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Survey of Machine Learning Techniques in Medical Imaging

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ABSTRACT

The cancers threaten human health that is regarded as dangerous and deadly. Among them, lung cancer, breast cancer, diagnosis of heart, and brain tumor. In this context, the machine learning techniques have been successfully used to solve several problems in different fields including medical imaging diagnosis. In this paper, investigates several articles related with the implementation of machine learning techniques for medical imaging diagnosing. Several research studies were selected for analysis and diagnosis between 2005 and 2018. It will give a concise introduction to the most important topics of machine learning techniques; like Decision Tree (DT), Support Vector Machine (SVM), Artificial Neural Networks (ANN) and Naive Bayes (NB). Also, it attempts to find the most efficient techniques used for medical diagnosing.

Key words: ANN, Cancer Disease, DT, Medical imaging Diagnosis, NB, SVM.

1. INTRODUCTION

Machine learning is a subfield of artificial intelligence, including techniques for changing and updating knowledge, accumulating in intelligent systems to be smart, and the system ability to learn in a changing environment. That system can learn and adjust to such updates that carried out by machine learning techniques, it is a scientific discipline involved with the design and development of techniques that optimize a performance using past experience or example data [1].

Applications of machine learning contain medical diagnosis, natural language processing, financial data analysis, video surveillance, and bioinformatics [2]. In the case of the medical diagnosis problems, the example data, referred to as training data, consists of many images of the medical images and their true labels (e.g., “malignant” and “benign”). The machine learning technique is trained using the training images, after which it can be applied to predict the label of new image. The machine learning techniques as Decision Tree (DT), Support Vector Machine (SVM), Artificial Neural Networks (ANN), and Naive Bayes (NB) are used for different applications in medical imaging classification [3]. The medical imaging classification includes diagnostic problems like classifying cancers [4]; these techniques are used to improve the accuracy of prediction models.

The cancer has become one of the most popular diseases that lead to death. It can be detected by recognizing tumors. We can recognize two types of tumors such as benign and malignant tumors. Physicians want a powerful diagnosis process to differentiate between these tumors. In general it is very hard to recognize tumors even by the experts. Hence for diagnosing tumors is needed by automation of diagnostic system. Numerous researchers have sought to use machine learning techniques for early diagnostic of the cancer. These techniques work better in the diagnostic of the cancer, which is proved by the researchers [5]. These techniques are used in many applications of medical imaging; it is one of the interested research topics of last decade. Nowadays machine learning techniques are especially used for diagnosing the tumor disease.

Medical imaging is a fundamental part in laboratories and hospitals, the different issues of healthcare institutions could be solved by medical imaging. These images provide observing patient’s body; and using the computers to get the effective treatment [6]. A review has been made on machine learning techniques for diagnostic in medical image classification, it is concerned with the classification of the tumor in the imaging technologies of ultrasound, mammography, magnetic resonance images (MRI), computed tomography (CT), X-ray etc. The early diagnosis of a malignant tumor have become important in cancer research, machine learning is a robust artificial intelligence tool that to diagnose cancer patients into low or high risk groups.

The aim of this paper is to present a survey of machine learning techniques in detecting the tumor from various applications of medical imaging.

2. AN OVERVIEW OF MEDICAL IMAGING

Fast development of digital devices for acquisition of medical images causes a reproducing of large number of medical image data. Medical imaging is the process and technique of making optical representations inner of a body for medical

intervention and clinical analysis. In recent years, numerous of published researches on focus the necessity of medical imaging in solving problems of healthcare centers. With the rapid use of medical equipment and medical imaging technology such as X-Ray, computed tomography (CT), mammography, magnetic resonance images (MRI), Ultrasound etc. are generated a large amount of medical images in clinical and hospital every day [7]. These images can provide information of matching for disease diagnosis. An important part of medical diagnosis is medical image database. An overview of medical imaging modalities is given in Figure 1 [7].

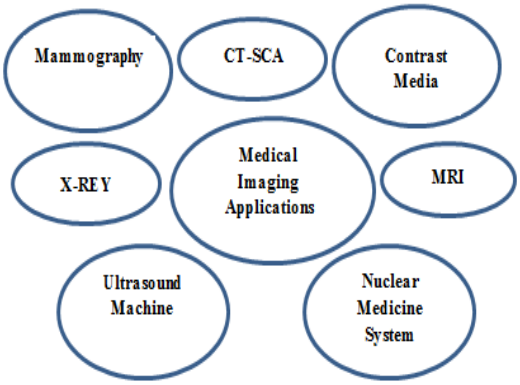

Figure 1: Medical Imaging Modalities.

Cancer as an important public health issue has economic burden and social in different countries. In developing countries there are more than 50 percent of new cancer cases are happened, so early detection, prevention as well as diagnosis of cancers leads to better health results. It is predictable more different types of cancer will happen in the future because of population increasing and old ages and impose more hardness to the societies. The priority of countries is reducing cancer burden and cancer control programs. There is a need to improve imaging, where improvement in medical imaging to make image clearer by using computers.

Automatic detection of any issue persist in medical image data motivated the researchers to design and develop a decision support system (DSS) to help physician in the decision making process. A DSS to assist the physician can be developed using various machine learning techniques [8]. A DSS model is developed by using machine learning techniques to classify the image either as a normal or abnormal as is shown in Figure 2 [8].

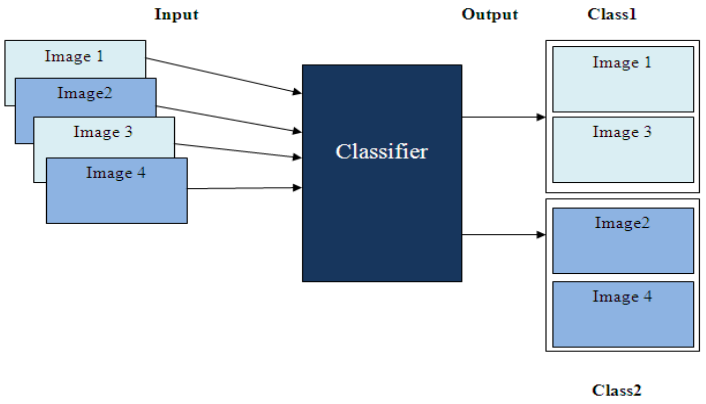

Figure 2: Image Classification Process.

There is a large of number of imaging modalities are under investigation to decide their benefits in imaging and obtaining a correct in vivo diagnosis of melanoma. These include total cutaneous images, SIA scope, dermoscopy, epiluminescence microscope, confocal scanning laser microscopy (CSLM), ultrasound, magnetic resonance imaging (MRI), and multispectral imaging. Figure 3 shows an example of Dermoscope equipment [9].

Figure 3: An example of Dermoscope equipment.

The Digital Camera is not capable of acquisition the interior images of the skin. Therefore a Dermoscope is required, skin lesion is magnified by tool, it is attached with a digital camera and lighting equipment providing light with fixed wavelengths and additional lens. The lens connected to the dermatoscope acts as a microscope magnifier with its own light source that illuminates the skin surface evenly.

Here, a view of the currently cutaneous imaging devices and advantages and limitations automated diagnosis of melanoma in Table 1.

Table 1: Imaging devices for the diagnosis of skin cancer [9].

Method	Advantages	Limitations
Dermoscopy	Facilitating 20–70% magnification of the skin. Melanoma dermoscopic characteristics are well correlated to histopathology features.	illumination changes across the photographs horizontally or vertically.
Spectrophotometric intracutaneous analysis	SIA scope can help in the diagnosis of lesions as small as 2 mm. Analyzing the location, quantity, and distribution of skin.	Difficult interpretation.
Ultrasound imaging	Can provide information about perfusion patterns of lymph nodes. Other soft tissues that can be used to stage the tumor.	Accuracy of results depends heavily on the skill of examiner and Anatomic site of lesion.
Magnetic resonance imaging	Obtaining information on the depth and extent of the underlying tissue involvement, and can be used to measure thickness or volume of the melanoma.	The need for sufficient resolution and adequate number of images per sequence for discriminating Skin lesions.

Images of melanoma are acquired using dermoscopy equipment or epiluminance microscopy. It uses equipment called derma to scope to observe and capture the skin lesion closely [10]. Images captured using dermoscopes can be stored and analyzed by personal computers or laptop platforms [11]. Machine learning techniques play an important rule for analyzing skin lesion images.

3. MACHINE LEARNING TECHNIQUES IN MEDICAL IMAGING

In this paper, investigates on the machine learning techniques that are implemented on different medical imaging applications like: lung cancer, breast cancer, diagnosis of heart, and brain tumor were selected. After the initial searches, different research studies were selected for analysis and diagnosis between 2005 and 2018.

In this section, it will give a concise introduction to the most important topics of machine learning techniques; we introduce DT, SVM, ANN and NB. The surveys about these techniques in medical imaging are given to find most popular and effective.

3. 1 DECISION TREE (DT)

Decision Tree (DT) is a hierarchical data construction achievement, and it has the divide-and-conquer strategy. It can be utilized for both regression and classification. It is a supervised learning; its local region is divided into a smaller number of steps in a sequence of recursive.

It includes of internal decision nodes node and terminal leaves. Each node in this approach assigns a test of some feature of the query example, and each division descending from that node identifies to one of the possible values for this feature. At the beginning an instance is classified by the root node of the tree, testing the feature assigned by this node, then moving down the tree division identifying to the value of the attribute. The sub-tree rooted at the new node in iterative process as long as it takes to reach the suitable leaf node, then the result of the classification associated with this leaf is returned [12].

Table 2 presents a survey on DT technique that was proposed earlier in different medical imaging applications.

Table 2: A survey on DT technique in medical imaging.

Author	year	Application	Algorithm	Accuracy
Rafiqul et al. [13]	2005	Classification of x-ray images for lung cancer diagnosis.	ID3 decision tree algorithm	high transparency and accuracy
Bellaachia and Guven. [14]	2006	prediction of survivability rate of breast cancer	C4.5 algorithm	86.7%
Rajendran and Madhesw	2010	classification of brain tumor in the CT scan	decision tree with	95%

aran. [15]		brain images.	association Rule	
Sivagami. [16]	2012	classifying Breast cancer	J48 algorithm	80%
Ahmad et al. [12]	2013	Predicting Breast Cancer	C4.5 algorithm	0.936%
Hota. [17]	2013	classification of breast cancer	C5.0 algorithm	92.61%
Chaurasia and Pal. [18]	2013	diagnosis of heart disease	J48 algorithm	84.35%
Naik and Patel.[19]	2014	Tumor Detection and Classification in Brain MRI	decision tree	96%
Zhang et al. [20]	2016	detect multiple sclerosis (MS) in magnetic resonance imaging	C 4.5 algorithm	97.62%
Murty and Babu. [21]	2017	Lung cancer prediction	C 4.5 algorithm	98.96%
Yadav et al.[22]	2018	Breast Cancer Diagnosis	decision tree algorithm	90% to 94%

From the above Table, it can be found that there are many articles based on cancer diagnosis, which have been presented by many researchers and they are still undergoing research on developing more algorithms to get more accuracy for detecting cancer. The hybrid method (decision tree with association rule) improves the efficiency than the traditional methods. C4.5 algorithm is implemented to analyze the lung cancer prediction using WEKA tool. It is found this algorithm gives a better performance 98.96% over the other algorithms [21].

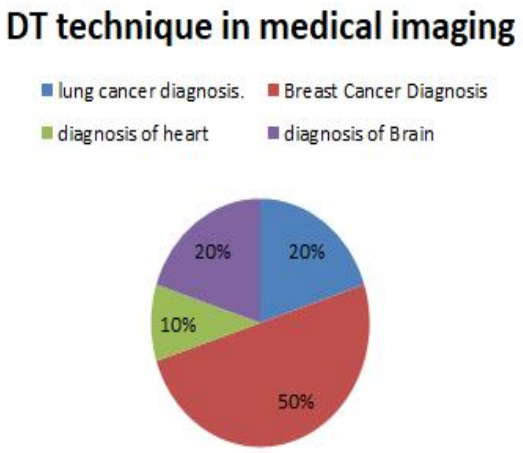

Figure 4: The area of various medical diagnosis using DT technique.

Fig. 4 shows the area of different medical diagnosis using DT technique for these articles separately. In Comparative, the breast cancer diagnosis is using DT technique more than other diseases.

3.2 SUPPORT VECTOR MACHINE (SVM)

Support Vector Machine (SVM) is a new method of machine learning techniques; it is used in the field of cancer detection. It is the technique for classifying both linear and non-linear data. It transforms the original training data into a higher dimension in a non-linear and characterizes the hyper plane that differentiates the data into two classes. It implements classification problems by maximizing the margin that splits both classes, and the classification errors are minimized as shown in figure 5. It can be used for the robust classification of new examples [3].

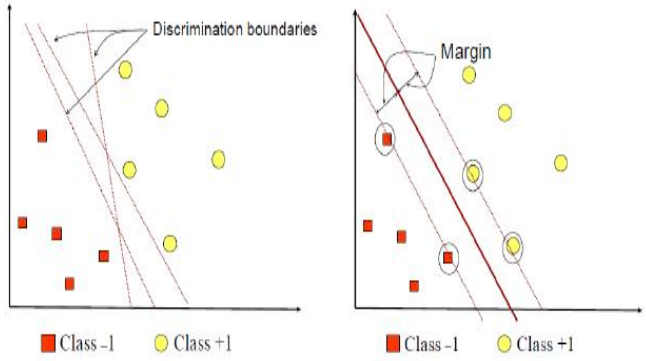

Figure 5: Hyper plane of SVM.

In the following Table 3 presents a survey on SVM technique that was proposed earlier in different applications of medical imaging.

Table 3: A Survey on SVM technique in medical imaging.

Author	Year	Application	Accuracy
Hong et al. [23]	2010	classification accuracy of chest DR	high accuracy
Zare et al. [24]	2011	classification of medical x-ray images	91 %.
Sivagami. [16]	2012	The classification of breast cancer	90%
Ahmad et al. [12]	2013	predictive models for breast cancer recurrence	0.957%
Punia and Singh. [25][24]	2013	for Automatic Segmentatio n of Liver Images	high accuracy
Hota. [17]	2013	Diagnosis of Breast Cancer	95.45%
Mamatha et al. [26]	2015	Classifying Diabetic Retinopathy (DR)	90.54%
Alfonse and Salem. [27]	2016	A brain tumor diagnostic system	98.9%
Shenbagarajan et al. [28]	2016	Tumor Diagnosis in MRI Brain Image	86.50%
Pareek et al. [29]	2017	brain tumor detection and classification in MRI Brain Image	90%
Yadav et al.[22]	2018	Breast Cancer Diagnosis	94.5% to 97%

From the above Table, it can be found that The SVM classification model predicts the cancer diagnosis with least error rate and highest accuracy. SVM is agreed to be the best classifier which gives the results in good accuracy for different medical image classification. It is based on risk minimization principle, it has a high recognition rate and robustness and good generalization ability in solving two-classification and recognition for small samples. SVM has been used for automatic liver image segmentation in [25]. It provides robust and accurate segmentation.

In research for medical x-ray images which are having large visual variability among images from the same anatomy category as well as inter class similarity. This classification model was built based on merging scheme where overlapped classes were combined with each other and SVM classifier was re-trained to construct the model, the accuracy rate of this model is high [24]. A brain tumor diagnostic system is assessed based on a series of brain tumor (MRI) images; it gives a best performance about 98.9% over the other applications [21].

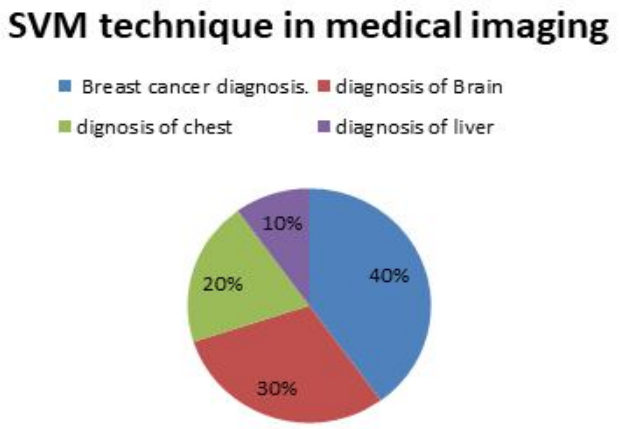

Figure 6: The area of various medical diagnosis using SVM technique.

Fig. 6 demonstrates the area of various medical diagnosis using SVM technique for these articles separately. In Comparative, the breast cancer diagnosis is using SVM technique more than other diseases.

3.3 ARTIFICIAL NEURAL NETWORKS (ANN)

Artificial Neural Networks (ANN), its structure and work of this approach is similar the human brain working. The brain of human contains of millions of neurons, which are interconnected by synapses, NN is a fixed of connected input/output nodes, which has a weight associated for each connection. In the learning phase, the network adjusts the weights, so it is able for predicting the correct class label of the input [1]. Also it represents the neural connections mathematically of multiple hidden layers as shown in Figure 7 [3]. Table 4 shows a survey for ANN technique, various experiments were implemented using different algorithms. Error Back Propagation Network (EBPN) provides efficient results rather than Learning vector quantization (LVQ) and Counter Propagation Network (CPN) [17].

Back propagation network (BPNs) and Probabilistic neural network (PNN) are used in detection the brain cancer. They classify the tumor types in brain MRI images, and give high accuracy [30][29]. The multi-layer perceptron (MLP) [12] is the most commonly used algorithm and performs efficiently better than other ANN architectures for medical classification

problems. RBF algorithm is implemented to analyze the lung cancer prediction using WEKA tool. It gives a best performance 95.8% over the other applications [21].

Table 4: A survey on ANN technique in medical imaging.

Author	year	Application	Algorithm	Accuracy
Bellaachia and Guven. [14]	2006	Prediction of survivability rate of breast cancer	BPN	86.5%
Sivagami. [16]	2012	classification of breast cancer	MLP	74.1%
Ahmad et al. [12]	2013	predictive models for breast cancer recurrence	MLP	0.947%
Hota. [17]	2013	Diagnosis of Breast Cancer	EBPN	95.45 %
			LVQ	92.04 %
			CPN	93.75%
Jain and Mishra.[30]	2013	Classify brain cancer	*BPN*	71.42%
			PNN	100%
Mamatha et al.[26]	2015	ClassifyingDiabetic Retinopathy (DR)	Multilayer Perceptron Back propagation(MLP)	94.11%
Shenbagarajan [28]	2016	Tumor Diagnosis in MRI Brain Image	The Levenberg-Marquardt (LM) with ANN	93.74%
Murty and Babu. [21]	2017	Lung cancer prediction	RBF Neural Network	95.8%
Fonseca et al. [31]	2018	diagnosis in Schizophrenia and Bipolar disorders	Supervised ANN	more than 90%

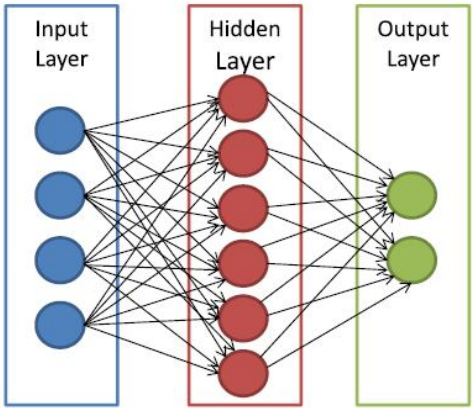

Figure 7: A structure of the ANN.

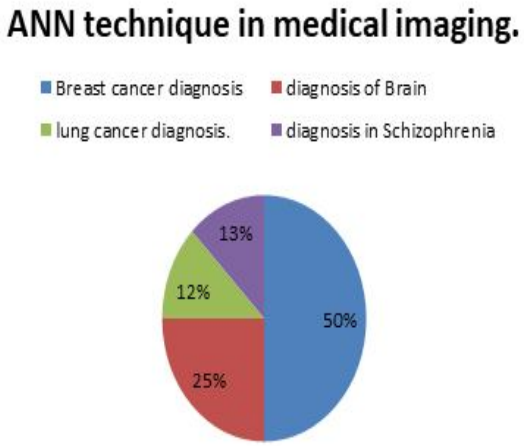

Figure 8: The area of various medical diagnosis using ANN technique.

Fig. 8 shows the area of different medical diagnosis using ANN technique for these articles separately. In Comparative, the breast cancer diagnosis is using ANN technique more than other diseases.

3.4 NAIVE BAYES (NB)

Naive Bayes (NB) technique is based on the probability. It works on the basis of Bayes theorem with assumptions which are strong and independent. This technique termed as independent feature model. Bayes classifier assumes that the absence or the presence of any feature is not dependent on the absence or presence of any other feature [3]. This classifier uses the maximum of a posteriori classification measure a finite set of features $\boldsymbol{x} = (x_1, \ldots, x_n)$ then select the class.

$$\text{posterior} = \frac{\text{prior} \times \text{likelihood}}{\text{evidence}} \quad (1)$$

P(C) is called the prior probability , p(**x**|C) is called the class likelihood and using Bayes' rule, we posterior calculate the posterior probability of the concept, *P(*C|***x****), after* having probability seen the observation, ***x***.

$$P(Ci|x) = \frac{p(x|Ci)P(Ci)}{p(x)} \quad (2)$$

In the following Table 5 presents a survey on NB technique that was proposed earlier in different applications of medical imaging.

Table 5: A survey on NB technique in medical imaging.

Author	Year	Application	Accuracy
Bellaachia and Guven. [14]	2006	Prediction of survivability rate of breast cancer	84.5%
Salama et al. [32]	2012	*Breast Cancer Diagnosis* on WBC dataset	95.99%
Chaurasia and Pal. [18]	2013	diagnosis of heart disease	82.31%
Hota. [17]	2013	classification of breast cancer	93.18%
Mangai et al.[33]	2013	Classifying Medical Images	100.00%
Imran et al. [34]	2013	Classification to Enhance Image Registration	high accuracy
Bhuvaneswari et al. [35]	2014	Classification of Lung Diseases	high accuracy
Naik and Patel. [19]	2014	Tumor Detection and Classification in Brain MRI	88.2%
Murty and Babu. [21]	2017	Lung cancer prediction	100%
Dulhare [36]	2018	Prediction system for heart disease	87.91%
Buvaneswari [37]	2019	facial images	91%

The NB technique is suited for medical image classification. The Table 5 shows a survey for NB technique [33]. The performance of the predictive model is depending on the efficient feature extraction and the feature selection methods. Moment invariants technique is used for extract the features, and the genetic technique is used for the feature selection, the naïve bayes classifier is generates more efficient results [35]. The PCA is as a feature reduction transformation method, which is used in WBC data set; it combines a set of correlated features. Reducing the redundancy of features is very important step in the cancer diagnosis problem [32].

The Local Naive Bayes Nearest Neighbor, an improvement onto the NB image classification algorithm that increases classification accuracy and improves its ability to scale to high object classes. This research [34] is successful and overcomes the limitation of other researches. NB is better suited for medical image classification [33]. It is implemented to analyze the lung cancer prediction using WEKA tool. It gives a best performance 100% over the other applications [21]. This research [37] proposed the new method named ELSA (Efficient Linear Selection of Adaptive Features) which implements on the several adaptive features such as ELB (Effective Local Binary Patterns), SIFT(Scale Invariant feature Transforms), GLCM(Gray Scale Covariance Matrix) , then tested with the Naïve Bayes Classifier. It gives accuracy about 91%.

It novels approach for detection of Coronary Artery Disease [38], which obtained by Minimum distance classifier. It gives a best performance 95.64% over the other application in [36].

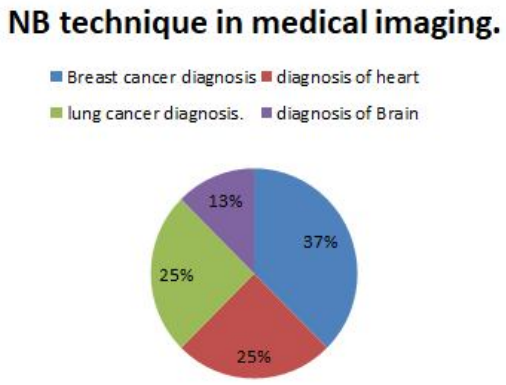

Figure 9: The area of various medical diagnosis using NB technique.

Fig. 9 demonstrates the area of various medical diagnosis using NB technique for these articles separately. In Comparative, the breast cancer diagnosis is using NB technique more than other diseases.

Table 5: Comparative results of different techniques.

Author	**Technique**	**Application**	**Accuracy**
Murty and Babu. [21]	DT C 4.5 algorithm	Lung cancer prediction	98.96%
Alfonse and Salem. [27]	SVM	A brain tumor diagnostic system	98.9%
Jain and Mishra.[30]	ANN (*PNN*)	Classify brain cancer	100%
Mangai et al.[33]	NB	Classifying Medical Images	100.00%

From the previous tables we have created the above table, which table5 shows the best techniques used in the diagnosis of cancer in medical images. Where it shows that the best technique is ANN (PNN) and SVM to classify brain cancer with accuracy about 100%, 0.98% respectively, and also NB the best technique to classify medical images with accuracy about 100%. In addition, the DT technique is best in classifying medical images of lung cancer with accuracy about 98.96%.

4. CONCLUSION

This paper presents a survey on different machine learning techniques that have been proposed the last years and consternate on the development of predictive models using these techniques and targeting to predict valid disease results in the field of medical imaging. Various articles on different medical imaging applications like: lung cancer, breast cancer, diagnosis of heart, and brain tumor were selected. After the initial searches, different research studies were selected for analysis and diagnosis between 2005 and 2018.

The performance of different machine learning techniques such as DT, SVM, ANN and NB are determined. In this review, it discussed the concepts of these techniques while it summarized their application in cancer prediction.

DT technique has been used to classify the medical images for diagnosis, but the hybrid method association rule with decision tree improves the classification process to be more accurate. C4.5 algorithm is implemented to analyze the lung cancer prediction. It is found this algorithm gives a better performance 98.96% over the other algorithms.

SVM is based on structural risk minimization principle. It is agreed to be the best classifier which gives the outcomes with least error rate and highest accuracy. It gives a best performance on brain tumor diagnostic system about 98.9% over the other applications.

ANN is found to be most widely used predictive technique in medical prediction as compare to traditional methods like DT, NB etc. Owing to the fact that ANN technique provides robust solution of medical prediction process. Probabilistic neural network (PNN) is used in detection the brain cancer. They classify the tumor types in brain MRI images, and give high accuracy about 100%.

NB is recently developed technique appropriate to perform prediction under uncertainty with incomplete data. It offers a very attractive form for representing uncertain knowledge; it is better suited for medical image classification. It is implemented to analyze the lung cancer prediction. It gives a best performance 100% over the other applications. In addition, the study attempts to determine the most efficient machine learning techniques used for medical diagnosing applications.

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