Artificial Intelligence and Healthcare

Salem Hamoud H Alanazi

University of Massachusetts, USA

Abstract

Rapid advancements in the field of science and technology have led to the increasing use of Artificial Intelligence in all fields, including healthcare. The use of Artificial Intelligence in healthcare globally has become more common, especially in connection with the immense amounts of data being generated. From data mining techniques to big data analysis to decision making systems to speech recognition to assisted living for the elderly, Artificial Intelligence is rapidly becoming a part of healthcare systems worldwide. This paper aims to review some of the research studies which have been carried out on the use of Artificial Intelligence in Healthcare. For this paper, specific search terms were used in Google Scholar search engine and the results were shortlisted according to the year of publication. From the review of the studies available on the subject, it was clear that the use of Artificial Intelligence in healthcare was not just ubiquitous but also increasingly pervasive in every field and area related to healthcare.

Keywords: Artificial Intelligence, Healthcare, Trends, Advances, Review

Introduction

Global healthcare systems have relied on storing patient information in order to provide the best quality of care possible. As a result of rapid technological advances, healthcare systems are today able to save immense amounts of patient data. In order to optimize the quality of healthcare, reduce costs and improve decision making, this data requires not just storage, but also appropriate utilization. Towards this goal, artificial intelligence has been making important strides over the past decade.

According to Pannu (2015), AI technologies have matured to the point in offering real practical benefits in many of their applications. As per Pannu, major Artificial Intelligence areas are Expert Systems, Natural Language Processing, Speech Understanding, Robotics and Sensory Systems, Computer Vision and Scene Recognition, Intelligent Computer Aided Instruction, Neural Computing. From these Expert System is a rapidly growing technology which is having a huge impact on various fields of life. The various techniques applied in artificial intelligence are Neural Network, Fuzzy Logic, Evolutionary Computing, and Hybrid Artificial Intelligence.

Methodology

In this paper, we will review some of the research studies which have been carried out on the subject of Artificial Intelligence and Healthcare. Towards this end, specific search terms were used in Google Scholar search engine. The results of these searches were shortlisted as per the year of publication. For the purpose of this study, only studies published after 2010 were used, in order to examine the phenomenon of Artificial Intelligence in Healthcare.

Results and Discussion

According to Jiang, Jiang, et al. (2017), Artificial intelligence (AI) aims to copy human cognitive functions. In their study, the authors say that AI is bringing a “paradigm shift to healthcare, powered by increasing availability of healthcare data and rapid progress of analytics techniques”.

Major disease areas that use AI tools include cancer, neurology and cardiology (Jiang et al., 2017).

Data Mining in Healthcare

Healthcare systems around the world are advancing rapidly. These are also generating huge amounts of data. The problem is how to use this available information into useful practices which can guide healthcare systems into greater efficiency and effectiveness. According to Ahmad, Qamar, & Rizvi (2015), data mining has a great potential to equip healthcare systems in a manner so that the data available can be used more effectively, reducing costs and improving the quality of care. The research by Ahmad, Qamar & Rizvi (2015) reviewed various data mining techniques such as classification, clustering, association, and regression in the healthcare industry.

Healthcare organizations across the globe store information on parents and parties involved in electronic format. This kind of information storage has been increasing significantly over the years. Due to the large quantities of data stored in healthcare systems, use of traditional methods is not equipped to deal with complexities. According to the research by Ahmad, Qamar, & Rizvi (2015), due to developments in mathematics, statistics and related fields, it is now possible to extract meaningful patterns from the large collections of data available in healthcare systems.

Data Mining Techniques

1. Classification – As per Ahmad, Qamar, & Rizvi (2015), classification is one of the most popular methods of data mining in healthcare, through which data samples are divided into target classes. This technique predicts the target class for each data point and through it, a risk factor can be associated to patients by analyzing their patterns of diseases (Ahmad, Qamar, & Rizvi, 2015). Classification algorithms used in healthcare include the following:
    a. K-Nearest Neighbor (K-NN)
    b. Decision Tree (DT)
    c. Support Vector Machine (SVM)
    d. Neural Network (NN)
    e. Bayesian Methods
2. Regression – Regression is a very important technique of data mining. Mainly a mathematical tool, regression helps identify functions which are useful to demonstrate correlation between variables.
   Divya et al. (2011) proposed the Weighted Support Vector Regression (WSVR) using weight factors based on sensor reading for providing continuous monitoring to patients in order to provide them better healthcare services (as cited in Ahmad, Qamar, & Rizvi, 2015).
3. Clustering – Clustering can be defined as "unsupervised learning that occurs by observing only independent variables while supervised learning analyzing both independent and dependent variables. Clustering is different from classification which is supervised learning method. According to Ahmad, Qamar, & Rizvi (2015), clustering may be best used for studies which are of an exploratory nature. Various clustering algorithms used in healthcare include the following:
    a. Partitional Clustering
    b. Hierarchical Clustering

   c. Density Based Clustering
4. Association
   Agarwal et al. (1993, 1994) introduced a novel association rule algorithm called Apriori (as cited in Ahmad, Qamar, & Rizvi, 2015).

Using the Apriori algorithm

The Apriori algorithm was coined by R. Agarwal et al., and requires two user inputs – support and confidence or percentages (Ahmad, Qamar, & Rizvi, 2015). This is because users are interested in association rules (sets of transactions) that frequently occur in a database (i.e., support) and which are accurate (i.e., confidence). Thus, support and confidence are used to filter out many uninteresting association rules. The core property of the algorithm is its use of the Apriori property. Thus, if an item is not frequent (i.e., not satisfying support in terms of transaction), its descendants are not frequent (e.g., if male breast cancer cases are not frequent, no association rules related to the disease are generated.). This property significantly limits the search for frequent item sets and considerably improves the efficiency of the algorithm (Ahmad, Qamar, & Rizvi, 2015).

Patil et al. (2010), used the apriori algorithm to generate association rules, which were then used to classify patients suffering from type-2 diabetes. This research proposed an approach for "discretizing the attributes having continuous value using equal width binning interval which was selected on the basis of medical expert's opinion" (Patil et al., 2010 - as cited in Ahmad, Qamar, & Rizvi, 2015).

In their study, Ying et al. (2011), proposed a data mining association approach based on fuzzy recognition-prime decision (RPD) model in order to develop the link between drugs and their associated adverse drug reactions (ADRs). This approach was tested on the real patient data obtained from Veterans Affair Medical Center in Detroit, Michigan (Ying et al., 2011 - as cited in Ahmad, Qamar, & Rizvi, 2015).

Ilayaraja et al. (2013), used apriori algorithm to discover frequent diseases in medical data and their study proposed a means for detecting the occurrence of diseases using in particular geographical locations at particular period of time (Ilayaraja et al., 2013 – as cited in Ahmad, Qamar, & Rizvi, 2015).

Nahar et al. (2013), used predictive apriori approach for generating rules for heart disease patients to develop rules for healthy and sick people. Based on these rules, this research discovered factors which caused heart problems in men and women. Nahar et al. concluded that women had a lesser possibility of having coronary heart disease as compared to men (Nahar et al., 2013 - as cited in Ahmad, Qamar, & Rizvi, 2015).

Kai et al. (2014) proposed a clinical decision support system to help healthcare workers to identify noncommunicable diseases in non-reachable communities. This proposed system, using the associate rule technique, was a remote healthcare consultancy system (Kai et al., 2014 – as cited in Ahmad, Qamar, & Rizvi, 2015).

Health Data Analysis

As per Alharthi (2018), the healthcare sector lacks actionable knowledge, mainly because even though healthcare data is large, it tends to be complex and fragmented. Health data analysis, especially predictive analysis, is fast emerging as a transformative tool which can enable more proactive and preventative treatment options.

Healthcare today generates a large amount of data, or 'big data', which are extremely large and complicated datasets and requiring customized software to analyze. In healthcare settings, digitized clinical data is generated at nearly every point along the continuum of care, which can add up very quickly. In 2011, the US stored roughly 150 exabytes (10^{18}) of health data, and this number was expected to have risen to more than a yottabyte (10^{24}) over the next few years (Alharthi, 2018). New technology is rapidly emerging to address such challenges. According to McAfee & Brynjolfsson (2012), Hadoop, an open source data storage framework, allows data storage "as is" without requiring especially designed schema, while keeping the data immediately accessible for processing (as cited in Alharthi, 2018). This kind of data storage is very helpful for decisionmakers who need to act quickly based on as the data comes in. As per Alharthi (2018), this is especially important for physicians in emergency departments or intensive care units who need to make quick decisions dealing with life or death situations, based on this data.

Another example of advanced technology to handle big data which can have significant implications for healthcare is data analytics (Alharthi, 2018). With the use of tools such as data analytics, patterns can be identified in immense and complex datasets in order to acquire knowledge and insights, which allow healthcare systems to provide better healthcare at lower costs.

According to Alharthi (2018), "as healthcare institutions enter into partnership with information technology companies to develop more advanced models, challenges still exist related to the inherent complexity of patient data and the need to integrate the results of predictive models within existing physician workflows".

In a country such as Saudi Arabia, most of the hospitals still rely on paper-based records. In such a setting, there is a genuine need for government to initiate programs that help digitize medical records (Alharthi, 2018). In his study, Alharthi says Saudi Arabia also needs to work on its data analytics workforce by preparing talented university graduates through generous grants which enable faculty and their students to collaborate with local hospitals.

Artificial Intelligence and Speech Recognition

According to the research by Alhawiti (2015), speech recognition is the main issue which affects the decoding of speech, which is also revealed by other research studies. Alhawiti (2015) says that some of the most prominent statistical models include acoustic model (AM), language model (LM), lexicon model, and hidden Markov models (HMM). Researchers have also formulated different decoding methods, which are being utilized for realistic decoding tasks and constrained artificial languages. These decoding methods include pattern recognition, acoustic phonetic, and artificial intelligence. Alhawiti (2015) says that it has been identified that artificial intelligence is one of the most efficient and reliable methods, which is being used in speech recognition (Alhawiti, 2015).

Speech recognition is an approach which deals with translating spoken words into the text. As per Besacier (2014), it has been established by that speech recognition can also be referred as ASR, as the technique offers to recognize the speech automatically (as cited in Alhawiti, 2015). In accordance with the views and perceptions of Rawat et al. (2014), some of the speech recognition systems utilize speaker independent speech recognition (as cited in Alhawiti, 2015).

According to Mikolov (2012), the approach of artificial intelligence is the most famous methods of speech recognition, which are being used for decoding. Artificial intelligence could be termed as a combination of the pattern recognition approach and acoustic phonetic approach because it incorporates the concepts and ideas of pattern recognition methods and acoustic phonetic approach (as cited in Alhawiti, 2015). The author says artificial intelligence is also referred as a knowledge-based approach which uses the information related to spectrogram, phonetic, and linguistic. According to Ammar (2012), "the approach of artificial intelligence plays an indispensable role in different activities of speech recognition, including designing of recognition algorithm, demonstration of speech units, and representation of suitable and appropriate inputs" (as cited in Alhawiti, 2015). According to Alhawiti (2015), it is important that among all methods of speech recognition, artificial intelligence is the most credible and efficient methods (Alhawiti, 2015). According to Alhawiti (2015), artificial intelligence is one of the emerging and continually developing fields of computer science, mainly focusing on the development of machines capable of getting engaged in the behaviors of human beings.

According to Saini, Preeti and Kaur (2013), these artificial machines collect information from their environments and respond in an intelligent manner, calculating appropriate and adequate steps, formulating answers, and presenting desired results (as cited in Alhawiti, 2015). According to studies by Anusuya (2009), and Choudhary & Kshirsagar (2012), artificial intelligence is extensively used in speech recognition (Alhawiti, 2015).

Clinical Decision Support System (CDSS)

In order to keep up with technological advances, the healthcare sector has shown inclination towards restructuring of their systems and adopting their decision support systems in routine clinical practices. Health sector personnel including administration, physicians, nurses, and pharmacists rely heavily on patients' medical information in order to improve the care provided to them and to rapidly adapt to the latest technological tools that support patients' information storage and processing. Healthcare information systems support the healthcare environment to address issues regarding quality and cost of care (Alqahtani, Alshahri, Almaleh, & Nadeem, 2016).

According to the study by Alqahtani, Alshahri, Almaleh & Nadeem (2016), Decision Support System (DSS) has been a part of healthcare information system for a long time, but it supported only the financial or administrative domain. It has recently entered the domain of clinical data, which has led to the emergence of the Clinical Decision Support System (CDSS). In its early stages, the CDSS was an extended form of the previous system where the aim was to create computer programs to simulate the human thinking by using machine-learning techniques. According to Alqahtani et al. (2016), "the machine learning is a class of computer algorithms that have the ability to understand human patterns of actions and intelligently use them to make decisions or forecast the future". According to Shin, & Markey (2006), these algorithms heavily rely on the available data from previous observations, which include information provided by the physician, staff, pharmacy and other healthcare individuals (as cited in Alqahtani, Alshahri, Almaleh, & Nadeem, 2016). The health records entered either electronically or manually by the clinicians is intelligently refined and presented to CDSS to improve the quality of care in real time. Alqahtani et al. (2016) say that CDSS is being used increasingly in the healthcare system, especially in the organizations that suffer from problems with healthcare quality. The problems in healthcare quality are mainly due to the errors caused by human inattention and dangerous

interaction between the treatments. CDSS can be effectively used to minimize such errors and enhance the patient's care quality.

According to Neill (2013), CDSS was one of the first successful applications of AI, which focused on the diagnosis of a patient's condition with the symptoms and demographic information available. In his article, Neill says that David Heckerman and his colleagues developed Pathfinder, which used Bayesian networks (a graphical model that encodes probabilistic relationships among variables of interest) to help pathologists more accurately diagnose lymph-node diseases.

Effectiveness of CDSS

Many research studies have talked about CDSS effectiveness. The system and the diagnostic programs alert clinicians about the dangerous interactions of drugs. These programs can minimize the problems and errors, prevent complications and thus improve the clinicians' diagnoses. According to studies by Doolan, Bates, & James (2003); Doolan & Bates (2002); Kucher, Koo, Quiroz, et al. (2005); & Abumelha, Hashbal, Nadeem, & Aljohani(2016); early warning on the occurrence of damage may affect the quality of care and the cost involved (as cited in Alqahtani et al., 2016). According to a study in England, researchers found that implementing computer-based guidelines could bring about a change in the health outcomes and unanswered questions faced by the clinicians during the clinical encounter will offer a chance for using the CDSS (Berner & La Lande, 2007; Berner, Maisiak, Phelan, Kennedy, Heudebert, & Young, 2002 – as cited in Alqahtani et al., 2016).

Impact of CDSS in Healthcare

To deal with some deficiencies, healthcare organizations have started to adapt CDSS that helps the clinicians to make decisions depending on the evidence by providing them with recommendation in real time (Kawamoto, 2005 – as cited in Alqahtani et al., 2016). There are more studies that discuss the impact of CDSS on clinical practices. Jaspers et al. (2011) found 52 of 91 studies, which showed the positive impact of CDSS in preventive care and drug prescription (as cited in Alqahtani et al., 2016).

There are studies, which explored how the CDSS can significantly improve clinicians' performance by recommending the order, dosage and frequency of drug. In addition, CDSS contributes in improving the diagnostic accuracy and reducing the error, which consequently develops the workflow procedure to enhance the healthcare. It analyzes the patient's situation and provides recommendation to assist physicians in making the decision appropriate for the patient. Alqahtani et al. (2016) say that CDSS can also create a plan to overcome the disease. It analyzes and matches patient data with clinical database and generates a special treatment plan and thus gives clinician a way to improve the patient health and attain preferable outcomes. CDSS improves clinical practices by cutting down the cost of care by using, for example, reminder system to test repetition or avoid the drug-drug-interaction that may lead to extra treatment to handle the caused problems (Casimir, 2015 – as cited in Alqahtani et al., 2016).

CDSS in Saudi Arabia

According to Alqahtani, Alshahri, Almaleh, & Nadeem (2016), the Saudi government has significantly supported the country's healthcare. Over the past decade, there has been rapid progress in the quality of care provided by healthcare systems due to implementation of powerful CDSS techniques used in developed countries (Alqahtani et al., 2016).

Applications in Cardiovascular Medicine

According to Krittanawong et al. (2017), "AI techniques have been applied in cardiovascular medicine to explore novel genotypes and phenotypes in existing diseases, improve the quality of patient care, enable cost-effectiveness, and reduce readmission and mortality rates". Over the past few years, various machine-learning techniques have been used for cardiovascular disease diagnosis and prediction. In the near future, AI will result in a paradigm shift toward precision cardiovascular medicine (Krittanawong et al., 2017).

Ambient Assisted Living (AAL)

Ambient Assisted Living can be understood as "intelligent systems of assistance for a better, healthier and safer life in the preferred living environment and covers concepts, products and services that interlink and improve new technologies and the social environment, with the aim of enhancing the quality of life for all elderly people in all stages of their life" (The European Ambient Assisted Living Innovation Platform, 2009 – as cited in Alsulami & Atkins, 2016).

The use of sensors and communication devices in AAL can provide elderly people with the means

for independence (Augusto & Mccullagh, 2007; Bick & Kummer, 2010; Botia, Villa, & Palma, 2012 – as cited in Alsulami & Atkins, 2016) while maintaining their safety and comfort (Sun, De Florio, Gui, & Blondia, 2009 – as cited in Alsulami & Atkins, 2016). Ambient intelligence is an emerging discipline that applies sensors and sensor networks, pervasive computing, and artificial intelligence to make the environment sensitive to the needs of the elderly population.

Many technologies and projects have been designed as smart environments which are capable of helping the elderly in independent living (Grady, Michael, Hare, & Greg, 2010 – as cited in Alsulami & Atkins, 2016). Recent AAL technological advancements include smart homes, assistive robotics, mobile devices, e-textile and wearable sensors (Rashidi, & Mihailidis, 2013 – as cited in Alsulami & Atkins, 2016).

Disease Screening

Rapid advancements in Artificial Intelligence and its use in medicine shows that in the future, it is likely that Artificial Intelligence might be used for disease screening. Under the broad umbrella term 'Artificial Intelligence', there is deep learning, which is a new branch of machine learning technology. According to Wong & Bressler (2016), technology companies such as Google and Facebook have been using this technology for years to carry out big data analysis for predicting their preferences. In their study, Wong & Bressler say that deep learning has significant potential for healthcare as it may allow the identification of possibility of diseases in patients – in particular, which patients need to be monitored more frequently, and treated more aggressively. Wong & Bressler call it 'Precision Medicine'. They suggest using deep learning for the purpose of screening patients for Diabetic Retinopathy.

References

Ahmad, P., Qamar, S., & Rizvi, S. Q. A. (2015). Techniques of Data Mining in Healthcare: A Review. *International Journal of Computer Applications, 120*(15), 38 – 50.

Alharthi, H. (2018). Healthcare predictive analytics: An overview with a focus on Saudi Arabia. *Journal of Infection and Public Health*, 11, 749-756.

Alhawiti, K. M. (2015). Advances in Artificial Intelligence Using Speech Recognition. *International Journal of Computer and Information Engineering, 9*(6), 1439-1442.

Alqahtani, S. S., Alshahri, S., Almaleh, A. I., & Nadeem, F. (2016). The Implementation of Clinical Decision Support System: A Case Study in Saudi Arabia. *International Journal of Information Technology and Computer Science, 8*, 23-30.

Alsulami, M. H., & Atkins, A. S. (2016). Elderly Saudi Arabians' Perceptions and Attitudes Towards Using Ambient Assisted Living Technologies. In *Proceedings of 64 The IIER International Conference*. Barcelona, Spain.

Jiang, F., Jiang, Y., Zhi, H., Dong, Y., Li, H., Ma, S., Wang, Y., Dong, Q., Shen, H., & Wang, Y. (2017). Artificial intelligence in healthcare: past, present and future. *Stroke and Vascular Neurology, 2*, 230-243.

Krittanawong, C., Zhang, H. J., Wang, Z., Adyar, M., & Kitai, T. (2017). Artificial Intelligence in Precision Cardiovascular Medicine. *Journal of the American College of Cardiology, 69*(21), 2657-2664.

Neill, D. B. (2013). Using Artificial Intelligence to Improve Hospital Inpatient Care. *AI and Health*, 92-95.

Pannu, A. (2015). Artificial Intelligence and its Application in Different Areas. International Journal of Engineering and Innovative Technology (IJEIT), 4(10), 79-84.

Wong, T. Y., & Bressler, N. M. (2016). Artificial Intelligence With Deep Learning Technology Looks Into Diabetic Retinopathy Screening. *The Journal of the American Medical Association*.