

Application and Prospects of Artificial Intelligence in Breast Cancer Early Diagnosis, Screening, and Treatment

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Abstract. In modern society, as artificial intelligence technology becomes increasingly mature, AI can already be utilized to assess and treat breast carcinoma. By summarizing results and data of experiments that use AI to help breast carcinoma diagnosis and cure, this article states the positive impact of AI on breast cancer screening, detection of breast cancer-related genes, and prediction of efficacy of breast cancer treatment drugs. What is more, illustrating the moral, legal, and social challenges encountered by scientists when they use artificial intelligence. Also, this article makes some suggestions for the future development of AI technology. The author believes that AI technology have the ability to contribute significantly to the diagnosis and cure of breast cancer and can enhance the chances of patients surviving to a considerable extent. However, currently, artificial intelligence technology remains in a relatively nascent stage, necessitating ongoing attention and dedicated efforts for its advancement.

Keywords: artificial intelligence; Breast Cancer; Diagnosis; Screening; Treatment.

1. Introduction

Breast cancer, as a common female malignancy, plagues many women worldwide. Until January 1, 2022, in the United States, there were over 4.1 million female who had a history of breast cancer. About 13% of females (equivalent to 1 in 8) will receive a diagnosis of invasive breast cancer, and about 3% of females (equivalent to 1 in 39) will die from this cancer [1]. Considering the high prevalence and fatality rate of breast cancer, medical scientists have never stopped studying breast cancer and have made many significant outcomes. Today, scientists have significantly improved the survival rates of patients with breast cancer. The most important part of curing breast cancer is early diagnosis. If breast cancer can be diagnosed in the early stage, the patient's survival rate and cure rate will be greatly improved [2]. Fortunately, a revolutionary technology, artificial intelligence, has greatly assisted medical scientists in the detection of breast cancer. By using deep learning models, artificial intelligence has the ability to detect breast cancer, which can quickly and accurately diagnose breast cancer with almost the same accuracy as professional human doctors. However, there are still many questions related to the application of AI in breast cancer. The diagnosis of breast cancer is still not precise enough, the data privacy of patients cannot be protected, and there are not enough relevant legal constraints AI. These are the challenges faced by humans. This article will summarize the utilization of AI technology in breast carcinoma, describe the challenges faced by artificial intelligence applications, and discuss the future development prospects of artificial intelligence. This article is written to help readers better understand the utilization of artificial intelligence and consider how to better apply AI to breast cancer in the future.

2. Application of AI technology in breast cancer

In modern society, artificial intelligence is mainly used in the screening and treatment of breast carcinoma [3]. While the utilized AI algorithms and analytical methodologies have slight disparities, the fundamental approach to their application remains analogous: by analyzing the provided big database and deep learning, artificial intelligence is trained to have the ability to distinguish images between healthy breasts and breast cancer breast [4], analyze disease-causing genes, and predict the efficacy of related drugs.



2.1. AI system in DM Test

The AI system can be employed to identify breast cancer in both digital mammography (DM) tests and digital breast tomosynthesis [5]. By utilizing convolutional neural networks, feature classifiers, and image analysis algorithms based on deep learning, the AI system can identify calcifications and abnormalities in soft tissue. For every test, AI assigns a continuous rating ranging from 1 to 10. (10 indicating a strong likelihood of malignancy), indicating the degree of suspicion for the presence of cancer. This score is determined based on the independently identified potentially concerning observations. By applying the AI system to the DM test, the hospital will be able to screen a large number of breast images and identify patients at risk of breast cancer. At the same time, the AI system is also very accurate. For example, in the experiment done by Alejandro Rodriguez-Ruiz et al., they analyzed the accuracy of artificial Intelligence for breast cancer detection with the detection accuracy of 101 radiologists. It was discovered that the artificial intelligence's accuracy was shown to be statistically equivalent to the average performance of 101 radiologists. The area under the ROC curve (AUC) of artificial intelligence was 0.840, while the average AUC for the radiologists was 0.814. The difference in AUC between the AI system and the radiologists ranged from 0.003 to 0.055. Furthermore, the artificial intelligence system's AUC is higher than 61.4% of the radiologists. This result can preliminarily prove that the application of AI systems on DM tests is reliable. The utilization of artificial intelligence in DM tests stands to yield substantial human resource conservation benefits. Specifically, it allows numerous medical practitioners to redirect their efforts away from the manual examination of breast imaging, thus enabling a more concerted focus on the direct provision of patient care. Moreover, the capacity of AI to efficiently process extensive datasets cannot be understated. It facilitates the expansion of patient screening within healthcare institutions, which holds the potential to markedly enhance the operational efficiency of medical facilities. As a result, the overall survival rates of patients are improved.

2.2. AI analysis in H&E slides

Histopathological images of tissue samples stained with hematoxylin and eosin (H&E) provide much valuable data on the human body [6]. From these cross-sectional samples, medical professionals can not only assess diagnostic and prognostic data but also identify precise genetic mutations associated with cancer. In academic research, it has been demonstrated that predicting molecular changes based on H&E (Hematoxylin and Eosin) staining is effective in the diagnosis of various types of tumors. By analyzing H&E slices using AI and deep learning, medical scientists find the possibility of predicting the possibility of genetic mutations directly based on hematoxylin and eosin (H&E) tissue slides. While it is important to note that not all mutations responsible for cancer can be forecasted through AI deep learning, it is worth highlighting that certain pathogenic genes associated with breast cancer can indeed be predicted utilizing this method. In the research of Coudray et al, the predictive ability of germline BRCA mutation status, a biomarker crucial for DNA repair mechanisms and genomic stability related to breast cancer, was observed, achieving a predictive accuracy with an AUROC of 0.77 when evaluated on an exterior dataset. As a result, AI can be employed to inform treatment determinations, including the selection of targeted therapies tailored to the specific genetic aberrations identified within a patient's tumor. Furthermore, AI-driven prognostication of genetic mutations perhaps offers a cost-effective and broadly accessible alternative to conventional methodologies, which often demand substantial time investments and necessitate specialized equipment and expertise.

2.3. Predict Drug Efficacy

AI Algorithms can also be utilized to forecast the efficacy of drugs by relying on molecular characteristics. A large amount of cancer drug efficacy data produced from cell experiments provides the basis for AI analysis. By employing machine learning and deep learning techniques on data, AI can convert genomic characteristics like genetic mutations and gene expression value into assessments of drug effectiveness. As a result, artificial intelligence has the capacity to accurately

predict drug efficacy, consequently facilitating healthcare professionals in prescribing the most appropriate medications tailored to individual patient conditions. At the same time, it also avoids adverse reactions caused by taking multiple drugs. Now, many medical scientists are already studying the feasibility of AI predicting drug efficacy. One example is the study done by Iorio and colleagues. In their study, they measured how 1,001 cancer cell lines reacted to 265 different anti-cancer substances [7]. Using these results as a foundation, they developed a set of Elastic Net models designed to convert gene attributes, for example, alterations in genetic makeup and the activity of genes, into drug effectiveness (expressed as IC50 values). These models demonstrated a high level of precision in predicting drug effectiveness. Due to their blend of accuracy and interpretability, random forests are frequently employed in drug response forecasting, and studies have indicated that they enhance overall accuracy when compared to alternative machine learning techniques. This example proves the feasibility of AI algorithms for drug efficacy prediction.

3. Challenges faced by using artificial intelligence in breast cancer

Although AI has a nonnegligible help in the early screening of breast cancer, when applying artificial intelligence to breast cancer, medical scientists still have to consider the adverse effects. Today, the application of artificial intelligence still faces many moral, legal, and social challenges [8].

3.1. Data Privacy of Patient

Not only do medical researchers and healthcare institutions utilize artificial intelligence (AI) systems for the purpose of researching and diagnosing breast cancer, but some profit-driven enterprises engage in the development of AI technologies to establish new ventures within the domain of breast cancer-related businesses. Numerous prominent corporations, including Google and IBM, employ proprietary artificial intelligence systems for the purpose of devising medical insurance products and other related medical offerings about breast cancer. Since AI deep learning requires huge databases for training and correction, data from many people is used by these corporations. Therefore, ensuring patient data ownership and ensuring data security are extremely important matters. However, to develop breast cancer-related businesses, many companies use the medical data of citizens to help artificial intelligence deep learning without citizens' permission. For instance, the Italian government provided IBM Watson with anonymized health records of all 61 million Italians, without the patients' explicit approval, the company was given exclusive usage rights to all patient data, even including genetic data. Many people are concerned about the practice of trading public resources and private information for monetary benefit. What is more, the Expansion of data also enhances the possibility of data exposure. According to statistics, from 2005 to 2019, a total of 6,355 breach incidents were reported, with 3912 of them occurring exclusively within the healthcare sector [9]. This breach accident can be caused by software vulnerabilities, security failures, and human error. As a result, citizens' databases can be accessed by unauthorized users.

3.2. Legal Risk

Artificial intelligence is an emerging technology. In recent years, artificial intelligence technologies have been rapidly introduced into the medical insurance market. Therefore, the current society lacks laws to regulate artificial intelligence. Only a few courts have established standards that directly address who should bear legal liability if AI causes any negative influence. When artificial intelligence inflicts harm, safeguarding the rights and interests of consumers and patients becomes a challenging endeavor [10].

3.3. Medical moral and professional responsibility

Artificial Intelligence, especially opaque AI, has the potential to challenge established notions of professional responsibility. If the AI system becomes increasingly dependable in detecting breast cancer in the future, it perhaps potentially take over some of the responsibilities currently handled by medical doctors. For example, potentially in the future, the task of reviewing patient X-ray images

shall not remain within the purview of the physician; instead, full responsibility for the analysis shall be assumed by artificial intelligence. AI will then proceed to generate a comprehensive report for the perusal of the doctor and patients. Nevertheless, if errors occur during the course of treatment and diagnosis due to AI involvement, the ethical and legal onus subsists upon the attending physician responsible for the patient's care. In instances where medical practitioners decline to take responsibility and attribute errors to artificial intelligence, the matter of identifying the responsible party becomes considerable significance, which induces a sense of distrust among patients towards the medical facilities. At the same time, the assurance of patients' rights and interests cannot be ensured.

3.4. Atrophy of Vocational Skills

After becoming accustomed to using AI systems, medical professionals experience a gradual diminishment in certain proficiencies they have hitherto possessed. For example, if a physician excessively depends on AI for the analysis of breast imagery, he or she perhaps will lose the ability to analyze breast images over time. Furthermore, artificial intelligence will prompt medical practitioners to cast doubt on their capabilities. In instances where diagnostic outcomes produced by AI diverge from those determined by medical professionals, professionals often lean toward embracing the AI-derived results, even when they perhaps be incorrect. This phenomenon can foster cognitive biases within physicians regarding their proficiency, consequently diminishing the overall level of their professional conduct.

4. Future Development of AI

Considering the substantial contribution of artificial intelligence within the realm of breast cancer, coupled with the imperative need to address prevailing issues, the enduring advancement and adjustment of AI is necessary. The adjustment should be comprehensive, encompassing not only technological advancement but also ethical and legal dimensions of progress.

4.1. Technological advancement

While the remarkable accuracy achieved by artificial intelligence in breast cancer diagnosis is indeed noteworthy, instances of misdiagnosis persist. AI developers must persistently draw lessons from previous errors (like misdiagnosis), to refine and advance algorithms with heightened precision and efficacy. It is anticipated that, in the future, continued enhancements in algorithmic sophistication and AI image recognition capabilities will lead to further improvements in the diagnostic precision of artificial intelligence in the context of breast tumor diagnosis.

4.2. legal advancement

In light of the existing deficiencies in legislation about artificial intelligence, government, and judicial institutions must enact more comprehensive and robust regulatory frameworks concerning AI technology. These legal measures should be designed with a paramount focus on safeguarding the privacy and fundamental rights and interests of the public. Furthermore, stringent provisions must be established to curtail any potential misuse of algorithms by commercial entities, specifically in the context of analyzing individuals' private data for financial gain.

Concurrently, the legal landscape should also encompass provisions that address the repercussions of AI errors, particularly when such errors result in harm or detriment to the well-being and interests of patients. In such instances, it is imperative to institute legislation that facilitates accountability and responsibility attribution to the entities responsible for these mistakes. This would not only ensure a fair and just recourse for affected parties but also serve as a deterrent against negligence or improper use of AI systems in contexts critical to public welfare.

4.3. Data Privacy Protection

The enhancement of user privacy protection constitutes a nonnegligible concern. In the context of medical facilities and enterprises utilizing patients' personal and health data, their utilization of data must be rigorously constrained. These entail the obligation to duly apprise patients before the utilization of their data and securing their informed consent. Furthermore, a stringent commitment to transparency is imperative. The purposes and manner of data usage must be openly disclosed during the use of data. To ensure the sanctity of patient data and its exclusive application within the realm of medical requirements, rigorous measures must be implemented to forestall any misuse. What is more, it is incumbent upon medical establishments and enterprises to fortify the safety of AI systems and databases. The cardinal objective should be the prevention of data breaches and the minimization of the likelihood of unauthorized individuals gaining access to the database.

4.4. Arrangement and training of professionals

The help and challenge of AI in the traditional medical industry coexist. Therefore, hospitals should better arrange the work of medical personnel to avoid unemployment or labor waste. Before using artificial intelligence in medical facilities as a replacement for human workers, medical facilities must proactively reallocate workers' jobs. At the same time, it is also crucial to provide relevant training programs. What is more, repeated training for doctors' professional skills is also essential. When AI encounters operational issues rendering it unusable, periodic skill training allows doctors to maintain their professionalism. Consequently, this safeguard ensures the uninterrupted provision of accurate diagnosis and treatment to patients.

5. Conclusion

Nowadays, although there are many applications of AI in breast cancer diagnosis and treatment, medical technology based on AI is still pretty immature. Although many advanced AI application methods have been developed, they still have many limitations and problems. Reviewing the development of AI, it faces many ethical and legal challenges. What is more, many people and companies only want to use AI to make profits and develop medical-related commercial businesses, rather than using AI to better treat patients and save them from the torture of breast cancer. In modern society, most AI remains in theory and experiment, with very few actual clinical applications. Currently, few hospitals are using AI systems for breast cancer diagnosis and treatment. From the perspective of the stability of diagnosis and treatment, AI is completely inferior to professional breast cancer doctors. However, the advancement of artificial intelligence holds significant promise, with a notably optimistic outlook for future developments. The potential contributions of AI in the realm of healthcare, particularly in the diagnosis and treatment of breast cancer, should not be underestimated, as they have the potential to catalyze a transformative revolution. If artificial intelligence technology attains a higher level of maturity, it has the potential to significantly enhance the survival rates of individuals diagnosed with breast cancer. Consequently, after perusing this paper, the author earnestly encourages readers to contemplate the utilization and trajectory of AI development, with the aspiration of ultimately integrating AI applications into the realm of breast cancer diagnosis and treatment.

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