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Application of deep-learning based computer vision in medical image analysis

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Abstract. The analyzing process of medical image has always been a crucial part for disease detection, diagnosis, surgery assisting and drug delivery. With the outbreak of population worldwide and the constant emergence of all types of complicated diseases, doctors nowadays are facing tremendous workloads and having difficulty in making precise diagnoses or performing more assured operations. Many experts have been striving to develop a wide range of techniques based on deep learning to ease doctors' burden and improve patient's recovery process or survival chances. This general review paper will mainly focus on providing readers with a brief understanding and knowledge about deep-learning based computer vision applied in modern medical image analysis. Several academic journals or books related to computer vision applications in medical image analysis were selected for review. Despite the advantages and convenience of this technique, this review finds out that potential obstacles still exist and can be overcome or amended in the future.

Keywords: Computer Vision, Medical Image Analysis, Convolutional Neural Networks, Medical Nanorobots, Drug Delivery.

1. Introduction

Medical image analysis has long been one of the most difficult and exhausting parts of the whole diagnosis and treatment process even for experienced doctors. Over the past three decades, a variety of algorithms and modern computer-aided technology applications have been developed to assist doctors in many ways among which deep-learning based computer vision technique has been viewed as a promising and powerful tool used for data collecting, classifying and analyzing. Some potential of vision-aided techniques have currently been revealed especially in the medical image analysis aspect. This paper will present both the recent applications of this technique in three main stages of diagnosis and some drawbacks or further developing obstacles that it is facing as well as potential remedies respectively. Generally, this review selects some typical current computer vision applications in medical image analysis and explains them in a rather easily understandable way. It could be of fundamental importance for researchers to quickly grasp the current two-sided situation of this rising and revolutionary technique and may thus enlighten them on developing more comprehensive and high-precision deep-learning based computer vision applications for the medical industry.

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2. Medical image analysis powered by computer-aided diagnosis and convolutional neural networks

2.1. Current application in detecting and classifying lesion via segmentation

Computer-aided diagnosis (CAD) is a modern technique which has been widely applied in disease detection and identification before final diagnosis or surgery. It has vital significance for early-stage disease detection because normally at this stage the symptoms of some diseases might be minor or imperceptible and thus difficult for doctors to find out. For example, it can be ambiguous and not straightforward to detect early-stage melanoma, a severe type of skin cancer, even for an experienced physician [1]. This type of cancer could be fatal if not found in the early stage and has been attracting more and more attention. However, once the deep-learning based CAD is applied, the success rate of detecting and identifying this kind of skin cancer will be over 84% as stated in this paper. CAD or computer vision is able to detect and extract more detailed information such as texture features and minor color differences which could rarely be observed by human eyes. Jain and his teammate pointed out that the normally imperceptible melanoma lesion in the initial stage could be relatively efficiently detected via computer vision-based segmentation and feature extraction. Besides, a new segmentation method called Potential Field Segmentation for brain tumor detection combining several former clustering algorithms introduced by Cabria and Gondrawhich is based on a simple concept of potential field in physics has proven its effectiveness in picking out the existing tumor region [2]. In this designed model, the intensity of each pixel in the medical resonance image can be considered as a mass point which generates a mass field and the pixel is classified as one part of the tumor region if its corresponding potential field is smaller than a certain threshold. This whole process can be done within half a second with the aid of CAD and other deep-learning based algorithms which undeniably improve the efficiency of classifying and identifying early-stage diseases and thus prevent the deterioration of the patient's condition.

2.2. Medical image retrieval system assisting diagnosis

Deep-learning based computer vision applications not only serve as an efficient index technique but could also assist doctors in making more precise disease diagnoses and releasing their working stress. Recently, according to Silva, doctors have been facing tremendous workload and pressure which could cause a lot of fatigue or even unintentional diagnostic errors which may do harm to their patients [3]. Two main techniques have been developed to tackle this problem. One of them is the Medical Image Retrieval (MIR) System, which can act as an effective classifier and locator for medical records with aspect to specific image analysis, diagnosis or relevant treatment method. With the support of Local Binary Pattern together with the local data analysis component, the classification and locating accuracy of this MIR system could reach approximately 99.86% within a fairly short period of time [4]. This would save the doctors a huge amount of time and vigor during the process of similar disease case diagnosis and therefore improve efficiency and accuracy. The other technique is deep-learning based algorithm such as computer vision. In particular, deep neural network model such as Convolutional Neural Network System (CNNS) is generally superior to conventional machine learning algorithms for medical image analysis which are excessively dependent on doctor-crafted structural features [5]. As mentioned in this paper, the CNNS can be provided with raw data and then it will automatically learn from the training sets and find useful patterns. Also, individual situation could vary among each patient and diagnosis could also differ from expert to expert which indicate that traditional diagnostic methods may not be sufficient enough to cope with this kind of problem. Convolutional Neural Network System, however, is not only able to precisely categorize and extract vital characteristics in medical picture analysis to assist doctors' diagnosis but also build models to predict patients' future health situation in case any long-term treatment plans need to be changed.

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2.3. Vision-based nanorobots establishing image during surgery and realizing targeted drug delivery

Modern Imaging-Navigated Surgery and targeted drug delivery are heavily reliant upon deep-learning based computer vision combined with surgical robots or nanorobots. It is reported that over 90% of prostate cancer tumor removal surgeries in America have been operated by surgical nanorobots powered by computer vision technology up to now. The well-known fourth-generation surgical robot Da Vinci could offer clear 3D visualization of the real-time condition within the lesion and therefore enable doctors to smoothly perform every complicated action such as grasping, stitching or resecting within the patient's body in a non-invasive way during the whole process of a surgery which consequently greatly reduces the damage of the surgery to the patient and difficulty of some operations [6]. Compared to passive low-efficiency drug delivery method, computer-vision based nanorobots are able to swim freely in the narrow blood vessels of the human body, locate the targeted regions and deliver an appropriate and precise amount of medicine which could otherwise hardly be achieved due to human estimation error [7]. After the nanorobots obtain the real-time information and features of the injured parts which are simultaneously presented on the computer screen, doctors can control them to release certain dosages of medicine remotely. Despite the convenience of this technology, there could still be problems with regard to the targeted drug delivery process in real life. For instance, sometimes blood vessels in human bodies might contain bubbles or impurities which become obstacles for the nanorobots. A recent research team found an approach to tackle this problem in some ways, they first enhanced the resolution rate of the impurity detection system within the nanorobots and then chose to use magnetic nanorobots to realize automatic obstacle avoidance and ideal route planning inside more complex blood vessel environments [7].

2.4. Further developing obstacles and remedies

While countless vision-based techniques used for medical image analysis have emerged over the past two decades, there still exist some obstacles and some possible remedies. For instance, during the process of medical image acquisition and analysis, both positioning features of the research points and other characteristics that are used to distinguish them from other points are needed. However, these two requirements actually conflict with each other. The potential compensation is to apply a trade-off with respect to the analysis window size and enhance the resolution ratio of the obtained features by adding more diverse information about the image [8]. In spite of the high efficiency and accurate segmentation rate of CNNS, it is hard for this technique to fully explore its potential because of the strict availability restriction on data that belongs to patients' private medical records. In addition, many medical experts nowadays are reluctant to share their personal huge amount of image analysis or treatment methods data which worsens the situation to some extent [9]. Therefore, in a gesture to take full advantage of deep-learning based computer vision in the medical graphics analysis area, it is vital for all parties to become more willing to share relevant useful data in the future.

3. Conclusion

In conclusion, through selecting relevant content from previous academic journals about computer vision applications in the medical industry, this review mainly presents that deep-learning based computer vision technique applications could be of crucial importance in detecting abnormality via segmentation, assisting doctors in making a more efficient and precious diagnosis, form clear image during surgery and realize accurate targeted drug delivery. Evidently, it cannot be denied that many applications based on this technique have partly released doctors' working burden and provided a certain guarantee for patient's safe and rapid recovery. Despite the effectiveness of this technique, steps still need to be taken and joint efforts are still required to perfect it and explore its potential to a greater extent in order to wrestle with more complicated obstacles it may encounter in the future. Due to the limitation of space and depth of the content, this review only gives a brief and comprehensible insight into deep-learning based computer vision applications, particularly in the medical image analysis aspect. More instances with vivid graphic demonstrations and data could be gathered and explained here if given more writing space.

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