Journal Publication of International Research for Engineering and Management (JOIREM)
Volume: 05 Issue: 07 | July-2025

AUTOMATED IDENTIFICATION OF BONE TUMORS IN X-RAY IMAGES USING ADVANCED MACHINE LEARNING

Mrs. Banothu Anitha[1], Mr. B. Ravindar Reddy[2],

[1] PG Scholar, Department of Computer Science & Engineering and Siddartha institute of Technology and sciences, Hyderabad. India
[2] Assistant Professor (HOD), Department of Computer Science & Engineering and Siddartha institute of Technology and sciences, Hyderabad. India
vishwanjadavajmeera@gmail.com

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Abstract - Bone sarcoma, usually known as bone cancer, is a rare type of cancer that refers to an abnormal growth of tissue inside the bone, with high probability to spread to other parts of the body. It commonly affects children, teenagers and young adults. As for all other types of cancer (breast, lung, prostate, stomach, brain...), there are no identified causes for bone cancer. Therefore, only an early detection could help increasing the chances to survive a bone sarcoma. The association of medical imaging modalities (such as X-ray, MRI and CT imaging) with image processing techniques can provide more accuracy while detection eventual bone tumors. In this paper, we introduced a new method for sarcoma diagnosis, using a Generalized Gaussian Density analysis (GGD) For future extraction and convolutional neural network (CNN) classification model. The process starts by generating sub-images of a given size from the processed bone MRI and conducting a GGD analysis on each of the sub-images. Then, a region of interest (ROI) corresponding to the sub-images with the highest value of the shape parameter α is selected from the original MRI. The classification performance by CNN model and gets good results in terms of accuracy, precision, recall, and F1-score.

Key Words: CNN, MRI, GGD, ROI, X-RAY, DATA SET, VGGNET, VGG-19, GPU, INCEPTION-V3.

1. INTRODUCTION

Bone cancer is an abnormal growth of tissue in the bone. It can be primary or secondary. Primary bone sarcoma starts growing from the bone cells, while secondary bone cancer starts from other organs of the body and then spread to the bone cells. Pain, bone loss and hyper calcemic are the most common symptoms of a bone cancer. Early bone cancer detection may lead to more efficient treatment and reduce the risk of disabilities. However, bone cancer is usually misdiagnosed due to the difficulties encountered by radiologists while interpreting medical images. Image processing techniques can offer more accurate interpretation tools for medical imaging and assist radiologists in bone cancer diagnosis. In this paper, we first described the bone anatomy and how cancer cells are developed inside the bone texture. Then we illustrated examples of different bone cancer forms.

This project focuses on identifying bone tumors using X-ray images, with techniques involving advanced methods such as CNN and image processing. Bone tumors are abnormal growths within the bone tissue. They can be either primary, which means they originated from bone cells, or secondary, spreading from other parts of the body; it is essential to detect this as early as possible in order to treat it efficiently and reduce risks. It will need a dataset of X-ray images, deep learning frameworks like Tensor flow or Kera's, CNN architectures like VGG Net or Inception-v3, and hardware like GPUs to do this efficiently. In implementation, one will require medical imaging, machine learning, and data preprocessing skills. Its applications include aiding the radiologist in making the accurate diagnosis, furthering research on cancer, training the doctors, helping in decision-making regarding health care, and routine analysis for reduction of error and workload.

2. LITERATURE SURVEY

Two of the most important mammographic indicators of breast cancer are masses (space occupying lesions, seen on two different impacts) and microcalcifications (tiny flecks of calcium, like grains of salt). Breast cancer studies have shown that early detection of these abnormalities boosts prognosis and reduces significantly the mortality rates. Mammography is actually the best diagnostic mean for screening, and several images processing techniques have been used for mammograms interpretation in order to assist radiologists while detecting and/or identifying eventual abnormalities. In this paper, we introduce a new masses detection technique, based on generalized Gaussian Density.

EXISTING SYSTEM:

MRI imaging offers better contrast; however, x-ray and CT imaging provide better resolution and specificity. Therefore, hybrid imaging modalities are often used to combine the advantages of different techniques while compensating their disadvantages. A few image processing works have been carried out aiming to detect bone tumors at different stages. has applied a region growing technique to detect bone cancer. He also identified the cancer stage using a mean Intensity calculating and a tumor size measurement.

Table -1:

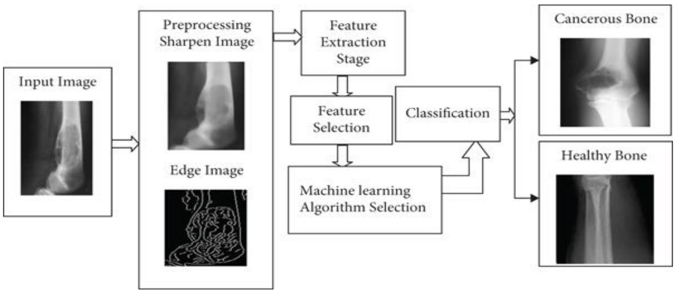
Author (s)	**Method**	**Advantages**	**Disadvantages**
C. Kishor Kumar Reddy, P.R. Anisha, and L.V. Narasimha Prasad	Region-growing for tumor detection and staging via intensity and size.	Reliable tumor segmentation; accurate staging.	Quality-dependent; struggles with complex shapes
D. Krupali Mistry and J. Bijal Talati	Comparative analysis of multiple segmentation techniques to detect and isolate bone tumors from X-ray and MRI images.	Improves tumor detection accuracy.Identifies strengths of various segmentation methods.	Depends on high-quality images.Computationally expensive.
H. Boulehmi, H. Mahersia, and K. Hamrouni	Image enhancement techniques for better segmentation.	Enhanced visibility of abnormalities; supports early diagnosis.	Requires specialized tools; computationally complex.

Proposed Methodology

The proposed methodology outlined in the document involves using a Deep Learning Convolutional Neural Network (CNN) for predicting and detecting bone tumors from X-ray images. Here are the key steps of the methodology:

- **Dataset Preparation**: Images of bone X-rays, with and without tumors, are collected. These images are used for training and testing the CNN.
- **Image Segmentation**: The input MRI image is divided into blocks of a chosen size. Generalized Gaussian Density (GGD) analysis is performed on these blocks.
- **Region of Interest (ROI) Selection**: Blocks with the highest shape parameter (αα) values from the GGD analysis are selected as the region of interest.
- **CNN Model Training:** The selected features are used to train a CNN model for detecting and classifying the presence of bone tumors. During training, extracted features are used to improve the model's accuracy.
- **Testing and Validation:** The trained CNN is tested with unseen X-ray images to evaluate its effectiveness. The results show tumor detection with segmentation and edge detection, alongside an accuracy graph indicating the model's performance.
- This methodology emphasizes simplicity, skipping preprocessing steps, and directly applying CNN and GGD-based feature analysis for detecting bone tumors effectively.

- **SYSTEM ARCHITECTURE:**



CNN ARCHITECTURES

Convolutional Neural Network (CNN, or Conv Net) are a special kind of multi-layer neural networks, designed to recognize visual patterns directly from pixel images with minimal pre-processing.

VGG Net

VGG Net consists of 16 convolutional layers and is very appealing because of its very uniform architecture. Similar to Alex Net, only3x3 convolutions, but lots of filters. Trained on 4 GPUs for 2–3 weeks. It is currently the most preferred choice in the community forex attracting features from images. The weight configuration of the VGG Net is publicly available and has been used in many other applications and challenges as a baseline feature extractor stands for Visual Geometry Group. VGG Net isa neural network that performed very well in the Image Net Large Scale Visual Recognition Challenge (ILSVRC) in 2014. It scored first place on the image localization task and second place on the image classification task.

VGG-19:

VGG-19 is a convolutional neural network (CNN) architecture developed by the Visual Geometry Group (VGG) at the University of Oxford. It is a deep neural network with 19 layers and was introduced as part of the ImageNet Large Scale Visual Recognition Challenge (ILSVRC) in 2014.One of the key innovations in VGG-19 is its deep architecture, which allows for a more expressive representation of image features.VGG-19 is trained on the ImageNet dataset, which consists of millions of labeled images from thousands of categories

Inception v3 algorithm:

Inception-v3 is a convolutional neural network (CNN) architecture developed by Google for image recognition and classification tasks. It is an improvement over the original Inception model. The Inception-v3 architecture is designed to be deeper and more powerful than previous CNNs. It consists of 48 layers, including convolutional layers, pooling layers, and fully connected layers. It also includes several unique features such as the Inception module. This technique reduces the number of parameters in the model, which helps to reduce over fitting and improve performance.

ADVANTAGES OF CNN

- Once trained, the predictions are pretty fast.
- With any number of inputs and layers, CNN cantrain.
- Neural networks work best with more data points.
- One of the powerful models in classification.

DISADVANTAGES OF CNN

- High Computational cost.
- They use to need a lot of Training data.

TOOLS AND TECHNOLOGIES

The Experimental setup for this project involves configuring the environment preparing the Dataset, and the bone tumor detection system using CNN and GGD based segmentation. The experiment was conducted in a Python-based deep learning and the required libraries, including TensorFlow, Keras, OpenCV, GPU (support for faster execution) and Numpy.

The model used is a Convolutional Neural Network (CNN) with Generalized Gaussian Density (GGD) segmentation to enhance tumor detection and pre-trained architecture like VGG-19 and Inception-v3 are used for improved accuracy.

The model extracts feature from X-ray/MRI images using Deep Convolutional layers and classifies them into tumor or normal cases.

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Experiment Result

First Experiment Result

- Used Generalized Gaussian Density (GGD) to extract texture features from X-ray images.
- Successfully identified potential tumor regions based on statistical shape parameters.

Second Experiment Result

- Compared CNN and SVM for bone tumor classification.
- CNN achieved higher accuracy due to deep learning-based feature extraction.
- SVM was less effective in handling complex tumor structures.

Third Experiment Result

- Evaluated the system's real-time processing capability for clinical use.
- Delivered fast and automated tumor classification with a user-friendly interface.

Experiment Analysis

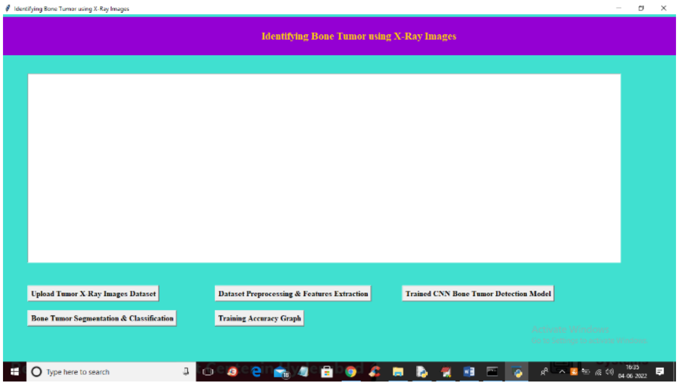
The experiment evaluated the effectiveness of automated bone tumor detection using Generalized Gaussian Density (GGD) analysis and deep learning models. The system was tested on X-ray images to identify and classify tumor regions based on statistical shape parameters. Various test cases with tumor-affected and normal bone images confirmed the accuracy of the GGD-based feature extraction and CNN classification model. The classification performance was assessed by analyzing accuracy, precision, recall, and F1-score.

The region of interest (ROI) selection process was validated by ensuring that the system correctly identified the most significant tumor-affected areas. The CNN model efficiently processed segmented images, differentiating between cancerous and non-cancerous bone structures.

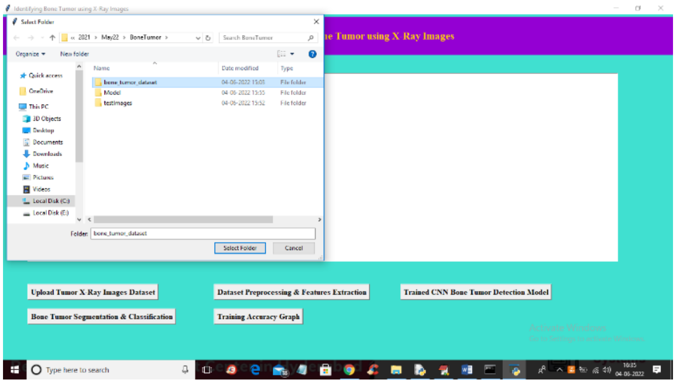
The user interface and system functionalities were tested for real-time tumor detection, automated classification, and result visualization. The system demonstrated high classification accuracy, reliable tumor segmentation, and efficient automated detection, making it a valuable tool for early bone cancer diagnosis.

RESULT ANALYSIS

To run project double, click on run.bat file to get below screen



In above screen click on 'Upload Tumor X-Ray Images Dataset' button to upload X-Ray images dataset and get below output



In above screen selecting and uploading brain tumor dataset and then click on 'Select Folder' button to load dataset and then get below output

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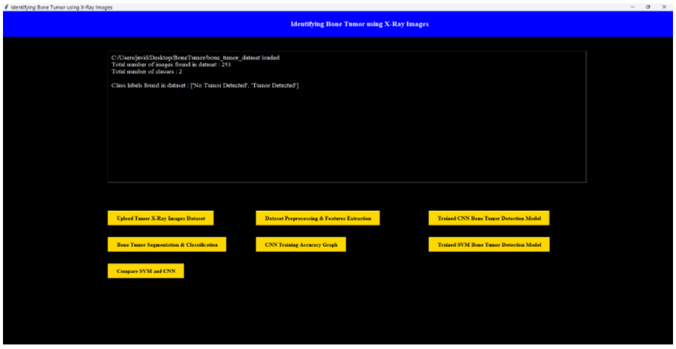
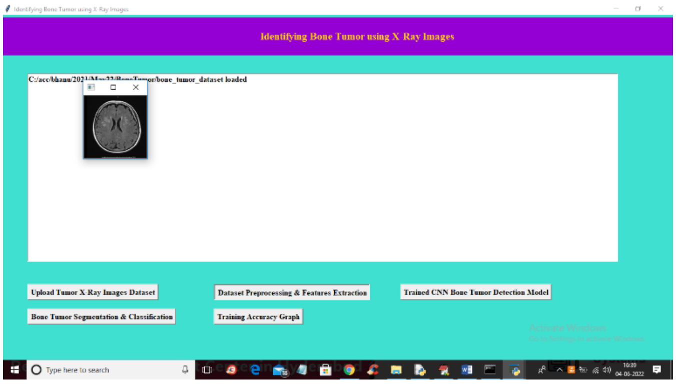
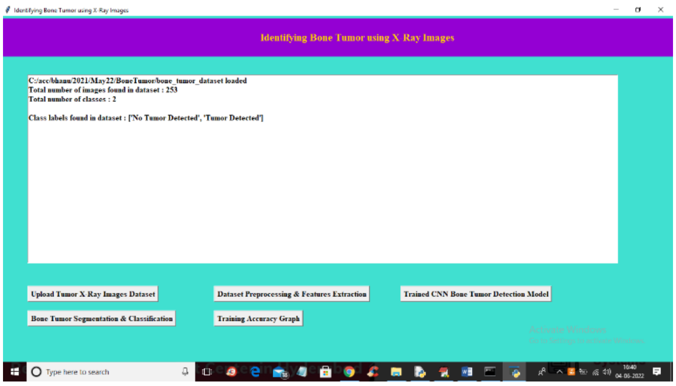


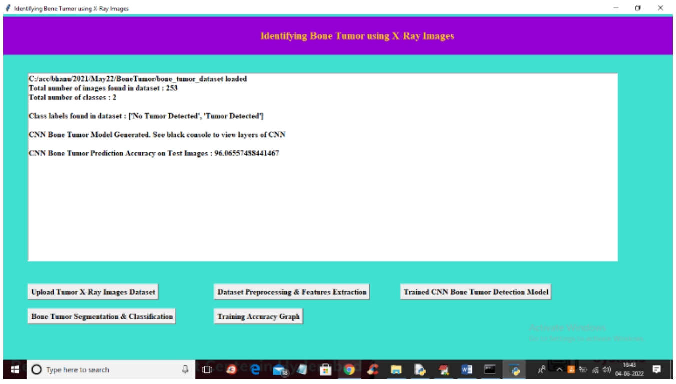
In above screen dataset loaded and now click on 'Dataset Preprocessing & Features Extraction' button to read all images and then process and extract features to train with CNN



In above screen all images are processed and to check images are loaded properly so I am displaying one sample processed image and now close that image to get below output

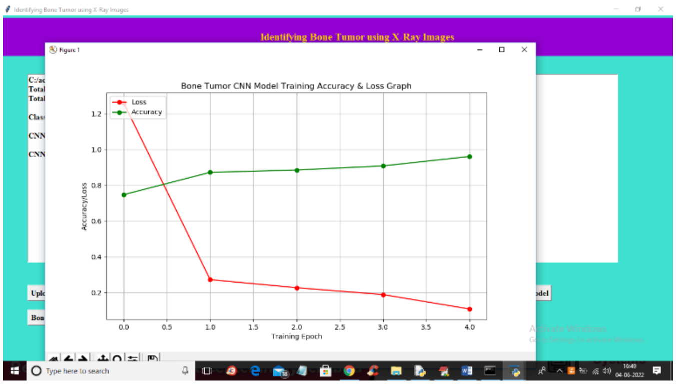


In above screen we can see dataset contains 253 images with and without tumor class label and now click on 'Trained CNN Bone Tumor Detection Model' button to train CNN with above extracted features and get below output



In above screen CNN training completed and we got it accuracy as 96% and now click on 'Bone Tumor Segmentation & Classification' button to upload test image and get below output

In above screen we can see tumor detected with segmented out tumor image and with tumor edge detected. Similarly, you can upload other images and test and now click on 'Training Accuracy Graph' button to get below graph



In above graph x-axis represents training EPOCH and y-axis represents training accuracy and loss values and green line representing accuracy and red line represents LOSS and in above graph we can see with each increasing epoch accuracy got increase and loss got decrease

3. CONCLUSION & FUTURE SCOPE OF WORK

The study successfully demonstrated an automated bone tumor detection system using Generalized Gaussian Density (GGD) for feature extraction and CNN-based classification. The proposed method efficiently identified tumor regions from X-ray images, providing high accuracy and faster diagnosis. The deep learning model, particularly CNN, outperformed traditional methods like SVM in classifying tumors. This approach reduces manual intervention and enhances the efficiency of medical diagnosis, making it a valuable tool for early detection of bone cancer. Future improvements, such as multi-modal imaging integration and larger datasets, can further enhance accuracy and reliability in clinical applications. GGD analysis has proved its efficiency in bone tumors detection from digitized MRI. However, lack of ground truth prevents us from having accurate evaluation of bone cancer segmentation rate. Thus, a bones MRI database has to be built with reliable and precise expert decision so that perfect evaluations could be done.

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