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Image Processing and Machine Learning Based Nutrition and Fitness Journaling System

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Abstract - People tend to lead a busy and stressful lifestyle with several responsibilities which makes them no time to be concerned about leading a healthy lifestyle which had led to most of the most common and serious non-communicable diseases including diabetes, cardiovascular diseases, and obesity worldwide with an increase in mortality rates. A lack of an easy and proper system to monitor and manage health has become a threat to the people in Sri Lanka. This had also affected the youth population with the rise of pandemic situations worldwide. Due to these reasons, there is a great demand for a proper nutrition and fitness journaling system especially during the pandemic situation that could be used without any physical meetups. The use of image processing and advanced machine learning algorithms for these systems are not very prominent which causes an enhanced urge for these systems. Four major components have been used in the proposed system to address this issue. These components include image processing with object detection to obtain body measurements which reduce the human errors caused by traditional methods where Waist to Hip ratio obtained from the body measurements is used to provide the health risk level to the users comparing the standard set of values which is an efficient method to identify the health conditions of the user, personalized workout recommendation system, personalized nutrient plan system and progress tracking and analysis system to track the progress of the users when using the system.

Keywords: image processing, machine learning, object detection, waist-to-hip ratio, non-communicable diseases, workout, nutrient, recommendation, progress tracking.

I. INTRODUCTION

The nutrition and fitness journaling system provides a productive way to observe and manage the health, nutrition, and fitness plans effectively by following up with necessary dietary intake and physical activities. Currently, nutrition and wellness applications have become a growing trend that provides recommendations for users in supporting weight loss and setting goals to achieve their required fitness goals in most countries. Most of the nutrition applications in use today use a general set of questions to know the current body aspects of the user which would give a generalized outcome and would follow the outcome towards weight management. Most of the serious common chronic disorder known as diabetes type 2 and obesity, has shown a drastic increase in countries of all income levels which is caused by in proper and healthy lifestyle. According to the statistics, about 422 million people in the world are diabetic patients, nearly 1.5 million diabetic patient deaths are reported annually and show a steady increase over the past few years [1]. Heart diseases are also considered to be another common disorder among the world population. It is estimated that 17.9 million cardiovascular deaths are reported each year [2]. In 2021, 3.81 million cardiovascular deaths have been reported [3]. The main purpose of our study is to identify and address the serious health risks that the user would be affected in the future by providing personalized recommendations. The application developed would use the image processing technique to obtain the body measurements that could provide the body ratios accurately. The waist-to-hip ratio (WHR), extracted from object detection algorithms is used by the system to identify and manage health risks. Based on the results, a personalized diet plan and/or workout plan is recommended considering the age, gender, and Body Mass Index (BMI) and health risks of the user.

A diet plan is provided by using machine learning algorithms based on a person's preferences and traits. Personalized nutrition plan suggestion systems have come to light as a possible response to this expanding demand. These systems use cutting-edge technologies like machine learning and data analytics to evaluate vast amounts of information and offer individualized nutritional advice. These systems seek to maximize nutrition interventions and improve overall health outcomes by considering elements including a person's health status, dietary constraints, cultural background, and nutritional goals. Personalized nutrition plan recommendation systems can go beyond the constraints of general dietary recommendations and offer personalized guidance that considers the various needs of individuals by utilizing the power of some important computational techniques. Automated personalized workout recommendation system that utilizes machine learning algorithms to create tailored fitness

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plans based on individual needs and goals by considering factors such as gender, age, weight, health risk levels, and health conditions, the system generates personalized workouts for both gym and home settings. Integration with wearable devices enables real-time tracking of important metrics like activity levels and calorie burn etc., facilitating self-monitoring. The system also incorporates dynamic adjustments to workouts, ensuring an appropriate level of workouts if exercises are not completed or repetitions being skipped. Furthermore, users' previous health issues are considered to ensure safe and suitable workout suggestions. This research aims to revolutionize the fitness industry by enhancing engagement and safety through the usage of automated personalized workout recommendations. The system consists of a progress tracker which accomplishes user end goals conveniently according to the generated personalized workout and diet plans. With a proper tracking system, users as well as the experts engaging with the system can obtain a significant number of advantages in a productive way. A system with user tracking functionalities provides self-assessment, dynamic feedback, and motivation to the users, while some recent studies revealed that the data from these applications can be beneficial for experts in advising their clients [4]. Also, a nutrition and fitness tracking system enable experts to monitor their user's development even in real-time or according to their work schedule, creating a more comprehensive picture of their progress. Also, the validity of the user's input data plays a significant role since the decisions are based on that data. Most available tracking systems in the market are based on manual user inputs which can cause accuracy issues when it comes to decision making based on captured data.

II. LITERATURE SURVEY

There have been a wide variety of web-based applications developed for weight management. Currently, available web applications used for weight management use different aspects in monitoring and managing the weight of the users. Some examples of already documented projects by several researchers using various approaches can be indicated as follows.

In a research study outlining a web-based nutrition assessment tool, Raluca-Monica Pop, Marian Pop, Grigore Dogaru, and Vladimir C. Bacarea, [5] in which they have developed the application for patient management targeting general practitioners and registered nutritionists. The patient data have been stored in a database and answers from an FFQ (Food Frequency Questionnaire) have been used to obtain the number of times each food is consumed per day then based on an algorithm, a food pyramid would be developed, in addition, the user needs to add the information manually in a patient page including the body measurements. Ultimately food recommendations are provided based on the manual data entered. This study does not use an image to extract body measurements, instead uses manual entry of measurements and does not identify any health risk indications which are main aspects used in our study to improve efficiency and user friendliness.

Fiona Johnson and Jane Wardle proposed an association between weight loss and engagement with a web-based food and exercise diary for weight loss [6]. Their study records food and exercise diaries online and charts the progress for a target weight. The user needs to enter their personal information about height, weight, activity levels, and speed of weight loss. Then the system provides an appropriate target for the user to achieve their desired weight. There is no process of extracting measurements from images, identifying health risk levels or providing personalized recommendations to users from their study, which could be improved further by including these features to their system. In recent research efforts, the field of fitness and workout recommendation systems has been explored to enhance the accuracy and personalization of workout recommendations provided to users. A study focused on providing workout recommendations, it does not appear to provide truly personalized plans adapted to each user's health profile and goals. The recommendations are based on limited criteria and preset training types rather than customized exercise and regimen planning. The criteria used in the system (Weighted Product method) were exercise tools, time, gender, and weight. Each was assigned a weight by the system reflecting its importance. And the system doesn't appear to dynamically adjust recommendations based on user feedback or progress because the criteria used in here are static [7]. Based on the paper, FitRec system does not provide fully personalized and unique workout recommendations tailored to each individual user's health conditions. However, it is taking steps towards more personalized recommendation by incorporating user-specific information. However, the system does not appear to explicitly consider specific health conditions or issues of individual users. Personalization is mainly based on learned patterns from a user's previous workout history data. The authors note that limitations of the dataset make it challenging to model individual user patterns. In summary, while this work represents steps towards personalized modelling and recommendation using sequential workout data, it does not provide fully tailored recommendations based on knowledge of each user's unique health profile. The authors acknowledge this as an area for future work with richer datasets [8].

Personalized Digital Fitness Coach provides generalized fitness and injury advice, the system described does not appear to go as far as fully personalized and unique workout

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recommendations based on analysis of each individual user's health status and issues. The focus seems more on applying general coaching expertise rather than tailoring workouts to individual needs [9]. Bloom Balance is an alternative solution for people who want to enhance their health by regulating their eating habits and exercising more [10]. The calorie counters in the application are divided into intake-calorie and burned-calorie counters. Users can select their consumed food daily from the application's database for the intake- calorie counter, while the burned calorie is computed from the number of walking/running steps worked out daily. The application can give users with health profiles (e.g., BMI, BMR, and TDEE) and recommend a calorie balance plan that includes an expected calorie consumption and an expected burnt calorie from the workout. Considering the above research paper, it has some negative aspects such as data privacy and security, the accuracy of calorie estimation, long-term maintenance, and updates etc. If one thing is explained, the application collects and stores personalized data, so data privacy and security become paramount concerns. The research should address how user data is protected, stored, and used to ensure compliance with data protection regulations and to gain user trust.

But in the personalized nutrition plan recommendation system, it is maintained a separate user management system to protect the user's personalized data. According to other research [11], they have investigated whether there are data available from modern low-cost activity trackers that can be used to estimate calories burntin physical activity for cardiac prevention. They collected ground truth data from 8 users over 50 days, comprising 157 steps, and used a threshold approach for step data processing, comparing the results to the users' annotations. To estimate the cardiac calories from the step data, they assumed that the intensity of physical activity is directly proportional to the number of steps per minute. By considering this research paper, it has some limitations such as small sample size users can use the application, limited activity variety, contextual factors etc. If one thing is explained, this application can only handle eight users, but in the personalized nutrition plan recommendation system, it can handle large number of users and can get personalized dietary plans with Sri Lankan foods. According to the research [12], users longitudinally and automatically quantify important health behaviors are measured such as sleeping time and other physical activities.

The research is based on selected college students and obtaining their data related to various physical activities using Fitbit wearable devices. Their purpose is to provide briefly highlight preliminary monitored characteristics of sleeping patterns and other monitored physical activities. This research has only focused on providing more common details of user sleeping patterns and health activities which represent an who interact with the system. Above mentioned research projects have used manual entry of the required information to provide recommendations for weight loss and provide solutions with the use of general data provided by the user. Furthermore, despite the growth of the fitness industry in Sri Lanka, there is still a lack of personalized workout plans and schedules provided through automated systems. This points out the novelty in our study, which is the use of image processing which is an object detection algorithm to locate specific regions and extract the body measurements by an image, use of leveraging machine learning algorithms, analyze user data including fitness histories, goals, and health conditions to create tailored workout plans, personalized diets, and ultimate progress tracking to see the progress of the user compared to the initial situation.

III. METHODOLOGY

1) Image processing for obtaining body measurements

a) Data Collection and Preprocessing

The study initially collects data including age, gender, weight, and height from the user, which is used to calculate the individual BMI from the system and to identify whether the user is overweight or underweight. Then the user must upload 2D images of front and side views of them to the system. The user needs to follow a set of guidelines prior to capturing the image for body measurements. These guidelines include selecting proper clothing before capturing the image and the system recommends wearing tight sportswear to obtain accurate body measurements. Furthermore, it is required to use a suitable location and background to capture the image which white background is recommended by the system.

b) Body detection

As shown in Figure 1 and Figure 2 Grayscale and mask generation technique is used ineffective body detection by the system. The real object is extracted by Gray scaling the image with shades of grey from black to white. The intensity values range from black (0) to white (255) in an 8-bit grayscale image, used in object detection. A mask is generated to identify specific parts of the image required by filtering and segmenting the image and controlling the pixels of the areas of interest. Masks properly identify the waist and hip regions through binary values, where 1 includes the pixels of the foreground and 0 includes the pixels of the background. In addition, contour lines are sketched in the image which is useful to detect the boundaries of the image separately.

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Figure 2: Gray scaling image of user

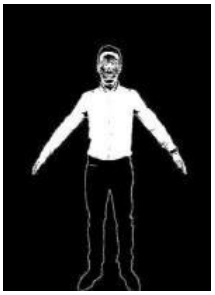

Figure 2: Mask Generation for the image of a user

Figure 3: Contour line sketch on an image of a user

c) Model training

The model training process is done to support the system to detect the waist and hip measurements efficiently. The datasets are currently in the process of preparation by collecting images and using the data obtained accurately. Then the model would be developed and followed on to training and testing stages.

d) Detect and notify health risk level

Finally, the health risk level of the user is determined by the calculation of WHR by the system. WHR is calculated by the waist and hip measurements selectively obtained through the body detection process as shown in Figure 4. The system checks the standard range of WHR and notifies whether the user is in low, moderate, or higher health risk levels. Then the system suggests personalized recommendations based on their health risk level either to follow a workout plan or the diet plan or both. The recommendation provided by the system also considers the data that the user provided initially including age, gender, and BMI calculated by the system.

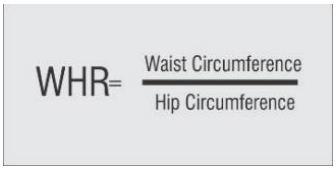

Figure 4: Waist to hip ratio formulae

2) Personalized workout recommendation system

a) Data Collection and Analysis

Collection of fitness data from various authorities and datasets. The collected data is then subjected to analysis to extract valuable insights. The categories of data that we plan to collect include workout and fitness exercises, physical fitness activities, consultant instructions, workout schedules (reps & sets), and activity levels. By gathering data from diverse sources, we aim to obtain an overview of the fitness and workouts and ensure the reliability and accuracy of our results.

To tailor the workout recommendations to individual users, we collect specific data from their user profiles. These profiles encompass various factors that are important in designing personalized workout plans. The data categories we collect from user profiles include gender, age, weight, risk level, health issues, and types of workouts preferred. By considering these individual characteristics, we can create workout recommendations that are unique to each user's needs and goals.

b) Data Preprocessing

Before utilizing the collected data to train our machine-learning model, we undergo a preprocessing stage. This ensures that the data is properly formatted, cleansed, and standardized, making it suitable for training the model. By preprocessing the data, we eliminate any inconsistencies or outliers that could adversely affect the model's performance.

c) Machine Learning Model Training

The model is trained using pre-processed data, considering various factors such as the user's preferences, health conditions, fitness goals, and personal data. By incorporating these elements, the model can generate workout plans that are tailored to the individual's capabilities, considering their physical limitations, health considerations, and desired outcomes.

d) Generation of Personalized Workout Plans

Once the machine learning model has been trained, it is ready to generate personalized workout plans for users. The system utilizes the trained model to develop a customized plan

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that addresses the specific needs and goals of each user. This plan includes a set of exercises that are appropriate for the user's physical capabilities and health conditions, while also considering their desired fitness outcomes. By creating personalized workout plans, we aim to provide users with a comprehensive and effective roadmap to achieve their fitness goals.

3) Personalized nutrition plan recommendation system

a) Data gathering

Compile a variety of datasets containing the pertinent data required to develop individualized nutrition regimens. Age, gender, height, weight, daily calorie count, and activity level are some examples of demographic information that may be included. This information is gathered through the initial stages of the system.

b) Data Preprocessing

To assure the quality and usefulness of the collected data for analysis, clean and preprocess it. This entails activities like eliminating redundant or incorrect entries, resolving missing data, and, if necessary, normalizing, or standardizing variables. Use the right approaches to deal with data anomalies or inconsistencies that could influence how well the machine learning algorithm function.

c) Feature Selection

Determine the appropriate components or factors that will affect the suggestions for a customized nutrition plan.

Analyze the dataset carefully to identify the variables that have the most effects on dietary demands and objectives. To choose the most useful characteristics for your recommendation system, use statistical approaches like correlation analysis or feature importance measures from machine learning models.

a) Machine Learning Model Selection

For the development of a personalized nutrition plan recommendation system, TensorFlow is the proper machine learning algorithm to achieve the research goals. This model can handle the complexity of the data and produce precise, individualized recommendations.

b) Model Training and Execution

Create training and testing sets from the dataset. Train the machine learning models on the chosen characteristics using the training set. Depending on the nature of the data and the objectives of the research, evaluate the performance of the trained models using the relevant assessment metrics. To find the best method for recommending a tailored nutrition plan, compare the performance of various models.

c) Generation of Personalized Nutrition Plans

Use the machine learning models to create customized nutrition programs based on unique user inputs or profiles once they have been trained and approved. Utilize the chosen features and tested models to offer nutritional suggestions that are suited to the requirements, objectives, and tastes of certain individuals. Make the created plans realistic, well- balanced, and in line with accepted dietary recommendations.

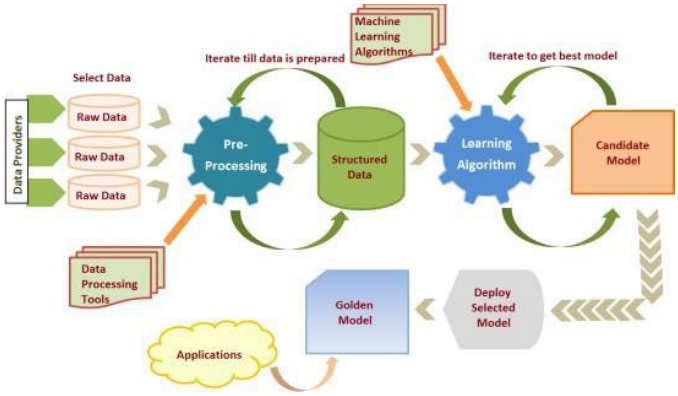

Figure 5: Machine learning process

4) Progress tracker and data analytical system

a) Collection of Datasets

In this section, comprehensive information on the user's exercise routines, physical activities, heart rate, sleep patterns, and calories burned are considered in order to create the dataset. The dataset consists of user data such as height, weight, BMI value, water consumption, sleep hours, and target variable of user progress which depends on the other values. Using the dataset, the machine learning models are trained and tested.

b) Data Preprocessing

Cleaning and preprocessing the collected data will ensure its quality and analytical value. To accomplish this, steps must be taken including removing duplicate or inaccurate entries, addressing missing data, and, if necessary, normalizing, or standardizing variables. Deal with data anomalies or inconsistencies appropriately to avoid having an impact on the performance of machine learning algorithms.

c) Model Selection

To achieve high accuracy and efficiency, machine learning models of decision tree and random forest are used in

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the system. In regression, decision trees divide the data recursively based on features to produce a model that predicts a continuous target variable. The splits are based on certain criteria to optimize the reduction in prediction error. The model then creates a tree-like structure by capturing the hierarchical relationship between features to make predictions. Random forest creates a collection of decision trees by training each tree on a different subset of data. During prediction, each tree in the random forest independently predicts the target variable and the final prediction is made by averaging or voting the predictions of individual trees. Random forest improves the robustness and generalization of the model by reducing overfitting and leveraging the diversity of individual decision trees.

d) Model Training

The DecisionTreeRegressor class and the RandomForestRegressor class from the scikit-learn library provide various parameters to control the model's behavior and they are used to train the decision tree and randomforest models.

e) Data Visualization

As shown in Figure [6], for plotting the user progress over time, the matplotlib library is used with its wide range of tools and functionalities. It provides several customized features such as color selection, legends, grid lines, annotations, etc.

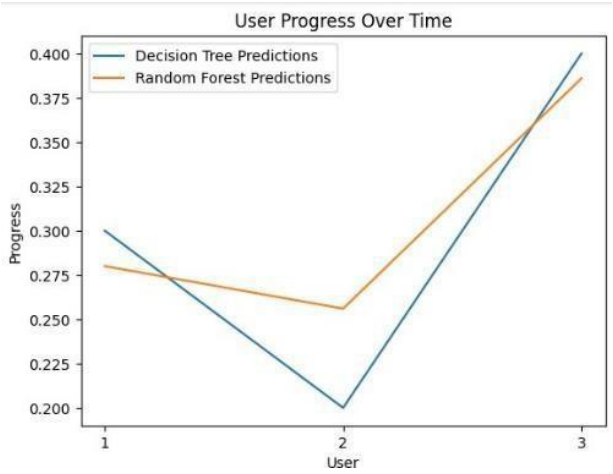

Figure 6: Visual Chart

IV. RESULTS AND DISCUSSION

Initially, according to the data obtained from the user, the BMI value is obtained and compared with the standard range to detect whether the user is overweight or underweight. According to the data obtained through the extraction of body measurements of waist and hip ratio using object detection algorithms, the WHR would be displayed. The obtained WHR would then be compared to the standard ratio range and the risk level (high, moderate, low) is displayed. According to the risk level detected, the future health risks could be determined by the system and then directed to the personalized recommendations to be followed either a workout plan or diet plan, or both according to the age and gender of the user. The system is trained to effectively detect the waist and hip regions of the body through body detection and the measurement obtained is considered throughout the system.

Next, the system directed recommendations either to follow a workout plan or diet plan, or both based on the results obtained from the initial stage. The workout recommendation system demonstrates the effectiveness and potential of an automated personalized workout recommendation system. By using machine learning algorithms, our system successfully generates personalized workout plans based on individual needs and goals, leading to improved engagement, motivation, and safety. The integration of wearable devices and dynamically adjusting the workouts further enhance user experience and adherence. The system's ability to consider diverse data sources and individual characteristics allows for a high level of customization and optimization of fitness outcomes. The system contributes to the ongoing efforts in developing comprehensive workout recommendation systems that use machine learning algorithms. The system provides personalized nutrition recommendations using machine language that is tailored to the user's needs, preferences, and health conditions by gathering and analyzing user data.

To make highly accurate decisions on a user's fitness and nutrition conditions, a proper tracking system with fewer user inputs can be considered a significant option in terms of quality and the accuracy of the data. The tracking system provides accurate and up-to-date information on user progress over time. In workout tracking, monitoring user progress for a recommended workout schedule helped them to stay consistent and accountable, and improved compliance with their fitness regimens. Furthermore, the fitness consultants were able to monitor and take appropriate decisions on the user's strengths and weaknesses with the help of the system. In diet plan tracking, users were able to identify the areas of improvements and adjustments needed to have a healthy diet such as better control over calorie intake and reduce overeating.

It is a critical step to obtain the body measurements accurately for the system to be successful. Use of Gray scaling, masks, and contour lines are used to obtain these parameters accurately to overcome any issues that may arise during the detection of the health risk level. WHO approved standard set of data ranges is used for WHR and BMI to notify

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the user with appropriate information about their health which proves that false information is not generated about the health conditions of the user. The workout recommendation system highlights the significance of personalized workout plans in promoting a healthier population and addressing the limitations of traditional, generic workout approaches. Future research can focus on expanding the system's capabilities, incorporating more data sources, and refining the algorithms to continually improve the accuracy and personalization of the recommendations. The design and development of a personalized diet plan system requires careful consideration of a variety of factors, including feature engineering, model selection and optimization, feature engineering, and user interface design. The system must also be commercialized by determining the target market, formulating a pricing strategy, creating a marketing strategy, and forming partnerships.

Personalized nutrition plan recommendation systems that use machine learning have the potential to revolutionize the field of nutrition and health by giving people more precise and individualized advice. Millions of people could benefit from better health outcomes and a higher quality of life as a result of the system's continued research and development. The presence of a proper tracking system helps to indicate the user adherence to the recommended plan and display remaining and completed schedule information which helps to understand the current user status. Furthermore, it helps to enhance the accuracy of decisions made about the user. The system is commercially important for the people, since due to the busy lifestyle and in pandemic situations, people face difficulty in meeting the nutritionist physically to provide body measurements and is helpful to avoid many of themost common non-communicable diseases including diabetes, obesity, and cardiovascular diseases that have become an emerging threat to people globally in past few years [13].

V. CONCLUSION

To conclude, the proposed study is conducted by classifying into four separate components as image processing to obtain body measurements, personalized workout recommendation system, personalized diet plan recommendation system, and progress tracking and analysis. Image processing and object detection used in the study provide an innovative and efficient method to know the health risks of people before they are prone to serious disease conditions. This advanced technique provides insights into obtaining body measurements more accurately and efficiently compared to manual measurements. Moreover, this technique minimizes the human errors that may occur when taking measurements by selectively recognizing the specific regions of the body by object detection algorithms. The personalized workout recommendation system and nutrition plan system are designed based on the data received during the initial stages of the system meeting all the requirements to provide appropriate solutions to the user. Overall, the proposed nutrition and fitness journaling system uses advanced innovative machine learning algorithms such as image processing and object detection to effectively provide personalized solutions for the user to suit the busy lives of people and ensure they follow proper healthy lifestyles minimizing serious common non-communicable diseases which would cause life-threatening conditions.

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