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A study on the application and limitations of artificial intelligence in the treatment of lung cancer

Yuhao Zhou

High School Affiliated to The University of Nottingham Ningbo China, Ningbo, Zhejiang, 315048, China

13626812388@163.com

Abstract. Lung cancer in China has the highest incidence rate and mortality rate. One reason is that it is difficult to make an early diagnosis. Artificial intelligence (AI) is a revolutionary technology rising at present. Combined with medical images and mechanical systems, it can diagnose and predict diseases through retrospective machine learning training of large sample cases. In this paper, the author studies the current application and limitations of AI in the medical treatment of lung cancer. Conclusions can be drawn that AI technology can be used for medical treatment because it has strong computing power and is more accurate than human beings. It can be used to operate some clinical operations that human beings cannot complete. Additionally, in order to achieve a comprehensive and standardized clinical application of AI in medical treatment, prospective, multi-center, and large sample studies are also needed to verify the robustness, accuracy, and generalization of the model.

Keywords: Artificial intelligence, Lung cancer, Medical robot, Semi-automatic operation

1. Introduction

With the breakthrough of image recognition, deep learning, neural network, and other key technologies, artificial intelligence ushers in a new round of great development. Artificial intelligence, also known as machine intelligence, refers to the intelligence shown by machines made by human beings. It usually refers to human intelligence technology realized by ordinary computer programs, represented by artificial neural networks, support vector machines, and convolutional neural networks [1]. In the field of clinical practice, artificial intelligence is used to diagnose, predict, and analyze various medical images, including photographs of retinal and skin lesions, pathological microscopic images, and radiological images, which can improve the comprehensive efficiency of imaging medicine in terms of diagnostic speed, accuracy, and reporting quality. Deep learning, as a subset of machine learning, is composed of multiple working layers, such as the visual cortex, and the workflow is from the initial layer to the highest layer. However, the deep learning technology used by AI can continuously improve the performance of the model to better match the actual needs, which has been widely used in research. AI combined with medical treatment belongs to the category of AI application level, which generally refers to the application of AI and related technologies in the medical field. From the perspective of transformation, AI is to transform the traditional medical industry from the perspective of productivity. Formally speaking, the application of AI in the medical field is a technological innovation. From the perspective of market impact, AI brings about an incremental market and the market space can increase with the increasing degree of intelligence. This paper enriches and supplements the relevant research materials on the development of AI in the medical field by summarising and sorting out the application and limitations of AI technology in lung cancer treatment in detail.

2. Pulmonary nodule

Pulmonary nodule is a characteristic of lung cancer. Pulmonary nodules are round-like lesions with a diameter of less than 30 mm. According to the British Thoracic Society (BTS) guidelines, pulmonary nodules can be divided into solid nodules and sub-solid nodules, while sub-solid nodules can be further divided into pure ground glass nodules (pGGN) and part-solid nodules (PSN) [2]. The pure ground glass nodule covers the bronchial structure. The density of the part solid nodule is higher than that of the background lung, but the bronchial structure is still clearly visible [3]. Lung nodules can be detected in lung cancer screening and clinical chest CT examination. Due to the promotion of low-dose chest CT lung cancer screening and the development of CT technology, the detection rate of lung nodules has been greatly improved [4].

Primary bronchogenic lung cancer can be abbreviated as lung cancer and China has always been the country that has the highest lung cancer incidence rate and mortality rate: 774,323 new cases are added annually and the number of annual death is 690,567. Although the age standardized incidence rate of lung cancer in China is similar to that in the United States, Britain, and other developed countries, the age standardized mortality rate is 1.4 times higher than that of the latter. The 5-year survival rate for all people with all types of lung cancer is only 22% [5], which is far lower than that of breast cancer and cervical cancer (the 5-year survival rates are 83.2% and 67.6% respectively). The poor survival prognosis of lung cancer patients in China is mainly due to the fact that lung cancer often has no specific clinical symptoms at the early stage, and it is difficult to make an early diagnosis. Phase I lung cancer (the early stage) accounts for only 19.0% in China, and Phase III/IV (the late stage) accounts for 64.6%. This has resulted in many problems, such as poor treatment effects, nonstandard diagnosis and treatment, and heavy economic, social, and family burden.

3. Application of AI in the treatment for lung cancer

3.1. Medical imageology

Medical imageology refers to the extraction of high-throughput quantitative features from medical images such as CT, MRI, PET CT, etc., and their analysis and further research. It can be applied to tumor diagnosis and differential diagnosis, staging and typing, gene mutation prediction, therapeutic effect prediction, and prognosis judgment. The core assumption of medical imageology is that imageology can mine a large number of quantitative features invisible to human eyes and build models. They contain biological and clinical data, which can reflect the temporal and spatial heterogeneity of tumors and provide valuable diagnostic, prognostic, or predictive information. The process of medical imageology includes data screening and acquisition, image segmentation, and feature extraction and validation of the screening model training set. In recent years, there have been many studies on imaging histology to assess the malignant risk of pulmonary nodules based on the baseline and follow-up CT [6].

Imaging histology can effectively judge the malignant risk of pulmonary nodules on the baseline chest CT [6]. Dilger et al. established a model based on the characteristics of the lung nodule itself, the surrounding lung parenchyma, and the whole lung. They found that there were 52 features that were predictive for differentiating benign and malignant lung nodules (including 8 nodule features, 39 peripheral lung parenchyma features, and 5 whole lung features). Only the characteristics of nodules were used to differentiate benign and malignant pulmonary nodules. The AUC of the model was 0.872. The performance of the model was improved after adding the peripheral lung parenchyma (AUC, 0.938) and the whole lung characteristics (AUC, 0.932) [7]. Huang et al. established an imaging histological label to identify the benign and malignant nodules less than 20 mm. The AUC of the

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model was 0.9154, the sensitivity was 0.95, and the specificity was 0.88, which was higher than the diagnostic level of three chest imaging physicians [8]. Based on the baseline chest CT, Hawkins et al. predicted the malignant risk of nodules after 1 year and 2 years of follow-up and established a prediction model using 23 imaging histologic features. The AUC of the model was 0.83 and 0.72, respectively, which was more effective than the Lung RADS score and volume [9].

3.2. Da Vinci robot

The robotic surgery system was approved for clinical use by the US Food and Drug Administration (FDA) in 2000 [10]. In 2002, Melfi FM reported the first robot-assisted pulmonary resection operation in the world. Because of its fine and minimally invasive operation, it was soon used in other medical fields, such as urology, gynecology, gastrointestinal surgery, hepatobiliary surgery, cardiothoracic surgery, and other surgical fields.

The Da Vinci robot is composed of three systems: the imaging system, the doctor's console, and the bedside mechanical arm system. It has a 3D high-resolution field of vision, which enables doctors to better judge the depth of tissue space position, and enhances the hand-eye coordination and surgical safety of the operator. The design of the console also reduces a lot of physical consumption in traditional surgery. During the operation, only one person is required to operate without the cooperation of assistants, which avoids side injury caused by the cooperation error. The machine-simulated arm system overcomes the limitation of only 5 free motion ranges of the human wrist joint and expands it to 7 motion ranges, including in and out, outward extension, inward extension, rotation, and grasping, so that the operator can perform various fine operations such as sewing, ligation, and cutting in a narrow space.

The Da Vinci robot system is the most advanced surgical machine system in the world at present. Its original design is to complete various complex operations in a more minimally invasive way. Although the system saves labor costs and changes the operation mode of surgeons washing their hands on the stage, it has high costs and long operation time are its main controversial points at present. Robotic surgery and video-assisted thoracoscopic surgery have similar rates of conversion to thoracotomy and postoperative complications, but the robot group has more advantages in lymph node dissection, intraoperative bleeding volume, and drainage volume on the first day after surgery. Therefore, it is believed that robotic surgery can be improved good prognosis, and this will be further improved with the increase of operator proficiency.

At present, the commonly used artificial intelligence research methods for lung cancer imaging are deep learning developed from machine learning technology and related imageology methods. Artificial intelligence has high value in tumor detection, efficient diagnosis, and efficacy prediction, but it is still in the early stage of development. There are limitations such as a small sample size, mainly manual or semi-automatic focus delineation and marking, and a lack of standards and norms for feature or model calculation methods. The research in lung cancer imaging needs to be further deepened.

4. Limitations of AI in the treatment of lung cancer

Machine learning is a subset of artificial intelligence. As an advanced technology in machine learning, deep learning is the most commonly used method in lung cancer imaging research. Deep learning has certain advantages. First of all, the input of deep learning is an image block containing nodules. Doctors only need to label the coordinates of nodules without segmenting the nodule themselves, which effectively reduces the workload of doctors. Besides learning the characteristics of the nodule itself, the model can also learn the characteristics around the nodule. Secondly, compared with the artificially defined texture, wavelet, shape, and other features of imageology, deep learning can automatically extract higher-order features, but it also has some limitations. Although some achievements have been made in the research of artificial intelligence for lung cancer imaging, it is still in the primary stage of development. Therefore, it is necessary to recognize the limitations and challenges of its research application.

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4.1. Small sample size

Deep learning requires a large amount of data because too little data will easily lead to the overfitting of the model. At present, the research of deep learning in malignant risk assessment of pulmonary nodules mostly uses the public data set LIDC and the screening data NLST. Although there are some studies on clinically diagnosed nodules, the amount of data is small and the accuracy is slightly lower than that of the screening population. Most studies are based on a single center and the number of cases is small, which may lead to biased research results. The relative lack of cases has also led to the use of imaging methods in most studies, rather than more intelligent deep learning or machine learning methods. Therefore, it is necessary to establish a multi-center database of large samples and carry out relevant artificial intelligence lung cancer research on this basis to obtain more objective and scientific research results.

4.2. Extensive use of automatic sketching or marking software

Due to technical reasons, in many cases, lung cancer lesions cannot be automatically drawn or marked, while manual sketching or marking and semi-automatic sketching or marking will cause repeatability problems. As there is no large sample to support deep learning training of automatic sketching or marking models, automatic sketching or marking software has not been widely used. With the development of computer technology and the establishment of a multi-center database with a large sample size, automatic sketching or marking technology will be widely proven.

4.3. Standardization and normalization of models

Research shows that there are some problems in the generalization of deep learning among people with different prevalence rates. Therefore, the model based on the training of people with a low malignancy rate (screening nodules) may not have a good generalization effect on people with a high malignancy rate (clinically diagnosed nodules). But in the real clinical field, the scene includes people with different malignant rates. Therefore, the clinical application of the deep learning lung nodule malignant risk assessment model needs to be validated in different populations. The standardization and normalization of models are at the initial stage of development. Various models and software have their own characteristics and specificity. There is a lack of standards, in other words, they are difficult to standardize and unify, which will lead to the repeatability and comparability of research results. Therefore, it is necessary for relevant research teams to cooperate as soon as possible to establish a unified standard feature computing technology and method, which is conducive to the research of imaging features and the construction of high-quality models for deep learning, machine learning, etc., in order to further achieve an efficient and accurate diagnosis and prediction of target diseases.

5. Conclusion

In this paper, the pulmonary nodule, a characteristic of lung cancer, and the current state of lung cancer in China are introduced. With the development of technology, the application of AI in the treatment of lung cancer is also studied by using medical imageology and Da Vinci robotic surgery system as examples. Finally, the author analyses the limitations of AI in the treatment of lung cancer from three perspectives, namely the sample size, the use of automatic sketching or marking software, and the standardization and normalization of models. In conclusion, AI has shown great application prospects in chest X-rays and chest CTs, but only a few fields have achieved preliminary clinical implementation and application promotion. Prospective, multi-center, and large sample studies are also needed to verify the robustness, accuracy, and generalization of the model to achieve a comprehensive and standardized clinical application of AI.

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