Tumor - assisted robots

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Abstract

At present, liver cancer has become a major threat to human health risks. However, patients with hepatectomy can only undergo a surgical resection of only 20% of the patients. As a modern minimally invasive treatment of liver cancer, surgical treatment of hepatectomy with general hepatectomy surgery does not have the treatment effect is good, minimally invasive, short recovery time, etc., for most patients with liver cancer. Its development prospects are very optimistic, the United States, France, Germany, Italy, Japan and other countries of the academic community to give a great help, research work flourished. However, precise needle insertion requires precise hand-eye coordination and is also affected by RF needle navigation. In this paper, we propose a tumor needle-assisted robot system, which is guided by gesture through the enhancement of practical techniques based on the field of surgery.The research and design of the robot in this subject is based on Pro / E software. Through the design calculation, the three-dimensional modeling and the force analysis, the complete design of the robot system, and to ensure the design of reasonable and reliable. The experimental results show that the gesture guidance can effectively guide the surgical robot and establish the robot aids to improve the accuracy of needle insertion. This mechanism of human and robot cooperation is a very promising method for precise percutaneous ablation.

Keywords

Pinning method; Assisted Robot; Pro / E.

1. Introduction

The world each year more than 60 million patients with liver cancer, of which half in China, China's high risk of liver cancer has more than 100 million people. Liver cancer patients can be surgical resection of patients accounted for only 20% of clinical. As a modern minimally invasive treatment of liver cancer, surgical treatment of hepatectomy with general hepatectomy surgery does not have the treatment effect is good, minimally invasive, short recovery time, etc., for most patients with liver cancer. Robot-assisted acupuncture surgery for the treatment of hepatocellular carcinoma is a kind of robot-assisted surgical technique, which can better treat patients with hepatocellular carcinoma and have important application significance in the development of the corresponding surgical structure.

Several multinational companies in the United States, Japan, Germany and other countries are developing digital medical equipment, and many molded products have been sold on a global market. Compared with foreign countries, China's medical robot research is still in its infancy, the robot function is relatively simple, able to perform fewer types of surgery. Therefore, it is of great practical significance to develop the surgical system with independent intellectual property rights and develop our own medical robots and digital medical equipment industry to improve the quality of life of the people and promote the development of medical undertakings in our country.

However, the current robot does not have automatic puncture function, in order to reduce the impact of factors and experience factors to reduce the intensity of the doctor fatigue, the development of medical puncture robot automatic needle into the body has a very important significance.

2. Mechanism design

2.1 Determination of the overall program

Tumor Penetration Assisted Robot is the needle to the liver of the human body, and then the appropriate angle to the liver tumor location, to achieve the process of surgical treatment. In the design process, put forward two kinds of ideas, one is made in series form of the robot, one is made in parallel robot form.

Parallel Mechansim (PM), which can be defined as a closed platform with two or more degrees of freedom, which is connected by at least two independent kinematic chains, and a closed platform driven in parallel mechanism[1].

(Serial mechanism, referred to as SM), the current series of robot research is more mature, with a simple structure, low cost, simple control, sports space and other advantages, has been successfully applied in many fields, a variety of machine tool assembly workshop[1].

Parallel robot research is a late start compared with serial robot, and there are still many theoretical problems unsolved. The parallel robot has the following characteristics: (1) no accumulated error, high precision; (2) the driving device can be placed on or near the fixed platform fixed platform position, this movement part of light weight, high speed, good dynamic response; (3) the advantages of compact structure, high rigidity, large bearing capacity; (4) parallel mechanism completely symmetrical has good isotropy; (5) smaller working space; because the parallel robot has high rigidity bearing ability and high precision end pieces of small inertia high speed and large capacity applications compared with serial robot has the advantage of many successful application cases than delta robot motion simulator. In the course design, the tumor puncturing auxiliary robot belongs to a small robot, and it should have high flexibility, wide range of application and strong applicability.

2.2 Main design technical requirement and performance index

According to the above overall design of the robot, get the main design technical requirements are as follows:

(1) joint length should be moderate (controlled at 300m), can achieve a certain range of surgery within the movement;

(2) joint material to light, easy to clean and disinfect, flexible and convenient;

(3) into the needle length (200mm), can adapt to different patients, into the needle speed is low, into the needle smooth;

(4) the body space is small, the needle position precision is millimeter level;

(5) institutions used in the operating room environment;

(6) the overall kinematic index of the intervention of the robot.

Determination of performance indicators:

From the above general design of the robot, you can know that the robot needs four degrees of freedom (two degrees of freedom, two degrees of freedom)[2].

Atmospheric pressure of 1.03 × 105Pa, after hospital research, needle processing of the tumor using the syringe needle diameter of 0.5mm. (1) can be roughly calculated:

$$F=PS=(0.5\div 2\div 1000)2\times 1.03\times 105\times 3.14=0.02N \quad (1)$$

With the smaller resistance of the muscle, the force of the syringe entering the liver is much smaller than 5N. The feed rate given by the hospital is maximum 2mm/s. The needle feeding requires steady speed and the position can be controlled. At this point, the performance indicators required for robot design are shown in table.1:

Table.1 robot performance index

DOF	Injection stroke	Needle insertion force	Needle speed
4	200mm	<<5N	<2mm/s

2.3 Material selection

Tumor needle-assisted robots have a special application environment, the choice of institutional materials must be based on interventional surgery. In the operation must consider the strength of the device stiffness to meet certain requirements, in addition to the operating room to be frequently disinfected, so the choice of materials must have corrosion resistance[3]. After the comprehensive consideration, the choice of the more common aluminum alloy on the market, aluminum alloy is the most widely used in a class of non-ferrous metal structure materials, in the aviation, aerospace, automotive, machinery manufacturing, ship and chemical industry has been a large number of applications. The rapid development of industrial economy, the demand for aluminum alloy welded structure is increasing, so that the welding of aluminum alloy also will be in-depth. Aluminum alloy is the industry's most widely used non-ferrous metal materials, with low density, high strength, close to or more than high-quality steel, plastic good, easy to disinfect and so on[4].

3. Introduction to the overall structure

The tumor needle-assisted robot uses four similar parts. The needle insertion mechanism is connected by a motor through a coupling, the lead screw is driven by the screw, and the syringe is fixed to the slide, and the process is guided by a linear guide shaft. Wherein the fixed end and the support end are fixed on the frame type frame, which is rigidly connected with the shaft by bolts and connects the rotating motor through the coupling to provide a rotational degree of freedom, the motor is fixed on the motor rack, Forked parts. The second part consists of motor, coupling, shaft, bearing, cover and several plates. The motor is fixed on a vertical plate connected to the base plate and is connected to the designed shaft by means of a coupling and the shaft is bolted to the forked part to provide a degree of freedom of rotation in the other direction. The third part consists of motor, coupling, screw, linear guide shaft, support end, fixed end, bearing, lock nut, cover and several boards. The motor is fixed on a vertical plate connected to the base plate and is connected by means of a coupling and a lead screw. The screw drive drives a slide with a special structure to move in a straight line so that the second part fixed to the slide moves along a straight line, For the needle into the body to provide a direction of freedom of movement. The fourth and third components are substantially the same, providing the mechanism with freedom of movement in the other direction and secured to the base by bolts. The four part of the assembly as shown in figure.1.

Through the assembly package can be seen, the overall design of the robot can be divided into three parts to design: two-dimensional feed platform structure design, two-dimensional needle posture adjustment rotation structure design and needle into the body design, the following specific description of three Parts of the design.

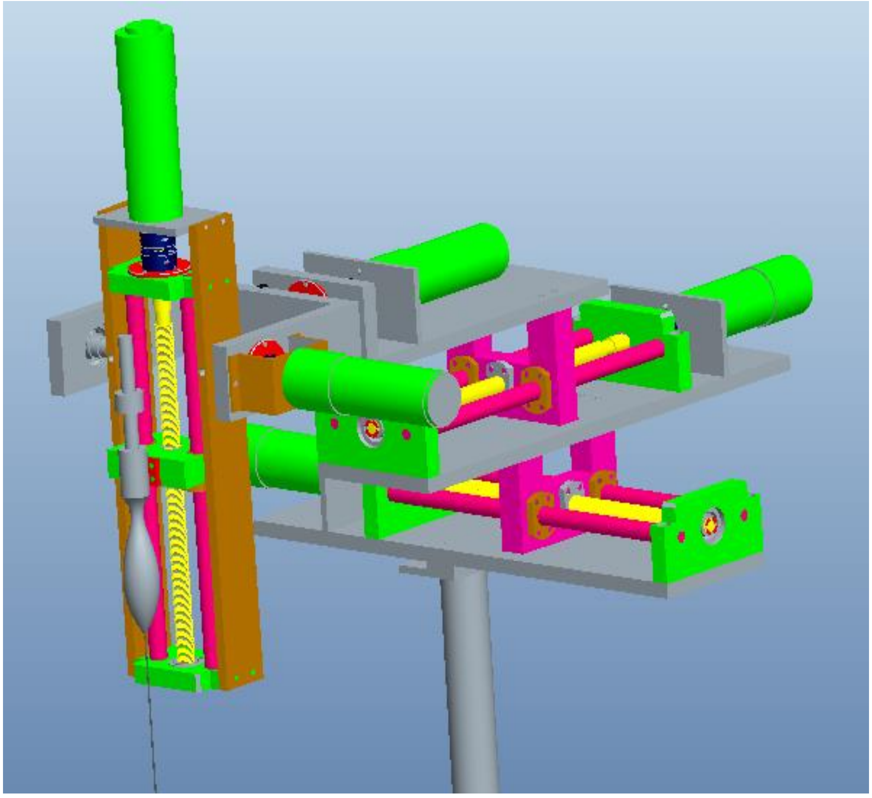

Figure.1 total assembly 3D drawing

4. Conclusion

This paper designs the robot assisted tumor needle, needle mechanism design of robot movement and the end of each joint, and check the key parts. For the work of the paper, below to do some summary. The main work of this paper is summarized as follows:

1. According to the actual requirements of tumor surgery, to discuss the robot design.

2. For the use of the requirements of the robot structure design, including the two directions of freedom of movement, the two directions of the degree of freedom of rotation, and a needle into the body, where the degree of freedom are through the ball screw drive, and its advantages Is: the movement is reliable and stable, the adjustment of the height of the robot is relatively high accuracy.

3. Using Pro / E software to carry out solid modeling of tumor needle-assisted robot. And then the key parts of the stiffness check to ensure that the design of reasonable and reliable. Finally, according to the obtained three-dimensional modeling of the robot and integrated design requirements using AUTOCAD get the drawing.

To sum up, the main innovation of this paper has the following two points:

1, proposed a four-degree-of-freedom liver tumor needle-assisted robot program;

2, designed the specific structure of this robot, and carried out three-dimensional modeling.

In the future, we will need further research.

1, further optimization of the robot body design;

2, the kinematics and kinetic analysis of the needle - assisted robot designed in this paper are carried out.

3, the design of the tumor needle-assisted robot for the control system design.

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