

Convolutional Neural Networks (CNNs) are specifically designed for image processing tasks. CNNs utilize convolutional layers to extract spatial features, pooling layers for dimensionality reduction, and fully connected layers for classification.

Transfer learning is a widely used approach in deep learning that involves reusing pre-trained models trained on large datasets such as ImageNet. This approach reduces training time and improves performance when data is limited.

In face mask detection systems, CNN-based models analyze facial images and classify them into masked and unmasked categories.

Chapter 4: Related Work

The COVID-19 pandemic triggered extensive research on automated face mask detection systems. Researchers proposed various deep learning-based solutions to address public health monitoring challenges.

Loey et al. proposed a hybrid approach combining deep transfer learning with traditional machine learning classifiers. Their model achieved high accuracy on controlled datasets but showed limitations in real-world conditions.

Chowdary et al. introduced a lightweight face mask detection system based on MobileNetV2. The model was optimized for mobile and embedded devices, offering a balance between accuracy and computational efficiency.

Nagrath et al. developed a real-time face mask detection framework using Single Shot Detector (SSD) with MobileNet. The system demonstrated effective performance in live video streams.

Several other studies explored different CNN architectures, data augmentation strategies, and transfer learning techniques to improve robustness and generalization.

Despite promising results, most existing studies rely on controlled datasets and limited testing scenarios, which restrict their applicability in real-world environments.

The review of related work highlights the importance of addressing challenges such as lighting variations, face occlusions, camera quality, and incorrect mask usage.

This project aims to address these limitations by proposing a more adaptable and robust methodological framework.

Key Outcome

The key outcome of Graduation Project 1 is to ensure that the student acquires a comprehensive understanding of the face mask detection problem domain, including its challenges and practical applications.

The student identifies a suitable dataset, typically sourced from public repositories such as Kaggle, and justifies its selection based on diversity and relevance.

A clear and structured methodological plan is defined, covering data preprocessing, model selection, training strategy, and evaluation metrics.

The project also demonstrates the student's ability to use reference management tools such as Mendeley or EndNote to organize academic sources and generate references automatically.

These outcomes provide a solid foundation for the implementation, experimentation, and evaluation phases to be conducted in Graduation Project 2.