Hamdard University

Department of Computing

Final Year Project


# Brain Tumor Detection And Classification Using Deep Learning

# (FYP-007/FL24)

## Software Design Specifications

Submitted by

Abdul Basit (1546-2021)

Shah Muhammad Uzair Subhan (2398-2021)

Muzamil Hussain (1474-2021)

Supervisor(s)

Mr. Mohsin Raza Khan

Co Supervisor

Mr.Khuram Iqbal

**Spring 2024**

# Document Sign off Sheet

## 1.1.1 Document Information

| | |
|---|---|
| **Project Title** | Brain Tumor Detection And Classification Using Deep Learning |
| **Project Code** | FYP-007/FL24 |
| **Document Name** | Software Design Specifications |
| **Document Version** | <1.0> |
| **Document Identifier** | FYP-007/FL24SRS |
| **Document Status** | Draft |
| **Author(s)** | Abdul Basit, Muzamil Hussain, Shah Muhammad Uzair Subhan |
| **Approver(s)** | MR. Mohsin Raza Khan |
| **Issue Date** | <03-07-2025> |

| Name | Role | Signature | Date |
|---|---|---|---|
| Abdul Basit | Team Lead | | |
| Muzamil Hussain | Team Member 2 | | |
| Shah Muhammad Uzair Subhan | Team Member 3 | | |
| MR. Mohsin Raza Khan | Supervisor | | |
| MR. Khuram Iqbal | Co-Supervisor | | |
| Faheem Ahmed Khan | Project Coordinator | | |

# Revision History

| Date | Version | Description | Author |
|---|---|---|---|
| <03/07/2025> | 1.0 | First Draft | Abdul Basit, Muzamil Hussain, Muhammad Uzair Subhan |
| | | | |
| | | | |
| | | | |

# Definition of Terms, Acronyms, and Abbreviations

*[This section should provide the definitions of all terms, acronyms, and abbreviations required to interpret the terms used in the document properly.]*

| Term | Description |
|---|---|
| | |
| | |
| | |
| | |
| | |
| | |
| | |
| | |

# 2 Table of Contents

# 3 Introduction

## 3.1 Purpose of Document

The purpose of this document is to outline the Software Design Specification (SDS) for the project "Brain Tumor Classification and Detection Using Deep Learning." This document serves as a comprehensive guide for the development team, stakeholders, and other relevant personnel, providing detailed insights into the system's design methodology, structure, and implementation. The project utilizes an Object-Oriented Design (OOD) methodology, which allows for modular, reusable, and scalable system architecture to meet the project's complex requirements effectively.

## 3.2 Intended Audience

This document is intended for software engineers, system architects, project managers, and quality assurance personnel involved in the development and deployment of the system. Additionally, it is directed at stakeholders such as medical researchers, healthcare professionals, and AI specialists who may utilize or analyze the system's outcomes. The document provides the technical details necessary to understand the design and architecture of the system.

## 3.3 Document Convention

This document follows a standardized format for consistency and readability. The font used throughout is **Times New Roman**, with a font size of **12pt** for the main body and **14pt bold** for headings. Subheadings are set to **12pt bold**, and all diagrams are clearly labeled and captioned.

## 3.4 Project Overview

The "Brain Tumor Classification and Detection Using Deep Learning" system is designed to assist medical professionals in the accurate and efficient diagnosis of brain tumors. Utilizing advanced convolutional neural networks (CNNs), the system classifies medical imaging data into distinct tumor categories. The software employs a layered design approach to separate user interaction, processing, and data management functionalities. This modular approach ensures flexibility, scalability, and ease of maintenance while achieving high accuracy and performance.

## 3.5 Scope

The system aims to:

- Enable accurate classification of brain tumors based on medical imaging data.
- Provide a user-friendly interface for medical professionals.
- Support integration with external databases and hospital systems.

- Offer scalability for future enhancements, such as additional tumor types or real-time processing capabilities.

The system will not:

- Replace professional medical diagnosis but serve as a decision-support tool.
- Process non-medical imaging data or handle unrelated medical conditions.

# 4 Design Considerations

## *4.1 Assumptions and Dependencies*

The system assumes access to a large, labeled dataset of brain tumor medical images for training and testing purposes. It depends on a robust GPU-based environment for deep learning model training and inference. Furthermore, it requires compatibility with standard medical imaging formats such as DICOM and seamless integration with hospital management systems for real-world deployment.

## *4.2 Risks and Volatile Areas*

- **New Requirements:** Changes in project scope or the addition of new tumor classifications.
- **Technology Risks:** Rapid advancements in deep learning frameworks that may render existing models outdated.
- **Data Quality:** Variations in data quality or incomplete datasets may impact model accuracy.

To mitigate these risks, the design incorporates modularity to allow for easy updates and adjustments. Regular stakeholder consultations and incremental model improvements are planned to address potential issues proactively.

# 5 System Architecture

## *5.1 System Level Architecture*

The system is decomposed into three main subsystems:

1. **User Interface Layer**: Provides an intuitive interface for medical professionals to upload images, view results, and access reports.
2. **Processing Layer**: Handles data preprocessing, model inference, and classification.
3. **Data Management Layer**: Manages data storage, retrieval, and integration with external systems.

The relationships between these elements are defined through well-documented APIs. The system employs a client-server architecture, with the client handling front-end interactions and the server managing computation and data storage. Error handling mechanisms are integrated across all layers to ensure robustness and reliability.

### 5.2 Software Architecture

The software architecture consists of:

- **User Interface Layer**: Manages input and output interactions with the user.
- **Middle Tier**: Executes the deep learning model and processes the data.
- **Data Access Layer**: Handles interactions with the database and external systems.

The interaction between these layers is depicted below:

```
[User Interface Layer]
        |
        V
[Middle Tier (Deep Learning Model)]
        |
        V
[Data Access Layer (Database)]
```

## 6. Design Strategy

The design strategy focuses on creating a flexible and scalable system to meet current and future requirements.

### Key Considerations:

- **Future System Extension or Enhancement**: The modular design allows for adding new features, such as real-time tumor detection or additional classification categories, with minimal impact on existing functionality.
- **System Reuse**: Components such as the preprocessing pipeline and neural network modules are designed for reusability across similar projects.
- **User Interface Paradigms**: The interface follows user-centric design principles to ensure ease of use for medical professionals with minimal technical expertise.
- **Data Management**: The system employs a relational database to store structured data and integrates with cloud storage for large-scale image datasets. Data persistence and security are ensured through encryption and access control mechanisms.

- **Concurrency and Synchronization**: The architecture supports concurrent user access, with synchronization mechanisms to handle simultaneous requests without compromising performance or data integrity.

# 7. Detailed System Design

## 7.1 Design Class Diagram

- **Class Diagram**:
  - Classes include `ImageProcessor`, `TumorClassifier`, `UserInterface`, and `DatabaseHandler`.
  - Attributes:
    - `ImageProcessor`: `image_id`, `image_data`, `preprocessed_image`
    - `TumorClassifier`: `model`, `classification_result`
    - `UserInterface`: `user_id`, `input_form`, `output_display`
    - `DatabaseHandler`: `db_connection`, `query`
  - Methods:
    - `ImageProcessor`: `preprocess_image()`, `extract_features()`
    - `TumorClassifier`: `load_model()`, `classify_image()`
    - `UserInterface`: `upload_image()`, `display_results()`
    - `DatabaseHandler`: `store_data()`, `fetch_results()`
- **Logical Data Model**:
  - Represents relationships between `Users`, `Medical Images`, `Classification Results`, and `Reports`.
- **Detailed GUIs**:
  - Mock-ups include:

    1. Upload Form: For uploading medical images.
    2. Classification Result Page: Displaying results.
    3. Report Download Page: Button to download classification reports.

## 7.2 Database Design

### 7.2.1 ER Diagram

- Entities:
  - `Users`: Attributes include `user_id`, `name`, `email`.
  - `Images`: Attributes include `image_id`, `user_id`, `image_path`.
  - `Results`: Attributes include `result_id`, `image_id`, `classification`, `confidence_score`.

### 7.2.2 Data Dictionary

| Column Name | Description | Type | Length | Nullable | Default Value | Key Type |
| --- | --- | --- | --- | --- | --- | --- |
| user_id | Unique ID for the user | INT | 11 | No | AUTO_INCREMENT | PK |
| image_id | Unique ID for the uploaded image | INT | 11 | No | AUTO_INCREMENT | PK |
| classification | Tumor classification result | VARCHAR | 255 | Yes | NULL | |
| confidence | Confidence score of classification | FLOAT | - | No | NULL | |
| timestamp | Timestamp of upload or result | DATETIME | - | No | CURRENT_TIME | |

# 7.3 Application Design

## *7.3.1 Sequence Diagram*

1. **Upload and Classification**:
    - User uploads an image.
    - Image is preprocessed and classified by the deep learning model.
    - Results are stored and displayed.
2. **Report Generation**:
    - User requests a report.
    - System fetches data from the database and generates a PDF.

## *7.3.2 State Diagram*

- **States**:
    - Idle: Waiting for user input.
    - Processing: Image preprocessing and classification.
    - Completed: Displaying results and storing data.

# 7.4 GUI Design

- **Mock Screens**:
    1. Upload Page: Simple

# 8 References

[1] Abbas, N., Saba, T., Mehmood, Z., Rehman, A., Islam, N., & Ahmed, K. T. (2019). An automated nuclei segmentation of leukocytes from microscopic digital images. Pakistan Journal of Pharmaceutical Sciences

[2] Abbas, N., Saba, T., Mohamad, D., Rehman, A., Almazyad, A. S., & Al-Ghamdi, J. S. (2018). Machine aided malaria parasitemia detection in Giemsa-stained thin blood smears. Neural Computing and Applications.

[3] Abbas, N., Saba, T., Rehman, A., Mehmood, Z., Kolivand, H., Uddin, M., & Anjum, A. (2019). Plasmodium life cycle stage classification-based quantification of malaria parasitaemia in thin blood smears. Microscopy Research and Technique.

[4] Gurbinà M., Lascu M. and Lascu D. 2019 Tumor Detection and Classification of MRI Brain Image using Different Wavelet Transforms and Support Vector Machines 2019 42nd International Conference on Telecommunications and Signal Processing (TSP) (Budapest, Hungary

[5] Dvorak P., Kropatsch W. and Bartusek K. 2013 2013 36th International Conference on Telecommunications and Signal Processing (TSP) (Rome) Automatic detection of brain tumors in MR images

[6] Ezhilarasi R. and Varalakshmi P. 2018 Tumor Detection in the Brain using Faster R-CNN

[7] A survey on cancer detection via convolutional neural networks: Current challenges and future directions 2024, Neural Networks.

[8] Analysis of Swin-UNet vision transformer for Inferior Vena Cava filter segmentation from CT scans 2023, Artificial Intelligence in the Life Sciences.

[9] Transfer learning architectures with fine-tuning for brain tumor classification using magnetic resonance imaging 2023 Healthcare Analytics.

[10] Raja N, Rajinikanth V, Fernandes SL, Satapathy SC (2017) Segmentation of breast thermal images using Kapur's entropy and hidden Markov random field. J Med Imaging Health Inf 7:1825–1829.

[11] Rajinikanth V, Madhavaraja N, Satapathy SC, Fernandes SL (2017) Otsu's multi-thresholding and active contour snake model to segment dermoscopy images. J Med Imaging Health Inf 7:1837–1840.

[11] Shah JH, Chen Z, Sharif M, Yasmin M, Fernandes SL (2017) A novel biomechanics-based approach for person re-identification by generating dense color sift salience features. J Mech Med Biol 17:1740011