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An Extensive Review on Cancer Detection using Machine Learning Algorithms

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ABSTRACT

Machine Learning (ML) is a specific type of artificial intelligence that allows systems to learn from data and detect patterns without much human intervention. As technology expands, machine learning provides an exciting opportunity in the health sector to improve the accuracy of diagnoses, personalise health care. Cancer has been characterised as a heterogeneous disease consisting of many different subtypes. In cancer research, it has become a necessity to diagnose and prognosis the type of cancer as early as it can facilitate the subsequent clinical management of patients. To accomplish the detection of cancer properly there are certain techniques in Machine learning which have been widely applied in cancer research for the development of predictive models, resulting in effective and accurate decision making. SVM, KNN, DT, LR, CNN, ANN, RF, MLP etc are such types of techniques in ML to model the progression and treatment of cancerous conditions. Apart from ML techniques there are certain image processing tools that are being introduced to detect cancer. Getting a clear cut classification from a biopsy image is an inconvenient task as the pathologist must know the detailed features of a normal and the affected cells. In this paper we are going to review the effectiveness of these various kinds of ML approaches to detect different types of cancer in some previous research papers which have already been done. The analyses and assessment techniques of the selected papers are discussed and an appraisal of the findings presented to conclude the article.

Keywords: Machine Learning, Cancer, Review, Biopsy

INTRODUCTION

Cancer is an irregular extension of cells and one of the most serious health problems in the human body. It is a genetic disease caused by changes to genes. It may take any form and is very difficult to detect during early stages. Among all cancer types, the mortality rate of lung cancer is highest. Other types of cancer are: Gastric Cancer, Liver Cancer, Carcinoma, Sarcoma, Leukaemia, Lymphoma, Multiple Myeloma.

In cancer detection, it often involves radiological imaging. Radiological Imaging is a process which is used to check the spread of cancer, meaning the affected areas and progress of the treatment and another use of this process is to monitor cancer. Oncological Imaging is more accurate.

In cancer research and oncology, the successful application of Machine Learning (ML) and Deep learning (DL) techniques has recently demonstrated fundamental improvements in image-based disease diagnosis and detection. ML and DL frameworks have been also applied towards cancer diagnosis, classification and treatment by exploiting genomic profiles and phenotype data.

In this review paper we focus on the ML aspect of Artificial Intelligence based applications in cancer research.

Various Machine Learning Techniques to detect cancer

CNN: In Image Processing, the image is taken as input and loaded into the program. Then, the image is divided into 12 segments and CNN(Convolution Neural Networks) is applied in each segment.

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CNN is used to extract the amount of each type of cancer cell present in each segment. After the segmentation it takes the average of 12 parts and that output will be stored to another file which acts as intermediate output.1][2].

ANN: Artificial Neural Network(ANN) is the theoretical mathematical model of the human neural network and also its called an information processing system based on the structure and function of the neural network. It is becoming more and more useful and their application fields are also expanding[3][4].

KNN: The K-nearest Neighbors Network(KNN) algorithm is one of the simplest and most used machine learning algorithms and a parameterized learning method function like Education distance or Manhattan distance and the majority class of the k-nearest data points to the data point in question is used to build the model[5][6]

SVM: Support Vector Machine(SVM) is one of the most popular supervised learning algorithms which can be utilised for classification, regression, and outlier detection. The goal of the SVM algorithm is to create the best line or decision boundary that can segregate n-dimensional space into classes so that we can easily put the new data point in the correct category in the future[7][8].

DT: Decision Tree(DT) is a type of supervised learning technique which has been used for both classification and regression problems, but mostly it is preferred for solving classification problems. It is a tree structured classifier that provides a nonparametric method for partitioning datasets. It has a hierarchical tree structure, which consists of a root node, branches, internal nodes and leaf nodes[9][10].

LR: Logistic Regression(LR) is one of the widely used supervised learning methods in machine learning which is used to predict the probability of a target variable. It basically predicts the output of a categorical dependent variable using a given set of independent variables.That is why it is the go to method for binary classification problems[11][12].

NB: Naive Bayes algorithm is a supervised learning technique that works on the principle of Bayes theorem and is utilised in a wide variety of classification tasks. It is a probabilistic classifier which predicts on the basis of the probability of an object and one of the most effective classification algorithms. NB is mainly used in text classification which includes a high-dimensional training dataset[13][14].

RF: Random Forest(RF) is a classifier that belongs to supervised learning in ML. It works on the principle of ensemble learning. RF basically contains a number of decision trees on various subsets of the given datasets and takes the average to improve the predictive accuracy of that dataset. For classification tasks, the output of the random forest is the class selected by most trees. Random decision forests correct for decision trees' habit of overfitting to their training set[15][16].

MLP: Multilayer Perceptron(MLP) is a special kind of feed-forward network which is widely used in neural networks in machine learning. It consists of three layers- the input layer, output layer, hidden layer. An MLP is characterised by several layers of input nodes connected as a directed graph between the input and output layers. MLP uses backpropagation for training the network[17][18].

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Table1 : Comprehensive analysis of various Machine Learning algorithms to detect Breast Cancer

Author & Year	Data Source	ML technique	Accuracy (%)
(Alireza Osareh , Bita Shadgar, 2010)	The dataset of fine needle aspirate of breast lesions (dataset I), a second dataset comprised of gene microarrays comes from reference [19] and [20].	SVM KNN PNN	98.00 96.00 97.00
(Meriem Amrane, Ikram Gagaoua, 2018)	UCI Machine Learning Repository	KNN NB	97.50 96.10
(Wenbin Yue, Hongwei Chen, 2018)	WBCD Database	DT ANN	93.60 91.20
(Ebrahimi M, , Eshlaghy AT, 2013)	ICBC dataset in the National Cancer Institute of Tehran for the years 1997-2008	DT ANN SVM	93.60 94.70 95.70
(Wang et al. , 2020)	WDBC	RBF SVM RF KNN ANN DT	97.66 97.02 92.80 93.34 92.92
(Hiba Asri, Thomas Noel, 2016)	UCI Machine Learning Repository	SVM NB KNN	97.10 95.90 95.20
(Mitra Montazeri, Mahdieh Montazeri, 2016)	A database which included the information of 900 patients during 1999–2007 that was recorded by the Cancer Registry Organization of Kerman Province, in Iran	SVM NB	94.00 95.00
(Omar Ibrahim Obaid, Salama A. Mostafa, 2018)	UCI machine learning repository	SVM KNN DT	98.10 96.70 93.70
(David A. Omondiagbe, Amandeep S. Sidhu, 2019)	UCI machine learning repository	SVM NB	96.40 91.10
(Jiande Wu, Chindo Hicks, 2021)	TGCA and GDC database	SVM KNN	90.00 87.00
(Anji Reddy Vaka, Badal Soni, 2020)	M. G Cancer Hospital & Research Institute, Visakhapatnam, India	SVM NB	95.70 95.60

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(Tolga Ensari, Ebru Aydındag Bayrak, 2019)	UCI Machine Learning Repository	SVM ANN MLP	96.90 95.40 95.30
(Shubham Sharma, Tanupriya Choudhury, 2018)	UCI Machine Learning repository	KNN NB	95.90 94.40
(Sadeq Darrab, Gunter Saake, 2020)	UCI Machine Learning Repository	NB SMO	71.60 69.60
(Yixuan Li, Zixuan Chen, 2018)	BCCD and WBCD database	DT LR SVM	68.60 65.70 71.40
(Abien Fred M. Agarap, 2018)	WDBC dataset	LR SVM	96.00 96.20
(Gunjan Chugh, Nanhay Singh, 2021)	The list of publicly available datasets used by the researchers in recent years	SVM CNN	90.00 83.10
(Habib Dhahri, Awais Mahmood, 2019)	UCI Machine Learning Repository	DT NB LR	97.60 98.00 96.90
(Vikas Chaurasia, Saurabh Pal, 2020)	WHO "Data WHO Coronavirus Covid-19 cases and deaths-WHO-COVID19-global-data".	RF ET	94.70 95.20
(Ch. Shravya, Shaik Subhani, 2019)	UCI machine learning repository	SVM LR KNN	92.10 92.80 92.20

Table2 : Comprehensive analysis of various Machine Learning algorithms to detect Lung Cancer

Author & Year	Data Source	ML technique	Accuracy (%)
(Zhihua Cai, Dong Xu, 2014)	TCGC and GEO database	RFs ROC mRMR	86.54 86.54 86.54
(Radhika P R, Rakhi.A.S.Nair, 2019)	UCI Machine Learning Repository	SVM DT NB LR	99.20 90.00 87.87 66.70
(Syed Saba Raoof, M A. Jabbar, 2020)	UCI ML Database	SVM ANN RNN	82 82 82

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(Ying Xie, Wei - Yu Meng, 2020)	Data collected from a group of patients of Hubei Taihe Hospital	NB SVM NN	100.00 94.70 94.70
(Nikita Banerjee, Subhalaxmi Das, 2020)	Sumathipala et al., [9] proposed a model where the image data are taken from LIDC-IDRI	ANN SVM RFs	96.00 (TB) 86.00 (RB) 79.00 (RB)
(Kwetishe Joro Danjuma, 2015)	Thoracic Surgery datasets obtained from the University of California Irvine machine learning repository	MLP J48 NB	82.30 81.80 74.40
(Elias Dritsas, Maria Trigka, 2022)	https://www.kaggle.com/datasets/mysarahmadbhat/lung-cancer	SVM ANN NB DT KNN	95.40 94.60 95.00 93.70 95.20
(Muhammad Imran Faisal, Saba Bashir, 2018)	UCI online repository	Auto MLP NB SVM DT GBT	78.33 85.00 79.17 78.33 90.00
(Qing Wu, Wenbing Zhao, 2017)	https://www.kaggle.com/c/ data-science-bowl-2017	NN	77.80
(Gur Amrit Pal Singh, P. K. Gupta, 2018)	Cancer Research UK (2017) Cancer mortality for common cancers. http://www.cancerresearchuk.org/health-professional/cancer-statistics/mortality/common-cancers-compared	KNN SVM DT NB RFs MLP	89.71 57.24 80.84 51.40 84.81 88.55
(Radhanath Patra, 2020)	https://archive.ics.uci.edu/ml/dataset/Lung+cancer	KNN NB RBF J48	75.00 78.12 81.25 78.12
(Dakhaz Mustafa Abdullah, Adnan Mohsin Abdulazeez, 2021)	UCI machine learning repository	SVM KNN CNN	95.56 89.65 92.11
(Amjad Rehman, Noor Ayesha, 2021)	Chest CT scan image dataset	SVM KNN	93.00 91.00

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(S. Shanthi, N. Rajkumar, 2020)	TCGA Database	MRMR - DT CFS - DT SDS - DT MRMR - NB CFS - NB SDS - NB	83.33 82.22 87.41 81.85 81.48 88.52
(Marta Borowska, Ewelina Bebas, 2021)	155 magnetic resonance images with a metabolic active lung tumour according to the PET / MR scan	SVM NB KNN ANN Deep ANN	75.50 68.40 72.90 71.00 69.00
(Chinmayi Thallam, Aarsha Peruboyina, 2020)	Text data collected from data.world	SVM ANN KNN RFs VC	95.00 95.99 97.00 97.50 99.50
(S. Baskar, P. Mohamed Shakeel, 2019)	Computed Tomography (CT) images	SVM	90.90
(Rashmee Kohad, Vijaya Ahire, 2015)	cancerimagingarchives.net, Mahatma Gandhi Mission and Tapadia Diagnostic Center situated at Aurangabad	ACO_SVM ACO_ANN	93.20 98.40
(Özge GÜNAYDIN, Melike GÜNAY, 2019)	Standard Digital Image Database, Japanese Society of Radiological Technology (JSRT)	KNN SVM DT ANN	75.68 55.41 93.24 82.43
(Kesav Kancherla, Srinivas Mukkamala, 2013)	Public Sample Collection	SVM RBF NB MLP Bagging RBF AdaBoost RBF RFs MLM SMO LLM AdaBoost LLM Bagging LLM	79.43 80.48 74.00 71.30 87.80 83.10 81.00 70.74 75.00 78.04 75.60 85.36

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Table3 : Comprehensive analysis of various Machine Learning algorithms to detect Liver Cancer

Author and Year	Data Source	ML technique	Accuracy(%)
(Amita Das, U. Rajendra Acharya, 2019)	Imaging centre of IMS and SUM Hospital, India	NB MLP SVM KNN AdaBoost M1 J48 RF DNN	91.94 91.65 95.17 93.87 90.72 95.98 94.86 98.38
(Sangman Kim, Seungpyo Jung, 2014)	Raw data of serums from 314 normal and 81 liver cancer patients	NN FNN	99.19 98.19
(Samreen Naeem, Aqib Ali, 2020)	Bahawal Victoria Hospital (BVH), Bahawalpur, Pakistan.	MLP SVM RF J48	99.00 98.50 98.17 97.11
(Somaya Hashem, Shahira Habashy, 2020)	Data were collected from two institutes in Egypt: the Egyptian National Committee for the Control of Viral Hepatitis and the multidisciplinary HCC clinic at Cairo University's Kasr Al-Aini Hospital	LR ADTree CART REP- Tree	93.20 95.60 94.10 93.80
(Maria Alex Kuzhippallil, Carolyn Joseph, 2020)	UCI ML Repository	KNN DT LR AdaBoost	79.00 84.00 76.00 83.00
(Elias Dritsas, Maria Trigka, 2023)	Indian Liver Patients' Records dataset.	SVM NB LR	75.10 75.50 75.00
(Zhaoyang Cao, 2020)	Bai et al's research, which is the NGS data of the pre-S/S region of the HBV genome with 400-500 base pairs of nucleic acids	SVM LR RF	96.00 94.60 92.30
(Bhawana Maurya, Manoj Kumar,2020)	Reference number [77] to [82]	SVM NN RF PSO-SFS-	87.00 99.39 95.00 96.40

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		SBS PSO-SFS	92.60
(Suruchi Fialoke, Anders Malarstig, 2018)	American Medical Informatics Association	RF LR DT	79.20 76.20 77.30
(Enagandula Prasad, V. Durga Prasad Jasti, 2022)	Data source not found	SVM ANN RF	93.23 86.00 77.10

Table4 : Comprehensive analysis of various Machine Learning algorithms to detect Skin Cancer

Author and Year	Data Source	ML technique	Accuracy(%)
(Kinnor Das, Anant Patil, 2021)	HAM10000, and BCN20000	InceptionV4 CNN	76.50 85.30
(Vrunda Shah, Manan Shah, 2022)	PH2;ISIC	KNN SVM	85.00 78.00
(Mahmoud Elgamal, 2013)	Data source not found	ANN KNN	95.00 97.50
(Carolina Magalhaes, Joao Manuel R.S. Tavares , 2021)	Data Source Not Found	SVM CNN	92.60 91.00
Zhoufeng Zhang Junle Qu	HMI	SVM CNN	87.40 88.90
(Yuheng Wang, Harvey Lui,2021)	Skin Care Centre of Vancouver General Hospital	SVM KNN RF	60.00 60.00 60.00
(Titus Josef Brinker, Achim Heckler, 2018)	ISIC 2018, HAM10000	SVM CNN	93.60 79.50
(Afsana Ahsan Jeny, Masum Shah Junayed, 2020)	Collected the data from some hospitals and flocked together some pictures available online.	ANN CNN InceptionV4	76.90 80.50 67.00
(Shunichi Jinnai Ryuji Hamamoto, 2020)	Department Dermatologic Oncology in the National Cancer Center Hospital	FRCNN BCD TRN	86.00 79.50 75.10

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Discussion and Analysis of various Machine Learning Algorithms

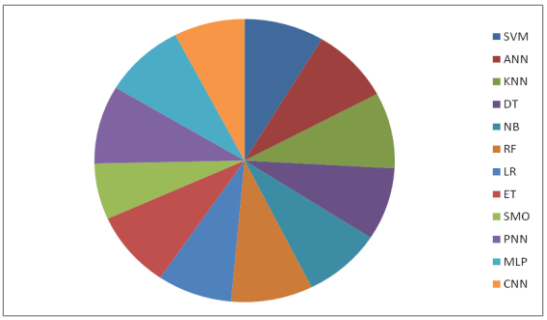

Fig. 1: Average accuracy for each ML technique used to detect Breast Cancer

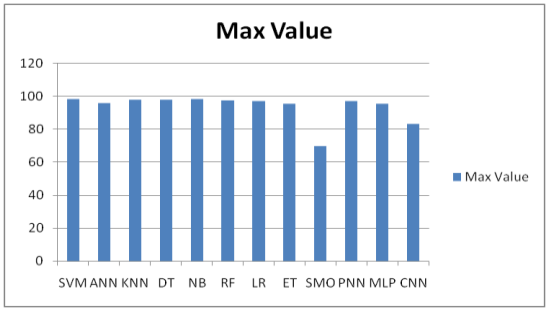

Fig. 2: Maximum accuracy of a particular ML technique in Breast Cancer detection

From the above discussions we can clearly see that in the detection of Breast Cancer, maximum accuracy of 98.00% has been achieved by using Support Vector Machine (SVM) and Naive Bayes (NB) algorithms. On the other hand, Probabilistic Neural Network (PNN) has given the highest average accuracy (97.00%).

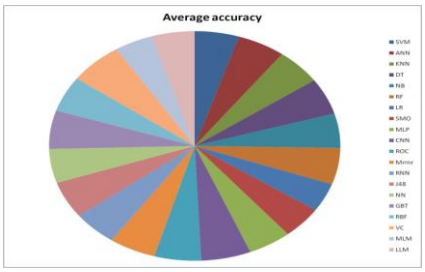

Fig. 3: Average accuracy for each ML technique used to particular detect Lung Cancer detection

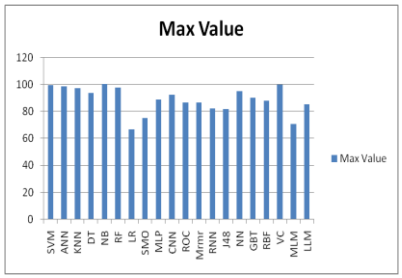

Fig. 4: Maximum accuracy of a ML technique in Lung Cancer

From the above discussions we can clearly see that in the detection of Lung Cancer, maximum accuracy of 100.00% has been achieved by using Naive Bayes (NB) technique followed by Voting Classifier (VC) (99.50%) and Support Vector Machine (SVM) (99.20%) techniques. On the other hand, Convolutional Neural Network (CNN) has given the highest average accuracy (92.11%).

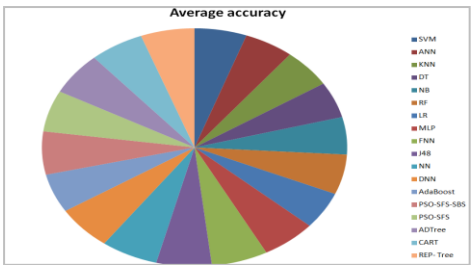

Fig. 5: Average accuracy for each ML technique used to detect Liver Cancer

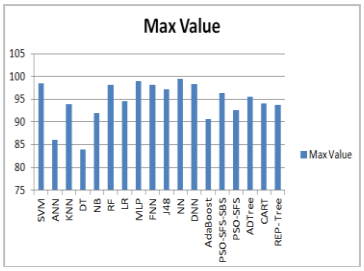

Fig. 6: Maximum accuracy of a particular ML technique in Liver Cancer detection

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From the above discussions we can clearly see that in the detection of Liver Cancer, maximum accuracy of 100.00% has been achieved by using Neural Network (NN) technique followed by Multilayer Perceptron (MLP) (99.00%) and Support Vector Machine (SVM) (98.50%) techniques. On the other hand, Neural Network (NN) has given the highest average accuracy (99.29%).

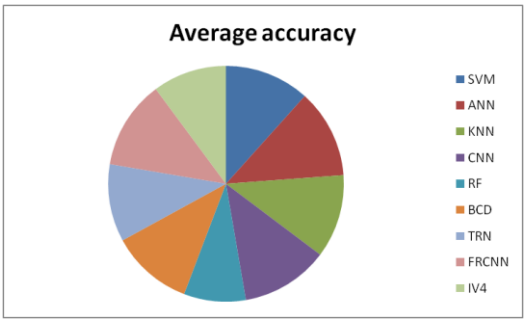

Fig. 7: Average accuracy for each ML technique used to detect Skin Cancer

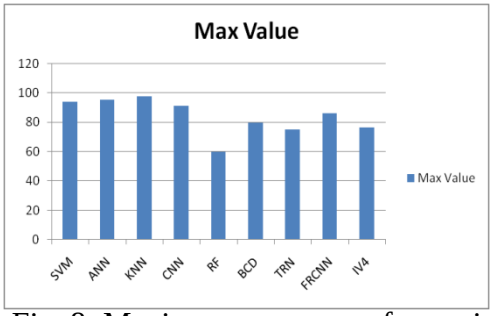

Fig. 8: Maximum accuracy of a particular ML technique in Skin Cancer detection

From the above discussions we can clearly see that in the detection of Skin Cancer, maximum accuracy of 97.50% has been achieved by using K- nearest Neighbour Network (KNN) technique followed by Artificial Neural Network (ANN) (95.00%) and Support Vector Machine (SVM) (93.60%) techniques. On the other hand, Artificial Neural Network (ANN) has given the highest average accuracy (85.95%).

CONCLUSION

The main aim of the system 'Cancer Detection using Machine Learning' is early detection of cancer. The wave is increasing day by day in the number of cancer diagnoses. As a result, better technology is needed to increase the chance of survival. In this review we have tried to explain, compare and assess the performance of different machine learning techniques that are being applied to cancer prediction and prognosis. We've studied about different types of cancer and also studied how accurately this machine learning technique calculates the outcomes. Compared to conventional statistical or expert-based systems it is clear that, machine learning methods generally improve the performance level or predictive accuracy of most prognoses. The enhancement of overall quality, generality and reproducibility of machine-based classifiers is based on improvements in experimental design along with improved biological validation. As long as the quality of studies will improve, the use of machine learning classifiers will increase in many clinical and hospital settings.

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