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# Medical Diagnostic Systems Using Artificial Intelligence (AI) Algorithms: Principles and Perspectives

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**ABSTRACT** Disease diagnosis is the identification of an health issue, disease, disorder, or other condition that a person may have. Disease diagnoses could be sometimes very easy tasks, while others may be a bit trickier. There are large data sets available; however, there is a limitation of tools that can accurately determine the patterns and make predictions. The traditional methods which are used to diagnose a disease are manual and error-prone. Usage of Artificial Intelligence (AI) predictive techniques enables auto diagnosis and reduces detection errors compared to exclusive human expertise. In this paper, we have reviewed the current literature for the last 10 years, from January 2009 to December 2019. The study considered eight most frequently used databases, in which a total of 105 articles were found. A detailed analysis of those articles was conducted in order to classify most used AI techniques for medical diagnostic systems. We further discuss various diseases along with corresponding techniques of AI, including Fuzzy Logic, Machine Learning, and Deep Learning. This research paper aims to reveal some important insights into current and previous different AI techniques in the medical field used in today's medical research, particularly in heart disease prediction, brain disease, prostate, liver disease, and kidney disease. Finally, the paper also provides some avenues for future research on AI-based diagnostics systems based on a set of open problems and challenges.

**INDEX TERMS** Big Data Analytics, Artificial Intelligence, Machine Learning, Deep Learning, Soft Computing, Chronic Disease, Diagnosis, Health Care Prediction

## I. INTRODUCTION

In the field of healthcare, the study of disease diagnosis plays a vital role. Any cause or circumstances that lead to pain, illness, dysfunction, or eventually, a human being's death is called a disease. Diseases may affect a person physically and mentally, and it considerably manipulates the living style of the affected person. The causal study of disease is called the pathological process [1]. A disease is made by signs or symptoms that are interpreted by clinical experts [2]–[4]. Diagnosis has been defined as the method of identifying a disease from its signs and symptoms to conclude its pathology. Diagnosis can also be defined as the method of figuring out which disease is based on an individual's symptoms and signs [5], as shown in Fig. 1. The data gathered from medical history physical examination of the individual having medical pathology constitutes the knowledge required for diagnosis. Often, at least one diagnostic procedure, such as medical tests, is done during this procedure. To form an honest diagnosis, a medical doctor will perform a process that involves several steps, allowing them to collect the maximum amount of information as possible [6]. Diagnosis of diseases is the most challenging process at the same time, a very pivotal phenomenon for a medical care professional as before reaching the conclusion.

The diagnostic process could be very tiresome and complex. To minimize the uncertainty in medical diagnosis health, the care experts collect empirical data to ascertain a patient's disease. The patient's correct treatment may be adjourned or missed with serious health issues due to making fault in the diagnosis process. Unfortunately, all doctors don't have expert knowledge in each domain of the medical field.

Hence, there was a need of automatic diagnostic system that provides benefits from both human knowledge and accuracy of the machine [7]. A suitable decision support system is needed to achieve accurate results from the diagnosis process with reduced costs. Classification of diseases depending upon various parameters is a complex task for human experts but AI would help to detect and handle such kinds of cases. Currently, various AI techniques have been used in the field of medicine to accurately diagnosis sicknesses. AI is an integral part of computer science by which computers become more intelligent. The vital need for any intelligent system is learning. There are various techniques in AI that are based on Learning like deep learning, machine learning, etc. Some specific AI methods that are significant in the medical field named as *a Rule-based intelligent system*, provides a set of if-then rules in healthcare, which act as a decision support system. Gradually, intelligent systems are being replaced in the medical field by AI-based automatic techniques where human intervention is very less [8], [9]. The neural network or artificial neural network (ANN) is a large collection of neural units designed based on biological neurons connected in the brain. It is a simulation of the human brain and works exactly like it. Each neural unit is linked with many other neurons approximately similar to the bipartite graph [10]. These kinds of systems learn and are trained automatically.

Finding the possibilities and predictions regarding health issues is a tedious task for doctors and surgical experts. In some cases, ANN provides decisions regarding healthcare at rapid speed wherein the systems can collect data, understand it, and detect pieces that will play a vital role in prediction [11], [12]. Deep learning, a subset of machine learning and also based on algorithms, is used in the medical field to assist specialists for the examination of any illness. Thus, resulting in better medical decisions. Deep learning provide benefits in different fields such as drug discovery, medical imaging, Genome, detecting Alzheimer's disease [13]. In this paper, we primarily focus on the three main branches of AI: Fuzzy logic, Machine learning, Deep Learning. The major trend in healthcare using deep learning is to detect breast cancer. In a recent study conducted by a cancer institute, it is clear that the accuracy of Automatic breast cancer is equal/high than a human radiologist. Moreover, AI trained itself continuously and have greater chances to produce more accurate results than before. Another significant application of AI is the Internet of Medical Things that helps to collect healthcare data using IOT Devices. AI-based software detects the disease even before its occurrence by sensing its symptoms. Neural networks can be trained to detect lung cancer, breast cancer, Stroke in less time than a trained radiologist. Various AI algorithms help doctors to analyze medical images such as MRIs, x-rays, and CT scans and diagnose specific diseases by just spotting signs. Detection of disease and providing correct treatment is always a tricky and complex process since some diseases have very similar signs. Using medical expert systems, doctors can diagnose patients more accurately and prescribe the most suitable treatment. Using AI tools, doctors can not only detect the disease but can also classify the types of different fatal diseases. Modern AI algorithms already help doctors in arranging a comprehensive approach to disease management. Moreover, they are often used to improve surgical robots that execute highly complex operations. The contributions of the this paper is three folds

- We first describe the existing elements that affect the initial outbreak of disease detection.
- We latter discuss how AI techniques have been altered for initial disease diagnosis
- We provide a thorough analysis through a systematic review for medical diagnostic systems. We make use of the well know PRISMA approach.
- We then provide a summary for all the selected articles; the diseases which were targeted,the AI techniques which were used, the articles' research goals along with their findings. We also present a thorough discussion of the reviewed articles followed by future research directions.

The rest of this paper is organized as follows. We present the related works on AI applied methods for medical diagnostic systems in section II. Whereas Section III discusses fuzzy logic-based medical diagnosis, Section IV and Section V present diagnostic systems using machine learning and deep learning algorithms, respectively, In Section VI, we present the review guidelines using the Prisma technique. Research findings, discussion, and future research directions are included reported in Section VII, whereas the final Section concludes this review.

## II. RELATED WORKS

In this section we discuss current applied AI techniques which are used for disease diagnostic process, relevant survey articles on diagnostic process and our contribution in regards to the existing work.

Van Mourik et al. [14] carried out a survey on automated surveillance techniques for healthcare-associated infections. In this review, authors have described how automatic surveillance systems based on machine learning algorithms bring enhanced performance and reliability compared to manual surveillance methods. Another finding of this review is that the use of regression models can improve the efficiency and sensitivity of surveillance programs. There are some challenges that need to be addressed in the near future such as post discharge surveillance, case-mix adjustment, quantification of device utilization. BRONCHIOLITIS is a lung infection that is commonly seen in younger children

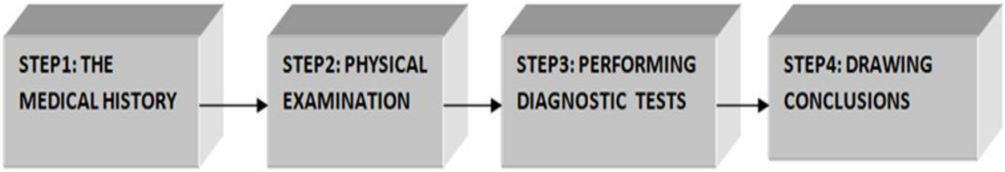


**FIGURE 1.** Block diagram of the diagnosis process

and infants. Luo et al. [15] reviewed this disease along with respiratory syncytial virus (RSV), an infection that can be a root cause of bronchiolitis. The systematic review provides some insights into predictive modeling and also reported how machine learning can use to overcome limitations of predictive modeling. SEPSIS is a life-threatening condition that occurs due to your body's response to infection, which causes inflammation that result in multiple organ failures at the same time. Bhattacharjee et al. [16] performed a systematic review to investigate the current trends in sepsis detection in hospitals. Authors have investigated various sepsis detection scoring systems and screening tools along with their pros and cons in general hospital wards. Finally, they observed biomarkers and electronic health records can have a huge effect in predicting sepsis. One more study on sepsis was performed by Sinha et al. [17]. They reported some drawbacks in routine blood culture testing for sepsis detection. To analyzed suitable automatic sepsis detection methods that they investigated seven molecular technologies that utilize blood samples. In this study, they have discussed the various present and future trends. In addition, they have also analyzed the impact of machine learning algorithms with electronic medical records in sepsis detection. They conclude that by merging various technologies can improve the detection process and minimize the risk of using the wrong antibiotic.

To the best of the knowledge, this is the first attempt that provide a comprehensive survey for disease prediction using the techniques of fuzzy logics, machine learning and deep learning. In addition, contrary to existing survey articles available in the literature, this work has focused on a particular range of sicknesses including heart disease, brain disease, prostate, liver disease and kidney disease

## III. FUZZY LOGIC AND DISEASE DIAGNOSIS

In this section we first summarize the current related work which are based on fuzzy logic. We later describe the fuzzy logic process for disease diagnosis.

### A. EXISTING WORKS USING FUZZY METHODS

Fuzzy logic provides dynamic methods that deal with difficult problems. Fuzzy logic is assumed to be a solid tool for decision-making systems, such as expert systems or Pattern classification systems [18]–[21]. Fuzzy logic plays a vital role in the medical evaluation as it provides an exact examination report. These sorts of frameworks provide an instant and straightforward strategy for clinical assessment. They are also useful where an expert or clinical specialist is absent. These frameworks give an outcome depending on the knowledgebase incorporated within or from specialists or experts in the field. Various clinical diagnoses systems created depend on the fuzzy set model and applied in the medical field [22]. The word fuzzy refers to things that are ambiguous. Sometimes we face a circumstance when we are uncertain about whether the state is valid or invalid, wherein fuzzy logic provides reasoning for such conditions as depicted in Fig. 2. It is a rule-based method. Fuzzy Rule-Based System (FRBS) is a frequently used technique in healthcare that drives from Fuzzy Inference Systems (FIS). FRBS applies *IF-THEN* rules for information portrayal [23]. Besides this, clustering and classifying techniques are also used in the medical domain. Also, FIS and FDSS are determined as the most common techniques in the area of medicine [24]. The main feature of fuzzy logic is that it can alleviate the inaccuracies and uncertainties of any situation. There is no logic for the absolute valid and absolute invalid value, but partially true and partially false intermediate value exists in a fuzzy logic system. Let's take the following example to show how fuzzy logic works.

In the past few years, Fuzzy logic is consistently gaining popularity in diagnosing disease based on different parameters. For instance, *coronary* illness is a sort of malady caused due to a damage or blockage of veins in the heart, thus influencing less oxygen supply to heart organs. Common heart diseases are heart failure, artery blockage, heart attack, stroke, etc [25]. Fuzzy logic is continually developing to distinguish heart patients all through the world with the assistance of growing new AI techniques.

Lots of articles have been published to detect coronary disease by utilizing Fuzzy logic. Sari and Gupta [26] discussed coronary disease detection using a neuron-fuzzy integrated system and their results reached a similar level of doctor's opinion in case of high/low cardiac risk. Junior et al. [27] presented a cardiovascular arrhythmia grouping framework utilizing fuzzy classifiers to recognize the particular point of the electroencephalogram utilizing network fuzzy Rules. In their system, the total time of ECG signal processing is reduced by a sequence of samples, without any essential loss. The ECG signals are imposed into the framework that implements cleaning, and afterward utilizes

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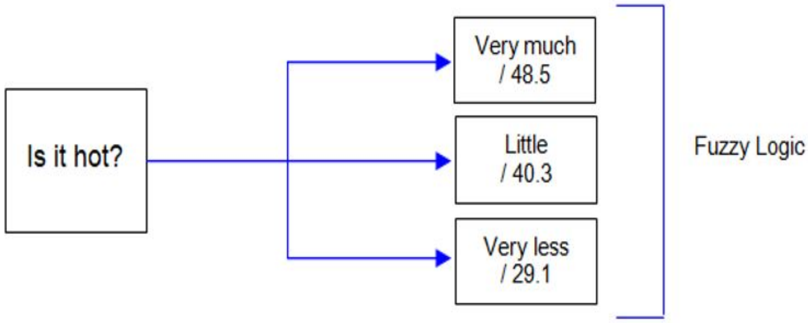


**FIGURE 2.** Process of Fuzzy Logic

a clustering algorithm "Gustafson–Kassel fuzzy" for the signal classification and correlation. Their study suggested that common heart diseases like myocardial infarct, arterial coronaria and angina diseases can easily be detected by their system. According to the obtained results, their method provided better disease diagnosis for *Pulse Pressure Variation* compared to other reported systems. Ebola Virus Disease is a fatal infectious disease also known as the "Ebola hemorrhagic fever". Hence, a secure method of diagnosis has been investigated. Oluwagbemi et al. [28] described that Ebola fuzzy informatics system was designed to diagnose EVD. They utilized fuzzy logic as its inference engine along with a collection of rules. A knowledgebase was created to help provide a diagnosis of the Ebola Virus Disease (EVD). The method used as a fuzzy inference method was Root Sum Square. According to the performance of their system, we can say that their system is a valuable addition to fight against Ebola. BRAIN DISEASE or disorder is a condition where a person loses the capability of reasoning, loss of memory; change personality, mild seizures, and twitching are common symptoms. The brain is the central control of the body. When brain problems occur, the results can be devastating. Brain diseases such as stroke, brain tumours, Alzheimer's disease can cause problems like vision loss, weakness, and paralysis, etc [29]. Early detection of these problems is very necessary for a doctor as well as a patient in order for the treatment to be started. Gopal and Karnan [30] proposed a system for diagnosing Brain Tumor. A system designed to diagnose brain tumors using MRI images by the use of the Fuzzy C Means clustering algorithm. The tools used along with Fuzzy C means algorithms are Genetic Algorithm and Particle Swarm Optimization. The suspicious block is fragmented by the use of two algorithms GA and PSO. Computer-aided System is then utilized for verification and correlation of brain tumor in the diagnosis algorithm. Fuzzy C Means helped to determine the adaptive threshold for brain tumor fragmentation. The results of previous techniques were compared with existing outcomes. Their results indicated that it improves the overall performances of the fragmentation and can find the optimal solution. Another representation was given by Chen et al. [31] to introduce a productive brain problem detection system by the use of fuzzy k-closest neighbour or SVM for Parkinson's disease diagnosis. A comparative analysis was performed between SVM and FKNN. The experimental outcome showed that the FKNN technique worked better over the SVM classifier. The accuracy obtained by the FKNN was 96.07 which is more than the SVM method. Different diseases such as neuro diseases, cancer, diabetes, heart diseases, thyroid disorder, asthma disease were also diagnosed by using various ANN mechanisms. The neuro-fuzzy model has been proposed by Patra and Thakur [32] for the proper diagnosis of adult Asthma disease. The dataset was collected from various hospitals. Three learning algorithms were used: ANN with Self Organizing Maps (SOM), ANN with Learning Vector Quantization (LVQ) and ANN with Backpropagation Algorithm along with NF tool to produce accurate results. Fuzzy inference was then used to classified data to diagnosis a disease.

Fuzzy logic is also capable to detect dangerous diseases like cancer, especially BREAST CANCER. Breast cancer is a sort of sickness caused by bumps found in the breast that frames the cells. Cancer appears when cells start to grow out of control. Miranda and Felipe [33] inter-operated on the Fuzzy Omega algorithm, an automated tool to detect breast lesions. The user availed elements like contour, size, and density and the system suggested the BI-RADS classification. Their method achieved an accuracy of 76.6 % for nodules and 83.34% for calcifications. Another approach was given by Nilashi [34] for early diagnosis to tackle the disease. The authors designed an information-based architecture for the classification of breast cancer disease using Clustering, and classification approaches. They used Expectation-Maximization for clustering the data. Fuzzy rules extracted from Classification and Regression Trees were used for the classification of breast cancer disease. Their method can be used as a decision support system for disease diagnosis. The liver ailment is also a sort of hepatic sickness that makes the liver stop its working partially or completely. Most of the factors of liver ailment are due

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to an alcoholic or hereditary nature. The most well-known kind of liver illness is fatty liver. In order to diagnose, a liver disease, Satarkar S.L, and Ali M.S worked to form an expert system that cooperated with fuzzy logic. According to the authors, the portrayal was provided by the *Mamdani* approach to recognize the risk factors. Their system could be used to make predictions of cirrhosis and avoid the need for liver biopsy [35]. DIABETES is a kind of sickness which is caused by the increase of blood glucose levels in the body. Apart from that, this disease decreases insulin level in body cells and cause type 1, type 2, or gestational diabetes. An excessive amount of sugar level in the body prompts different issues like harming the kidney and nerves. Kalpana and kumar [36] focused on developing a model to analyze diabetes malady using a fuzzy determination mechanism. To decide whether a person has the possibility of diabetic or not, the author used the fuzzy determination system to asses rules with the fuzzy operator in their study and portray knowledge with descriptions. Lukmanto [37] proposed an intelligence system by using a fuzzy hierarchical model that can perform initial diagnosis against diabetes. The proposed model was implemented on 311 relevant data and acquired an accuracy of 87.46 % as equivalent to a medical doctor's statement. Another proposal was given by Rajeswari et al. [38] on diabetic diagnosis using an associative classification method based on fuzzy logic to tackle the problem of the boundary value confusion while partitioning risks. Tooth Decay, Periodontal Disease, Gingivitis, Dental Plaque, etc are diseases that occur in teeth, and are commonly termed as DENTAL DISEASES. Allahverdi and Akcan analyzed based on periodontal dental disease around 164 fuzzy rules taken with some inputs. The prime goal of their study was to decrease the time taken for early recognition of dental disease [39]. Son et al. [40] designed a system called Dental Diagnosis System to find out dental problems which depend on the hybrid technique of fragmentation, classification and decision making. They investigated that the accuracy of DDS in dental problem detection is 92 % approximately that is higher than any other systems like fuzzy inference system (89%), fuzzy k-nearest neighbor (80%), prim spanning tree (58%) and Kruskal spanning tree (58%). Bacterial diseases like Cholera arises after swallowing polluted or infected water. This kind of disease can prompt drying out, diarrhea and can also become the reason for death, if not handle at the perfect time. Uduak and Mfon proposed a system based on Mamdani fuzzy approach. Centriod method was used as a deffuzifier and performed better in MATLAB simulation [41]. Another representation was given by Okpor M.D, they classified their investigation on cholera using fuzzy classification. The results were satisfactory for tackling cholera as compared to previous applications [42]

### B. MEDICAL DIAGNOSIS PROCESS USING FUZZY LOGIC

Fuzzy logic has the ability to portray information and outcomes in the form of semantic articulation. It tends to be valuable since most diagnosis processes have been performed based on the probability of medical findings [43]. The power of human thinking and decision-making ability develop a clinical proof-based theory to make the process of diagnosis better [44]. Due to the demonstrated viability of applying fuzzy methods in the field of healthcare to display uncertainty, it has been used in the finding procedure with various applications as per the kind of illness and targets of the researchers [45]. The main rule of this framework in medical science has two major elements in which symptoms are used as input and the disease as output. Generally, the Fuzzy logic process to disease diagnosis as described in Fig 3 is made by the following steps:

- **Fuzzifier**: The Fuzzification process is done by a Fuzzifier. It is a process of changing a crisp input value to the fuzzy set. Hence Fuzzifier is used as a mapping from observing input to fuzzy value.
- **Inference engine**: After completing the fuzzification process, fuzzy value processed by the inference engine using a set of rules act as a collection of rules to the knowledge base.
- **Knowledgebase**: This is the main component of the fuzzy logic system. The overall fuzzy system depends on the knowledge base. Basically, it consists of rules, structured and unstructured data also named the database.
- **Defuzzifier**: The process of converting the output from the inference engine into crisp logic. Fuzzy value is an input to the defuzzification that maps fuzzy value to crisp value.

Fuzzy Logic is taken into account among the techniques for AI, where intelligent behavior is achieved by creating fuzzy classes of some parameters. The rules and criteria are understandable by humans. These rules and the fuzzy classes are defined by a domain expert mostly. Therefore, a great deal of human intervention is required in fuzzy logic. The actual processing of data basically provides a presentation of the information in fuzzy logic. One of such representations can be done using machine learning in the medical field even in a much better way than fuzzy logic. The statistical model used for estimation is not capable to produce good performance results. Statistical models fail to detect missing values, large data values and hold categorical data [46]. All the above-mentioned reasons can be achieved through machine learning (ML). ML plays an essential role in numerous applications such as natural language processing, information mining, image detection, and disease detection. In all the above-mentioned domains, ML provides appropriate solutions as per the problem. Thus, ML also facilitates advanced diagnosis systems and treatment options in healthcare. In the following section, we describe how ML was used for disease diagnostic systems [47].

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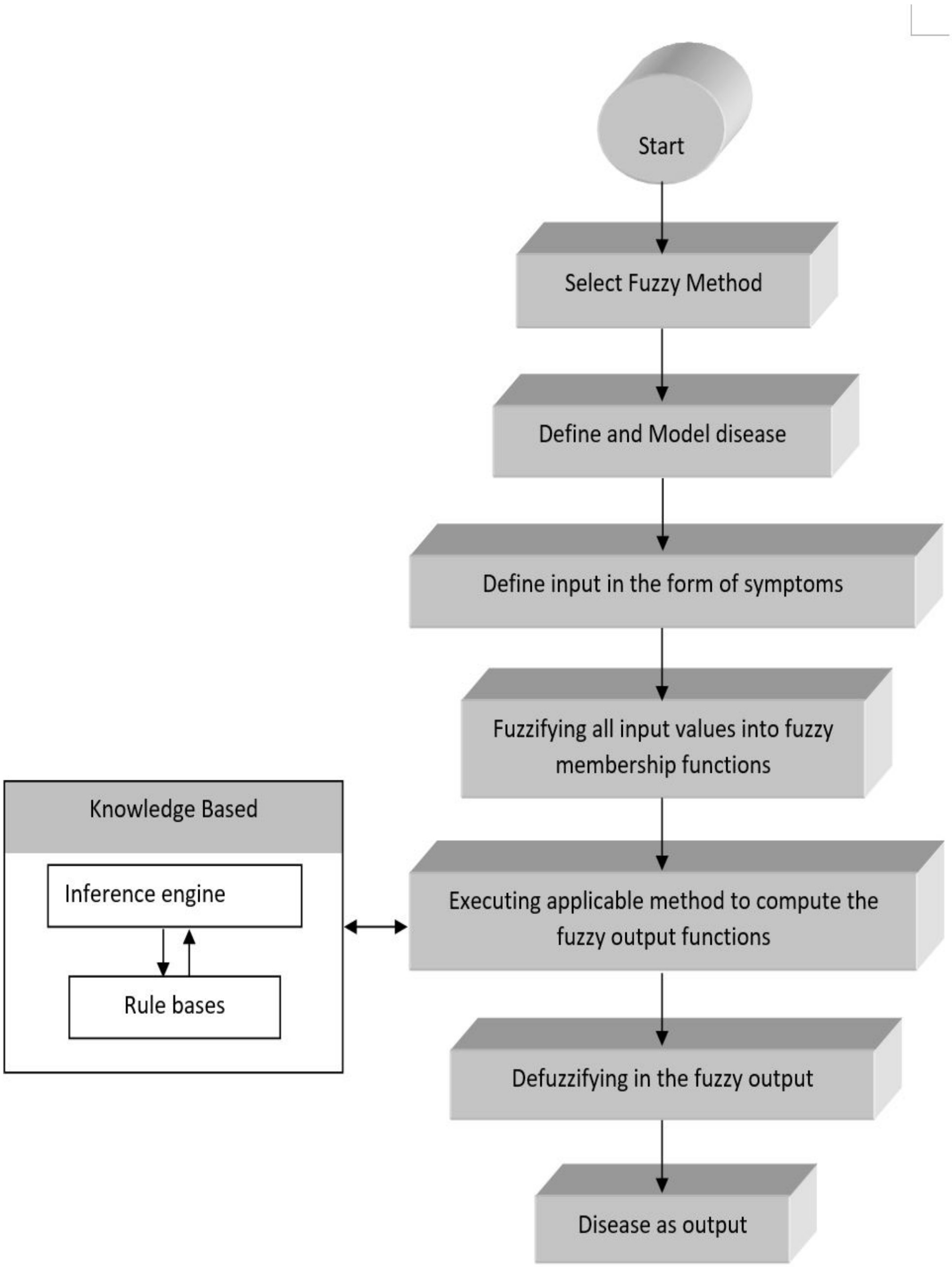


**FIGURE 3.** Flow chart of the Fuzzy logic process

## IV. MACHINE LEARNING AND DISEASE DIAGNOSIS

In this section we first present the current related work which are based on machine learning. We then describe the ML process for disease diagnosis.

### A. EXISTING WORKS USING FUZZY ML

Machine learning is a field that comes within the broader area of AI in which by training, a machine learns itself and perform tasks. In machine learning, there are algorithms for supervised learning (under the control and "guidance" of a human expert) in which we are initially aware about both input and results, as well as unsupervised learning (requiring very little human intervention or domain expert's service) where we are not aware of what will be the results. A machine is trained to learn a concept by giving examples and creating pattern models that are supposed to differentiate between two or more objects. In the medical field, machine learning assist the experts to handle large and complicated medical data and also helps to investigate the results. The output of this process can be used for further research. Therefore, when machine learning is applied in healthcare, it increases the trust level of patients in medical science in order to predict a disease by implementing machine learning algorithms. Sometimes, illness is not early detected by human experts, in such types of cases machine learning can be used to detect early stages of the disease before its occurrence or it becomes dangerous to someone. In this way, it can help to prevent future problems as "Prevention is better than cure". The popularity of machine learning in different areas has tended it towards machine learning algorithms that produce correct outcome as compared to traditional models with little processing of raw data. Machine learning algorithms like Decision trees, Support vector machine, Multilayer perception, Bayes classifiers, K-Nearest Neighbour, Ensemble classifier techniques, etc are used to determine various ailments. Using machine learning algorithms can lead to rapid disease prediction with high accuracy. The learning process begins with observations or information, such as examples, direct experience or instruction. In particular, the algorithms look for data patterns and makes better decisions. The key goal is to allow the machines to learn automatically without human interference and adjust the response accordingly [48]. The intended contribution of AI in the field of medical science is to develop programs that can help a medical expert in practicing expert and more accurate diagnosis. The forecast for diseases plays an important role in machine learning. Various types of diseases can be predicted using ML techniques. Here, we examine how machine learning techniques are used to predict various disease types. We focused on the prediction of some chronic diseases like kidney disease, diabetes, heart disease, and breast cancer, lung disorders, etc.

KIDNEY DISEASE is a common word for diverse disorders affecting the kidney's structure and working. The definition of chronic kidney disease is centered on kidney damage or reduced kidney function for three months or more. Kidney failure is among the most serious outcomes of chronic renal disease, with complications of decreased kidney function being the primary reason [49]. Sinha and Sinha [50] proposed a decision support framework to diagnose kidney disease. They compared the performance of two classier, SVM, KNN. The comparison was based on accuracy, precision and execution time of both algorithms. From the investigation they observed that KNN works better than SVM. In another study, Charleonnan et al. [51] classified his analysis on performing a comparative analysis based on four ML techniques KNN, SVM, logistic regression (LR), and decision tree classifiers to detect diagnosis kidney disease. In order to pick the best technique, they compared their performance with each other. It was observed that the SVM method is best than the rest of others and gives a maximum accuracy of 98.3 %. BREAST CANCER which is a chronic disease for females, is the most common cancer disease and a leading cause of death. In recent years, machine learning was used a helpful tool in the detection of breast cancer. Zheng et al. [52] focused on developing a model to diagnose breast cancer based on the extracted tumor features. To extract useful information and diagnose the tumor, the K-means algorithm was used to identify the hidden designs of benign and malignant tumors. Afterward, SVM was utilized to get the classifier to differentiate the incoming tumors. Their system improves accuracy up to 97% approximately. In another study, Asri et al. [53] classified their analysis on breast cancer using different methods of machine learning. The authors have done comparatively performance based analysis between ML methods such as SVM, k Nearest Neighbors, Decision Tree using the Breast cancer dataset. The prime objective was to evaluate the accuracy in classifying data relating to each algorithm in terms of correctness, precision, sensitivity. Results produced by those algorithms showed that SVM provided the highest accuracy. Soreness of one or more joints, the reason for pain and stiffness that can become worsen with age is referred as ARTHRITIS. Various sorts of arthritis exist such as osteoarthritis and rheumatoid arthritis. Each type has a different way of treatment. ARTHRITIS reduces the quality of life of a person. Hence, early detection of arthritis is necessary which can be achieved using ML [54]. Neeraj et al. [55] presented a system to classify patients with arthritis dataset which was taken from Koch. Their system classified the data with features such as identity, gender, age and treatment with an algorithm CART to find out true or false rates. DIABETES is a chronic disease that appears when the pancreas is not able to make insulin. To predict diabetes disease, Nahla and Bradely [56] worked on diagnosis by classifying based on a blood test to diagnose diabetic disease using SVM classification. SVM prediction accuracy of 94%, the sensitivity of 93%, and specificity of 94% were achieved. Kandhasamy and Balamurali [57] compared machine learning classifiers Random Forest, K-Nearest Neighbors, J48 Decision Tree and SVM to classify patients who have symptoms of diabetes. These techniques have been tested with data taken from the UCI data repository. The results of the algorithms have been tested with noisy data and dataset set without noisy data and compared in terms of specificity, sensitivity and accuracy. Their investigation concluded that the decision tree J48 classifier got higher efficiency than the other three classifiers. PARKINSON'S DISEASE is a disorder responsible for the dysfunction of nervous system progress and its movement. Gradually symptoms arise may be some time starting from tremor in just one hand. Sriram et al. [58] proposed a system in which the tools used for experimentation analysis included classification and evaluation using Orange along with weka tools. UCI Machine learning repository provided Voice dataset for Parkinson's disease. Classification algorithm such as Random Forest showed good accuracy (90.26) compared to all remaining algorithms like KNN, SVM (88.9%) and Random Forest(90.26). Naïve Bayes has shown the least accuracy (69.23). In 2014 Salvatore [59] supervised a machine learning algorithm which was used to diagnose patients with Parkinson's disease and *Progressive Supranuclear Palsy*. They took 28 MRI image records of both PD and PSP patients based on feature extraction technique and SVM was used as a classifier. The algorithm

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was able to differentiate PD patients from PSP patients at an individual level. Respiratory system-nose, throat, and lungs affected by a viral infection is known as Influenza. Pineda et al. [60] investigated seven different classifier of ML for detection of influenza and compared their results within built influenza Bayesian classifier. Their study demonstrated that ML had the power to provide a diagnosis of irresistible sicknesses. Concerning the occurrence of cancer in liver cells, Sandeep et al. [61] proposed a model for Lung images which can be classified into normal or dangerous categories. According to the authors, by following this mechanism results could be achieved with high accuracy. Through the use of electronic records, ML can predict various diseases.

### B. MEDICAL DIAGNOSIS PROCESS USING ML

Machine learning has granted computer systems new abilities that we could have never thought of. Machine learning is a field of AI that gives machines to power to learn itself by examples [62] in order to analyze how to different models perform in ML without using human judgment. The working of ML are explained step by step as follow [63] as shown in Fig. 4.

1) **Data Collection**: The very first step is to collect data. It is a very critical step as quality and quantity affect the overall performance of the system. Basically it is a process of gathering data on targeted variables.
2) **Data Preparation**: After the collection of data, the second step is data preprocessing. It is a process to change raw data to useful data, on which a decision could be made. This process is also called data cleaning.
3) **Choose a Model**: To represent preprocessed data into a model, one chooses an appropriate algorithm according to the task.
4) **Train the Model**: ML use supervised learning to train a model to increase the accuracy of decision making or doing predictions.
5) **Evaluate the Model**: To evaluate the model, a number parameters is needed. The parameters are driven from the defined objectives. Also, one needs to capture the performance of the model with the previous one.
6) **Parameter Tuning**: This step may include: numbering of training steps, performance, outcome, learning rate, initialization values, and distribution, etc.
7) **Make Predictions**: To evaluate the developed model with the real world, it is indispensable to predict some outcome on the test dataset. If that outcome will match with domain expert or opinions nearer to it, then that model can be used for further predictions.

The basic steps of for disease detection using ML is described as follows [64][62]

1) Collect test data with patient details.
2) The feature extraction process picks attributes which are useful for disease prediction
3) Afterward, the selection of attributes, then select and process the dataset.
4) Various classifications methods as mentioned in the diagram can be applied to preprocess dataset to evaluate the accuracy of prediction of disease
5) The performance of different classifiers compared with each other in order to select the best classifier with the highest accuracy.

In Machine learning, all the features extracted by a domain specialist to minimize the complications of data and to develop patterns in such a way that would easily visible to ML algorithms. However, deep learning based technique can extract features manually without human intervention, the only condition is to make precise decisions in which the testing data could be accurate. This technique eliminates the requirement of a domain expert for feature extraction. In the following section, we describe how deep learning has been used for disease diagnostic system.

## V. DEEP LEARNING AND DISEASE DIAGNOSIS

In this section we first present the current related work which are based on deep learning. We further describe how deep learning is used for disease diagnosis processes.

### A. EXISTING WORKS USING DEEP LEARNING

An artificial intelligence technique that mimics the workings of the human brain and creating patterns for decision making is known as Deep Learning. While machine learning methods required to break down a problem statement into different parts first and then their outcome to be integrated at the final stage; the Deep Learning method's objective is to solve the issue end to end. In medical science, deep learning achieves better results than traditional machine learning models [65].

Deep learning has got great interest in each field and especially in medical image analysis. The term deep learning refers to utilize of deep neural network models. The main component of the neural network is the simulation of the human brain in the form of neurons. It works on the scenario in which different signals use as input, join them suing weights and pass those joined signals to produce output [66]. The AANs (artificial neural networks) and deep learning can be differentiated by the variations in a number of hidden layers and their inter-connectivity and the efficiency to yield a suitable result of the inputs. The ANNs are generally constituted of three different layers and are instructed to retrieve well-structured information that could be suitably utilized only to perform the specialized task [67]. On the other hand, in Deep learning, physical and clinical examination of the patient are determined through the nature of the diseases. Though there are many tools and techniques that are available for diagnosis of diseases, a certain degree of inaccuracy and uncertainty still persists in the diagnosis process. It is quite evident from various analytics survey that using machine learning techniques has its own limitations. In addition to that, the present system

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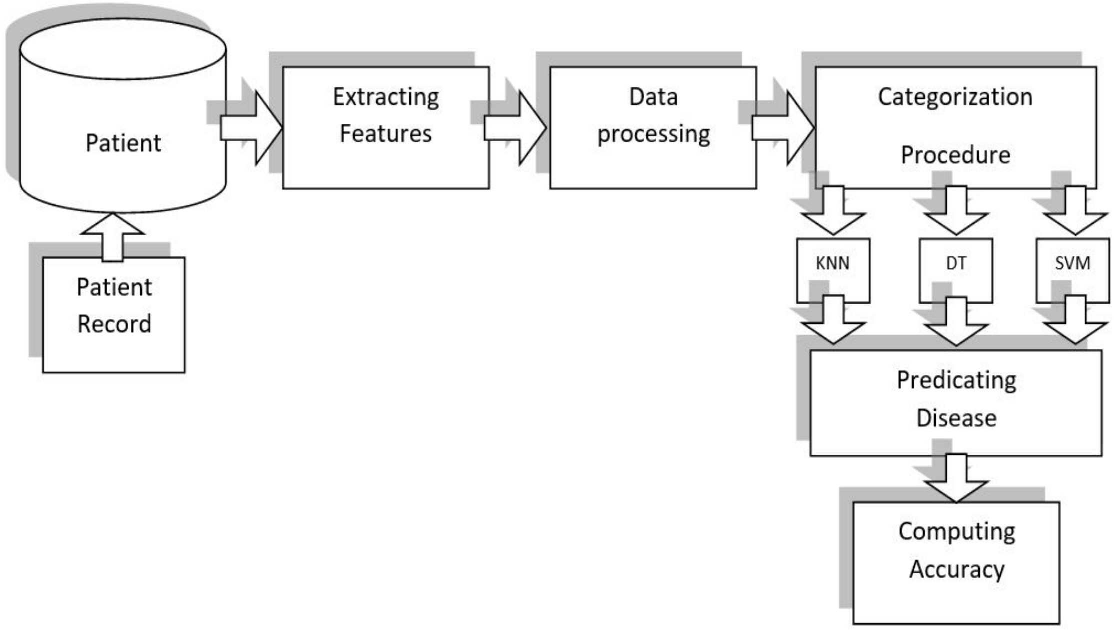


**FIGURE 4.** Machine Learning System

of diagnosis only considers attributes to determine diseases. The conventional way of selecting attributes which is used for disease prediction some time yield erroneous result. In contrary to machine learning, deep learning is capable to select the most relevant attributes out of the database which in turn leads to the prediction of diseases with a great degree of precision [68]. A considerable number of diagnosis systems using deep learning can be found in the literature.

Skin diseases may affect human skin and mostly seem to be an external disease as it originates and affects the layers of the skin. But sometimes it gives very important clues to diagnose underlying causes of internal diseases. There is a variety of skin disease that can be acne, skin cancer, rashes, etc. Early detection of skin disease is important as a preventive measure of future skin problems. Liao [69] proposed a system to classify different skin diseases using deep convolutional neural networks. Using 2300 skin disease images taken from Dermnet and OLE dataset, the proposed system was able to train the CNN model and assess its results. Their system could achieve Top-1 accuracy of 73.1%. Another classification was given by Shoieb et al [70] to diagnose skin cancer. Their model detected the infected part of skin and CNN which is used for feature extraction. Their model used SVM as a classifier and utilize CNN to train the model suing skin image data. Their results represented significant improvement and accuracy compared to previous ones in skin diagnosis. Chronic disease such as breast cancer when detected using deep learning get higher accuracy compared to other techniques. Zaher and Eldeib [71] proposed a system CAD approach for the diagnosis of breast cancer that has been modeled using a deep belief network. In their technique, the unsupervised path followed by back propagation supervised path with "Liebenberg Marquardt's learning function" and weights were initialized using the deep network path. Their function was tested on Breast Cancer Data and provided a correctness in results up to 99% greater than previous approaches. Charan et al. [72] used CNN for breast cancer diagnosis. A total 322 mammograms records extracted for testing in which 189 were used and showed negative results and 133 were of abnormal breast records. Their results showed the effectiveness of deep learning for breast cancer diagnosis for mammogram images.

Diabetes is a metabolic illness influencing people groups around the world. Its frequency rates are expanding alarmingly and consistently. Goutham et al. [73] proposed a model for the classified diabetic and normal Heart rate signals with help of deep learning system. They utilized CNN for extracting features and HRV data was used use as input. Classification of features was done by SVM. Their proposed system is predicted to help medical doctors to diagnose diabetes using ECG signals with very high accuracy. Another representation was given by Sisodia and Sisodia [74] on the early detection of diabetics. The main aim of their research was to develop a system that can predict the possibility of diabetics with maximum correctness. Hence three ML algorithms SVM, Naive Bayes, and Decision Tree were used to diagnose diabetes at an early stage. The Pima Indians Diabetes Database was used to perform experiments. The performances of these algorithms were assessed on various measures like Accuracy, Precision, F-Measure. Their results

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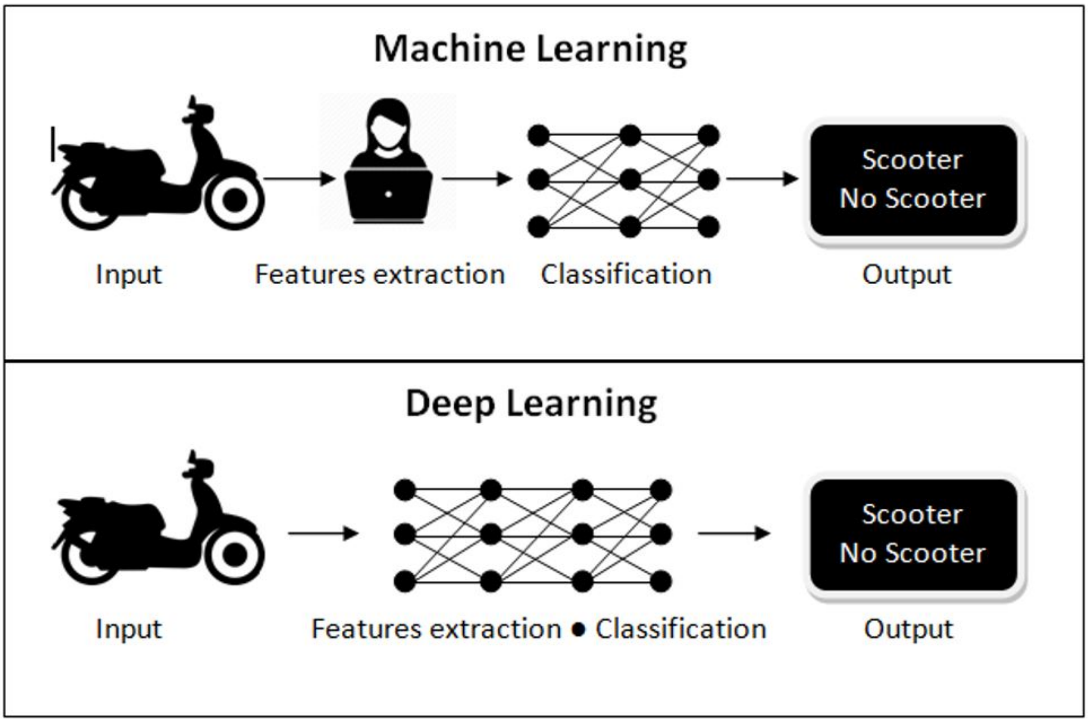


**FIGURE 5.** Difference between Machine Learning and Deep Learning

indicated that Naive Bayes performed better with the highest accuracy of 0.76 compared to previous models. Heart disease classification was done by Rubin et al. [75] and their study identified variabilities heart sounds using an automatic cardiac auscultation system. Their algorithm collected the time-frequency rate of heart sounds and classified with the help of a deep convolutional neural network. The motive of their research was to determine normal and abnormal heart sounds. The authors achieved high specificity score out of all entries. Miao and Miao [76] developed an enhanced deep neural network (DNN) to diagnose heart disease. The designed deep neural network model was based on a deeper multilayer perceptron framework. Their model classified the data based on the training set. To investigate the performance of this model, 303 test data were taken from patient with coronary disease. Their model achieved accuracy of 83%, sensitivity of 93% approximately. For Liver cancer, Sun et al. [77] developed three deep learning algorithms implemented using Convolutional Neural Network, Deep Belief Networks and Stacked Denoising Autoencoder to diagnosis lung cancer diagnosis. They compared the performance of all three algorithms on 28 image features of the lungs dataset. SVM was used for classification. CNN, DBNs, and SDAE provided accuracies of 0.7976, 0.8119, and 0.7929, respectively.

COVID-19 (Coronavirus) disease is an infectious virus. It spreads when an infected person coughs, sneezes, and his generated droplets are transmitted to other persons. Most people who get infected by COVID-19 experience high temperature, cough, difficulty in breathing. COVID-19 has killed millions of people across the world. Due to the increasing number of cases and limited test kits, it becomes difficult to detect the presence of COVID-19. Here at this point, the need for other alternatives such as X-ray has been arisen. When researchers use X-RAYS with AI techniques it becomes easy to detect COVID-19 [78], [79]. Using deep learning authors have developed a model with four phases: data augmentation, preprocessing, stage-I, and stage-II deep network model designing. The model has been implemented on 1215 X-RAY images. Initially, in stage1 model differentiates induced pneumonia, bacteria-induced pneumonia, and normal/healthy people with 93.01% accuracy. After that images detected with viral-induced pneumonia are sent to stage2 for detection of COVID-19 that has gained 97.22% accuracy. Overall results of this model were accurate, reliable, and fast [80]. Most often COVID-19 disease makes doctors confused with lungs infection in this condition and diagnosis become a difficult task here. For this, quick diagnosis is required that can be possible with different deep models. Authors introduced a novel Convolutional CapsNet using chest X-ray images. This model provides accurate results with the binary classification of 97.24% and multi-class classification of 84.22% [81]. In this study, a Pre-trained deep neural network was used to diagnose COVID-19 on chest CT images.

Brain Hemorrhage refers to bleeding within the brain, it can happen due to a brain tumor, clot, or hypertension. Whenever a Hemorrhage occurs, oxygen cannot be able to reach the brain cells and eventually brain cells die rapidly [82]. A novel convolutional neural network based on ResNet to diagnose and predict the type of brain hemorrhage is also developed [83]. 752,803 DICOM files have been collected to conduct this study. This model obtained an accuracy of 93.3%.

### B. MEDICAL DIAGNOSIS USING DEEP LEARNING

As mentioned earlier, the conventional automated diagnostic method used a machine-learning algorithm in that clinical expert manually fetched features in diagnosis reports. But sometimes it became difficult to extract features from large dataset [47] [48]. Hence, those methods suffered with accuracy and efficiency as depicted in Fig. 5.

Absence of important information is a considerable obstacle for deep learning models. Presently, medical research use electronic health records, but there is no predictable technique to evaluate the EHRs, which implies that accuracy of diagnostic process using automated system could be limited. If the system fail to collect accurate data, the model will not able to diagnose a disease precisely, which makes it complicated to show accurate prediction. To tackle this kind of problem, the authors in [64], [65] developed effective deep learning model for early correct detection of various diseases. In conventional approach, a Deep CNN model is used to detect diseases. Then the neural system utilizes approaches to data expansion. Each layer inside CNN filters the raw data in the image to get a specific pattern. The few initial layers find the large feature set like diagonal lines and the next few layers are used to get better details, organize them into complicated features. The most final layer works as an ordinary neural network and the network becomes fully connected [66], [67]. Then it put together highly specific features like various symptoms of the disease and as a result, perform the prediction of the disease. The authors in [64], [84] rectified the approach in order to solve the issue of lacking information or missing values. Afterward, a deep learning model trained by the processed data have proved their efficiency as shown in Fig 6.

## VI. RESEARCH METHODOLOGY

PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analysis) method was used for a systematic review. This method was invented by Moher et al. [85], [86]. In this method, a survey is carried out on basis of a predefined question by the virtue of which data from the studies that are included in the survey, are collected and subsequently analyzed systematically and evaluated critically. Meta-analysis is a statistical, formal, quantitative study design technique used for systematic evaluation and integrating the results of the included studies or previous study to derive the conclusion. Both systematic review and meta-analyses are an integral part of research to summarize evidence relevant to the efficacy and safety of medical care interventions precision and certainty. In a systematic review method, the least collection of elements is based upon evidence and meta-analyses that summarize and analyze scientific reliable literature by utilizing a structure method based on predetermined queries that can be used by various researchers. Different findings and ideas which are published in the conventional papers by different researchers can be investigated with a correct and comprehensive analysis in a systematic review method. With the help of the PRISMA method, an investigator can perform systematic reviews and meta-analyses with a degree of accuracy that can lead research in a well-structured manner.

### A. LITERATURE SEARCH

In this study, various 8 databases were extracted for accurate review: BMC, Springer, ACM, IEEE, Elsevier, Google Scholar, Wiley digital library and ACM were selected based on our research questions. Based on predefined questions and goals, the literature search was done by utilizing the keywords including “fuzzy logic”, “machine learning”, “deep learning”, “disease prediction”. Previous useful articles were extracted and recognized by a search strategy. The search strategy has shown for every journal described in Table 1 150 articles from 2009 to 2019 have been extracted and the detailed selection process is displayed using the PRISMA diagram in Fig. 7.

### B. DISTRIBUTION OF PAPERS BY JOURNALS

In the study, 7 reputed journals have been selected to search for papers. Following table shows the various database providers. Table 1 shows the names of publishers which were selected, the number of articles selected and corresponding percentages. As shown in the Table 1, IEEE, Elsevier, Springer ranked first with 35.29%, 23.40% and 19.60% respectively.

### C. STUDY SELECTION AND ELIGIBLE PAPERS

In this segment, the outcome of 80 research articles was taken into consideration. As shown in Fig. 7 those research articles were chosen or taken into consideration based on inclusion and exclusion criteria. As per exclusion criteria, only qualified articles were chosen and chapters from book, thesis, and summary reports. Journal editorials, newsletter and papers which were not in English were excluded. According to inclusion criteria, we considered the following criteria: reference of the author, year of publication, where it belongs to a journal or conference proceeding, the definition of the diseases; its types and complications, objectives, a loophole in the research, type of fuzzy methods used, type of machine learning methods used, type of deep learning methods used, results and concluding remarks. In connection with this, 15 academic papers were excluded and 105 articles included. After reviewing all collected articles, only 80 papers qualified the eligibility criteria from where relevant articles were chosen for in-depth analysis and study. Furthermore, we proceeded by scrutinizing the abstract and summary of the chosen articles to investigate whether

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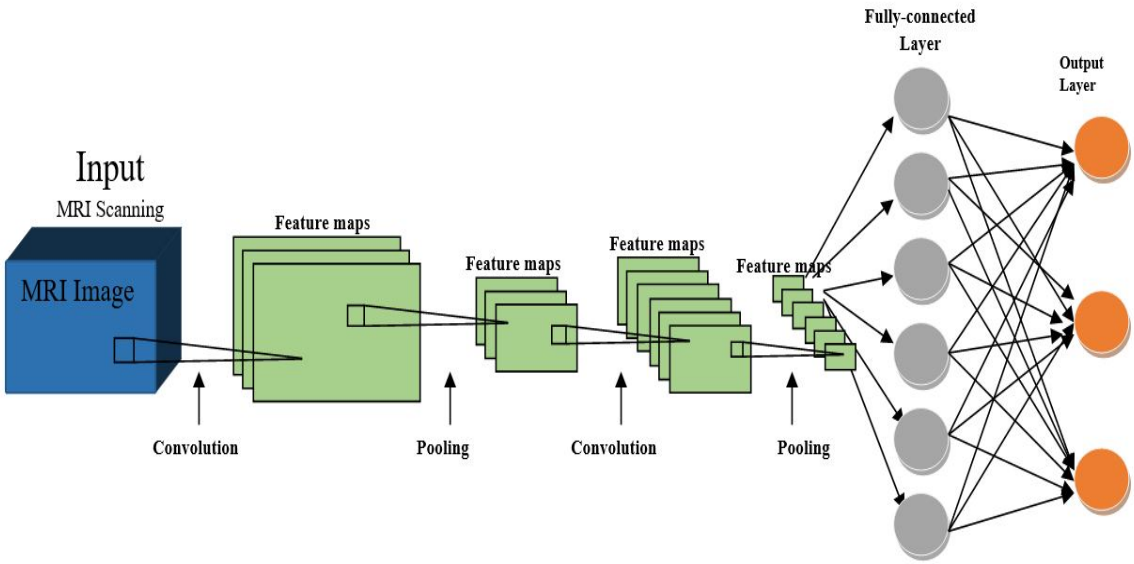


**FIGURE 6.** Deep Process to diagnosis a disease

**TABLE 1.** Different published articles selected for the literature review along with frequency

| Publisher | Articles | Percentage |
|---|---|---|
| Elsevier | 11 | 23.40 |
| IEEE | 18 | 35.29 |
| Springer | 10 | 19.60 |
| ACM | 5 | 9.80 |
| BMC | 1 | 1.96 |
| IOSPress | 1 | 1.96 |
| BioMed central | 3 | 5.88 |
| Wiley online library | 2 | 3.92 |
| Total | 51 | 100 |

the selected articles fully satisfy the inclusion criteria. All insignificant and unrelated articles were discarded in this stage. Similarly, all academic research papers which did not match the inclusion criteria of disease diagnosis were discarded while selecting appropriate articles. In total, 89 articles were qualified as per the inclusion criteria and were found to be compatible with our study and were taken into account in this systematic review. Table 2 contains the primary keywords used to search the relevant contents.

### D. EXTRACTION AND SUMMARIZING OF DATA

In the last stage, we reviewed all the papers which consisted of 95 articles in order to complete the final study and achieve the desired result. The articles which were extracted for the research were vetted meticulously to find out the answer to the crucial questions as per the requirement of the research. A form was formulated for the extraction of data that make the necessary classification, inspection, and incorporation of the included articles in the light of the present criteria. The data extraction form which was formulated helped to a great extend to accomplish the desire results and draw a suitable conclusion. The criteria which were incorporated included the reference of the author, its year of publication, whether it belongs to a journal or conference proceeding, the definition of the diseases; its types and complications, objectives, loophole in the research, methods used fuzzy logic, machine learning, and deep learning methods, results, finding and positive impact on diagnosis process. Fig. 8 indicates a chart related to classification. After reviewing all collected papers, 80 academic research papers from 30 international scientific journals and 10 conferences proceeding which were published from the year 2009 to 2019 were taken into account in this systematic research. We thoroughly reviewed all selected article and finally retained those articles which applied fuzzy logic, machine learning, and deep learning for diagnosis of a disease. Notwithstanding, though adopting the PRISMA method and selecting articles accordingly is a time-consuming process, still this method is a most suitable method for carrying out research as it is a structured method for which we have to include only those articles in the study which were explicit to the subject of the systematic review.

## VII. DISCUSSIONS AND FUTURE RESEARCH DIRECTIONS

### A. RESEARCH FINDINGS AND LESSONS LEARNED

This study was conducted to inspect the effect of AI methods in the diagnosis of various diseases. Very few review articles have been published to evaluate how AI methods are effective in Healthcare. In this review article, we were capable to locate and review 51 papers that used different

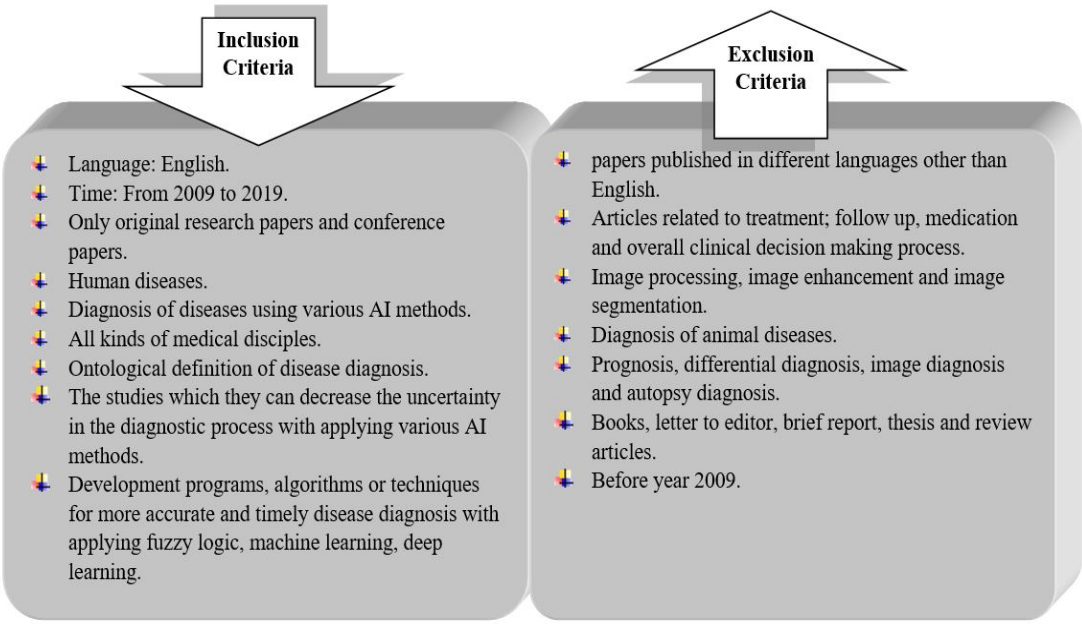


**FIGURE 7.** Article Selection Process

**TABLE 2.** Search strategy in different databases

| Database | Search Strategy |
|---|---|
| IEEE | (Fuzzy Logic, Machine learning, Deep learning) AND (Disease Diagnosis) |
| Elsevier | Pub-date > 2009 AND (AI Techniques) AND (Disease Diagnosis) |
| Springer | (fuzzy logic, Machine learning, Deep learning] AND (Disease Diagnosis) AND Publication Date: (01/01/2009 TO 01/11/2020) |
| BMC | AI techniques in Abstract AND Disease Diagnosis in Abstract |
| Taylor & Francis | (AI methods) AND (disease diagnosis) |
| Google Scholar | "AI methods" AND "Disease Diagnosis" anywhere in articles |

**TABLE 3.** The distribution of AI methods by medical disciplines

| Disease Name | Fuzzy Logic | Machine Learning | Deep Learning |
|---|---|---|---|
| Cardiology | 2 | 2 | 2 |
| Neurology | 2 | 2 | 2 |
| Dermatology | 0 | 2 | 2 |
| Breast Cancer | 2 | 2 | 2 |
| Diabetics | 2 | 2 | 2 |
| Kidney disease | 2 | 2 | 2 |
| Arthritis | 0 | 1 | 0 |
| Liver cancer | 0 | 0 | 1 |
| Thyroid | 0 | 0 | 1 |
| Dental disease | 2 | 2 | 0 |
| Ebola | 1 | 0 | 0 |
| Asthma | 1 | 0 | 0 |
| Cholera | 2 | 0 | 0 |
| Influenza | 0 | 1 | 0 |
| Skin cancer | 0 | 0 | 2 |

AI methods for diagnosing various diseases from January 2009 to December 2019. The review considered eight most used databases, in which a total of 105 articles were found. A detailed analysis of those articles was conducted in order to classify most used AI techniques for medical diagnostic systems. Since when were writing this review paper we were at the beginning of 2020, so we could not determine the articles published this year. Firstly, in this research, we identify which mechanisms had the greatest effect on the disease diagnosis and conducted our research based on this purpose. Hence we examined appropriate classifications for the study of AI methods such as fuzzy logic, machine learning, and deep learning are reviewed basis on our analysis. The results show that deep learning is very popular among the present researchers especially in the area of medical science as shown in Table 3. Another division is about classifying the percentage of articles published every year. Over the past few years, the rapid growth in the study of AI in diagnosing diseases is reflected in the analysis of papers in our research. The results indicate that the average published volume from 1% in 2009 reached 20% in 2019 as shown in Fig. 9. AI helps doctors to early detection of disease and produce beneficial results in improving the diagnosis process that's why AI is popular among investigators. Based on our investigation, three widely used AI techniques (fuzzy logic, machine learning, and deep learning) were considered to review the articles in the field of healthcare and produced results based on this research. We considered the classification of articles that recorded the positive effect of AI methods in diagnosing complex diseases that can cause a serious

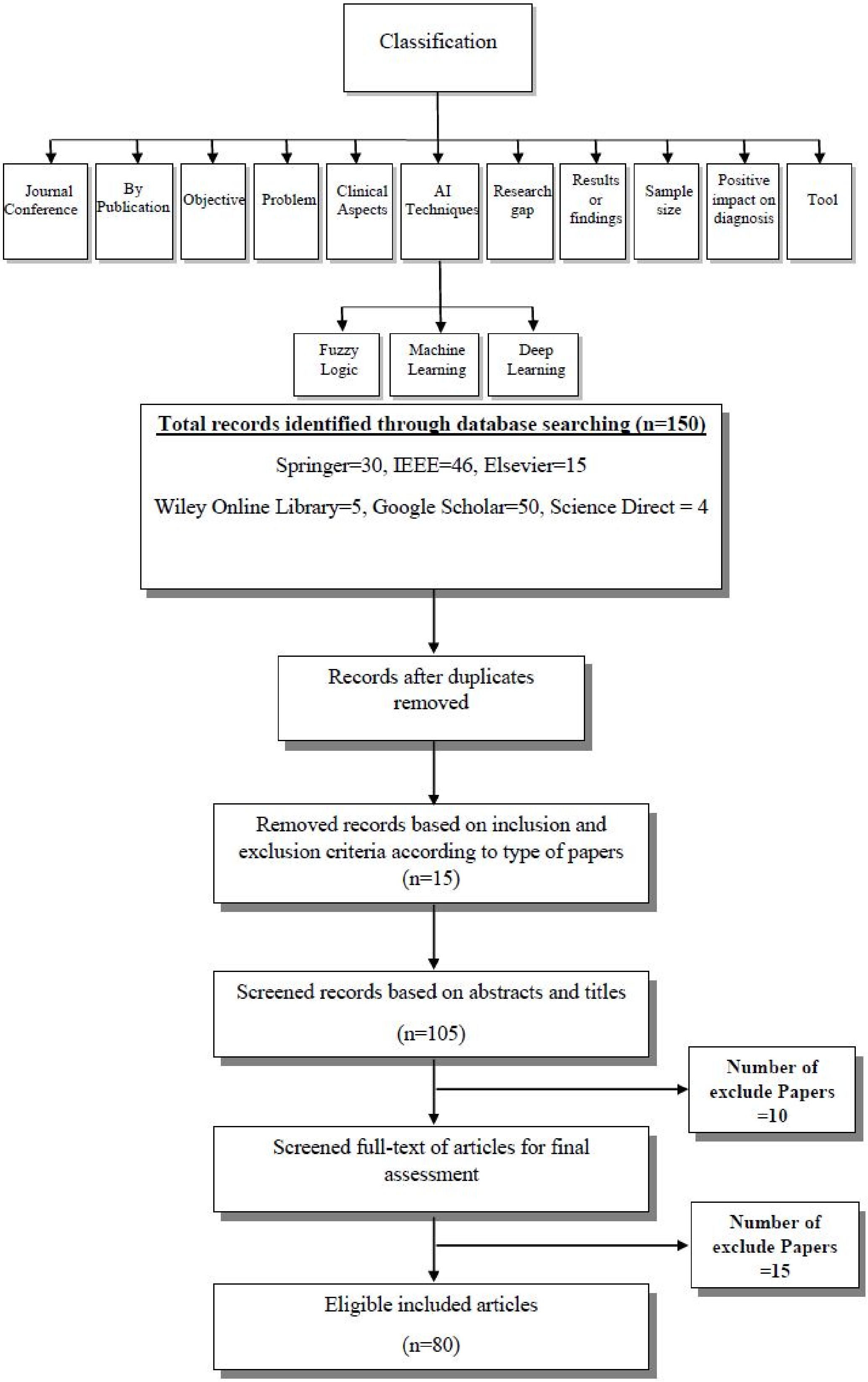


**FIGURE 8.** PRISMA methods for review

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**TABLE 4.** Fuzzy logic method review

| Study | Disease | Research Goals | Methodology | Findings |
|---|---|---|---|---|
| [26] | Heart Disease | To measure the accuracy of the framework system for heart disease | Neuron-Fuzzy Integrated System and tool used is MATLAB | The results produced by this study by applying neuron-fuzzy integrated systems matched with expert's opinion. |
| [27] | Cardiology | The main goal of this research is to reduce time in processing of ECG signal by minimizing the number of data samples, without losing any essential bit and analysis the heart signals | The algorithm is used for the signal classification and the correlation is Gustafson Kassel fuzzy clustering | Only twenty samples to determine disease using fuzzy clustering algorithm. This algorithm use. It takes a little measure of memory to store the information and requires littler processing, in this manner producing the reaction in a small period. |
| [28] | Ebola | The prime objective of this study is to develop a fuzzy system to diagnose Ebola with useful recommendations | Fuzzy expert system was used along with The Root Sum Square | The accomplishment of Ebinformatics shows the possibilities of applying an informatics device as a method for encouraging basic tasks, for example, understanding finding, forecast, and suitable suggestions. |
| [30] | Brain Tumor | To improve the segmentation process. | clustering algorithms Fuzzy C Means is used along with tools Genetic Algorithm (GA), and Particle Swarm Optimization (PSO) | The results have provided substantial evidence that for brain tumor segmentation is The performance accuracy is 0.95 and rate of error reduced to 13%,tumor diagnosis reached to very high rate 98% |
| [31] | Parkinson disease | the fuzzy k-nearest neighbour system was used for detecting Parkinson disease | The proposed FKNN-based system is compared with the support vector machines based methods. To further enhance the diagnostic correctness for the detection of PD | FKNN based framework get accuracy up to 96.07% .this method can ensure a reliable diagnostic model for detection of PD |
| [32] | Asthma Disease | This prime goal of this study is to design a system that assist to diagnosis of adult Asthma by use of Neuron-Fuzzy Logic. This model is helpful in diagnose Asthma and will get the accurate result | Self-Organizing Map (SOM),Learning Vector Quantization, Back-Propagation Algorithm, along with Neuron-Fuzzy Fitting | Tool The effectiveness of this model assed based on dataset of asthmatic patients. And use Back-Propagation to produce results and best validation performance at 535 samples |
| [33] | Breast cancer | To achieve high accuracy in results we applied Fuzzy Logic to automatic BI-RADS categorization of breast lesions | They proposed fuzzy inference system. Fuzzy Omega algorithm was used to generate membership function. | Initially domain expert investigates the images and produced results assess into Fuzzy Omega algorithm. The results are compared with previous study and achieve very high accuracy of 0.76. |
| [34] | Breast cancer | The developed information-based framework used as a medical decision support assistant to assist medical experts in the healthcare. | Clustering method Expectation-Maximization used for clustering. Fuzzy rules are designed based on Classification and Regression Trees. The rules generated by CART algorithm used to classy breast cancer disease | Two data sets to evaluate breast cancer from UCI data repository. The outcome produced from this dataset indicates fuzzy rule-based techniques achieved good prediction accuracy for breast cancer |
| [35] | Liver disease | Objective of this research is to develop a fuzzy expert system for the detection of Cirrhosis that is one of the most commonly diseases arises in liver | Mamdani Fuzzy Logic was parameters along with Fuzzy Logic tools Identify risk status with max-min method | centroid technique improve outcome with defuzzification |
| [36] | Diabetes Disease | To diagnosis diabetic a Fuzzy Expert System used to investigate the diabetes data.it is set off fuzzy membership functions and rules | The fuzzy mechanism consists of fuzzy inference, Collection of rules. also use fuzzy T-norm and T-Conorm operators. To convert fuzzy values into crisp set Defuzzification has been used. | The developed model obtain much accurate results than previous models. |

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| | | | | |
|---|---|---|---|---|
| [37] | Diabetes Disease | This model is proposed to get exact results as Clinical expert concluded related Diabetes Mellitus | Fuzzy Hierarchical Model IS designed to measure the results. | The outcome based on 311 records equivalent to clinical expert. |
| [38] | Diabetes Disease | Early detection of the prediabetic condition and compare the results with the crisp method. | Associative classification technique depend on fuzzy logic-based | The proposed technique can make sense of the specific hazard factors like Age, Glucose, DPF, BMI, and BP alongside its right unsafe estimations to anticipate prediabetes in an enhanced manner than the crisp method. |
| [39] | Dental Disease | The research aims to propose a Fuzzy Expert System for detection of periodontal dental illness by examining and build up a PC program to help dental specialists for examination, finding, and treatment of the disease. | Mamdani Fuzzy Logic with 5 input variables and 164 rules along with a fuzzy logic toolbox | Dental Disease identification time minimized |
| [40] | Dental Disease | The designed system for dental diagnosis problem was DDS. | Perform segmentation process they use semi-supervised fuzzy clustering algorithm | Accuracy of the used DDS algorithm is compared with other algorithms.DDS achieved 0.92 highest accuracy greater than other algorithms like prim spanning tree, fuzzy k-nearest neighbour, affinity propagation clustering. |
| [41] | Cholera | fuzzy expert system for the diagnosis and monitoring of cholera | Mamdani Fuzzy Logic parameter. utilize MATLAB with max-min approach and centroid | MATLAB achieved outcome 0.05 better as indicated in calculated results |
| [42] | Cholera | Analysis cholera based on the FC algorithm. | Fuzzy Classifier Algorithm With five input parameters and one Outcome parameter Fuzzy Logic Toolbox | Simulation results were satisfactory for diagnosing cholera |

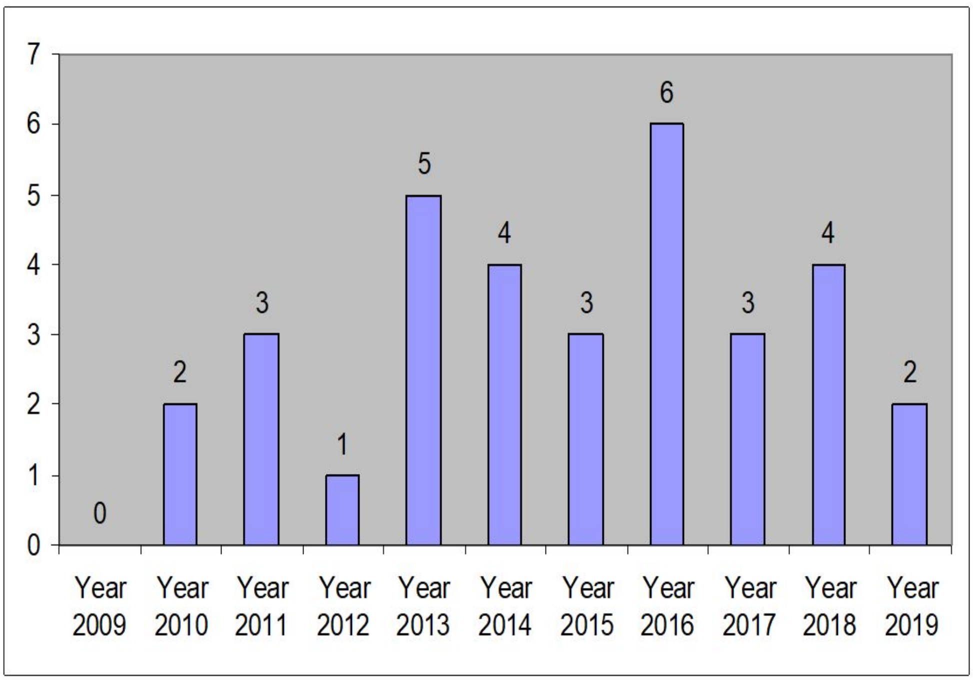


**FIGURE 9.** Article Selection per Year

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**TABLE 5.** Machine learning method review

| Study | Disease | Research Goals | Methodology | Findings |
|---|---|---|---|---|
| [50] | Kidney Diseases | The main objective is to make a comparative study between the performance of SVM and KNN and make classification on the basis of its precision, correctness and completion time for the predication of CKD. | Classification, SVM, KNN. | From the outcome of the test it is evident that the KNN give better result in comparison to SVM in term of classification. |
| [51] | Kidney Disease | Provide assistance to doctors for deciding the accurate treatments methods for the chronic diseases related to kidney by using clinical data. | So far 4 types of machine learning methods are invented viz: KNN (K-nearest neighbors), SVM (support vector machine), decision tree classifiers and LR(logistic regression) | SVM shows maximum in comparison to other three methods at 0.99 whereas the sensitivity of Logistic recorded at 0.94, Decision Tree recorded at 0.93 and KNN recoded at 0.96. |
| [52] | Breast cancer | The aim of this particular study is to identify diseases related to breast cancer based 23 and determine the charactertics of the tumour. | Algorithms generated related to K-SVM (K-means and support vector machine) | 30 investigation on the Wisconsin Diagnostic Breast Cancer (WDBC) data set carried out in this method and recorded 97.38% accuracy which my be considered as better result. |
| [53] | Breast cancer | In this comparative study of Performance among various machines learning algorithms done viz: SVM, Decision Tree, NB and k-NN on the Wisconsin Breast Cancer datasets. Subsequently effectiveness and efficacy of all algorithms with respect to its precision, accuracy, and specificity in classifying data is recorded | WEKA data mining tool. | It's observed that SVM perform better with highest degree of accuracy at 97.13% with the minimum uncertainty. |
| [55] | ARTHRITIS | Design a model to analyze the predicted improvement in arthritis patient | On dataset of arthritis Simple CART Algorithm and WEKA technique are used in tandem. | This method provides assistance to treat more critical cases for Arthritis or solve its queries. |
| [56] | Diabetics | Early detection of Diabetes Mellitus to decrease the death rates. | SVM | SVM is a useful device to examine diabetes and result yield 94% accuracy and its sensitivity and specificity recorded at 93%, and 94% respectively. |
| [57] | Diabetics | The objective of this research is to make a comparative study between algorithms and it performances which are useful in the detection of diabetes. | KNN, SVM, RF, J48Decision Tree; | Research result indicates that Decision tree J48 gives better outcomes with 73.82% accuracy in comparison to other methods. |
| [58] | Parkinson's disease | Voice data examination is a very critical aspect in the current decade for studying and determining suitable diagnostic techniques for Parkinson's disease. | In this study for statistical analysis Orange v2.0b and weka v3.4.10 has been used whereas for classification SVM, KNN classifier have been used | In this technique Parkinson's disease are diagnosed with the help of voice dataset using machine learning algorithms. |
| [59] | Parkinson's disease | The main objective of this study is to analyze the viability of a oversee machine learning algorithm for the assisted diagnosis of patients who already tested positive to Progressive Supranuclear Palsy and Parkinson's disease and | SVM | The algorithm provides excellent discrimination of PD patients from PSP patients at an individual level, Accuracy, Specificity, and Sensitivity > 90% |
| [60] | Influenza | To reduced uncertainty and vague data in the detection process by applying fuzzy methods | Machine learning classifiers | In the case of data with missing values ML constantly provide enhanced performance |
| [61] | Liver cancer | developed a model to detect the normal and abnormal region. | neural network classifier, fuzzy c means, multinomial multivariate Bayesian | This model provide a mechanism to get results with more accuracy. |

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**TABLE 6.** Deep Learning Methods

| Study | Disease | Research Goals | Methodology | Findings |
|---|---|---|---|---|
| [69] | Skin disease | The study aims to analyze the efficiency of universal building skin disease detection system using DCNN. | 23,000 skin disease images extracted from the Dermnet and OLE dataset to asses the performance of CNN framework. | the system obtained high accuracy in detection of skin disease |
| [70] | Skin cancer | It is difficult to recognize melanoma during its initial stages by manual examination.hence development of automated system was required to assist early diagnosis of skin cancer | A classifier system has been developed based on a multiclass linear Support Vector Machine.This system trained with CNN features extracted from skin images dataset | The outcome of this system shown very high performance related to accuracy, specificity and sensitivity. |
| [71] | Breast Cancer | To diagnose breast cancer CAD strategy has been designed based on deep belief network along with backpropagation supervised path | Backpropagation neural network | The proposed model provide an accuracy of 0.99 in results over previously-published models. |
| [72] | Breast Cancer | This method helps to detect the region of tumor. | This study utilized different K Means, Closing, Dilation and Canny Edge Detection algorithms. | The outcome described that K Means algorithm is more accurate in diagnosing tumor |
| [73] | Diabetes | This study proposed methodology to classify diabetic disease HRV signals using deep learning frameworks. | Heart rate variability, ECG, CNN, LSTM | Developed to assist doctors in diagnose diabetes using ECG signals.it achieve accuracy up to 0.95. |
| [74] | Diabetes | The goal of this study is to proposed a framework that able to prognosticate the possibility of diabetes in patients with maximum accuracy | Decision Tree, SVM, and Naive Bayes | Results obtained show Naive Bayes outperforms with accuracy of 0.76. |
| [75] | Heart disease | The study shown the how deep learning is used to diagnosis automated cardiac recognizing variabilities in heart sounds | deep convolutional neural network | The overall results achieved with this model is 0.83 |
| [76] | Heart disease | The objective of this study to designed deep neural network learning to diagnose the patients and aid the clinical expert .it enhance the correctness and reliability of heart disease detection and prognosis in patients | Deep neural network learning | The model acquire accuracy of 0.83,sensitivity of 0.93,precision 0.79. |
| [1] | Liver cancer | The objective is to investigate lung cancer using deep learning algorithms on LIDC database | CNN, DBNs, Stacked Denoising Autoencoder | The correctness of CNN, DBNs, and SDAE are 0.79, 0.81, and 0.79, respectively. |
| [78] | COVID-19 | The objective is to minimize the need of test kits by providing alternatives | Deep learning with four phases and implemented in Python with FastAi library | Overall results of this model to detect the presence of COVID-19 were accurate, reliable, and fast. In stage1 with 93.01% and stage2 97.22% with accuracy. |
| [80] | COVID-19 | To Provide a model for fast screening in detection of COVID-19 | A novel artificial neural network, Convolutional CapsNet | This model provides accurate results with the binary classification of 97.24% and multiclass classification of 84.22%. |
| [81] | COVID-19 | To use Pre-trained neural networks for diagnosis of coronavirus using Chest CT Images | DenseNet201 based deep transfer learning | This model obtained an accuracy of, 99.82% in training, 96.25% in testing, and 97.4% in the validation. |
| [87] | COVID-19 | To conduct a comparative study on deep learning models and find out a model with high accuracy | VGG16, VGG19, DenseNet201, InceptionResNetV2, InceptionV3, Resnet50, and MobileNetV2 | InceptionResnetV2 and Densnet201 provide better results in terms of accuracy 92.18% and 88.09%, respectively. |
| [82] | Brain Haemorrhage | To Analyse acute brain haemorrhage using non-contrast CT images | Aidoc (Tel Aviv, Israel) neural network software | Aidoc software efficiently assist the doctors in making decisions. |
| [83] | Brain Haemorrhage | Detection of brain haemorrhage in less time | A novel convolutional neural network based on ResNet | Accuracy of this model is 93.3%. |

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health issue when detection is too late. We can say that AI is a boom in such complex cases. From the relevance of these approaches concerning healthcare, we have reviewed various AI techniques. The most common approach was associated with the use of AI technology in the area of cardiovascular. We discussed cardiology through three main AI techniques namely fuzzy logic, machine learning and deep learning. Since cardiology covers a wide variety of cardiovascular diseases, therefore we reviewed only a few of them. Different AI methods have some limitations in some disease detection or produce effective results. However, we tried to review the best articles with various diseases like cardiology, Alzheimer's disease, dental problems, Ebola virus, cholera, liver cancer, breast cancer with various AI techniques. This study enhanced our understanding of the effectiveness of AI techniques in diagnostic tests. Thus, this research provides information for people working in clinical disciplines. Moreover, based on the results produced by this research, we were able to find out the areas and diseases which used AI techniques and which have been ignored. A brief description of reviewed articles is also provided in Table 4, Table 5, and Table 6 for available articles which used fuzzy logics, machine learning, and deep learning, respectively.

### B. OPEN PROBLEMS AND FUTURE TRENDS

As evident from the progress and discussion presented in this paper, AI algorithms are potential to provide a significant contribution to medical diagnostic systems. Nonetheless, in order to obtain the maximum potential of AI for mining novel insights from the associated medical data, AI-based diagnostic systems must address some major issues as follows.

#### 1) Explainable Diagnosis

AI models are often criticized because of its internal unclear decision-making process. In this regard, explainable AI deals with the implementation of clarity and reasoning of the behaviors of statistical black-box AI learning methods, particularly deep learning. As such, in addition to uncovering the pattern recognition problems, AI systems should come with causal models of the world supporting explanation and understanding. This is even more important when we seek for the applications of AI in medical diagnostics. Researchers argue that it is essential to look at even beyond explainable AI [88]. Causability will eventually results in explainable diagnosis covering measurements for the quality of explanations.

#### 2) Quality of Training

The performances of machine learning and deep learning algorithms largely depend on the availability of high-quality training models to achieve the required diagnostic capability. Moreover, the problem of data scarcity is very central since data are at the key of AI-based medical applications. There exist some efforts to create additional annotated information by utilizing alternative methods, such as information augmentation and picture synthesis. However, it is not fully clear whether they are suitable for AI-based medical diagnostics [89], [90].

#### 3) Clinical Translation

The development in AI research used in medical diagnostics is indeed rapid, and their possible adoption has been shown by systems including the detection of various cancer metastasis [91], brain recognition [92], and diagnosing diseases in retinal pictures. Nevertheless, the adoption of AI-based system in clinical settings will undergo various transformations and phases and many methods still to come [89]. As mentioned before, present studies focus mainly on optimizing the performance of complex machine learning models, while disregarding their explainability. As a result, physicians struggle to interpret these models, and feel it is hard to trust them. Therefore, reliable and trustworthy communications between medical experts and AI model experts is also highly important to transform the AI-based diagnostic potentials into clinical practice.

#### 4) Medial Data Characteristics

Since the medical data is the ultimate basis of mining knowledge required for disease diagnosis, the information should be of high quality. Moreover, the volume of medical data is usually very high, the data sources are diverse, and the data is often coming from real-time sensors. Therefore, preserving the data quality is a challenging task. With more and more mobile sources used for medical data, with complex applications that need remote access to healthcare data, having it stored on the cloud seems a more viable option [93]. Although various solutions have been introduced to solve issues with cloud storage, none of them can handle all aspects of medical data characteristics precisely, because of the additional need to maintain the compliances with medical data security policies.

#### 5) Standardization and Interoperability

In the diagnosis context, there are many ways that vendors can manufacture a diverse range of diagnostic products while integrating a set of AI algorithms selected from many possible methods. However, they may not follow standard rules and regulations for compatible interfaces and associated protocols across diverse computing frameworks. This prompts interoperability issues. To address system diversity, immediate efforts are required to set the technical standards for AI-based medicine and diagnosis [94]. In this regard, various technical and medical organizations including the AI group run by the international organization for standardization, world health professions alliance, and world health organization can work together [95], [96].

#### 6) Secure Diagnosis

AI methods in general and deep learning techniques in particular are vastly application-specific where a model trained

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for diagnosing one disease might not be able to work well for another diagnosis. The algorithms usually need to be retrained with respective medical data to be utilized for other diseases; otherwise, false diagnosis will be unavoidable. Also, improper selections of hyper parameters, by even slight change, can invoke large change in model's performance resulting in bad diagnosis. For example, whereas supervised learning is considered stable due to fixed data sets, reinforcement learning is not stable at all [97]. On that, more insights are required for AI algorithms to be optimized for particular disease diagnosis. Another important aspect of secure diagnosis is that the diagnostic systems must be protected from wrongdoers. The attackers exploit the features of the AI algorithms to break the system. For example, an adversary can play with the training parameters and mislead the diagnostic system to learn the opposite of what it is supposed to do. It is, therefore, very vital to deeply investigate the characteristics of AI algorithms, reexamine the respective roles in diagnostic systems, and address the respective challenges.

## VIII. CONCLUDING REMARKS

Recent advancements in AI techniques lead to successful applications of AI in healthcare. Even it has become a hot topic of discussion whether AI expert systems will eventually replace human doctors. Still, we consider the fact the AI expert system can assist the human doctor to make a better decision or even replace human judgment in some cases. Different AI techniques can help to find out relevant information from a large amount of clinical data. Also, AI methods are trained in such a way that can have the ability of self-learning, error-correcting, and they produce results with high accuracy. This survey is about the use of three AI approaches in disease diagnosis. In this review, we assess the impact of the AI methods and their constancy on disease diagnosis to minimize the errors in misdiagnosis, with the PRISMA method. To accomplish the primary goal, we developed a search scheme. In this prospect, different scientific journals including Google Scholar, IEEE, Science Direct, Web of Science, Wiley Online Library, and Elsevier were chosen to fetch the published scientific papers from the years 2009 to 2019.

All the retrieved papers are distributed based on authors, published years, various AI tools, the fuzzy methods, machine learning methods and deep learning methods various kinds of diseases, results and lastly the influence of AI methods that are applied in disease detection. The results have shown that the frequency of paper publishing in the medical field has rapidly enhanced. Another aim of this study was to investigate which AI method was most effective for disease diagnosis according to most of the researchers. Based on our study we concluded that applied methods of AI in healthcare provide beneficial results by improved diagnosis process and to detect the disease in early stages which follows to pick the suitable treatment plan. The other key concept to keep in mind is that we investigated three AI techniques (Fuzzy logic, machine learning, and deep learning) that are widely used in healthcare and we produce our results using these three methods. Also, the effect of every AI technique based on the frequency of influence recorded by papers was analyzed. Major medical areas that we have reviewed were related to cardiology, neurology, cancer, kidney disease, diabetics, cholera, and dental disease respectively using AI diagnostic criteria. Besides this, we also discovered that the papers differed significantly depending on the type of disease. In this study we observe that AI is not limited to identify any specific disease, we can utilize various AI techniques to detect any kind of disease or to improve the diagnosis process for all diseases. Therefore we can say that this survey will be helpful in future research. Moreover, in this research paper, we observe that over 91% of AI methods reported a positive impact on disease diagnosis. The efficiency to detect disease by AI cannot be ignored. Another significant finding in this review is that most of the researchers use tools like MATLAB, Python, Java, C# for designing AI architecture. This research also has some limitations. PRISMA method analyzed the articles published only in a specific decade in terms of healthcare using AI techniques. Although some selected articles published in 2020 were considered in this survey, the main review focus was on the articles published from 2009 to 2019. For future studies, we project to consider the diagnosis in a broader sense to indicate the applicability of AI methods in Alzheimer's disease [98] and Parkinson's Disease [99] Diagnosis. Moreover, the roles of AI techniques for the diagnostics systems using sensors-based computing frameworks [100], [101] will also be investigated. An in-depth assessment of the economic impact of AI in health care [102] is also a part of our future works.

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