Software Requirements Specification (SRS)

Project Title: Face Mask Detection System (FMDS)

Attribute	Value
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1. Introduction

1.1 Purpose of the Document

This Software Requirements Specification (SRS) formally defines the complete functional, non-functional, and technical requirements for the **Face Mask Detection System (FMDS)**. The document serves as the authoritative blueprint for the system's development, ensuring all stakeholders—including the student, supervisor, and potential integrators—share a common understanding of the system's capabilities and constraints.

1.2 Scope of the Product

The FMDS is a specialized deep learning model designed for binary image classification. Its core function is to analyze a static image of a face and determine the presence or absence of a protective face mask. The system is a modular, back-end component intended for integration into broader monitoring or access control applications.

The scope of this final year project is limited to:

1. The development and training of a robust Convolutional Neural Network (CNN) model.
2. The implementation of a Python-based inference engine capable of processing static images.
3. The achievement of a high classification accuracy on an independent test dataset.

1.3 Definitions, Acronyms, and Abbreviations

Term/Acronym	Definition
SRS	Software Requirements Specification
FMDS	Face Mask Detection System
CNN	Convolutional Neural Network, the core deep learning architecture.
Inference	The process of using a trained model to make a prediction on new data.
Epoch	One complete cycle through the entire training dataset.
Latency	The time delay between inputting an image and receiving the classification output.
RGB	Red, Green, Blue; the three color channels of the input image.

1.4 References

1. **Project Implementation Notebook:** `Face_Mask_Detection_using_CNN_DeepLearning_Project(1)(1).ipynb` (Source of technical specifications and performance metrics).
2. **Dataset Source:** Face Mask Dataset (Kaggle).

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2. Overall Description

2.1 Product Perspective and System Interface

The FMDS is a standalone software module that acts as a classification service. It is designed to be integrated via a simple Application Programming Interface (API) or function call within a host application. It does not require a graphical user interface (GUI) for its core operation. The primary interface is the function signature that accepts image data and returns a prediction.

2.2 Product Functions

The system’ s operation is defined by the following sequential functions:

ID	Function Name	Description
F-100	**Image Input Handling**	Accepts raw image data (e.g., NumPy array or file path) from the host system.
F-200	**Data Preprocessing**	Resizes the input image to the required **128x128x3** dimensions and normalizes pixel values to the **[0, 1]** range.
F-300	**Model Inference**	Executes the trained CNN model to perform the classification task.
F-400	**Result Output**	Returns a structured object containing the predicted class label and the confidence score.

2.3 User Characteristics

The system is designed for two primary user groups:

User Class	Technical Proficiency	Key Interaction
Integrator/Developer	High proficiency in Python, TensorFlow/Keras, and software integration.	Integrating the model into a larger application or deployment environment.
System Operator/End-User	Low technical proficiency; requires clear, immediate feedback.	Monitoring the final application’ s output (e.g., a visual alert or log entry).

2.4 General Constraints

Constraint Type	Description
Technology	Constrained to the Python ecosystem, specifically requiring **TensorFlow/Keras** for model execution.
Performance	The system must meet the specified accuracy and latency requirements to be viable for real-world deployment.
Input Format	The model is strictly trained for **128x128 RGB** images; all inputs must conform to this specification after preprocessing.
Classification	The system is limited to **binary classification** (Mask/No Mask) and does not currently support multi-class detection (e.g., improper mask wearing).

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3. Specific Requirements

3.1 Functional Requirements

3.1.1 FR-1.1: Input Preprocessing

The system shall ensure that all input images are resized to a resolution of 128x128 pixels and converted to a 3-channel (RGB) format.

3.1.2 FR-1.2: Classification Output

The system shall output a classification result that maps to one of the following two labels:

- **Label 1:** Mask Worn (Positive Class)
- **Label 0:** No Mask Worn (Negative Class)

3.1.3 FR-1.3: Confidence Reporting

The system shall provide the prediction confidence as a floating-point value between 0.0 and 1.0, representing the model's certainty in the classification.

3.2 Non-Functional Requirements

3.2.1 Performance Requirements

The model's performance, as demonstrated during the training phase, must be maintained in the deployed environment:

Metric	Requirement	Achieved Value (from Notebook)
Classification Accuracy	Must exceed 90.0% on the test set.	**92.05%**
Model Latency	Target inference time of < 50ms per image on GPU-accelerated hardware.	TBD (Deployment Dependent)
Training Stability	The model must be trained for 5 epochs, demonstrating convergence without significant overfitting.	5 Epochs

3.2.2 Security and Privacy

The system shall not perform any facial recognition or store any image data after the classification process is complete, ensuring compliance with basic privacy standards.

3.2.3 Maintainability

The model architecture and training configuration shall be fully documented and stored in a version-controlled repository to facilitate future retraining and maintenance.

3.3 Technical Requirements (Model Architecture)

The FMDS utilizes a Sequential CNN model, compiled with the Adam optimizer and Sparse Categorical Crossentropy loss function.

Layer Type	Output Shape	Activation	Purpose
Conv2D (1)	(126, 126, 32)	ReLU	Initial feature map generation.
MaxPooling2D (1)	(63, 63, 32)	N/A	Spatial down-sampling.
Conv2D (2)	(61, 61, 64)	ReLU	Deeper feature extraction.
MaxPooling2D (2)	(30, 30, 64)	N/A	Further spatial reduction.
Flatten	(57600)	N/A	Prepares data for fully connected layers.
Dense (1)	(128)	ReLU	High-level feature combination.
Dropout (1)	(128)	N/A	Regularization (Rate 0.5).
Dense (2)	(64)	ReLU	Secondary feature combination.
Dropout (2)	(64)	N/A	Regularization (Rate 0.5).
Output Dense	(2)	Sigmoid	Final classification output.

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4. Future Enhancements

The following enhancements are recommended for future iterations of the Face Mask Detection System to improve its utility, robustness, and real-world applicability.

4.1 Real-Time Video Stream Processing (FE-1)

The system should be extended to process live video feeds. This requires integrating a frame-by-frame processing pipeline using libraries such as OpenCV, which will introduce a new requirement for frame-rate performance (e.g., 15-30 FPS).

4.2 Face Localization and Bounding Box (FE-2)

A critical enhancement is the integration of a dedicated face detection algorithm (e.g., MTCNN, YOLO, or SSD) to:

1. Locate all faces in a frame.
2. Draw a bounding box around each detected face.
3. Crop the face for classification by the CNN model.
4. Overlay the classification result (Mask/No Mask) onto the bounding box in the output stream.

4.3 Improper Mask Detection (FE-3)

A future iteration should expand the model to a multi-class classification problem, including a third class: **"Improperly Worn Mask"** (e.g., mask covering only the mouth, or worn on the chin). This requires acquiring and labeling a new, expanded dataset.

4.4 Edge Device Optimization (FE-4)

To enable deployment on low-power devices (e.g., Raspberry Pi, mobile phones), the model should be optimized for size and speed. This involves:

1. Model quantization (e.g., converting to 8-bit integers).
2. Conversion to lightweight formats such as **TensorFlow Lite** or **ONNX**.
3. Evaluation of model performance on embedded systems.

Appendix A: Project Personnel

Role	Name	Identifier
Student/Author	Laraib Qandeel	F22BINFT1E02142
Project Supervisor	Sir Syed Ali Nawaz Shah	N/A
Organization	The Islamia University of Bahawalpur	N/A