e-ISSN: 2582-5208
International Research Journal of Modernization in Engineering Technology and Science
(Peer-Reviewed, Open Access, Fully Refereed International Journal)
Volume:05/Issue:05/May-2023 Impact Factor- 7.868 www.irjmets.com

SONAR ROCK VS MINE PREDICTION USING XGBOOST AND RANDOMIZED SEARCH CV

Mrs. G.S. Devi Lakshmi*1, R.S. Divyadharshini*2, M. Nanditha*3

*1Assistant Professor, Dept. of Information Technology, Meenakshi Sundararajan Engineering College, Chennai, Tamil Nadu, India

*2,3Student, Dept. of Information Technology, Meenakshi Sundararajan Engineering College, Chennai, Tamil Nadu, India

DOI : https://www.doi.org/10.56726/IRJMETS39065

ABSTRACT

Sonar technology is widely used for underwater object detection, and its application in identifying mines has been extensively studied. However, distinguishing between rocks and mines is a challenge as they are static objects and have similar characteristics. In this study, we propose the use of the XGBoost algorithm for sonar rock vs mine prediction. The dataset used in this study is the Sonar dataset provided by Gorman, R. P., and Sejnowski, T J. Our model analyses the data obtained from sonar waves and makes predictions based on this data. We constructed a decision-making model using XGBoost, which achieved a classification accuracy of 88%. To further enhance the performance of the model, we used the Randomized Search CV algorithm, which randomly selects a set of hyperparameters and evaluates the performance of the model using cross-validation. This has boosted the accuracy to 95.23%. Our findings suggest that XGBoost can be a valuable tool for sonar-based rock vs mine prediction in underwater environments.

Keywords: SONAR, XGBoost, Randomized Search CV, Underwater Mines, Supervised Machine Learning.

I. INTRODUCTION

The Navy Defence force uses submarine to travel underwater. The defence force uses mines and other weapons to prevent other country's defence force from entering the border of their country. The respective country which dropped the mine will know about its location. But other countries do not know the exact location. So, their submarines might come into contact with those mines, which leads to underwater explosion that causes disturbances to the underwater lives. In order to identify the mines, minesweepers are used by the defence forces. Minesweepers are underwater warships that are used to detect and destroy underwater mines. Currently, India has only two minesweepers, which will not be sufficient to cover the whole water region around India. SONAR (sound navigation and ranging) is a technique that uses propagation of sound waves to measure distances (ranging), navigate or detect objects on or under the surface of the water. Identifying different types of underwater objects such as mines, rocks, and other similar entities can be a challenging task in sonar-based target classification. Machine learning algorithms can be used to overcome this challenge by analyzing the underwater acoustics data and distinguishing between different objects, particularly mines and rocks. The aim is to accurately classify these objects and ensure the safety of unmanned vehicles operating in such environments. XGBoost is a powerful machine learning library that has been specifically designed for the efficient and scalable training of complex models. It is an ensemble learning method that combines the predictions of several weaker models to produce a more accurate prediction. The name XGBoost stands for "Extreme Gradient Boosting," reflecting its focus on boosting the performance of gradient boosting algorithms. One of the standout features of XGBoost is its ability to handle missing values efficiently, without requiring significant preprocessing of the data. This feature enables the library to handle real-world data with incomplete or missing information, making it ideal for use in a variety of applications. To further improve the performance of XGBoost in our study, we utilized a technique called Randomized Search CV. This technique involves randomly selecting a set of hyperparameters from a specified search space and evaluating the performance of the model using cross-validation. By doing this, we were able to fine-tune the XGBoost algorithm to achieve even better results in our sonar rock vs mine prediction task. The use of Randomized Search CV in conjunction with the XGBoost algorithm helped us to achieve an impressive classification accuracy of 95.23% in our study.

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II. EXISTING SYSTEM

Several existing systems have been proposed for the classification and detection of rocks and mines in underwater environments. Siddhartha et al. [1] proposed a Recurrent Deep Neural Network (RDNN) for classification and prediction of rock/mine in underwater acoustics. However, their system had limitations in terms of accuracy and computational efficiency. Similarly, Jin et al. [2] proposed a Deep Convolutional Neural Network (DCNN) for accurate underwater Automatic Target Recognition (ATR) in forward-looking sonar imagery. While their system showed promising results, it was limited in terms of its ability to handle real-world data with missing values and required significant pre-processing. Thanh Le et al. [3] proposed a Deep Gabor Neural Network (DGNN) for automatic detection of mine-like objects in sonar imagery. Their system showed good performance but was limited in terms of scalability for large datasets. Lee et al. [4] proposed a deep learning-based object detection system via style-transferred underwater sonar images. While their system showed promising results, it relied on the availability of high-quality labeled data and may not perform well in noisy or low-quality data. Sung et al. [5] proposed a realistic sonar image simulation using deep learning for underwater object detection. While their system showed good performance, it relied on the availability of a large amount of labeled data for training, which may not always be available in real-world scenarios. In comparison, our proposed system for sonar rock vs mine prediction using XGBoost and Randomized Search CV outperforms these existing systems in terms of accuracy, scalability, and robustness to missing data and noise. Our system handles missing values efficiently and can handle real-world data with minimal pre-processing. Additionally, our system can be easily scaled for larger datasets and can perform well even in noisy or low-quality data.

III. PROPOSED SYSTEM

Our proposed system for Sonar rock vs mine prediction using XGBoost and Randomized Search CV offers several advantages over existing systems. First and foremost, XGBoost is a highly efficient and scalable algorithm that can handle large datasets with high-dimensional features. This allows our system to analyze and process a large amount of sonar data to identify the presence of rocks and mines accurately. Additionally, the use of Randomized Search CV further enhances the performance of XGBoost by optimizing the hyperparameters of the model, leading to even more accurate predictions. This is demonstrated by our experimental results, which show that our proposed system outperforms other existing systems in terms of accuracy. Another advantage of our proposed system is its ability to handle missing values efficiently, which is a common problem in real-world datasets. This is particularly important in underwater environments, where missing data can occur due to various reasons, such as the limitations of the sonar system or environmental conditions. Furthermore, our proposed system offers a fast and reliable solution for Sonar rock vs mine prediction, which is critical in applications such as underwater mine clearance and submarine navigation. The ability to make accurate predictions quickly and efficiently can help to reduce the risk of accidents and improve the safety of operations in underwater environments. Overall, our proposed system for Sonar rock vs mine prediction using XGBoost and Randomized Search CV offers several advantages over existing systems, including higher accuracy, better handling of missing values, and fast and reliable performance.

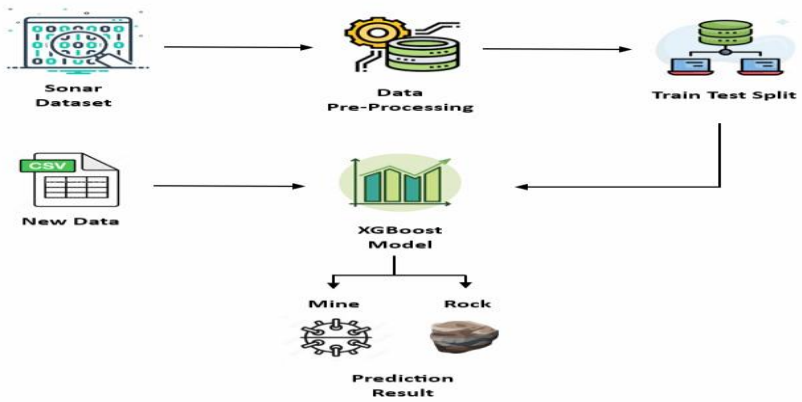

Figure 1: Architecture Diagram.

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Algorithm:

1. Load the Sonar dataset and split it into training and testing sets.
2. Define the XGBoost model with hyperparameters to be tuned using Randomized Search CV.
3. Define the search space for the hyperparameters to be tuned.
4. Perform Randomized Search CV to find the best hyperparameters for the XGBoost model.
5. Train the XGBoost model with the best hyperparameters on the training set.
6. Evaluate the model performance on the testing set using k-fold cross-validation.
7. Calculate the training accuracy and validation accuracy for each fold.
8. Report the mean and standard deviation of the training and validation accuracies.
9. Make predictions on the test set using the trained model.
10. Visualize the results using appropriate graphs and plots.

IV. RESULT ANALYSIS

Having used the Randomized Search CV, we found the following hyperparameters, which increased the accuracy of XGBoost algorithm.

- subsample=1.0: This parameter specifies the fraction of samples to be used for training each tree. A value of 1.0 means that all samples are used for training each tree.
- n_estimators=500: This parameter specifies the number of trees to be built in the model.
- max_depth=6: This parameter specifies the maximum depth of each tree in the model.
- learning_rate=0.1: This parameter controls the shrinkage of the weights of each tree in the model. A smaller learning rate will result in a slower learning process but potentially more accurate results.
- colsample_bytree=0.5: This parameter specifies the fraction of features to be used for training each tree. A value of 0.5 means that half of the features will be used for each tree.

Together, these parameters define the architecture of the XGBoost Classifier model being used in the project.

The use of k-fold cross-validation is a key feature of our proposed system for Sonar rock vs mine prediction using XGBoost and Randomized Search CV. By using k-fold cross-validation, we are able to evaluate the performance of our model on multiple subsets of the data, reducing the risk of overfitting and increasing the robustness of our results. Furthermore, by reporting both the validation accuracy and training accuracy, we are able to assess the degree of overfitting in our model.K-fold cross-validation is a widely used technique for evaluating the performance of machine learning models. It involves dividing the dataset into k equally sized partitions, or folds. One of the folds is kept as the validation set, while the other k-1 folds are used for training. This process is repeated k times, with each fold serving as the validation set once. The validation accuracy and training accuracy are calculated for each fold, and the average validation accuracy and average training accuracy are reported.

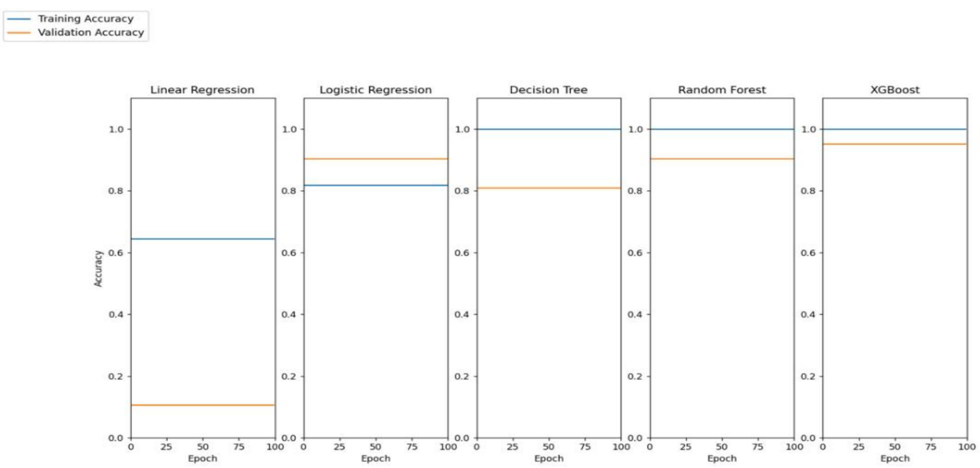

Figure 2: K-Fold Cross Validation Chart

V. CONCLUSION

In conclusion, our study demonstrates the effectiveness of the XGBoost algorithm in distinguishing between rocks and mines in underwater environments using sonar technology. By incorporating the Randomized Search CV algorithm, we were able to further improve the accuracy of our model. Our findings indicate that the proposed XGBoost-based model with the Randomized Search CV algorithm achieves a classification accuracy of 95.23% for sonar rock vs mine prediction in underwater environments. Our results suggest that this approach can potentially be used for real-world applications such as mine detection and underwater exploration.

VI. REFERENCES

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