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The Essence of the surgical navigation system using artificial intelligence and augmented reality

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Abstract - *Artificial intelligence is the technology which is now being applied to medicine to assist the doctors for detecting diseases and performing diagnosis and surgery on their patients, this technology promotes the drastic development in field of precision in giving medicine and doing precised surgery. Here it is shown that surgical navigation system based on the AI and AR is explored by lighting onto the future treatments of patients via image processing techniques and with the use of the special instruments, which will be tracked by the navigation system and gets displayed onto the screen. In the near future, the surgical navigation system is going to be based on the artificial and augmented reality which will smartly and intelligently assist doctors to perform the operations and achieve the goal of the minimum risks in surgery and also operating on patient in doctor's absence.*

Key Words: **Artificial intelligence, augmented reality, surgical navigation system, minimally invasive surgery**

1. INTRODUCTION

Artificial intelligence (AI) is a branch of computer science. It attempts to understand the essence of intelligence and to produce a new intelligence machine which can respond in a similar way with human intelligence. In this field, the research includes robots, language recognition, image recognition, natural language processing and expert systems. AI is proposed in 1956 at the conference of Machine Simulated Intelligence (MAI) and it has been developed rapidly and gradually applied in medical field. AI in medicine can provide the complete and effective information for doctors, thus providing a scientific and reliable basis for the diagnosis and treatment of disease. It can greatly improve the automation of the measurement and analysis of medical data, thus greatly improving the speed of work, reducing the intensity of human work and the subjective arbitrariness. With the increase of patient cases, it can not only enrich the systematic knowledge, but also accumulate and analyze the knowledge automatically or under the artificial intervention to improve the medical level. In a word, AI can be applied in medicine to discover rules from large-scale medical history data, thus providing decision support for future disease prevention and control.

In recent years, AI plays an increasingly important role in medical field, and its application in medicine has reached an unprecedented height and scale. Many people are eagerly hoping that the artificial intelligence can replace the doctors to diagnose diseases and do highly intelligent computation that the human brain can not do. Here, the highly intelligent computation is that the artificial intelligence can choose the best treatment scheme based on the big data. At present, the application of artificial intelligence in medical field can be roughly divided into the following four aspects: medical robot, medical imaging, clinical assistant diagnosis and treatment options, drug research and development.

With the gradual popularization of the deep learning algorithm, the artificial intelligence diagnosis technology has achieved unprecedented accuracy by building deep learning neuron mathematical model, finding rules from the massive data of the medical image diagnosis, learning and imitating doctor's diagnosis technology. However, the application of the artificial intelligence in medical diagnosis has just started in China, and many artificial intelligence techniques need to be improved in clinical application.

The emergence of computer-aided surgery system has changed the traditional surgical mode. With the wide application of artificial intelligence in medicine, the computer aided surgery system based on artificial intelligence becomes a new research and a hot topic in clinical application. The concept of artificial intelligence assisted surgical system starts from the concept of remote field surgery which is developed by NASA from 1985 to 1990 in America. The emergence of the first generation of Da Vinci surgery assistant system in 1997 accelerates the development of artificial intelligence assistant surgery system. Artificial intelligence assisted surgery system can increase the accuracy of surgery,

reduce trauma, blood loss and the difficulty of nursing, avoid complications, save medical resources and so on. In China, the application and discussion of the artificial intelligence assisted surgery system appears late, and the most common one is the Da Vinci-assisted surgical system which is purchased abroad. Because of the high purchase cost and some defects of the system itself, it is urgent to develop and popularize artificial intelligence assistant surgery system.

2. THE PROSPECT OF SURGICAL NAVIGATION SYSTEM BASED ON AI AND AR

Conventional surgery is difficult to meet the needs of mod-ern delicate surgery. With the rapid development of modern medical imaging technology and medical robot technology, the surgical navigation system come into being. Surgical navigation system can accurately correspond the preoperative or intraoperative medical image with the anatomical structure of the patient. During the operation, the surgical instrument is tracked and the position of the surgical instrument is displayed in real time in the form of a virtual probe on the image of patient, so that the doctor can see clearly the position of the surgical instrument relative to the anatomical structure of the patient. The surgical navigation system can make the surgery faster, more precise and safer. In order to reduce the surgical trauma, shorten the operation time and improve the quality of surgery, computer aided surgery navigation system is gradually applied in clinical practice. The structure of the human body is firstly reconstructed by the system according to CT or MRI images before the operation. Then the real structure of the surgical area and the location needed in the operation can be determined by the surgeon according to the system. Finally the surgeon can be guided to operate through a motion analysis system of the system. In recent years, with the development of artificial intelligence technology, the artificial intelligence technology can be introduced into the computer-aided surgery navigation system. The computer aided surgery navigation system based on artificial intelligence is a hot research topic and the future development trend.

The procedure of general surgical navigation, as shown in Fig.1:

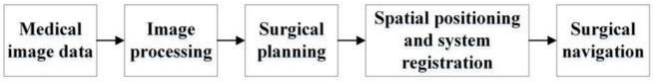

Fig. 1: The procedure of general surgical navigation.

Image data acquisition: Most surgical navigation systems require three-dimensional MRI or CT images of the pre-operation. The quality and the thickness of images in the process of these images acquisition affect the accuracy of the subsequent image reconstruction. If the acquisition time is too long, patients will motion during the images acquisition, which may lead to the anatomical structure of an image is inconsistent with the adjacent image. Even though it is imperceptible to the naked eye, it is very obvious on the three-dimensional reconstruction image, especially at the position of the sudden changes in anatomical structure. At present, the continuous development of medical imaging technology has laid the foundation for high-precision 3D reconstruction. At the same time, with the popularization of DICOM 3.0 and PACS, the acquisition, transmission and storage of the medical images are guaranteed.

Image processing: Fast and high-precision three-dimensional image processing system is an important prerequisite for the implementation of surgical navigation system, which involves image segmentation, image registration, three-dimensional reconstruction, image display and other image processing technology, and the accuracy of the image processing of each part has a direct impact on the performance of the system.

Surgical planning: According to the anatomical structure of the patient after image processing, the lesion area can be determined, the surgical route can be selected and the optimal surgical planning scheme can be made.

Spatial positioning and system registration: In order to correlate the preoperative three-dimensional visual images with the position of the surgical machinery and the actual surgical site of the patient, the spatial positioning and the system registration are needed. The spatial positioning is the real-time measurement of the position and attitude of surgical instruments through the equipment, so as to get real-time display in the computer. The preoperative three-dimensional visualization image is established in a spatial coordinate sys-tem, and the real-time location of the surgical area and surgical instruments is established in another coordinate system. The registration of the system is the process of registration of two different spatial coordinate systems with the coordinate system of the surgical site of patient.

Surgical navigation: In this part, the augmented reality (AR) technology is applied. AR is a technology that computes the position and angle of the camera image in real time and adds the corresponding image to it. The goal of this technology is to overlay the virtual

world on the screen and interact with it. When a doctor wears AR glasses, the patient immediately becomes a transparent person, and the parts of the patient that need to be operated on become clear, which makes the efficiency and success of the operation improved. During surgery, the patients three-dimensional images which include the preoperative planning are projected into the real field of vision and are precisely matched with the real vision. Even if the surgeon or patient moves during surgery, the virtual images also will be overlap with the real field of vision precisely. So that the surgeon is able to quickly and accurately locate the position of the patient, determine the angle and depth of the operation that needs to be performed.

In general computer aided surgery navigation system, surgery planning requires doctors to diagnose the lesion area based on experience and relevant medical knowledge and to plan the surgical plan for treatment. The doctor's planned surgical route will be displayed on a three-dimensional visualized image, then the patient will be operated on by a surgeon according to the follow-up surgical navigation. If the artificial intelligence is applied to surgery navigation, a large number of patient data and the knowledge and experience provided by experts can be collected, so that the computer can learn the medical knowledge of expert doctors, simulate the doctor's thinking and diagnosis reasoning, which can give the doctors reliable diagnosis results and surgical planning scheme. When one patient need surgery, the computer aided surgery system based on artificial intelligence not only can give the diagnosis results of patients' diseases, but also for the disease that needs surgery, it can will also give the best surgical plan to assist doctors to find the best surgical plan. With the help of AI and AR technology, the computer aided surgical navigation system will be transformed into a doctor's assistant.

In the future, the surgical navigation systems based on artificial intelligence and augmented reality technology can be used in neurosurgery, spinal surgery, laparoscopic surgery and plastic surgery. Artificial intelligence can diagnose disease for patient and provide the best treatment for patients by learning a lot of information about patients and the information provided by doctors, which help doctors to better diagnose the disease and operate on the patient, thus speeding up the development of minimally invasive surgery.

3. CONCLUSIONS

With the development of artificial intelligence, it has attracted more and more attention in the field of medical and health, especially in surgery. However, there are still some problems in the current surgical navigation system, such as the lack of consideration of tissue deformation, the inaccuracy of 3D reconstruction, the disparity between the image display effect and the real scene, the immaturity of spatial location registration technology and so on. Therefore, the development and application of surgical navigation system based on artificial intelligence needs the cooperation of medical and health workers and computer experts to develop more accurate and intelligent applications, provide doctors with more accurate diagnosis and treatment assistance, and bring higher quality medical services for patients.

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