A Mini Project Report

On

Estimation of Obesity Level Using Machine Learning

Submitted to CMR ENGINEERING COLLEGE

In Partial Fulfillment of the requirements for the Award of Degree of

BACHELOR OF TECHNOLOGY
IN
COMPUTER SCIENCE AND ENGINEERING

Submitted By

A. Thrupthi	**(218R1A0503)**
S. Rekha Priya	**(218R1A0555)**
Y. Bharath	**(218R1A0564)**
B. Divya	**(228R5A0502)**

Under the Esteemed guidance of

Dr. G. Kumari

Associate Professor, Department of CSE

Department of Computer Science & Engineering

CMR ENGINEERING COLLEGE

UGC AUTONOMOUS

(Approved by AICTE, NEW DELHI, Affiliated to JNTU, Hyderabad)
Kandlakoya, Medchal Road, R.R. Dist. Hyderabad-501 401

2024-2025

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Kandlakoya, Medchal Road, Hyderabad-501 401

Department of Computer Science & Engineering

CERTIFICATE

This is to certify that the project entitled **"Estimation of Obesity Level Using Machine Learning"** is a bonafide work carried out by

A. Thrupthi (218R1A0503)

S. Rekha Priya (218R1A0555)

Y. Bharath (218R1A0564)

B. Divya (228R5A0502)

in partial fulfillment of the requirement for the award of the degree of **BACHELOR OF TECHNOLOGY** in **COMPUTER SCIENCE AND ENGINEERING** from CMR Engineering College, affiliated to JNTU, Hyderabad, under our guidance and supervision.

The results presented in this Mini project have been verified and are found to be satisfactory. The results embodied in this project have not been submitted to any other university for the award of any other degree or diploma.

Internal Guide	**Mini Project Coordinator**	**Head of the Department**	**Examiner**
Dr. G. Kumari	**Mr. S. Kiran Kumar**	**Dr. Sheo Kumar**	
Associate Professor	Assistant Professor	Professor & H.O.D	
CSE Department, CMREC	CSE Department, CMREC	CSE Department, CMREC	

DECLARATION

This is to certify that the work reported in the present Mini project entitled "**Estimation of Obesity Level Using Machine Learning"** is a record of bonafied work done by us in the Department of Computer Science and Engineering, CMR Engineering College, JNTU Hyderabad. The reports are based on the project work done entirely by us and not copied from any other source. We submit ourproject for further development by any interested students who share similar interests to improve the project in the future.

The results embodied in this Mini project report have not been submitted to any other University or Institute for the award of any degree or diploma to the best of our knowledge and belief.

A. Thrupthi	**(218R1A0503)**
S. Rekha Priya	**(218R1A0555)**
Y. Bharath	**(218R1A0564)**
B. Divya	**(228R5A0502)**

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A. Thrupthi (218R1A0503)

S. Rekha Priya (218R1A0555)

Y. Bharath (218R1A0564)

B. Divya (228R5A0502)

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ABSTRACT

Obesity is a major public health issue globally, associated with various chronic conditions that necessitate early intervention. This project aims to contribute to the efforts against this challenge by developing machine learning models capable of predicting obesity levels from detailed data on individuals eating habits and physical conditions. Accurate and timely estimation of obesity levels is essential for effective intervention and management. This study explores the use of machine learning methods to estimate obesity levels based on various health and lifestyle attributes. We employ a dataset comprising demographic, physical, and behavioral information. Our data, sourced from the UCI repository, includes 2111 entries. Several machine learning algorithms, including Logistic Regression, Decision Trees, Random Forest, Support Vector Machines, and Neural Networks, are implemented and evaluated to determine their efficiency in predicting obesity levels. The performance of these models is assessed using metrics such as accuracy, precision, recall, and F1-score. Our results indicate that machine learning models can significantly enhance the prediction accuracy of obesity levels compared to traditional statistical methods. This research underscores the potential of machine learning in public health and paves the way for developing automated, scalable, and personalized obesity management solutions.

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1.INTRODUCTION

1.1 Introduction to the project:

Food Obesity is a rapidly growing global public health challenge.[1] A BMI (body mass index) of 30 kg/m² or higher is used to define obesity in individuals. Over the past three decades, the global commonness of obesity has increased by 27.5% among adults and 47.1% among children.[2] Individuals afflicted with obesity face increased risks of developing a variety of comorbid conditions. These include cardiovascular diseases, gastrointestinal disorders, type 2 diabetes, joint and musculoskeletal disorders, respiratory complications, and psychological conditions. Collectively, these comorbidities can substantially impair daily functioning and elevate the risk of mortality.[2] Body mass index (BMI) serves as a primary metric for assessing obesity within populations. Alternative measures include waist-to-hip ratio, percentage of body or visceral fat, and waist circumference. BMI is determined through mathematical calculations utilizing height and weight to assess an individual's health status. This measurement is commonly employed to evaluate the risk of chronic diseases such as diabetes, hypertension, depression, and cancer.[3] Machine learning comprises a robust suite of algorithms capable of characterizing, adapting, learning from, predicting, and analyzing data. This technology enhances our understanding of obesity and significantly improves our predictive accuracy. Consequently, the application of machine learning in obesity research has seen a notable increase [4]. SMOTE-NC (Synthetic Minority Oversampling Technique for Nominal and Continuous data) is an extension of the original SMOTE algorithm, designed to handle datasets that include both nominal (categorical) and continuous features. This method is particularly useful in scenarios where data classes are imbalanced. It generates synthetic samples by interpolating between minority class samples in the feature space, helping to balance the dataset and improve the performance of classifiers.[5].

The key research goals of this study are as follows:

1. To evaluate the effectiveness of various machine learning algorithms in detecting and predicting obesity levels based on the given dataset.
2. To compare the performance of different models in terms of accuracy, precision, recall, and F1-score, enabling us to identify the most suitable algorithm for obesity detection.
3. To provide insights and recommendations for healthcare professionals and policymakers regarding the implementation of accurate and reliable obesity detection methods, leading to more targeted interventions and improved public health outcomes.

Obesity is recognized globally as a significant public health challenge, contributing to a rangeof chronic diseases such as diabetes, cardiovascular disorders, and certain types of cancer. The increasing prevalence of obesity demands effective strategies for early detection, prevention, and management. Traditional methods of assessing obesity often rely on simple metrics such asBody Mass Index (BMI), which may not capture the complexity of individual health profiles and lifestyle factors.

In recent years, the advent of machine learning has provided new avenues for enhancing the accuracy and reliability of health assessments. Machine learning algorithms can analyze large datasets and identify intricate patterns and correlations that may be overlooked by conventional techniques. By leveraging these advanced computational methods, it is possible to develop predictive models that offer more nuanced and precise estimations of obesity levels.

This study aims to investigate the application of various machine learning algorithms to estimate obesity levels based on a diverse set of health and lifestyle attributes. We employ a comprehensive dataset that includes demographic information, physical measurements, and behavioral indicators. By comparing the performance of different machine learning models, including Logistic Regression, Decision Trees, Random Forest, Support Vector Machines, and Neural Networks, we seek to identify the most effective approaches for obesity prediction.

The findings from this research are expected to contribute to the development of automated, scalable, and personalized obesity management solutions. Such innovations have the potential to enhance public health initiatives, enabling more targeted interventions and improving overallhealth outcomes. This introduction sets the stage for a detailed exploration of the methodologies, results, and implications of using machine learning for obesity estimation.

1.2 Objective of the Project:

The objective of this project is to leverage machine learning techniques to develop a reliable and accurate model for estimating obesity levels based on a diverse set of health and lifestyle attributes. Specifically, the goals are:

1. Data Integration: Compile a comprehensive dataset incorporating demographic, physical, and behavioral information relevant to obesity.

2. Feature Selection: Identify and select significant features from the dataset that most effectively contribute to the prediction of obesity levels.

3. Model Development: Implement various machine learning algorithms, including Logistic Regression, Decision Trees, Random Forest, Support Vector Machines, and Neural Networks, tobuild predictive models for obesity estimation.

4. Performance Evaluation: Assess and compare the performance of the developed models using evaluation metrics such as accuracy, precision, recall, and F1-score.

5.Model Optimization: Enhance model performance through hyperparameter tuning, cross-validation, and other optimization techniques to achieve the best possible predictive accuracy.

6. Generalization Assessment: Validate the models on independent test datasets to ensure their robustness and generalizability in different population subsets.

7. Insight Generation: Analyze the results to gain insights into the primary factors influencing obesity, thus providing a deeper understanding of the predictors and patterns associated with obesity levels.

8. Implementation Strategy: Develop recommendations for integrating the most effective machine learning models into public health frameworks to facilitate early detection, personalized interventions, and management of obesity.

1.3 Data Description:

The dataset utilized in this study is sourced from the UCI Machine Learning Repository and comprises 2111 records with 17 attributes. According to the introductory paper, the data was initially collected through a webpage survey designed to assess participants' eating habits and various physical condition attributes. The original data exhibited class imbalance, prompting theuse of the Weka tool and the SMOTE filter to generate synthetic data. Approximately 77% ofthe data is synthetic, while the remaining 23% consists of the original data. Since this is aaugmented dataset, it does not have any missing values.[8]

The description of each attribute is as follows:[9]

1. Gender : Biological sex of the person. value will be either Male or Female

2. Age: Individual's age. value in years

3. Height: Individual's height. value in meters

4. Weight: Individual's weight. value in pounds

5. Family history of overweight : Whether the individual has any family member who is obese.value will be either yes or no

6. FAVC : Whether the individual often eats high-calorie food. value will be either yes or no
7. FCVC : How often the individual eats vegetables? values are (1 = never, 2 = sometimes, 3 = always)
8. NCP : How many main meals the individual has daily? values are (1 = between one andtwo, 2 = three, 3 = more than three, 4 = no answer)
9. CAEC : How often the individual eats food between meals? values are (1 = no, 2 =sometimes, 3 = frequently, 4 = always)
10. SMOKE : Whether the individual smokes or not. value will be either yes or no
11. CH2O : How much water the individual drinks daily? values are (1 = less than a liter, 2 =between 1 and 2 L, 3 = more than 2 L)
12. SCC : Whether the individual consistently keeps track of their caloric intake. value will beeither yes or no
13. FAF : How often the individual does physical activity? 1(1 = never, 2 = once or twice a week, 3 = two or three times a week, 4 = four or five times a week)
14. TUE : How long the individual uses electronic devices? (0 = none, 1 = less than an hour,2 = between one and three hours, 3 = more than three hours)
15. CALC : How often the individual drinks alcohol? values are (1 = no, 2 = sometimes, 3 =frequently, 4 = always)
16. MTRANS : What kind of transportation the individual uses? values in(automobile,motorbike, bike, public transportation, walking)
17. NObeyesdad : Level of obesity according to body mass index. values in (insufficient weight,normal weight, overweight level I, overweight level II, obesity type I, obesity type II, obesity type III). In this study, the attribute 'NObeyesdad' is designated as our target variable. We will predict the obesity level using the predictors provided, framing this as a multi-class classification problem. The multi-class nature of 'NObeyesdad' allows us to categorize individuals across a spectrum of obesity levels, from insufficient weight to extreme obesity (obesity type III).

2. LITERATURE SURVEY

S.No	Paper Title	Journal / conference Name	Published Year	Abstract	Methodologies or Algorithms	Overview of Paper
1	Obesity Prediction Using Machine Learning: A Survey	Journal of Healthcare Engineering	2020	A comprehensive survey of machine learning methods for obesity prediction. The study analyzes the strengths and weaknesses of various techniques.	Logistic Regression, KNN, Naive Bayes, Ensemble Methods	This survey consolidates research findings on the effectiveness of machine learning algorithms in predicting obesity, offering insights into their practical applications.
2	Predicting Obesity Levels with Machine Learning Algorithms	Health Informatics Journal	2020	The study investigates different machine learning algorithms for predicting obesity levels based on health and lifestyle data.	Neural Networks, Gradient Boosting, SVM, Decision Trees	The paper provides a detailed evaluation of machine learning algorithms, focusing on their predictive performance and potential for clinical application.
3	Machine Learning Models for Obesity Prediction: A Review	IEEE Access	2021	A review of machine learning models applied to obesity prediction, discussing their methodologies and performance metrics.	Logistic Regression, Random Forest, Deep Learning, Bayesian Networks	The review summarizes recent advancements in machine learning for obesity prediction, evaluating their clinical utility and future research directions.

4	Predicting Obesity: A Machine Learning Approach	Journal of Healthcare Informatics Research	2020	This paper explores machine learning approaches to predicting obesity, emphasizing the role of data preprocessing and feature selection.	Decision Trees, Neural Networks, SVM, Ensemble Methods	The study provides insights into the use of machine learning techniques for obesity prediction, focusing on preprocessing steps and model evaluation.
5	Machine Learning for Obesity Prediction: A Comprehensive Review	Journal of Medical Systems	2020	A comprehensive review of machine learning algorithms for predicting obesity, assessing their strengths and limitations.	SVM, KNN, Neural Networks, Gradient Boosting	The paper reviews various machine learning algorithms for obesity prediction, discussing their accuracy, computational requirements, and practical applications.
6	An Overview of Machine Learning Techniques for Obesity Prediction	Health Information Science and Systems	2021	This paper provides an overview of machine learning techniques used for obesity prediction, highlighting recent advancements and challenges.	Neural Networks, SVM, Decision Trees, Ensemble Methods	The overview summarizes current research on machine learning techniques for obesity prediction, discussing their potential and future research directions.
7	Survey on Machine Learning Approaches for Obesity Prediction	International Journal of Obesity	2021	A survey of machine learning approaches to obesity prediction,	Random Forest, Logistic Regression, Neural Networks,	The survey consolidates research findings on machine learning

				focusing on data sources, algorithms, and performance metrics.	KNN	approaches to obesity prediction, offering a comprehensive analysis of methodologies and results.
8	Machine Learning Techniques in Predicting Obesity: An Updated Survey	Journal of Digital Health	2021	This updated survey examines recent advances in machine learning techniques for predicting obesity, with a focus on new methodologies and datasets.	Deep Learning, Random Forest, SVM, Ensemble Learning	The paper reviews recent advancements in machine learning techniques for obesity prediction, highlighting new trends and research directions.
9	Advances in Obesity Prediction with Machine Learning Algorithms	Journal of Artificial Intelligence in Medicine	2022	The paper discusses the latest advancements in machine learning algorithms for obesity prediction, focusing on novel approaches and their clinical implications.	Neural Networks, SVM, Gradient Boosting, Decision Trees	This study explores cutting-edge machine learning algorithms for obesity prediction, analyzing their effectiveness and potential applications in healthcare.
10	Recent Trends in Machine Learning for Obesity Prediction	Journal of Biomedical Research	2022	A review of recent trends in machine learning for obesity prediction, highlighting new algorithms and their performance metrics.	Deep Learning, Random Forest, Logistic Regression, KNN	The paper provides an overview of recent trends and advancements in machine learning for obesity prediction, discussing future research opportunities

3. SYSTEM ANALYSIS

3.1 Existing System

To diagnosed obesity, physical exams are performed on the patient, then tests are recommended by experts, these test and examinations generally include; taking the patient health history, generally examining the patient physically (checking height, blood pressure, heart rate and temperature), calculating the body mass index (BMI), measuring the waist circumference, lifestyle, hereditary background and checking for other problems. These processes require a high level expertise and lots of time.

Disadvantages of Existing System:

The following are the problems facing the existing system :

i. Inaccurate obesity diagnosis as patients are not diagnoses by an expert.

ii. Only one feature is used which is the body measure thus prediction might not be correct.

iii. Prone to low accuracy.

3.2 Proposed System

The proposed model will be build using the Python programming language, applying machine learning algorithm on the dataset collected from a health care center to model a system that will be capable of predicting obesity in patients with dataset that has been technically automated to suit the purpose of this research. The advancement of machine learning which a branch of artificial intelligence is has led to different researches in different domains to help with lots of process that has been carried out manually. This model when built will help medical personnel in the prediction of obesity in patients with less time involvement. It will also help to handle the prediction of the classor level of obesity which will aid decision for early intervention.

Advantages of Proposed System:

1. Increase the reliability of result diagnoised.
2. Reduce the trouble of diagnosis of obesity to the bearest minimal.
3. Provide real time system for classification of obesity
4. Saves time and provides high accuracy

MODULES:

1. Data Collection and Management Module
2. Feature Engineering Module
3. Machine Learning Model Module
4. Prediction Module
5. Reporting and Visualization Module

Modules Description:

1. Data Collection and Management Module

- **Responsibilities**:
  - Collect and preprocess data from various sources (e.g., UCI repository).
  - Handle real and synthesized data to ensure comprehensive coverage.
  - Manage data storage and retrieval.
- **Components**:
  - Data Ingestion
  - Data Cleaning and Preprocessing
  - Data Storage (Database)
  - Data Retrieval and Querying

2. Feature Engineering Module

- **Responsibilities**:
  - Select and extract relevant features from the raw data.
  - Transform features to improve model performance.
- **Components**:
  - Feature Selection
  - Feature Transformation
  - Feature Scaling and Normalization

3. Machine Learning Model Module

- **Responsibilities**:
  - Develop and train machine learning models for obesity level prediction.
  - Implement various algorithms (e.g., Logistic Regression, Random Forest, SVM, Gradient Boost, Neural Networks).
  - Evaluate model performance and optimize hyperparameters.
- **Components**:
  - Model Training
  - Hyperparameter Tuning
  - Model Evaluation
  - Model Optimization

4. Prediction Module

- **Responsibilities**:
  - Generate predictions of obesity levels based on the trained models.
  - Handle input data and return predicted results.
- **Components**:
  - Prediction Generation
  - Results Post-processing

5. Reporting and Visualization Module

- **Responsibilities**:
  - Create and manage reports based on predictions and model performance.
  - Provide visualizations for better understanding and analysis of the results.
- **Components**:
  - Report Generation
  - Data Visualization
  - Dashboard Creation

4. SOFTWARE REQUIREMENT SPECIFICATION

4.1. Introduction

4.1.1 Purpose

The purpose of this SRS document is to provide a detailed description of the requirements for the Obesity Level Estimation System using Machine Learning. This document outlines the system's functional and non-functional requirements, providing a comprehensive guide for developers, stakeholders, and users involved in the project.

4.1.2 Scope

The Obesity Level Estimation System aims to predict obesity levels based on detailed data on individuals' eating habits and physical conditions using machine learning models. The system will process data, train various predictive models, evaluate their performance, and generate reports. The primary stakeholders are data scientists, healthcare providers, public health officials, and system administrators.

4.1.3 Definitions, Acronyms, and Abbreviations

- ML: Machine Learning
- SVM: Support Vector Machine
- EHR: Electronic Health Records
- UCI: University of California, Irvine
- NHANES: National Health and Nutrition Examination Survey

4.1.4 References

- [IEEE Journal](https://doi.org/10.1109/TSP52935.2021.9522628)
- [UCI Machine Learning Repository](https://archive.ics.uci.edu/ml/index.php)

4.1.5 Overview

This SRS document includes the system's functional and non-functional requirements, use case descriptions, system architecture, and detailed requirements specifications. It serves as a blueprint for the development and implementation of the obesity level estimation system.

4.2. General Description

4.2.1 Product Perspective

The system is a standalone application designed to interact with various data sources, process and analyze data, and provide predictions and reports to end-users. It integrates machine learning models and a web-based interface for user interaction.

4.2.2 Product Functions

- Data Collection: Ingest data from various sources such as UCI repository, EHR, and NHANES.
- Feature Engineering: Process and extract relevant features from the collected data.
- Model Training: Train multiple machine learning models including Logistic Regression, Random Forest, SVM, Gradient Boosting, and Neural Networks.
- Prediction: Generate obesity level predictions based on trained models.
- Evaluation: Assess model performance using accuracy, precision, recall, F1 score, and AUC.
- Reporting: Generate and display prediction results and performance metrics.
- User Management: Manage user roles and access permissions.

4.2.3 User Classes and Characteristics

- Data Scientists: Require tools for data processing, model training, and evaluation.
- Healthcare Providers: Need accurate predictions and comprehensive reports for patient care.
- Public Health Officials: Require detailed reports for public health analysis and intervention.
- System Administrators: Manage system deployment, maintenance, and user access.

4.2.4 Operating Environment

The system will operate on standard web browsers and will be deployed on a server with sufficient computational resources to handle data processing and model training tasks.

4.2.5 Design and Implementation Constraints

- Data Privacy: Must ensure compliance with data protection regulations.
- Performance: System must be capable of handling large datasets and providing timely predictions.
- Scalability: System should be able to scale with increasing data volume and user base.

4.2.6 Assumptions and Dependencies

- Reliable and representative data will be available.
- Necessary computational resources will be provided.
- Stakeholders will provide timely feedback and requirements.

4.3. System Features

4.3.1 Data Collection and Preprocessing

Description: Ingest data from multiple sources and preprocess it for feature extraction and model training.

Functional Requirements:

- The system shall import data from the UCI repository and other sources.
- The system shall preprocess data to handle missing values, outliers, and normalization.
- The system shall store preprocessed data in a database.

4.3.2 Feature Engineering

Description : Extract and process features relevant to obesity prediction.

Functional Requirements:

- The system shall extract relevant features from the preprocessed data.
- The system shall perform feature selection to identify the most impactful features.
- The system shall transform features as needed for model training.

4.3.3 Model Training

Description: Train multiple machine learning models using the processed data.

Functional Requirements:

- The system shall train Logistic Regression, Random Forest, SVM, Gradient Boosting, and Neural Network models.
- The system shall perform hyperparameter tuning to optimize model performance.
- The system shall store trained models for future use.

4.3.4 Prediction and Evaluation

Description: Generate predictions and evaluate model performance.

Functional Requirements:

- The system shall generate obesity level predictions based on the trained models.
- The system shall evaluate model performance using accuracy, precision, recall, F1 score.

4.3.5 Reporting

Description: Generate and display prediction results and performance metrics.

Functional Requirements:

- The system shall generate reports detailing prediction results and model performance.
- The system shall provide visualization tools for interpreting results.
- The system shall allow users to export reports in various formats (e.g., PDF, CSV).

4.3.6 User Management

Description: Manage user roles and access permissions.

Functional Requirements:

- The system shall support user authentication and authorization.
- The system shall allow administrators to manage user roles and permissions.
- The system shall log user activities for auditing purposes.

4.4. External Interface Requirements

4.4.1 User Interfaces

- Web-based interface for data input, model training, prediction, and reporting.
- Dashboard for visualizing prediction results and performance metrics.

4.4.2 Hardware Interfaces

- Server with sufficient computational resources for data processing and model training.

4.4.3 Software Interfaces

- Integration with databases for data storage and retrieval.
- APIs for importing data from external sources.

4.5. Non-Functional Requirements

4.5.1 Performance Requirements

- The system shall process and train models on large datasets within a reasonable time frame.
- The system shall provide prediction results within seconds of input data submission.

4.5.2 Safety Requirements

- The system shall ensure data privacy and protection against unauthorized access.

4.5.3 Security Requirements

- The system shall implement user authentication and authorization mechanisms.
- The system shall encrypt sensitive data both at rest and in transit.

4.5.4 Software Quality Attributes

- Usability: The system shall have an intuitive and user-friendly interface.
- Reliability: The system shall be available 99.9% of the time.
- Maintainability: The system shall be easy to update and maintain.

4.5.5 Constraints

- The system must comply with data protection regulations such as GDPR and HIPAA.
- The system must be deployable on standard server infrastructure.

Other Requirements:

- The system should support future integration with additional data sources and machine learning models.
- The system should provide documentation and training materials for end-users.

This SRS document serves as a comprehensive guide for the development of the Obesity Level Estimation System, ensuring that all functional and non-functional requirements are clearly defined and understood by all stakeholders.

HARDWARE REQUIREMENTS:

- Processor - Dual core I7
- Speed - 1.1 Ghz
- RAM - 8 GB
- Hard Disk - 20 GB
- Key Board - Standard Windows Keyboard
- Mouse - Two or Three Button Mouse
- Monitor - SVGA

SOFTWARE REQUIREMENTS:

- Operating System - Windows 8/10/11
- Programming Language - Python
- IDE - Jupyter Notebook / Python IDE
- Libraries - NumPy, Pandas, Scikit-Learn, Matplotlib.

5. SYSTEM DESIGN

5.1 UML Diagram:

The Unified Modeling Language allows the software engineer to express an analysis model using the modeling notation that is governed by a set of syntacticsemantic and pragmatic rules.

A UML system is represented using five different views that describe the system fromdistinctly different perspective. Each view is defined by a set of diagram, which is as follows.

- **User Model View**

    i. This view represents the system from the users perspective.

    ii. The analysis representation describes a usage scenario from the end-users perspective.

- **Structural Model view**

    i. In this model the data and functionality are arrived from inside the system.

    ii. This model view models the static structures.

- **Behavioral Model View**

    It represents the dynamic of behavioral as parts of the system, depicting the interactions of collection between various structural elements described in theuser model and structural model view.

- **Implementation Model View**

    In this the structural and behavioral as parts of the system are represented as they are to be built.

- **Environmental Model View**

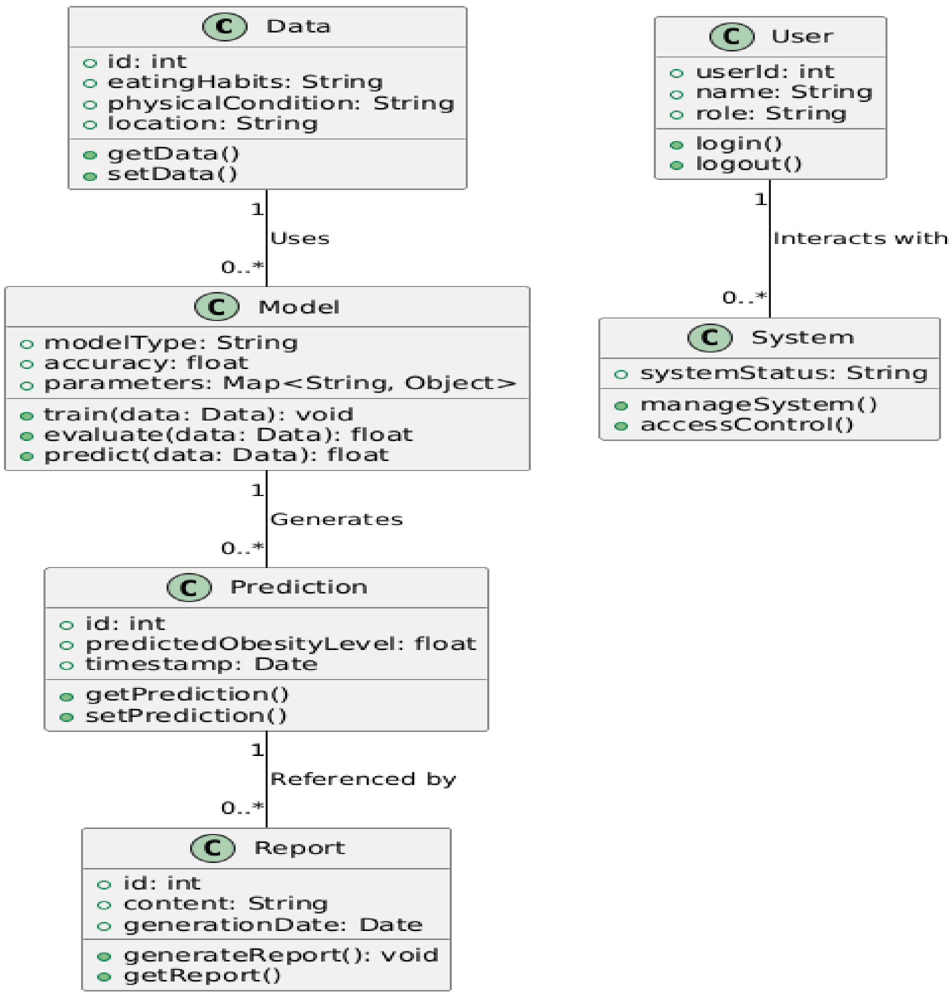
    In this the structural and behavioral aspects of the environment in which the system is to be implemented are represented.

5.1.1. Class Diagram:

The class diagram is the main building block of object oriented modeling. It is used both for general conceptual modeling of the systematic of the application, and for detailed modeling translating the models into programming code. Class diagrams can also be used for data modeling. The classes in a class diagram represent both the main objects, interactions in the application and the classes to be programmed. In the diagram, classes are represented with boxes which contain three parts:

- The upper part holds the name of the class
- The middle part contains the attributes of the class
- The bottom part gives the methods or operations the class can take or undertake

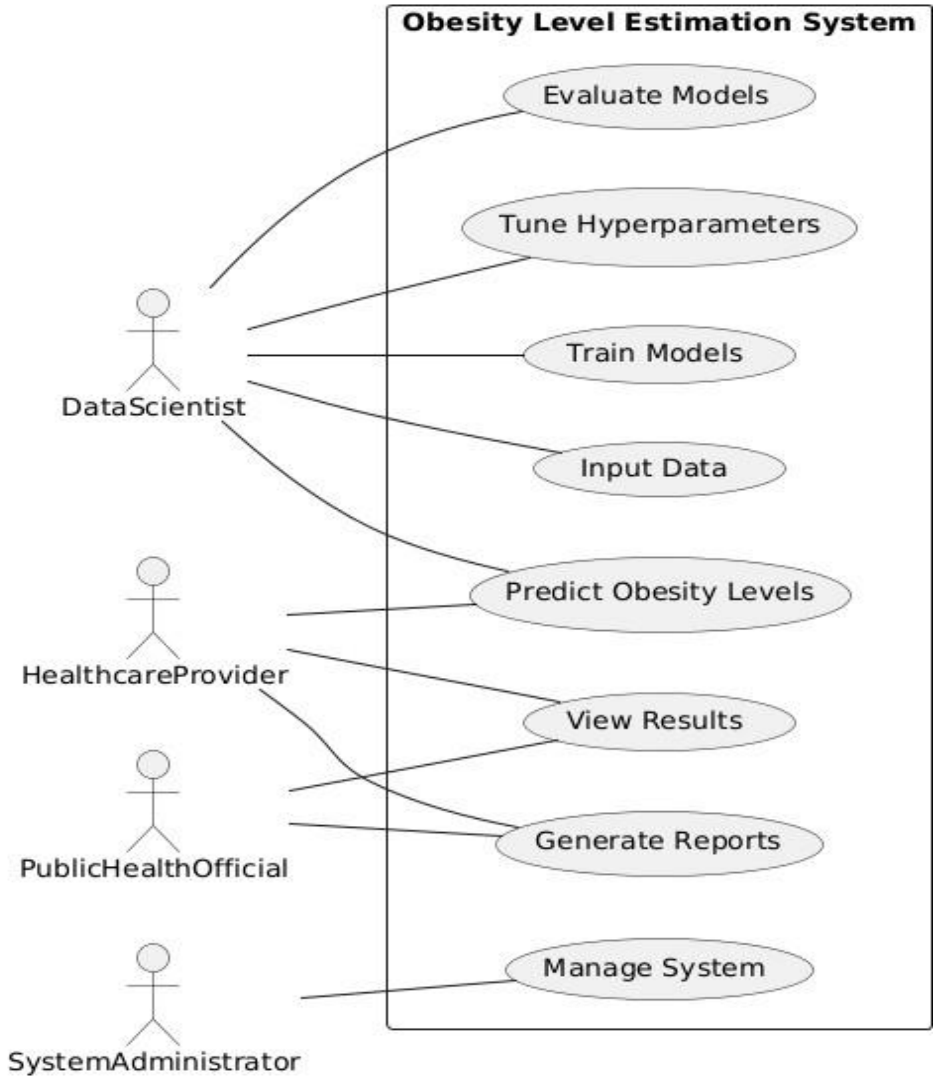
Class Diagram:



5.1.2. Use case Diagram:

A **use case diagram** at its simplest is a representation of a user's interaction with thesystem and depicting the specifications of a use case. A use case diagram can portray thedifferent types of users of a system and the various ways that they interact with the system. This type of diagram is typically used in conjunction with the textual use case and will often be accompanied by other types of diagrams as well.

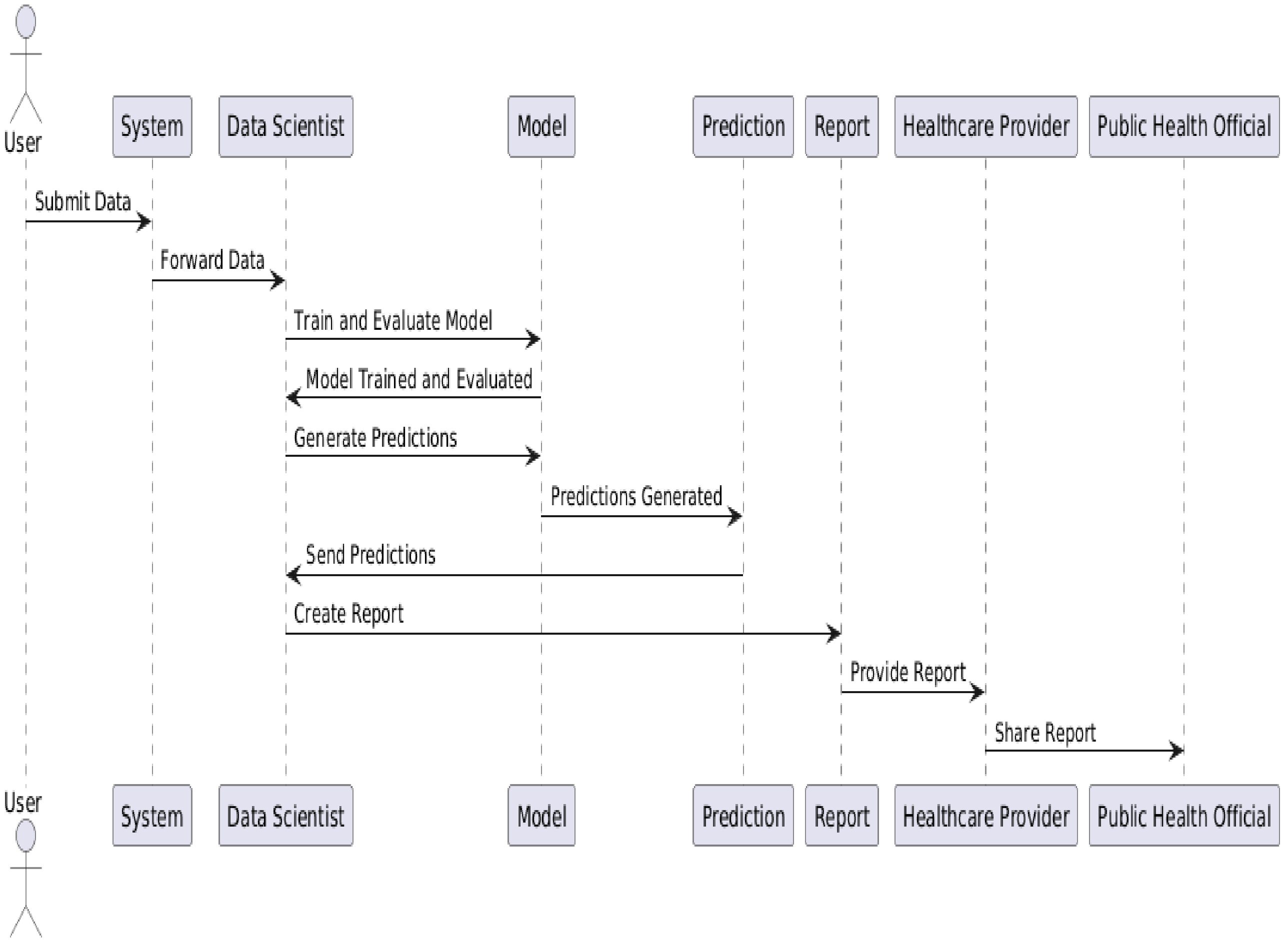
Use case diagram:



5.1.3. hSequence diagram:

A **sequence diagram** is a kind of interaction diagram that shows how processes operate with one another and in what order. It is a construct of a Message Sequence Chart. A sequence diagram shows object interactions arranged in time sequence. It depicts the objects and classes involved in the scenario and the sequence of messages exchanged between the objects needed to carry out the functionality of the scenario. Sequence diagrams are typically associated with use case realizations in the Logical View of the system under development. Sequence diagrams are sometimes called **event diagrams**, **event scenarios**, and timing diagrams.

Sequence diagram:

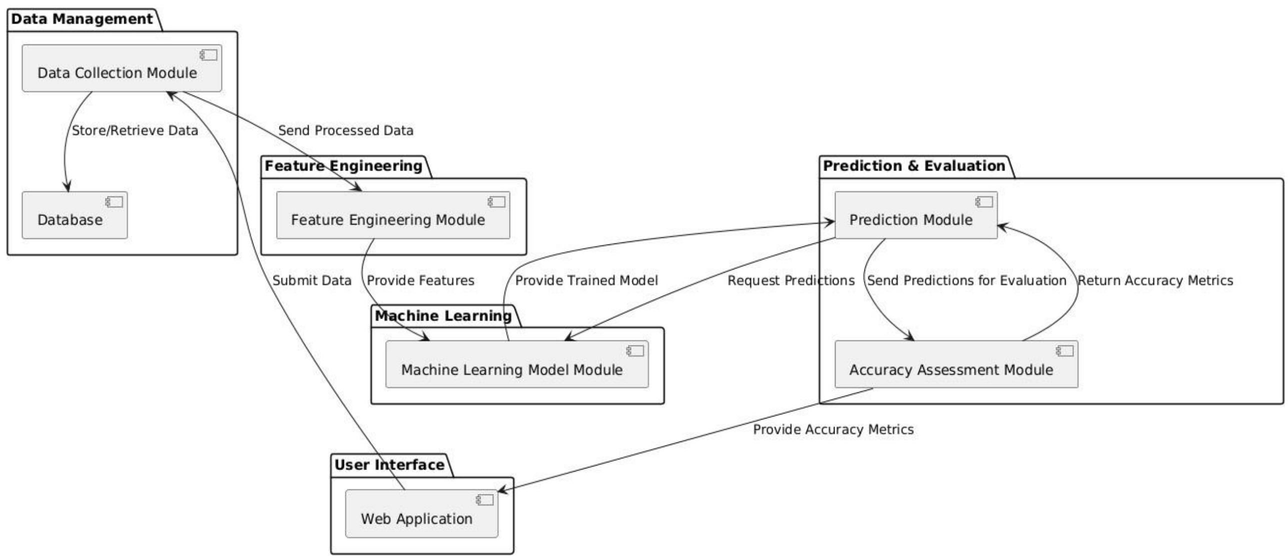


5.1.4. Component Diagram:

In the Unified Modeling Language, a component diagram depicts how components are wired together to form larger components and or software systems. They are used to illustrate thestructure of arbitrarily complex systems.

Components are wired together by using an assembly connector to connect the required interface of one component with the provided interface of another component. This illustrates theservice consumer - service provider relationship between the two components.

Component Diagram:

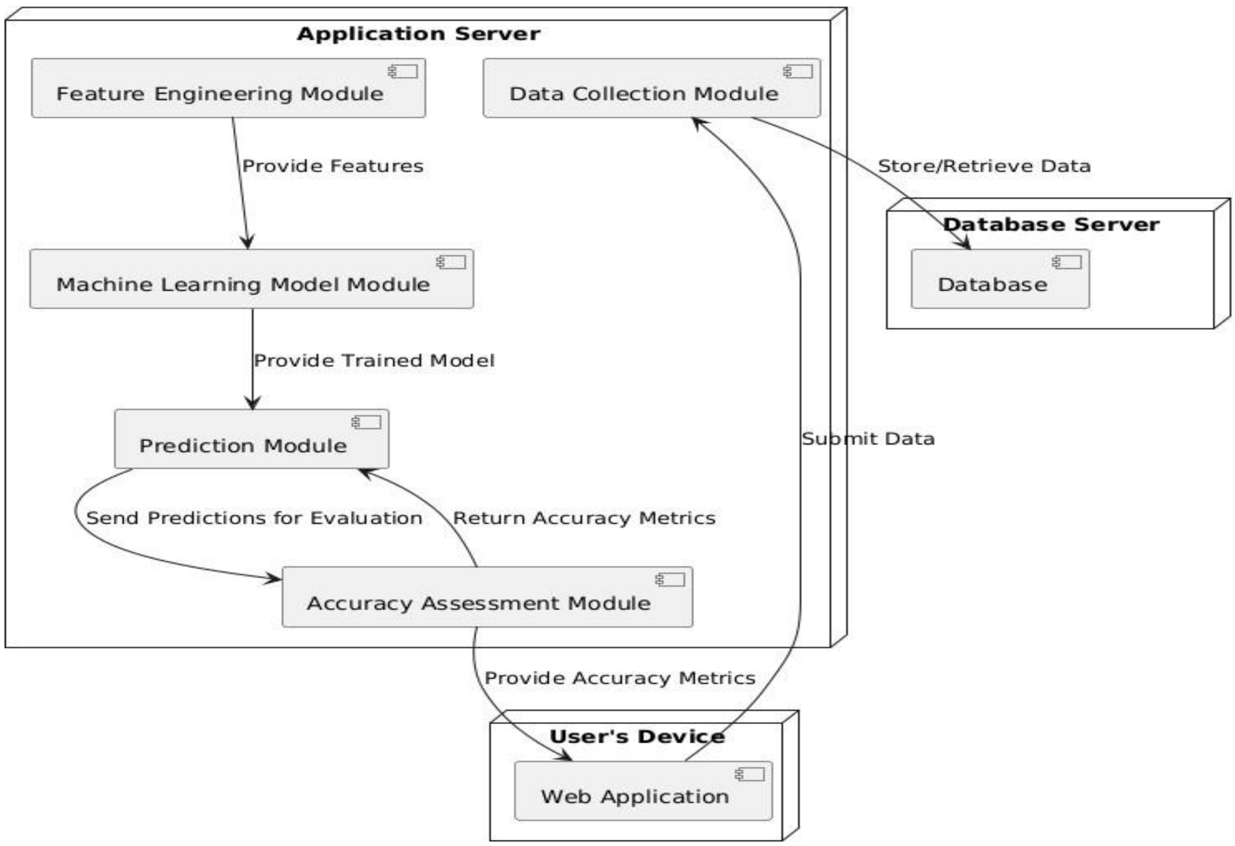


5.1.5. Deployment Diagram:

A **deployment diagram** in the Unified Modeling Language models the physical deployment of artifacts on nodes. To describe a web site, for example, a deployment diagram would show what hardware components ("nodes") exist (e.g., a web server, an application server, and a database server), what software components ("artifacts") run on each node (e.g., web application, database), and how the different pieces are connected (e.g. JDBC, REST, RMI).

The nodes appear as boxes, and the artifacts allocated to each node appear as rectangles within the boxes. Nodes may have sub nodes, which appear as nested boxes. A single node in a deployment diagram may conceptually represent multiple physical nodes, such as a cluster of database servers.

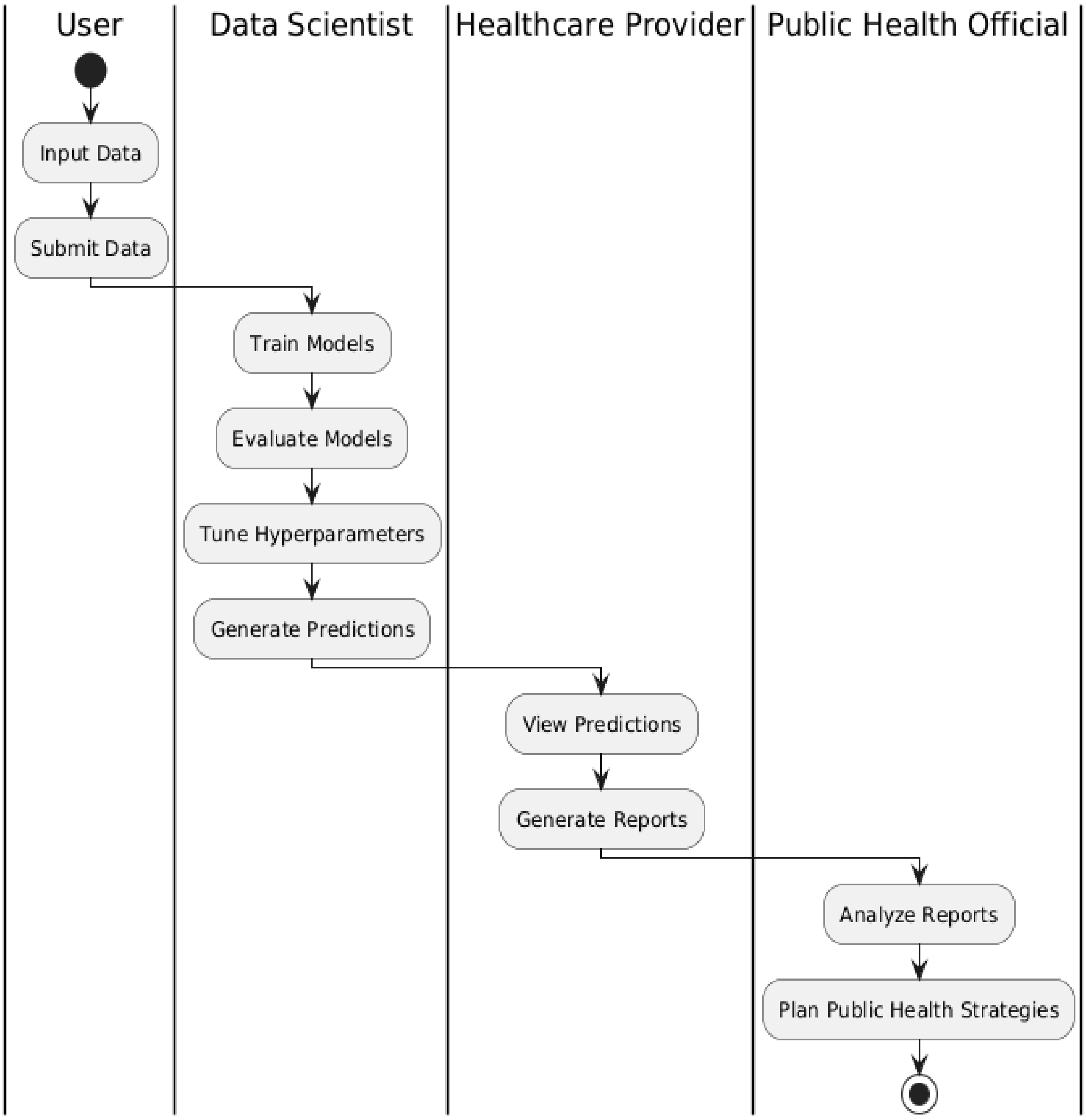
Deployment Diagram:



5.1.6. Activity Diagram:

Activity diagram is another important diagram in UML to describe dynamic aspects of the system. It is basically a flow chart to represent the flow form one activity to another activity. The activity can be described as an operation of the system. So the control flow is drawn from one operation to another. This flow can be sequential, branched or concurrent.

Activity Diagram:

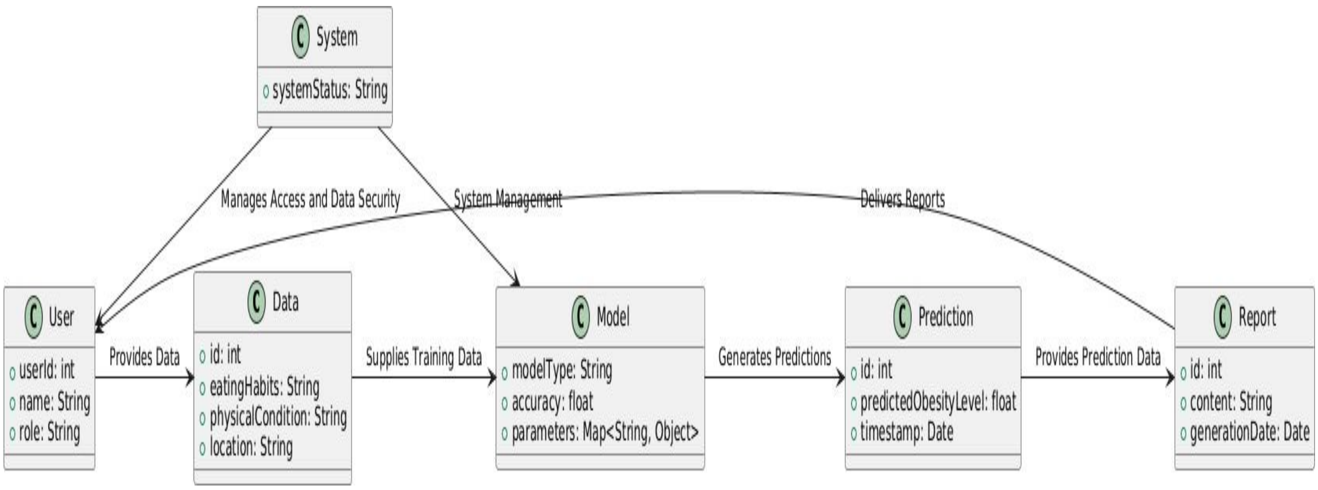


5.1.7. Data Flow Diagram:

Data flow diagrams illustrate how data is processed by a system in terms of inputs and outputs. Data flow diagrams can be used to provide a clear representation of any business function. The technique starts with an overall picture of the business and continues by analyzing each of the functional areas of interest. This analysis can be carried out in precisely the level of detail required. The technique exploits a method called top-down expansion to conduct the analysis in a targeted way.

As the name suggests, Data Flow Diagram (DFD) is an illustration that explicates the passage of information in a process. A DFD can be easily drawn using simple symbols. Additionally, complicated processes can be easily automated by creating DFDs using easy-to-use, free.

Dataflow diagram:



6. SOURCE CODE

Python:

Python is a general-purpose language. It has wide range of applications from Web development (like: Django and Bottle), scientific and mathematical computing (Orange, SymPy, NumPy) to desktop graphical user Interfaces (Pygame, Panda3D). The syntax of the language is clean and length of the code is relatively short. It's fun to work in Python because it allows you to think about the problem rather than focusing on the syntax.

History of Python:

Python is a fairly old language created by Guido Van Rossum. The design began in the late 1980s and was first released in February 1991.

Why Python was created?

In late 1980s, Guido Van Rossum was working on the Amoeba distributed operating system group. He wanted to use an interpreted language like ABC (ABC has simple easy-to-understand syntax) that could access the Amoeba system calls. So, he decided to create a language that was extensible. This led to design of a new language which was later named Python.

Why the name Python?

No. It wasn't named after a dangerous snake. Rossum was fan of a comedy series from late seventies. The name "Python" was adopted from the same series "Monty Python's Flying Circus".

Features of Python:

- A simple language which is easier to learn
- Free and open-source
- Portability
- A high-level, interpreted language
- Object-oriented

Applications of Python:

- Simple Elegant Syntax
- Not overly strict
- Expressiveness of the language
- Great Community and Support

app.py

```
import os
from unittest import result
import numpy as np
from flask import Flask, request, render_template
import pickle

# creating an instance of the class
app = Flask(__name__, template_folder='Templates')
model = pickle.load(open('modelkmeans.pkl', 'rb'))

# telling flask what url should trigger the function home()
@app.route('/')
@app.route('/index')
def home():
    return render_template('index.html')

# prediction function
def valPredictor(to_predict_list):
    to_predict = np.array(to_predict_list).reshape(1,16)
    # loading the model
    loaded_model = pickle.load(open('modelkmeans.pkl', 'rb'))
    # predict values using loaded model
    result = loaded_model.predict(to_predict)
    return result[0]

@app.route('/result',methods=['POST'])
def result():
    if request.method == 'POST':
        to_predict_list = request.form.values()
        to_predict_list = list(map(float, to_predict_list))
        result = valPredictor(to_predict_list)

        if float(result) == 0:
            prediction = 'You have a normal weight level but could easily relapse to insuffient weight
level'
        elif float(result) == 1:
            prediction = 'You have obesity type II weight level but are at a high risk of obesity type III'
        elif float(result) == 2:
            prediction = 'You are at overweight level I but are at a high risk of being overweight level II'

        elif float(result) == 3:
            prediction = 'You have obesity type I weight level'
        elif float(result) == 4:
            prediction = 'You are at overweight level I'

        return render_template('result.html', prediction=prediction)
# starting the flask server
if __name__ == "__main__":
    app.run(debug=True)
```

index.html

```
<!DOCTYPE html>
<html lang="en">
   <head>
      <meta charset="utf-8">
      <meta name="viewport" content="width=device-width, initial-scale=1">
      <title>OBESITY LEVELS</title>
      <link rel="stylesheet"
href="https://cdn.jsdelivr.net/npm/bootstrap@4.6.2/dist/css/bootstrap.min.css">
      <style>
         * { -webkit-box-sizing:border-box; -moz-box-sizing:border-box; -ms-box-
sizing:border-box; -o-box-sizing:border-box; box-sizing:border-box; }

      html { width: 100%; height:100%; overflow:visible; }

      body {
         width: 100%;
         height:100%;
         font-family: 'Open Sans', sans-serif;
         background: #092756;
         color: #fff;
         font-size: 18px;
         text-align:justify;
         letter-spacing:1.2px;
         background: -moz-linear-gradient(-45deg,  #092756 0%, #670d10 100%),-
moz-linear-gradient(top,  rgba(57,173,219,.25) 0%, rgba(42,60,87,.4) 100%), -moz-
radial-gradient(0% 100%, ellipse cover, rgba(104,128,138,.4)
10%,rgba(138,114,76,0) 40%) ;
         background: -webkit-linear-gradient(-45deg,  #092756 0%, #670d10 100%), -
webkit-linear-gradient(top,  rgba(57,173,219,.25) 0%,rgba(42,60,87,.4) 100%), -
webkit-radial-gradient(0% 100%, ellipse cover, rgba(104,128,138,.4)
10%,rgba(138,114,76,0) 40%) ;
         background: -o-linear-gradient(-45deg,  #092756 0%, #670d10 100%), -o-
linear-gradient(top,  rgba(57,173,219,.25) 0%,rgba(42,60,87,.4) 100%), -o-radial-
gradient(0% 100%, ellipse cover, rgba(104,128,138,.4) 10%,rgba(138,114,76,0)
40%) ;
         background: -ms-linear-gradient(-45deg,  #092756 0%, #670d10 100%), -ms-
linear-gradient(top,  rgba(57,173,219,.25) 0%,rgba(42,60,87,.4) 100%), -ms-radial-
gradient(0% 100%, ellipse cover, rgba(104,128,138,.4) 10%,rgba(138,114,76,0)
40%) ;
         background: linear-gradient(135deg,  #092756 0%, #670d10 100%), linear-
gradient(to bottom,  rgba(57,173,219,.25) 0%,rgba(42,60,87,.4) 100%), -webkit-
radial-gradient(0% 100%, ellipse cover, rgba(104,128,138,.4)
```

```
10%,rgba(138,114,76,0) 40%);
          filter: progid:DXImageTransform.Microsoft.gradient(
startColorstr='#3E1D6D', endColorstr='#092756',GradientType=1 );

          }

       h3 {color: rgb(226, 209, 209); text-shadow: 0 0 10px rgba(0,0,0,0.3); letter-
spacing:1px; text-align:justify;}

       label {
          color: #cfc2ba;
          font-weight: lighter;
          float: inline-start;

          }
       label:after { content: ": " }

       </style>

   </head>

   <body>
       <main>
          <div>
             <h3>EVALUATION OF OBESITY LEVELS</h3>
             <p>There are 7 levels of obesity: </p>
                <ul>
                   <li>Insufficient Weight</li>
                   <li>Normal Weight</li>
                   <li>Overweight Level I</li>
                   <li>Overweight Level II</li>
                   <li>Type I</li>
                   <li>Type II</li>
                   <li>Obesity Type III</li>
                </ul>

             <p>Would you like to know yours? Enter your details below and click on
CHECK LEVEL.</p>

             <br>

             <form action="/result" method="post" class = "form-group">
                <label for="age">Age</label>
                <input type="text" id="age" name="age" class = "form-control"
```

```
placeholder="0" required>
                <br>

                <label for="weight">Weight</label>
                <input type="text" id="weight" name="weight" class = "form-control"
placeholder="0.0" required>
                <br>

                <label for="height">Height</label>
                <input type="text" id="height" name="height" class = "form-control"
placeholder="0.0" required>
                <br>

                <label for="gender">Gender</label>
                    <select id="gender" name="gender" class = "form-control">
                        <option value="1">Male</option>
                        <option value="0">Female</option>
                    </select>
                <br>

                <label for="genetics">Has a family member suffered or suffers from
overweight?</label>
                    <select id="genetics" name="genetics" class = "form-control">
                        <option value="1">Yes</option>
                        <option value="0">No</option>
                    </select>
                <br>

                <p>Eating habits: </p>

                <label for="calories">Do you eat high caloric food frequently?</label>
                    <select id="calories" name="calories" class = "form-control">
                        <option value="1">Yes</option>
                        <option value="0">No</option>
                    </select>
                <br>

                <label for="vegetables">Do you usually eat vegetables in your
meals?</label>
                    <select id="vegetables" name="vegetables" class = "form-control">
                        <option value="1">Always</option>
                        <option value="2">Never</option>
                        <option value="3">Sometimes</option>
                    </select>
```

```html
<br>

<label for="meals">How many main meals do you have daily?</label>
   <select id="meals" name="meals" class = "form-control">
      <option value="0">Between 1 and 2</option>
      <option value="2">Three</option>
      <option value="1">More than 3</option>
   </select>
<br>

<label for="food">Do you eat any food between meals?</label>
   <select id="food" name="food" class = "form-control">
      <option value="0">Always</option>
      <option value="1">Frequently</option>
      <option value="3">No</option>
      <option value="2">Sometimes</option>
   </select>
<br>

<label for="smoke">Do you smoke?</label>
   <select id="smoke" name="smoke" class = "form-control">
      <option value="1">Yes</option>
      <option value="0">No</option>
   </select>
<br>

<label for="water">How much water do you drink daily?</label>
   <select id="water" name="water" class = "form-control">
      <option value="2">Less than a litre</option>
      <option value="1">Between 1 and 2 litres</option>
      <option value="3">More than 2 litres</option>
   </select>
<br>

<label for="alcohol">How often do you drink alcohol?</label>
   <select id="alcohol" name="alcohol" class = "form-control">
      <option value="0">Always</option>
      <option value="1">Frequently</option>
      <option value="3">No</option>
      <option value="2">Sometimes</option>
   </select>
<br>

<p>Physical Conditions: </p>
```

```
                <label for="mon_cal">Do you monitor the calories you eat
daily?</label>
                  <select id="mon_cal" name="mon_cal" class = "form-control">
                    <option value="1">Yes</option>
                    <option value="0">No</option>
                  </select>
                <br>

                <label for="act">How often do you have physical activity?</label>
                  <select id="act" name="act" class = "form-control">
                    <option value="0">I don't have</option>
                    <option value="1">1 or 2 days</option>
                    <option value="2">2 or 4 days</option>
                    <option value="3">4 or 5 days</option>
                  </select>
                <br>

                <label for="tech">How much time do you use technological devices per
day?</label>
                  <select id="tech" name="tech" class = "form-control">
                    <option value="0">0-2 hours</option>
                    <option value="1">3-5 hours</option>
                    <option value="2">More than 5 hours</option>
                  </select>
                <br>

                <label for="trans">Which mode of transport do you usually use?</label>
                  <select id="trans" name="trans" class = "form-control">
                    <option value="0">Automobile</option>
                    <option value="1">Bike</option>
                    <option value="2">Motorbike</option>
                    <option value="3">Public Transport</option>
                    <option value="4">Walking</option>
                  </select>
                <br>

                <br>
                <button type="submit" class="btn btn-primary btn-block btn-
large">CHECK LEVEL</button>

              </form>
            </div>
        </main></body></html>
```

7.TESTING

Implementation and Testing:

Implementation is one of the most important tasks in project is the phase in which one has to be cautions because all the efforts undertaken during the project will be very interactive. Implementation is the most crucial stage in achieving successful system and giving the users confidence that the new system is workable and effective. Each program is tested individually at the time of development using the sample data and has verified that these programs link together in the way specified in the program specification. The computer system and its environment are tested to the satisfaction of the user.

Implementation

The implementation phase is less creative than system design. It is primarily concerned with user training, and file conversion. The system may be requiring extensive user training. The initial parameters of the system should be modifies as a result of a programming. A simple operating procedure is provided so that the user can understand the different functions clearly and quickly. The different reports can be obtained either on the inkjet or dot matrix printer, which is available at the disposal of the user. The proposed system is very easy to implement. In general implementation is used to mean the process of converting a new or revised system design into an operational one.

Testing

Testing is the process where the test data is prepared and is used for testing the modules individually and later the validation given for the fields. Then the system testing takes place which makes sure that all components of the system property functions as a unit. The test data should be chosen such that it passed through all possible condition. Actually testing is the state of implementation which aimed at ensuring that the system works accurately and efficiently before the actual operation commence. The following is the description of the testing strategies, which were carried out during the testing period.

System Testing

System testing is a comprehensive type of testing that focuses on the complete, integrated system as a whole. This phase ensures that all components work together as expected in a real-world environment and that the system meets the functional, non-functional, and security requirements outlined in the project specifications. For the obesity level estimation project, system testing would involve running end-to-end tests, where data is inputted into the system (e.g., weight, height, activity level), and the system generates the corresponding obesity level or BMI prediction. The performance of the system, including speed and accuracy, would also be assessed under different conditions, such as handling large datasets or serving multiple users simultaneously. Security testing is another critical aspect of system testing, especially since healthcare data is sensitive. The system must be tested for compliance with regulations like HIPAA or GDPR, ensuring that user data is securely handled. Additionally, usability testing would confirm that the system is intuitive and user-friendly for healthcare professionals or patients interacting with the model.

Module Testing

Module testing, also known as unit testing, is focused on verifying that individual components or modules of the machine learning system function correctly in isolation. Each part of the system, such as data preprocessing, feature extraction, model training, or metrics calculation, must be tested to ensure that it performs its intended task as expected. For example, in the obesity level estimation project, module testing would involve validating the data preprocessing module to ensure that features like weight, height, and age are correctly cleaned, normalized, and encoded. Similarly, the model training module would be tested to confirm that the machine learning algorithm is correctly applied to the training data, and that the model learns effectively. By ensuring that each individual component is working properly before integration, module testing helps identify issues early in the development cycle, making debugging easier and faster.

Integration Testing

Once the individual modules have been tested, integration testing focuses on verifying that the interactions between these modules work as expected when combined. The goal is to ensure that different components of the system integrate smoothly and that data flows correctly through the entire pipeline. For instance, in the obesity level estimation project, integration testing would verify that the preprocessed data is properly passed to the model and that the model's predictions can be correctly received by the evaluation module. Additionally, integration testing might involve checking the interaction between the model and the user interface, ensuring that the predictions generated by the machine learning model are appropriately displayed to the end-users. Any issues that arise during integration are often related to how modules exchange data or work together, which makes integration testing crucial for identifying incompatibilities or bugs that wouldn't be apparent in isolated unit tests.

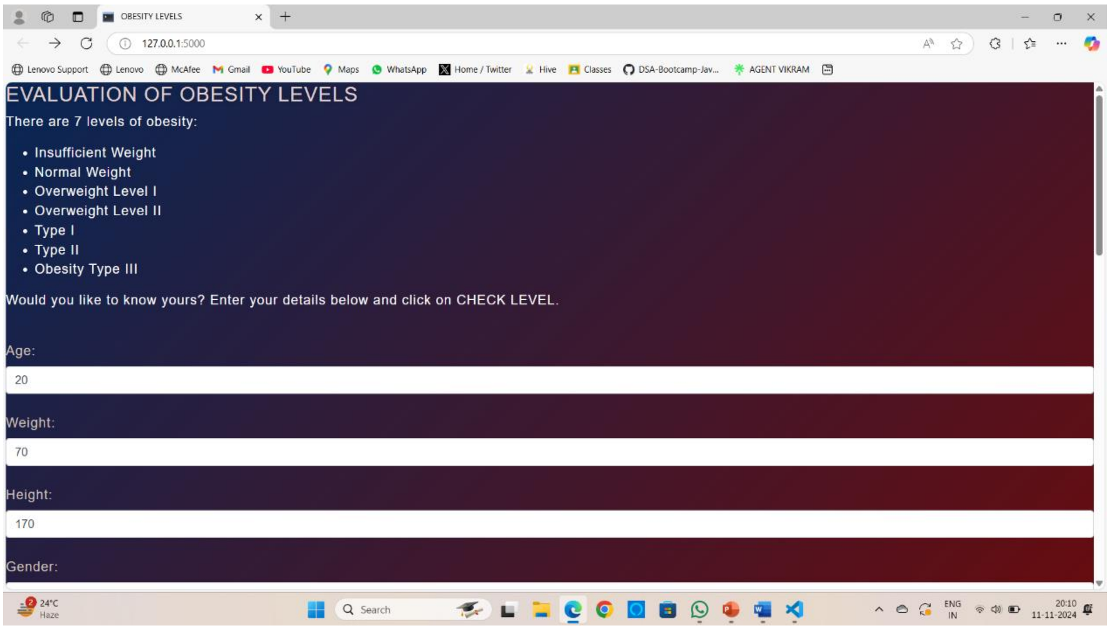
Acceptance Testing

Acceptance testing ensures the system meets business requirements and stakeholder expectations before deployment. It is typically performed by clients or end users. In the obesity level estimation project, functional acceptance involves verifying that the model accurately classifies obesity levels or estimates BMI. User acceptance testing (UAT) involves healthcare professionals assessing the system's practicality and whether it provides valuable insights based on predicted obesity levels. This testing confirms the system is ready for production, with stakeholders satisfied with its functionality, usability, and performance**.**

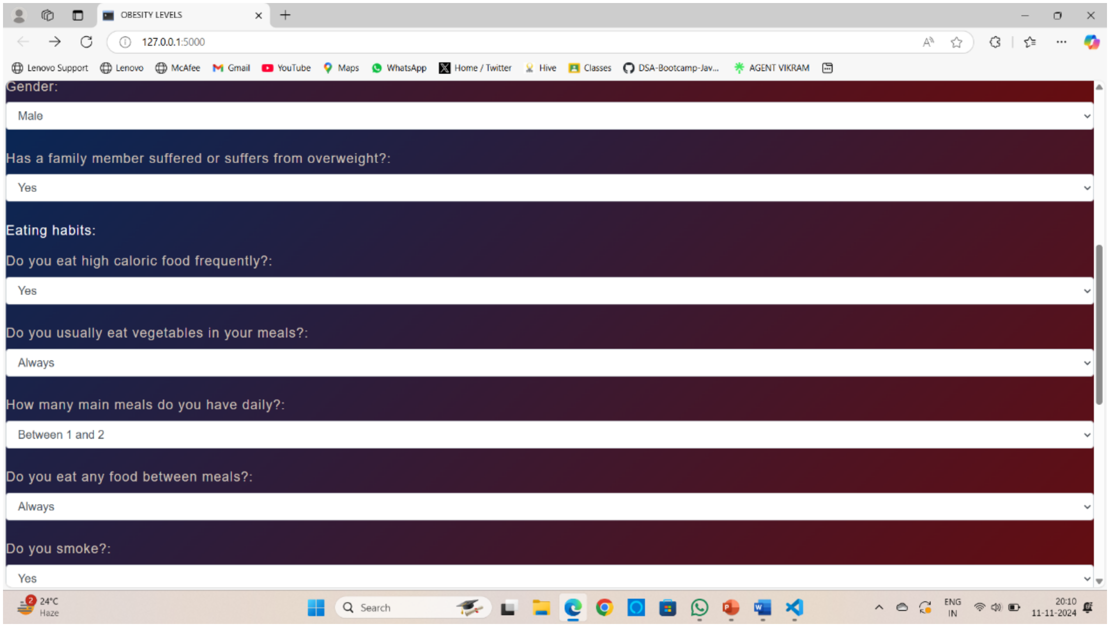
Test ID	Test Area	Test Description	Expected Outcome	Pass/Fail Criteria
01	Model Accuracy	Verify the model accurately classifies obesity levels based on input data.	The model should correctly predict obesity levels (Normal, Overweight, Obese).	Accuracy ≥ 90% or as defined by stakeholders.
02	BMI Estimation	Check if the model accurately estimates BMI from weight and height.	The model should predict BMI values within a valid range.	Error margin ≤ 1 BMI point.
03	Usability	Assess the ease of use of the user interface for healthcare professionals**.**	The UI should be intuitive and allow users to input data and receive predictions easily.	≥ 80% of users find the UI intuitive and easy to use.
04	Data Privacy & Security	Ensure compliance with data privacy regulations (e.g., HIPAA, GDPR).	User data should be securely handled and comply with privacy laws.	No violations of data privacy regulations**.**

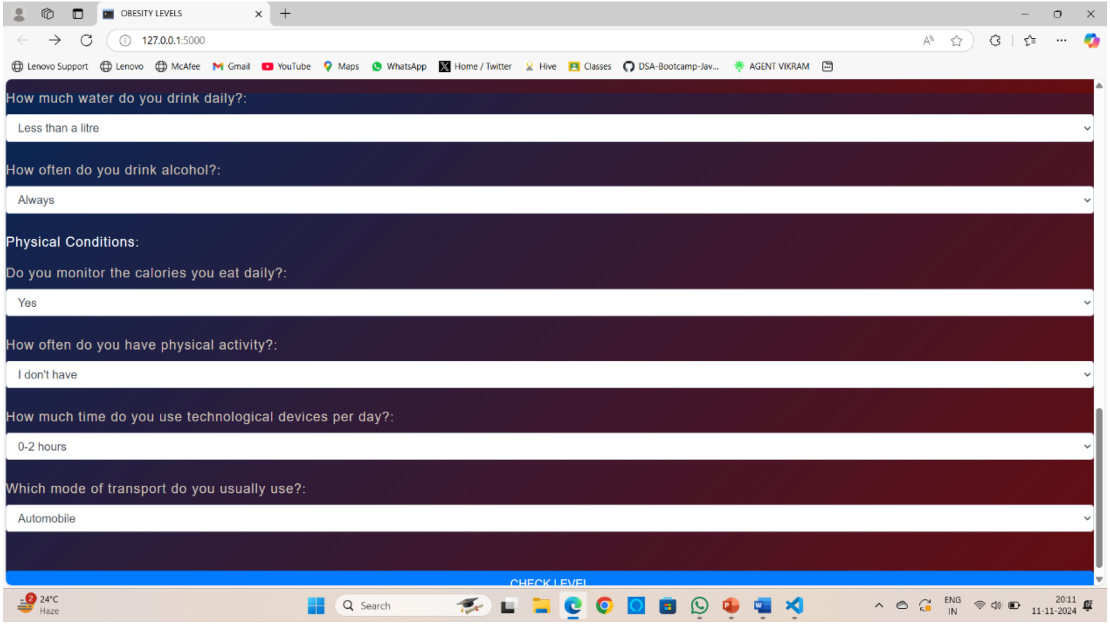
8.OUTPUT SCREENS

After running the code, a web page will be opened like this



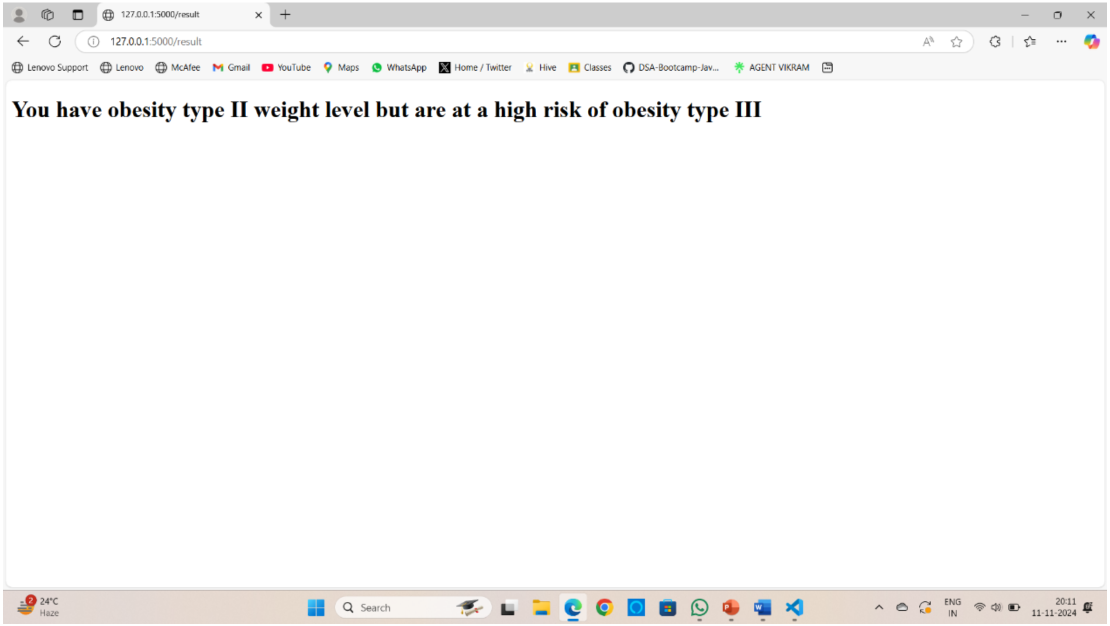
We need to fill the required answers in the boxes





After filling all the required values, we need to click the check level button.

Then a page will be appeared by indicating which levelof obesity does the patient had.



8.CONCLUSION

In this paper, we introduced the Obesity Level Estimation System using Machine Learning leverages modern techniques and a diverse dataset from the UCI repository to predict obesity levels with high accuracy. By implementing multiple models such as Logistic Regression, Random Forest, SVM, Gradient Boosting, and Neural Networks, the system surpasses traditional methods in performance. It emphasizes the importance of hyperparameter tuning and feature engineering, providing early obesity detection, actionable insights, and valuable reports for healthcare providers and public health officials. The system demonstrates scalability and efficiency, contributing significantly to public health by facilitating early interventions and promoting preventive measures against obesity.

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