Survey on Bone Cancer Detection and classification using Machine Learning Techniques

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Abstract: Machine learning is one of the research areas that authorize the computers to learn and improve from the huge datasets. It also provides many techniques that helps scholar to develop models that allow accurate predictions and intelligent behaviour. Machine learning is typically categorized into three distinct classifications: Supervised, Unsupervised, and Reinforcement Learning. The supervised learning paradigm necessitates the use of labelled datasets, while the unsupervised learning framework operates on unlabelled datasets. Classification constitutes a technique that is linked with supervised learning paradigms, whereas clustering is congruent with unsupervised learning frameworks. Some supervised learning techniques in machine learning are: (a) Neural networks, (b) support vector machine and (c) decision tree and widely used unsupervised technique is (a)k-mean clustering, (b) KNN (k nearest neighbour), and (c) hierarchical clustering etc. and reinforcement techniques are (a) Q-learning, (b) State-Action-Reward-State-Action (SARSA) and (c) Deep Q network.

The objectives of this review paper include:

1. The study discussed about the bone cancer and its types, stages.
2. Machine learning techniques used for the bone cancer detection and classification.
3. Mentioned few image processing technique for feature extraction and classification.
4. Readers envisage the bone cancer detection and classification approaches by using machine learning techniques.
5. This scholarly review delineates numerous domains within the field of machine learning that warrant further exploration in forthcoming research endeavors.

Keywords: Supervised learning, unsupervised learning, reinforcement learning, CNN, SVM, K-mean, KNN, SARSA, Fuzzy Logic, ANN.

1. Introduction:

Cancer is one of the serious health issues. According to the world health organization more than 70% of the people in India diagnosed with bone cancer. The prognostications provided by the American Cancer Society regarding the incidence of primary malignancies affecting the bones and joints for the year 2024 are as follows:
Approximately 3,970 novel cases are anticipated to be diagnosed (2,270 in the male population and 1,700 in the female population).
Approximately 2,050 fatalities are projected (1,100 in the male demographic and 950 in the female demographic). [22]
If it is not identified or diagnosed with the proper treatment, it leads to patients' death. To identify cancerous bone or unhealthy bone doctors use medical images like X-ray, MIR and CT-scan images. Most of the time it is very difficult and time consuming using of manual process because cancer images and the healthy bone images have same morphological differences. Consequently, it is imperative to establish an automated system aimed at the identification and classification of bone cancer. In medical terms the bone cancer is called as sarcoma, which initiates in bone, muscles, blood and some in tissues.
There exists a multitude of classifications of bone malignancies, which include: chondrosarcoma, osteosarcoma, pleomorphic sarcoma, Ewing's sarcoma, and fibrosarcoma [21]. The various stages of cancer are characterized by distinct classifications, and the stages of bone cancer are determined according to specific grades. These grades

help in finding how the cancerous cells are different from the normal cells. In medical terms sometimes doctors use words localized and metastatic [4][5]. Localized signifies that the neoplasm is confined exclusively to the osseous tissue and has not disseminated to other regions of the organism. Metastatic cancer refers to the phenomenon whereby malignancies disseminate to various regions of the body.

To get the details or the level of the advancement bone cancer categorised into many stages [22]:

Stage 1: It shows tumor is small and not spread over the other parts of the body.

Stage 2: It shows tumor is more aggressive than the stage 1 and in low grade.

Stage 3: It demonstrates neoplasms located in multiple distinct regions of the identical osseous structure and exhibits a high histological grade.

Stage 4: Tumor is spread to the other parts of the body and it is serious condition [22].

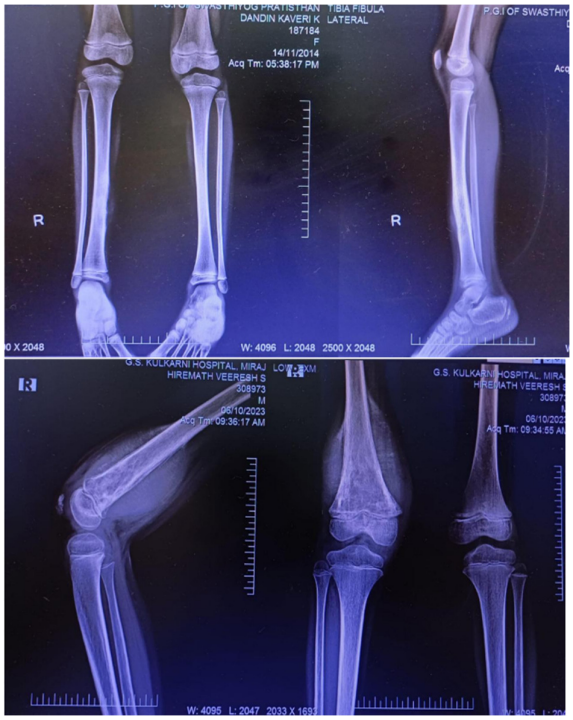

Fig 1: Ewing Sarcoma [11]

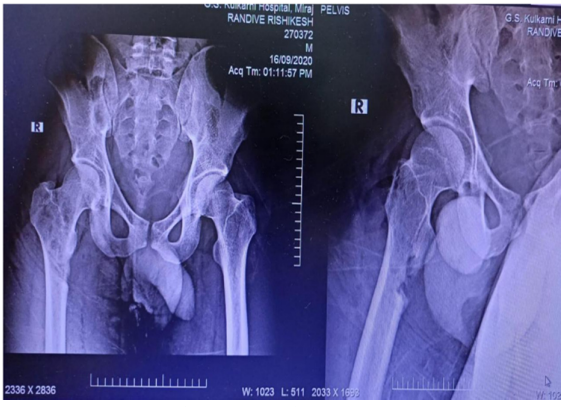

Fig 2: Osteosarcom [12]

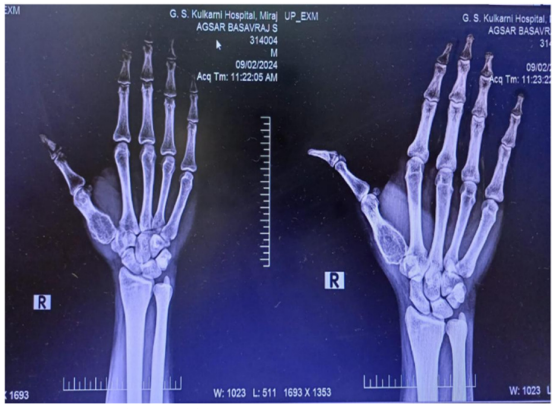

Fig 3: Giant cell Tumor [13]

Fig 4: Osteoid Osteoma [14]

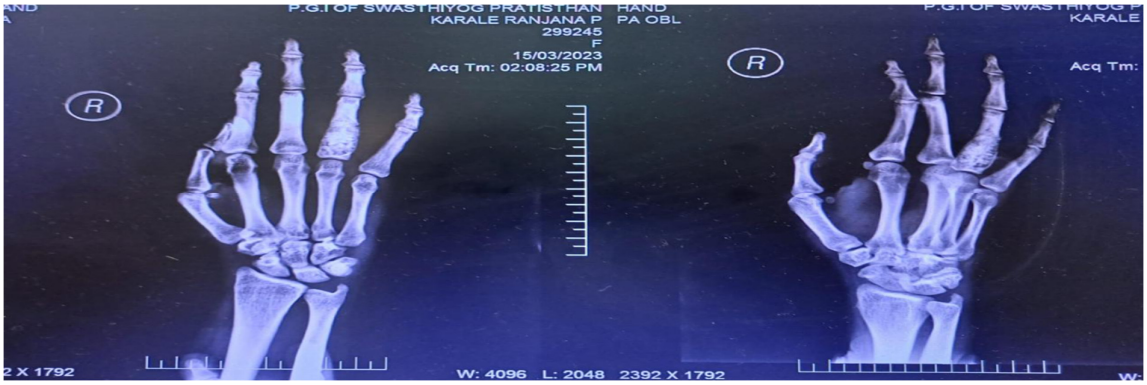

Fig 5: Enchondroma [15]

2. Machine Learning Techniques for the classification of bone cancer:

There are many different types of machine learning and deep learning techniques are used in medical field and the biomedical imaging or input images includes Magnetic Resource Imaging (MRI), X-ray Images, Ultrasound, computed tomography images (CT- Scan) and microscopic images. We can also use many image processing techniques for image classification. It is one of the best references for the all researchers, scholars, industry scientist and students to have a combination of biomedical images and machine learning techniques such as Support Vector Machine (SVM), Convolutional neural network (CNN), Artificial Neural Network (ANN), K-nearest Neighbour, Naïve Bayes Algorithm, Random Forest Algorithm, Decision tree algorithm, Random Forest, Evolutionary algorithms.

2.1 Convolutional Neural Network (CNN):

we will start with the discuss about Convolutional neural network (CNN). As we know that convolutional Neural Network is used for image classification, feature extraction and so on. This model is trained to classify the segmented tumour regions into non-cancerous or cancerous categories [1]. The CNN model is chosen for its ability to automatically learn and extract features from the images, leading to high accuracy in classification [1][10].

CNN has many layers in it. Each layer performs different functions. Convolution layer extracts much unique information from the cancer cell images using various types of convolutional filters, the CL characteristics retrieved are merged with a non-linear activation unit that has been mapped into a functional region (reLu) [2]. The dimensions of the feature map produced by CL are diminished, while simultaneously optimizing the retrieval of the most comprehensive visual information through the application of PL. In the proposed architecture, Max-Pooling Layers are employed to preserve the integrity of the image data. The final CNN layer is fully connected, and it is this layer that classifies the highlight function mappings [2].

Numerous variants of Convolutional Neural Network algorithms have been employed in the investigation of image classification: VGG16, VGG19, DenseNet201, and ResNet101. Among these, VGG16 specifically focuses on the implementation of convolutional layers that utilize 3 × 3 filters with a stride of 1, consistently applying the same padding throughout the architecture. It is a 16-layer convolutional neural network architecture, VGG19 is widely used for image classification and other applications, DenseNet201 enhances feature reuse and lessens the issue of disappearing gradients and RenseNet101 which stands for ‘‘Residual Network’’, is a version of this one and is frequently used for image classification and object recognition applications [3].

Convolutional Neural Networks (CNNs) are recognized for their capacity to autonomously and adaptively acquire spatial hierarchies of characteristics from input images, rendering them exceptionally proficient for tasks involving image recognition [6].

2.2 Support Vector Machine (SVM):

Two machine learning models are used for classifying the bone images: Support Vector Machine (SVM) [4]. The model is trained to differentiate between malignant (cancerous) and healthy bone tissues based on the features extracted from the images [4]. The SVM model, especially when combined with HOG features, achieves a high F-1 score of 0.92, indicating its effectiveness in accurate classification [4]. This system aims to reduce the time and effort required for manual review by experts, thereby supporting precise diagnoses and informed treatment decisions for bone cancer patients [4].

Support Vector Machine (SVM) classifier, which is a type of machine learning algorithm that helps in classifying data into different categories based on the features provided to it [5]. The SVM classifier in this study uses a linear kernel function, which is a mathematical function that helps in transforming the data into a higher-dimensional space to make it easier to classify [5].

The SVM classifier is trained and tested five times, each time using a different part of the data for testing and the remaining parts for training. This method helps in reducing the bias and variance in the results, leading to a more

accurate and stable performance of the classifier [6]. The extracting Haralick textural features from Computed Tomography (CT) images, which are essential for analysing the texture of bone tumors and distinguishing between benign and malignant types. The extracted Haralick features are then used to train and test a Support Vector Machine (SVM) classifier. Which is a type of machine learning model that helps in categorizing the bone tumors into benign (noncancerous) and malignant (cancerous) categories [6][26].

2.3 Random Forest Algorithm:

Two machine learning models are used for classifying the bone images: Support Vector Machine (SVM) and Random Forest [4]. These models are trained to differentiate between malignant (cancerous) and healthy bone tissues based on the features extracted from the images [4]. The SVM model, especially when combined with HOG features, achieves a high F-1 score of 0.92, indicating its effectiveness in accurate classification [4].

The features that have been extracted are subsequently employed to both train and evaluate a Random Forest classification model. A Random Forest is a machine learning algorithm that builds multiple decision trees and merges them together to get a more accurate and stable prediction. This classifier helps in distinguishing between benign (non-cancerous) and malignant (cancerous) bone lesions [7].

2.6 k-nearest Neighbour (KNN):

This methodology categorizes data instances in accordance with the nearest training samples within the feature dimensionality. In this context, it helps in determining whether the segmented area from the k-means process is cancerous or not by comparing it with known examples of cancerous and non-cancerous regions [8]. it helps in isolating and classifying potential cancerous regions with high accuracy [8].

K-Nearest Neighbor (KNN) classifier, which has been applied to segment and classify bone cancer in medical images such as JPEG and CT scans [9]. This method typically involves segmenting the bone regions using techniques like k-means clustering, followed by mean intensity evaluation to identify potential cancerous areas. The KNN classifier then uses threshold values to determine the presence or absence of bone cancer, achieving better accuracy in classification [9].

The K-Nearest Neighbours (KNN) algorithm represents a straightforward, non-parametric approach employed for both classification and regression tasks. In this context, it classifies bone tumors by comparing the new data points with the most similar data points in the training set [10].

2.7 Fuzzy Neuro Classifier or Fuzzy Logic:

This method is used to group similar data points together, which in this case are the pixels in the MRI images, to identify potential cancerous regions. It helps in detecting bone cancer by clustering the MRI images into different groups based on their pixel intensity values [11]. Adaptive Neuro Fuzzy Inference System (ANFIS): ANFIS is a hybrid system that combines neural networks and fuzzy logic principles to make decisions based on the input data. ANFIS is used to classify the bone cancer as either benign (non-cancerous) or malignant (cancerous) by learning from the features extracted from the MRI images [11].

The FPCM algorithm is used to classify each pixel in the MRI and CT images. The FPCM calculates the membership degree for each pixel, which helps in determining how likely a pixel belongs to a particular class, such as bone cancer or healthy tissue. This classification helps in identifying the initial regions of interest for further analysis [12]

The Fast and Robust Fuzzy C Means Clustering (FRFCM) algorithm represents a sophisticated approach in the domain of data analysis methodologies. This algorithm is employed to segment the MRI images, which means it helps in dividing the image into different parts to isolate the tumor from the rest of the bone structure. FRFCM is an advanced version of the traditional Fuzzy C Means (FCM) clustering algorithm, designed to be faster and more robust in handling the variability in medical images [13]. The segmentation technique used, involves the application of the FRFCM algorithm to the MRI images. This technique helps in accurately identifying the boundaries of the tumor within the bone. By segmenting the image, the algorithm can distinguish between normal bone tissue and the tumor, which is crucial for further analysis and classification [13][14].

2.8 Image Processing Techniques:

Feature Analysis: The study includes an analysis of the features of bone cancer, which helps in understanding the different characteristics and behaviors of bone tumors, thereby aiding in the development of more effective detection techniques [15].

Comparison of Techniques: The paper compares various image processing techniques to determine their effectiveness in interpreting medical images, which is essential for improving the early detection and treatment of bone cancer [15].

Predictive Modeling: The research also explores predictive modeling techniques that can be used to estimate the likelihood of bone cancer based on the features extracted from medical images, thereby providing a more accurate diagnosis [15].

Integration of Imaging and Processing: The integration of medical imaging with advanced image processing techniques is highlighted as a key approach to achieving better results in the detection and diagnosis of bone cancer, which is critical for increasing survival rates [15].

3. Conclusion:

This paper provides comprehensive assessment of machine learning technique`s performance and provides greatest output results of each technique. There is a finest range of research on several machine learning techniques, including CNN and other supervised, unsupervised learning techniques. CNN and SVM, Supervised techniques performed well and provided best outcomes. We can also use combination of other techniques for the classification presuppose. Machine learning techniques have gained more popularity because of their improved performance. This will definitely help the doctors, clinicians, and other medical profession diagnose disease more quickly, accurately in selecting the best machine learning technique and it helps scholars for their future work in research.

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