Stacking classifier method for prediction of human body performance

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Article Info

ABSTRACT

A healthy body is the capital of success and supports human activities. To maintain health, humans need to avoid disease. A healthy life is everyone's dream and should start early. Busy activities often hinder a healthy lifestyle. Nonetheless, it is important for every individual to lead a healthy lifestyle. Human activities determine health and the implementation of a healthy life. One method that can perform classification with machine learning is extreme gradient boosting (XGBoost). XGBoost is one of the techniques in machine learning for regression analysis and classification based on gradient boosting decision tree (GBDT). By using gradient descent to minimize the error when creating a new model, the algorithm is called gradient boosting. In determining a classification starting from determining the model to the results, usually only using one algorithm method, and combining other methods together with the method is an algorithm called random forest classifier. Among these merging methods are, stacking classifier, voting classifier, and bagging classifier. The conclusion obtained from the results of this research is that the test results show that the stacking classifier achieves the highest accuracy of 76.07%, making it the best method in this research. And the stacking classifier has a precision of 76.96%, recall of 75.83%, and F1-score of 75.81%. This shows that the model has a good balance between the ability to provide true positive results and the ability to recover positive data.

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1. INTRODUCTION

A healthy body is one of the capitals of everyone's success and a healthy body will support every activity carried out by humans. A healthy body is a body that avoids disease so that every human being must maintain their health so that the body remains healthy. A healthy life is the dream of every human being where usually to get a healthy life, the human being only needs to run a healthy lifestyle from an early age even though there is no age limit to start a healthy lifestyle. Nowadays, a healthy lifestyle is no longer practiced because of the many activities of humans, so they do not have time to do it. However, a healthy lifestyle should be important for every human being. Departing from this human activity that determines his healthy lifestyle, whether it is considered healthy or not affects the implementation of his healthy life [1].

One method that can perform classification with machine learning is extreme gradient boosting (XGBoost). XGBoost is one of the techniques in machine learning for regression analysis and classification

based on gradient boosting decision tree (GBDT). The XGBoost method was first introduced by [2], in his research Friedman connects boosting and optimization in building a gradient boosting machine (GBM). In determining a classification starting from determining the model to the results usually only use 1 algorithm method, then what if 1 algorithm method is compared with 2 algorithm methods combined, whether the results of its accuracy will be better or not, which when combined with other methods is an algorithm method called random forest classifier.

This research will try to provide solutions or contributions to research, where researchers will analyze the XGBoost method for body performance classification and conduct a comparative analysis of whether the method will have good accuracy results when combined with other algorithm methods, namely random forest classifier in terms of classifying human body performance. Researchers chose the XGBoost method because this method is one of the most effective techniques in machine learning to perform regression analysis and classification based on gradient boosting decision tree (GBDT). XGBoost has the advantage of predicting errors and minimizing errors with gradient descent, so it is believed to be able to provide accurate and useful analysis results in research related to body performance. Researchers are interested in combining the two methods because both are popular ensemble models in predictive modeling, with each having its own advantages and disadvantages. XGBoost is known for its ability to produce high performance in various modeling tasks, while random forest classifier tends to be more stable and less prone to overfitting, and both methods use a tree approach in building the model.

In addition to XGBoost and random forest classifier, this research will also involve other ensemble methods, such as stacking classifier, bagging classifier, and voting classifier, where these three methods combine XGBoost with random forest classifier. These methods utilize a combination of different models to improve prediction performance. The stacking classifier combines the outputs of different ML models, the bagging classifier creates variation in the training dataset to prevent overfitting, and the voting classifier makes decisions based on the majority of votes from different models. The advantages of each of these methods are that they improve prediction accuracy and model stability.

In exploring existing problems, it is necessary to conduct a literature study that serves to find the right solution in solving existing problems and determine the differences between the research being carried out and previous research that has been done, as well as its contribution to research. In this case, the difference is the use of base learner for stacking classifier is XGBoost method and random forest method. This research uses the XGBoost method because this method is one of the most effective techniques in machine learning to perform regression analysis and classification based on GBDT, while random forest classifier tends to be more stable and less prone to overfitting, then both methods use a tree approach in building models. By analyzing comparisons ranging from accuracy results, performance evaluation of combining methods and without combining methods, and classification results. Researchers can provide important information about the evaluation results and determine whether or not combining two methods can significantly improve performance.

2.   THE PROPOSED METHOD

In this study, several stages were carried out to conduct research related to the classification of body performance and analysis of the XGBoost method, random forest classifier, stacking classifier, bagging classifier, and voting classifier. After analyzing each of these methods, a performance metrix is obtained from the method that gets the highest accuracy value. After that, the conclusion of the research stages is carried out as the final stage of the research. The following are the research stages shown in Figure 1.

Based on Figure 1, in the early stages of this research the author collected data from public open-source sites, namely: www.kaggle.com. Next is to do pre-processing or commonly referred to as pre-processing which serves to ensure data quality before being used during data analysis, the stages can include: data cleaning, data integration, data transformation, and data reduction. After that, exploration of the analysis data on several parameters as an overview of the dataset, then dividing the proportion of data that serves to divide the training data, test data and test data. After this division, training is carried out with the aim of forming a machine learning model. After the model is formed, testing of the model is carried out and observing the accuracy of each model. Then the implementation of each method, namely: XGBoost, random forest classifier, stacking classifier, bagging classifier, and voting classifier. After getting the method with the highest accuracy value, a comparison of the performance metrix of the method that gets the highest accuracy results is carried out, then conclusions are drawn from the series of research stages.

This study consists of 12 attributes which consist of "age", "gender", "height_cm", "weight "kg", "body fat_%", "diastolic", "systolic", "gripforce", "sit and bend forward_cm", "situps count", "broad jump_cm", "class" and consists of 13393 rows in it. The data is taken and stored in Microsoft Excel in .csv format to make it easier and can be imported into the python program that is being built. At the data pre-processing stage, several pre-processing stages are carried out, where pre-processing is the process of

cleaning duplicate or other data, transforming data or others so that the accuracy value is better than without doing this pre-processing stage. In this data pre-processing, 4 steps are carried out, including: The first is to check whether there is NaN data in each data row, then the second is to check whether there is duplicate data in each data row, then the third is to convert the 'gender' column where the variable "F" is converted to a numeric value of '1' and otherwise changes to numeric '0' where in this column only contains 2 variables, namely 0 and 1. Then the fourth process is pre-processing called LabelEncoder, label encoder is a method in data pre-processing that is used to convert categorical variables into numeric values as done before, where for the column that was converted was the 'class' column with the following changes: "0: 'A', 1: 'B', 2: 'C', 3: 'D'". Exploration of data analysis is a stage that aims to identify data, understand the relationship between variables. In this section, several examples of EDA will be presented, including: Heatmap diagram which serves to see the correlation between classes that have an influence on feature 'class' with other features to give a positive or negative indication of the predictive feature 'class' that has been determined, then the second is the stacked bar chart diagram which serves to display the number of women and men in each feature 'class' and provide a visual representation of the gender distribution in each class starting from class A to class D. At the data proportioning stage, first a separation is made between features and targets from the dataset. The 'class' column in the dataset is first removed as the target of the dataset, and the result is stored in an independent variable, for example put into the variable 'X' as a feature. Furthermore, the 'class' column is also stored in the 'y' variable as the target. Next, the dataset that has been separated into features and targets is divided into training and test data subsets using the 'train_test_split' method. In this case, 20% or 0.2 data is used as test data, while 80% or 0.8 data is used as training data. Dataset splitting is done using a random state of 101 to ensure consistent results. In the model training stage, two different types of classification models were initialized. First, using a method model called random forest classifier and the second using a method model called XGBoost. At the model training stage, two different types of classification models are initialized. First, using a method model called random forest classifier where the initialization variable ('rfc') is initialized using 'n_estimators' of 1000, where this parameter serves to determine the number of decision trees to be used in the ensemble, then the second parameter is initialized using 'random_state' of 101, where this parameter serves to control the randomization of data in the process of forming decision trees, then using 'criterion' which is used to measure the quality of the separation of nodes in the decision tree, then using 'n_jobs' which indicates the use of all available CPU cores to train the model in parallel, thus speeding up the training process. Second, using a model method called XGBoost where a variable initialization ('xgb_clf') is initialized using 3 parameters, namely 'n_estimatos' of 1,000, 'random_state' of 101, then there is a parameter called 'learning_rate' of 0.05, this parameter serves to determine the learning rate used in gradient boosting. The 'leraning_rate' parameter assumes that the larger the value tends to have a greater influence on learning at each iteration, which does not mean that the higher the value, the faster the learning because the model can adjust more quickly to the training data, but it can also make it more prone to overfitting or errors in model building.
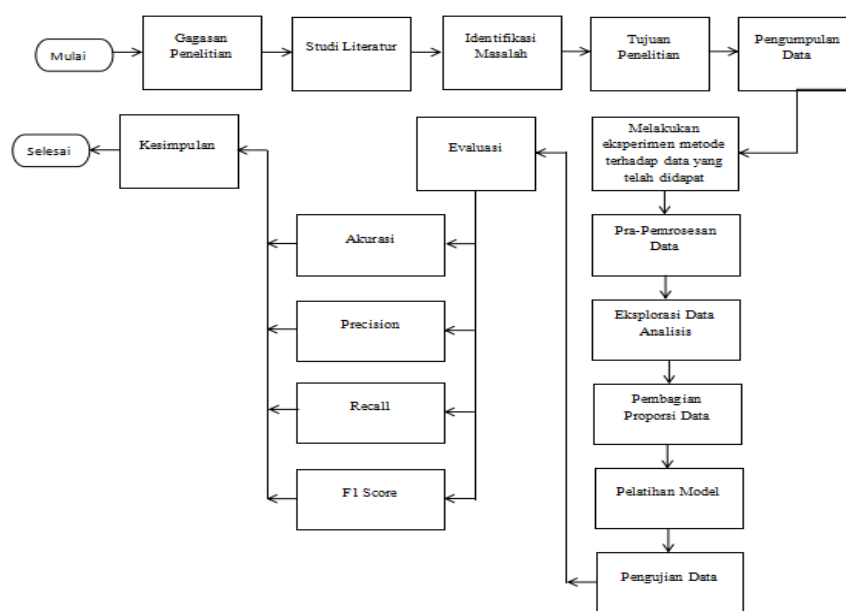

Figure 1. Proposed method

3.   METHOD

Body performance is the ability of an individual to perform physical tasks efficiently and maintain optimal physical condition [3]. XGBoost is a powerful algorithm for regression, classification, and ranking. XGBoost builds an ordered regression tree model and reduces its complexity to avoid overfitting [4]. In addition to XGBoost, there is also the random forest algorithm that uses ensemble decision trees for classification. Random forest has been shown to improve accuracy in various contexts, and the randomized selection of features in each tree enables its use in body performance analysis [5]. Bagging helps reduce the variance in the model by training separate models, while voting classifiers make decisions based on the majority of results from different classifiers [6]. Machine learning is a branch of artificial intelligence (AI) that adopts principles from computer science and statistics to create models that reflect patterns in data [7]. Machine learning can also be defined as the application of computer and mathematical algorithms adopted by learning from data and generating future predictions [8]. Classification in machine learning is the process by which a machine sorts objects based on certain characteristics, similar to how humans distinguish objects. There are several learning methods in machine learning. Supervised learning uses information that has been labeled on the data, such as previously classified data. Unsupervised learning, also known as clustering, does not require labels on the data and produces identifications without reference to predefined classes. reinforcement learning, which falls between supervised and unsupervised learning, works in a dynamic environment to achieve a goal without explicit notification from the computer when the goal is achieved [9], [10].

3.1. Body performance

Body performance pertains to an individual's ability to carry out physical tasks like sports and daily activities efficiently, maintaining optimal physical condition. It encompasses the efficiency and effectiveness of one's body in performing various activities. This aspect of performance reflects the capacity of the body to function effectively across different tasks and activities [3].

3.2. XGBoost

XGBoost is an effective GBoost algorithm for regression, classification, and ranking. By using a structured regression tree model, XGBoost reduces overfitting and improves performance by iteratively adjusting parameters to lower the loss function. Decision tree algorithms like XGBoost tend to be effective on categorical feature data and are less affected by class imbalance [4]. XGBoost, a new algorithm in machine learning, proved to be very powerful in modeling complex behaviors such as occupant windows compared to logistic regression analysis. Its advantages are expected to be applied to other behaviors such as blind control and air conditioning operation [11]. XGBoost in its process requires several parameters as a reference [12].

3.3. Stacking classifier

Stacking is a common procedure where a learner combines several individual learners (first-level learners), and the results are used by another learner (second-level learner or meta-learner). This technique, also called stacked generalization, combines multiple different classifiers such as decision tree, neural network, rule induction, naïve bayes, and logistic regression. Different from bagging and boosting, stacking allows combining heterogeneous models to improve prediction performance [13].

3.4. Bagging classifier

Bagging is a widely used meta-algorithm in machine learning, aimed at enhancing stability and accuracy in tackling classification and regression tasks. This approach involves creating multiple bootstrap samples from the original training dataset and training individual models on each sample. By combining these models, bagging reduces variance, effectively mitigating overfitting issues [14].

3.5. Voting classifier

Voting classifier is a model that trains an ensemble of other models and provides output predictions based on the highest probability. It takes the results from various classifiers and then predicts the outcome with a greater majority. There are two types of classifiers, including hard and soft voting. In hard voting the result is based on the majority, while for soft voting the result is based on the average of the votes in it [6].

3.6. Random over sampling and class counting

Random over sampling aims to increase the size of the minority class by synthesizing a new sample or training dataset by randomly duplicating samples of the minority class [15], [16]. Class counting is a technique used to identify and measure imbalances between classes in a dataset. It involves counting the

number of samples belonging to each class to understand the extent of the sample size difference between classes.

3.7. Confusion matrix and macro average

Confusion matrix is a tool for predictive analysis in machine learning to check the performance of machine learning model-based classification [17]. Confusion matrix is a square matrix with columns representing actual values and rows representing predicted values from the model. Macro averages is predicting a multiclass into multiple binary predictions, calculating the metrics and then averaging the results [18].

3.8. Python

Python is a multipurpose interpretive programming language with a design philosophy that focuses on code readability. Python is claimed to be a language that combines capability, ability, with a very clear code syntax, and comes with the functionality of a large and comprehensive standard library. Python is also supported by a large community [19]. Python data analysis library or pandas is an open source, BSD-licensed library providing high performance, easy-to-use data structures and data analysis tools for the python programming language.

3.9. Literature review

Research conducted in the prediction system of body health or body performance is carried out using selection using machine learning models with the XGBoost algorithm, random forest, stacking classifier, bagging classifier, and voting classifier. Each of these methods has been carried out by previous research in their research. The following is a review of research related to algorithms that have been used for classification in these methods. In the first study entitled "coastal wetland mapping using ensemble learning algorithms: a comparative study of bagging, boosting and stacking techniques." It focuses on coastal wetland mapping using various ensemble learning algorithms such as bagging, boosting, and stacking. The results showed that all these ensemble algorithms performed significantly better than individual classifiers. This highlights the great potential of using ensemble learning in the field of wetland mapping and environmental monitoring [20].

The second journal entitled "exploring the performance of ensemble machine learning classifiers for sentiment analysis of COVID-19 tweets" focuses on sentiment analysis of COVID-19-related tweets using three different ensemble machine learning models. The results show that the stacking classifier (SC) model has the best performance with the highest f1-score value of 83.5% compared to the other models. This research highlights the effectiveness of ensemble learning in analyzing sentiment on social media related to contemporary issues such as the COVID-19 pandemic [21].

The third journal entitled "implementation of stacking ensemble classifier for multi-class classification of COVID-19 vaccines topics on Twitter" proposes the use of a stacking ensemble classifier model to overcome the differences in public opinion on Twitter regarding the COVID-19 vaccine. The model uses logistic regression, support vector machine (SVM), and random forest as first-level learners, with logistic regression as the meta-learner. The results show significant improvements in accuracy and F1-score compared to other models, even with less data. This research highlights the importance of ensemble classifiers in analyzing public opinion on social media related to public health issues [22].

The fourth journal entitled "exploring the performances of stacking classifier in predicting patients having stroke" explores the use of stacking classifiers to predict stroke risk in patients. Stroke is a serious medical problem, and accurate diagnosis is crucial. This research shows that the stacking classifier model has a high accuracy of about 95%, which can help in early stroke detection and appropriate treatment. These findings encourage the use of machine learning models for more accurate medical diagnosis and early treatment [23].

The fifth journal entitled "cardiovascular and diabetes diseases classification using ensemble stacking classifiers with SVM as a meta classifier" proposes the use of ensemble stacking classifiers to improve the diagnosis of these diseases. The results show that these stacking models have higher accuracy in diagnosing diabetes and cardiovascular diseases compared to individual classifiers. These findings emphasize the importance of ensemble approaches in the identification of diseases that have a major impact on human health [24], [25].

4. RESULTS AND DISCUSSION

After performing several processes ranging from data pre-processing to model training, then testing data from each method is carried out to find which method produces the best accuracy value. The results of

the comparison of the accuracy value of each method are shown in Table 1. Based on the results of analysis and evaluation in Table 1, the smallest to largest accuracy can be described: first, the stacking classifier method gets an accuracy result of 76.07% which puts the stacking classifier combined method into the method with the greatest accuracy of the five methods tested. Second, there is a combined method called voting classifier with an accuracy result of 75.85% which makes it second with the highest accuracy method. Third, it is in the method called bagging classifier with an accuracy result of 75.77%, so for the top three best methods are in the combined method, where the method we combined was the XGBoost method with random forest. Then the fourth, is in the XGBoost method with an accuracy result of 75.10%. Then the fifth or last order is in the random forest method with an accuracy result of 74.43%.

Table 1. Comparison of method accuracy with XGBoost tuning

Method	Test data result	Training data result
XGBoost	75.10%	82.70%
Random forest	74.43%	99.57%
Stacking classifier	76.07%	99.93%
Bagging classifier	75.77%	95.17%
Voting classifier	75.85%	98.85%

Based on the results of analysis and evaluation in Table 2, the smallest to largest accuracy can be described: First, the stacking classifier method gets an accuracy result of 75.25% which puts the stacking classifier combined method into the method with the greatest accuracy of the five methods tested. Second, there is a combined method called bagging classifier with an accuracy result of 75.25% which makes it second with the highest accuracy method. Third, it is in the method called voting classifier with an accuracy result of 75.03%, so for the top three best methods are in the combined method, where the method we combined was the XGBoost method with random forest. Then the fourth, is in the XGBoost method with an accuracy result of 74.80%. Then the fifth or last order is in the random forest method with an accuracy result of 74.65%.

Table 2. Comparison of method accuracy with random forest tuning

Method	Test data result	Training data result
XGBoost	74.80%	98.70%
Random forest	74.65%	99.57%
Stacking classifier	75.25%	99.89%
Bagging classifier	75.17%	94.80%
Voting classifier	75.03%	99.57%

Based on the results of analysis and evaluation in Table 3, the smallest to largest accuracy can be described: first, the stacking classifier method gets an accuracy result of 75.85% which puts the stacking classifier combined method into the method with the greatest accuracy of the three methods tested. Second, there is a combined method called voting classifier with an accuracy result of 75.74% which makes it second with the highest accuracy method. Third, it is in the method called bagging classifier with an accuracy result of 75.47%, so for the top three best methods are in the combined method.

Based on the evaluation results of the metrics Table 4, it can be concluded that the stacking classifier method has performed quite well in solving the classification problem in this study. Although the accuracy, precision, recall, and F1-score values do not reach the perfect level, but overall, this model is able to provide predictions with an adequate level of truth. The accuracy value of 76.07% shows that the model can classify most of the data correctly. In addition, the almost balanced precision and recall of 76.69% and 75.83% respectively, shows that the model tends to give correct positive results and is able to recover most of the positive data. Recall, on the other hand, is a metric that measures the extent to which the classification model can recover all data that is actually positive. From the evaluation results, a recall value of 75.83% was obtained. This means that the model successfully recovered about 75.83% of all positive data in the test dataset.

Table 3. Comparison of accuracy of XGBoost and random forest methods

Method	Test data result	Training data result
Stacking classifier	75.85%	99.72%
Bagging classifier	75.47%	94.68%
Voting classifier	75.74%	98.78%

Table 4. Metrics comparison

Method	Test data result	Training data result
Accuracy	76.07%	99.89%
Precision	76.96%	99.89%
Recall	75.83%	99.89%
F1-score	75.81%	99.89%

5.　CONCLUSION

Based on the results of data analysis and testing, this study found that in the performance comparison between XGBoost and random forest classifier, XGBoost showed superiority with higher accuracy both on test data (75.10%) and on training data (82.70%), while random forest classifier had higher accuracy on training data (99.57%) but slightly lower on test data (74.43%). Overall, XGBoost is more stable in preventing overfitting and provides better performance. The best parameter settings for the XGBoost model are 'n_estimators=1000, learning_rate=0.05, random_state=101' with 80% training data and 20% test data. Of the various classification methods tested, the stacking classifier showed the highest performance with an accuracy of 76.07%, followed by the voting classifier (75.85%) and bagging classifier (75.77%). The stacking classifier also has precision (76.96%), recall (75.83%), and F1-score (75.81%) which shows a good balance between the ability to give correct positive results and the ability to re-identify positive data. This conclusion provides a comprehensive understanding of the best model choice and parameter configuration in the context of this study.

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