The Application of Intelligent Control in Clinical Medicine

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Abstract. Since the emergence of intelligent control, it has continuously developed and been applied to various fields, which has also greatly promoted the progress of clinical medicine and solved some difficult problems in clinical work. The development of intelligent control pushes the emergence and development of new technologies and new industries. It promotes a new wave of information technology, which continuously penetrates medicine. Intelligent control plays an increasingly important role, and its application in medical field is an inevitable trend. This article mainly gives examples of intelligent control in some clinical departments.

1 Introduction

In recent years, with the rapid development of artificial intelligence and robotic technology, the development of intelligent control has been greatly promoted.

Intelligent control is an important research area of artificial intelligence and automatic control. It is regarded as the top level of automatic control of autonomous machine hierarchy.

Various expert controls have been applied to various intelligent robots, such as intelligent decision-making, learning control, neural control, fuzzy control, fault diagnosis, intelligent planning and autonomous visual control.

Intelligent control reflects the development trend of modern automatic control which has covered the whole science and technology. It is the inevitable result of history.

Intelligent control has become a new milestone of automatic control development. It is developing into an increasingly mature control method and gradually being widely used.

Since the 1970s, this technology has been successfully applied in the medical field. The research on intelligent control in the medical field has been emerging largely. Some intelligent control technologies have been fully applied in the clinical work, which has brought security and convenience to the medical treatment. Of course, many of them are not perfect enough, so further exploration is necessary.

2 Definition of intelligent control

Intelligent control is a new and interdisciplinary subject developed on the basis of artificial intelligence and automatic control. Through qualitative and quantitative methods, it can effectively and autonomously realize the processing of complex information and the decision-making and control function of optimization in view of the complexity and uncertainty of environment and task.

3 Application of intelligent control in clinical medicine

3.1 Surgery

Intelligent control is widely used in surgery, especially in bone and joint rehabilitation. According to the data from the second national survey of disabled people, the total number of disabled people in China is 82.96 million, of which 24.12 million are physically disabled and 2.26 million have amputations. Intelligent control opened the door to a wide range of possibilities for these people [1].

Since the invention of electromyography in 1948, it has been widely used in China and abroad. The principle is that the residual muscle has its control signal source, which is used for identification processing and amplification, making it a myoelectric control signal to control the movements of the fake hand.

In recent years, the development of prosthetics has become more and more perfect. It even has developed the ability to record limb temperature while transmitting visual and tactile stimuli, make temporary responses, as well as record related biological signals that may be affected by illusions. Users can feel the irritation of rubber hands, just like their own hands.

A new type of intelligent knee joint structure is designed using the similarity of hydraulic damping property and knee joint damping torque. According to the principle of speed adaptive control in the oscillating airflow, the damping adjustment of the knee joint of the

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intelligent hydraulic prosthesis is used to realize the function of the hydraulic knee joint controlled by the microprocessor, so as to achieve the effect closer to the physical knee joint movement.

There are also studies on applying intelligent control system to wheelchair, which contains three components: intelligent control unit, engine and environment recognition sensor. It is based on the reality of virtual reality technology, the environment scene reconstruction and display on the screen, the use of a preset polar grid to determine a set of destinations.

The user selects the destination through the p300-based BCI, and then the system automatically navigates to the destination as long as the target is locked [2]. As shown in figure 1, it is a brain based on electroencephalogram (EEG)-computer interface diagram. It allows people with disabilities to interact with the external environment without relying on peripheral muscles and nervous systems. By using target recognition technology and automatic navigation technology, automatic control technology is combined with brain-computer system to build a dynamic system driven by goals. Specifically, the target recognition module identifies and locates the target in the online environment. The user selects the target directly through the BCI system to identify and locate a target. The automatic navigation module guides the wheelchair to the specified destination. The system can deal with dynamic environment and the process of target approximation is simple and straightforward.

In addition, specific destinations are often accompanied by navigation tasks, for example getting close to a desk. In order to get something, a wheelchair is equipped with a lightweight robot arm as an additional actuator. On the basis of the result of target recognition, the nature of the target, the current condition and other factors of the target are considered comprehensively, so a more reasonable scheme is designed.

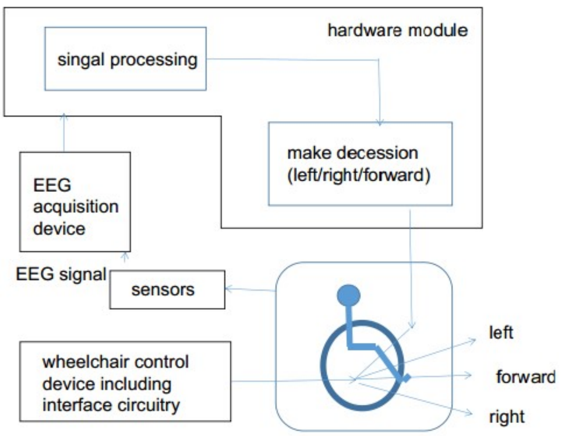

Figure 1

Urolithiasis is one of the ommon diseases in human beings. The prevalence rate of urinary calculi is 10-15% at present, and it has an upward trend. Urology is greatly affected by technology. On the fragmentation, all types of stones can be treated by laser which has become the standard technique for urolithiasis. By improving the technique of the sighting glasses and high-resolution imaging and enhancing the robustness of the laser fibers, it continuously improves the laser characteristics. The accuracy and safety of patients are greatly improved. However, the pulses release of high-energy laser in the upper urinary tract is controlled by surgeons alone. Only the surgeon's control from visual feedback can prevent tissue damage. There is no automatic feedback control in this process. Therefore, the use of high energy sources in the upper urinary tract can cause serious damage. Misalignment of the fibrous tip or accidental activation of the laser system can easily lead to serious complications, such as tissue burns and even urethral perforations or kidney tissue damage. The automatic target recognition and feedback control of intelligent laser system can be used in removing of kidney stones and ureteral calculi by monitoring the spectrum information. The release of energy in the process of ureteroscopy treatment could be controlled by the condition of the laser pulse and not allowing destructive energy release. It receives satisfactory effect and greatly improves the safety of patients and surgical precision. [3] Ureteroscopy under the intelligent pressure control in the treatment of urinary stones has also made considerable curative effect [4]. Traditional ureteroscopy (URS) is easy to cause high pressure of the renal pelvis and has higher possibility of liquid absorption into the bloodstream. Bacteria and bacterial endotoxin absorption can lead to systemic complications. Long-term complications include inflammatory response syndrome (SIRS), sepsis, renal pelvic and ureteral tumor proliferation and renal function damage. [5] The clinical research of endourological society ureteroscopy is a global study. Intelligent pressure control during inhalation ureteroscope is a flexible URS suction system, including perfusion platform and UAS for the treatment of upper urinary stones and automatic control of alveolus. From November 2013 to August 2015, 40 cases of upper urinary calculi were treated with this technique with good results. Based on irrigation suction theory, combined with pressure sensor and pressure feedback technology, the device USES self-designed intelligent pressure control device includes medical irrigation water and irrigation platform with pressure control to monitor and control intraoperative RPP. The ureteral approach sheath (UAS) can be delivered to the target site under flexible ureteroscope monitoring to avoid injury. Its special design allows the continuous suction of the liquid to regulate RPP, which can be used to extract small gravel particles for reference through the sheath gap. Another channel of the UAS is connected to the pressure monitoring and feedback platform to realize monitoring and automation of the function pressure-feedback regulation RPP.

3.2 Internal medicine

The application of intelligent control is more and more extensive in the field of internal medicine. Traditional chemotherapy drugs usually spread rapidly in the body in non-specific ways, resulting in poor efficacy and severe systemic toxicity. The remote control of anti-cancer chemotherapy is emerging [6]. The well-designed nanometer carrier can response to the changes of PH value, enzyme, oxidation reduction, internal or external stimulation reaction, and then trigger on-demand release of drugs to enhance anticancer effect. Many stimulate responses are established on the basis of these stimuli, between extracellular and intracellular area of the cells. REDOX systems, for example, respond to higher REDOX concentrations in the cytoplasm to trigger drug release. PH-sensitive vectors are often released as needed, by detecting differences in extracellular PH values. Inflammation is closely related to diseases such as cancer, AIDS and psychosis. Effectively-integrated approaches remain a research area of patient feedback control. Ouassim Bara et al. proposed the model-free feedback control could be the treatment of acute inflammation. They applied the mathematical model and functional feedback control to the study of acute inflammatory response. Traditional calculus equations for identifying various rate need a sufficient number of detailed data, especially a lot of research objects. The scale is very difficult. There are no model feedback control system to overcome these shortcomings, because there many factors will be involved from patients to environment, at the same time there are a variety of diseases and personal characteristics, etc. [7] Oxygen therapy has become standard care for chronic obstructive pulmonary disease (COPD) and other hypoxic chronic lung diseases. Supplemental oxygen is also widely used in intensive care patients and during transportation prior to admission. The purpose of oxygen therapy is to maintain adequate oxygenation while avoiding hypoxemia. [8] However, although supplementation of oxygen is valuable in many clinical situations, inappropriate supplementation of oxygen is harmful. Some studies have found that compared with traditional operation, oxygen treatment with physiological closed loop control spends less time under target saturation and saves oxygen resources. [9] Congenital central ventilation deficiency syndrome, characterized by insensitivity to hypercapnia and hypoxemia during sleep. The treatment is long-term ventilation. However, due to differences in respiratory control at different sleep stages, especially in children, nocturnal ventilation can change significantly. This usually leads to higher pressure settings in the first half of the night when non-rem sleep dominates, compared to the later half when rem sleep dominates. Abdullah Khayat et al. found that volume-controlled intelligent pressure support mode had two-stage positive airway pressure ventilation mode, which could be intelligently adjusted to ensure continuous alveolar ventilation. Whether hypercapnia control is more effective than simple positive airway pressure ventilation in spontaneous/timing (t/t) mode, and night control of CO_2 levels is more effective.

3.3 Anesthesiology

Target controlled infusion (TCI) is one of the best examples of intelligent control applied in anesthesia. Since it was first introduced in 1979, it has been developing and applied more and more widely. TCI systems are available in more than 90 countries, with more than 60,000 units sold each year. It is used to deliver product-based intravenous injections and anesthesia to millions of patients worldwide. It has become a mature technology in 30 years since it was proposed. [10]

TCI refers to the infusion of intravenous anesthetics based on pharmacokinetics and pharmacodynamics. The computer can calculate the amount of drug production in central nervous system tissue during infusion, and then adjust the infusion speed to maintain the stable concentration in plasma or target tissue (usually the brain). The computer takes advantage of the best models in the literature and computes the mathematical complexity of patient characteristics (weight, height, age, sex, and additional biomarkers). [11] TCI system can be divided into two kinds of works, closed loop and open loop modes, according to the preset program given. In the closed loop, the plasma drug concentration or the indicators such as blood pressure and heart rate variation obtained through real-time monitoring were fed back to the program module, and then the administration speed was adjusted automatically to meet the real-time need of anesthesia depth during the operation.

Syue et al. have invented t2 - solfc which is a kind of fuzzy controller. According to the rules of its control performance, this system generates and modifies its base adaptive fuction, using an amount of fuzzy uncertainty and the real surgical data to construct and capture the anesthesia composed by single factor in the process of adjusting the variability in the physiological parameters of patients. The adaptive control includes the types of reasoning and the control rules. Input values are taken from the patient's anesthetic model output, which minus the set point of the modulated parameters. These input values are integrating data of blood pressure and BIS to control the patient's anesthesia depth. According to the change of propofol infusion rate, the system outputs control signal. Based on the integration of output value, it promotes the real-time adjustment of narcotic drugs. The controller output is converted to real value, and the output zoom element is used to send to the patient anesthesia model. The output of the patient model was compared with the set point of blood pressure and BIS to calculate the input control signal, and then fed back to adjust the infusion rate.

3.4 Others

In cataract phacoemulsification surgery, excessive ultrasound energy is one of the main causes of corneal endothelial cell damage. Therefore, under the premise of ensuring the effect of cataract phacoemulsification, how to shorten the operation time, reduce energy intensity, and improve the safety and utilization rate of energy has become a concern. [12] The ultrasonic energy intelligent control is realized by multimode intelligent controller. The digital signal processing chip is used in the controller hardware. The intelligent cataract phacoemulsification system is composed of multi-mode intelligent controller, intelligent identification system and phacoemulsification hardware [13, 14].

It has a vital role on normal blood dialysis to maintain stable temperature and quickly reach a stable state. Hemodialysis machine temperature control system has obvious nonlinear and large time delay characteristics. The traditional PID method is difficult to realize effective control fast. What' more, the affected factors are relatively more, and it is difficult to establish accurate mathematical model. In the control process, the intelligent control USES simulates the ability of human's control behavior to identify and make use of the information feature. It is provided by the dynamic process of the control system to the maximum extent for inspiration and intuitive reasoning, so as to control the complex object. Shen Lin put forwarded intelligent PID control method which was applied to hemodialysis machine temperature control system, and temperature control system transfer function model is established. The hemodialysis machine temperature control system has good stability, and it can well restrain big lag. The effects of time-varying, hemodialysis machine temperature control system will not be big overshoot. [15, 16] of course, there are many examples of the application of intelligent control in clinical work, and the development continues. It is impossible to list them all in this paper.

4 Summary and outlook

The development of intelligent control pushes the emergence and development of new technologies and new industries. It promotes a new wave of information technology, which continuously penetrates medicine. Intelligent control plays an increasingly important role, and its application in medical field is an inevitable trend. Although a lot of technology is not mature and widely used at present, the exploration of intelligent control will certainly puts glorious greatly in the future.

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