IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

Artificial Intelligence In Personalized Medicine

[1] **J. Navya, Assistant Programmer, Telangana University, Dichpally, Nizamabad, Telangana, India – 503322.**

Abstract—Artificial Intelligence has significantly gained grounds in our daily livelihood in this age of information and technology. As with any field of study, evolution takes place in terms of breakthrough or developmental research leading to advancement and friendly usability of that specific technology. Problems from different areas have been successfully solved using Artificial Intelligence algorithms. In order to use AI algorithms in solving Personalized Medicine problems such as; disease detection or prediction, accurate disease diagnosis, and treatment optimization, the choice of the algorithm influenced by its ability and applicability matters. This paper reviews the application and ability of artificial neural network (ANN), support vector machines (SVM), Naïve Bayes, and fuzzy logic in solving personalized medicine problems, and shows that the obtained results meet expectations. Also, the achievement from the previous studies encourages developers and researchers to use these algorithms in solving Medical and Personalized Medicine problems.

Keywords : Artificial Intelligence(AI), Artificial Neural Networks(ANN), Support Vector Machines (SVM), fuzzy logic.

INTRODUCTION

It is always a surprising problem seeing a drug work for some people and be less effective on others, or causing side effects in another. Another problem is the question of why some people develop some diseases e.g. cancers, while others do not. Genetic make-up and other differential factors such as age; lifestyle could be reasons for these problems. As such,[1] believes medicine should approach each patient's illness as unique, with medication tailored to the person's history and biology. This approach to medical practice is known as Personalized or Precision Medicine.

Patients with same diagnostics result must not be treated the same way; they can receive different treatment in order to achieve efficient treatment as illustrated in Fig. 1. Personalized medicine as a branch or extension of Medical Sciences uses practice and medical decisions to deliver customized healthcare service to patients. The major role of personalized medicine as posited by [2] is to predict the possibility of an individual developing a disease, achieve accurate diagnosis, and optimize the best treatment available.

This is accomplished with the help of genetic information, which is used as part of the baseline data in tailoring or customizing medical treatment or administration. But the majority of replicable findings do not pinpoint common genes underlying susceptibility or protection from disease; instead, current understanding centers primarily on rare genetic variants, although a number of common variants have

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furthered understanding as well. The field of medicine has significantly grown over the years and emphasis is put on considering the possibility of preventing diseases by the use of modern technologies to find out the possibility of person having a disease and giving the person treatments (maybe drugs) to control the occurrence of the foreseen disease. Also with the use of technology, clinical personnel (i.e. doctors & pharmacist) can deliver a very much efficient healthcare service as opposed to traditional techniques[3] .

The use of Artificial Intelligence techniques in setting up or building personalized medicine is important in terms of precision and accuracy of disease discovery, treatment, and drug administration. The control of adverse drug reactions and enzymes metabolism which results in some people having issues eliminating drugs from their bodies, hence leading to overdose; while others eliminate the drug from the body before it gets the chance to work[4] . The use of computers in hospitals and clinics to record medical activities or use of electronic health record (EHR) systems nowadays provides medical knowledge and data that can be used as a benchmark to enhance medical service delivery. Fig. 1. Diagnosis and treatment of patients group .

AI ALGORITHMS USED IN PERSONALIZED MEDICINE

There are number of algorithms from Machine Learning and Artificial Intelligence that are used in the Medical Field, and in specific Personalized Medicine. Some of these algorithms are discussed here.

A. Naive Bayesian

Naïve Bayesian (NB) algorithm named after Thomas Bayes (1702- 1761) who proposed the algorithm is based on probabilistic model and allows the capture of uncertainty in a model in a principled way through determining the probabilities of different outcomes. NB is widely used today in different systems that ranges from spam filtering, recommender systems, and text classification. It is also used in medical applications, and weather forecast. This makes it a good algorithm for classification and prediction as well.
Some of the advantages of NB are; it is robust for noise in input data, requires a small amount of training data. Some of the disadvantages of NB as mentioned by [5] are; loss of accuracy as a result of class conditional independence cause by assumption.

B. Artificial Neural Network

The application of ANNs in medicine includes, but not limited to the diagnosis, imaging, back pain, dementia, pathology and prognosis evaluation of appendicitis, myocardial infarction, acute pulmonary embolism arrhythmias, or psychiatric disorders diseases,[6] as stated by [7]. Some of the advantages of ANN as stated by [7]are: Neural networks can learn linear and non linear models. Also the accuracy of models created by neural network can be
measured statistically. Incomplete data and noise are tolerable by neural network. Neural networks models are flexible because they can be updated, hence making it suitable for dynamic environment such as health sector. ANNs are black box algorithms, hence weak in providing insight into its structure. Also, although it is able to generalize from a set of examples, if it sees only cases of a certain range; it predictions outside these range could be
completely invalid .

C. Support Vector Machines (SVM)

SVM has advantages, and as mentioned by[8] they are: SVM produces accurate result classification result on theoretical basis, even when input data are non-linearly separable. Also, the accuracy result does not rely on the quality of human expertise judgment for choice of the linearization function for non linear input data. A disadvantage of SVM as a non-parametric technique mentioned by[8] is its lack for transparency for results. The biggest limitation as mentioned by[9] is that which lies in the choice of the kernel. It has to be set correctly to achieve an accurate result for any given task or problem. Kernel choice that produces accurate results for task ‘A’may produce poor results for task ‘B’.

APPLICATION OF AI TECHNIQUES TO SOLVE THE PROBLEMS

The problems mentioned in Fig. 2 are sequentially discussed in the subsequent sections with regards to how AI algorithms are employed by researchers to solve the problems.

Detection/Prediction

The solution to detection or prediction of disease is important for the solving of the next two (i.e. diagnosis and treatment) problems. In this section Artificial Intelligence algorithms from machine learning are reviewed with respect to how the problem of disease detection or prediction is solved.

1) Support vector machines (SVM)

In a study by [7], SVM was used to classify and detect fall types. The study was relevant because, falling as accident especially in the elderly aged members of the society has to be prevented; but before it can be prevented; it has to be detected and classified. Five different classifiers were used in the research, but SVM was one of two that achieved 99% accuracy.
Also, [11] used SVM to detect the accuracy of cardiac monitoring devices. The generic systems for monitoring cardiac arrests lacks the ability to differentiate between artifacts and true events across a range of individuals because they are trained just on a general population level. So, they used SVM to refine and achieve a more accurate patient specific result by making use of population level prior knowledge for initial model creation, then refining further by selectively interacting with human experts to get examples from a new patient until a stopping condition is met. The result from their study shows that patient specificity improves the Atrial Fabrillation (AF) of detection and the poor specificity of the generic detector.

2) Fuzzy logic

Case Based Fuzzy Cognitive Map (CBFCM) is an extension of fuzzy cognitive maps that is used for classification and prediction. CBFCM works by representing the causal relationship between different concepts and then analyzing inference patterns. This is applied in personalized medicine by analyzing the relationship between different nature of diseases and patient specific information e.g. gene, blood pressure, and blood type to infer a pattern match in the approach to disease detection in a patient. A research by [3] on Genomic and Personalized Medicine for classification as a means of disease detection in the Decision Support System they developed. For each patient, they used three parameters (C1, C2, and C3) as input values which could be Clinical signs, genetic information, age or biological results. Fuzzy rules were then applied on the concepts. If there is a good similarity between known cases and patient a conclusion is drawn, else an FCM is used for diagnosis and therapeutic decision. In a related work by [12], Fuzzy logic was used to detect heart disease using 6 input fields (chest pain, blood pressure, cholesterol, blood sugar, maximum heart rate, old peak) and 2 output fields (result, and precautions) with rule base that consist 22 rules. The output detects the presence of heart disease and precautions accordingly. And the observed result was 92% accurate.

3) Artificial neural network (ANN)

In a study by [13] neural networks and decision tree were used to develop a patient specific real time alarm algorithms. They observed that alarms are built retrospectively by dataset that encompass thousands of patients to detect adverse clinical and medical conditions. But without further improvement, studies found that a model built from one patient population has worse performance on data from other two populations. So, their research explores building patient-specific alarming models from a specific individual models data. Of the two algorithms employed in the research (Decision Tree and Neural Network), Neural Network was recommended because it has a higher accuracy rate (96%, 99%, 79%, and 99%). However, the result from Decision Tree (84%, 98%, 72%, and 98%) was not so bad, just that it was

not good enough compared to the ones from neural networks. Data from 11 different patients of various ages was collected from 196 hours. And neural network of single output layer with one hidden layer was used with two different training times i.e. 2 and 8 hours. Although the performance of the 2 hours trained network was poor, the 8 hours trained network was considered very well because it outperforms the generic alarm algorithms in devices.

FUTURE TRENDS

Personalized Medicine is an active research area with a lot of envisioned products and achievements. Some of these future trends include: Preventive Medicine: Preventive Medicine is a future trend related to personalized medicine. It is envisioned that, sooner or later, every inanimate object will be able to recognize your genetic code—including that taunting vending machine in your office, which may or may not advise you to skip the chocolate bar today, so that you can skip diabetes tomorrow .

Robotic Surgery: Researchers are currently working on developing robots that could perfectly perform surgery on humans. Robotic surgery such as da Vinci® help enables surgeons operate with enhanced vision, precision, dexterity, and control. Also, the use of robotic surgery remotely is envisioned in the new future; especially to carry out surgery on Astronauts. A fist-sized robot is scheduled for its first zero-gravity test in the next several months—one small step toward enabling robotic medical attention for humans stuck on deep-space missions lasting for months, [19]. Also, the use injected micro chips to perform surgical or organ correctional operations are envisioned instead of cutting out the human body.

CONCLUSION

The implementation of Personalized Medicine heavily relies on AI algorithms as discussed in this review. However, it is still in its early stage and levels and faces some challenges; some of which have a direct link to AI were discussed in this report. While other problems such as
research and implementation costs, and government regulations are also challenges which are critical to the successful implementation of personalized medicine, but not addressed by the algorithms discussed in this report.

However, Personalized Medicine does not only faces challenges; it does pose some challenges as well, such as; changing the medical profession and practice to the extent that some futurist think algorithms and machines could replace most of the jobs doctors do today. Finally, a successful implementation of personalized medicine would save many lives and perfect the medical profession.

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