Analysis of Obese Patients Using Machine Learning to Categorize Hidden Risk Factors in Explorative Assessment

R.Krishnamoorthy
Centre for Advanced Wireless Integrated Technology, Chennai Institute of Technology

Tanaka, Kazuaki
Kyushu Institute of Technology

R.Thiagarajan
Prathyusha Engineering College

https://doi.org/10.5109/7323336

出版情報：Proceedings of International Exchange and Innovation Conference on Engineering & Sciences (IEICES). 10, pp.685-691, 2024-10-17. International Exchange and Innovation Conference on Engineering & Sciences
バージョン：

Analysis of Obese Patients Using Machine Learning to Categorize Hidden Risk Factors in Explorative Assessment

R.Krishnamoorthy[1], Kazuaki Tanaka[2], R.Thiagarajan[3]
[1]Centre for Advanced Wireless Integrated Technology, Chennai Institute of Technology, Chennai, India
[2]Kyushu Institute of Technology, Japan
[3]Prathyusha Engineering College ,Chennai, India.
Corresponding author email: krishnamoorthyr@citchennai.net

Abstract: *Obesity has a multitude of detrimental impacts on both mental and physical health, along with an increased risk of acquiring chronic illnesses including coronary heart disease, diabetes, and stroke, as well as anxiety and depression conditions. Using forecasting analytics, researchers may develop therapies and prevention methods that are tailored to a particular behavior and medical knowledge. Data analytics examines the greater risk of contracting diseases associated with obesity in order to target a specific group. In order to undertake efficient treatments, it is primarily important to gather and evaluate data on issues associated with obesity. Gathering the abnormal diet, lifestyle, and previous medical history tends to indicate whether the individual is affected by an obese hidden risk factor. Machine learning can assist in early diagnosis and anticipate potential health problems associated with obesity. The proposed approach involves various machine learning techniques to analyze comprehensive data on diet, lifestyle.*

Keywords: Obesity, Machine Learning, Data Analytics, Coronary Heart Disease, Chronic Illness

1. INTRODUCTION

Obesity is a global health epidemic that increases the risk of mental health illnesses including anxiety and depression in addition to chronic diseases includes diabetes, cardiovascular conditions, and stroke. To effectively address this intricate health issue, advanced methods of diagnosis and therapy are required. The complex nature of obesity implies traditional techniques are frequently inadequate for providing personalized therapies [1]. An advanced approach that makes use of machine learning (ML) techniques to improve the detection and control of hidden risk factors associated with obesity. This approach combines various algorithms for machine learning to examine comprehensive datasets that include lifestyle choices, food habits, and medical history data. We use supervised learning models to forecast the likelihood of diseases and identify risk variables, such as random forests, decision trees, and logistic regression. In addition, if any underlying patterns emerge and related risk profiles are grouped, unsupervised learning approaches like K-means clustering and hierarchical clustering can be used. To get a model with optimal performance, the development process involves splitting the data into subsets for training and testing, performing cross-validation, and fine-tuning hyperparameters [2]. Metrics including accuracy, precision, recall, F1-score, and ROC-AUC are used to assess the effectiveness of the model. The findings demonstrate the effectiveness of machine learning models in identifying hidden risk factors and facilitating the creation of tailored therapies based on each patient's unique characteristics. This method reduces administrative responsibilities for healthcare practitioners, freeing them up to focus more on patient care while simultaneously improving diagnostic accuracy and treatment tailoring. A prospective strategy based on machine learning might enable the detection of high-risk patients, the development of personalized medicines, and the reduction of time spent on documentation and administrative activities. Obesity increases the risk of developing chronic illnesses like diabetes, stroke, and cardiovascular disease. It also has a number of detrimental consequences on mental and physical wellness, such as anxiety and depressive disorders. Furthermore, mobility problems, an increased risk of disease, and a general decline in quality of life can be brought on by obesity. Obesity has detrimental effects that vary from impaired mobility and an increased risk of accident to serious health problems including hypertension and stroke. With rising obesity, the risk of developing serious health issues increases [3].

However, gathering the amount of data required for machine learning systems to provide accurate forecasts can be difficult. Complex algorithms can be challenging to use and comprehend, and they take a lot of work to develop and maintain. Furthermore, medical practitioners with limited resources may find it challenging to use machine learning techniques because they may require a significant amount of processing power. When excess weight reaches a point where it may be harmful to one's health, it is diagnosed as obesity [4]. This is usually done by measuring one's body mass index (BMI) and taking into account characteristics such as waist-hip ratio, body shape, and cardiovascular disease risk factors. Obesity is a recognized serious health concern that has been connected to psychological problems like worry and low self-esteem. Obesity is mostly caused by an imbalance between calories burned and ingested, genetic susceptibility, and inactivity. By identifying possible health risks in those who are at risk for diseases associated with obesity, this technology can help to avoid complications before they arise.

Continuous improvement of these models guarantees their efficacy and applicability, resulting in a deeper comprehension and better handling of obesity. By modeling the link among multiple variables and the likelihood of obesity, logistic regression offers an overview of important risk factors. By capturing non-linear correlations and interactions between data, decision trees are used to generate interpretable models that emphasize the primary variables contributing to obesity. An ensemble technique called random forests reduces overfitting and increases forecast accuracy by mixing several decision trees [5]. In order to distinguish between patients who are obese and those who are not, the best hyperplane is found in a high-dimensional space using support vector machines (SVMs), which are robust when dealing with complex data distributions. Decision trees are used to capture non-linear correlations and interactions between features by recursively partitioning the data into subsets depending on the most significant predictors, resulting in an interpretable model that focuses on the key obesity risk factors. The proposed strategy seeks to provide a comprehensive and reliable study of obesity-related risk variables by combining these various machines learning algorithms, surpassing conventional techniques documented in the literature.

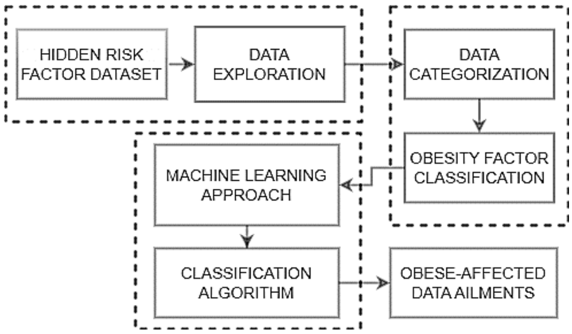

Fig.1. Proposed Architectural Diagram

Initially, Figure 1 shows the architecture design where the dataset containing several obesity-related risk factors, such as nutrition, lifestyle, medical history, and other pertinent data, is stored. The data exploration process involves analyzing the dataset to find trends, comprehend its structure, and spot any irregularities. To get insights, this entails doing preliminary analysis, displaying distributions, and summarizing the data. Next, the data is split into numerous categories or groups according to predetermined standards using data categorization. This could be identifying the data, placing related qualities in groups, or structuring it up such that it can be easily analyzed further. This step entails selecting and applying suitable machine learning techniques for analyzing the categorized data. The goal is to discover trends, correlations, and hidden contributors to obesity.

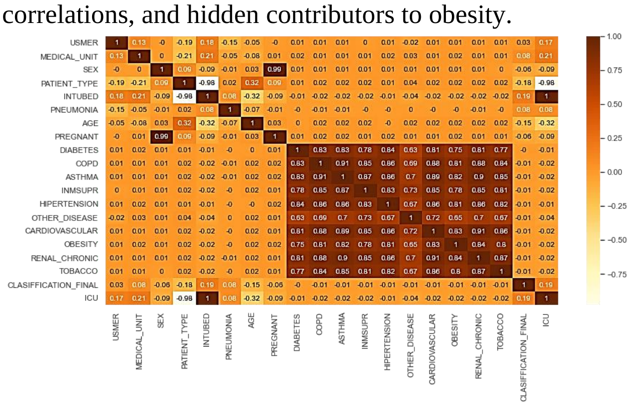

Fig. 2. Correlation Map Structural Analysis

2. LITERATURE REVIEW

Obesity is the worldwide health issue where the higher risk occurs mostly in people suffering from CHD, stroke, and hypertension. Obesity is caused by a lack of physical activity, caloric food, an excess of energy, and an extremely anxious and depressed state. Using the UCI machine repository dataset with different machine learning algorithms tends to combine with other models to measure the prediction test's accuracy and overall score. Based upon the evaluation results, the best prediction accuracy is obtained. [2] obtains the open-source repository that describes the statistical analysis of overweight using big data analytics. Using the Map Reduce technique, we update the cluster center, which streams up the data using the sensors. The Apache Map Reduce accesses the dataset used to analyze the obesity from the large-scale data using the Pydoop package. [3] impacts obesity in children with different classifications, which estimate different obesity levels. Different machine learning methodologies compare results by selecting the features where accuracy is evaluated. [4] Excessive weight impacts adverse health risks. The prevalence of obesity with different machine learning models where the data derives from population surveys. [5] Obesity-related diseases occur due to several diseases where several researchers are used to predict the possibility of an obese patient history. Different machine learning techniques classify the diet, which increases the possibility of reducing weight. Physicians can provide better prescriptions based on the prediction results. [6] Research denotes the mobile application that connects with nutritionists, where the patient gets timely-based information that establishes communication between personalized care and physicians and patients. The proposed application indicates mobile-based technology with rapid development over applications. [7] The amount and quality of medical data ingested affects the accuracy of precision analysis. Using the machine learning algorithm, effective prediction of the obesity ailments is considered based upon the behavioral and socio-physiological factors.

3. METHODOLOGY

3.1 Machine Learning Model Development

Supervised Learning

Logistic Regression: A basic yet powerful classifier for binary outcomes, useful for its interpretability. Logistic regression simulates the link between many factors and the likelihood of obesity. Based on input factors including food, lifestyle, and medical history, it employs a logistic function to assess the probability that a specific patient is obese. The factors that are statistically significant in predicting obesity are found using logistic regression analysis of the model's coefficients. These coefficients aid in the identification of latent risk variables by indicating the direction and degree of the relationship between each predictor and the likelihood of obesity.

Decision Trees: Decision trees find hidden factors in obese individuals by recursively partitioning the information into subsets depending on the most significant predictors of obesity. A feature is represented by each node in the tree, and a decision rule is represented by each branch. At each stage, the algorithm chooses the feature that best divides the data into classes (such as obese vs. non-obese) depending on criteria.

Random Forests: Random forests discover hidden characteristics in obese patients by forming an ensemble of decision trees, each trained on a random subset of the data and features. Each tree provides a separate prediction about the result, and the ultimate forecast is derived by adding together all of the trees' projections, usually by majority vote in classification tasks. This technique captures a wide range of patterns and correlations within the data, which decreases overfitting and boosts accuracy. Random forests can discover the most significant contributors to obesity by assessing the relevance of each attribute across all trees, demonstrating hidden risk factors that other approaches might overlook.

Support Vector Machines (SVM): In a high-dimensional space, support vector machines (SVM) function by determining the ideal hyperplane that splits patients into obese and non-obesity groups. Support vectors, a subset of training data, are used by SVM to define this hyperplane. SVM efficiently discerns between various patient profiles according to their attributes by optimizing the margin between the two classes. Through kernel functions, the model can manage intricate, non-linear interactions, which enables it to reveal hidden patterns and causes that contribute to obesity. This method is effective in detecting important risk variables in obese individuals because it can handle a wide range of data distributions.

3.2. Model Training and Validation

Training

Data Split: The main reason for dividing the dataset into training and testing sets is to assess how well the model performs when applied to untested data. Ratios like 80/20 and 70/30 are frequently used to partition the data. This indicates that the model is trained using 80% (or 70%) of the data, with the remaining 20% (or 30%) set aside for evaluating the model's performance. In order to ensure that the model parameters are adjusted precisely without overfitting to the training set, the validation set is used for model tuning and hyperparameter optimization. Stratified splitting can be utilized to guarantee that the training and testing sets contain the same proportion of classes as the original dataset in cases when the dataset is imbalanced. This is especially crucial for medical data because it can show that some illnesses (like obesity) are less common.

Cross-Validation: K-fold cross-validation lowers the chance of overfitting by providing a thorough performance overview across several data splits, which improves hyperparameter modification. This guarantees that on both training and unreliable data, the model operates consistently. To reliably forecast less common situations, such as those in medical data, stratified k-fold cross-validation is used to maintain the proportion of each class in every fold for imbalanced datasets. We can create robust, dependable, and generalizable models that work effectively with real-world data by employing k-fold cross-validation.

Hyper parameter Tuning

Grid Search: For each hyperparameter (such as learning rate, number of trees in a forest, or kernel parameters in SVMs), a grid of potential values is specified, and the model's performance is assessed for each combination in the context of finding obesity-related characteristics. Grid Search ensures a thorough analysis of every potential configuration, despite the fact that it can be computationally expensive, particularly when handling massive data sets and numerous hyperparameters. For instance, Grid Search can assist in identifying the ideal regularization strength and kernel type in an SVM when developing a prediction model for obesity, resulting in a more precise identification of risk factors like dietary habits and activity levels.

Bayesian Optimization: Bayesian optimization can effectively identify the optimum learning rate, maximum depth, and number of boosting rounds when creating a gradient boosting model to predict obesity risk, resulting in more accurate and reliable models. Compared to traditional methods, our probabilistic approach guarantees that the model learns the intricate relationships between different risk factors, such as dietary habits, activity levels, and genes, with minimal evaluations. By striking a balance between exploration and exploitation, this approach iteratively updates a model of the performance function based on prior assessments and chooses the next set of hyperparameters to be evaluated.

3.3 Model Evaluation

Performance Metrics

Accuracy: In the field of obesity prediction, high accuracy indicates that the model is effectively discriminating between obese and non-obese patients. But in imbalanced datasets with low prevalence of obesity, accuracy could be deceiving on its own because the algorithm might obtain high accuracy by just correctly classifying the majority.

Precision: High precision in detecting obesity-related characteristics indicates that the model is probably accurate if it predicts a patient will be obese. In medical settings, where false positives can cause unnecessary stress and more testing, this is especially important.

Recall (Sensitivity): Recall is essential to the evaluation of obesity because it helps identify the majority of patients that are really obese. A high recall rate lowers the possibility of overlooking patients who are actually in danger, allowing for prompt actions.

F1-Score: When evaluating obesity models, this parameter allows for an appropriate balance among precision and recall. A high F1-Score suggests that the model minimizes false negatives and false positives while maintaining an adequate balance.

ROC-AUC (Receiver Operating Characteristic - Area under Curve): The model's ability to differentiate among classes is measured by ROC-AUC, where a model that performs better has an AUC that is closer to 1. In the identification of obesity determinants, a high ROC-AUC value indicates that the model is capable of differentiating obese and non-obese patients across multiple threshold settings.

Confusion Matrix: In obesity prediction, the confusion matrix provides specific information on where the model produces errors. It assists in determining, for instance, if the model is more likely to produce false positives (misclassifying non-obese individuals as obese) or false negatives (failing to identify obese patients). Enhancing model performance and guaranteeing the predictive tool's dependability and practicality in a clinical context depend on this fine-grained research.

Correlation Structure: In the exploratory assessment of detecting obesity-related factors, a correlation map Figure 2 serves as vital for highlighting the correlations between various dataset elements. With correlation coefficients ranging from -1 to 1, this structured depiction visually shows significant relationships and helps with feature selection by pointing out redundant variables, such as waist circumference and BMI, which have a strong correlation. It reveals hidden relationships, such as the one among obesity and sedentary behavior, and directs model development by giving weight to important predictors, such as food behavior. Furthermore, correlation maps help generate hypotheses, highlight possible confounders, and enhance data interpretability—all of which contribute to a comprehensive understanding of the intricate interactions between the many variables impacting obesity.

3.4 Obese Ailment Risk Factor

To lower the overall likelihood of coronary artery disease, regular exercise and proper nutrition are crucial. A healthy diet and regular exercise can help you maintain a healthy weight and lower your risk of heart disease. A significant risk factor underlying type 2 diabetes includes obesity. Insulin deficiency brought on by excessive fat raises the chance of getting diabetes and having high blood sugar levels. The likelihood of developing diabetes can be lowered by keeping your weight under control, consuming a nutritious diet, and participating in consistent physical activity. Frequent medical visits might also aid in early diabetes detection and management. Whenever an individual possesses excessive excess weight, they develop obesity, a significant medical disease. It may result in diabetes, cardiovascular disease, a stroke, and other illnesses, among other health problems. Certain additional stresses imposed on their bodies by being obese, obese people frequently have a higher chance of developing certain diseases.

Among the most frequent diseases linked to obesity are cardiovascular diseases. High blood pressure, high blood cholesterol, and a higher risk of stroke can all be triggered by being overweight. To lower the chance of getting cardiovascular disease, it's crucial to keep a healthy body weight. Obesity can increase joint stress, which can result in discomfort and inflammation in the joints. As a result, arthritis, a condition characterized by stiffness and discomfort in the joints, may emerge. Arthritis risks can be lowered by staying at an appropriate weight, consuming a healthy diet, and doing regular physical exercise. Breast, colon, and endometrial cancer are among the cancers for which obesity is a recognized risk factor.

Obesity can make cancer increasingly likely to occur and more challenging to cure. Cancer risk can be lowered by keeping your weight under control, consuming a nutritious diet, and participating in consistent physical activity. To lower the chance of having certain diseases, it's crucial to keep a healthy weight. The accumulation of excess body fat can lead to several disorders, including diabetes, heart conditions, respiratory issues, and certain types of cancer, as shown in Figure 3. Obesity is linked to an increased risk of various ailments, such as type 2 diabetes, hypertension, strokes, and coronary artery disease, as illustrated in Figure 4.

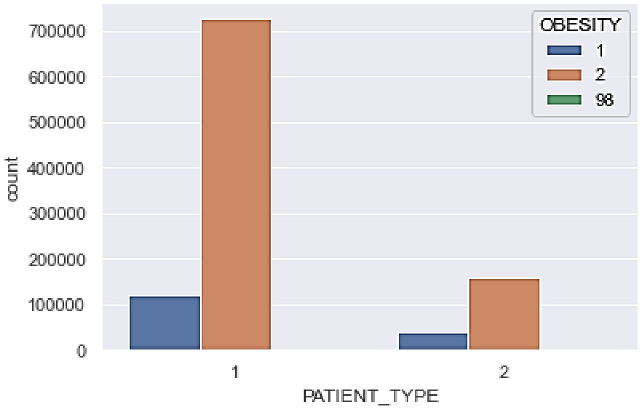

Fig. 3. Attribute between Patient Type vs Count.

Fig. 4. Attribute between Age vs Count Imbalanced Diet.

A diet that is out of proportion does not allow the body to absorb enough of the important nutrients it requires for good health. Major medical issues, including overweight, cardiovascular disease, hypertension, and other chronic diseases, can result from it. In order to make sure that we are obtaining the vitamins that we need to stay healthy, it is crucial TO understand the importance of balancing our overall diet. A diet that is out of balance might negatively impact the health. It can cause weight gain, fatigue, and a higher chance of acquiring chronic conditions. Moreover, it might result in nutritional shortages, which can have a major negative impact on health. A balanced diet can reduce your risk of chronic illnesses, help you manage your weight, and decrease fatigue, as shown in Figure 5. To guarantee that individuals are receiving the nutrients their bodies require to be healthy, it is essential to comprehend the forms, impacts, and advantages of a healthy diet.

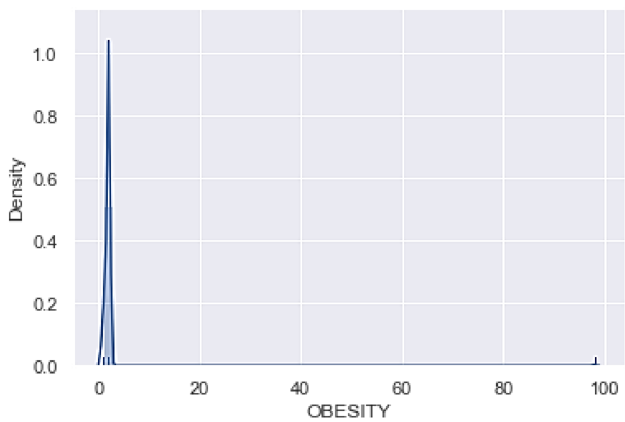

Fig. 5. Attribute between Obese vs Density.

4 CONSTRUCTION

4.1 Data Analytics

With the use of data analytics, we can comprehend the root causes and consequences of obesity. Researchers can find trends and connections that can guide the development of more potent medicines and preventative measures by obtaining information on nutrition, environment, and health. Data analytics can provide insight on the best ways to fight the obesity epidemic, including monitoring dietary habits and examining the effects of activity. Furthermore, data analytics can assist in identifying potential risk factors and uncover insights about which treatments might be most effective for specific patients, as illustrated in Figure 6. Data analytics targets a certain population by analyzing the higher risk of developing obesity-related illnesses primarily to collect and analyze data on obesity-related issues by identifying patterns and correlations and performing effective treatments.

By combining multiple machine learning approaches to evaluate extensive data on diet, lifestyle, and medical history, the suggested method considerably enhances the field of obesity prediction and management by identifying latent risk factors linked to obesity. In contrast to Devi et al.'s study [1], which utilizes a machine learning model to predict adult obesity solely, our method takes into account a wider range of data inputs to offer a more comprehensive analysis. While doing a descriptive statistical analysis on large data sets, Ali et al. [2] neglect to investigate the prediction powers of machine learning models. Similar to this, Celik et al. [3] estimate obesity levels using machine learning techniques and artificial neural networks; however, they lack the inclusion of data from a variety of sources, including lifestyle and medical history, into their approaches.

Global trends in obesity are predicted by Barzinji et al. [4]. However, customized risk assessments are made possible by the granularity of our approach. Pinto et al. [5] and Weerakoon and Pemarathne [6] use machine learning for particular patient populations and situations, but they neglect the wide range of data that approach examines. Although earlier research, like that of Montenegro et al. [7] and Pereira et al. [8], offers platforms and illness prediction models, respectively, it is constrained by less advanced machine learning methods and smaller data sets.

Additionally, although Xue et al. [10] and Singh and Tawfik [9] concentrate on activity data and weight gain hazards, respectively, our technique integrates many data aspects for more precise risk detection. Our research differs from previous studies by Montañez et al. [[11] and Zheng and Ruggiero [12], which focused on high school pupils and genetic profiles, respectively. While historical research by Novak and Bigec [15] [16], Kato et al. [14], and Albu-Shamah and Zhan [13] provide important basic insights, our suggested approach incorporates advanced machine learning. Utilizing a larger dataset and more advanced algorithms, our method is able to identify subtle risk variables that other studies may have neglected, in addition to producing a more accurate prediction of obesity. This makes our technique a more comprehensive and adaptable strategy for the fight against obesity.

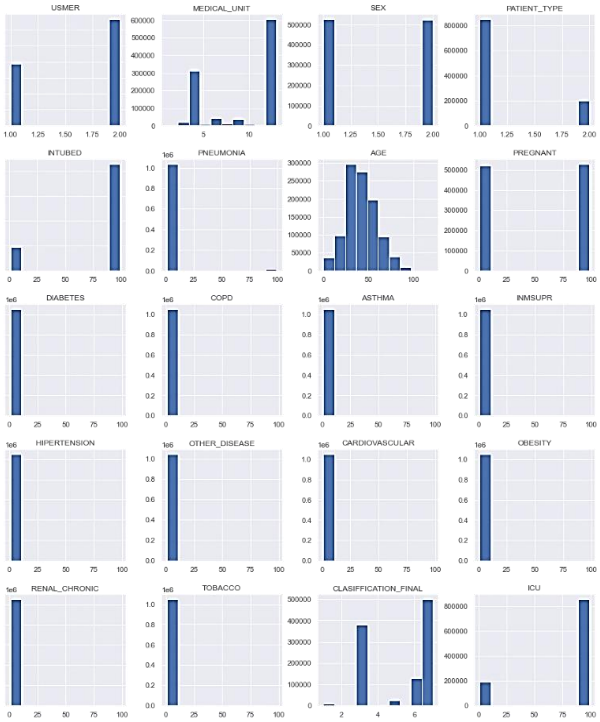

Fig. 6. Various Features Dependencies

5. EXPERIMENTAL ANALYSIS

5.1 Machine Learning Technique

Machine learning can aid in early detection and help forecast the possibility of obesity-related health risks. Machine learning is increasingly being used to forecast obesity-related illnesses. Algorithms for machine learning can precisely detect patterns and developments that might help forecast possible health hazards by using information gathered from an array of resources, including medical information, personal decisions, and genetics. The following table 1 presents a comparative analysis of four predictive algorithms—Logistic Regression, Random Forest, Support Vector Machine, and Decision Tree—evaluating their training scores, testing scores, and overall accuracy in identifying obesity-related factors.

Table 1. Comparative ML Analysis

Algorithms	*Training Score*	*Testing Score*	*Accuracy*
Logistic regression	0.98373	0.98384	0.98
Random Forest	0.98648	0.98569	0.99
Support Vector Machine	0.98769	0.98658	0.99
Decision Tree	0.98579	0.98546	0.99

In summary, comparative analysis of various ML algorithms—Logistic Regression, Random Forest, Support Vector Machine, and Decision Tree—demonstrate strong performance in identifying obesity-related factors, with accuracies ranging from 0.98 to 0.99. Logistic Regression, while showing slightly lower accuracy, still performs well with minimal overfitting. Random Forest, Support Vector Machine, and Decision Tree all achieve high accuracies of 0.99, with SVM having a slight edge in training and testing scores. Each algorithm provides robust predictive capabilities, and the choice of algorithm may depend on specific application needs, computational resources, and the balance between interpretability and model complexity.

By employing this technology, medical practitioners may discover obesity-related sickness risk factors in patients as problems manifest and offer them individualized guidance for managing their health. Regarding individual patients, health practitioners may develop personalized health regimens that will aid in both preventing and treating diseases associated with obesity. In order to forecast and diagnose illnesses, machine learning can be employed to find patterns and trends in data. Algorithms using machine learning evaluate masses, forms, and dimensions to comprehend and anticipate obesity. In order to produce precise forecasts regarding the likelihood of becoming obese, these techniques are utilised to find patterns and patterns in the information. Machine learning is a potent approach to information analysis and model creation to diagnose and treat diseases associated with obesity. Using this technology, prediction methods are being developed that can readily identify ailments associated with obesity and suggest appropriate therapies, as illustrated in Figure 7, which depicts a confusion matrix. Machine learning, a natural progression in medicine, uses information to appropriately identify and suggest therapies for ailments associated with obesity. This technique, which employs predictive algorithms, is quickly becoming a powerful tool for identifying and treating obesity-related diseases, as shown in Figure 8.

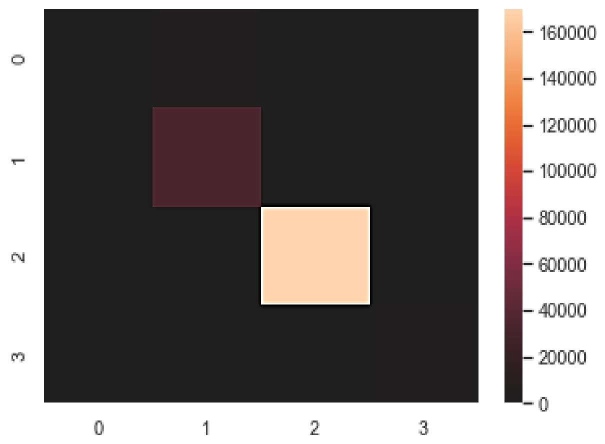

Fig. 7. Confusion Matrix

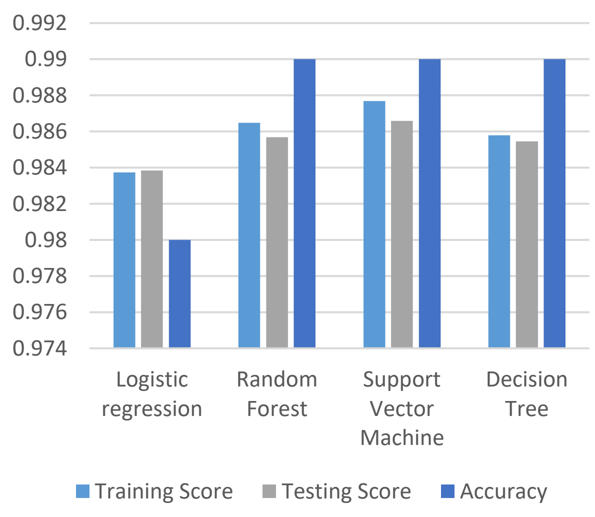

Fig. 8. Score Analysis

6. CONCLUSION

The application of machine learning to predict obesity-related illnesses is still in its nascent stages, yet the potential of this approach is vast. As data sources and machine learning algorithms become more advanced, the precision and accuracy of predictions will improve. These algorithms will also become more efficient and user-friendly, making them more accessible to healthcare professionals. The use of machine learning in forecasting obesity-related disorders could revolutionize how physicians identify and treat these conditions. Although machine learning techniques can be computationally intensive for health practitioners with limited computing resources, integrating information from various sources allows for the development of personalized healthcare plans. Such plans can help in the prevention and treatment of obesity-associated diseases. With appropriate methodologies and values, health practitioners can tailor care to individual patients, enhancing the effectiveness of interventions for obesity-related health issues.

REFERENCES

[1] K. N. Devi, N. Krishnamoorthy, P. Jayanthi, S. Karthi, T. Karthik and K. Kiranbharath, "Machine Learning Based Adult Obesity Prediction," 2022 International Conference on Computer Communication and Informatics (ICCCI), Coimbatore, India, 2022, pp. 1-5, doi: 10.1109/ICCCI54379.2022.9740995.

[2] S. A. G. Ali, H. R. D. AL-Fayyadh, S. H. Mohammed and S. R. Ahmed, "A Descriptive Statistical Analysis of Overweight and Obesity Using Big Data," 2022 International Congress on Human-Computer Interaction, Optimization and Robotic Applications (HORA), Ankara, Turkey, 2022, pp. 1-6, doi: 10.1109/HORA55278.2022.9800098.

[3] Shaqour, Ayas ; Hagishima, Aya Recent Advances in Reinforcement Learning Applications for Building Energy Management: A Mini Review., Proceedings of International Exchange and Innovation Conference on Engineering & Sciences (IEICES). 8, pp. 239 - 245, 2022-10-20, Interdisciplinary Graduate School of Engineering Sciences, Kyushu University

[4] Yuhan, Zhao ; Farzaneh, Hooman, Analysis of the different maximum power point tracking strategies in a load-connected photovoltaic system, Proceedings of International Exchange and Innovation Conference on Engineering & Sciences (IEICES). 8, pp. 1 - 6, 2022-10- 20. Interdisciplinary Graduate School of Engineering Sciences, Kyushu University.

[5] K. A. Pinto, N. L. Abdullah and P. Keikhosrokiani, "Diet & Exercise Classification using Machine Learning to Predict Obese Patient's Weight Loss," 2021 International Congress of Advanced Technology and Engineering (ICOTEN), Taiz, Yemen, 2021, pp. 1-5, doi: 10.1109/ICOTEN52080.2021.9493560.

[6] W. Weerakoon and W. Pemarathne, "Machine Learning Based Weight Prediction System for Bariatric Patients," 2021 IEEE 16th International Conference on Industrial and Information Systems (ICIIS), Kandy, Sri Lanka, 2021, pp. 203-208, doi: 10.1109/ICIIS53135.2021.9660730.

[7] J. Montenegro, L. Muñoz, M. Nielsen and V. Villarreal, "Platform for monitoring obesity and

overweight," 2020 15th Iberian Conference on Information Systems and Technologies (CISTI), Seville, Spain, 2020, pp. 1-5, doi: 10.23919/CISTI49556.2020.9140892.

[8] N. C. Pereira, J. D'souza, P. Rana and S. Solaskar, "Obesity Related Disease Prediction from Healthcare Communities Using Machine Learning," 2019 10th International Conference on Computing, Communication and Networking Technologies (ICCCNT), Kanpur, India, 2019, pp. 1-7, doi: 10.1109/ICCCNT45670.2019.8944798.

[9] B. Singh and H. Tawfik, "A Machine Learning Approach for Predicting Weight Gain Risks in Young Adults," 2019 10th International Conference on Dependable Systems, Services and Technologies (DESSERT), Leeds, UK, 2019, pp. 231-234, doi: 10.1109/DESSERT.2019.8770016.

[10] Q. Xue, X. Wang, S. Meehan, J. Kuang, J. A. Gao and M. C. Chuah, "Recurrent Neural Networks Based Obesity Status Prediction Using Activity Data," 2018 17th IEEE International Conference on Machine Learning and Applications (ICMLA), Orlando, FL, USA, 2018, pp. 865-870, doi: 10.1109/ICMLA.2018.00139.

[11] C. A. C. Montañez et al., "Machine learning approaches for the prediction of obesity using publicly available genetic profiles," 2017 International Joint Conference on Neural Networks (IJCNN), Anchorage, AK, USA, 2017, pp. 2743-2750, doi: 10.1109/IJCNN.2017.7966194.

[12] Z. Zheng and K. Ruggiero, "Using machine learning to predict obesity in high school students," 2017 IEEE International Conference on Bioinformatics and Biomedicine (BIBM), Kansas City, MO, USA, 2017, pp. 2132-2138, doi: 10.1109/BIBM.2017.8217988.

[13] Albu-Shamah and J. Zhan, "Towards Obesity Causes, Prevalence and Prevention," 2013 International Conference on Social Computing, Alexandria, VA, USA, 2013, pp. 852-857, doi: 10.1109/SocialCom.2013.128.

[14] Y. Kato, T. Suzuki, K. Kobayashi and Y. Nakauchi, "A web application for an obesity prevention system based on individual lifestyle analysis," 2012 IEEE International Conference on Systems, Man, and Cybernetics (SMC), Seoul, Korea (South), 2012, pp. 1718-1723, doi: 10.1109/ICSMC.2012.6377985.

[15] B. Novak and M. Bigec, "Childhood obesity prediction with artificial neural networks," Proceedings Ninth IEEE Symposium on Computer-Based Medical Systems, Ann Arbor, MI, USA, 1996, pp. 77-82, doi: 10.1109/CBMS.1996.507129.

[16] B. Novak and M. Bigec, "Application of artificial neural networks for childhood obesity prediction," Proceedings 1995 Second New Zealand International Two-Stream Conference on Artificial Neural Networks and Expert Systems, Dunedin, New Zealand, 1995, pp. 377-380, doi: 10.1109/ANNES.1995.499512.