International Journal of Trend in Scientific Research and Development (IJTSRD)
Special Issue on Smart Innovations in Computer Science and Applications
Available Online: www.ijtsrd.com e-ISSN: 2456 – 6470

Bone Tumor Detection Using Machine Learning

Dev Omprakash Paliya
Department of Science and Technology, G.H.Raisoni Skill Tech University, Nagpur, India

ABSTRACT

Bone tumor detection is an important area of research in the medical and healthcare fields because we need to find and diagnose tumors early and accurately. Medical datasets have a lot of clinical attributes that can be analyzed using Machine Learning techniques to help doctors make diagnoses and decisions. With more Artificial Intelligence being used in healthcare we are using models to look at clinical data find patterns in tumors and make diagnoses more accurate while reducing mistakes made by humans.We are still talking about bone tumor detection. Systems that use data to make healthcare decisions have led to the creation of classification models that can tell the difference between tumor and nontumor cases based on clinical features. However the quality of how we prepare and medical datasets is very important for how well the models work.In this study we used a machine learning framework to classify bone tumors using a dataset with 570 samples. We cleaned the data scaled the features and split the data into training and testing sets to make sure the evaluation was fair. We used algorithms like Logistic Regression, Random Forest and Support Vector Machine to compare and find the best model for bone tumor detection. We did steps including cleaning the data looking at the data analyzing how features are related training the model and evaluating how well it worked. We looked at how accurate the model was made a confusion matrix and used ROC-AUC metrics to evaluate the model. The results showed that the model was very accurate with an accuracy of 0.99 and an AUC score of 0.99 which means it is very good at telling the difference, between malignant bone tumor cases. These results suggest that if we have prepared structured clinical data and use supervised machine learning we can classify bone tumors reliably and efficiently.

Keywords: Bone Tumor Detection; Machine Learning; Clinical Tabular Data; Supervised Learning; Classification; ROC-AUC.

1. Introduction

Bone tumor detection is a problem in healthcare because more and more people are getting bone diseases and we need to find tumors early and know if they are malignant or benign. A bone tumor is when cells in the bone grow in a way and it can be malignant or benign so we need to find out fast so we can treat it properly and people can live longer. With technology like Artificial Intelligence and Machine Learning computers are helping doctors look at patient information more quickly. Usually doctors look at files and test results by hand which can take a long time and they might make mistakes. So now we are using computers to help find diseases by looking at patterns in data.Some studies have used Machine Learning to look at tumor information and predict if someone has a disease. They use tools like Logistic Regression and Decision Tree to look at numbers like how big the tumor is and how much pain the person is in.. Sometimes these tools do not work well

because we do not have enough information or the information is not good. Also some old ways of doing things do not clean up the information properly so they do not work well. That is why we need a plan that includes cleaning up the information looking at it picking the right numbers to look at and testing the tools to make sure they work.Machine Learning is really good at helping with healthcare because it can look at numbers and find patterns. It is better at looking at numbers than, at looking at words or pictures. If we clean up the information and make sure it is good then the tools can work better. So computers can help doctors find tumors faster and more accurately. This study is trying to use Machine Learning to look at bone tumors and find a way to do it by cleaning up the information looking at the numbers and testing different tools to see which one works best. Bone tumor detection is important and we need to find a way to do it so this study is focusing on bone tumor classification using a structured clinical dataset. Bone tumor classification is the goal. We want to achieve accurate and robust results.

1.1. Motivation

Early detection of bone tumors is a critical task in the medical field, as delayed diagnosis may lead to severe health complications and reduced survival rates. Traditional diagnostic procedures often depend on manual clinical analysis and expert interpretation of patient records, which can be time-consuming and prone to human error. In many healthcare systems, large volumes of structured clinical data are generated, including attributes such as tumor size, bone density, pain level, and other diagnostic indicators. However, extracting meaningful patterns from such tabular medical datasets using conventional methods is challenging. Small variations in clinical features can significantly influence the final diagnosis, and improper handling of medical data may result in inaccurate classification of benign and malignant tumor cases. Therefore, there is a strong need for an intelligent and automated system that can efficiently analyze clinical attributes and assist in reliable tumor prediction.In this study, we employ supervised machine learning models to analyze structured tabular clinical data for bone tumor classification. Unlike image-based approaches, the proposed system utilizes preprocessed numerical medical features that are directly supplied as input to machine learning algorithms after data cleaning, normalization, and feature analysis, as illustrated in Fig. 1. Automatic pattern learning is performed using multiple classification models trained on the clinical dataset, followed by performance evaluation using standard metrics. The final prediction is obtained through trained machine learning classifiers that learn decision boundaries between benign and malignant tumor cases based on the given clinical attributes, thereby improving diagnostic accuracy and supporting data-driven medical decision-making.

1.2. Contribution

1. we tries to make a machine learning system to classify bone tumors using information from records.
2. Model uses different machine learning methods like Logistic Regression, Random Forest and Support Vector Machine to predict tumors correctly.
3. We cleans up the data makes sure it is all the same and looks at the features to make the system work better.
4. We tries to get the results by using good features from medical records and preparing the data properly.
5. we makes a system that can tell the difference between harmless and harmful tumors very well.
6. We compares different machine learning systems using measures like accuracy and special scores to see which one is best.

The rest of the paper is set up like this. The first part talks about why we need a system to classify tumors and what other people have done. The second part looks at what other people have done in this area. The third part explains how we made our system how we prepared the data and what the

system looks like. The fourth part talks about how we tested the system how well it worked and what we found out. Finally the last part sums up what we did. Talks about what we can do next, with our bone tumor detection system.

2. Related Work

This section looks at the research that's already out there on medical diagnosis and tumor classification using machine learning techniques. Machine learning is getting better and better in the field so a lot of people are working on creating systems that can help doctors find diseases using the information they have. Tumor detection are really important because they can help doctors figure out what is going on with a patient and make decisions. People have tried a lot of machine learning and deep learning approaches to classify medical conditions based on the information doctors have like pictures and test results.We have a lot of information available now which has helped people create systems that can automatically classify tumors and help doctors do their jobs better. Some studies have used kinds of machine learning like Logistic Regression and Decision Tree, to look at medical information and figure out if someone has a tumor. They use things like the size of the tumor and how weird the cells look to make a guess. They also do things like clean up the data and make sure it is all the same to make the system work better. Sometimes they compare systems and find that the ones that use a lot of different kinds of machine learning like Random Forest work better because they can understand complicated relationships. It is also really important to look at the data and figure out which pieces of information are important for predicting diseases. We have to be careful when we are dealing with missing information and making sure the system is fair.To see how well these systems are working we use measurements like accuracy and something called the Receiver Operating Characteristic Curve. This curve is really useful when we are trying to figure out if someone has a Tumor or not because it shows how good the system is at telling the difference, between people who're sick and people who are not. If we use machine learning and do it right we can create systems that're really good at classifying tumors. So this study is trying to create a system that uses machine learning to classify bone tumors using the information doctors have. We are going to try a few different approaches and see which one works best. evaluation of multiple supervised learning models to achieve reliable and accurate diagnostic performance.

3. Research Methodology

3.1 Problem Statement

Creating a system to diagnose bone tumors is really tough in the medical field. Finding tumors whether they are Benign or Malignant on and getting it right is crucial for making treatment better and reducing medical problems. The information doctors collect about patients usually includes lots of numbers and categories like the size of the tumor how dense the bone's if the cells are irregular and the levels of certain biomarkers. These things are different for each patient.. When you add in errors missing information and the fact that some types of tumors are more common than others it becomes a really complicated problem for computers to solve.The old way of diagnosing tumors by hand takes a time and relies heavily on what the experts think, which can lead to mistakes and delays. So we really need computer systems that can automatically analyze information quickly and give consistent results. These systems can find patterns in the data that're not easy to see and tell the difference between Malignant and Benign.In this project we are making a system that uses machine learning to detect bone tumors from a set of organized data. The system follows a step-by-step process that includes collecting data cleaning it up looking at the data to understand it better choosing the important features training the computer models and testing how well they work. We start by putting the data into the system then we clean it up. Make it better. After that we split the data into two groups: one for training and one, for testing. We use different machine learning methods to teach the computer to find patterns in the medical information and then we use these trained models to decide if a sample is a tumor or not based on what the computer has learned from the features.The goal of the system is to help doctors diagnose bone tumors accurately and quickly

using bone tumor detection as the main focus. The bone tumor detection system is designed to analyze data and provide consistent results, which is the main purpose of the bone tumor detection system.

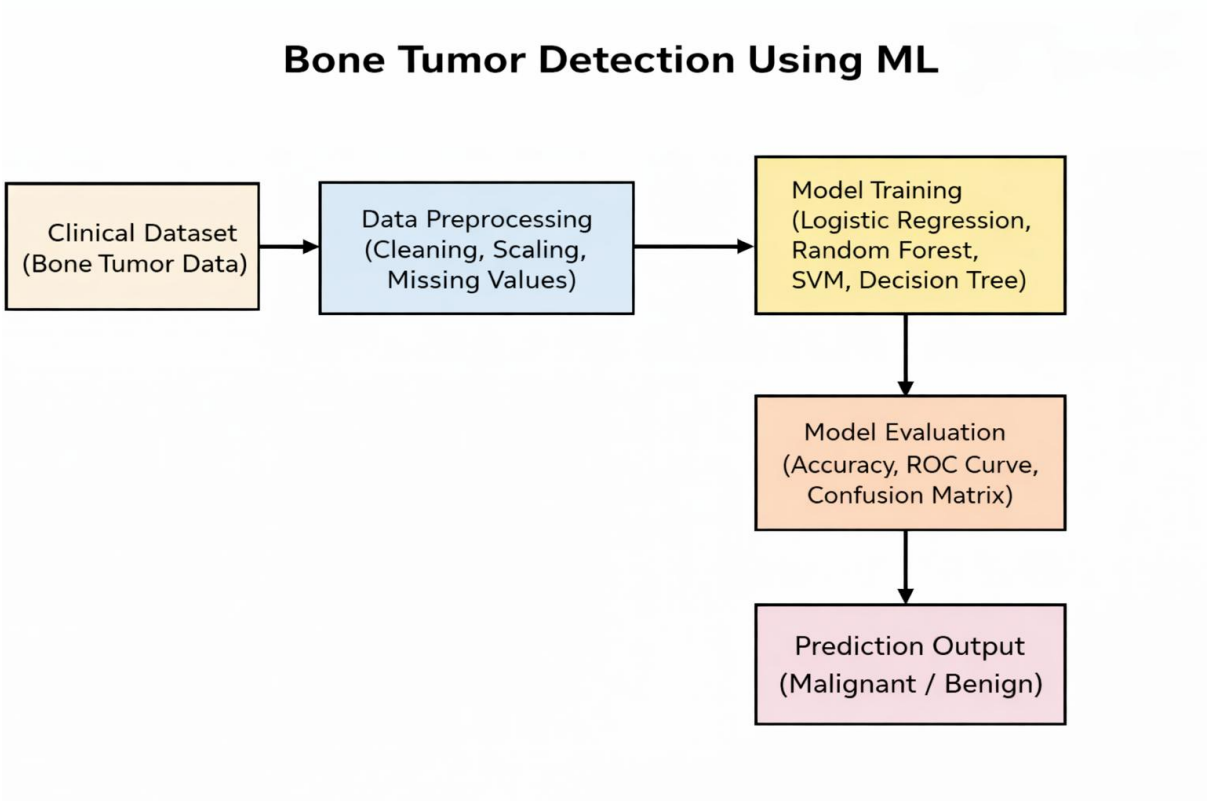

Fig. 1. Block diagram of the proposed model

This part is about how we plan to sort information, into Malignant or Benign We will use a series of machine learning steps to do this. These steps are shown in a block diagram. The block diagram shows the order of these machine learning steps. We will follow this order to classify the data into Malignant and Benign categories using machine learning processes.

3.1.1 Dataset Collection and Feature Description

The bone tumor diagnosis data we are looking at has a lot of information about each patient. This information includes things like the size of the tumor how dense the bone's if the cells are irregular how fast the tumor is growing, how much pain the patient is in if there is any inflammation and the level of certain biomarkers in the patients body. We also know if the tumor is benign or malignant.The diagnosis is what we are trying to figure out. If the diagnosis is 0 that means the tumor is benign. If it is 1 that means the tumor is malignant. We have data from 570 patients with bone tumors. All of this data is, in a format called CSV. We use a tool called Pandas to look at the data and try to classify the bone tumors using machine learning. The bone tumor diagnosis data is used for machine learning classification and analysis.

3.1.2 Exploratory Data Analysis (EDA) and Feature Selection

Before we train the machine learning models we do something called exploratory data analysis to see how the clinical features are spread out and how they are connected to each other. We make some charts and graphs to get a sense of how important each feature's for classifying tumors.The graph that shows the distribution of the data helps us see how Benign and Malignant cases we have and we want to make sure we have a pretty even number of each. We also use a graph called a correlation heatmap to see how strong the connections are between the different medical attributes and the diagnosis. The features that are closely connected to the diagnosis are really important for

making predictions while the features that are not connected can be left out when we train the model.We pick the features we want to use by separating the variables, which are the clinical attributes from the dependent variable, which is the diagnosis. We use the diagnosis column as the target label and the other clinical attributes as the input features for classifying the tumors. We do this to get the features to use for the machine learning models and to make sure the clinical features we choose are the ones that will help the model make the best predictions, for tumor classification.

3.1.3 Data Pre-processing

When we are working with machine learning models we have to make sure the data is good. This is where data preprocessing comes in. We need to do this to make our machine learning model work well.The data we get from things can be a problem because it might have missing information or be in the wrong format or even have wrong data. This can make our model not work well. So we have to use some techniques to make the data before we put it into the machine learning model.First we use Pandas to clean up the data. We look for spaces, wrong information and things we do not need. We take care of any missing information so that our data is consistent.After we clean the data we change the words in the diagnosis part into numbers. We do this so that the machine learning model can understand it. For example we use 0 for things that're benign and 1 for things that are malignant.Then we make all the feature values the same. We do this because the medical things we measure are different and have units. If we do not do this some features might be more important, than others just because they are bigger. We want all features to be equal when we train the machine learning model.

3.1.4 Data Split: Training and Testing

We take the dataset. Split it into two parts after we do some work on it. We use one part to train the models and the other part to test them. In this case we use 80 percent of the data to train the models and 20 percent to test them.The training part is what the machine learning models use to learn from the features. The testing part is what we use to see how well the models do when they look at data they have not seen before.

3.1.5 Machine Learning Models for Classification

In this research we use machine learning algorithms to classify bone tumors based on clinical features.We do not rely on one model.Instead we compare four classifiers:1.Logistic Regression2.Decision Tree 3.Random Forest 4.Support Vector Machine (SVM) . Logistic Regression serves as our baseline model because it works well for classification problems like bone tumor classification.Decision Tree offers a rule-based approach that's useful for medical decision-making, such as identifying bone tumors.Random Forest improves prediction accuracy by combining Decision Trees and Support Vector Machine (SVM) handles high-dimensional medical datasets effectively by finding the best decision boundaries for bone tumor detection.We train these models on our preprocessed dataset. Compare their performance to find the best classifier, for detecting bone tumors using Logistic Regression, Decision Tree, Random Forest and Support Vector Machine (SVM).The goal is to see which of these models including Logistic Regression, Decision Tree, Random Forest and Support Vector Machine (SVM) works best for bone tumor detection.

3.1.6 Proposed Algorithm

Here is the Clinical Bone Tumor Dataset. We want to find out if a tumor is Benign or Malignant.

To do this we follow these steps.

Step 1. We load the Clinical Bone Tumor Dataset using Pandas.

Step 2. We make sure the data is clean and fix any values in the Clinical Bone Tumor Dataset.

Step 3. We take a look at the Clinical Bone Tumor Dataset.

We do a things here.

A. We make a distribution graph to see how the data is spread out in the Clinical Bone Tumor Dataset.

B. We make a heatmap to see how things are related in the Clinical Bone Tumor Dataset.

Step 4. We give a code to the diagnosis. We say Benign is 0 and Malignant is 1.

Step 5. We divide the dataset into input features (X) and the target label (y), where features help in prediction and the target is Benign or Malignant.

Step 6. We scale the input features so that all values are in a similar range before training the model.

Step 7. We split the Clinical Bone Tumor Dataset into two parts. We use 80 percent to train and 20 percent to test.

Step 8. We try a different ways to make a guess.

We try these methods on the Clinical Bone Tumor Dataset.

A. We use Logistic Regression on the Clinical Bone Tumor Dataset.

B. We use Decision Tree on the Clinical Bone Tumor Dataset.

C. We use Random Forest on the Clinical Bone Tumor Dataset.

D. We use Support Vector Machine on the Clinical Bone Tumor Dataset.

Step 9. We see how good our guess is by looking at how we are right and by making a ROC Curve (Receiver Operating Characteristic Curve), for the Clinical Bone Tumor Dataset.

Step 10. The model learns from the dataset and classifies tumors as Benign or Malignant.

4. Research Methodology

Python programming language and its scientific libraries like NumPy, Pandas and Matplotlib were used for this research.The proposed model is, about classifying clinical bone tumor data into two classes: Benign and Malignant.This is done using machine learning algorithms.The dataset was. Split into training and testing sets.The split was done in an 80-20 ratio.This ensures that the model evaluation is reliable.The performance of the models was checked using Accuracy.The performance was also checked using ROC-AUC and Confusion Matrix and Classification Report.These are used to get a picture of how well the model classifies the data.The goal is to see how efficient the classification is.

4.1 Data Description

The bone tumor diagnosis data we used for this study is made up of information from patients. This bone tumor diagnosis data has 570 records with lots of details like age and tumor size. The bone tumor diagnosis data also includes things like bone density and cell irregularity. Each patient record in the bone tumor diagnosis data is for one person. It says if they have a Benign tumor or a Malignant tumor.The bone tumor diagnosis data is in a CSV file. It has numbers that are easy for computers to understand. We looked at the bone tumor diagnosis data before we started training the computer model. We checked the bone tumor diagnosis data for missing information and to see if the numbers were evenly spread out. We also changed the diagnosis part of the bone tumor diagnosis data into 0s and 1s so the computer could understand it. Figure 2 shows how many people, in the bone tumor diagnosis data had Benign or Malignant tumors.

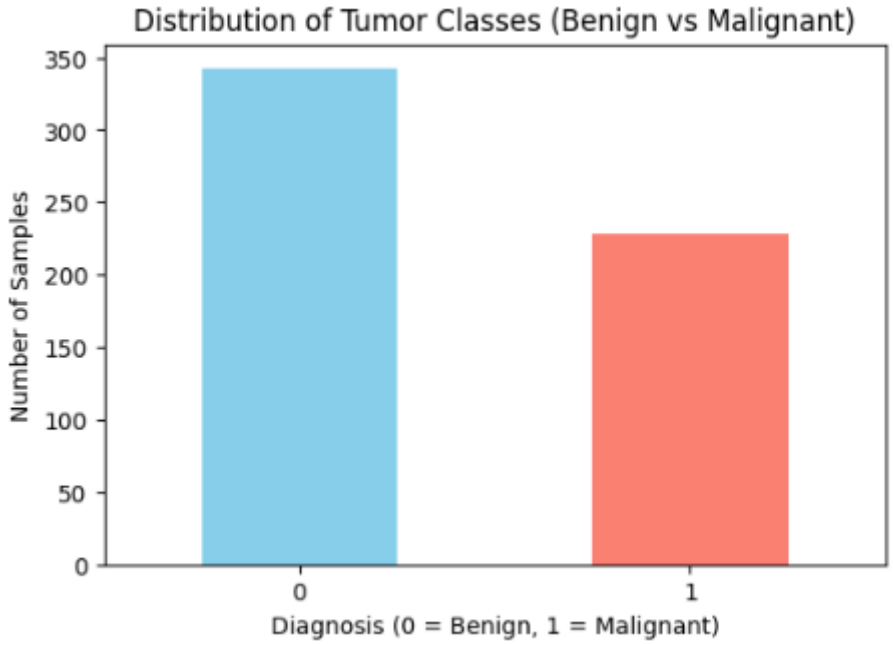

Fig. 2 – Dataset Distribution Graph (Benign vs Malignant)

4.2 Performance Evaluation Metrics

Evaluating machine learning models is really important, for classification systems. If we only look at how accurate they're we might get the wrong idea, especially when it comes to healthcare data. So in this study we used different ways to evaluate the model to see how strong and reliable the machine learning model is.

The machine learning model was evaluated using these methods:

- Classification Accuracy of the machine learning model
- Confusion Matrix of the machine learning model
- ROC Curve and AUC Score of the machine learning model
- Precision and Recall and F1-Score of the machine learning model

4.2.1 Classification Accuracy

The accuracy of something is basically how things we get right compared to the total number of things we try to figure out. This gives us an idea of how well our model is doing.We can calculate the accuracy by doing this:Accuracy = Number of things we get right divided by number of things we try to figure out.Just looking at accuracy is not enough when we are dealing with medical things because even if our model is very good, at getting things right it might still get the really important bad cases wrong. So we need to look at ways to evaluate how well our model is doing. We need to look at things besides just the accuracy of our medical model.

4.2.2 Confusion Matrix

The confusion matrix is a tool that helps us see how well a model is doing by looking at the predicted class labels. It has four parts:

- True Positive: This is when the model correctly says a tumor is malignant
- True Negative: This is when the model correctly says a tumor is benign
- False Positive: This is when the model says a benign tumor is
- False Negative: This is when the model says a malignant tumor is benign

The confusion matrix gives us a better understanding of how reliable a model is, which is really important in medical diagnosis because confusion matrix and false negatives can be very bad. The confusion matrix is especially useful when we are talking about the confusion matrix and its role, in diagnosis

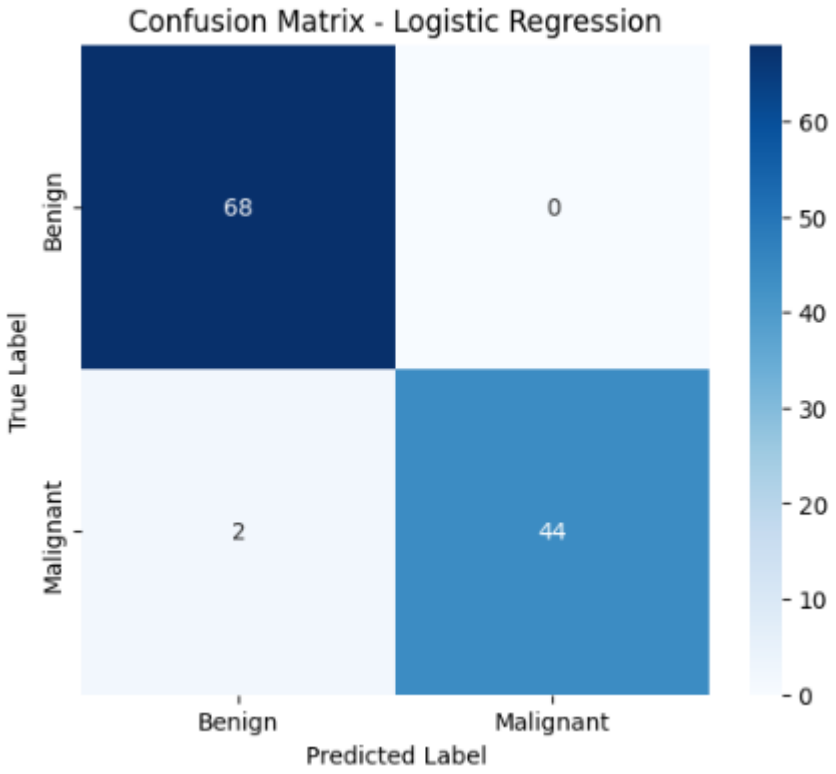

Fig. 3 – Confusion Matrix for Test Data

4.2.3 ROC Curve and AUC Score

The Receiver Operating Characteristic curve is a deal when we are trying to figure out if something is one thing or another. It shows us how good we are at finding the things and not finding fake things when we are looking at lots of different possibilities.The Area Under Curve tells us how well our model can tell things apart. The Area Under Curve score goes from 0 to 1. Here is what those scores mean:

- 0.5 is like guessing
- 0.7 to 0.8 is a good model
- 0.8 to 0.9 is a very good model
- 0.9 or higher is an excellent model

In this study the Receiver Operating Characteristic curve and the Area Under Curve score of the proposed model were really high. This means the proposed model is very good at telling the difference, between benign tumors and malignant tumors. The proposed model had an Area Under Curve score which is great.

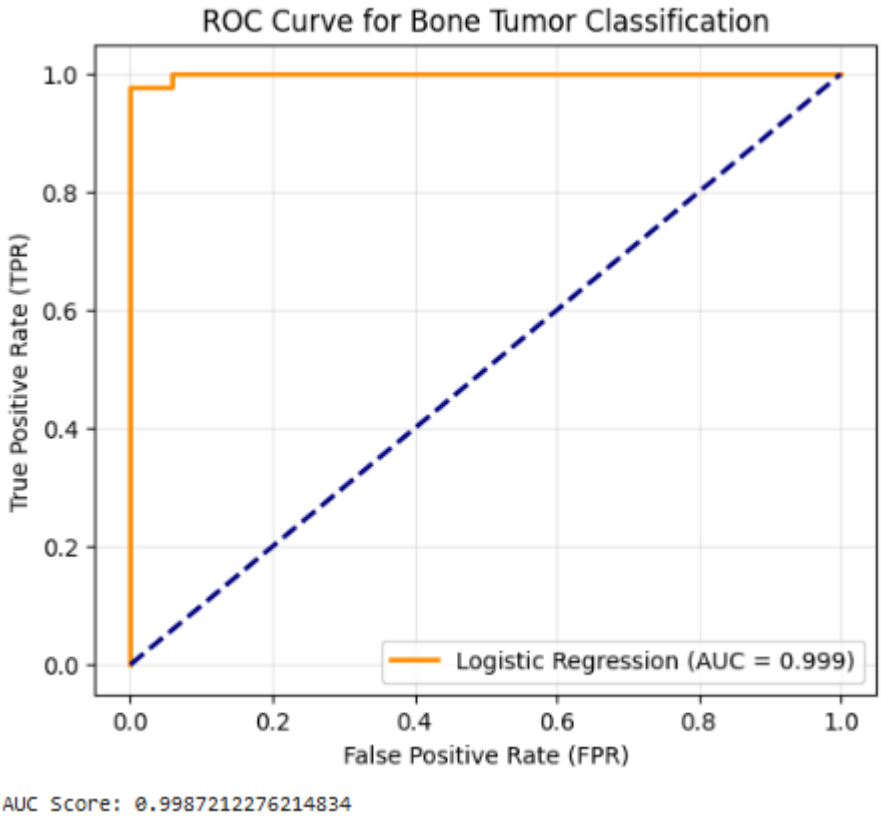

Fig. 4 – ROC Curve for Bone Tumor Classification

4.3 Result Evaluation and Analysis

The results of our experiment show that the machine learning system we came up with can tell if a bone tumor is benign or malignant. We tried out a few methods like Logistic Regression, Random Forest Support Vector Machine and Decision Tree on the data from the hospital.We looked at how each method worked and it turns out that Logistic Regression was the best at getting the right answer. Random Forest and Support Vector Machine were also pretty good. The fact that we got good results means that the data we used is really useful, for figuring out if a tumor is benign or malignant.We also learned that if we prepare the data carefully pick the features and make sure we have an equal number of benign and malignant cases the machine learning system works even better. The bone tumor cases were classified into two categories, malignant using the proposemachine learning framework and the results were very accurate.

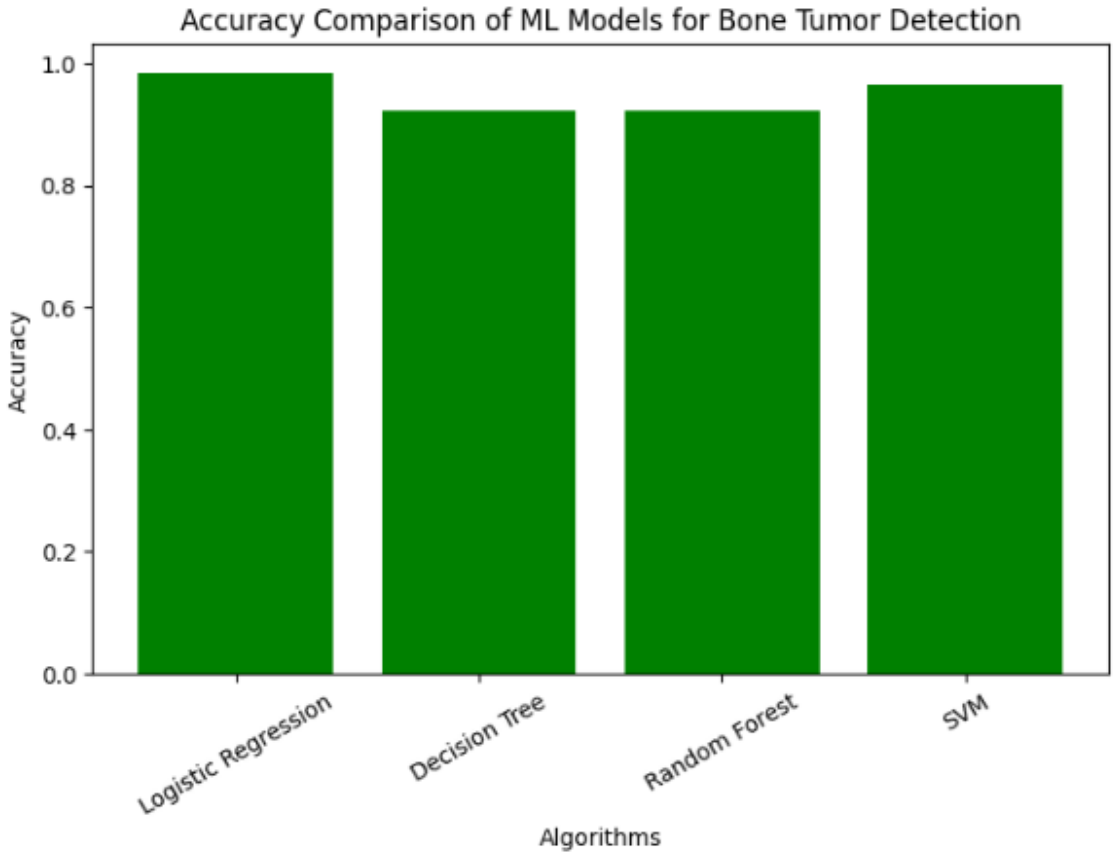

Fig. 5 → Accuracy Comparison Bar Graph (Algorithms vs Accuracy)

5. Conclusion and Future Work

This study is about using machine learning to detect bone tumors from data. We did this study came up with a system that uses machine learning to look at the data and find bone tumors. We tried out a few ways of teaching the system to do this and they checked how well it worked by looking at how accurate it was and some other things.We found out that one way of teaching the system called Logistic Regression worked the best. It was really good at detecting bone tumors. It gave them a lot of confidence in the system they came up with. This is a deal because it can help doctors find bone tumors early on.The system they came up with is a way to detect bone tumors using the information that doctors have. In the future they can make it even better by using data from hospitals and some other new techniques. This will help the system get better at detecting bone tumors and it will be more useful, to doctors.

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