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An Deep Learning Model for Bone Cancer Detection Using Image Processing

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ABSTRACT

Cancer is a fatal condition that affects people of all ages. With over one out of every three people will experience cancer and at a certain point in their lives. There are many different types of cancer and bone tumor is one of the part of it and this has to be detected at earlier stage. Bone cancer is considered a serious health problem, and, in many cases, it causes patient death. The X-ray, MRI, or CT-scan image is used by doctors to identify bone cancer. Here, Magnetic Resonance Images (MRI) will be used as input data and then pre-processing operations will be done and then features will be extracted and given to the Deep Learning (DL) which is an algorithm used in order to classify the images as tumor and non tumor. But, the manual process is time-consuming and required expertise in that field. Therefore, it is necessary to develop an automated system to classify and identify the cancerous bone and the healthy bone. The texture of a cancer bone is different compared to a healthy bone in the affected region. An automated system needs development to detect accurately between cancerous and non-cancerous bone tissue since efficient distinction between both types is an undeniable necessity. In this paper, a low-cost and high-efficiency tumour detection method based on deep learning and x-ray images is proposed. Therefore, the outcomes of the suggested method demonstrate a higher incidence of early diagnosis of bone cancer. Lastly, the data's performance is evaluated using Accuracy, Precision, Recall, F1-Score.

I. INTRODUCTION

A human body contains 206 bones organized as a structural framework that enables mobility together with stability. The health of bones depends heavily on the presence of ligaments together with fibrous tissues and their spongy bone marrow content. Normal cell transformations lead to tumor development in the bones. A characteristic symptom of bone cancer appears as tumor formation that enlarges gradually until it reaches neighboring parts of the body. Bone tissue suffers severe damage as well as bones become weaker through this specific action. The statistics in 2018 showed that 3,500 Americans were diagnosed with bone cancer and the disease claimed 47% of their lives. Xray imaging stands as a vital tool for detecting malignancies because it serves as one of several diagnostic tests used in bone cancer detection. The assimilation rate of malignant bone tissue differs from normal tissue which produces irregular and broken X-ray images.

Bone cancer is an intense and lifestyles-threatening condition that impacts thousands of humans global. Early detection and accurate analysis are vital for effective treatment. Traditional methods of bone cancer detection, inclusive of biopsy and imaging techniques, are regularly invasive, time-ingesting, and might not provide correct results. To deal with those demanding situations, the utilization of Artificial Intelligence (AI) in the diagnosis of bone cancer has shown promise. AI primarily based methods for bone cancer detection contain the usage of device studying and deep learning algorithms to investigate clinical images and consider cancerous cells. These strategies can offer quicker, greater accurate, and non-invasive options to traditional detection techniques. AI algorithms can examine large volumes of statistics and become aware of styles that won't be obvious to human observers, thereby improving the accuracy of cancer detection. One promising AI-based technique for bone cancer detection is Generative Deep Belief Neural Networks (GDBNN).

GDBNN is a deep learning algorithm that can research complex styles and representations from data. In bone cancer detection, GDBNN is used to analyze clinical images, such as Xrays, CT scans, and MRI images, and discover cancerous cells based on their texture, shape, and different functions [1]. Finally, GDBNN has the potential to provide a more comprehensive, efficient, and accurate approach to bone cancer detection compared to many existing deep learning models. The GDBNN method can efficiently use both labelled and unlabeled data. This feature improves the learning performance for bone cancer detection without needing large labelled datasets. The use of AI for bone cancer detection has the capability to revolutionize the sphere of oncology and improve patient effects. By providing faster, more accurate, and non-invasive detection strategies, AI can help doctors diagnose bone most cancers in advance and offer more powerful remedy.

There were several deep learning methods proposed in literature for bone cancer detection, each addressing distinct issues. Pictures of bone tumors have been used to categorize them as benign or malignant using Convolutional Neural Networks (CNNs) and DL models. For instance, a study through a deep learning is based on CNNs to categorize bone tumors the use of X-ray images. Another problem addressed in bone cancer detection is the usage of deep gaining knowledge of is the segmentation of bone tumors. Segmentation involves pointing the out the limits of the tumor in medical images, which is important for surgical making plans and remedy. Bone cancers in MRI images have been segmented using Deep Learning (DL) techniques like U-Net [2]. Moreover, bone metastases cancer cells that have traveled from other parts of the body to the bones have been identified using DL models.

Deep learning models had been used to expect the survival of bone cancer sufferers based on scientific and genomic information. For example, a look at with the aid of Wang et al. Deployed a Recurrent Neural Networks (RNN) to predict the survival of bone most cancers sufferers the use of gene expression information. Deep learning models had been used for the automatic prognosis of bone cancer the usage of medical images. CNNs are used to diagnose bone cancer via X-ray images. In precision, DL methods for bone cancer detection have addressed diverse problems, consisting of class, segmentation, detection of bone metastases, prediction of survival, and automated diagnosis.

These strategies have proven promising outcomes and consume the capability to enhance the accurateness and performance of bone cancer analysis and treatment. They designed a framework which employs the Machine Learning (ML) approach, Image Processing and SVM were used to identify the infection and categorize the cancer. They found SVM endeavors finest for prognosis of the bone they carried out two experiments, with and without hog feature sets practiced on ML models, Random Forest (RF) and Support Vector Machine (SVM) [3]. And using 5-fold cross validation the attainment of the models was calculated.

Early detection seems to be the only factor that increases the chance of survival of cancer-affected patients. This paper deals with the system which uses the machine learning algorithm SVM and image processing techniques to detect the tumor and classify cancer. Similar researches in this field have been carried out by researchers to develop an automated system to assist a doctor. An automated system is fast with low error probability. Machine learning algorithm SVM and digital image processing technique, preprocessing, edge detection, and feature extraction have been used to proposed a strategy to distinguish the bone malignant growth from MR images utilizing mean pixel power [4].

In this paper, we propose bone cancer detection method at low cost using X-ray images. Utilizing a proficient preparing method is considered as a fundamental step to improve the in general visual representation of clinical pictures, and as an outcome gives better results. We use various image processing techniques such as contrast enhancement, classification and edge detection using Neural Network to detect cancerous tissue in the bone in a simple, fast, and reliable way.

The organization of the paper is: Section 2 offers a summary of the current literature, Section 3 expounds on the proposed methodology, Section 4 gives an analysis of the results, and Section 5 concludes the research.

II. Literature Survey

M. Avula Narasimha et al., [5] proposed a study, which used the k-means clustering algorithm to segment bone images. By measuring the mean density of the selected area, the segmented image is also processed for bone cancer detection. To identify medical images for the presence or absence of bone cancer, threshold values have been proposed. This system uses jpeg files, but if any changes are made, it also works with the original DICOM (Digital medical communication imaging) format.

A novel neural network model for segmenting and categorizing irregular hotspots is presented by T. Apiparakoon et al. [6] as a semi-supervised treatment for chest metastases of bone cancer. MaligNet, the proposed model, is an instance segmentation model that uses ladder grids to capture both labelled and unclassified data. A data set will be produced using labelled and unlabelled data from 544 and 9280 to evaluate the proposed model's results. The proposed model outscored a convolutional neural network based on the core mask area, the Mask-R, CNN, by 3.92 percent, with mean precision, sensitivity, and F1score of 0.852, 0.856, and 0.848, respectively.

The Generalized Gaussian Density analysis (GGD) analysis technique was proposed by H. Boulehmi et al. [7]. Commonly known as bone malignancy, Bone sarcoma is a rare condition characterized by irregular tissue development within the bone and a high risk of spreading to other areas of the body. Teenagers and young adults are commonly affected. With respect to any remaining sorts of cancer (brain, stomach, lung...), there are no distinguished reasons for bone malignancy. In this manner, just an early identification could assist expanding the odds with enduring a bone sarcoma. Combining image processing techniques with medical imaging approaches (like X-rays, MRI, and CT scans) can help identify bone tumours with greater precision.

Eftekhar Hossain et al., [8] proposed a paper which defines Bone cancer detection and classification technique using fuzzy clustering and neuro fuzzy classifier. This research looks at using a fuzzy C-mean clustering tool to identify bone cancer. To test the accuracy of the proposed procedure, a total of 120 magnetic resonance imaging (MRI) images of the bone were used. The Adaptive Neuromuscular Inference System (ANFIS) was used to distinguish both benign and malignant bone cancer in this research. A correct cross-validation was performed on bone images captured for separation into training and test images. The accuracy, sensitivity, and specificity of the classification result were evaluated using three output matrices: accuracy, sensitivity, and specificity. The proposed method of bone cancer classification has a 93.75 percent accuracy rate.

Eftekhar Hossain et al., [9] suggests a study in which the position of bone lesions is determined using a wavelet-based segmentation technique. The separated bone tumour section is also ready for classification. The k-Nearest Neighbour (KNN) classifier is used in this study to classify bone tumours as cancerous or non-cancerous. For the development of a learned classifier model, various pictures are gathered and Gray Level Co-event Matrix (GLCM) features are separated from these pictures. 92.5% accuracy was obtained for the proposed model which used KNN classifier.

The investigation of connected elements and neural networks necessary for the identification and future categorization of tumor cells in bone MR images has been proposed by E. Hossain et al. [10]. The bone tumour can be detected by using algorithm known as connected component labelling. The Artificial Neural Network (ANN) is used in this study to identify bone tumours. In this study, bone MR images of recently examined patients are collected, and the texture features of these images are used to train and evaluate the neural network. By removing the high- frequency noise main edges of the objects are conserved by Although anisotropic diffusion filter (ADF).

N. H. Ho, H. J. Yang et al., [11] has proposed, On radiographs, Regenerative Semi-Supervised Bidirectional W-Network Based Knee Classification of bone tumors led by three-zone bone division. This paper is a shows new development and evaluation Deep learning architecture, i.e., a W bidirectional network, which is semi-supervised regenerative (RSS – BW), for tumor prediction of Knee bone condition from radiographs. First, the knee bone is divided into three regions i.e. the femur, tibia, and fibula, by constructing an bidirectional W-network which is an automatic coding model. Using these regions as input data, the RSS - BW architecture consists of an automatic coding model for bone regeneration Structures, which is an backcone model for feature extraction uses a pre-trained images, and then model is established for knee bone tumor classification which is predicting model.

The primary goal of this study, according to Prabhakar Avunuri et al., [12], is to examine the situation in ability to track tumor in bone cancer pictures. In this work, K-means and fuzzy C-Means clustering methods are used to identify presize accuracy tumor percent in the bone. In this study, the segmentation mechanism is examined first, and then the kmeans and fuzzy C-means algorithms are employed to locate the precise position of the tumor in the bone. For importing and segregating pictures, this work makes considerable use of MATLAB as a computer program. Using the fuzzy c-means method, the tumor area may well be identified with 86 percent accuracy.

Reddy et al., [13] proposed a novel methodology to distinguish the size of the tumor and the bone malignancy stage utilizing developed area calculation. This strategy fragmented the district of enthusiasm by utilizing the area developed calculation. The tumor size is determined by the number of pixels in the extricated tumor part. The contingent on the absolute pixel esteem malignant growth stage is recognized. Determination of seed point relies upon the picture, and it is hard to choose precisely.

In the recent survey, Shrivastava et al., [14] have gone through various techniques to classify the cancerous and the healthy bone. In this work, bone computed tomography (CT) dataset in Digital Imaging and Communication in Medicine (DICOM) format are used. This work explains distinctive AI methods for tumor recognition and order. AI is an immense area of research, out of which medical image processing is a critical territory of work. In medicinal analysis like ulcer, break, tumor, and so forth image processing made the work simpler in finding the specific reason and most ideal arrangement. AI strategies are applied to restorative pictures for irregularity discovery. It can be seen that an acceptable degree of progress has been accomplished by applying the machine learning procedures. In this work, diverse AI methods for clustering are explained

Vandana et al., [15] have worked on the basic bone tumor. They have upgraded the graph cut-based clustering algorithm for the identification of the cancerous part and the healthy part. Their method can be utilized to measure the attributes of danger and characterize them as typical, amiable, and malignant by utilizing multiclass irregular texture.

III. An Deep Learning Model For Bone Cancer Detection using Image Processing

In this section, An Deep Learning Model For Bone Cancer Detection Using Image Processing is presented. This section describes the methodology utilized to develop the proposed model, illustrated in figure1. The system for bone cancer detection is proposed with deep learning methods, specifically Convolutional Neural Networks (CNNs), used to process medical imaging data. The approach is systematic with multiple stages to achieve precise detection and classification of bone tumors.

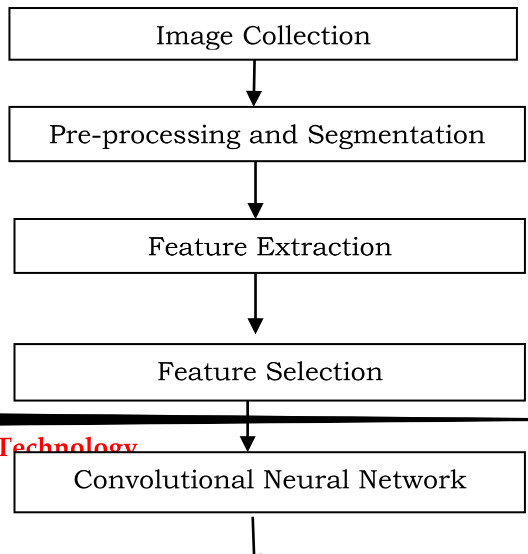

Fig. 1. The architecture of proposed system

The first step involves gathering medical imaging data, including X-rays, MRI, and CT scans. Publicly available datasets such as the Bone Cancer X-ray & MRI Dataset and the Cancer Imaging Archive are used to train and test the model. There are different image modalities such as CT scans, MRI, and X-rays. The MR images are considered to be the best because of its higher resolution. The MRI is used to show the 2D images of the body. The dataset used in this study consists of 1141 CT scan images (730 CT scans from radiopeadia and 411 CT scans from cancer_imaging_archive), with 530 bone cancer images and 511 normal images.

It is a primary step to improve the quality of an image. The image processing stage is started with the filtering technique. Usually, an image contains noises such as occlusions, variations in the illuminations and so on. So these noises should be eliminated. Gabor filter is used in order to remove the noise and to smoothen the images. The main advantage of this filter is, it produces excellent noise reduction with less blurring when compared with other filters. The next step in the preprocessing is the gray conversion. This is the process of converting the pixels having RGB (Red Green Blue) level into the gray level. This is carried out because the gray level image can be easily processed compared to the color image. Once preprocessing is complete, the next step involves object detection through segmentation. However, segmentation is the process of partitioning the image into multiple segments. This methodology used super pixel segmentation and multilevel segmentation. This method segments the image into bigger pixels compare to other segmentation techniques. The initial step in defining objects is the segmentation of the image. The reliability of the segmentation process directly affects its overall accuracy, making it crucial and beneficial for object identification. To facilitate the segmentation process and gather data from objects, the image is initially divided into pixels. In this research, the CNN algorithm was employed to categorize the images. However, it is important to note that this research has certain limitations due to the restricted dataset.

The image feature extraction is the most important technique in image processing. It plays a major role in the detection of cancer. After segmentation is done image features are extracted from the image to detect cancer. Feature extraction is an essential stage that represents the final results to predict cancer and non-cancer of an image. Feature extraction reduces the number of resources required to describe a large set of data. It is the process by which certain features of interest within an image are detected and represented for further processing. The feature is described as a function of one or more measurements. Each feature specifies some quantifiable property of an object and is computed such that it quantifies some significant characteristics of the object.

Variable selection is another name for feature selection. It is the method for selecting a limited number of useful features for potential use. Preprocessing must pick features or regions from the preprocessed image using a genetic algorithm, which is the best at selecting features for biomedical images. The process of accurately determining the amount of resources needed from a wide collection of data is known as feature extraction. The Extraction stage, which uses bone cancer detection, is a critical stage. Detecting different desired portions or forms using CNN algorithms and techniques. It is necessary to extract the selected features (affected part).

In deep learning, a convolutional neural network is a form of deep neural network. The uses can be found in the analysis of visual imagery. The term "convolutional neural network" refers to the network's use of convolution, a mathematical process. Convolutional networks, which are a particular form of neural network, use convolution rather than general matrix multiplication in at least one of their layers. An input layer, hidden layers, and output layer are all components of a convolutional neural network. Any feed-forward neural network's middle layers are referred to as secret because their inputs and outputs are covered by the final convolution and activation function.

Convolution layers are used in the secret layers.

The features are fed into fully connected layers for classification. Each CNN model was trained to perform two-way classification (normal and malignant). The input image size, number of epochs, loss function, and learning optimizer were the same for all the CNN models to facilitate the comparison in terms of accuracy and computational processing time. Since the X-ray pictures are sourced from various origins, it is necessary to eliminate any noise present in the images. A suitable denoising filter is applied for this purpose. The skeletal images are then separated using the Canny edge detection method. Features are extracted from both cancerous and healthy tissue images. CNN are employed for training and classification tasks. Skewness of an image indicates whether its pixels are evenly distributed or not. Malignant bone exhibits a smaller size compared to healthy bone due to the uneven distribution of pixels observed in cancerous bone.

IV. Result Analysis

In this section, An Deep Learning Model For Bone Cancer Detection Using Image Processing is presented. The experiment was performed, obtaining the results as shown in Table 1. Using important evaluation indicators like recall, accuracy, F1-score, and precision, they evaluated our system's efficiency. These metrics were calculated using four key parameters: where TP represents the true positive rate (i.e., diseased images are correctly predicted as diseased images), FP represents the false positive rate (i.e., normal images are wrongly predicted as diseased images), FN represents the false negative rate (i.e., diseased images are wrongly predicted as normal images) and TN represents the true negative rate (i.e., normal images are correctly predicted as normal images Each statistic has a specific role in assessing various aspects of the model's performance:

Precision: shows the percentage of all positive forecasts that were accurately expected to be positive. Precision is a classification's accuracy rate or number of positive cases. To determine precision, apply the formula below: Precision is expressed in Equation 1.

$$Precision = \frac{TP}{(TP+FP)} X100 \quad (1)$$

Recall: A model's ability to recognize every instance of a relevant deep learning class is measured by its recall. The proportion of correctly predicted positive observations to all positive observations demonstrates how well a model can recognize examples of a class. Equation 2 expresses recall.

$$Recall = \frac{TP}{TP+FN} \quad (2)$$

F1-Score: An accurate deep learning model is indicated by a high F1 score. combining precision and recall to increase model correctness. The accuracy statistic quantifies the frequency with which a model correctly predicts a dataset. Equation 3 expresses the F1-Score.

$$F1 - Score = 2 * \frac{Precision*Recall}{Precision+Recall} \quad (3)$$

Accuracy: Accuracy is determined by dividing true positives by all possible outcomes, which shows how many positive predictions are correctly classified as positive. There is an inverse association between these two variables. Equation 4 expresses accuracy.

$$Accuracy = \frac{TP + TN}{TP + TN + FN + FP} \quad (4)$$

Table 1. Performance analysis evaluation

Models	Precision (%)	Recall (%)	F1-Score (%)	Accuracy (%)
RF	73.59	77.79	82.89	85.87
SVM	77.68	85.67	90.99	94.45
CNN	84.56	86.78	94.64	98.98

Figure 2 compares the precision of the Random Forest (RF) and Support Vector Machine (SVM) based methods with the proposed CNN strategy. The models are shown on the x-axis, while the precision percentage is shown on the y-axis. The proposed model outperforms the Random Forest (RF) and Support Vector Machine (SVM) models in terms of precision.

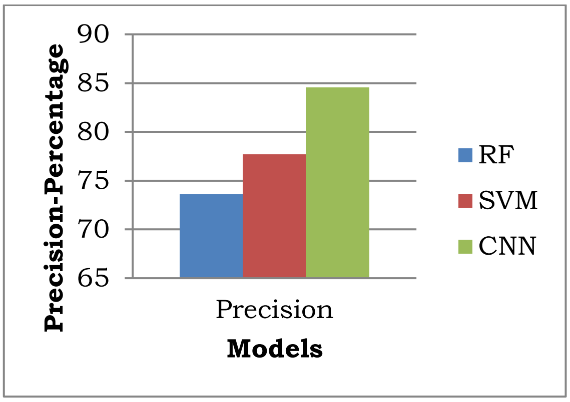

Fig. 2. Precision Comparison Graph

The recall of the suggested CNN strategy is compared with the RF and SVM-based method in figure 3. Models are displayed on the x-axis, whereas the recall % is displayed on the y-axis. The recall of the described model is higher than that of RF and SVM models.

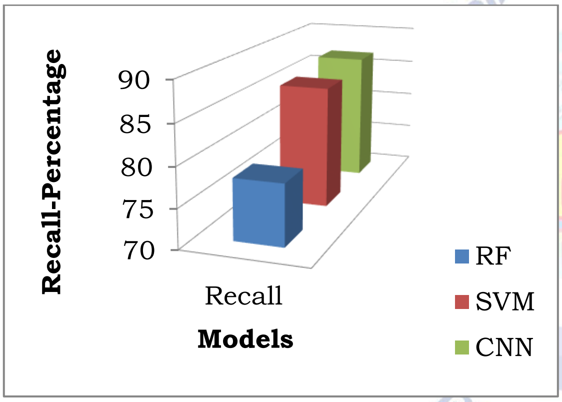

Fig. 3. Recall Comparison Graph

Figure 4 shows the F1-Score comparison between the RF and SVM-based approach and the suggested CNN strategy. As shown on the y-axis (F1-Score%) in comparison to the models shown on the x-axis, the model performs better in terms of F1-Score than the RF and SVM models.

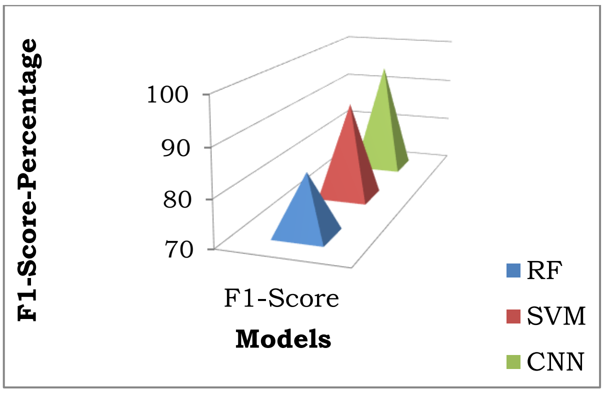

Fig. 4. F1-Score Comparison Graph

Figure 5 compares the accuracy of the RF and SVM-based approaches with the suggested CNN strategy. The y-axis % on the graph, which displays models along the x-axis, indicates that the model under discussion achieves more accuracy than RF and SVM models.

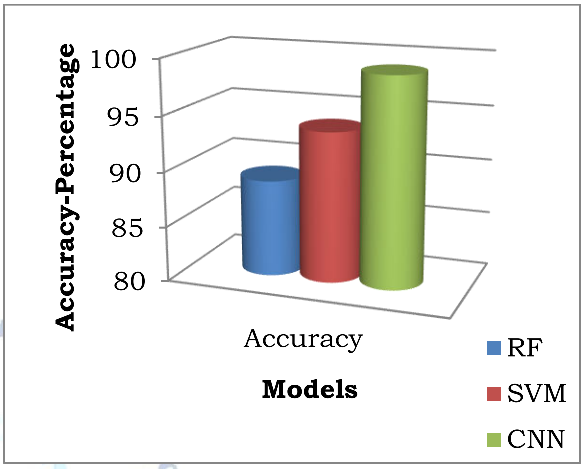

Fig. 5. Accuracy Comparison Graph

V. CONCLUSION

In this analysis, An Deep Learning Model for Bone Cancer Detection Using Image Processing is presented. The Bone Cancer is one of the most dangerous cancer so this must be taken care in the early stages only. In this model Magnetic resonance images will be used as the input. Our proposed system detects whether the cancer is present or not. If the image have no tumor segments then this model gives the result as normal. In this paper we have studied the basic mechanism for tumor detection. In this review article we have specifically focused on the bone cancer detection using feature extraction and CNN for classification. The proposed method is a combination of feature extraction and classification model that discriminate vitality of the cancerous and healthy bone identification and classification. Thus our proposed system provides a different way for detecting the bone cancer with high accuracy. This model achieves expected desired result at the end of the model. Compared to other based architectures, the proposed CNN= architecture has better performance in terms of Precision 84.56%, Recall 86.78%, F1-Score 94.64%, Accuracy 98.98%.

Conflict of interest statement

Authors declare that they do not have any conflict of interest.

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