Low Level Design (LLD)

Concrete Compressive Strength Prediction

PREPARED BY

Milan Kumar Behera

email id - milanbeherazyx@gmail.com

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Document Version Control

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1. Introduction

1.1. What is a Low-Level Design Document?

The Low-Level Design (LLD) document for the Concrete Compressive Strength Prediction project provides a detailed internal logical design of the actual program code. It describes the class diagrams, methods, and relations between classes, enabling the programmer to directly code the program from the document.

1.2. Scope

The scope of this Low-Level Design document is to give a component-level design process for the Concrete Compressive Strength Prediction project. It outlines the step-by-step refinement process for designing data structures, software architecture, source code, and performance algorithms. This document will help in implementing the machine learning models, data processing, user interface, and database management for the concrete strength prediction system.

2. Technical Specification

2.1 Dataset

Name	*source*
Concrete Compressive Strength	https://archive.ics.uci.edu/static/public/165/concrete+compressive+s ngth.zip

2.1.1. Data Characteristics:

The dataset contains the actual concrete compressive strength (MPa) for a given mixture under a specific age (days), as determined from the laboratory. Data is in raw form (not scaled).

2.1.2. Summary Statistics:

Number of instances (observations)	**1030**
Number of Attributes	09
Attribute breakdown	08 quantitative input variables, and 01 quantitative output variable
Missing Attribute Values	None

2.1.3 Variable Information:

Given is the variable name, variable type, the measurement unit, and a brief description. The concrete compressive strength is the regression problem. The order of this listing corresponds to the order of numerals along the rows of the database.

Component No	***Name***	***Data Type***	***Measurement***	***Description***
1	Cement	Quantitative	kg in a m3 mixture	Input Variable
2	Blast Furnace Slag	Quantitative	kg in a m3 mixture	Input Variable

3	Fly Ash	Quantitative	kg in a m3 mixture	Input Variable
4	Water	Quantitative	kg in a m3 mixture	Input Variable
5	Superplasticizer	Quantitative	kg in a m3 mixture	Input Variable
6	Coarse Aggregate	Quantitative	kg in a m3 mixture	Input Variable
7	Fine Aggregate	Quantitative	kg in a m3 mixture	Input Variable
8	Age	Quantitative	kg in a m3 mixture	Input Variable
9	Concrete compressive strength	Quantitative	kg in a m3 mixture	Output Variable

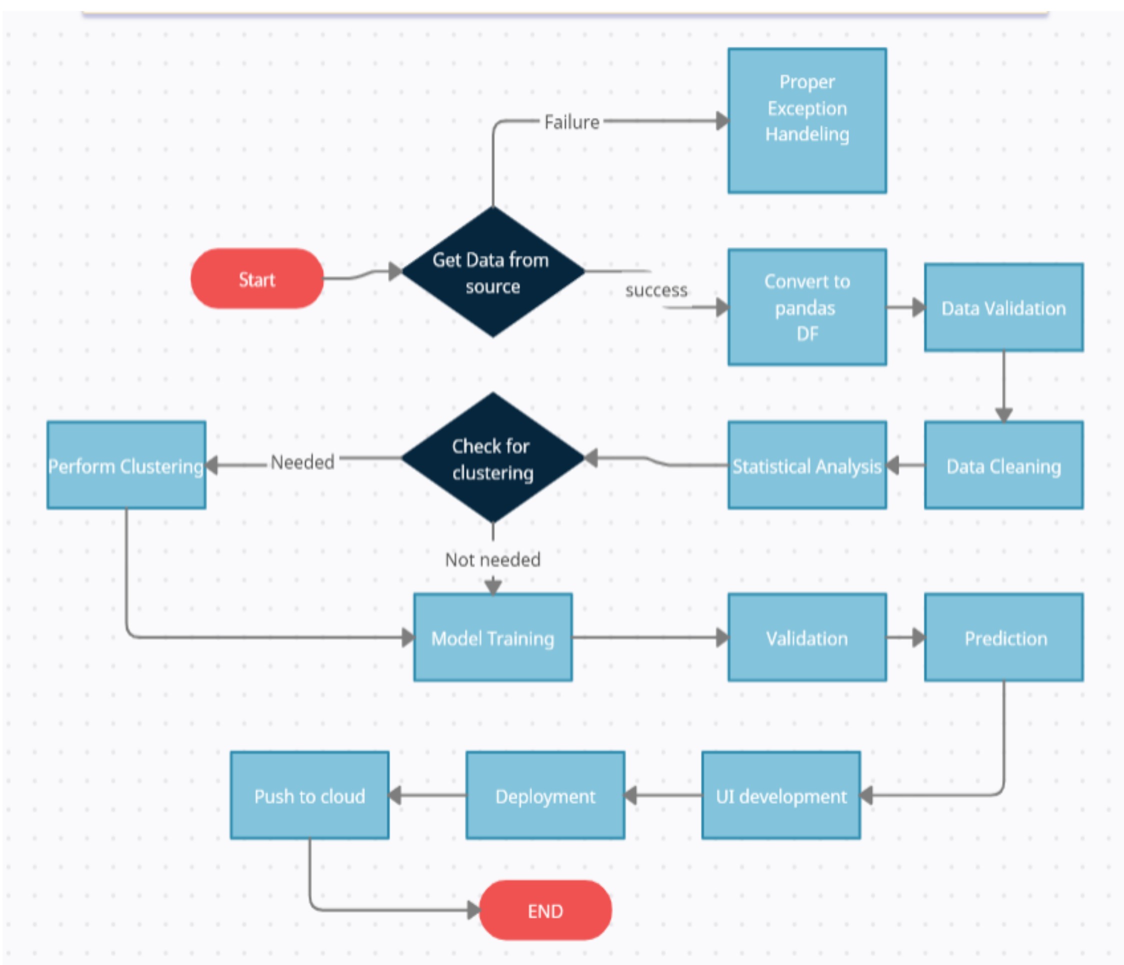
2.2. Input Schema

Data Types:	
Cement	float64
Blast Furnace Slag	float64
Fly Ash	float64
Water	float64
Superplasticizer	float64
Coarse Aggregate	float64
Fine Aggregate	float64
Age	int64
Concrete compressive strength	float64

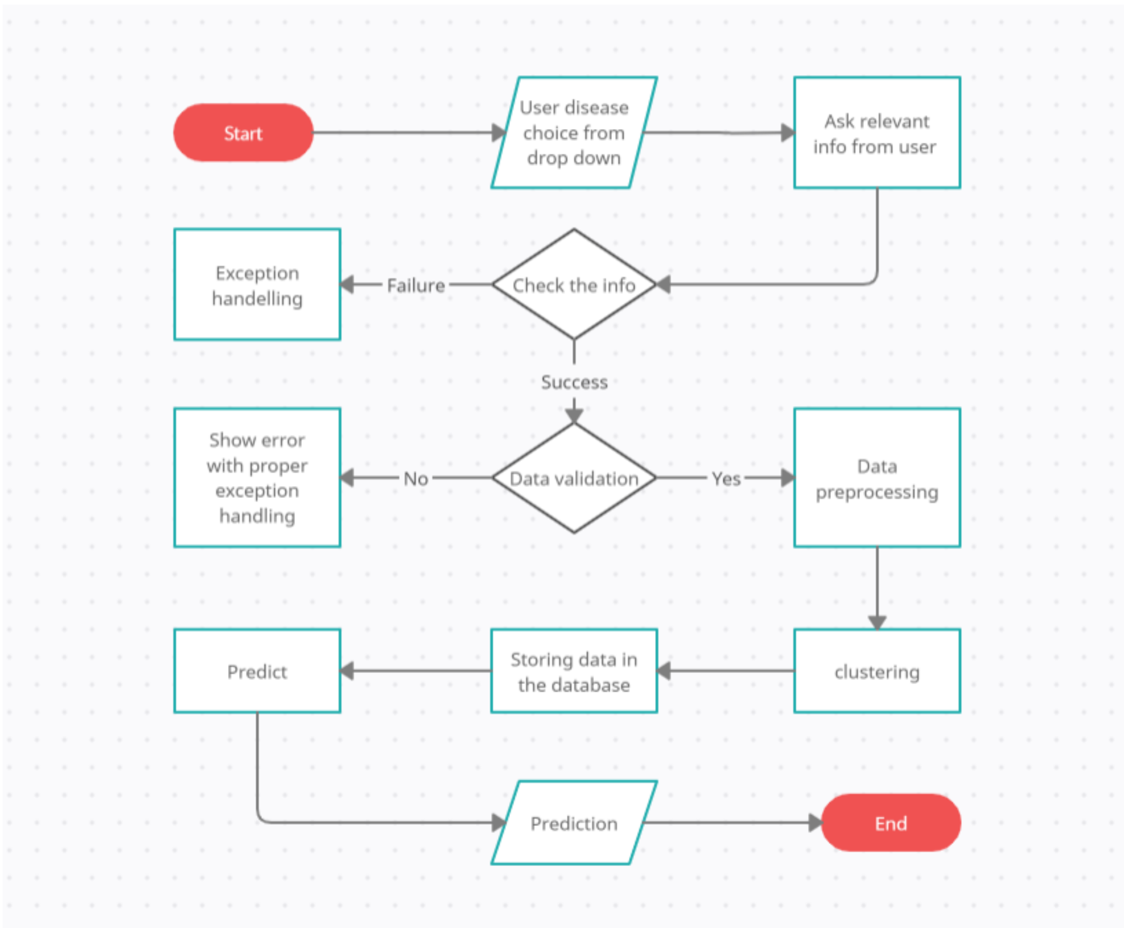
3. Architecture

The Concrete Compressive Strength Prediction project follows a modular architecture, divided into several key components that work together to achieve the desired functionality. The main architectural components include data ingestion, data validation, data transformation, data preprocessing, model building, user interaction, and deployment.

3.1. Workflow & Architecture



3.2. User IO Workflow



4. Architecture Description

4.1. Data Description

The project utilises a dataset containing properties of concrete mixes and corresponding compressive strength values. The dataset includes features such as cement, blast furnace slag, fly ash, water, superplasticizer, coarse aggregate, fine aggregate, and age. It contains a significant number of concrete mix records for model training and evaluation.

4.2. Data Transformation

The project involves converting the raw dataset into a format suitable for model training. Data transformation processes such as data cleaning, feature engineering, and handling missing values will be applied to prepare the dataset for machine learning models.

4.3. Data Insertion into Database

The cleaned and transformed dataset will be inserted into a database for storage and retrieval during model training and prediction. The database schema and tables will be designed to efficiently store the dataset.

4.4. Export Data from Database

Data stored in the database can be exported as needed for data pre-processing, model training, and analysis.

4.5. Data Pre-processing

Data pre-processing steps will include handling missing values, scaling features, and any other necessary transformations to ensure the dataset is suitable for model training.

4.6. Data Clustering

K-means clustering will be used to create clusters within the pre-processed data. The optimal number of clusters will be determined using the elbow method. Clustering will help in deploying different machine learning models for different clusters of concrete mix properties.

4.7. Model Building

After clusters are created, machine learning models will be built for each cluster to predict compressive strength accurately. Hyperparameters will be tuned using techniques like Grid-Search. Models with the best performance for each cluster will be selected for prediction.

4.8. Data from User

The web application will collect user inputs, including concrete mix properties, through a user-friendly interface.

4.9. Data Validation

Data validation mechanisms will be implemented to ensure that user inputs are valid and within acceptable ranges.

4.10. User Data Inserting into Database

User inputs will be stored in the database for future reference and to keep track of user preferences.

4.11. Data Clustering

The model created during training will be loaded, and clusters for the user data will be predicted based on their concrete mix properties.

4.12. Model Call for Specific Cluster

The machine learning model corresponding to the user's data cluster will be loaded to predict the compressive strength for the specific concrete mix.

4.13. Concrete Compressive Strength Prediction & Saving Output in Database

Based on the user's input and the selected model, the application will predict the concrete compressive strength and save the output in the database for analysis and future reference.

4.14. Deployment

The web application and machine learning models will be deployed to a cloud environment like AWS, ensuring accessibility and scalability.

4.15. Logging

The Concrete Compressive Strength Prediction project incorporates logging mechanisms to record various activities and events within the application. The logging system captures essential information such as user interactions, prediction requests, data preprocessing steps, model training progress, and any errors encountered during the process. By maintaining detailed logs, the application can be effectively monitored and analysed for performance, troubleshooting, and improvement purposes.

4.16. Exception Handling

The project implements comprehensive exception handling mechanisms to handle unexpected errors and exceptional situations gracefully. Exception handling ensures that the application remains stable and responsive even when faced with unforeseen circumstances. Proper error messages are generated, providing meaningful information to users and developers to identify and resolve issues effectively.

5. Unit Test Cases

The project will include unit test cases to verify the proper functionality of the web application and the accuracy of the prediction results. The test cases will cover different scenarios, including user input validation, model accuracy, and output validation.

This Low-Level Design (LLD) document provides a detailed internal design of the Concrete Compressive Strength Prediction project. It outlines the architecture and workflow of the system, data processing, model building, user interaction, and deployment. The document will serve as a reference for the development team to implement the project effectively.