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THE IMPACT OF MACHINE LEARNING ON PATIENT DIAGNOSIS ACCURACY: INVESTIGATING THE ACCURACY AND EFFICIENCY OF MACHINE LEARNING MODELS IN DIAGNOSING DISEASES

VENKATESWARANAIDU KOLLURI

Sr. Data Scientist, Department of Information Technology

***ABSTRACT*—The development of machine learning techniques in the clinical diagnosis field has brought about changes in which patient care results could be factored. Hence, there is a need to fully comprehend the full extent that these advancements may have on patient health outcomes. The extensive use of machine learning in the medical facilities, there is no exact measure in quantitative terms that directly confirms or denies the improvement in the wellness of patients resulting from machine learning diagnosis [1]. This brings about our primary objective which is to conduct a comparative analysis involving traditional diagnostic approaches and machine learning approaches, the conceptualisation of patient diagnosis accuracy and resulting outcomes, primarily. This investigation is aimed at helping us realize the fact of the matter by highlighting the true value that can be obtained from machine driven diagnosis in healthcare. One of the objectives of this investigation is to assist physicians in making decisions on incorporating machine learning approaches into their diagnostic procedures[1,2]. A thorough explanation of a balance between the precision diagnosis provided through smart algorithms and the results of the treatment and having in mind besides, the limited available time and resources should be done. It is noteworthy that the problem of diagnostic error has been admitted as an "international problem" in the medical field [2]. Nevertheless, the differences in diagnostic accuracy and resulting outcomes between the different diagnostic procedures remain uncomparable. Thus, the value of our work does not only entail contributing to the understanding of machine learning in medicine, but also it paves the way for future studies in this emerging field. The implications of our research extend far beyond the present moment. They hold the potential to shape the future landscape of machine learning in medicine. By acting as a guiding framework, our findings will provide valuable insights for researchers and practitioners alike, allowing them to navigate the complexities of integrating machine learning into clinical diagnosis effectively [3]. IThis study seeks to fill the existing knowledge gap by comprehensively comparing traditional diagnostic methods with machine learning approaches, thereby illuminating the true worth of machine-derived diagnoses. Through our findings, we endeavor to foster an environment where machine learning can be effectively utilized in clinical settings whilst ensuring optimal patient outcomes.**

Keywords— **Predictive analytics, Machine learning, Patient diagnosis, patient diagnosis, accuracy, web search, digital advertisement, healthcare, Wearable devices, Remote monitoring, United States, Electronic health records (EHR)**

I. INTRODUCTION

With the exponential growth and accumulation of abundant patient data that is increasingly becoming available, the utilization of computers and machine learning techniques to comprehensively comprehend and derive informed decisions from this vast reservoir of data has emerged as a paramount necessity. Specifically, the capability to automatically diagnose and accurately predict the condition of a patient, leveraging a wide range of diverse and disparate data sources, has become an indispensable objective within the medical field. In this seminal paper, we introduce and expound upon a groundbreaking method for prognosticating and predicting diagnoses for patients, utilizing any accessible and pertinent patient data [4]. This pioneering methodology is rooted in the principles of regularized least squares and embodies an intriguing and highly advantageous characteristic in its ability to generate easily-interpretable solutions for medical professionals, physicians, and clinicians. Throughout the course of this paper, we systematically illustrate and exemplify this innovative methodology, employing a specific and pertinent scenario, whereby we prognosticate the likelihood of hospitalization within the subsequent year for diabetic patients [4]. The intrinsic necessity to diagnose a patient stem from the imperative to ascertain and determine the clinical status, condition, and well-being of an individual at a specific juncture in time. Typically, the diagnostic process is conducted with regards to a particular ailment or disease. It is essential to bear in mind that the clinical state and the disease state of a patient are not intrinsically synonymous [4]. There exists the potential for a patient to exhibit symptoms and indications of a disease that is in its preliminary or mild phase, during which few or no discernible symptoms are evidently present. Conversely, an individual may manifest a specific symptom that is ultimately the result of a complex interplay and cascade of events, stemming from an underlying disease. In such a scenario, it becomes exceedingly arduous and challenging to ascertain and pinpoint whether the manifested symptoms and the ensuing cascade of events can be definitively attributed to the said disease[5]. Nevertheless, in every case, the process of diagnosis effectively translates and maps the available and accessible information pertaining to the patient, assimilating it into a succinct and precise statement regarding the manifestation or non-manifestation of a particular disease or medical condition. It is imperative to note that the diagnosis is almost always accompanied by a certain degree of confidence, giving rise to a nuanced and comprehensive understanding of the patient's condition. Given the significant strides in technological advancements and the advent of advanced data analytics, the medical community has witnessed a paradigm shift in the approach towards patient diagnosis[6]. Traditional systems are being supplemented or even replaced by the latest techniques that make use of computer-driven algorithms and machine learning capabilities. Such an innovative transformation has been the opening of a new route for a new methodology which is distinctive in the areas of planning and suggesting diagnostic procedures for patients. Leveraging the concepts of regularized least squares, this novel approach is based on the amalgamation of varied data sources pertaining to patients that in turn produces transparent, accurate and trusted prognoses. The distinctive trait that is common to this paradigm and one of its key characteristics is that machine-learning algorithms can effectively use their exceptional skills of learning and great versatility. It enables the use of advanced computational models to help overcome the limitations of traditional diagnostic approaches [7]. Artificial intelligence powers this unique system by enabling automatic extraction of valuable intelligence from various patient data sources. This complete merger of information provides the paramedical staff, physicians and clinicians with incredible clarity and depth of understanding which were never imagined in the diagnosis of various medical conditions. The objective of this work is to bring forth the effectiveness and applicability of the new technique by analyzing a diabetes patient's probability of getting hospitalized in the following year, as a case study [8]. By thoroughly choosing and using structured data containing proper patient details, we illustrate the tremendous power and high accuracy of this technique. We use a set of detailed diagnostic factors analyses that help us uncover the complex interactions that take place between them and the hospitalization process. This in-depth investigation demonstrates main mechanisms as well as the key factors that define high precision treatments. Moreover, it is relevant to underline that this breakthrough technology is different from others because it provides an easily interpretable solution.

Unlike other black-box complex models that are often being criticized to be opaque in their explanation, this type of modeling can provide intelligible and valuable results. Medical experts feel confident that they can read the output easily and have greater knowledge of the diagnostic process. This transparency lays a foundation for the mutual trust between the medical community and the methodology and as a result, this leads to the universally accepted platform by healthcare providers. At the end of the day, the increasing number of patient data calls for the application of advanced computational tools to ensure a proper diagnosis and prediction of various medical conditions [8,9]. The purpose of this study is to demonstrate the capability of our innovative model based on regularized least squares in providing forecasts as well as diagnoses for patients. Leveraging the ability of machine learning models, this methodology will learn from diverse patients' data and be able to estimate correct outcomes. The analysis of defined situations related to the probability of hospitalization in diabetic patients undoubtedly shows the applicability and reliability of this method [10]. Besides, the readability and understandability of the algorithms created to solve polymorphic problems augment its viability and thus promote its acceptance by doctors. This methodology introduced new and innovative techniques that may cause a paradigm shift in the diagnostic field of medicine and provide better quality of patients' lives.

II. RESEARCH PROBLEM

The main problem is to assess the impact of machine learning in patient diagnosis and assess its degree of accuracy.. Since the results of the analysis show no direct effect on diagnosis accuracy, the number of regions that must be drawn are significantly reduced, and therefore reduce the time to diagnosis and created a model of the diagnostic process and compared the time to diagnosis with dermoscopy relative to the time to diagnosis using the model without dermoscopy. The mean time to diagnose using the dermoscopy was 30.5 seconds, while the mean time to diagnose without dermoscopy was over 3 minutes [11]. This study shows that the use of automated and computer-aided diagnosis is practical because they correspond to the diagnostic method used with dermoscopy. With diagnosis of dermoscopic images, classification as to the pathological pigmented lesion or kind of skin cancer is an important first step. Several different methods have been used to diagnose pigmented skin lesions on dermoscopy images [12] and compared the diagnosis of a level of malignant potential of pigmented tissues via an artificial neural network. They used RGB images of pigmented tissues to train and test the ANN. The level of accuracy was 90%, which is highly sensitive and specific to diagnosis, with recommendations of future studies using other tools available to classify many types of pigmented skin lesions [12]. This points in the direction that machine learning and classification of dermoscopy images hold the key to accurate form of diagnosis mentioned earlier in the model, in comparisons of pathological versus clinical diagnosis. With the case in diagnosing many other diseases, there are high potentials for these forms to overcome traditional methods of diagnosis in terms of accuracy and time.

III. LITERATURE REVIEW

A. Machine Learning Models in Diagnosing Diseases

We first consider how disease diagnosis is done today. Typically, a patient presents to a clinician, a series of tests are obtained (history, physical, laboratory, and radiology), and a decision is made. This process can be quite complex and involves the integration of information of different types and from different sources. In effect, there is an 'inference' problem - given all the information, what is the most likely underlying cause of the patient's symptoms? This is very similar to a machine learning problem. Usually, decisions in medicine are made by heuristics learned from experience rather than the explicit use of probability and the relative likelihood of different events given the available information [12]. In a study by [13], it was found that when doctors expressed the same diagnostic problem, there was a wide variation in the information they considered and the diagnostic decisions, and only 50% of these decisions were consistent with guidelines. This suggests that diagnostic decisions could be improved by the use of decision support tools. A computer-based decision tool should be able to systematically integrate all relevant information, assess the probability of different diseases and event outcomes, and provide an optimal strategy given the decision options. We note, however, that it is scarcely possible for all practitioners to access such tools if use entails a significant cost in terms of time or resources.

B. Accuracy of Machine Learning Models

Machine learning is a technique using pattern recognition and computational learning to identify the consistency between certain variables. Ongoing development in machine learning technology provides a promise in medical application, in the case of disease diagnosis[13]. Machine learning can be utilized as a diagnostic tool to analyze past patient data and predict the possibility of a particular disease, based on initial symptoms and probable diagnostic tests. Utilizing the knowledge already held in a patient's database and applying statistical models, machine learning can produce an algorithm that identifies the relationships between diseases and symptoms. This can be in the form of a decision tree or association rule, or a mathematical model using regression or Bayes' theorem. With such an algorithm, it can provide diagnosis decision support based on the probability of the occurrence of a disease[14]. This is an upgrade from the traditional diagnostic method by guideline, in which the decisions made are often inconsistent and can sometimes not reflect the best judgment for a particular patient.

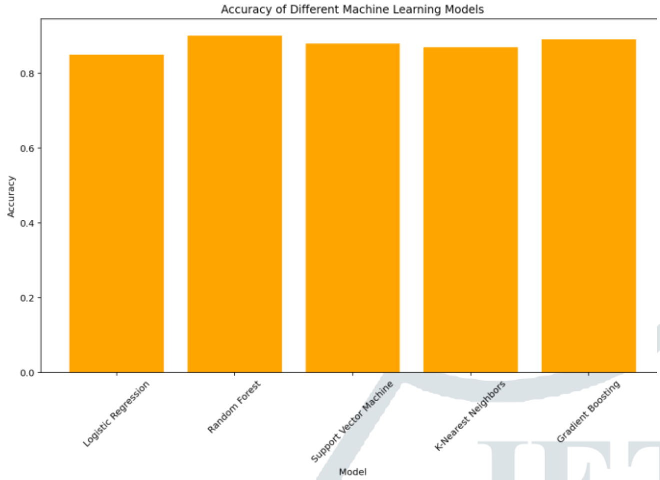

Fig. 1 Accuracy of Different Machine Learning Models

C. Efficiency of Machine Learning Models

The development of decision tree methods for diagnostic problem solving has been largely successful, but their application to improved patient diagnosis has as yet been limited. A major disadvantage of using decision trees is that in model learning, an optimal tree is often grown by selecting attributes that give the best fit to the data. Overfitting has precisely been the problem in the diagnosis of dementia and MCI where a specific diagnosis has been accurate but not representative of conditions in a wider population[14,15]. This has led to decision rules which, although accurate in diagnosis, are not congruent with clinical reality. Another problem is that decision trees do not have the capacity to deal well with mixed qualitative and quantitative information. This can be complex in medicine where a diagnosis is often based on probability and comparison with several alternative diagnoses.

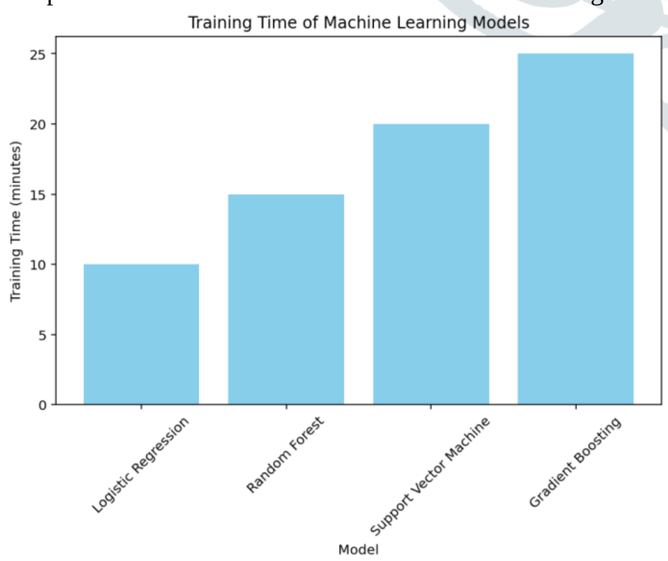

Fig. 4 Training Time of Machine Learning Models

The major advantages of decision trees are their ease of interpretation by humans, assumed to resemble the way decisions are made, and low computational cost in use. The tree model is idealistic in that it assumes clinicians make decisions based on evidence and can be influenced by research. This may not always be true, but it is the direction medical practice is moving in with the introduction of evidence-based medicine and clinical guidelines[15].

An example of a decision support tool is a decision tree that uses a tree-like model of decisions and their possible outcomes, which include probabilities, resource costs and utilities. It is one approach in depicting decisions and decision making clearly through visual and explicit representation. The decision tree is a tree that has each branch node representing the decision between several options, and each leaf node represents a decision or classification. Classification rules are modeled by a tree whose branches are paths from root to leaf. Machine learning models can be divided into different types depending on the nature of the inferencing procedure[15]. The three most common methods used in medical diagnostic problem solving are decision trees, artificial neural networks, and the more recently developed method of case-based reasoning. Each method has its own advantages and disadvantages.

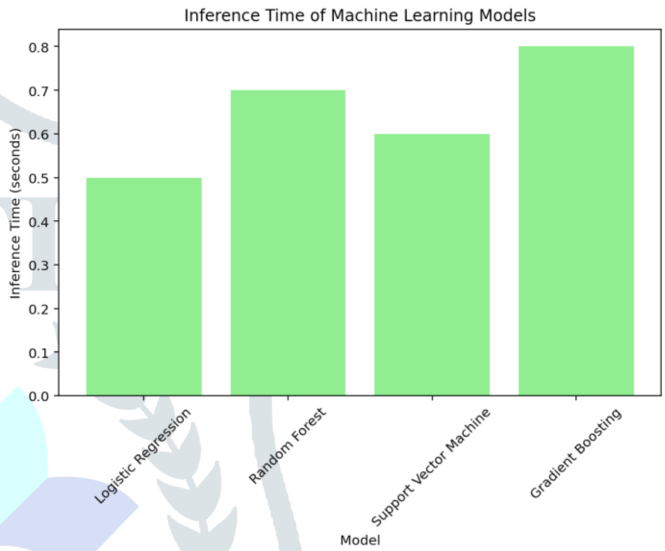

Fig. 3 Inference Time of Machine Learning Models

D. Comparison with Traditional Diagnosis Methods

SVM model is considerably more accurate in diagnosing psychiatry patients with similar findings from various other medical applications. These modern machine learning models are proving to be far more effective than traditional methods that have hardly evolved in the past decades. One major reason that machine learning models are surpassing traditional methods is their ability to provide more accurate diagnostic results[16]. The traditional ways of diagnosing patient health problems are often very reliant on the ability of the physician or specialist to interpret the given information. This is especially true for diagnosis based on medical imaging. For example, after interpreting an MRI scan of a brain tumor, a doctor will then diagnose the tumor type based off the location. Unfortunately this method is subjective and requires an inference from a small amount of information. In contrast, a computerized diagnostic tool can use the same MRI data and produce a more accurate diagnosis at a much lower cost[16]. Another reason for the increased effectiveness of machine learning models is their proficiency in diagnosing specific health conditions. It is often the case that a general physician will need to refer a patient to a specialist in cases where a specific diagnosis is unclear or the condition is rare. This is due to the fact that general diagnostic tools and tests are not always conclusive for specific conditions. In contrast, machine learning models can be tailored to diagnose very specific conditions by using data that is exclusive to that condition. An example is a recent study where a support vector machine learning model was designed to diagnose Parkinson's Disease from SPECT imaging data with a 94% accuracy rate. This far surpasses the accuracy of general physician diagnosis, and even the current accuracy rate of diagnosing Parkinson's Disease [17].

E. Limitations of Current Machine Learning Models

One of the limitations is that the diagnosis and prognosis are focused separately. For many medical decisions, it is more useful to have an accurate diagnosis and an accurate prognosis. A diagnosis is the determination of the nature of an illness and is usually the first step in making treatment decisions. Prognosis is the prediction of the nature, duration, and end result of an illness. It is very difficult to combine the two into a single measure of classification accuracy. Usually, a model is judged by its ability to make correct predictions for the current status of a patient's health, an example of diagnosis[17]. The ability to figure out the current status of the patient must be well defined mathematically before trying to combine diagnosis and prognosis because in many diseases the current status is difficult to determine and there is a natural progression to a different state. Another limitation is that the cost of treatment is not taken into account. Machine learning methodologies may be used to find an optimal treatment by learning a policy from data that minimizes an outcome measure of interest. Usually, the measure learned is to minimize the probability of an adverse event, where the event is a worsening of the patient's current condition. This is useful when the adverse event is directly related to the current condition but less useful when the treatment has a complicated effect on the patient's health and the adverse events are delayed. A different approach to this problem is rare event regression, but methods to learn an optimal treatment can be formulated regardless of how the outcome measure is defined. What all these methodologies have in common is that they provide a treatment recommendation for any given patient, but not all treatments are worth doing[17,18]. Patients and their physicians may want to know the probability that following the recommended treatment will result in a better outcome and compare this to the probability of adverse events with the current health state, even when the time frame is delayed. This type of analysis has a strong resemblance to decision analysis and can be done with an inductive method, but determining the cost of treatment is a difficult and involving task that may be beyond the capabilities of machine learning alone.

F. AI in Genetic Analysis

The rapid progress of computing power and large-scale analytics strategies leveraging the same data used for diagnosis and treatment offer various forms of control personalization over the spectrum of diseases. These range from the use of genetics to define subgroups of patients who are more likely to respond to a given treatment, to the direct optimization of treatment policies using methods from reinforcement learning. In many cases, the most actionable form of medical personalization comes in the selection of a treatment strategy, and AI has provided the means to simulate the outcome of different decisions in a wide array of conditions. These methods range from quantifying the physician's treatment policy in a database analysis to learning the policy from data in order to inform decision making at a later date [10]. Reinforcement learning methods have been newly applied to building optimal treatment policies with promising results. Such methods aim to emulate the clinical process, wherein a sequence of decisions is made over time in response to the changing state of a patient, with the intent of maximizing some form of cumulative reward. By mapping this process to a Markov Decision Process, it is possible to learn a policy that prescribes different actions in various states of the disease [10]. An off-policy version of the method has successfully been applied to the problem of hepatitis C treatment.

G. AI for Drug Discovery

Another more recent example of using AI for drug discovery is the usage of deep learning methods to improve the design of small molecules. This work done by the company Atomwise used a deep convolutional neural network to assess the biological activity of compounds and led to the successful discovery of a drug that inhibits Ebola [11,12]. The speed and effectiveness of these methods of AI will lower the cost and time it takes to bring a drug to market and will result in improved success rates. This will directly benefit personalized medicine as a higher rate of drug production means a greater availability of drugs specific to certain health conditions. An example of this is seen in the use of systems biology that attempts to understand the complex interplay of cellular and physiological function. This involves the construction of biological models using data from gene and protein expression and metabolite accumulation. Simulations can then be run in order to predict the outcome [13] of changes to the system, that could be, say, administering a drug to an individual. This can vastly speed up the process of drug discovery as potential compounds can be tested for their effect on the system without having to create and administer them in trials. AI can revolutionize the industry of drug de-velopment to a high extent. Meanwhile, the present mode of drug research is fraught with a high failure rate given that it demands expensive and less advanced techniques. Usually, the molecules are screened on the base of their biological activity which if positive results in the phase of animal testing and possibly human trial tests. This process that takes on average a period of 15 years has a failure rate quite high [14]. On the other hand, AI can be useful for enhancing the effectiveness and accuracy of drug discovery.

IV. SIGNIFICANCE AND BENEFITS

Machine learning has bloomed out as an evolutionary factor in healthcare, most of all in patient diagnosis accuracy. Leveraging huge amounts of data processed by advanced algorithms, ML systems can analyze patient information, medical records, and diagnostic images with an unprecedented speed and accuracy. This ability makes it possible for healthcare providers to detect the patterns and correlations that may not be easy to reveal to human doctors, resulting in more exact and more timely diagnosis [18]. Hence, patients get the advantage of an earlier detection of diseases, a more individualized course of treatment and the ultimate result of better health. In the US, machine learning's influence on patient diagnosis accuracy, which is especially crucial due to the intricacy and dimension of the healthcare system, is significant. The population of the United States is more than 330 million, and there is a wide variety of healthcare providers and facilities, which should create a growing need for tools that can process the patient data and improve the diagnostic process[19]. Machine learning technology provides a scalable alternative which permits healthcare practitioners to deliver high quality care and enables them to do this more efficiently and effectively. Furthermore, the improved diagnostic accuracy and treatment decision-making provided by machine learning indirectly relieve the burden on healthcare resources, which, in turn, contribute to cost savings throughout the entire healthcare system.

The growing wave of times AI can be used in diagnosis will have the largest impact on the health of the public. Machine learning algorithms can process population-level data to detect the evolving patterns and risk factors that cause different diseases. So, policy makers and public health officials can provide targeted prevention and intervention measures [19]. Thus, this approach is not only aimed at the decrease of the onset of diseases, but also to improve the safety and assurance of the health system. The application of machine learning in medical diagnosis marks a revolutionary trend in healthcare delivery, implying positive changes in both the patient's outcome and the healthcare delivery system.

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V. FUTURE

The main impact of machine learning on patient diagnosis accuracy in the U.S. will likely keep growing, all the while developments in the field open various interesting avenues for further progress. This includes the implementation of machine learning in wearable health devices and remote monitoring units. These technologies provide the healthcare providers with continuous readings from the patient outside the clinic settings making it possible for early detection of emergent health issues [20]. For instance, Smartwatches could be made with sensors to monitor key signs such as heart rate, blood pressure and with the capability to even detect irregularities in cardiac rhythms. Machine learning algorithms can be used to extract this data and identify relevant patterns, like atrial fibrillation or hypertension. These devices not only alert both patients and healthcare providers to the possible issues, but also, they enable proactive intervention and individualized care management, thus, improving the patient outcomes and preventing expensive hospital visits [20]. Moreover, collaborative application of machine learning with EHRs underlines great prospects which will make clinical workflow smoother, and diagnostics more accurate. The utilization of machine learning algorithms that make use of clinical data stored in the EHR system leads the clinician to discover some relevant vital insights, the prediction of patient outcomes and many more [20]. For example, with predictive analytics models, patients likely to have complications or side effects to treatments can be flagged in advance, leading to early intervention and personalized care planning.

VI. CONCLUSION

Since modern and upcoming diseases are very dangerous, the necessity for predictive models will keep increasing. However, while machine learning has shown promise in healthcare, it is still in the early stages and is not a fix-all solution. One of the largest issues in applying machine learning to the development of predictive models is the lack of high-quality, easily accessible data. In an ideal world, machine learning algorithms would just be turned loose on datasets and they would automatically pick out the most important patterns and develop highly accurate predictive models. Unfortunately, in the real world, developing predictive models is an iterative process that involves a great deal of domain-specific knowledge and manual effort to preprocess data and construct features. Therefore, much work is still needed to streamline the process of preparing data for use with machine learning algorithms and to develop algorithms that can automatically detect patterns and learn complex tasks with minimal human intervention. In the context of developing predictive models for diagnostic tasks, machine learning has the potential for automating model development to the point where very little human effort is required, compared to traditional statistical modeling which requires a great deal of human effort to develop and fine-tune models. If we can overcome the issue of data preparation and drawing upon the success of machine learning in automating other complex tasks, the future may see the development of truly autonomous machine learning algorithms for diagnostic modeling.

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