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Utilization of Machine Learning in a Responsible Manner in the Healthcare Sector

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ABSTRACT

Artificial Intelligence and Machine Learning technologies have improved the ability to forecast and recognize health emergencies, disease populations, and disease status and immune response. Many people still need to be convinced about using ML-based approaches in healthcare, yet their incorporation is increasing regardless of such reservations. Here are brief descriptions and examples of supervised, unsupervised, and reinforcement learning algorithms and machine learning-based methodologies. Second, we discuss how ML is used in healthcare, like X-rays, DNA analysis, EHRs, and MRIs. We also offer solutions to the problems that arise when applying ML to healthcare, such as system privacy and ethical considerations, and point the way toward potential future applications.

Key words: Medical Informatics, Machine Learning, Healthcare, Patient Outcome, Artificial Intelligence

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INTRODUCTION

Machine learning has been used in various contexts since Alan Turing's proposal of the first learnable machine in the 1950s. Since its inception, machine learning has been used in multiple fields, including but not limited to security services (through face identification), public transit (improving efficiency while decreasing risk), and, more recently, healthcare and biotechnology. Changes in business operations and people's day-to-day lives have resulted from advancements in artificial intelligence and machine learning; similar improvements are expected in Medicine and healthcare. Recent developments in this area have shown extraordinary success and the possibility of relieving physicians' workloads while enhancing accuracy, prediction, and quality of care. Machine learning's contributions to healthcare have been somewhat ancillary, helping doctors and analysts spot trends in the industry and create disease prediction models. Organization of electronic health records, identification of irregularities in blood samples, organs, and bones using medical imaging and monitoring, and robot-assisted surgeries are just a few examples of how machine learning-based approaches have been implemented in large medical organizations to increase efficiency. In the fight against this, machine learning techniques have lately allowed for faster testing and hospital response (Yan et al., 2013). During the pandemic, hospitals have employed a deep learning system by GE called the Clinical Command Center to coordinate the movement of patients, beds, rooms, ventilators, electronic health records (EHRs), and even employees. The identification of SARS-CoV2 genetic sequences, the development of vaccinations, and the monitoring of these interventions have all used artificial intelligence. As healthcare expands into the modern era of technology, many innovations have emerged. Improvements in diagnostic speed, accuracy, and simplicity are all possible with the help of AI and ML-based techniques and applications (Lal, 2015). This study aims to weigh the merits and drawbacks of machine learning-based methods currently being used in healthcare. Our goal is to present a high-level overview of the many machine learning techniques and highlight the domains where these approaches are most commonly utilized as the application of new machine learning technology sweeps the healthcare business. Their pervasiveness in healthcare, as well as the potential for their further development, is discussed. We also discuss the potential dangers and difficulties that arise from their implementation from an ethical and logistical perspective.

ROLE OF MACHINE LEARNING IN THE MEDICAL INDUSTRY

Machine learning's contributions to healthcare have been somewhat ancillary, helping doctors and analysts spot trends in the industry and create disease prediction models. Organization of electronic health records, identification of irregularities in blood samples, organs, and bones using medical imaging and monitoring, robot-assisted surgeries and so on.

- **Systems for the Clinical Support of Decision Making**: The clinical decision support systems help evaluate vast volumes of data to detect a condition, decide on the next stage of treatment, identify any potential difficulties, and increase the overall efficiency of patient care. The Clinical Decision Support System (CDSS) is a vital tool that assists physicians in performing their jobs effectively and rapidly. Additionally, it lessens the likelihood of receiving an incorrect diagnosis or prescribing ineffective medication. Although the application of machine learning systems in Medicine (also known as healthcare) has been around for some time, their prevalence in this field has significantly increased in recent years. The widespread adoption of the electronic health record system (EHR) and the digitization of numerous data points, including medical photographs, are the primary factors contributing to this development.
- **Keeping diligent records:** Due to the monotony of the data-entering process, it might be challenging to ensure that all patient records are regularly kept current. However, it is also essential for making sound decisions and providing superior care to patients. The use of optical character recognition (OCR) technology in the handwriting of medical professionals is one use of machine learning in the healthcare industry. This helps to ensure accurate and efficient data entry. The results of these analyses can then be used by other machine learning techniques to facilitate improvements in decision-making and medical care for patients.
- **Using Artificial Intelligence in Medical Imaging:** Images used in Medicine, such as X-rays, have remained analog for most of their history. Because of this, the use of technology for identifying anomalies, categorizing individual cases, and researching the disease has been restricted. To our good fortune, the digitalization of the process has increased opportunities for data analysis, including machine learning. According to a recent meta-analysis, deep learning algorithms of machine learning for health do the job just as well as (and in some cases, even better) than human specialists, with 87.0% sensitivity and 92.5% specificity for the deep learning algorithms compared to 86.4% sensitivity and 90.5% specificity for human physicians. In other words, deep learning algorithms of machine learning for health do the work as well as (and in some cases, even better than) human specialists. Microsoft's InnerEye project is one of the most well-known and practical examples of machine learning being successfully applied in healthcare. Initially, it concentrated on three-dimensional radiological imaging, where machine learning algorithms were developed to distinguish between healthy cells and malignancies.
- **Individualized medical treatment:** Every patient's unique condition contributes to Medicine's reputation as a complex and resource-intensive specialty. People frequently suffer from several states, all of which must be treated simultaneously. Therefore, difficult choices must be made to design an effective treatment plan considering probable drug interactions and reducing the likelihood of unwanted effects. How can we overcome this issue by applying machine learning in healthcare? However, IBM has solved this problem with its Watson Oncology system. This technology analyzes patients' medical data to generate possible treatment alternatives.
- **Modifications of Behaviour:** In healthcare, disease treatment is less critical than disease prevention. Modifying one's behavior to eliminate unhealthy habits and build a healthy lifestyle is one of the most essential aspects of preventive Medicine. In the field of Medicine, one of the benefits of machine learning is that it may draw attention to things that humans might otherwise miss (Ibrikci et al., 2012). That is precisely what it is that Somatix does. Based on machine learning, this program does daily medical research on patients' activities. It draws attention to patients' unconscious habits and routines so that patients can concentrate on breaking them.
- **An Approach to Treatment That Is Predictive:** When it comes to the diseases that pose the greatest threat to human health, diagnosing them in their early stages can considerably increase the odds of successfully treating them. This helps to discover any potential deterioration of the patient's condition before it occurs, which is another benefit of doing this. The fact that machine learning can accurately forecast some of the most deadly diseases in patients at risk is one example that demonstrates the importance of machine learning in the healthcare industry. This covers the diagnosis of liver and renal illnesses, as well as oncology, using an algorithm called Naive Bayes.

- **The Accumulation of Data:** Gathering accurate information about a patient's medical history is one of the most essential obligations of a physician. This is challenging because the patient is not an expert and must know which information must be shared with the doctor. Regarding patient care, experts in the healthcare industry can use machine learning in healthcare management to identify, depending on various factors, which questions are the most pertinent to ask a patient. This will assist in collecting relevant clinical data while predicting the most likely present conditions.
- **Care for Seniors and People with Reduced Mobility:** The application of machine learning to the field of Medicine can assist individuals with limited mobility, such as the elderly and people who use wheelchairs, in enhancing their day-to-day lives with helpful reminders and assistance with scheduling, predicting and avoiding the possibility of injury by locating common obstacles and determining the most effective routes, and receiving aid as soon as it is required. Even if these solutions work, their adoption should be more prevalent. However, healthcare and pharmaceutical businesses are already taking steps to ensure they are readily available to many people. For instance, there is a plan to have artificial intelligence do 75% of the care for older people in Japan.
- **Operation Using a Robotic Arm:** Surgical operations call for high precision, the capacity to respond quickly to shifting conditions, and the ability to maintain composure over an extended period. Although trained surgeons possess all of these attributes, one of the potentials that machine learning presents for the medical field is the possibility of robots performing these duties. At this point, human surgeons can use robotic surgery as a helpful assisting tool. To be more specific, machine learning can be utilized for improved modeling and planning of surgical procedures, as well as for assessing the skills of the surgeon and simplifying surgical duties such as suturing.
- **The Process of Developing and Manufacturing Drugs:** Healthcare machine learning algorithms can simulate an active component that would work on another comparable condition by using data that they have previously obtained on active ingredients in pharmaceuticals and how those active components affect the organism (Sweeney et al., 2014). This technique can build a personalized drug for patients with specific ailments or certain criteria. This tool for machine learning could be employed in conjunction with nanotechnology to improve the delivery of drugs.

APPLYING MACHINE LEARNING TO MEDICINE

Provides diagnostic and prognostic strategies, techniques, and tools for several medical fields. ML is used to analyze clinical parameters and their combinations for prognosis, such as illness progression prediction, to extract medical knowledge for outcomes research, therapeutic planning and support, and patient care. Data analysis using ML includes detecting regularities in imperfect data, interpreting continuous data utilized in the Intensive Care Unit, and intelligent warning for inefficient and efficient monitoring. Successful ML implementation can assist in integrating computer-based systems in the healthcare environment, facilitating and improving medical professionals' work, and improving medical care efficiency and quality (Thaduri et al., 2016). Below, we list major medical ML applications. Medical diagnostic reasoning is a crucial computer-based application. Expert systems and model-based techniques generate hypotheses from patient data in this framework. Expert systems use expert knowledge to extract rules. Unfortunately, specialists often do not know or articulate what information they utilize to solve problems. Expert systems learn and manage knowledge using symbolic methods like inductive learning through examples. Learning in intelligent systems can be performed using ML approaches to describe clinical attributes that uniquely identify clinical situations given a set of clinical cases. This knowledge can be described as simple rules or decision trees. The ECG interpretation system KARDIO is a classic example. This method can be used for medical data interpretation without prior experience. Hau and Coiera propose an intelligent system that uses real-time patient data from cardiac bypass surgery to develop standard and pathological cardiac physiology models to detect patient changes. In research, these models might be hypotheses that inspire additional experimentation. Learning from patient data is difficult due to its incompleteness (missing parameter values), incorrectness (systematic or random noise), sparseness (few and non-representable patient records), and inexactness.

Another use is biological signal processing. Since our understanding of biological systems is incomplete, physiological signals hide important traits and information. Also, subsystem impacts are indistinguishable. Physical signs vary due to spontaneous internal mechanisms or external inputs. Conventional methods may not solve complex parameter associations. ML approaches use these easier-to-produce data sets to model nonlinear interactions and extract parameters and characteristics that can improve medical care. Computer-based medical image interpretation systems aid diagnosis. These systems are usually designed to mimic doctors' skill in identifying malignant regions in minimally invasive imaging procedures. The goal is to improve the expert's cancer region identification, reduce intervention, and maintain accurate diagnosis. It can also analyze living tissue in vivo, possibly remotely, to reduce biopsies' drawbacks, such as patient discomfort, diagnosis delay, and restricted tissue samples. More effective early detection methods like computer-assisted medical diagnosis systems are needed. As the healthcare environment becomes more computer-dependent, ML methods can help physicians, in many cases, eliminate fatigue and habituation issues, identify abnormalities quickly, and enable real-time diagnosis.

ETHICAL IMPLICATIONS OF USING ML IN HEALTHCARE

Using Machine Learning in Healthcare Raises Ethical Concerns The application of artificial intelligence has been a source of ethical problems for quite some time. However, a few of them are unique to the application of machine learning in the medical field. Let us go over the most important ones first.

Privacy and the Protection of Data: The confidentiality of the patient's information is protected by HIPAA and other privacy standards. Everyone must be able to safeguard the confidentiality of information about their health. Despite this, many data breaches in the healthcare industry occur daily, which can result in fines of up to $16 million for healthcare providers. Nevertheless, data is the organism that machine learning draws its life force from. In what ways are these perspectives compatible with one another? The difficulty of this obstacle makes it harder to conquer it. Therefore, it is possible to effectively anonymize it so that the person's identity cannot be revealed, while the precision of the ML algorithm will not be discounted. Machine learning does not require a full spectrum of information on the patient in most cases (such as name, email, phone number, and insurance policy number). For the rest, data security strategies must be implemented to guarantee patient confidentiality. Check out our in-depth post on creating HIPAA-compliant software if we want to learn more about the importance of security in developing software for the healthcare industry.

Concerns Regarding Autonomy: Machine learning algorithms can be utilized effectively to assist older persons and people struggling with psychological disorders in making decisions that benefit their health. This includes taking the appropriate drugs as directed, developing healthy habits, and consulting the professional whenever necessary. On the other hand, this raises ethical concerns because it could lead to individuals relinquishing their autonomy in favor of doing what they are taught (Wang, 2015). This restricts the prospective options available to them to include those that have been recommended. Therefore, there should be a distinct equilibrium between the directives offered by the algorithm and the flexibility for individuals to make their own decisions.

Security of Patients: The data that the machine learning algorithm has been trained on is the basis for the decisions it will make in the future. If the input is inaccurate, the output will also be wrong. The careless decision may put the patient in danger or result in their passing. Who would be accountable for the death of a patient caused by the choice made by machine learning technology? This is the ethical problem that this situation presents. This is something that has yet to be determined. Before choosing the treatment method, the patient should know each treatment approach's potential benefits and hazards.

Transparency and Free and Voluntary Consent: Data is essential for machine learning algorithms to function correctly. The better they perform, the more accurate outcomes and forecasts can be achieved when more relevant data is accessible. There are laws in place in many countries that ban the use of patient data without the patients' prior agreement and knowledge. Therefore, using machine learning in healthcare should go hand in hand with alerting patients about it and the data security procedures to keep patients' data safe. This is to ensure that machine learning is used appropriately.

The importance of representation and inclusivity: When building an all-encompassing software solution for the healthcare industry, we should ensure its algorithms can produce accurate results for diverse patients. According to PMC, people of various racial and ethnic backgrounds may have variable responses to the same medicinal treatment, requiring further attention. As a result, a solution based on machine learning should be "learned" from patient cases and histories that are sufficiently broad and varied. In addition, preventing and educating physicians about instances in which the machine learning algorithm would need more research data is recommended, which would probably generate fewer accurate conclusions.

USE OF AI IN HEALTHCARE

Machine learning has advanced in healthcare for years. AI can improve case triage, diagnosis, image scanning, segmentation, decision-making, disease prediction, and neuroimaging. We summarize AI achievements in health science here. The applications described are included because ML-based approaches leverage more digital data and incorporate learning methodologies with clinical applications and tests. This review focused on ML applications in electronic health records, medical imaging, and genetic engineering. These domains contain healthcare's "BIG" data—structured and unstructured—and have shown promise for clinical applications. The articles and publications covered machine learning and artificial intelligence in healthcare: existing and future applications. Machine learning in healthcare, AI medical imaging, BIG data and machine learning, genomics, electronic health records, healthcare AI problems, and medical AI applications were searched for. These terms were varied to provide thorough search results.

Scientists use EHRs to construct deep learning models for clinical diagnosis and prediction because prediction is crucial to treatment. Liu, Zhang, and Razavian created a deep learning system employing LSTM networks (reinforcement learning) and CNNs (supervised learning) to predict heart failure, renal failure, and stroke. Unlike prior prediction algorithms, this method combined organized EHR data with unstructured progress and diagnostic notes (Katherine et al., 2014). Liu and colleagues found that adding unstructured input to the model improved all baseline accuracy measurements, demonstrating the versatility and robustness of such techniques. Another deep neural network study by Ge and colleagues predicted post-stroke pneumonia within 7 and 14 days. The model accurately predicted pneumonia after a stroke with an Area under the ROC curve (AUC) of 92.8 percent for 7-day predictions and 90.5 percent for 14-day predictions. Lockheed debuted EHRs, then clinical information systems, in the 1960s. The plans have been rebuilt multiple times to achieve an industry standard. To increase work quality and efficiency, the US federal government committed billions to implementing EHR in all practices in 2009. By 2015, approximately 87% of office-based procedures nationwide had implemented EHRs. Big data from EHR systems with structured feature data has helped deep learning applications like prescription refills and diagnosis prediction. This has improved data organization, accessibility, and care quality, assisting doctors to diagnose and treat patients. Standardizing features across datasets has enhanced research access to health records.

Additionally, some ML-based models predict ICU patient death. Ahmad and colleagues used EHRs to predict mortality in paralytic ileus (PI, an incomplete intestinal blockage that prevents food passage, eventually leading to total intestine blockage) patients. Statistically Robust Machine Learning-based Mortality Predictor (SRML-Mortality Predictor) predicted PI patient mortality with 81.30% accuracy. By predicting death, EHR prediction algorithms can help patients and doctors make better clinical treatment decisions.

Due to the digital nature of data and structured data formats like DICOM (Digital et al. in Medicine), medical imaging has advanced with machine learning-based approaches to CT, MRI, X-ray, PET, Ultrasound, and more. Several ML-based tumor detection models exist. Recently, McKinney and colleagues used a deep learning algorithm to detect early-stage cancers using mammograms. Deep learning-based screening methods can identify and locate breast cancer tumors in early stages, improving resection rates. Deep learning outperformed experienced radiologists by 11.5% in a direct comparison. In an objective assessment, CNN performed "on par" with 21 board-certified dermatologists, verifying the results. This strategy can simplify use and diagnose early when used with the average consumer mobile platform. Parallel studies have used ML to quantify retinal disease development. In a word, Arcadu and colleagues used a deep learning CNN to detect Diabetic Retinopathy (DR) aneurysms that cause visual loss. The CNN caught minuscule, low-contrast microaneurysms despite not being designed to do so. Diabetic retinopathy, which affects 60% of type 1 diabetics, is hard to identify early. Early CNN prediction may avoid or delay permanent visual impairment. X-rays have been used for decades to diagnose chest cavity and lung problems, but a trained radiologist must scrutinize them. In a retrospective study, Rajpurkar and colleagues tested a 121-layer convolutional neural network to identify irregularities in chest X-rays from various thoracic diseases to mimic radiologists' detection [8]. CNN's identification accuracy was 81%, 2% higher than radiologists'. Although retrospective, this study and CNNs developed by Tsai and Tao, Asif and colleagues, Liang and colleagues, and Lee and colleagues show incredible support for examining and diagnosing illnesses, reducing the burden on healthcare professionals.

ML-based techniques have also been used to predict and diagnose neurodegenerative diseases like Alzheimer's and Parkinson's, significant mental disorders including psychosis, depression, and PTSD, and developmental disorders like autism and ADHD. Faturrahman and colleagues developed a higher-level model employing DBNs (unsupervised learning) to predict AD progression using structural MRI scans with 91.76% accuracy, 90.59% sensitivity, and 92.96% specificity. Early diagnosis helps delay AD symptoms and deterioration, but no cure exists. Patel and colleagues used decision tree models and feature-rich data sets like functional MRI, cognitive behavior scores, and age to predict depression diagnosis and treatment response. The model had 87.27% diagnostic and 89.47% treatment response accuracy. This predictive diagnosis can identify depressed people and tailor treatment based on their reactions. Due to its accuracy, classification, sensitivity, and specificity in prediction and diagnoses, ML applications in medical imaging are beneficial to medical advancement.

Genetic engineering has grown since the discovery of CRISPR, an adaptable DNA system. The development of "programmable endonucleases" has simplified genetic engineering, made genetic alteration and diagnostics easier, and significantly reduced the cost of the technique. Though imperfect, CRISPR-Cas editing has transformed genetic editing. Several machine learning methods have recently emerged for Cas9 gene editing off-target mutation prediction. Jiecong Lin and Ka-Chun Wong's new algorithm uses deep CNNs (AUC score: 97.2%) and deep FFs (AUC score: 97%) to improve machine learning predictions. Outside of CRISPR gene editing, O'Brien and colleagues have developed a service to improve nucleotide editing efficiency utilizing random forest algorithms (supervised learning) to study how nucleotide composition affects HDR (homology-directed repair) efficiency. They created the Computational Universal Nucleotide Editor (CUNE) to find the best way to spot a point mutation and predict HDR efficiency. Pan and colleagues have created ToxDL, a CNN-based gene editing prediction model that predicts protein toxicity in vivo using sequence data. Pharmacogenomics, another discipline of genetic engineering, has also advanced using AI and machine learning to establish stable doses of widespread drugs. Tang and colleagues used ML to find a steady Tacrolimus dose for renal transplant patients to prevent acute rejection. Recent machine-learning applications in pharmacogenomics include psychiatry, oncology, bariatrics, and neurology.

Machine learning and genetic engineering have helped tackle this. Malone and colleagues used machine learning algorithms to "predict which antigens have the required features of HLA-binding, processing, presentation to the cell surface, and the potential to be recognized by T cells to be good clinical targets for immunotherapy" in a recent study. This software's immunogenicity predictions and antigen presentation to infected host-cells allowed the team to profile the "entire SARS-CoV2 proteome" and epitope hotspots. These findings suggest global virus vaccine templates.

CONCLUSION

The overview shows how far machine learning has come but might still grow further. Many medical machine-learning advances promise to help doctors treat patients faster, better, and more precisely. Develop and execute improvements in data collecting, storage, and distribution or create algorithms to handle unstructured data to overcome data shortages to tackle ML algorithm development challenges. Future applications may deliver cheap medical imaging and exams, reducing health inequities and making services more accessible to countries and low-income populations. Scientists expect improvements in tailored drug response prediction, prescription selection and dosage optimization, and genetic alteration for hereditary illnesses and mutations [103]. ML can improve patient care and physician roles. While the dangers and obstacles of the future application are addressed and solved, present ML algorithms can give an excellent framework for healthcare ML developments and applications.

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