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A Review Paper on Detection and Classification of Cancer using Machine Learning Algorithms

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Abstract : Today, cancer has become a very common disease which can affect any other person in current scenario and leading towards death. Cancer, for which early diagnosis and detection is especially important. The earlier cancer is detected, the higher the chances of the patient being treated. Therefore, many early detection or prediction methods are being investigated and used in the fight against cancer. In this paper, the aim was to review the methods and algorithms used for detection and classification of cancer early with noninvasive and painless methods that use various Machine Learning algorithms and its accuracy.

Keywords: Machine Learning(ML), Cancer, Classification, Detection, Machine learning algorithms, Prediction of tumor

I. INTRODUCTION

Cancer is a disease in which some of body's cell growth unmanageable, and travel and spread to the other part of body which causes cancer in human body. A neoplasm and malignant tumour are other common names for cancer. Cancer is the second leading cause of death globally, accounting for an estimated 9.6 million deaths, or one in six deaths, in 2018. Lung, prostate, colorectal, stomach and liver cancer are the most common types of cancer in men, while breast, colorectal, lung, cervical and thyroid cancer are the most common among women.

Machine learning is a subset of artificial intelligence, which is majorly defined as **the capability of a machine to imitate intelligent human behavior**. Artificial intelligence systems are used to perform complex tasks in a way that is similar to how humans solve problems .

Machine Learning has various algorithms available, by using those algorithm and creating tools we can be able to early diagnosis of cancer. Many people who have suffering from cancer and have no specific symptoms, hence regular cancer screening (PET scan stands for stands for positron emission tomography) is very important for early detection of cancer [1].

II. MACHINE LEARNING IS USED FOR EARLY DIAGNOSIS OF DISEASE

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Early detection of cancer aids for early diagnosis and treatment, because the prognosis is very important for long term survival [2]. Since early detection, diagnosis, and treatment of cancer can reduce the risk of death, it plays a significant role in saving the life of the patient. Any delay in detection of cancer in early stages leads to disease progression and complication of treatment [2], therefore long waiting time prior to diagnosis of cancer and starting the treatment process is of prognostic concern [3].Early detection of cancer boosts the increase of survival chance to 98% [4].

Machine Learning is a process that machines (computers) are trained with data to make the decision for similar cases [5]. ML is employed in various applications, such as object recognition, network, security, and healthcare. There are two ML types i.e. single and hybrid methods like ANN, SVM, Gaussian Mixture Model (GMM), K-Nearest Neighbor (KNN), Linear Regressive Classification (LRC), Weighted Hierarchical Adaptive Voting Ensemble (WHAVE), etc. [3]

Following ML algorithms are used:

1) Artificial Neural Network (ANN)

ANN is a model like human brains nerve system that has a large number of nodes connected to each other. Each node has two states: 0 means active and 1 means active. Also, each node has a positive or negative weight that adjusts the strength of the node and can activate or deactivate it. ANN provides samples of data to train the machine. The trained machine is used to detect the pattern of hidden date. It can search for patterns among patients' healthcare and personal records to identify high-risk lesions [6].

2) Support Vector Machine (SVM)

SVM is a supervised pattern classification model which is used as a training algorithm for learning classification and regression rule from gathered data [7]. The purpose of this method is to separate data until a hyperplane with high minimum distance is found. SVM is used to classify two or more data types. SVM include single or hybrid models such as Standard SVM (St-SVM), Proximal Support Vector Machine (PSVM), Newton Support Vector Machine (NSVM), Lagrangian Support Vector Machines (LSVM), Linear Programming Support Vector Machines (LPSVM),and Smooth Support Vector Machine (SSVM). [3]

3) K-Nearest Neighbours (KNN)

KNN is a supervised learning method which is used for diagnosing and classifying cancer [8]. In this method, the computer is trained in a specific field and new data is given to it. Additionally, similar data is used by the machine for detecting (K) hence, the machine starts finding KNN for the unknown data. It is recommended to choose a large dataset for training also K value must be an odd number.

4) Decision Tree (DT)

DT is a data mining technique used for early detection of breast cancer. It is a model that presents classifications or regressions as a tree. In this model, the data set is broken to small sub-data, then to smaller ones. As a result, the tree is developed and at the last level, the result is revealed. In a tree structure, the leaves characterize the class labels whereby the branches characterize conjunctions of feature leading to the class labels Hence, DT is not sensitive to noise [9].

5) Random Forest (RF)

Algorithm RF algorithm is used at the regularization point where the model quality is highest, variance and bias problems are compromised [10]. RF builds numerous numbers of DTs using random samples with a replacement to overcome the problem of DTs. Each tree classifies its observations, and majority votes decision is chosen. RF is used in the unsupervised mode for assessing proximities among data points.

6) AdaBoost Classifier

This algorithm is used for classification and regression to predict breast cancer existence. It converts weak learners to strong ones by combining all weak learners to form a single strong rule. It gets the weight of the node and changes it continuously until an accurate result is found. However, it is sensitive to noise and quality of features [11].

7) Naïve Bayes (NB) Classifier

Naïve Bayes refers to a probabilistic classifier that applies Bayes' theorem with robust independence assumptions [12]. In this model, all properties are considered separately to detect any existing relationship between them. It assumes that predictive attributes are conditionally independent given a class. Moreover, the values of the numeric attributes are distributed within each class. NB is fast and performs well even with a small dataset. However, it is difficult to find independent properties in real life. [12]. have deployed NB classifier for breast cancer detection and it gave the maximum accuracy with only five dominant.

III. HRV ANALYSIS

Heart rate variability (HRV) is a non-invasive measurement for investigating autonomic influence on the cardiovascular system that has generated significant interest in recent scientific literature [16]. HRV may be defined as the change in the time interval between heartbeats, from beat to beat. HRV is controlled by the autonomic nervous system, including the sympathetic nervous system and the parasympathetic nervous system [17, 18]. There is recognition of a significant relationship between the autonomic nervous system and cardiovascular mortality, including sudden cardiac death [19, 20]. Recent studies have found strong associations between HRV from short-term (2 to 30 minutes) electrocardiogram (ECG) recordings and post-acute myocardial infarction mortality [21, 22].

HRV provides an important index as a potential marker of stress and health for organism functions associated with adaptability and health [19] and as a method to identify patients at risk for an increased cardiac mortality [20]. Currently, HRV is considered a predictor of organism functions; low values of HRV are related to cardiovascular risk factors [21] and can be an efficient predictor of survival in patients with advanced cancer [26, 27]. BC patients can present lower HRV than healthy people, which implies vagal dysfunction and could be used as a risk factor for cardiovascular diseases [24]. HRV analysis has the potential to provide additional valuable insight into multiple physiological and pathological conditions. In the present study we aimed to investigate the clinical importance of cardiac autonomic modulation assessed by HRV analysis in BC patients and survivors. We expect to find out the possible repercussion of HRV analysis on BC treatment and patients survival.

IV. ROLE OF HEART RATE VARIABILITY IN EARLY STAGE CANCER DETECTION

It is well-known that HRV is the strongest indicator of the autonomic function. Lowering certain HRV parameters may tell us that parasympathetic tonus is in trouble. Regular HRV testing helps in assessing the autonomic function and monitoring its dynamics over longer time frame. However HRV is a non-specific method of health assessment. It cannot be used to make specific diagnoses. It serves as a strong marker of the autonomic health and estimates the possibility of developing cancer when the autonomic function is chronically low.

For HRV analysis 5-minute heart rhythm recording must be done using inexpensive devices and special software. Taking this simple test in a doctor's office or at home on a regular basis helps catching a negative tendency in the autonomic function way before the first symptoms of cancer may occur.[4]

V. PREVIOUS RELATED WORK

We have gone through the related work done since 2019-2021 in the domain, by which early detection of life style based disease like cancer, cardiac arrest, diabetes etc.

- Shukla and Aggrawal used HRV analysis to predict and classify lung cancer stages using ANN and SVM algorithms with 93.09% and 100%accuracies respectively [25]
- The same authors applied a Lavenberg Marquardt algorithm-based artificial neural network (ANN) and support vector machine (SVM) to classify cancer vs healthy individuals based on spectral features of HRV, with maximum accuracy of 54.2% and 100% respectively [26]
- Christina Hui Lee Ng, NurShahidah, Tong had proposed a model for the Prediction of cardiac arrest in critically ill patients presenting to the emergency department using a machine learning score incorporating heart rate variability [27]

- Elena Agliari, Adriano Barra, Orazio Antonio Barra developed statistical algorithms for Detecting cardiac pathologies via machine learning on heart rate variability time series and related markers[28]
- Chumachenko, Dmytro have developed four models based on the k-nearest neighbour classifier, radial basis function, decision tree, and random forest to diagnosis Myocardial Infarction Based on Short-Time HRV Data. An analysis of time parameters showed that the most significant parameters for diagnosing myocardial infarction are SDNN, BPM, and IBI. An experimental investigation was conducted on the data of the open PTB-XL dataset for patients with suspected myocardial infarction. The results showed that, according to the parameters of the short ECG, it is possible to classify patients with a suspected myocardial infarction as sick and healthy with high accuracy. The optimized Random Forest model showed the best performance with an accuracy of 99.63%, and a root mean absolute error is less than 0.004. The proposed novel approach can be used for patients who do not have other indicators of heart attacks.[29]
- Faust, Oliver have developed system which focuses on HRV based medical decision support for automated healthcare systems, which create a resource for researchers which encourages future work on HRV application. It indicates the best machine and deep learning techniques for specific application areas and also highlight shortcomings of current HRV based medical decision support and propose possible solutions.[30]
- Alharbi, Eaman, and Akram Alomainy have developed machine learning models to investigate the relationship between HRV and cognitive performance in several cognitive domains. They have tested whether physiological variables obtained from ultra-short-term (10s) HRV could predict the cognitive performance of different cognitive domains. The results showed that the support vector machine (SVM) classifier reached 82% accuracy in detecting cognitive performance, whilst Linear Discriminant Analysis successfully achieved 90% accuracy in categorising data into high and low performance between different tests.[31]
- Yin, Qiang have proposed a method to extract signal features from heart rate variability signals and classify patients' states using the long short-term memory network and enable effective monitoring of noxious stimulation. For data processing, the heart rate variability signal is decomposed and recombined by the empirical mode decomposition method, and the signal features of the noxious stimulation are extracted by the sliding time window method. Compared with the average accuracy of direct classifications, the classification accuracy based on the proposed method is proved more accurate. The model based on the extracted features proposed can realize the classification of consciousness and general anaesthesia with an accuracy rate of more than 90% and accurately estimate the occurrence of tracheal intubation stimulation.[32]
- Ramteke, Ramyashri B., and Vijaya R. Thool have presented a new approach motivated by the long short-term memory network (LSTM) in sequence learning to generate a concrete decision about the signal category. They proposed deep learning-based Inception-LSTM network to improve performance and to reduce computational cost. Two different stress datasets, self-generated stress data and Physionet driver stress data were used to perform the proposed method's performance analysis. The presented Inception-LSTM architecture outperforms existing literature methods, achieving an accuracy of 93% for self-generated stress data and 97.19% for driver stress data.[33]
- Mouli, Pullagura M. Chandra have analyzed the effects of obesity on ANS(autonomic nervous system) using HRV parameters. Initially, 16 control subjects and 16 obese subjects of each sex between the ages of 20 and 50 were included when the synthetic minority oversampling technique (SMOTE) was used to increase the sample size of subjects control and overweight 16 to 48. Independent tests determined the statistical differences between the agencies. The study's statistical results suggest asympathetic imbalance due to a decrease in parasympathetic activity Machine Learning(ML)algorithm determines the most significant visionary that can distinguish between control and obese subjects.[34]
- Shukla, Reema Shyamsunder, and Yogender Aggarwal have developed decision making in diagnosis of breast cancer (BC) at the earliest is the necessity to decrease the mortality rate. The 5-minute electrocardiogram of 114 BC subjects and 13 age-matched healthy controls were recorded and spectral features of heart rate variability (HRV) were calculated. Fast Fourier transform (FFT) and autoregressive (AR) spectral methods were compared to analyze the frequency domain of HRV. Lavenberg–Marquardt algorithm-based artificial neural network (ANN) and support vector machine (SVM) classified all the spectral measures with maximum accuracy of 54.2% and 100%, respectively.[35]
- A pivot study has been carried out to examine whether nonlinear indices of HRV can be biomarkers of GC severity. Resting electrocardiogram (ECG) of 5-min was collected prior to surgical treatments to enable the HRV analysis. The results support the hypothesis that perturbations in nonlinear dynamical patterns of HRV predict increased GC severity. [36]

Table1: Review Table

Sr. No.	Author	Dataset Used	Technique Used	Advantages	Accuracy	Conclusion
1	Wang et al. (2018)	Electronic health records	Logistic regression	5-year survivability prediction using logistic regression	96.4%	Prediction for survival not for early detection of cancer
2	Akbugday (2018)	Breast Cancer Wisconsin dataset	KNN and SVM	Optimal k-Value for a k-NN classifier, g k-NN is a lightweight, lazy	KNN-96.85% SVM – 96.85%	Used for Classification of Breast Cancer

				learning algorithm with very short build times.		
3	Keles, M. Kaya (2019)	Wisconsin Diagnostic Breast Cancer dataset	SVM vs KNN, decision trees, and Naives Bayes	SVMs map the input vector into a feature space of higher dimensionality and identify the hyperplane that separates the data points into two classes. The marginal distance between the decision hyperplane and the instances that are closest to the boundary is maximized.	up to 96.91%	Data Mining classification algorithms are used for to identify Breast cancer tumor
4	KELES et al., (2019)	Wisconsin Dataset	RANDOM FOREST	Each dataset is generated with displacement from the original dataset. Then, trees are developed using a random selection feature but are not pruned.	92.2 %	Accuracy might to be increased and more accurate result can be achieved using other ML algorithms
5	Sinthia et al. (2017)	Wisconsin Diagnosis Breast Cancer BCI dataset	Logistic Regression and the Backpropagation Neural Network	It gives the most optimal hyperplane to distinguish between two classes	97.13%	Algorithm is useful to detect BC only if the mammogram image is provided
6	Khourdifi et al. (2018)	Wisconsin breast cancer dataset	Fast Correlation-Based Filter with SVM, Random Forest, Naive Bayes, K-NN, and MLP	Attributes are reduced by deleting irrelevant and redundant attributes, which have no meaning in the classification task techniques.	96.1%	Useful for prediction of Breast Cancer classification
7	Shi, Bo, et al (2019)	Data of 61 participants was collected	Linear regression model	It support the hypothesis that perturbations in nonlinear dynamical patterns of HRV predict increased GC severity	-	Study has been done for relatively small sample size
8	Shukla, Reema Shyamsunder, and Yogender Aggarwal (2021)	114 BC subjects and 13 age-matched healthy controls	FFT and AR method with ANN and SVM	clinicians can understand the severity of the disease so patients can improve standard of living	ANN 52% and SVM 100%	Only severity of disease can be predict for BC patients
9	*Ramtek*	Dataset-I	LSTM	comprised	93% and	Early

	e, Ramyashri B., and Vijaya R. Thool	self-generated ECG data Dataset-II Physionet driver stress ECG database	Network Model	the classification of stress and relaxation conditions of humans	97.19% for Dataset-I and Dataset-II	detection of disease cannot be predict
10	Pullagura M Chandra Mouli	ECG data of 16 normal controls and 16 obese controls of both gender	Classificationa ndRegression Tree (CART) and the Gradient Boosting Discussion Tree (GBDT)	ML algorithms can determine distinguish between control and obese subjects.	CART 96% and GBDT92%	Relatively small dataset has been used which may affect accuracy.

VI. RESEARCH GAP

Previous research has been carried out for classification of patients with tumours most consistently related to various cancers (i.e., breast cancer, prostate cancer, colorectal cancer, lung cancer, and pancreatic cancer). As per study conventional approaches like SVM, KNN, Random Forest, Naïve Bayes, ANN have been used for cancer classification which have accuracy between 70% to 96%. According to research reports, the changes in non-liner HRV measures have been reported as early signs of several diseases including Cancer but there is a lack of periodic HRV analysis in early diagnosis of cancer.

In order to identify cancer from Non cancer, several linear and non linear HRV features can be used. There is no clear agreement among researchers regarding the direction of influence between HRV and cancer and the timeline of observed cancer-related changes in HRV. A pilot study has been done for classification of cancer patient and healthy individuals for relatively small data (i.e. 72). It is possible that future studies could demonstrate on whether and how ML techniques and HRV analysis could be useful as a supplementary tools in Oncology for early detection of Cancer.

VII. CONCLUSION

This paper shows that various research has been carried out to classify cancer(BC, lung cancer, GC etc.) stages, also to classify between healthy individual and cancer patients using known machine learning algorithms and HRV analysis. Some research has been done for prediction of cardiac arrest in critically ill patients also HRV based medical support system has been developed for overall healthcare. We will be approaching novel algorithm and ensemble model for early detection of cancer using HRV analysis and Machine Learning along with external parameters like some life style habits e.g. smoking, drinking, obesity, lifestyle etc. Using all the parameters a supplementary tool will be developed which will be useful in Oncology.

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