REVIEW

AN ANALYSIS AND FRAMEWORK FOR HEALTHCARE AI AND ANALYTICS APPLICATIONS

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ABSTRACT

Following the advent of AI and analytics, the healthcare industry quickly became one of the most anticipated use cases for the new technology. By integrating analytics with AI, medical practice and healthcare are undergoing remarkable transformations, made possible by effective algorithms derived from diverse areas of IT. Indeed, many publications are released annually from various academic institutions and innovation hubs throughout the globe, yet there are worries regarding developments in their practical effectiveness. The healthcare industry is seeing an increasing number of potential instances of AIA implementations. This review article aims to provide a concise overview of artificial intelligence (AI) in healthcare during the last five years, covering a variety of methodologies and medical specialities. It also delves into the current concerns and challenges surrounding this groundbreaking technology. A grand total of 24,782 items were located. This paper's goal is to lay the groundwork for future research in artificial intelligence and artificial intelligence applications by outlining a framework that can be used to integrate different AIA technologies based on patient needs in different healthcare settings. This framework will be particularly useful for patients with chronic conditions, who often have multiple health issues and require extensive care.

KEYWORDS: Artificial Intelligence; Big Data; Data Mining; Healthcare; Ontologies; Smart Homes

INTRODUCTION

"The science and engineering of making machines, especially intelligent computer programs" [1] is how AI pioneer Alan Turing has described the field. Artificial intelligence systems are computer programs that allow computers to do cognitive tasks in a way that is similar to a human. We can trace the origins of AI back to ideas in philosophy, potential, demonstrations, dreams, and imagination [2]. There were a number of demands, opportunities, and interests that coalesced to form the area of IA.

Many industries are embracing AIA, or AI paired with analytics, and healthcare is no exception. One of the best uses of analytics in the past and a potentially fruitful use of AI now is medicine. The research that would later become applications was initiated in the middle of the twentieth century, with the goal of providing doctors with tools that would improve their work. Among these uses are healthcare administration, patient monitoring and aid, automated surgery, clinical decision support systems, and many more. The present approaches rely heavily on reasoning, data and machine learning for knowledge discovery, ontologies and semantics [3-8].

This study primarily aims to cover five important technologies that incorporate AIA: data mining; clinical decision support systems; smart homes; medical big data; ontologies, semantic reasoning, and ontology-extended clinical guidelines. Many areas rely on data mining techniques, including learning, prediction, imaging, speech processing, and even the study of human emotions and feelings. The medical field has begun to embrace ontologies because to their reasoning power and their utility as tools for understanding, sharing, reusing, and integrating [9-17]. In order to improve the quality of treatment provided in clinical practice, clinical decision support systems utilise both disciplines. They are also utilised in smart homes to assist those with cognitive impairments with their everyday tasks. Analytics based on medical big data are here to stay, and their presence in the industry is only going to grow.

METHODOLOGY

We used the PRISMA Statement and the accompanying flowchart to conduct the literature review [3]. Since Scopus encompasses a wide variety of publications and is the biggest abstract and indexing database globally (as per Elsevier), it served as our primary source. The review was conducted by doing a comprehensive search of publications published between 2016 and 2020 that discussed the use of big data in healthcare. First, we break down each topic into its component parts. Then, for each concept, we add synonyms or equivalent terms to the vocabulary. Then, we learn the logical links (AND, OR, NOT) between words so we can put them correctly. Then, we check the details of the search tool to make sure we can use quotes, for example. Then, we formulate the first research request. Finally, we analyse the results and make improvements to the query. To narrow our search, we looked for terms that closely relate to the fields that attracted us. The right combination operators were selected by us. Variants of the word "a" can be found in the database by using the asterisks * at the end of the word. Using acronyms for certain techniques, such as Support Vector Machine (SVM) and K-nearest neighbour (KNN), the code [tiab] limits the search to the paper's title and abstract.

AI USE CASES

DATA MINING USING SPARK

Data mining is a hybrid field that combines data science with machine learning; it entails automatically or semi-automatically extracting characteristics and knowledge from datasets. In reality, data mining explains, finds pertinent patterns, correlations, and information in order to provide predictions based on pre-established standards. The use of data mining is growing in importance and popularity within the healthcare industry. Data mining has a lot of promise for the medical field. Healthcare administration, assessment of diagnostic and therapeutic efficacy, CRM, and abuse and fraud detection are some broad categories under which they fall [18-25].

One research looked at how data mining may be used for breast cancer detection, therapy, and prognosis [3]. Differential diagnosis (DD) and final or provisional diagnosis (FD) are often two distinct steps in the decision-making process in medicines. As input data, doctors in the first stage consider patients' medical histories, illness symptoms, and the outcomes of various laboratory tests (blood tests, etc.). The latter are dealt with by doctors who use their medical skills to diagnose diseases. Once the condition has been recognised, the second stage involves making first recommendations and beginning therapy. Discovering the most prevalent symptoms that can aid in cancer diagnosis has been a significant difficulty in cancer therapy up to this point. The patterns of malignancies and a clever way for early tumour detection were the subjects of several research investigations. The approach also recommends the most effective therapies. A surgical biopsy is the method of choice for most doctors when trying to distinguish between benign and malignant breast tumours. The majority of them, however, held the view that biopsy is an essential procedure that ought to be avoided at all costs. Therefore, it would benefit both doctors and patients to propose a smart system that may aid in cancer diagnosis without the need for invasive surgical biopsy. By utilising a variety of data mining approaches and reporting their findings, the writers of [26-45] sought to cover scientific papers pertaining to breast cancer diagnosis. Comparing the accuracy rate of data mining algorithms or methodologies is the main focus of most of the examined research works (on breast cancer diagnosis, therapy, or prognosis). No reliable method exists at this time for the automated detection or prognosis of breast cancer. In addition, no studies have been conducted that use personalised characteristics to provide patients with optimal therapies. Current practices, developments, and possibilities in medical data categorisation using data mining were examined and analysed by [46-57]. Their focus was on the primary methods employed to raise the level of predictive precision. Data mining appears to be highly successful for the categorisation problem according to a large body of studies.

Decision trees, neural networks, support vector machines, k-means, logical regression, K-nearest neighbours, and naïve Bayes classifier are many data mining methods used in healthcare applications. Combining algorithms like random forest, decision trees, neural networks, support vector machines, logistic regression, and K-nearest neighbours (KNN) can greatly enhance data analysis. For example, in [28], the authors used a combination of these methods to determine the health of COVID-19 patients and to predict the likelihood of their mortality. To prevent delays in providing patients with necessary care, the program will assist hospitals in determining the patient priority order in the event that the system is inundated.

From the moment it emerged, the COVID-19 pandemic has captivated the medical informatics community. Combining deep learning algorithms with CT scans to test for Covid-19 is a common practice, as shown in [29]. In order to provide a clinical diagnosis before to the pathologic test, the authors suggested a framework for deep learning algorithms to extract certain graphical elements from CT scans. Reducing wasted time in disease control is the end goal. A novel approach is detailed in [29] for the purpose of real-time mortality estimation and prediction due to COVID-19. Utilising data collected during an outbreak, this technique employs the Patient Information Based Algorithm (PIBA). To evaluate the approach, the authors utilised preliminary data from China, the algorithm was effectively applied to estimate the mortality rate and predict the death numbers in the Korean population. The researchers claim that their system can foretell future fatalities and provide real-time estimates of the mortality rate associated with newly discovered infectious diseases. An additional intriguing study suggested an automated detection method as a quick alternate diagnostic choice for COVID-19 prevention [30]. The method involves identifying patients with coronavirus pneumonia from chest X-ray radiographs by utilising three distinct models based on convolutional neural networks: ResNet50, InceptionV3, and InceptionResNetV2. Findings from this study include the fact that chest X-ray pictures are an excellent method for detecting COVID-19.

CONCEPTS AND REASONING BASED ON ONTOLOGIES

Gruber states that an ontology is a formal description of a theory [31]. In engineering, it denotes a product that relies on a predetermined set of assumptions about the meaning of words to describe a given reality. The idea of ontology has grown in significance as a result of the data deluge, the proliferation of sources, and the diversity of that data.

The significant advances in medicine has made it one of the most popular areas for ontologies to test their theories in. Two of the most important requirements for these ontologies are that they be reusable and interoperable. The scientific community is involved in their construction and sharing through four primary resources: (i) the Open Beliefs and Ontologies Foundation (OBOFoundry) (http://www.obofoundry.org/), whose mission is to create a set of well-formed, scientifically correct, interoperable ontologies. As of May 2020, it has 175 ontologies that address various topics including as anatomy, illnesses, diagnostics, therapy, and more;

(ii) the BioPortal [32], which is working towards the goal of developing software and ancillary services to apply ontologies in biomedical research. This repository houses 1016 ontologies as of May 2020 and is managed by the NIH National Centre for biological Ontology. Additionally, there is the Ontology Look-up Service, which is a repository of biological ontologies and may be accessed at https://www.ebi.ac.uk/ols/index. It attempts to give ways to discover, query, and explore controlled vocabularies and biological ontologies; (iv) UMLS (https://www.nlm.nih.gov/research/umls/index.html), which has 237 ontologies as of September 2019. Diabetes, breast cancer, Alzheimer's, hypertension, asthma, and many more disorders are covered by the created ontologies. In addition to drugs, cells, phenotypes, radiography, anatomy, chemistry, infectious illnesses, clinical research, psychology, nursing, laboratories, units of measurement, mass spectrometry, epigenetics, biological systems, etc., they also stand for a variety of other concepts. Not long ago, COVID-19 became a part of Infectious Disease Ontology (IDO), which offers comprehensive information on infectious diseases [58-69].

The authors of [34] envisioned the function of ontologies in biomedical and biological research more generally. From a practical standpoint, they demonstrated intriguing outcomes. A variety of ontology features in the biomedical and biological areas are described in the article. Metadata describes the intended meaning of the classes and relations in ontologies; providing machine-readable axioms and definitions allows computational access to some aspects of the meaning of the classes and relations; providing a vocabulary for a domain; and providing standard identifiers for the phenomena within a domain are the four main features that, when combined, contribute significantly to the success of ontologies. The authors offer a practical view of ontologies in biomedicine and biology, outlining their potential uses and highlighting their potential to facilitate integrative research. Concerning data-driven research, structured data mining, and machine learning, they also detailed potential uses for ontologies.

As stated in [35], air pollution has emerged as a major public health concern in several east Asian nations throughout the last decade. The prevalence of pollution-related diseases and symptoms, such as asthma, bronchitis, sinusitis, laryngitis, etc., has become a major health concern in Taiwan. The authors put out the idea of an ontology-based herb treatment recommendation online for the health of the respiratory system. The goal was to organise the information and create a user-friendly website. The latter offers thorough and trustworthy information about herbs that can boost the health of the respiratory system. User reviews validate the system's functionality and practicality. Herbs have been around for a while, and many people have turned to them for relief, but there is a serious lack of information and marketing surrounding their usage in everyday cooking and alternative medicine. It will take a long time and a lot of effort to spread this information.

Conversely, [36] were curious in drug misuse epidemiology and its potential use to an ontology. The intention of the authors' enhancements to an ontology-based system (PREDOSE for PREscription Drug abuse Online Surveillance and Epidemiology) was to glean useful information on illegal drug use from various online sources. PREDOSE does not address the dangers of illegal substances or their common names or slang. Drugs that are illegal in one country may be legal in another; this database does not include this information. By furnishing helpful data pertaining to drug addiction and its forbidden information, the suggested method intends to make up for any deficiency in PREDOSE. Users may now search the knowledge base for specific phrases, such drug slang or street names, made possible by this innovative method. The many brand names of a drug's chemical formulation, together with information on the drug's negative effects, are also available to users. With an increase from 43 to 114 classes, the approach contains some updated and enlarged material. Furthermore, by outlining semantic rules, the model becomes more efficient.

In order to give knowledge practitioners with a systematic and practical platform, the authors of [37] utilised a Semantic-Based Knowledge Management System (SKMS) that facilitates knowledge collection and combines different methodologies. Tasks that are carried out as part of clinical process goals may be specified with the help of SKMS, which also aims to identify the responsibilities of healthcare professionals and the activities that can be completed according to personnel skills. The writers of this piece suggested an ontology-based strategy for studying problems with information flow and implicit knowledge acquisition. When it comes to the many operations and procedures carried out by healthcare units, SKMS is helpful in assisting with the provision of appropriate information to appropriate users as required. Management of both tacit and explicit knowledge can be facilitated by this system. A health information system (HIS) that offers a range of services to better satisfy the needs of users and health care professionals can be developed using this method, which systematically acquires implicit knowledge from knowledge mentors or subject matter experts, models it formally, and then converts it into a machine-readable form. By using an ontologically-based modelling approach, we want to encourage the company to adopt patient-centered systems, expand opportunities, and streamline the reuse of current healthcare practices for future reform projects. A fresh perspective on knowledge management and assistance in developing HIS with alternative and innovative implementation methodologies are both offered by using an ontology [70-84].

Research in [38] looked at the difficult problems of upgradeable ontology verification and tested crowdsourcing approaches' capacity to find mistakes in SNOMED CT (Systematised Nomenclature of Medicine Clinical Terms). Microtasking and a Bayesian classifier are the tools that the authors provide as a crowdsourcing approach to ontology verification. It is expected that the suggested technique will work well on comparable ontologies, as the study's findings shown that the public can detect mistakes in SNOMED CT that specialists also notice. Crowdsourcing can be a lifesaver in situations when expert evaluations are either not accessible, too expensive, or the ontology is too broad to be feasible. In addition to solving simple, commonsense problems, it can handle complex, expert-level ontology verification problems. Issues requiring a high level of biological knowledge may be amenable to crowdsourcing, as shown in this study.

An extensive critique of care in the treatment of eating disorders in the United States is presented in the research [39] published in Transcultural Psychiatry. The author elaborated on all the concepts related to ontology, recognition, and the elusiveness of care within the specified context by using a patient as an example. Eating disorder clinical care is fundamental yet illusive, a guiding concept but an ever-dwindling target. The clinic is responsible for providing care for individuals with eating disorders, which aims to address their psychological, social, and medical requirements. The issue is that managed care organisations, not the clinic, have the resources necessary to deliver such treatment. Care management organisations have final say over who gets treatment, how it is provided, and whether or not certain requirements are met. A dangerous reflection of eating disorders is the managed care framework's belief that a patient is better regarded the less resources they require. The idea of "care" functions in several realms at once, occasionally inverting to create indirect manifestations or even damage. On a semiweekly basis, managed care firms checked in with patients to see how they were doing with their therapy and whether they were following their predicted recovery paths. The treatment coverage might be cancelled if the progress is deemed satisfactory by the companies. It is possible for a patient to be asked to quit therapy by the clinic or for her insurance benefits to be revoked if it is determined that she is habitually manipulative. So, care is a goal that is ever-changing, malleable, and elusive since the logic of care in this setting paradoxically tears the client's agency apart [85-90].

Diabetes mellitus [40–42], liver cancer [43], myocardial infarction [44], dermatosis [45], hypertension [46], Ebola virus infection [47], fibrotic interstitial lung disease [48], breast cancer [49,50], pneumonia [51–53], and Alzheimer’s [54] are just a few of the diseases that have inspired the development of numerous ontologies. There are ontologies for medications [58-60] and ontologies for differential diagnoses [55-57]. Lastly, Ontology-Extended Clinical Guidelines is a main field of semantic applications in healthcare. An open-source and freely-accessible knowledge base is made available through the OpenClinical.net knowledge sharing initiative [61]. Supporting the community to build, document, and share models of clinical expertise; providing open access to the content for clinical and research use; ensuring fair recognition of efforts and value created by the tool users; and empowering them to disseminate their expert knowledge are the four principles that govern its operationalisation. The tool's solutions are based on ontologies and aid in comprehending, collecting, and organising data, expertise in the field of hospital medical item management.

CLINICAL DECISION SUPPORT SYSTEMS

From decision support and treatment planning to message systems, reminders, and suggestions, the medical informatics industry is keen on creating ways and tools to bolster clinical operations. Healthcare practitioners have been approached with the idea of clinical decision support systems (CDSS) over fifty years ago, with the goal of enhancing patient care through better decision-making. Both diagnosis and therapy are addressed by this assistance [62]. Quality, safety, and high performance might all be enhanced with this tool's proper application, according to many studies of medical treatment [63-66]. Providing the appropriate information to the right person in the right format through the right channel at the right moment in workflow to enhance health and health care choices and outcomes is the lynchpin of CDSS success, as stated in [67].

CONCLUSION

An intriguing essay delves into the topic of fuzzy decision support systems and how they may be utilised to diagnose diabetes. For the purpose of diabetes diagnosis, the authors introduced an ontology-based system and used a novel framework for Fuzzy Rule-Based Systems (FRBS) that is semantically interpretable. The authors included several elements of knowledge-fuzzy inference, ontology reasoning, and a fuzzy analytical hierarchy process (FAHP) into their framework to provide a more comprehensible and precise design. In order to create a CDSS that is accurate, dynamic, semantically intelligent, and interpretable, the suggested system provides a plethora of distinct and necessary improvements. Concepts of symptoms and the ontology-based semantic similarity of diabetic complications are both taken into account during the assessment procedure of fuzzy rules. Validation using a real-world dataset proved that the suggested system aids in the correct diagnosis of diabetes mellitus by both doctors and patients. The authors developed hierarchical FRBS (H-FRBS) while working on a hospital in Egypt. They used JAVA APIs to integrate the suggested FRBS. While every element is necessary in a real medical setting, some are more important than others. For instance, a person's lipid profile is less essential than diabetic symptoms. On top of that, doctors have to make do with what they have when not all aspects are known about a particular patient. With varying degrees of certainty and combinations of data sources, the final system may make judgements. The authors assert that their approach is intelligent and capable of producing more precise findings than previous research. Because it was developed using an open design, it may be enhanced and made to work more. Moreover, the technique may be easily and simply adapted to any other area of medicine.

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