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Prediction of BMI from Facial Image using Deep Learning

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ABSTRACT: Body mass index (BMI) is a person's weight in kilograms divided by the square of height in meters. It is a measurement of obesity based on measured height and weight. The traditional method of calculating BMI is cumbersome, requiring physical measurements and specific instruments. A proposed healthcare system aims to predict BMI using Kinect and data mining techniques, allowing individuals to easily determine their BMI values using facial images. The system includes a face detection and feature extraction component using Haar cascade to identify relevant facial information. By utilizing machine learning algorithms for data mining, such as Data Preprocessing, Data Extraction, data evaluation, and presentation, the framework trains models to predict obesity levels (Classification), body weight, and fat percentage levels (Regression) based on various parameters. This system is particularly beneficial for advancing research on body weights and assisting paralyzed or severely ill patients who are unable to undergo basic measurements for emergency medical services.

KEYWORDS: Body Mass Index, Face to BMI, Deep Learning, Facial Feature.

I. INTRODUCTION

The Body Mass Index (BMI) serves as a critical indicator of an individual's health status, determining whether they are underweight, normal, overweight, or obese. Unfortunately, health is often overlooked today, with technology, while beneficial, also contributing to negative impacts. The sedentary lifestyle brought about by technology has led to decreased physical activity levels, resulting in an increase in BMI and a higher risk of chronic diseases. A higher BMI is associated with a greater likelihood of developing cardiovascular and other detrimental health conditions. Conversely, some individuals face issues such as malnutrition and deficiencies. Monitoring BMI can assist individuals in maintaining a record of their health status. Research indicates that approximately one in three adults is obese, accounting for around 36% of the population, with an estimated 20% of the global population projected to be obese by 2030. Human facial features provide valuable insights into an individual's health. Recent studies have revealed a strong connection between facial characteristics and BMI. Individuals with slender faces are more likely to have lower BMIs, while the opposite holds true for those with fuller faces, particularly in the middle and lower regions. Calculating BMI can be challenging without access to measuring tools like a tape measure and scale. Recent advancements in deep learning have enabled models to extract meaningful features from images, allowing for the prediction of BMI based on facial features. This paper introduces a technique for predicting BMI from facial images, which could prove beneficial for health insurance companies in maintaining customer health records and for governments in formulating region-specific health policies.

There are various factors that influence the motivation behind this research. Firstly, the visual perception of weight and fat in the human body can be easily observed through facial images [17-19]. Humans can effortlessly detect changes in body fat just by using their eyes. Secondly, machine learning techniques can be utilized to identify facial features such as cheek-to-chin width, ratio of width to upper face height, perimeter-to-area ratio, eye size, lower face to face height ratio, and mean eyebrow height. These features are indicators of obesity and malnutrition and are associated with BMI [20, 21]. Recent research in health science suggests that a computational approach to studying body BMI through human face images should be explored [22]. Considering the strong correlation between BMI and certain diseases, BMI plays a crucial role in personal health monitoring and medical research. Traditionally, BMI is measured using specialized devices. However, this work aims to develop an automatic BMI prediction method using everyday photos taken by individuals for convenient monitoring. With the widespread use of smartphones, a large number of photos are uploaded and shared on the internet daily. These photos can be leveraged for assessing an individual's health condition through image processing and machine learning techniques [23-25]. Our research can greatly benefit medical

researchers by providing access to BMI data from social networks, which can serve as a valuable resource for health monitoring in large populations. By applying our model to photos, individuals affected by malnutrition and obesity can be easily identified, and their BMI can be predicted. The obtained results can then be communicated to the concerned individuals via email.

II. LITERATURE REVIEW

1. "Estimation of BMI from Facial Images using Semantic Segmentation based Region-Aware Pooling", computers in biology and medicine, Volume 133, June 2021, PP 104392. Authors: Nadeem Yousaf, Sarfaraz Hussein, Waqas Sultani. Their suggestion is to utilize deep features extracted from various facial regions, showcasing how this specific pooling technique can greatly enhance the accuracy of BMI prediction. To tackle the challenge of precise localization of facial regions at the pixel level, they advocate for the integration of face semantic segmentation within our framework.

2. "AI based BMI Inference from Facial Images: An Application to Weight Monitoring", Computer Vision and Pattern Recognition, Oct 2020 Authors: Hera Siddiqui, Ajita Rattani, Dakshina Ranjan Kisku, Tanner Dean. To encourage exploration and advancement in this field, have conducted an evaluation and comparison of the performance of five distinct deep learning Convolutional Neural Network (CNN) architectures.

3. "Investigation on Body Mass Index Prediction from Face Images", 2020 IEEE- EMBS Conference on Biomedical Engineering and Sciences (IECBES), March 2021. Authors: Chong Yen Fook, Cheechin Lim, Vikneswaran Vijejan. Within this structure, there will be three phases executed, starting with image pre-processing tasks like face detection utilizing the Viola-Jones technique, iris detection, image enhancement, and image resizing. Following that, face feature extraction will be conducted using facial metrics, and classification will be carried out using three different machine learning methods: artificial neural network, Support Vector Machine, and k-nearest neighbor, to evaluate the classification performance.

4. "A Framework for Healthcare Everywhere: BMI Prediction Using Kinect and Data Mining Techniques on Mobiles", 2015 16th IEEE International Conference on Mobile Data Management, September 2015. Authors: Chih-Hua Tai, Daw-Tung Lin. This research is to develop a BMI prediction system that can be accessed through mobile devices. By utilizing Kinect and data mining techniques, individuals will be able to conveniently monitor their BMI by simply capturing an image of their face. The underlying idea behind this approach is the belief that there exists a connection between facial features and BMI values, which individuals often rely on when observing changes in their friends' weight.

5. "A computational approach to body mass index prediction from face images", Image and Vision Computing, Volume 31, Issue 5, May 2013, PP 392- 400 Authors: LingyunWen, GuodongGuo. approach the task of predicting BMI based on facial features as a machine vision problem. Our method is evaluated on a vast database containing over 14,500 face images. The obtained results are highly promising, showcasing the potential for developing a computational system capable of predicting BMI from face images on a large scale.

III. METHODOLOGY

Random Forest Algorithm: Random forest is a popular Supervised Machine Learning Algorithm utilized for both Classification and Regression tasks. It constructs decision trees on various samples and aggregates their majority vote for classification or average for regression.

KNN Algorithm: K-Nearest Neighbour is a straightforward Machine Learning algorithm rooted in Supervised Learning methodology. K-NN algorithm operates under the assumption of similarity between new and existing data points, assigning the new data point to the category most akin to the available categories.

Decision Tree Algorithm: Decision Tree algorithm is part of the supervised learning algorithms family. Differing from other supervised learning algorithms, decision tree algorithm can address both regression and classification problems effectively.

Data flow diagrams depict the flow of data in a corporate information system graphically. Data Flow Diagram symbols are standardized notations, like rectangles, circles, arrows, and short- text labels, that describe a system or process' data flow direction, data inputs, data outputs, data storage points, and its various sub-processes. DFD denotes the steps involved in transferring data from the input to file storage and report production in a system. There are two types of data flow diagrams: logical and physical. The logical data flow diagram depicts the movement of data through a system in order to fulfill specific business functions. The physical data flow graphic depicts how the logical data flow is implemented.

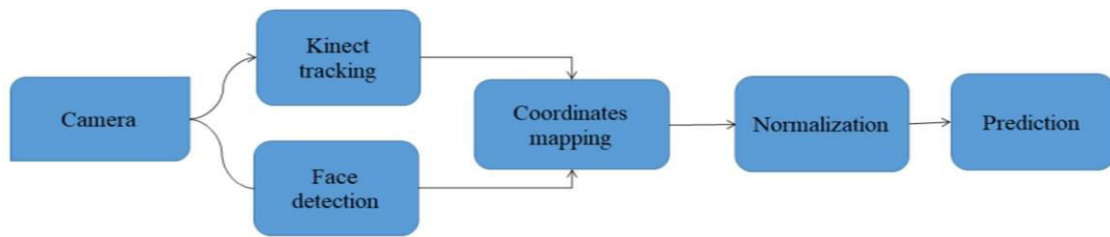


FIGURE ABOVE SHOWS THE DATA FLOW DIAGRAM.

A use case involves interactions between external entities and the system with a specific goal in mind. External entities interacting with the system are known as actors. Use Case Diagrams consist of four main elements: actors, system, services, and relationships between elements. These diagrams provide a graphical representation of the system's functionality at a certain level of detail. The use case model includes various parts, with the use case, actors, and their relationships being the most important. Use case diagrams help simplify communication by visually representing a portion of the model, such as system requirements and actors. They illustrate how a system's events and flows are depicted, although they do not detail how they are implemented.

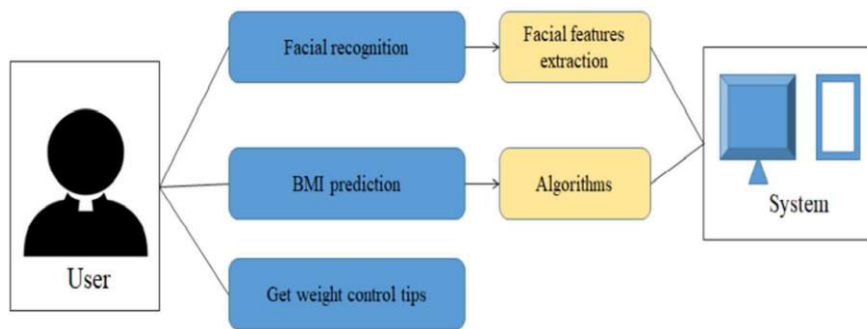
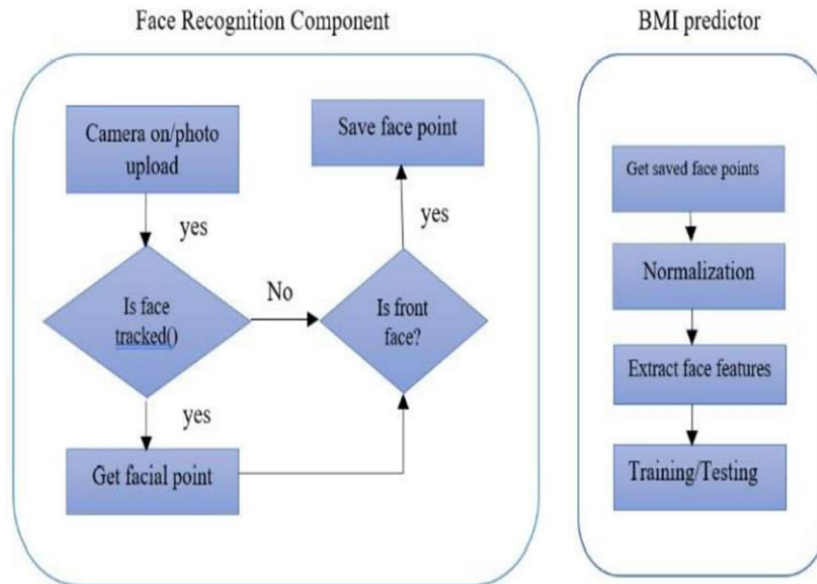


Figure above shows the Use case model.

IV. SYSTEM ARCHITECTURE

BMI prediction system consists of two parts as shown in Fig 4.1. The first part is a face detection and feature extraction component using Harr Cascade to grab useful face outline information. Here Harr Cascade is chosen because they are very fast at computing Haar-like features due to the use of integral images (also called summed area tables). They are also very efficient for feature selection using the AdaBoost algorithm. The second part of the system is the BMI predictor. The predictor responses for extracting facial features related to the BMI values and perform the prediction using keras model, which uses CNN algorithm.



V. IMPLEMENTATIONS

Implementation includes mainly 4 steps:

- Face detection or Recognition
- BMI Prediction
- Data Mining Phase
- Image Normalization

Face Recognition:

- ResNet-34, a python library for face recognition, is built upon the Deep Residual Learning for Image Recognition. It leverages the power of ResNet-34 to accurately identify faces in images.
- On the other hand, Haar Cascade is an Object Detection Algorithm specifically designed for face recognition. It surpasses rough estimation and delivers precise information, making it an effective tool in the field of image analysis.

BMI Prediction:

- The angle and distance of the photo can significantly impact the facial features captured. A standard front-facing photo is taken, and normalization is conducted to rectify any slanting of the face, ensuring relevant facial features are obtained.
- The BMI prediction model was developed using the Keras Application Programming Interface (API), a neural network API closely integrated with TensorFlow, a machine learning framework. This model utilizes the Convolutional Neural Network (CNN) algorithm, a Deep Learning system that assigns learnable weights to objects in input images.

Data Mining Phase:

- During the mining phase, relevant information regarding image features is gathered through data preprocessing, data extraction, data evaluation, and presentation.

Normalization:

- The process of normalization involves adjusting the pixel intensity levels in an image to make it appear more natural or familiar to the human eye.
- Image normalization is a technique that can help eliminate high-frequency noise and very low noise from an image, making it more visually appealing. Our goal is to enhance the contrast of an image so that it appears more natural to our eyes, especially when the original image has low contrast.

VI. PERFORMANCE ANALYSIS

Performance analysis involves examining or comparing the performance of a particular scenario in relation to the intended outcome and what has been achieved.

Process Of Execution: In this project, we will employ the python CNN technique to estimate BMI by analyzing facial characteristics. The CNN will take an image as input, extract the facial features, and then calculate BMI using these features. To implement this project, we have developed the following modules.

1.Generate & Load BMI & Face Detection Models: The CV2 library will be loaded for facial detection, while the CNN model will be loaded for BMI estimation. The facial detection library helps identify human faces in uploaded images, which are then analyzed by the CNN model to calculate BMI.

2.Upload Image: This module will be utilized for uploading an image to the application, with the Dashboard displaying the address of the uploaded image.

3.Run the Face and BMI Detection Algorithm: The algorithm in this model isolates a face from a given image and evaluates facial features in order to calculate the BMI value. By utilizing the BMI value, individuals can assess their health status, and potentially receive insurance quotes tailored to their estimated BMI.

VII. RESULTS

BMI is considered a measure of body fat based on a person's height and weight. It can serve as a screening tool. BMI may also be used to diagnose a variety of health issues.

Based on BMI, a person is classified as follows:

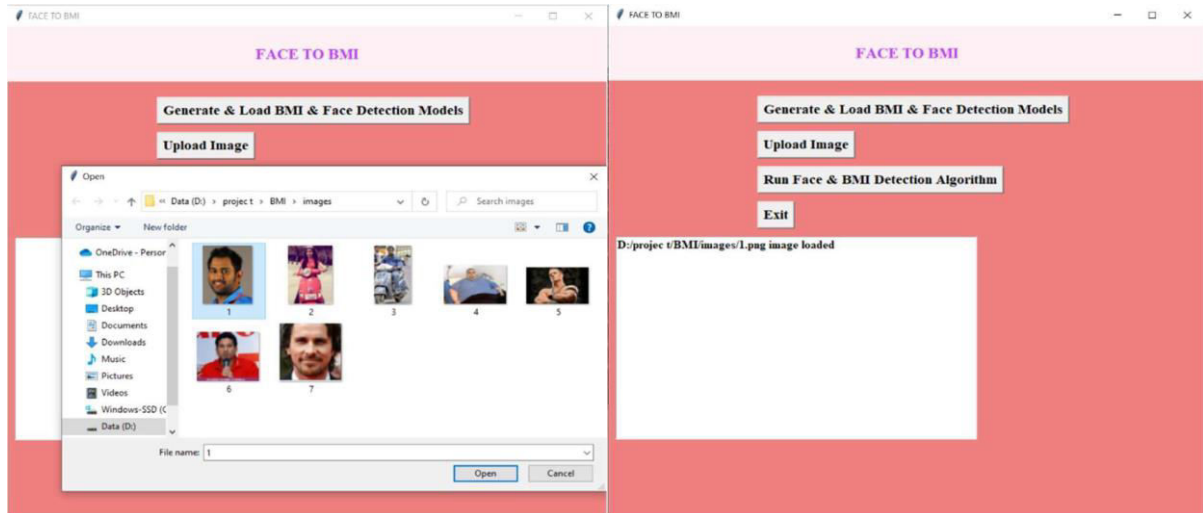
1. Underweight if $BMI < 18.5$
2. Healthy Weight if $BMI > 18.5 < 24.9$
3. Overweight if $25 < BMI < 29.9$
4. Obese if $30 < BMI$



Dashboard of Face to BMI Calculator

The functionality of the interface is as follows:

- 1.To load the CNN model, click on "Generate and Load BMI & Face detection Model".
- 2.To provide an image as input to the model, click on "Upload image" and select a picture from the saved location on the desktop. (Ensure that there is only one person in the picture for more accurate results).
- 3.To predict the BMI, click on "Run Face and BMI detection Algorithm" to obtain the result.
- 4.After the process is finished, the output will appear in the following format.



Your BMI predicted as : 23.450632019042965
This is considered as Healthy Weight

Fig: Output on UI screen



The BMI of the above images are 26.5 and 20.6 respectively classifying the two pictures as overweight and healthy weight.

VIII. CONCLUSION

The BMI values are provided by the System through the utilization of data mining techniques. This system utilizes data to evaluate the BMI-related facial traits of individuals and employs visualization to ensure that human judgments align with intuitions. By analyzing these BMI values, individuals can gain an understanding of their health and take appropriate measures to maintain it. The development of this BMI prediction system involved the use of data mining approaches. Our technology guarantees the use of front-facing photos through the implementation of the Harr Cascade object detection algorithm and calculates BMI by creating a model using the built-in TensorFlow and Keras modules, where the CNN algorithm is utilized. This study utilized data to identify the facial characteristics related to BMI in participants, and employed visualization techniques to ensure that human judgments were in line with intuitions. Additionally, the system classifies individuals into specific categories such as under-weight (BMI value below 18), healthy (BMI value between 18.1 to 30), over-weight (BMI value between 30.1 to 40), and obesity (BMI value above 40).

Future Enhancement

A potential advancement for the future could involve implementing a BMI detection system within a mobile application. This would offer a more convenient and user-friendly experience compared to using a PC or laptop, considering the widespread usage of smartphones among many individuals. Additionally, the improved application could generate a comprehensive health report based on the predicted data.

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