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Review Article

A Comprehensive Survey of Machine Learning in Healthcare: Predicting Heart and Liver Disease, Tuberculosis Detection in Chest X-Ray Images

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***Abstract** - The utilization of Machine Learning (ML) has become widespread across several disciplines. ML is utilized as an effective support mechanism in clinical diagnostics due to the abundance of publicly accessible data. The prevalence of heart and liver disease has been seen to increase dramatically due to factors such as excessive alcohol intake, inhalation of toxic gases, narcotics usage, food contamination, and bad lifestyle choices among individuals. Both cardiovascular disease and liver disease are significant contributors to global death rates. The early detection of these disorders is of utmost importance in order to preserve individuals' lives. The integration of ML classification algorithms into healthcare institutions has demonstrated notable results, enabling medical professionals to expedite and enhance illness diagnosis with heightened precision. The use of healthcare data may be effectively employed to select the most suitable trial sample, gather more data points, evaluate continuous data from trial participants, and mitigate mistakes arising from data analysis. ML techniques play a crucial role in identifying initial signs of an epidemic or pandemic. The system analyses satellite data, news and social media reports, as well as video sources to ascertain the potential escalation of the illness. The use of ML in the healthcare sector has the potential to introduce a multitude of opportunities and advancements in this domain. The automation of information retrieval and data entry tasks allows healthcare personnel to allocate their time more effectively towards patient care rather than being occupied with such administrative duties. This paper explores the many uses of ML in the field of healthcare industry, highlighting its significance. It subsequently explores the relevant characteristics and essential components of ML that are suitable for the healthcare framework. Ultimately, the study successfully discovered and thoroughly examined the notable uses of ML in the field of healthcare. The utilization of this technology in healthcare operations can yield significant benefits for society.*

***Keywords** - Artificial Intelligence (AI), Chest X-ray, Deep Learning (DL), Healthcare, Machine Learning (ML), Heart disease, Liver disease, Particle Swarm Optimization (PSO), Tuberculosis, Support Vector Machine (SVM).*

1. Introduction

The heart is considered one of the most vital organs in the human body, and the second is the brain. The basic function of the heart is to facilitate blood circulation throughout the whole body. Heart illness encompasses a range of conditions that possess the capacity to impede the normal functioning of the heart. A large array of cardiovascular illnesses exists on a global scale. As per the World Health Organization (WHO), cardiovascular functions such as heart attacks and strokes are the primary contributors to global mortality. According to the WHO, cardiovascular disorders are responsible for a significant number of global fatalities annually. Cardiovascular problems accounted for almost 50% of mortality rates in the United States (US) and several other nations. In several geographical areas, it stands as a prominent factor contributing to mortality. It is well recognized as the primary factor contributing to mortality among adult individuals. Cardiovascular disease is a prominent contributor to mortality rates in industrialized countries around the globe. Several conditions might contribute to an increased risk of heart failure. Medical professionals have categorized risk factors into two distinct groups: modifiable and non-modifiable risk factors. The risk variables of family history, gender, and age remain unaltered. Modifiable risk factors encompass several aspects that may be altered or influenced, such as obesity, smoking, physical ailments, elevated blood pressure, and excessive levels of happiness. The early detection of cardiovascular issues has the potential to reduce death rates. However, a significant number of individuals remain uninformed about the precursory variables that contribute to the development of cardiovascular illnesses. Healthcare groups are endeavouring to detect the disease during its initial phases. The illness is commonly identified just during the advanced stages or postmortem. This phenomenon has prompted healthcare organizations to strive towards early detection of illnesses. Heart illnesses may be classified into two main categories, namely coronary heart disease and cardiovascular disease. The phrase "cardiovascular disease" encompasses a range of disorders that affect the heart, blood vessels, and the body's circulatory and cardiac systems. Cardiovascular illnesses encompass a wide range of ailments, impairments, and fatalities. The process of disease diagnosis is a crucial and challenging undertaking within the field of medicine [1].

ML is a specialized field within the discipline of computer science that is dedicated to enhancing the capacity of computers to innovate. The field of ML encompasses a multitude of practical implementations that have become integral to our everyday existence, with a notable emphasis on the healthcare sector. ML encompasses several components, such as feature extraction/selection, algorithm selection, training, and testing. The significance of ML in the healthcare domain stems from its robust capacity for data analysis. Scientists commonly demonstrate their interest in prediction and diagnosis by utilizing ML methodologies that aim to reduce the time required for diagnosis while simultaneously enhancing accuracy and efficiency. By employing supervised ML algorithms, it is possible to identify any sickness [2].

Supervised ML algorithms may be employed to diagnose several categories of diseases, with a particular emphasis on the detection of heart and liver diseases in the context of this work. Cardiovascular and hepatic diseases have emerged as prominent contributors to global mortality rates, underscoring the urgent need for quick and accurate diagnosis in order to combat these conditions and prevent loss of life effectively. The heart and liver are often recognized as the most vital organs within the human body. Consequently, cardiovascular and hepatic diseases are widely recognized as significant health issues in daily existence. Multiple findings indicate that heart and liver problems are the prevailing factors contributing to instances of abrupt mortality in developed nations. Cardiac and hepatic diseases are now affecting neonates as well. Consequently, the practice of conducting tests to diagnose heart and liver problems is widely prevalent in routine daily activities [3].

The healthcare sector has consistently demonstrated a strong inclination towards embracing state-of-the-art technologies. AI and ML have been widely utilized in the healthcare sector, similar to their uses in the realms of business and e-commerce. The potential applications of the technology are nearly endless. ML is playing a pivotal role in the advancement of the healthcare sector by using state-of-the-art technologies [4]. Big Data tools have been employed by healthcare institutions for advanced data analytics, mostly due to the implementation of compulsory protocols such as Electronic Medical Records (EMR). ML tools are poised to provide further value to this process. These technologies enhance the efficacy of automation and intelligent decision-making in primary and tertiary patient care as well as public healthcare systems. The potential ramifications of ML techniques are considerable since they can enhance the overall well-being of a substantial global population [5-7].

ML technologies offer a diverse array of applications in enhancing the research conducted in clinical trials. By utilizing advanced predictive analytics on clinical trial candidates, healthcare practitioners may assess a wider array of data, hence mitigating costs and time associated with medical examinations. There exists a diverse range of ML applications that possess the potential to enhance the efficiency of clinical trials. These applications can aid in the determination of ideal sample sizes to maximize efficacy and mitigate the occurrence of data mistakes by leveraging Electronic Health Records (EHRs). The approach presented herein aims to tackle a notable concern within the healthcare domain, namely the global scarcity of proficient radiologists. A further advantage of ML in the healthcare industry is the ability to provide personalized medicines that are both dynamic and efficient through the integration of personal health data with predictive analytics [8-10].

ML possesses several potential applications in the domains of research and clinical trials. Utilising ML-based prediction methodologies for the identification of latent clinical trial participants enables researchers to efficiently leverage a multitude of data sources, including past medical consultations, social media activity, and other relevant information. Additionally, it guarantees real-time access to data. It effectively oversees trial associates, hence facilitating the determination of the most suitable sample size for investigation and harnessing the potential of electronic systems, which contributes to the mitigation of mistakes associated with data analysis [11, 12]. Currently, there is a substantial number of electronically captured medical imaging data available. This collection may be analyzed using different algorithms to identify and detect trends and abnormalities. ML algorithms can interpret imaging data with a level of proficiency comparable to that of a proficient radiologist. They are able to identify and discern irregularities such as aberrant skin patches, lesions, tumours, and instances of brain hemorrhaging. Consequently, it is anticipated that there would be a significant enhance in the use of these platforms for the purpose of assisting radiologists [13, 14].

2. Ground and Related Work

In relation to the subject, we have included a selection of scholarly articles pertaining to studies focused on predicting heart-related conditions. The development of methods to forecast the likelihood of an individual experiencing cardiovascular disease holds significant potential benefits for both the medical field and people. Although we acknowledge the potential dangers linked to cardiovascular disease, it is within our capacity to enhance public consciousness and promote proactive measures for prevention. Consequently, a multitude of researchers have identified diverse methodologies and models for detecting cardiac ailments. The study shown below is the latest contribution in this field.

In [15], many feature selection strategies into different classifiers are used. The data underwent preprocessing through the removal of missing data and the utilization of standard and min-max scalars. Three feature selection strategies were utilized to pick crucial attributes. The lowest redundancy maximal relevance feature selection approach is designed to identify significant traits while eliminating duplicate features. It is the choice of relief features. The algorithm selects attributes by considering the weights supplied to them. These algorithms employ a method that minimizes relative shrinking and selection, selecting features by updating coefficients and deleting characteristics that have values close to zero. In [16], the rates of cardiac breakdown in relation to changes in pulses are examined. They employed temporal analysis, ML techniques, and Convolutional Neural Network (CNN) models to evaluate this phenomenon. In [17], the application of ML methods for the estimation of cardiovascular risk in persons diagnosed with severe Dilated Cardiomyopathy (DCM) during one year is introduced.

The ML model produced 40 healthcare information highlights, from which the information gain algorithm selected important highlights that exhibited a strong association with heart disease. The research is centered on cardiovascular infections in individuals who were utilizing prescribed medications. In [18], the identification of continuous arrhythmia heartbeat is demonstrated. This identification was achieved by the utilization of two techniques: parallel delta modulations and rotational linear SVMs (SVM). Photonic crystals facilitate the detection and identification of fluorescence phenomena, a computational model aimed at forecasting the probability of cardiac events in persons with hypertension. The algorithm uses Electrocardiogram (ECG) data as its input [19]. The researchers used a CNN [21] with a long short-term memory network to construct a hybrid model. Time series data were employed to identify an early increase in hypertension among the participants [20].

A number of researchers in the field of medicine have conducted studies on diverse methodologies aimed at enhancing the accuracy of data categorization. Methods that provide improved and precise categorization will yield further evidence for identifying potential patients and enhancing the accuracy of diagnosis. Various ML classifiers, such as Decision Tree (DT), K-Nearest Neighbour (KNN), Random Forest (RF), and Logistic Regression (LR), as well as optimization algorithms like Particle Swarm Optimization (PSO), Firefly Algorithm (FA), and Genetic Algorithm (GA), have been utilized in the context of predicting heart and liver diseases. In the second reference, a novel approach for categorizing cardiac arrhythmia beats is introduced. The method incorporates several algorithms, including the Pan-Tompkins algorithm for R-peak recognition, the Discrete Orthogonal Stockwell Transform (DOST) for feature extraction in ECG signals, and SVMs for automatic cardiac arrhythmia beat classification.

The parameters of these algorithms are adjusted using the PSO [22, 23] method. In this study, the researchers utilized classification methods, namely Naive Bayes and SVM approaches, to make predictions regarding liver illnesses [24]. The performance parameters employed for the purpose of comparing these classifier techniques encompass classification accuracy and execution time. Depending on the experimental results, it is concluded that the SVM has superior classification performance in the prediction of liver illnesses [25]. The main objective of this work is to employ several classification approaches in order to forecast liver disease. The methods utilized in this research are Logistic Regression, K-Nearest Neighbours, and SVMs. The evaluation of this categorization system involves the utilization of an accuracy score and a confusion matrix for comparison. The effectiveness of LR in predicting liver sickness has been established. In this work, the researchers investigate the efficacy of several ML techniques, including KNN, DT, LR, and SVMs, in accurately predicting cardiac diseases.

The UCI repository dataset is utilized for both training and evaluating the SVM model [26]. According to the study referenced in [27], opinion mining employs DT-based feature selection techniques to predict heart disease with reduced characteristics, resulting in improved accuracy in the experimental findings. In a previous study [28], researchers have recommended the use of unsupervised rough set approaches for online opinion text clustering. The objective of this approach is to get enhanced outcomes in terms of clustering performance. Nevertheless, the current methods for classifying liver diseases have a low level of accuracy, rendering them inadequate for practical use. The rising prevalence of heart and liver disorders, along with the potential reduction in death rates with effective treatment, underscores the imperative for robust diagnostic measures. Nevertheless, the current methods for classifying liver and heart diseases exhibit a limited and unsatisfactory level of accuracy, rendering them impractical for real-world applications. The primary aim of the project is to develop a hybrid model that combines a modified PSO approach with an

SVM for the prediction of heart and liver diseases. The primary aim of this project is to develop a hybrid model that combines a modified PSO [29, 30] approach with SVM for the prediction of heart and liver diseases. The current hybrid algorithms and ML classifiers exhibit limitations in providing precise outcomes for illness prediction.

In the study conducted by the researchers, cognitive approaches were employed to make predictions on the occurrence of heart illness [31]. This investigation is to evaluate the predictive accuracy of five ML techniques. The prediction of heart illness is accomplished through the use of bagging models. In contrast, the implementation of the logistic model tree is employed to enhance the accuracy and effectiveness of the predictive outcomes. It is well acknowledged that research employing random forest estimates has yielded outcomes of notable accuracy. According to source [32], the enhancement of the model's predictive capacity for heart illness was achieved through the resolution of the overfitting problem. Overfitting is a phenomenon in which a model achieves perfect accuracy in predicting cardiac illness when trained on a specific dataset but exhibits greater performance on test data than first expected.

A model with high efficacy on both training and testing datasets has been developed to tackle these issues. The model is predicted by two algorithms, namely, the random forest method and the random search algorithm. The presented strategy yielded improved outcomes in both the testing and training datasets. A hybrid AI model was developed to forecast coronary disease by integrating the strengths of the LR and RF techniques. By employing this approach, the predictive model attains the utmost degree of precision. Minimizing the presence of unneeded symptoms and indicators can contribute to a reduction in the number of tests that patients need to undertake [33]. The utilization of an Internet of Things (IoT)-enabled system, specifically designed for diagnostic prediction and patient monitoring, yielded the most favourable outcome with a 93% accuracy rate when employing the RF algorithm. Furthermore, the study employed bagging, RF, Naive Bayes (NB), and KNN techniques [34].

3. Methods Based on ML

AI is a broad concept, including machines and/or programmes that exhibit varying degrees of intelligence. ML is a main domain within the study of AI that focuses on the development and implementation of algorithms capable of autonomously acquiring patterns from data without the need for explicit instruction from a human agent. Figure 1 illustrates the correlation between AI and ML.

In recent years, the increased accessibility of substantial volumes of data and computing capabilities has resulted in a surge in the use of ML across several domains. Deep Learning (DL) is a specialized domain within the broader subject of ML that focuses on the use of Artificial Neural Networks (ANNs). ANNs are structured algorithms designed to emulate the learning processes seen in human beings. In recent times, DL has gained preference over conventional ML approaches for handling intricate jobs involving substantial volumes of intricate data. There are three primary categories of ML algorithms, namely supervised, unsupervised and reinforcement learning. The following paragraphs provide a comprehensive examination of the three primary categories, while Figure 2 provides a concise summary of illustrative methodologies.

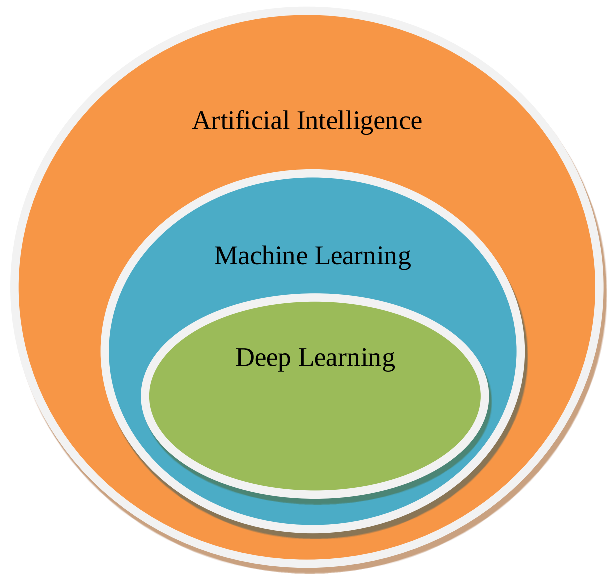

Fig. 1 AI and ML Relationship

ML algorithms are often categorized into two distinct classes, namely generative models and discriminative models. This research utilizes a range of supervised ML approaches to analyze activity recognition. Consequently, NB, KNN, and SVM demonstrate a greater ability to identify the activities accurately. The NB approach may be classified as a generative model, whereas KNN and SVM can be categorized as discriminative models. The classification method known as Naïve Bayes [36] is founded upon the principles of Bayes' theorem and the assumption of naïve independence. The classification approach for activity recognition is straightforward. The technology utilizes a comprehensive dataset of user behaviour sensor data to discern and classify human activities. The classifier utilizes the autonomy assumption to make predictions on the distribution of parameters. A discriminative model is used for the purpose of classifying data into the appropriate class, using the SVM classifier. The SVM model effectively distinguishes between two classifications, enabling the reliable identification of the appropriate class for new data points. Various established procedures may be used in order to ascertain and delineate this division. One potential method for effectively separating the partition from its support vectors is by using a linear approach that aims to maximize the separation. The support vectors refer to the data points in the training dataset that are nearest to each class. The SVM [37] use a hyperplane formulation to categorise fresh data points xi into distinct classes using a specific function. In several cases, SVM classifiers exhibit reluctance to partition the input data into specific classes via the use of a linear hyperplane. The resolution of this issue involves the use of non-linear functions to convert input data that exists in high-dimensional spaces. This methodology facilitates the differentiation of the input data, hence enabling the transformed space to provide a linearly separable plane. The considerable magnitude of the space, conversely, presents challenges in calculating the inner product of two vectors that have transformed.

Kernel functions are specifically developed to address this concern since they are used inside the feature space as a substitute for the inner product of two transformed data vectors. By appropriately using kernel functions, it is possible to reduce the computational work required to accomplish operations. The selection of an appropriate kernel function is crucial for some applications of SVM-based categorization. The judicious selection of a kernel function enables SVMs to harness their learning capabilities effectively. The literature has discussed a range of kernel characteristics. The first assumption made by SVMs is that the dataset is linear and hence constructs a hyperplane. The use of the kernel is thereafter applied to reduce the error in the dataset generated by the assumptions of SVMs [38]. The Alternating DT is an ML technique that aims to improve and generalize the decision tree classification algorithm. The categorization of the decision tree comprises decision and forecast nodes.

A single numerical value characterizes prediction nodes, whereas Decision nodes generate a predicate. Both the roots and the leaves have the potential to include prediction nodes. The classification approach operates by systematically traversing each possible route to the conclusion of all decision nodes while including any encountered prediction nodes. The classifier used in this study is a Random Forest [39], which utilizes the cluster approach. The proposed approach integrates the decisions made by many weak classifiers in order to provide optimal outcomes in the classification task. RF is an ensemble learning technique that mixes many DTs to achieve optimal classification accuracy. The tagging approach is used to enhance a group of decision tree classifiers with limited performance. This strategy involves either modifying the data samples or selecting an arbitrary input from a selection of features.

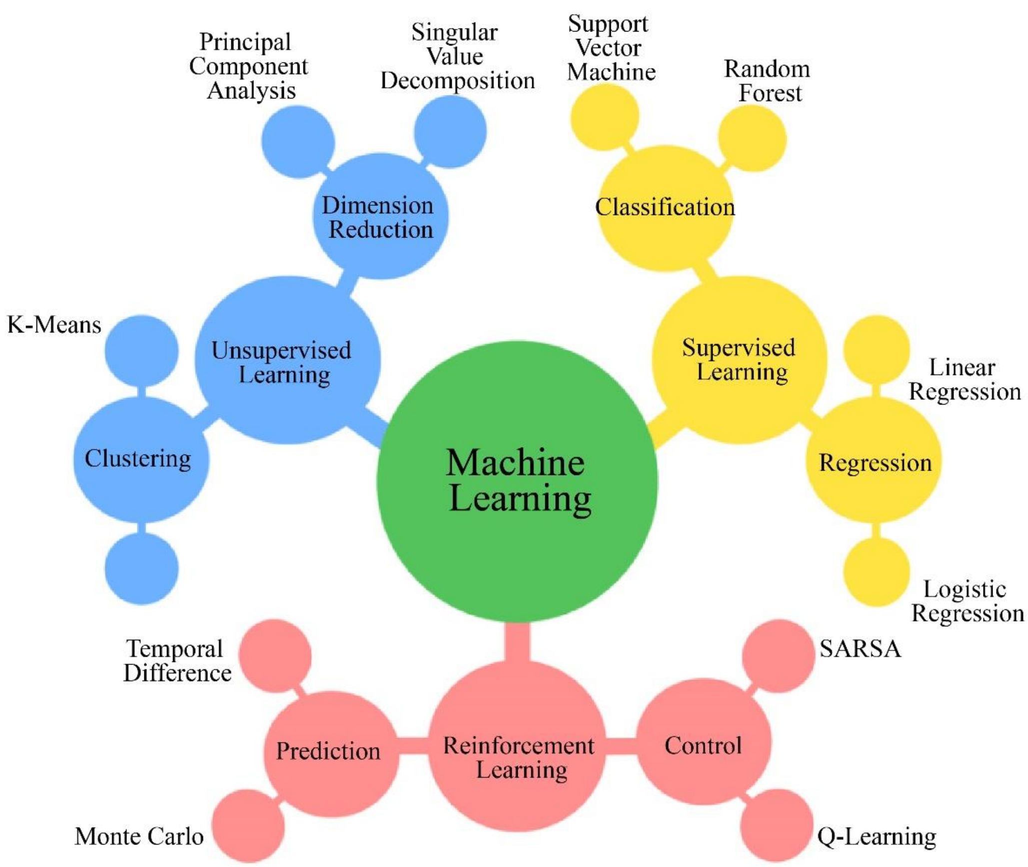

Fig. 2 ML techniques

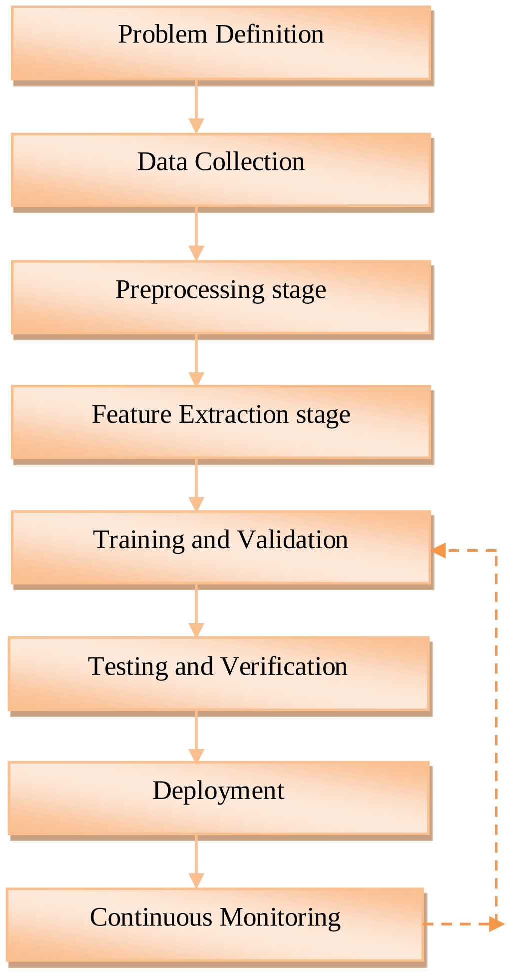

Fig. 3 Pipeline for general ML approach [35]

4. The Significance of ML in the Healthcare Sector

The main objective of ML is to enhance patient outcomes and provide novel medical insights that were previously inaccessible. Predictive algorithms provide a means to verify the thinking and judgments made by clinicians. There is a continuous improvement in the quality of healthcare services and the capacity to manage complicated conditions effectively. However, other obstacles persist, particularly in determining the appropriate dose and duration of therapy tailored to individual features or for patient groups that have few clinical trials available, such as children [40]. Recently, ML has been effectively incorporated into the field of paediatric care, enabling the prediction of optimal and personalized treatment approaches for children. The field of ML has gained significant attention and recognition in light of the global COVID-19 epidemic. Organizations have increasingly used ML techniques as a means to maintain competitiveness and achieve a strategic edge. ML has been employed to optimize operational processes and facilitate Research and Development (R&D) activities, particularly in the context of a dynamic and unpredictable work environment. ML has been shown to be important in assisting hospitals and health systems in effectively addressing distinctive difficulties [41, 42]. The field of ML technology is widely regarded as a very captivating domain within the realm of AI, prompting several firms to explore its potential applications for their objectives actively. ML is seeing a growing trend in popularity. The system employs methods to enable data-driven learning and may be used in many contexts, spanning from business to healthcare. The healthcare industry undergoes continuous transformation as a result of ongoing advancements in technology and the emergence of novel concepts. ML has the potential to aid medical practitioners in several emerging situations. The current advancements in technology have enabled the extraction of valuable information from unstructured text, a task that was previously difficult to do and implement on a widespread basis. The use of ML-derived intelligence provides doctors and administrators with an abundance of valuable information. This enables them to make well-informed choices in a timely manner about patient care and operational initiatives that have a significant impact on a large population [43-45].

5. Applications - ML in Several Aspects of Healthcare

The expanding range of applications of ML in the healthcare sector provides a look into a future where data, analysis, and innovation synergistically contribute to the improvement of patient outcomes, sometimes unbeknownst to the patients themselves. In the near future, the integration of ML technology with real-time patient data sourced from diverse healthcare systems across various nations is anticipated to become widespread.

This development is expected to enhance the effectiveness of previously inaccessible treatment alternatives. The role of ML in healthcare has shown to be a benefit, not just for the efficiency of hospitals but also for the accuracy of diagnoses, and this is true for both patients and the medical personnel who treat them. The following are some of the most important uses of ML in the healthcare business, which are reshaping the industry and generating a brighter future for patients.

5.1. Identifying Diseases and Diagnosis

The primary ML application in the field of healthcare is the identification and diagnosis of illnesses and conditions that are often difficult to identify. This encompasses a range of conditions, including malignancies that exhibit low detectability in their early stages, as well as many hereditary disorders. IBM Watson Genomics serves as a notable illustration of the efficacy of combining cognitive computing with genome-based tumour sequencing to expedite the process of diagnosis. Berg, a prominent biopharmaceutical company, is using AI to advance the development of therapeutic interventions in several domains, including cancer. The primary objective of P1vital's PReDicT (Predicting Response to Depression Treatment) initiative is to provide a commercially viable approach for diagnosing and administering treatment inside standard clinical settings.

5.2. Drug Discovery and Manufacturing

The early-stage drug development process is a key area where ML has significant therapeutic benefits. This encompasses R&D technologies, such as future-generation sequencing and precision medicine, which have the potential to identify alternative therapeutic approaches for complex illnesses. Presently, ML methodologies include unsupervised learning, a methodology capable of discerning patterns inside data without generating predictive outcomes. Microsoft's Project Hanover utilizes ML technologies to drive several efforts, such as the advancement of AI-based solutions for cancer therapy and the customization of medication combinations for Acute Myeloid Leukaemia (AML).

5.3. Medical Imaging Diagnosis

ML and deep learning play key roles in the development of the groundbreaking technology known as Computer Vision. The Inner Eye project, created by Microsoft, has garnered approval for its use in image diagnostic tools and image analysis. With the enhancing accessibility and expanding explanatory capabilities of ML, it is anticipated that the integration of diverse medical imaging data sources into the diagnosis process led by AI will become more prevalent.

5.4. Personalized Medicine

Personalized therapies have the potential to enhance effectiveness by integrating individual health data with predictive analytics, hence offering opportunities for additional study and improved illness evaluation. At now, medical practitioners have constraints in their diagnostic options since they must select from a predetermined range of potential diagnoses or assess the patient's risk by considering their symptomatic history and the genetic data that is accessible. ML is significantly advancing in the field of health, and IBM Watson Oncology is leading this progress by using patient medical records to provide a variety of treatment alternatives. In the foreseeable future, there will be an increase in the availability of advanced health-measuring devices and biosensors in the market. This will result in a greater abundance of data that state-of-the-art ML-based healthcare solutions can use.

5.5. ML-Based Behavioral Modification

Behaviour modification is a significant component of preventive medicine. With the widespread use of ML in the healthcare sector, several companies have emerged, focusing on various areas such as cancer prevention, identification, and patient treatment. Somatix is a Business-to-Business-to-Consumer (B2B2C) data analytics startup that has developed an ML-based application for the purpose of identifying and interpreting the gestures we do in our everyday activities. This technology enables individuals to get insight into their unconscious behaviour and then implement any required modifications.

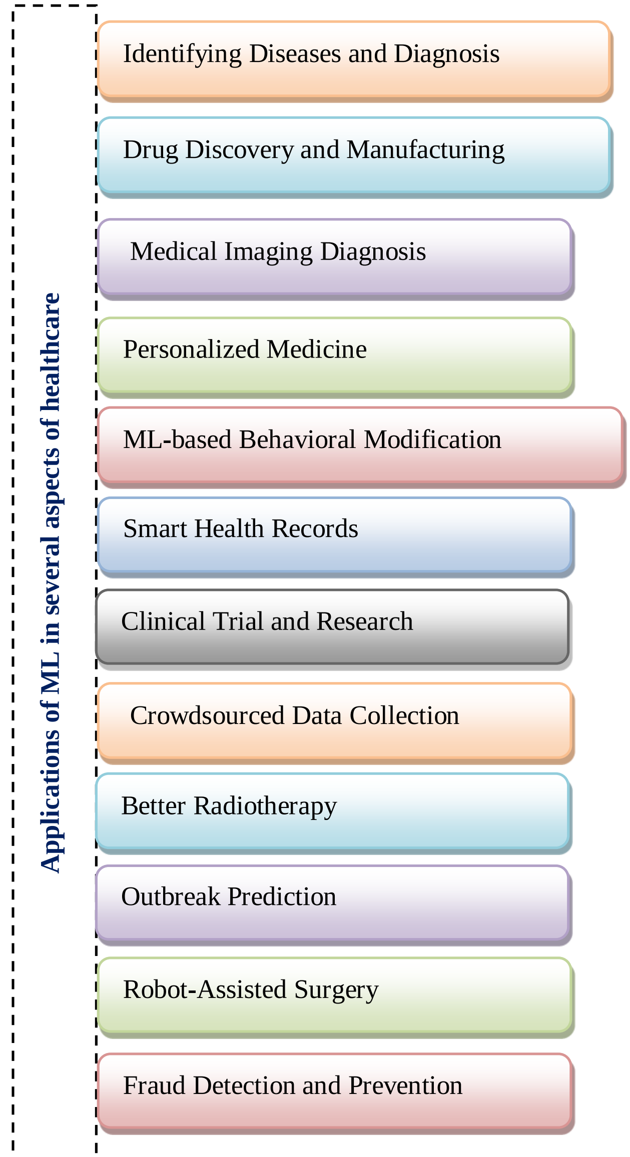

Fig. 4 The use of ML techniques has found significant applications in the healthcare sector

5.6. Smart Health Records

The process of keeping health records current is laborious. While technology has contributed to streamlining data input, it remains the case that a significant portion of these procedures still need a substantial amount of time to be accomplished. The primary function of ML in the healthcare sector is to streamline operations, resulting in time, labour, and cost savings. The use of SVM and ML-based Optical Character Recognition (OCR) techniques for document classification is gradually gaining momentum. Prominent examples include Google's Cloud Vision API and MATLAB's ML-based technology for recognizing handwritten text. The

Massachusetts Institute of Technology (MIT) now leads in the advancement of intelligent health records, focusing on the development of the next generation. These records include ML tools from the very beginning to enhance many aspects, such as diagnosis and clinical treatment recommendations.

5.7. Clinical Trial and Research

The topic of clinical trials and research has multiple possible uses for ML. As per professionals in the pharmaceutical sector, it is well acknowledged that clinical trials incur substantial temporal and financial expenses, sometimes spanning several years for completion. The use of ML-based predictive analytics in the identification of prospective candidates for clinical trials enables researchers to access a diverse range of data sources, including but not limited to past medical consultations and social media activity. ML has been used to facilitate real-time monitoring and data accessibility for trial participants, find the optimal sample size for testing, and harness the potential of electronic records to mitigate mistakes associated with data analysis.

5.8. Crowdsourced Data Collection

Crowdsourcing has gained significant popularity in the contemporary medical domain, facilitating the acquisition of a substantial volume of information that individuals voluntarily contribute. This approach enables researchers and practitioners to access a diverse range of data sets. The use of real-time health data has significant implications for the future perception of medicine. The ResearchKit developed by Apple enables users to use interactive applications that employ ML-based face recognition technology in an attempt to address the symptoms of Asperger's and Parkinson's illness. IBM has just formed a partnership with Medtronic with the aim of analyzing, aggregating, and providing real-time access to diabetes and insulin data using information obtained from the public. The healthcare business is continuously exploring novel applications of IoT technology, using the data generated to address challenging diagnostic situations and enhance overall diagnostic and therapeutic outcomes.

5.9. Better Radiotherapy

The use of ML in the area of Radiology is highly coveted in the healthcare industry. The field of medical image analysis encompasses several discrete factors that might manifest at any one instant in time. Numerous instances of lesions, cancer foci, and similar phenomena provide challenges in their modelling due to the inadequacy of complicated equations alone. ML algorithms have the advantage of learning from a diverse range of accessible samples, which facilitates the process of diagnosing and identifying factors. One of the prevailing applications of ML in the field of medical image analysis is the categorization of objects, such as lesions, into distinct classes, including normal or abnormal, lesion or non-lesion, and so on. DeepMind Health, a division of Google, is actively collaborating with academics at University College London Hospital (UCLH) to create algorithms aimed at accurately distinguishing between healthy and malignant tissue. The objective of this collaboration is to improve the efficacy of radiation therapy for cancer patients.

5.10. Outbreak Prediction

AI and ML are now being used for monitoring and forecasting global epidemics. Currently, researchers possess a substantial volume of data obtained from satellites, real-time updates on social media platforms, website data, and other sources. ANNs play a crucial role in aggregating this data and making predictions on a wide range of health-related phenomena, including but not limited to malaria epidemics and severe chronic infectious illnesses. The ability to forecast these epidemics is particularly advantageous in developing nations due to their limited access to essential healthcare facilities and educational resources. One prominent illustration of this phenomenon is ProMED-mail, an online reporting network that actively tracks the progression of both developing and emerging illnesses, offering real-time epidemic notifications.

5.11. Fraud Detection and Prevention

Based on the findings of the National Health Care Anti-Fraud Association (NHCAA), instances of healthcare fraud result in substantial financial losses of up to billions of dollars annually, representing an estimated range of 3 to 10% of total healthcare expenditures for the year. This translates to an approximate yearly loss of $300 billion. The use of ML in the healthcare sector enables organisations to identify and prevent the payment of fraudulent insurance claims, hence expediting the approval, processing, and disbursement of legitimate claims. In addition to its capacity for identifying instances of insurance fraud, the use of ML in the healthcare sector also has the potential to mitigate the unauthorized acquisition of patient data.

5.12. Detecting Diseases in Early Stages

The early detection of various illnesses is important for healthcare practitioners in order to ascertain the most optimal treatment approach and assist patients in achieving a high quality of life. ML offers enhanced support to medical professionals in the timely identification of illnesses via the comparison of fresh data with existing data pertaining to a certain medical condition. Doctors can make well-informed judgements and develop optimal treatment regimens based on the analysis and comparison of data.

5.13. Robot-Assisted Surgery

The use of ML in surgical robotics has significantly transformed surgical procedures by enhancing precision and efficiency. These technologies can execute intricate surgical operations while minimizing the potential for blood loss, adverse reactions, and discomfort. Moreover, the process of recuperation after surgery is significantly expedited and simplified. The surgical robot used by Maastricht University

Medical Centre uses ML technology to do suturing procedures on tiny blood arteries with a diameter not exceeding 0.03 millimeters.

5.14. Improve Trauma-Care Response

The development of sensors and equipment capable of transmitting a patient's vital information to the hospital prior to their arrival by ambulance or other emergency means reduces the temporal gap between the patient's arrival and the administration of life-saving medical intervention.

5.15. Visualization of Biomedical Data

ML techniques may be used to generate three-dimensional visual representations of biological data, including various aspects such as RNA sequences, protein structure, and genetic profiles.

6. Advantages - Using ML in the Healthcare Industry

There is a vast array of uses that might be developed for ML technologies in the medical field. Some of the possibilities include enhancing patient data, medical research, diagnosis and treatment, as well as lowering costs and increasing the efficiency of patient safety. The following is a list of just some of the advantages that ML applications in healthcare have the potential to deliver to healthcare professionals working in the sector of healthcare.

6.1. Faster Data Collection

IoT-connected medical devices are used in the healthcare business to collect real-time data, which can be promptly processed and adapted via ML. It is exactly for this reason that the Food & Drug Administration (FDA) of the US has been aggressively integrating AI and ML into the software of medical devices.

6.2. Improving Care

Medical personnel may use ML in the healthcare sector to enhance the standard of patient care. One potential use of DL algorithms within the healthcare sector is the utilization of these algorithms to create proactive monitoring systems. These systems would be designed to detect and promptly notify medical equipment or electronic health records of any changes in a patient's status. The use of data collecting using ML has the potential to improve the delivery of appropriate healthcare services to patients in a timely manner.

6.3. Predictive Analytics

The use of ML in healthcare may assist in identifying a patient's health decline, the evolution of a disease, and the risks of readmission. This enables carers to intervene proactively and reduces the number of times patients return to the hospital.

6.4. Costs-Efficient Process

When applied to the healthcare industry, ML can enhance the speed and efficiency of medical services, both of which may result in considerable cost savings. For instance, ML can rapidly scan Electronic Health Records (EHRs) in order to maintain patient data, arrange appointments, and automate a variety of activities. This use of ML in the healthcare industry may assist in minimising the amount of time, money, and resources that are spent on repetitive jobs.

6.5. Patient Education and Engagement

In order to improve patient engagement and adherence to treatment programmes, chatbots and virtual assistants powered by ML offer patients accurate medical information, prescription reminders, and answer patient questions.

6.6. Accelerated Drug Discovery and Development

Researchers have developed models that enhance the accuracy of predicting effective medication compounds by integrating ML and deep learning techniques. The acceleration of the drug discovery process is facilitated.

6.7. Improving Diagnosis

The use of ML in the healthcare sector enables medical practitioners to enhance the efficacy of diagnostic tools employed for the analysis of medical pictures. An instance of an ML algorithm may be used within the domain of medical imaging, including modalities such as X-rays or MRI images. The algorithm leverages pattern recognition techniques to identify discernible patterns that are indicative of a certain condition. This particular ML technique has the potential to assist medical professionals in expediting the diagnostic process and finding enhanced patient outcomes via increased accuracy.

The use of ML in the healthcare sector has already shown favourable outcomes, and the full extent of its capacity to provide healthcare services is still in the nascent phase of realization. In the next years, the significance of ML in the healthcare sector is expected to escalate, driven by the need to comprehend expanding clinical datasets.

7. Challenges - ML in the Healthcare Industry

7.1. Patient Safety

The decision-making process of ML algorithms is entirely dependent on the training data it has been exposed to. Regrettably, the precision and standardization of medical data often fall short of the requirements. The existence of gaps in records, inconsistencies in profiles, and other deficiencies have been observed. In the event that the input data is deemed untrustworthy or inaccurate, there exists a considerable probability that the resultant outcome would also be erroneous. This, in turn, may engender an improper course of therapy for patients, hence exacerbating their condition or perhaps resulting in fatality.

7.2. Biases in Dataset

ML algorithms, regardless of the business, undergo training using extensive datasets. In the absence of adequate oversight and instruction, these algorithms have the potential to perpetuate and disseminate the biases inherent in the dataset. This has the potential to result in significant ramifications, particularly within the healthcare industry.

7.3. Privacy Concerns

One significant obstacle in the integration of ML within the healthcare sector pertains to the substantial volume of data gathered, which often includes sensitive or secret information. Consequently, the implementation of further security measures becomes necessary. It is important to collaborate with a reputable ML and AI development organization that can provide high-quality security measures to guarantee the proper handling of consumer data.

8. The Prospects of ML in the Healthcare Sector

The potential of ML in the healthcare industry is quite encouraging. Despite encountering some obstacles, ML plays a crucial role in addressing present healthcare issues and proactively mitigating potential difficulties, therefore effectively averting global epidemics. Moreover, it contributes to the improvement of patient satisfaction, the efficacy of healthcare professionals' practices, and the efficiency of pharmaceutical processes. The technology is responsible for the analysis of many data points, customization of treatment plans, anticipation of risks and outcomes, and execution of diverse activities. AI and ML in the healthcare domain have the potential to provide timely alerts for medical disorders such as seizures or sepsis. These illnesses need the thorough examination of intricate datasets to identify patterns and make accurate predictions. In the foreseeable future, ML may be used in tandem with nanotechnology to improve the administration of medical treatments. The use of ML in the healthcare sector has the potential to facilitate the implementation of "virtual biopsies" and propel the progressive domain of radiomics. ML technologies have the potential to assist clinicians in reducing surgical risks by providing detailed treatment information at a very granular level. Furthermore, it is plausible that in the future, robots with programmed capabilities may be used to assist medical professionals inside the confines of the operating theatre. Healthcare ML technologies provide significant benefits to doctors, clinicians, researchers, and patients alike. On a daily basis, technological advancements give rise to significant developments, leading to the emergence of novel applications that address real-world challenges or achieve noteworthy milestones. The field of ML in healthcare is seeing ongoing progress and is anticipated to achieve significant advancements in the foreseeable future.

9. Predicting Heart and Liver Disease Using ML

This section provides a comprehensive description of the algorithms used for predicting heart and liver diseases, as well as an overview of the heart and liver datasets included in these predictions.

9.1. Particle Swarm Optimization (PSO)

The PSO algorithm is a population-based metaheuristic approach that aims to optimize systems by leveraging swarm or collective social behaviour. Due to its inherent simplicity, ease of implementation, and notable efficacy in addressing optimization problems, this particular optimization approach has garnered significant popularity. During the search process, individuals exhibit random movement patterns characterized by varying velocities. These velocities are used to modify the positions of each person. In this strategy, the goal function is used to modify both the location and velocity of each particle inside the swarm, with the aim of achieving optimal simulation results [46].

9.2. Hybrid Particle Swarm Optimization SVM Algorithm (PSOSVM)

The PSOSVM classification method combines the PSO technique with SVMs to achieve improved classification outcomes compared to the conventional SVM classifier. The act of determining the most advantageous solution to a given issue is referred to as optimization. In comparison to other optimization algorithms, PSO is characterized by its simplicity, efficiency, and ease of implementation. SVMs exhibit a high degree of sensitivity to variations in their parameter values. To address this issue, a hybrid technique is proposed in which PSO is used as an optimizer. The purpose of this hybrid approach is to optimize the parameters of the SVM model, hence enhancing its classification accuracy. By searching for the optimal SVM parameter values [47], the dependability of the hybrid method may be ensured.

9.3. Hybrid Cauchy Crazy Particle Swarm Optimization SVM Algorithm (CCPSOSVM)

The CCPSOSVM technique incorporates the Cauchy mutation operator in conjunction with the CPSOSVM approach to enhance the precision of classification outcomes when applied to datasets related to heart and liver diseases. The use of the mutation operator in an optimization approach is a frequently seen practice. The Cauchy distribution is widely acknowledged as a continuous probability distribution. The primary objective is to regularly create minimal fluctuations in the overall population with the aim of preserving its variety [48]. According to the experimental findings, it is seen that prior to convergence, particles in the Particle Swarm Optimization (PSO) algorithm exhibit a behaviour where they alternate between the previously identified best particle and the globally best particle as viewed by each particle. Expanding the search space for the smallest particle would be facilitated by including neighbouring explorations of the most optimal particle in each iteration, hence facilitating the movement of every particle towards the most optimal point attainable. In each iteration, the use of a Cauchy mutation operator on the particle with the highest overall fitness may accomplish this.

10. Tuberculosis Detection in Chest X-Ray Images via ML

The approach is done using the framework that was specifically built for the early identification of TB. According to the established framework, an early step involves acquiring a chest X-ray as the input picture. The acquired picture undergoes pre-processing in order to improve its quality and provide accurate results. This pre-processing involves applying several filters to determine which one yields the most effective image improvement. Following the use of image-enhancing techniques, the processed picture underwent a segmentation procedure. The segmentation method is used to partition the picture into several segments or to reduce the complexity of the image, therefore extracting valuable information from it. The process of picture segmentation achieves the identification of the infection level of TB bacilli. Subsequently, the picture is sent to the DL system in order to forecast the TB stage. The system undergoes training using the existing patient database, followed by testing to evaluate its accuracy. Subsequently, the system is used to determine whether a given case is classified as primary TB or secondary tuberculosis.

Figure 6 illustrates the overall structure that the system is designed to possess. Patients presently get diagnoses of a common cold, a cough, or Tuberculosis (TB) with the assistance of their physician's expertise. However, it is important to note that not all situations need the use of this strategy. Researchers have created many models to enhance the ability of clinicians to provide timely and precise diagnoses at an early stage. Consequently, the proposed system framework places significant emphasis on the timely detection of tuberculosis. Sputum imaging and chest X-ray imaging are commonly used diagnostic techniques for TB identification. Based on the survey findings, it has been determined that a chest X-ray is the most economically efficient choice for a straightforward diagnostic procedure, in contrast to the alternative method that requires the use of a high-resolution microscope in order to achieve enhanced precision. Performance measures are used to assess the accuracy based on the final picture. The criteria under consideration in this study include accuracy, specificity, and sensitivity. This study compares the performance metrics of the present system with those of the proposed system and concludes that the suggested system exhibits more accuracy. The values are used to distinguish between Primary and Secondary TB. In the event of primary TB, the patient is administered the fundamental therapy, whereas, for secondary tuberculosis, treatment is determined according to the isolation status. The suggested system implementation is executed according to the following procedure. The first stage of the implementation process involves picture capture, which is then followed by pre-processing, segmentation, deep learning, and ultimately the detection of TB. This study elucidates the sequential processes involved in the suggested system and delineates the progression of work from one step to the subsequent phases.

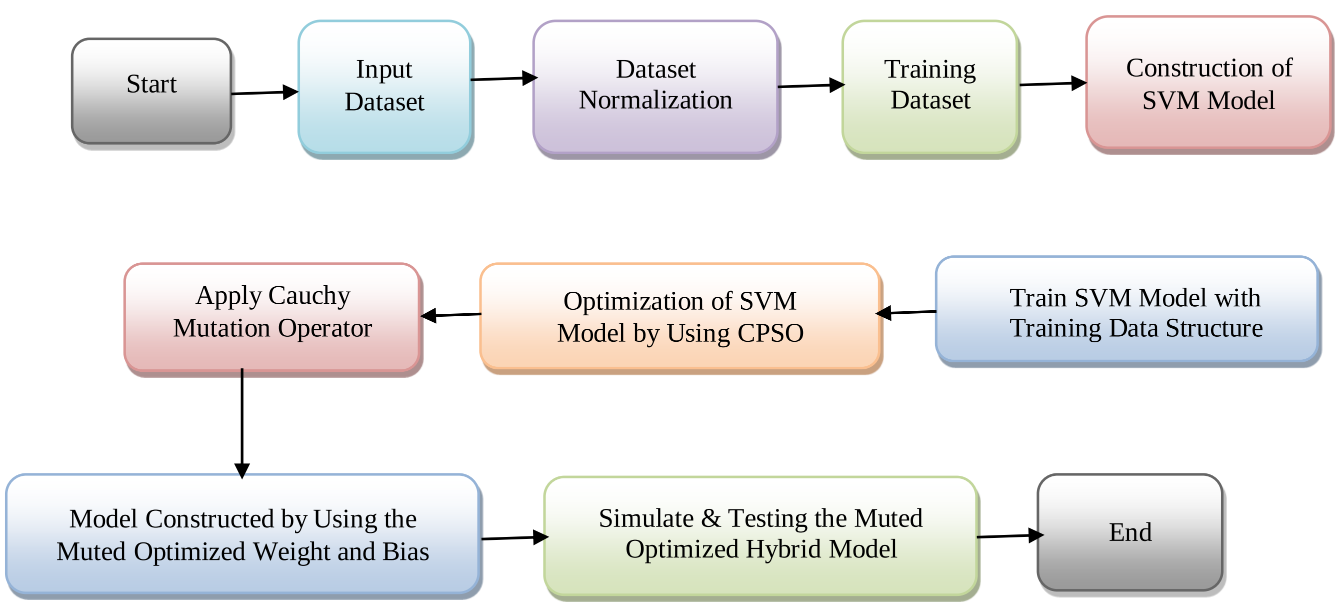

Fig. 5 Flow diagram of predicting heart and liver disease

Tuberculosis is a critical illness that significantly impacts the economic development of a nation, sometimes leading to life-threatening consequences. It is essential to proactively address the ramifications of TB by using the available resources for the prevention and treatment of this disease in individuals. The detection of TB is accomplished by using deep learning approaches, whereby emphasis is placed on picture pre-processing prior to subsequent processes such as segmentation and feature extraction. Based on the obtained data, it can be concluded that the median filter exhibits a considerable level of precision. The picture that has undergone pre-processing will be used for feature extraction and segmentation in subsequent tasks. The segmentation method is used to partition a picture into many components and retrieve pertinent information. A variety of classifier types are used for the purpose of distinguishing TB bacilli from chest x-ray images. The evaluation of the classifiers' efficacy is conducted by a comparison of their accuracy, sensitivity, and specificity values. To ascertain the classification of TB in a patient, such as primary or secondary tuberculosis, the acquired data is inputted into a deep learning model that has undergone training for this purpose.

11. Conclusion

The ML has significant potential as an effective tool for medical practitioners, scientists, and researchers. It is observed that on a daily basis, significant advancements are being made in the field of ML. With every advancement, a new ML application arises that can address a legitimate issue inside the healthcare domain. The progress of ML is steadily on the rise, and the healthcare sector is closely monitoring this development. ML ideas are playing a crucial role in aiding medical professionals in many aspects of healthcare. These concepts have shown to be vital in saving lives, as they enable physicians and surgeons to identify illnesses and potential health issues before they manifest, thus allowing for timely intervention. Additionally, ML techniques contribute to the improved management of patients, facilitating more effective engagement in the recovery process. The impact of ML in healthcare extends beyond these examples, including a wide range of applications and benefits. Global businesses enhance healthcare delivery by using AI-powered technologies and ML models. This technology facilitates the expedited and enhanced development of therapies for severe disorders for organizations and pharmaceutical manufacturers. Virtual clinical trials, sequencing, and pattern detection have emerged as effective tools for companies to expedite their testing and observation procedures. Health habits and socioeconomic characteristics, such as money, social support networks, and education, have been shown to be more influential in predicting individuals' overall health outcomes. In order to enhance total well-being, health institutions acknowledge the need to address the holistic needs of individuals, including their lifestyle choices and surrounding environment. ML algorithms can accurately detect individuals who are more susceptible to acquiring avoidable chronic illnesses such as heart disease and diabetes.

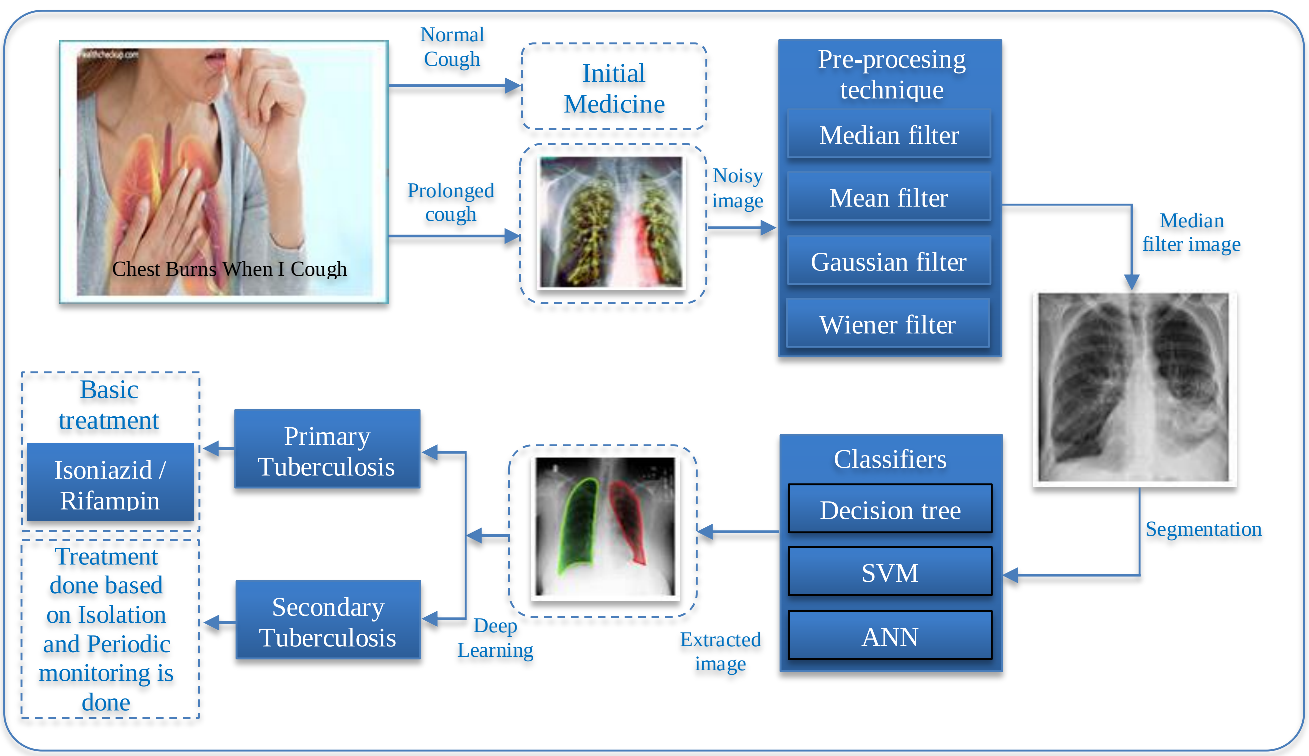

Fig. 6 Structure of tuberculosis detection in chest X-ray images [49]

11.1. Future Scope

The increasing prevalence of intelligent medical equipment is leading to the realization of technology-enabled healthcare. Due to the healthcare industry's propensity for fostering innovation, the potential for ML in healthcare seems very auspicious. This technology is responsible for processing a multitude of diverse data points, effectively predicting potential hazards and consequences, and carrying out a range of other tasks. This approach may be used to provide an individualized prescription for individuals with distinct and specific requirements. The potential use of this ML technique in combination with nanotechnology holds promise for enhancing the administration of medication in the future. ML plays a significant role in addressing the present challenges and forecasting future obstacles. ML can predict and forecast the occurrence of disease epidemics on a global scale. In contemporary times, the proficient individual is required to acquire a substantial volume of data obtained from online sources, real-time updates on social media platforms, and several other channels. This technology will facilitate the verification of data and enable the forecast of many phenomena, ranging from outbreaks of illnesses to severe infectious diseases. The use of ML in scientific research is very prevalent. The significance of its use has increased, ranging from the handling of extensive quantities of data to the generation of precise forecasts and aiding scientists in their pursuit of research, thus enhancing their ability to achieve discoveries more efficiently. ML is used as a novel methodology for conducting epidemiological investigations, demonstrating potential implications for the advancement of precision medicine in the coming years. The effectiveness of therapies is maximized when they are tailored to individual health issues. ML and its predictive analytics component have the potential to play a crucial role in personalized therapies. Healthcare professionals have a limited range of diagnostic options at their disposal or may assess the potential danger to their patients by considering their medical history and genetic data. In the future, ML algorithms have the potential to create several therapeutic possibilities by using the whole medical history of patients. Additionally, it is recommended that medical institutions consider the integration of a curriculum focused on ML and its many applications inside their curricula. There is an excellent reason for including instruction on ML and data science in the curricula of medical students, residents, and fellows as part of their training.

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