PROJECT SYNOPSIS

ON

PRECTION OF ROCK AND MINE USING MACHINE LEARNING

BACHELOR OF TECHNOLOGY

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ABSTRACT

This project delves into the imperative task of accurately discerning underwater mines from rocks, utilizing Sonar signals for enhanced safety within naval defense systems and environmental conservation. The prevalence of mines, often resembling innocuous rocks, poses a dual threat to marine life and submarine vessels, necessitating a meticulous and reliable predictive system.

Drawing upon a dataset provided by Gorman, R. P., and Sejnowski, T. J. (1988), this research employs Python and supervised machine learning classification algorithms to harness the potential of Sonar signals. These signals, recorded at 60 different angles, offer a nuanced understanding of the frequencies associated with various underwater objects. The crux of the project lies in training three binary classifier models, each tailored for optimal accuracy in distinguishing between mines and rocks.

The significance of this work becomes evident in its potential to mitigate risks associated with misidentifying underwater objects, thereby enhancing the overall security of naval defense systems. The accurate categorization of mines and rocks through advanced signal analysis is crucial for preventing inadvertent damage to both marine ecosystems and naval assets.

Our methodology involves constructing prediction models based on the trained classifiers, forming a robust framework for real-time identification. The emphasis on achieving a high level of accuracy is paramount, given the potentially dire consequences of misclassification in underwater environments.

In summary, this research amalgamates data science, signal processing, and machine learning to contribute to the development of a sophisticated prediction system. By harnessing Sonar signals and employing advanced classification algorithms, the project endeavors to provide a reliable and accurate means of distinguishing between underwater mines and rocks, thereby fostering enhanced security and environmental preservation.

INTRODUCTION

UNDERWATER MINES:

Underwater mines or naval mines are self-contained explosive devices placed in water to destroy enemies' surface ships or submarines. Underwater mines are used since the mid-19th century. Sea mines were introduced by David Bushner in 1977 during the American civil war. There is an estimate of 5000 naval mines remaining from the two world wars in the Adriatic Sea.

Previously mines were only activated by physical contact but the newly created mines can be activated by various methods. Modern mines can be activated by acoustic, pressure, and, magnetic changes in the water which provoke them to explode. These are called influence mines. Generally, underwater mines are classified as offensive or defensive warfare. Mines are strewn across hostile shipping lanes in order to damage merchant ships and military boats.

Defensive mines are placed along coastlines to divert enemy submarines and ships away from critical locations and into more heavily guarded places.
Usually, mines are mistaken as rocks during their identification, as mines can have the same shape, length, and width as rocks. To avoid this confusion it is better to use a more accurate input to receive an accurate output. One of the methods in detecting the mines is SONAR.

The challenge in mine identification arises from their resemblance to rocks, sharing similar shapes and dimensions. To enhance accuracy in discrimination, sophisticated methods are imperative. One such method is the application of SONAR technology, instrumental in detecting underwater mines. Employing SONAR ensures a more precise input for accurate output, mitigating the potential misidentification of mines as benign rocks and contributing to enhanced maritime security.

SONAR:

The Sound Navigation and Ranging (SONAR) system, a cornerstone of underwater exploration, relies on sound waves to navigate and detect objects beneath the water's surface. Primarily recognized for its military application in acoustic mine detection, SONAR's utility extends to diverse areas such as fish finding, seabed mapping, and sea diver location for non-military purposes. The effectiveness of SONAR, however, is intricately tied to the careful consideration of sound wave frequencies, dictated by the challenging dynamics of underwater environments.

In underwater mine hunting, SONAR frequencies typically range from 0.1 to 1 MHz, corresponding to distances between 1 and 0.1 km. This deliberate frequency selection, influenced by the rapid attenuation of sound waves with increasing frequency, optimizes the system for military applications. Importantly, ultrasonic waves are favored over infrasonic waves due to their ability to propagate underwater. Despite their long wavelengths, ultrasonic waves capture minimal energy, making them suitable for precise underwater detection.

SONAR technology encompasses both active and passive systems. Active SONAR involves a sound transmitter and receiver, with the transmitter emitting sound waves that, upon reaching a target, reflect back as echoes. These echoes are then decoded by the receiver, capturing the frequencies associated with the target object. Notably, active SONAR frequencies typically fall within the 20 kHz range. This project capitalizes on the frequencies obtained by active SONAR at 60 different angles, utilizing them as inputs to discern whether the target is a mine or a rock.

Beyond the realm of underwater exploration, this project expands its focus to address a contemporary societal challenge: student dropout rates in educational institutions. The project's dual objectives aim to rigorously analyze existing data, identifying patterns and trends related to student attrition, and actively engage with stakeholders such as educational institutions, policymakers, parents, and communities. The overarching goal is to create a supportive ecosystem that not only facilitates academic success but also reduces dropout rates.

By contributing to the body of knowledge on student attrition, the project seeks practical implementation through evidence-based policies and initiatives. This multifaceted approach reflects a commitment to making a tangible difference in the lives of students, emphasizing the transformative potential of informed interventions. The consequences of student attrition ripple far beyond the individual, impacting societal well-being and the collective advancement of communities.

This introductory overview sets the stage for a deeper exploration of the project's goals, methodologies, and expected outcomes. The urgency of addressing student dropout in the modern educational landscape is underscored, emphasizing the potential for positive change in the lives of countless students and the communities to which they belong. Through interconnected efforts and a holistic understanding of the challenges at hand, this project aspires to contribute significantly to the fields of underwater technology and education, aligning with the broader objectives of societal progress and well-being.

LITRATURE REVIEW

1.This paper main end is to develop an accurate forecasting model, united by the machine learning characteristics, which can figure out if the target of the sound surge is either a gemstone or a mine or any other organism or any kind of other body. The paper attemts to clear- cut case study which comes up with a machine literacy plan for grading of jewels and minerals, executed on a huge, largely spatial and complex SONAR dataset. The attempts are done on a largely spatial SONAR dataset and achieved an delicacy of 83.17 and AUC came out to to be 0.92. With arbitrary timber algorithm, the results are farther optimized by point selection to get the delicacy of 90. Assuring results are set up, when the fulfillment of the designed root is set side by side with the standard classifiers like SVM, arbitrary timber, etc., using different evaluation criteria like delicacy, perceptivity, etc. Machine literacy is performing a major part in perfecting the quality of discovery of aquatic natural coffers and will tend be better in the near future. **[H Singh et.al. (2020)].**

2.The paper aim is to detect the underwater minerals(mines) or rocks. The detection of rock and mines and underwater objects have been difficult without the expansion of the sound Navigation and ranging methodology, which uses specific parameters to determine is a barrier or a surface is a mine or a rock. Moreover, this work introduced novel technique as rock or mine detection Neural Network (RDNN) for performing rock/mine prediction and classification in underwater acoustics. The proposed RDNN method outperforms the outcomes by attaining high accuracy as 92.85% mean accuracy that makes better model performance.**[Jetty Bangaru Siddhartha et.al. (2023)].**

3. The paper makes use of the sound waves dataset to work on as the sound waves penetrate the sea more deeply than radar and light waves. Along with this SONAR dataset they have used PCA and t-SNE to extract features. Utilizing classification approaches such as Logistic Regression and Random Forest Tree, an accuracy of 72% and 91%, respectively, was attained. Similarly, CNN and LSTM models are also employed to get an accuracy of about 80.77% and 99% respectively **[Akshat Khare et. al. (2022)].**

4. The paper main aim is the detection and classification of rocks and mines. The detection and classification steps are usually performed using a sonar mounted on a ship’s hull or on an underwater vehicle. After retrieving the sonar data, military personnel scan the seabed images to detect targets and classify them as mine-like objects (MLOs) or benign objects. To reduce the technical operator’s workload and decrease post-mission analysis time, computer-aided detection (CAD), computer-aided classification (CAC) and automated target recognition (ATR) algorithms have been introduced. Further on the author uses the deep learning and various machine learning algorithms to improve the mine detection and classification algorithm. **[Stanislaw Hozyn et.al. (2021)].**

5.The paper main objective is to use the SONAR dataset and apply the random forest algorithm because the random forest algorithm works best in all categories as compared to other algorithms. The paper main is to improve the accuracy of the underwater object detection algorithm. **[Vendururu Sireesha et.al. (2023)].**

6. Nowadays, artificial Intelligence appears in the domain of geotechnics, underwater acoustics, tunnelling, geomorphology engineering and also in several fields too. The paper main aim is to apply the machine learning algorithms in the field of underwater objects to accurately classify whether it is a rock or a mine. The machine learning algorithms used are Random forest, gradient boosting and logistic regression. **[Sivachandra K et.al. (2023)].**

7.Underwater mining of minerals and rocks is a highly challenging task before the discovery of SONAR (Sound Navigation and Ranging) system. Lately, the mine detection process was performed by the divers trained in the disposal of hazardous ordnance, marine mammals, video cameras mounted on mine-neutralization trucks, and laser systems. which leads to risk and loss to the marine life. SONAR system is capable of capturing Scan-side sonar images, but the model’s accuracy is a concern. So Naval defense system need to use a much more accurate system as mines can be easily mistaken as rock, to obtain accurate results we will be working on the dataset of frequencies. Recently, this prediction system was constructed using many machine learning methodologies. The research study proposes to apply XGBoost algorithm to develop a prediction system to predict whether the object is rock or mine. Here, the accuracy of the proposed model is compared with the accuracy of the existing models.**[M Sitha Ram et. al. (2023)].**

8.The paper main aim is to predict if the substance is a metal or rock from sonar returned data. There are two types of sonar technology used passive (listening to the sound emitted by vessels in the ocean) and active (emitting pulses and listening for their echoes). The Prediction can be done using Machine Learning Algorithm namely logistic Regression Algorithm. The main advantage is we can predict from a longer distance and the accuracy is high. They employed SONAR to perform trials in a simulated region with metal cylinders in place of mines. The object was struck with sonar signals from 60 various angles, and the results were recorded. The dataset is then trained to the evaluated models. The Sonar output frequencies are sent into the predictive system as input. **[Mr. K. Shiva Kumar et. al. (2022)].**

9.Ocean mines are the major threat to the safety of great vessels and other living beings in the marine life. It is a self-contained explosive device placed in water to destroy ships or submarines. Due to various factors like variations in operating and target shapes, environmental conditions, presence of spatially varying clutter, compositions and orientation, detection and classification of sonar imagery with respect to underwater objects is a complicated problem. It is well known that many post processing techniques in image processing have done to receive high resolution images to distinguish the objects. However, the mentioned technique needs a special method to detect the metal from the usual sub bottom materials mainly rocks. Hence the data collection made in simulated environment locating metals in rock bed and collected with the sonar and the distinguished features of metals from rock have been identified with the totally different approach called intruder detection technique using data mining/machine learning. The paper proposes a novel for discriminating and detection of objects in underwater environment with accuracy of 90% (full feature set) and 86% (selected feature set). Hence, it is quite revealing that the new technique is better in classification of mine like objects in underwater, justified with samples of sonar data sets. **[Venkataraman Padmaja et.al. (2021)].**

10. Naval and military research pays significant attention on the targets within the seabed. Identification of hidden mines is a crucial research problem and sonar images aid in the process by providing signal features. Previous studies on underwater mines classification have used

standalone algorithms for classification, which lacks the ability to generalize and are prone to errors. Driven by the challenge, an ensemble approach by stacking the machine learning classifiers is presented in the paper. Also, lack of availability of data in dense has been overcome by generating synthetic data with the available data from the repository. Proposed approach is tested with synthetic as well as real-time dataset which reached classification accuracy and F1-score of 91%. Observations reveal that proposed model has improved performance than individual classifiers on the Mines versus Rocks data. **[G. Divyabarathi et. al. (2020)].**

Existing System

In the existing system, the detection of mines is done by explosive ordnance disposal divers, marine mammals, video cameras on mine neutralization vehicles, laser systems, etc but not by using a definite data set or equipment which can cause risk and loss to the marine life if it goes wrong. As technology improved SONAR is being used as a primary tool to detect the mines.

Proposed System

We have proposed a predictive system to give accurate results and outcomes. We will utilize the dataset from "Analysis of Hidden Units in a Layered Network Trained to Classify Sonar Targets" by R. Paul Gorman and Terrence J. Sejnowski. We will employee SONAR to perform trials in a simulated region with metal cylinders in place of mines. The object was struck with sonar signals from 60 various angles, and the results were recorded. The dataset is then trained to the evaluated models. The Sonar output frequencies are sent into the predictive system as input. We will use classification machine learning techniques to predict if the object is a Rock or a Mine.

Objectives

This project will fulfil the following Objectives:-

- Underwater Mine usage by the Naval Defence System provides great Security but also possesses a threat to the marine life and submarine vessels as the mines can be easily mistaken for rocks. So, we need a much more accurate system to predict the object as it is very dangerous if a mistake is made.
- Sonar Signals record the various frequencies of underwater objects at 60 different angles.
- Mines are mistaken as rocks during their identification, as mines can have the same shape, length, and width as rocks. Since Sonar Signals record the various
- frequencies of underwater objects at 60 different angles so it provides more accurate system to predict the object precisely. Thus, reduces risk and loss to the marine life

Methodology

ALGORITHM:

Step 1: We gather the dataset and perform data preparation and Exploratory Data Analysis to clean the dataset.
Step 2: We split the data into train and test datasets. Using them we evaluate the classification models.
Step 3: Following the evaluation, the top three performing models are determined to be KNN, SVM, and Logistic regression.
Step 4: The accuracy of these models is evaluated, and a classification report is generated.
Step 5: We now fit the models to create a prediction system that's both accurate and efficient.
Step 6: Using the predictive systems, we can finally determine if the object is a Mine or a Rock.

EVALUATION OF CLASSIFICATION MODELS:

Performance, understandability, complexity, dataset size and dimensionality, and interface time should all be considered while choosing an ML model. To increase the model's performance, it's critical to analyze it before choosing and fitting it. Model assessment techniques as well as a model evaluation measure are required. Here, classification metrics are taken into account. These are the most commonly used in machine learning and data science. We assess the potential of various techniques using the same set of criteria, which are the assessment metrics. The easiest approach for assessing a Model's performance is to look at its accuracy.

Accuracy=(TP+TN)/(TP+TN+FP+FN)

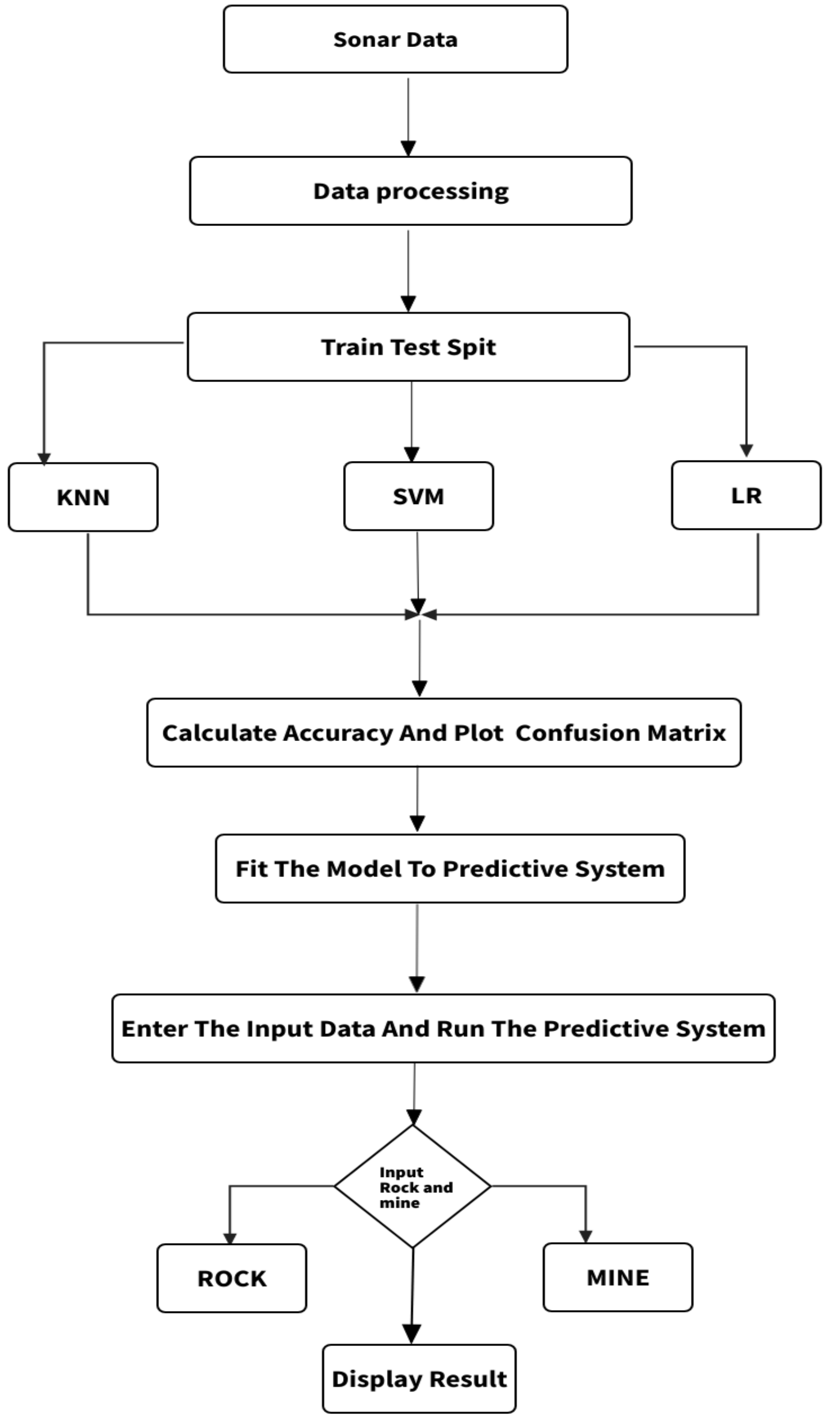

Fig 1: Flowchart Of the Proposed algorithm

KNN ALGORITHM:

The KNN Technique is the most basic supervised machine learning algorithm for classification. It comes in handy while doing a pattern recognition task for data categorization based on features. When the K-nearest neighbors are determined and the distance between them is calculated, it determines which class the input belongs to first, the dataset must have categorical values, and then it is divided into dependent and independent variables. The target variable is the dependent variable in this case. Using the train test split() method, we split the data into training and testing data. We go for the most appropriate distance measure. The k value, on the other hand, must be calculated. We fit the KNN model to the train and test data, using the optimal k value.

Fig 2: Steps involved in the KNN Algorithm.

SVM ALGORITHM:

The Support Vector Machine (SVM) method is a supervised learning technique that may be used for classification and regression, however, it is most commonly employed for classification tasks. The goal of this approach is to find a hyperplane in an N-dimensional space that categorizes data points clearly. The support vector classification (SVC) algorithm is a variation of the support vector machine (SVM). The dataset must first have categorical values, after which we partition it into dependent and independent variables. The target variable is the dependent variable in this case. Using the train test split() method, we split the data into training and testing data. We choose the optimal hyperparameters, such as the kernel function and the c parameter, using the grid selection approach. We now utilize correct hyperparameters to fit the svc model to the train and test data .We used rbf and c=1.5 in our model.

LOGISTIC REGRESSION:

Logistic Regression is a statistical method used to determine the binary outcome of the dependent variable in a dataset with one or more independent variables. This model predicts the dependent variable by the analysis of the relation between one or more independent variables.

The dataset must first have categorical values, after which we partition it into dependent and independent variables. The target variable is the dependent variable in this case. Using the train test split() method, we split the data into training and testing data. 3. For the perfect fit of input data to the regression model, we utilize a binary encoder. We now apply an accurate solver to fit the logistic regression model to the train and test data, in our case a liblinear solver.

We created a confusion matrix using the values of TP, TN, FP, and FN in the three classifiers we evaluated. To have a better understanding of the model's accuracy, the classification error and precision numbers must be determined. Finally, we utilize this model to create a prediction system that predicts the output based on the input values we supply.

Conclusion

Our project “Underwater mine and rock prediction by the evaluation of machine learning algorithms” are used to detect rocks and mines in the ocean bed. Naval mines are an effective method for blocking ships and restricting naval operations which result in significant negative economic and environmental impacts.

There are two existing ways to detect a mine, one by using sonar signals and the other by using manpower. Using Sonar signals has been a better option as the risk for the latter is more. The data is collected and stored in a CSV file. By using different machine learning techniques we can observe and understand the nature of the predictive system.

By the evaluation of algorithms, we get to check and compare the accuracies to build a better performing prediction model. A python is open-source software and the machine computation is also faster than many others and the cost might decrease dependently. Through this project, we want to make the process a bit easy and simple to achieve and use.

In conclusion, our project is positioned at the intersection of cutting-edge technology and maritime security, addressing the pressing need for effective underwater mine detection. Through the strategic evaluation of machine learning algorithms, we strive to contribute to a safer and more secure maritime environment. By simplifying the detection process and enhancing accuracy, we hope to make a tangible impact on mitigating the risks associated with naval mines, ultimately fostering a more resilient and protected maritime landscape.

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