RAPID COMMUNICATIONS

Artificial intelligence in the diagnosis of cardiovascular disease

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SUMMARY

Artificial intelligence (AI) is a field of computer science that aims to mimic human thought processes. AI techniques have been applied in cardiovascular medicine to explore novel genotypes and phenotypes in existing diseases, improve the quality of patient care, enabling cost-effectiveness, and reducing readmission and mortality rates. The potential of AI in cardiovascular medicine is tremendous; however, ignorance of the challenges may overshadow its potential clinical impact. This paper gives a glimpse of AI's application in cardiovascular clinical care and discusses its potential role in facilitating precision cardiovascular medicine.

KEYWORDS: *Machine learning. Artificial Intelligence. Algorithms.*

INTRODUCTION

Artificial intelligence (AI) is a field of computer science that seeks to mimic the human thought processes, learning ability, and the storage of knowledge. In the 21st century, the paradigm is shifting from the use of traditional statistical tools to AI in cardiovascular (CV) medicine to allow for better accuracy.

Big Data

There are a series of demographic data (such as electronic records and standardized platforms) available today that alone bring no benefits, but, when processed by AI, these *Big Data* improve the practice of clinical care. Big Data analysis by AI can predict the identification of new phenotypes, such as of heterogeneous syndromes, support clinical decisions such as the selection of anticoagulant agents in patients with nonvalvular atrial fibrillation, and assist in the identification of unknown risk factors, such as in acute coronary syndrome. With that, the availability of automated tools for real-time decision support using AI in standardized electronic records also grows[1,2].

Machine Learning

Machine learning is a subdiscipline of AI and can be categorized into three types of learning, i.e., supervised, unsupervised, and by reinforcement. The learning curves and the area under the curve (AUC) are important considerations when choosing a machine learning algorithm, while C-statistic is important in the choice of traditional methods of data processing. As in traditional statistics, machine learning requires a sufficient data set for training (the sample size in traditional statistics), and there should be no lack of adjustments, i.e., underfitting and overfitting (and alfa should not be greater than 0.05 in traditional statistics).

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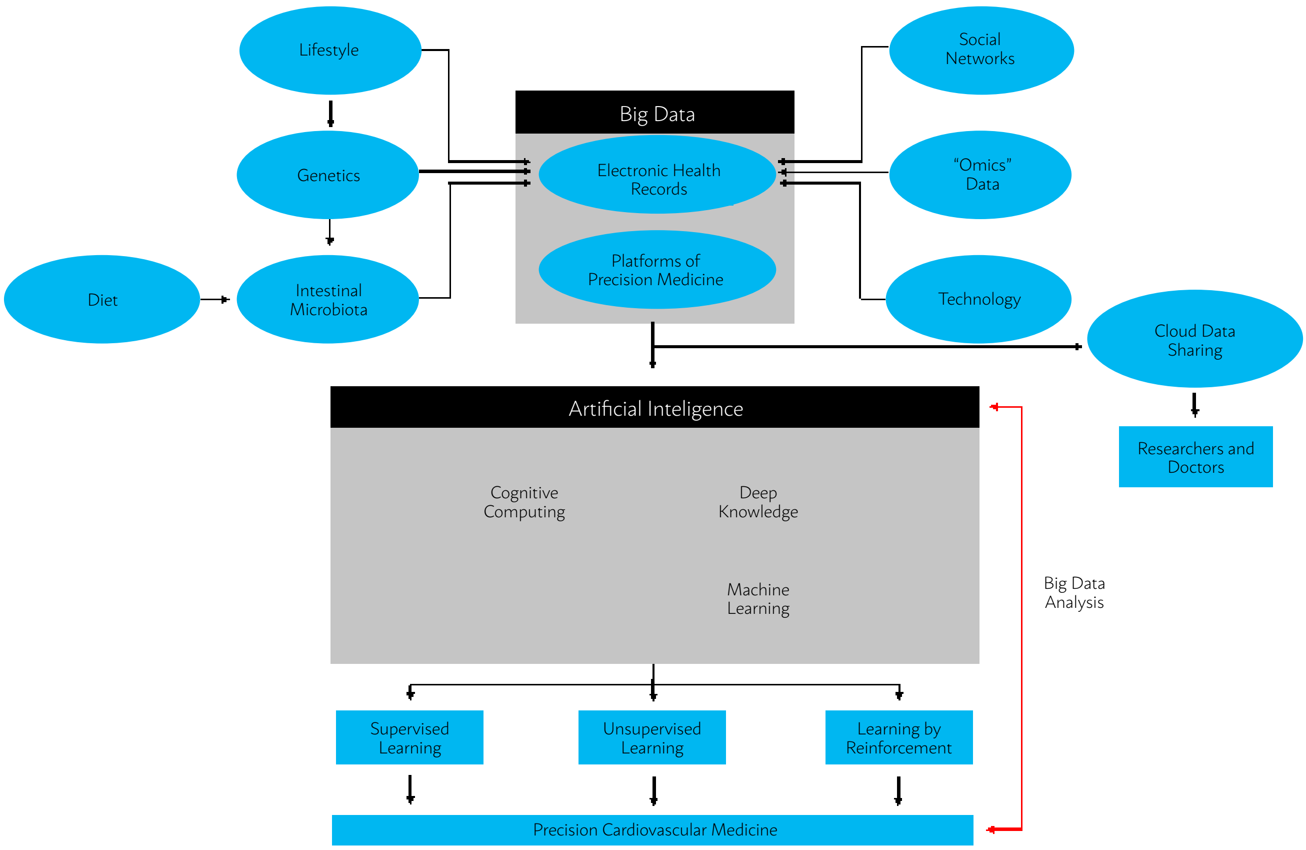
Supervised Learning

Supervised learning has algorithms that use a data set labeled by humans to predict the desired and known outcome; these are successfully applied in the prediction, diagnosis, and treatment of CV diseases, as well as in the analysis of CV images. Such learning is great for classification and regression. The algorithms that can be used include artificial neural networks (ANN), support vector machine (SVM), random forests, decision tree, naive Bayes classifier, fuzzy logic, and K-nearest neighbor (KNN). The selection variables of a particular algorithm include the characteristic of the data and training time. ANN and SVM are the most popular types because they are compatible with "omics" data (genomic, metabolomic, and proteomic). ANN and SVM feature good performance in the classification of text in electronic health records[3]. ANN algorithms mimic the human neurons and present good results for processing electrocardiogram (ECG) data and can be used on deep knowledge[4,5]. The *random* forests decision tree and Naive Bayes classifier algorithms are less accurate than ANN and SVM but are easier to be used and require fewer data. Random forests present each independently trained forest and have been used in coronary computed tomography angiography[6,7]. The system of the decision tree is easy to understand, unlikely to find overfitting, and used to predict CV risk[8]. The naive Bayes classifier is a simple classifier derived from Bayes theorem and can be used in problems of text classification, in the identification of CV risk factors[9]. Fuzzy logic is similar to human reasoning, in which the logic returns values (for example, 30% of probability of acute myocardial infarction)[10]. KNN runs quickly on small training data sets and can be used to interpret ECGs but requires more space

FIGURE 1. ILLUSTRATION OF ARTIFICIAL INTELLIGENCE IN THE DIAGNOSIS OF CARDIOVASCULAR DISEASE



Adapted from Krittanawong, C. et al. J Am Coll Cardiol. 2017;69(21):2657-64.

Big Data (Genetics, Social Networks, Environment, and lifestyle-related factors, or 'omics' data") can be stored in Electronic Health Records or Platforms of Precision Medicine and can be shared on clouds with other researchers or doctors for data analysis using secure technology systems. Big Data analysis using artificial intelligence (Machine Learning, Deep Learning, or Cognitive Computing) and the three main types of learning algorithms (Supervised, Unsupervised, and Reinforcement) will allow for Precision Cardiovascular Medicine.

for the large amount of data[11]. In supervised learning, small training data sets can lead to inaccurate decisions in the data sets test if the training data set is skewed.

Unsupervised Learning

Unsupervised learning is based on finding hidden patterns in data without human feedback. This type of learning is often used in deep knowledge and can allow for the identification of new phenotypes of cardiomyopathy and be used on blood bank platforms to identify hypertension genotypes. The algorithms used can be classified into clustering or association rule algorithms. Clustering algorithms can be used to group unlabeled data. Algorithms for association-rule learning help discover relationships between data items that are apparently unrelated (for example, 70% of patients who have had angioedema with angiotensin receptor-neprilysin inhibitors). Since the final cluster pattern depends on the initial cluster, one limitation of this learning process is the difficulty in identifying the pattern of the initial cluster.

Learning by Reinforcement

Learning by reinforcement can be seen as a hybrid of supervised and unsupervised learning. The objective of this type of learning is to maximize the accuracy of the algorithms by trial and error.

Deep Knowledge

Deep knowledge mimics the functioning of the human brain by using multiple layers of artificial neural networks that can generate automatic forecasts from a training data set. This knowledge can be widely used to recognize images (cardiac angiography and magnetic resonance)[12]. It can also be trained to perform an unsupervised learning task, such as a drug-drug interaction. Furthermore, there is no limitation regarding working memory. Deep knowledge has proved to be superior to other techniques of machine learning, such as SVM, because it can use multiple layers and transformations, in comparison to the two layers of MVR. Since deep knowledge is usually a non-linear analysis with many parameters and multiple layers, overfitting may be large, leading to a weak predictive performance[13,14].

Cognitive Computing

Cognitive Computing involves a self-learning system that uses machine learning, pattern recognition, and natural language processing to mimic the functioning of the human thought processes (Figure 1). A machine algorithm of cognitive learning, the classifier of associative memory (accuracy: 93.7%; AUC: 96.2%) used to classify constrictive pericarditis of restrictive cardiomyopathy for automated interpretation of data from tracking echocardiography of stains has proved to be superior than the random forest (accuracy: 88.3%; AUC: 94.2%) and SVM (accuracy: 87.4%; AUC: 92.2%)[15].

CONCLUSION

Over the past decade, several machine learning techniques have been used to diagnose and predict cardiovascular diseases. Each problem requires some degree of understanding, regarding CV medicine and statistics, to apply the optimal algorithm for machine learning. In the near future, AI will cause a paradigm shift toward precision cardiovascular medicine.

Contribution of the authors:

All authors contributed equally to the development of this work.

RESUMO

A inteligência artificial (IA) é um campo da ciência da computação que tem como objetivo imitar os processos de pensamento humano. Técnicas de IA têm sido aplicadas na medicina cardiovascular para explorar novos genótipos e fenótipos em doenças existentes, melhorar a qualidade do atendimento ao paciente, possibilitar custo-efetividade e reduzir taxas de readmissão e mortalidade. Existe um grande potencial da IA na medicina cardiovascular; no entanto, a ignorância dos desafios pode ofuscar seu impacto clínico. Esse artigo fornece a aplicação da IA no atendimento clínico cardiovascular e discute seu papel potencial na facilitação da medicina cardiovascular de precisão.

PALAVRAS-CHAVE: *Aprendizado de máquina. Inteligência artificial. Algoritmos.*

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