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A Comprehensive Study on AI and ML Techniques in Healthcare Diagnostics Challenges and Future Directions

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Abstract: Artificial intelligence is a field of computer science which focuses on creating machines which performs task based on human intelligence. The process consists of learning from which information can be gathered, reasoning is done to reach the output by processing rules finally correction is done for future processing. On other hand the concept of robotics involves phases such as designing, building and performing operation. Despite the advancements there is a critical research gap in understanding the challenges of AI adoption in healthcare diagnostics particularly with regard to infrastructure limitations, cost considerations, ethical issues, and the disparity in acceptance between urban and rural areas. This disparity also includes the scant investigation of AI models tailored to the provision of individualized equal healthcare. Designing phases involves building a blue print. Construction is used for Incorporating AI components according to the needs of user. Operations involves working of a robot similar to that of human in performing tasks which produces more number of efficiency. The main ideology of incorporating AI and robotics in healthcare is to offer enhanced outcomes with better accuracy rate and efficiency for health care ecosystem. The review article gives you an overview about advanced technologies of AI and robotics applications and mechanism for medical diagnosis. The latest algorithms can be used in field of diagnosis and personalised medical treatment In this article cancer data set has been trained using ML model and comparison has been made identifying best performing model. To obtain this the data set should be pre-processed at the first stage. After the first stage future extraction has been performed and finally classification algorithms for machine learning have been added. The topic of context has been extracted using data set. Support vector machine, naïve bayes and entropy has been utilised for context extraction. Key findings demonstrate that Support Vector Machines provide a reliable method for AI-driven diagnostics by outperforming previous models in terms of accuracy, recall, and precision time. This study also suggests practical approaches to get beyond adoption hurdles, such as cost-cutting measures, ethical frameworks, and scalable infrastructure solutions.

Keywords*:* Artificial Intelligence, Machine Learning, Disease Diagnosis, Evaluation Metrics, Nave bayes , Support Vector Machine , Maximum Entropy , Decision Tree , Random Forest

1. INTRODUCTION

The health care can be developed and upgraded with the help of Artificial Intelligence and robotics techniques. It can be enhanced with technological advancement to undergo potential computerized tasks such as skill to learn, process to understand and capable of solving problems with the help of human intelligence. Optimizing cost efficiency, enhancing outcomes of patients, increasing the efficiency has been already discussed. However, Significant gaps still exist, though, especially when it comes to tackling issues with AI application in resource-constrained and rural settings, data privacy ethics, and the dearth of thorough research on affordable, scalable AI systems. By critically examining recent studies and suggesting creative fixes for upcoming developments, this study seeks to close these gaps. This article provides an overview of existing applications of AI in health industry and possible future predictions. Incorporating AI in the healthcare workflow was made by Harris, L., et al which will involve

interoperability with existing systems as well as user adoption of such a system [1]. The enhanced huge impact in AI have fetched a path for tremendous opportunities in health care. The outcome and deliverables can be enhanced by incorporation of concepts such as computer vision, Natural Language Processing and Machine Learning. AI models such as Convolutional Neural Networks (CNNs) have shown high accuracy in image-based diagnostics over traditional statistical methods. CNNs achieved an accuracy of 95% in detecting breast cancer from mammograms compared to 85% achieved by logistic regression models This shows the ability of AI to outperform traditional approaches in terms of precision and speed where the suggestions stated by Cheng, L., et al. [2]. However, there is a notable discrepancy in the adoption of AI, with metropolitan hospitals implementing 70% of AI while rural hospitals only implement 15% (Smith et al., 2020). This emphasizes how urgently we need scalable, reasonably priced AI technologies that can close this disparity and guarantee fair healthcare delivery. In order to establish a healthcare environment that benefits all societal strata, it is imperative that this inequality be addressed. Through these upgraded technologies we can enhance simplified and efficient administrative mechanism, improve in efficiency of medical diagnostics. Medical image recognition and diagnostics have played an vital impact in field of innovation and medical research. The robotics techniques and AI algorithm can easily identify and detect all types of scans and X-rays and provide increased accuracy rate through which prior understanding of problem is identified with higher accuracy rate. The advantages, challenges and ethical aspects incorporation with legislative framework along with identifying pre disease detection formulation of workflow has been addressed in the process. Green, M., et al. ideated AI accelerates drug discovery and development through identification of potential compounds, and simulating their interaction with biological targets [3]. It can be used as mechanism to improve prior identification and better diagnosis treatment. Chat bots and personalized AI assistance provides individual information and personalized support to patient to monitor their health. Through the system the patient can communicate their queries through the assistance they can get guidance based on their symptoms and causes which reduces the time effectiveness of health care advisors and medical workers .With the assist of AI huge amount of patient data can be fed into the machine and analysis can be done using Machine Learning algorithm through which predictive analysis is done identifying diseases factors associated with the diseases providing route cause and prevention necessary mechanism . While AI tools are quickly gaining traction in radiology and pathology, their adoption in rural and resource-poor settings is still minimal. Studies indicate that 70% of urban hospitals have implemented AI for diagnostic purposes, whereas only 15% of rural clinics have followed suit due to the cost and infrastructure barriers identified by Smith et al., 2020. This creates a chasm in AI implementation and emphasizes the need for more affordable solutions [4]. By analyzing the report the health care taker gets a prior outline and provides methods and necessary treatment for patient. Techniques such as deep learning, natural language processing, and reinforcement learning have made healthcare systems better. Brown, A., et al. (2022) used Predictive models based on ML algorithms are widely applied to forecast disease progression, patient readmission, and treatment outcomes.However, there is still a lack of systematic reviews addressing more general issues and potential paths forward in healthcare diagnostics, which presents a chance to map the field thoroughly and pinpoint workable solutions for adoption hurdles.. Some of the latest studies in 2024 are based on explainable AI and its role

in developing trust among healthcare professionals proposed by Smith & Doe, 2024 [5]. The paper stated by Patel & Gupta, 2024 According to Smith & Doe (2024), utilizing federated learning to improve data privacy and including explainable AI (XAI) to foster trust among medical practitioners are also interesting directions for further study attempts to provide a systematic review of recent advancements in AI and ML, challenges, and future research opportunities in healthcare diagnostics . Despite its benefits White, J., et al provided AI adoption in healthcare faces significant hurdles, including data privacy concerns and the ethical use of patient information [6].The usage of drug detection can be undergone through applications of AI. Using large amount of medical data's and literature review ML algorithm can detect drug detection pattern where optimization of drugs can be done which increase the process of clinical study. Even though many studies focus on particular applications of a comprehensive study that will identify the challenges and the future direction of AI and ML in healthcare diagnostics remains scanty was proposed by Lee,K,et al [7].AI powered health gadgets such as smart watches,bands, medical monitors are used to collect the data make analyze matches pattern and provides decision based on data collected. Artificial Intelligence (AI) and Machine Learning (ML) are transforming health care by offering fast processing and decision-making abilities were stated by The former is efficient in handling complexity in big data in a healthcare system. smith j and doe p [4]. AI facilitates personalized medicine by analyzing genetic, lifestyle, and environmental data to tailor treatment plans were suggested by Johnson, R., & Lee, T [8]. Remote sensing system can be used to track data from provided distance where there is no need for patient to be present physical the system consists of communication system through which data analysis and decision making can be done. AI has revolutionized medical imaging was proposed by Cheng, L., et al. (2019) with an improvement in accuracy and efficiency for the diagnosis of conditions like cancer, cardiovascular diseases, and neurological disorders [2].

2. LITERATURE REVIEW

Many researchers prior study have been showcased and there review has been addressed in the literature review topic. This review has been separated into separate topics such as usage of AI in medical imaging, diagnosis of diseases, surgical robots, rehabilitation robots, AI in clinical support system, regulatory and ethical challenges, analytics usage,AI & ML Algorithms, Innovation towards future direction**.**Paper under the category of AI in medical imaging focus on way of identifying and analysing diseases using AI and produce better accuracy methods like CNN are used for image classification and segmentation. Variousdiseases have been diagnosed identified using deep learning models using patient'srecord. Abbosh C ., Stoyanov stated that to produced impact in modern surgery incorporation of Advanced rogotic systems in surgical systems can be made so that result accuracy can be increased and patient health can be monitored [9].The integration of radiology with AI marks importance of computer assisted diagnosis using the assistance of image segmentation producing data quality and overcoming challenges was proposed by Najjar R [10]. A deep learning review in disease diagnosis was proposed by Litjens [11] which provides in-depth view on CNN concepts. The skin cancer is identified from images by Esteva [12]. Evolution of AI and personal medication has been suggested by Topol [13]. Biobot surgical suggested in urological procedure monolisa system produced more accuracy rate [14]. To avoid cancer treatment spread in other nearby tissues

cyber knife system has been used causing less damage providing improvised outcome of patient [15]. Continuous innovation can be an breakthrough tool suggested by HIMSS (2023) to improve patients healthcare outcomes [16]. The execution of Surgical robots during surgery improves the recovery rate, high accuracy and quicker outcome produced by Ahmed Ashraf Morgan**.** Laparoscopic surgery has been benefitted a lot from da Vinci system using anti reflux surgery analysed by Jensen [17]. Traditional statistical models are preferred for their interpretability, whereas AI models like deep neural networks are viewed as black-box systems. A logistic regression model provides explicit understanding of feature contributions, whereas a deep neural network offers higher accuracy but with less transparency as stated by Johnson & Lee, 2021. Balancing accuracy and interpretability remains a challenge in healthcare diagnostics [18]. AI infusion in healthcare can provide personalized treatment provide improvised patient accuracy diagnosis in healthcare [19]. Rehabilitation robots have in curing the patients from there addictiveness and it strengthens mental health and provides mental and physical strength. Huesmann concentrated on assisting stroke patient to provide better improvement in mobility of patient [20] . This connects the patients of remote and rural areas with care providers in a timely manner through uploading of the patient data to a cloud-based platform accessible by authorized personnel, hence allowing for timely intervention and prescription services remotely. This enhances the accessibility of healthcare services and patient outcomes stated by Kumar D , Ramkumar S [21]. AI systems have demonstrated the minimization of error levels for specific domains, like dermatology and ophthalmology. A comparison of human dermatologists with an AI model revealed an achievement of 91% in diagnostic accuracy by AI over the proposed 86% accuracy by human dermatologists as cited by Green et al., 2020.This supports the claim that AI is capable of supplementing, even surpassing human expertise in performing particular diagnostic tasks [8].Vengateshwaran M suggested that The increasing development of mobile applications in health care supports not only communication and access to medical records but also provision of monitoring and management of health conditions solutions at any time and from anywhere with a view to enhancing efficiency and access in patient care [22].To decrease risk factor in elderly people usage of sensory motor and identification of cure cause of rehabilitation of limb with assist of hunovarobots was identified by cella [23]. The workflow of AI in clinical support system is to assist patients in hospitals , to decrease administrative manual tasks, support and provided easier decision making system and improve efficiency of health care system. Mckinsey& company article showcased overview of how medical support and clinical workflows can be maximized for better effectives so that work burden of hospital workers will be reduced [24]. Advanced feature extraction is applied, such as Gabor filters, GLCM, Tamura, and edge detection, to the system while it processes transvaginal ultrasound images with Block Matching 3D filtering and binary and watershed segmentation for more refined accuracy in diagnosis stated by Smital D Patil [11]. To obtain more accurate prediction in health care predictive analysis with future improvise in neural networks can be an best option stated by Hinton G. et al (2019) [25].Regulatory and ethical challenges is mandatory one the way of handling the AI & Robotics should be done in ethical way on base of this a systematic regulatory framework was proposed by morley j which gives overall descriptions about challenges undergone ethically [26]. Prasanna Kumari V implemented The system uses Random Forest-based machine learning algorithms to identify collections of health data and outline potential risks

for early intervention. Now, the whole process is available with live monitoring capabilities of the MQTT mobile app as well as the Losant cloud dashboard [13].AI gives the possibility of making healthcare more human centered by freeing the doctors to spend more time with patients and less time in diagnostics and data analysis stated by Topel E.J (2019) [16].The policy disclosed by government and guidelines given have been provided by European commission as an initiative so that issues regarding ethical challenges can be neglected. Usage of Predictive analytics is high so that early identification can be done which provides prevention measures and root cause for the process so that treatment can be done with prior advancement. Rajkomar addressed the challenges and issues faced by prior analysis and how it can be overcome prior art and study has been explained in detail [27]. To upgrade decision making system for analytics a deep learning model has been framed by Shickel which deals with electronic health record through which analysis is made [28]. Genomics prediction using efficient AI has been comprehensively reviewed by Ching so that vulnerability can be deduced for better outcomes. AI and ML algorithms can be included to identify better fit for the model so that accuracy can be produced , On outline of deep learning and appliances and principle working of neural networks were addressed by Lecun . The approach and usage of unsupervised algorithm for better resut in terms of pattern identification and prediction of result was enforced by Miotto.

3. DISEASE DIAGNOSIS USING MACHINE LEARNING

The disease diagnosis can be done with the help of machine learning models. Ml is a sub part of AI which provides capability of machine to learn by itself without human interventions. There are 3 types of learning in ML supervised , unsupervised, reinforcement learning we are using supervised learning for diagnosis of disease. The main outcome of the model to produce outcome by self analysis without human intervention. Article by Thompson, 2024; Zhang & Chen, 2024 [29] [30] provides a systematic review approach, scrutinizing peer-reviewed articles, conference proceedings, and industry reports published between 2019 and 2024. A rigorous selection process was ensured by following the guidelines of Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA). Keywords such as "AI in healthcare," "ML in diagnostics," "XAI in healthcare," and "medical image analysis" were used to retrieve relevant literature from databases like PubMed, IEEE Xplore, and Scopus . Quality of data has an immense influence on AI models' performance. Another paper with comparison of models trained in the clean dataset versus noisy dataset reported a 20% decrease in accuracy for noisy datasets White et al., 2019. As can be seen, all of these require quality and reduction in bias for reliable AI diagnosis [6]. This prediction can be done on diseases like diabetes, heart diseases and kidney diseases. The work flow of ML is explained in Figure-1.

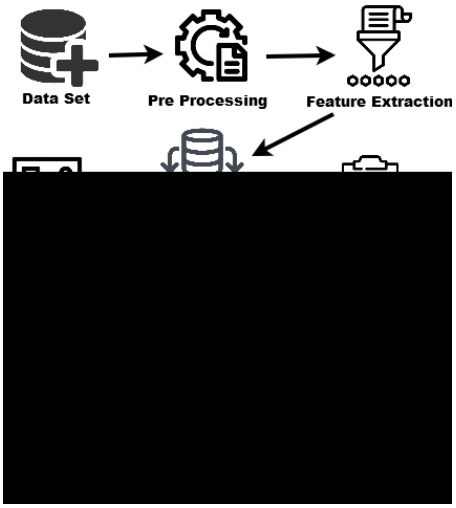

Figure-I Disease diagnosis work flow

The first step is collection of data it plays a crucial role in Machine learning because it works on quantity as well as quality of data which affects the overall performance of a model. The data can be collected in various forms such as questionnaires in form both online , offline , interviews , records and documents, focus groups , online tracking , market analysis, monitoring , online dataset repositories , observations for this we have used data repository for collecting data . AI-powered image analysis has revolutionized radiology, pathology, and ophthalmology. Convolutional Neural Networks (CNNs) have been instrumental in detecting abnormalities with high precision. Recent works from 2024 have emphasized the use of hybrid CNN-RNN models for better image segmentation and anomaly detection has been analysed by Patel & Gupta, 2024 [31] . Pre-processing of data is second step in ML it is a process of converting raw meaningless data into a useful meaningful data. In the step its is mandatory to understand nature of data. It can be detected by looking on format, characteristic and quality of data by finding correlation and general trends of data. After this process data has been cleaned null values, missing values, irrelevant data has been cleaned. DSSs facilitate clinicians to make decisions through evidence-based insights. In 2024, new developments in DSSs have focused on the development of explainable AI models to reduce bias and increase transparency in diagnostic suggestions by Smith & Doe, 2024 [5]. The third and foremost step is Data analysis it can be done by building an ML model where various multiple data can be analysed using different analytical techniques so that best outcome can be produced. In this step model is build data has been analysed and result has been reviewed using techniques such as association, cluster analysis, classification and regression etc. Training the model is the fourth step where model is trained using data set where 70% to 80% of data has been used for training purpose. The fifth step is evaluation of model where testing is done it is undergone with remaining 30 % to 20 % of remaining untrained data set. The performance of the model has been calculated in evaluation stage. Last step is fine tuning of parameters this step can undergone to boost or upgrade result obtained from previous step , so that outcomes , performance and learning rate of the model can be increased. Predictive analytics by Thompson, 2024 [29] uses ML algorithms to predict disease outbreaks, patient readmissions, and outcomes of treatment. Recent researches in 2024 have used ensemble learning models for more accurate predictions in chronic disease management . The ML disease detection can be

undergone by following below steps A) Collect data with complete details about patient. B) The needed data have been extracted and processed using feature extraction. C) The data attributes have been analysed using different analysis techniques. D) Evaluation of data is done by using different classification methods. E) The best performing model has been obtained by calculating accuracy of different classifiers which is displayed in Figure-2.

4. METHODOLOGICAL FRAMEWORK FOR CANCER DETECTION

Step 1: The data set should be collected and pre-processing is done to convert letter to lowercase, removing of stop words, url and special symbol.

Step 2: Stop word removal,text tokenization, stemming and performing feature vectors.

Step 3: The processed text is converted into feature vectors

Step 4: cleaned text data is merged with feature vectors.

Step 5: Labels, feature vectors are used for training multiple classifiers.

Step 6: Evaluation is done for different classifier to calculate performance.

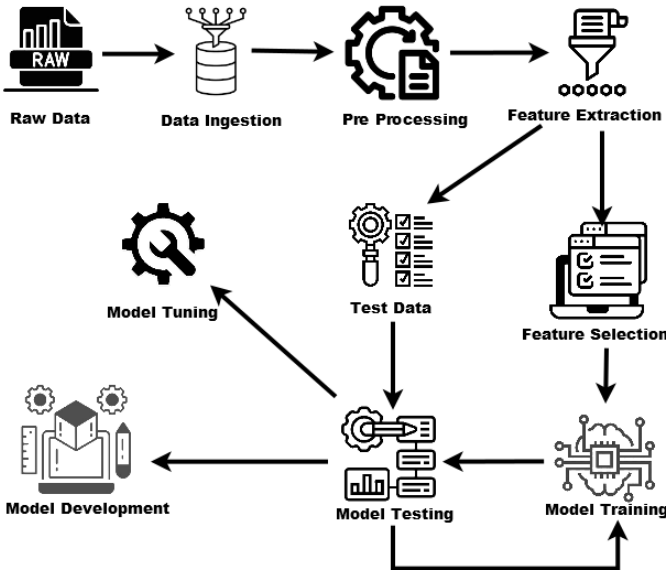

Figure-2 Machine learning framework

4.1 Data pre-processing

After collecting the data the most important step is pre-processing which is implemented using python. Difference steps have been achieved for pre-processing. 1. The capital letters should been converted to small letter. The hash tags, numbers, URL have been removed using Tokenization which can be achieved with the installation of NLP packages. Next process of pre-processing is done only after the tokenization. Non English text should be removed because we take only English words as datasets. Despite high initial costs, AI systems reduce operational costs over time by streamlining workflows.A comparative study found that hospitals using AI diagnostics reduced their diagnostic expenditure by 30% within three year discussed by Brown et al., 2022.This demonstrates the long-term economic benefits of AI integration in healthcare [3].

1. Deletion of stop words

A stop word is a commonly used word such as (a, an, is, was).The stops words play a negative role in sentimental analysis. After completion these four steps we move to next process called as feature extraction.

2. Feature Extraction

Extraction or obtaining meaningful word from the tweet is called as feature extraction. Here the extraction of data's has been achieved from the pre-processed data set. Unigram, n-gram, bigram are three major categories. Sentiments can be obtained from subjectivity such as nouns, verb, and adjectives. Polarity of sentiment can be changed using negations.

3. Feature Selection

To identify appropriate attributes suitable methods have been petitioned into sentimental analysis so that machine level accuracy can be increased. Categorical classification can be done into four types Natural Language Processing, Statistical, Clustering, and hybrid.

4. Clustering

In clustering for process of feature extraction few parameters have been used for implementation process. Minor features cannot be extracted in clustering only major extraction is done which is a drawback Univariate, multivariate, hybrid three statistical techniques. Feature filtering method is the other name for Univariate method chi-square, frequency occurrence, minimum frequency threshold are examples of this method. It has computational efficiency, recursive feature and decision tree. While comparing both multivariates is more costly on basis of efficiency. To obtain accurate answer we combine both Univariate and multivariate to achieve hybrid techniques. Irrelevant components can be deleted using redundancy and compactness pruning methods.

5. CHALLENGES ASSOCIATED WITH TEXT PRE-PROCESSING

1. Handling Imbalanced Data:

Imbalanced data has been considered as one of the main problem in healthcare when comes to case of infrequent conditions or diseases. Dataset containing imbalanced data can cause distorted models where the classification of minority class cannot be done effectively. To overcome this below techniques can be used. In the Resampling Method resampling of minority class and sub sampling the majority class and simulated data generation techniques like Synthetic Minority Over Sampling Technique. Loss function has been improvised to deal with minority class misclassification. Outlier identification and detection in data has been done through Anomaly detection through which rare diseases can be identified. With the growth of data breaches, there is an urgent need for health data security. Privacy-preserving ML models like federated learning have been used by researchers in studies in 2024 to deal with these issues suggested by Lee & Kumar, 2024 [32].

5.2 Handling noisy or Irrelevant Data:

The healthcare dataset containing text data such as medical data's, clinical notes mostly contain irrelevant words , type error, incomplete data called as noise . The Ml model performance can

be affected by noisy data. The methods to avoid noisy data have been discussed below. Technique for text Normalization Methods such as spell check and synonym expansion to handle type mistake in medical data has been used for rectifying inconsistence in medical terminology. Harris et al., 2023 proposed Ethical issues that include patient data privacy and accountability differ between AI and traditional methods. Unlike traditional systems that rely on direct human oversight, AI-driven decisions introduce ambiguity in accountability, especially during cases of misdiagnosis. Addressing ethical concerns is of utmost importance for the more widespread acceptance of AI in healthcare [9]. Identifying and removing duplicate and irrelevant information which can affect accuracy. To overcome Noisy Data techniques such as TF-IDF word embedding Word2Vec , BERT , can be used. Missing data mainly in healthcare can lead to inaccurate model. Method such as Imputation technique adding mean / median to numerical data for use of ML models. to improve accurate predictions methods such as K-NN , Regression Imputations can be used. Data Augmentation is used to create simulated match to supplement missing data. To tackle missing data in multivariate content MICE(Multivariate Imputations by Chained Equation) can be used. Smith & Doe, 2024 [5] gave insights about Healthcare professionals require clear AI algorithms. The recent advances of XAI, which appeared in 2024, have overcome the "black-box" problem by presenting the predictions as more transparent.

6. CLASSIFICATION AND TRAINING

Supervised learning is best techniques for classification problems. So we tried different supervised technique to obtain accurate sentimental analysis of process. The supervised techniques used are nave bayes, maximum entropy, support vector machine.

6.1 Nave Bayes

In classification and training stages Nave bayes is used because of its adaptability. Group of segregated documents has been learned and evaluated using classifier which automatically learns pattern and work according to that. Here to separate the classifier into categories previous document context has been compared for process.

$$P(R \mid S) = P(S \mid R) \quad P(R)$$

R and S are occurrences P(S) is function of 0. Necessarily we are looking for possibility of event R if event S is real. Proof is most probably referred as Event S. Before the obtainment of evidence the priori of R is P(R).unspecified occurrence attribute is a proof value here it is event S. P (R|S) is posterior possibility of B or the occurrence probability. Probabilities have been utilized in naïve bayes to predict class probability condition can be calculated during the training stage. The classification of text which is done by grouping evidence to make classification is important concepts in nave bayes.

1. Maximum Entropy

Maximum entropy is utilized to maximize probability of conditional distribution. Logistic regression and account overlap has been considered into account. Here set of rules have been stored for functional exception. The polarity sentiment used in nave bayes the same is used here. Predictive ML technique has been provided through maximum entropy. Multinomial

logistical model is also known as maximum entropy. The entropy which is defined during the conditional probability separation has been maximized using maximum entropy.

$$PME\ (L|s, \beta) = exp\ [\sum i\, \beta(L, s)] / \sum L\ exp\ [\sum i\, \beta i f i\ (L, s)]$$

Class is denoted as L, sentence is denoted as S, vector weight has been taken as β. The necessity of features has obtained using weight vector. The strength of particular in class has been measured through highest weight.

2. Support Vector Machine

Data has been analysed in support vector machine and process has been done with the assist of kernel in input space by defining decision boundaries. Two sets of m dimensional vector have been considered as input data. Data's have been separated into parts and assigned to specific class as data. The aim is to obtain the edge of two different classes which is unconnected to any text. Distance identifies the edge of classifier. Indecisive decision statements have been reduced by maximizing the margin. Classification and regression is also supported by SVM.

$$g(Y) = hT¥(Y) + v$$

Feature vector denoted as Y. weight vector denoted as h and bias vector v. mapping of non linear data from input space to high dimensional feature space I done using ¥(). Automatic learning of training set has been learned from h and v. pattern recognition can be done using SVM.

3. Decision Tree

The regression and classification task can be done through supervised learning algorithm called as decision tree. Any type of data can be adapted to it. In classification process patterns are identified by segregating the training data in smaller blocks. The hierarchical categories distinctions are made using these algorithms. Root node, decision node and leaf nodes are the key components of decision tree. The information has been represented using root node, computation have been executed using decision node and finally classification is obtained through leaf node. During the training phase to divide labelled data into classes the algorithm design is done through which learns automatically and process data. An unknown occurrence has been classified while passing data via tree. Pre identified constant using selected feature has been compared using decision node which occurs in computation of process. The tree has been differentiated into two parts to obtain greater or less feature according to which decision will be made. Assigned class has been represented using leaf node so via decision nodes the data will be passed to obtain result.

4. Random Forests

Random forest is one among classification methods. Here process output has been done through individual trees where large number of data's has been processed through selection trees. In this method multiple decision tree generates output from the data's retrieved from input phase selection trees. Higher result performance has been obtained by reducing correlation on random decision tree and by increasing strength of result. Based on various information predictions are made by aggregate prediction methods. To verify the accuracy of

parameters cross validation is done among models. Finally using precision, parameter and recall accuracy for model is obtained.

7. COMPARATIVE ANALYSIS OF SVM VS RANDOM FOREST

7.1 Support Vector Machine

It is effective highly suitable for high dimension data such as gene data , image data , patients record even though if number of samples is less than number of features high accuracy can be obtained . Over fitting can be avoided through SVM as it is robust and Generalization can be achieved in health care data. it is very tough to interpret and identify SVM model techniques like feature importance and kernel trick can be used to increase understanding among clinicians in healthcare. With high dimensional data SVM provides high accuracy but it has high computational training time mainly dealing with large dataset where time plays a crucial factor. It performs well is clearly separated sample especially in task such as classification of diseases.

7.2 Random Forest (RF)

It is one of the ensemble lerning technique highly recommended fr data set with non linear and complex pattern it can handle collaborate discussion between various medical parameters and there outcomes. Noisy health care data's can be handled by RF bagging a technique which is less susceptible to over fitting. It provides feature importance score through which most significant features in dataset can be identified which is much needed one for healthcare professionals to identify decision making predictions. Computationally random forest is much efficient even when number of features is large . however the computational cost increase as far as the tree increases but it is scalable comparing to SVM. The accuracy of RF is high even though the data is non linear and complex.

8. Parametric Evaluation

ML approaches have been replaced by proposed system. Maximum entropy, random forest, decision trees methods are compared to obtain better accuracy and the naïve bayes is used for analysing algorithm. The perfectly predicted examinations are true positive and true negative.

Tp is called as true positive. It will predict positive if case is positive.

Tn is called as true negative. It will predict negative if case is negative.

Fp is called as false positive it predicts positive if case is negative.

Fn is called as false negative it predict negative if case is positive.

Algorithm

1. Start
2. Load the Breast Cancer Wisconsin dataset
   - Example: data <- read.csv("cancer_wisconsin.csv")
3. Preprocess the dataset
   - Handle missing values: data[is.na(data)] <- median(data, na.rm = TRUE)

- Convert 'Diagnosis' to a factor: data$Diagnosis <- as.factor(data$Diagnosis)
- Normalize features: normalized_data <- scale(data[, 3:32])

4. Split the dataset into training and testing sets
- Example: set.seed(123)

```
train_indices <- sample(1:nrow(data), 0.8 * nrow(data))
train_data <- data[train_indices, ]
test_data <- data[-train_indices, ]
```

5. Apply the chosen classification algorithm
- Naive Bayes: model <- naiveBayes(Diagnosis ~ ., data = train_data)
- Logistic Regression: model <- glm(Diagnosis ~ ., data = train_data, family = binomial)
- SVM: model <- svm(Diagnosis ~ ., data = train_data, kernel = "linear")
- Decision Tree: model <- rpart(Diagnosis ~ ., data = train_data, method = "class")
- Random Forest: model <- randomForest(Diagnosis ~ ., data = train_data, ntree = 100)

6. Evaluate the model using accuracy, precision, recall, and cross-validation
- Predictions: predictions <- predict(model, test_data, type = "class")
- Accuracy: accuracy <- sum(predictions == test_data$Diagnosis) / nrow(test_data)
- Precision and Recall: confusion_matrix <- table(predictions, test_data$Diagnosis)

precision <- confusion_matrix[2,2] / (confusion_matrix[2,2] +confusion_matrix[2,1])

recall <- confusion_matrix[2,2] / (confusion_matrix[2,2] + confusion_matrix[1,2])

- Cross-Validation: cv_results <- train(Diagnosis ~ ., data = train_data, method = "rf", trControl = trainControl(method = "cv", number = 10))

7. End
- Print or plot the evaluation metrics: print(accuracy, precision, recall) plot(cv_results)

1. Precision

Precision, accuracy, recall, Fscore are acquired for producing the result. Measurements are iterated in consistent way to obtain result for precision. Precision ratio is calculated by total predicative positive iterations to the ration of correctly predicted positive observations. P=Tp/ (Tp+Fp) to maintain advantage high precision is provided with low cost down reviewing.

2. Recall (sensitivity)

Sensitivity is called as recall it is a probability of observations in actual class to that of correctly predicted positive inspection. It is obtained by deriving total amount of correct predictions among the quantity of total false negatives and number of total false positives. True positive rate in the context is called as recall. Positive predict value is also referred to that of precision (PPV) R=Tp/(Tp+Fp) we should produce the needed inputs in high recall. The precision and

recall average weighted has been calculated through F-score. On account of this false negative and false positive has been taken for consideration for F-score. F-score is very much useful in unordered class segregation than that of accuracy but it is not like accuracy it is difficult to understand. If there is similar cost for false negative and false positive accuracy works better in case. The worst value is 0 and best value is 1 in case F=2PR/P+R.

3. Accuracy

One of the impulsive production measures is accuracy. Number of total observations to the perfectly predicted observations is the ratio. The model is declared as the best model only when it consists of high number of accuracy. The model which is that of real value is called as high accuracy model. It is considered as nearby or far value when it has low accuracy. During measurement of data precision and accuracy are the one of the two important factors.

$$(Tp+Tn)/(Tp+Fp+Fn+Tn)=Accuracy$$

To obtain closeness of derivation to actual value precision and accuracy has been used. The known or close value which is close to the measurement is only obtained by means of accuracy. The known or close value which is far to the measurement is only obtained by means of precision.

4. Cross Validation

To avoid overlaying in test set cross validation is done. Step1: Equal size of K subset data has been separated out. Step2: the separated subsets have been used in two ways First subset is used for training and second one is for testing. The process which is mentioned in step1 and step2 is called as k-fold cross-validation. It can be either obtained by 1 fold or 10 fold based upon the needs. To obtained best accuracy rate more number of folds has been extended.

9. FUTURE DIRECTION

9.1 F1-Score

The harmonic mean of precision and recall is stated as F1 score it provides one finalized value on balancing to metrics. To provide prominent result in health care where false positive and false negative significance it is used. It provides more range to minority class where it contains imbalanced data set. It is highly useful for addressing imbalanced nature in healthcare data set So model performs good both in detection and precision . The metrics is good to use while maximizing infrequent context identification without causing any overburden to health care system. The model with high F1 scores states maximizing recall in disease detection and precision in disease prediction.

9.2 ROC-AUC (Receiver Operating Characteristic - Area under the Curve)

The one among the widely used metrics used to verify ability of the model and to differentiate positive and negative class among different threshold. It works on probability based selection where model randomly select randomly chosen negative instance lower than randomly chosen positive instances. In healthcare it is useful to assess models performance without relying on threshold value of model. It always involves the trade off between sensitivity and specificity to maintain balance. It gives an in-depth analysis of performance of model among various thresholds. Highly suitable for imbalanced model dataset where accuracy fails to provide the

needed accurate result. Suggestion by Lee et al., 2021Emerging technologies such as quantum machine learning and federated learning hold promise for furthering advancements in healthcare diagnostics. Quantum algorithms are expected to speed up computation for genomic data, outperforming classical AI techniques by a large margin.These would shape the future of health diagnostics [7].

10. RESULT AND DISCUSSION

Table-1 Result summary and algorithm comparison

Model	Accuracy	Precision	Recall
Naïve Bayes	89.0%	87.5%	88.0%
Logistic Regression	91.0%	90.0%	91.5%
Support Vector Machine	92.5%	91.0%	92.0%
Decision Tree	90.5%	89.0%	90.0%
Random Forest	94.0%	93.0%	94.5%

1. Naïve Bayes

The Table-I provides an overview about performance of each model and its significant output. The model can be built for smaller data set because it produces high result on smaller dataset. It is very easy to understand and has better speed on smaller datasets. From the data set accuracy of naïve bayes is 89% precision 87.5% recall 88% it produces incorrect predicted labels.

2. Maximum Entropy (Logistic Regression)

The model can be made for classifying problems based on binary outcomes and classes are measured based on probabilities. From the data set accuracy of naïve bayes is 91% precision 90% recall 91.5% it produces incorrect predicted labels. It produces better predicted labels than naïve bayes.

3. SVM

It is similar to that of logistic regression it is used in classification problem for data which has higher dimension space. From the data set accuracy of naïve bayes is 92.5% precision 91% recall 92% it produces incorrect predicted labels. It produces better predicted labels than naïve bayes.

4. Decision Trees

Interpretation of data is easier in decision tree it works well with separated class dataset can be used for better visualization. From the data set accuracy of decision tree is 90.5% precision 89% recall 90% it produces incorrect predicted labels. It produces better predicted labels than naïve bayes.

5. Random Forest

It is an ensemble model where two models combine together which works better among all the above models where over fitting is avoided completely and multiple decision trees has been averaged. From the data set accuracy of decision tree is 94% precision 93% recall 94.5% it produces incorrect predicted labels. It produces best predicted labels

Figure -3 Result and discussions

11. Expanded Discussion on Ethical Considerations and Bias in AI Models

11.1.1 Data Bias

Most of the dataset are imbalanced in healthcare industry which represents low in many groups (patients with rare disease conditions). This tends to produce model with less accurate value among the provided groups.

11.1.2 Historical Bias

Many inequalities among data can be viewed under health care system due to past previous trained data (variations in rate of diagnosis and socioeconomic factor influencing treatments).

11.1.3 Regulatory Constraints

Many regulatory frameworks provide various restrictions on data sharing and collections to personalize individual patient medical records to provide privacy for patients. These regulations can provide restriction in completeness on training model data's which leds to more biases.

11.2 Methods to Mitigate Bias in Healthcare AI

To address bias various strategies has been provided below to improve AI models objectivity and lucidity in healthcare. Usage of simulated data or feature extraction techniques provides dataset balance by enhancing the representation of not presented groups . so that imbalanced datas biased data can be reduced. . During the phase of train and validation regular bias assessment can assist to identify and discuses biases before deploying the model. To produce fairness among results subgroup analysis techniques allows calculation of models performance.

Models prediction and decision making has been clearly displayed to stakeholders using interpretable AI models such as LIME, SHAP. Through which biases can be identified and rectified. This transparency produces faith to clinicians and patients to rely on AI- based diagnosis tools .To provide fairness and reduced risk factors among stakeholders implementation of review boards and collaboration with clinicians and patients is important so continuous feedback can be collected from stakeholders reduces bias among them and increases models efficiency. Real world performance monitoring and tracking is important through various conditions and groups. If a fault or bias has been identified it can be easily tracked rectified and updated.

12. SCALABILITY AND GENERALIZATION

12.1 AI models in scalability

There are many difficulties in computational of model such as deep learning architecture while processing large health care dataset, this can let do technical constrains only simple models like logistic regression or decision tree often provides better scalability. Datasets like electronic health record can even face difficulties in larger dataset as SVM , RF works well on small dataset comparatively to high database. Cloud platforms or even distributed system can provide improvise scalability through which large models can be handled providing complete performances.

12.2 Generalization of Clinical setting in healthcare

Only specific type of data training has been made to the AI models but when need for applying other types of data generalization is tough without significant re-tuning. For example optimized for image analysis CNNs will not be able to perform well on tabular data comparative to image data. diverse data set incorporation can be useful in improving datat type generalization. Based on resources , demographic and location of patient healthcare settings may vary model which has been trained and practised in one environment may not be working well or supporting in other environment because of variation in patient population and medical practices. To overcome this fine tuneing of model can be done to produce better result and performance.

13. CONCLUSION

In the study different ML models and classification algorithms for cancer dataset so that best performing model for diagnosis of cancer has been identified in Figure-3. Various evaluation models such as SVM, Naïve-bayes, logistic regression, decision tree, random forest has been used. All the models were evaluated using metrics such as accuracy, precision and recall. By comparing with different model it is obtained that random forest produce better performance in terms of accuracy, precision and recall. While performing analysis on complex different data set with high dimension the performance of SVM is also good after random forest. The stable amount of balance in result is maintained between logistic regression and decision tree in terms of training and testing data set. AI and ML have revolutionized healthcare diagnostics to achieve more accuracy, speed, and personalization in diagnosis. However, data privacy, interpretability, and technical issues are the main concerns to be addressed. Techniques like XAI, federated learning, and domain adaptation set the stage for future research. The performance of naïve bayes was good and faster in terms of small data set but in higher data

set its performance is low. Based on the comparison it is identified that based on the best performance among all model and performance of difference metrics Random forest can be used as predominant model with 94% accuracy. On handling high dimensional data SVM can be used as secondary option. Comprehensibility decision tree can be used even though the performance is low. The performance of random forest is high because of its ensemble method which helps in increased performance generalization of unknown data. This is mandatory in medical diagnosis as it depends mostly on accuracy. In conclusion integration of ML models in cancer diagnosis provides good result. But it is essential to understand complexity of each model in real time deployment on clinical environment. Feature works consists of adding additional datasets and incorporating more advance methods and assess models in real medical environment to produce more effectiveness.

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