System Development of an Artificial Assistant Suit

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Abstract: The artificial assistant suit is a kind of assistant suit which can be put on the human upper body and help the actions of human's two arms. It is actuated by Mckibben pneumatic artificial muscles (simply call it Mckibben muscles later). This paper introduces the whole system and its structure. The configuration of the Mckibben muscles is discussed. The measurement and control system is introduced in detail. The electropneumatic valve's characteristics are analyzed. The detection of the motion intention of human arms by SEMG signals is discussed too.

Keywords: Artificial assistant suit, Mckibben muscle, electropneumatic valve, SEMG signal.

1. Introduction

The McKibben muscle has advantages such as small size, safe and compliance, great power/weight ratio. And it is simply constructed, easy-fixed, and cheap. Its force-length characteristic is similar to that of the biological muscle. Mainly it is used in robots. The robot joint actuated by it behaves a little like humen's or anminal's because of its similarity to the biological muscle. The robot actuated by McKibben muscles is much safer to human who interacts with it. Therefore, the McKibben muscle is a kind of very promising actuator in human recuperate field [1].

The world should be welfare. Developments of the robot capable of assisting elders, handicappeds, and patients are one of the main directions. Developing the devices capable of help getting well for patients is one of the main tasks of the modern technology. It's expectant for the McKibben muscle to play an important role in these fields. In some places such as Japan, china, America, and Europe, the artificial assisted suit made of McKibben muscles has come out. The suit is called as "dressable robot"[2]. Besides, the bipedal robot actuated by McKibben muscles has been developed. But to all of the developed artificial suit, Their structure is very complicated, and their weights are very large. Here what we are developing is a very light one, and its cost is very low.

2. Structure of the artificial assistant suit

To help the human arms act correctly, the Mckibben muscle actuators must be configured reasonably. Only one piece of the Mckibben muscle can't complete all the actions, because that the structure of the human arm is complicated and its actions are many and varied. Therefore, many pieces of the Mckibben muscles are required and they need to operate coordinately to achieve the required force. Based on the above analysis, we resolve the arm actions into the following basic ones：

①Shoulder's rising up and down (including to the front, to the back, and to the side)；

②Shoulder's swinging around the vertical axis；

③Elbow's bending and stretching；

④The forearm's rotating around the anatomic axis.

We think that all of the main arm actions can be realized based on the above four basic actions. The configuration of the Mckibben muscles can be done based on the requirement of the four basic actions. Let's analyze the anatomic structure of the human arm firstly. There are more than 20 pieces of muscles with the actions of both the shoulder joint and the elbow joint in the same arm[3]. All the actions of the shoulder and the elbow can be realized by these muscles' operating coordinately. Based on both the analysis to the anatomic structure and the dynamic requirement for the artificial assistant suit, 8 pieces of the Mckibben muscles are selected for the configuration of each arm of the suit, shown in Fig.1. They are corresponding to the functions of the following 8 muscles:

① Triceps brachii
② Brachioradialis
③ Biceps brachii short head
④ Biceps brachii long head
⑤ Deltoid anterior part
⑥ Deltoid middle part 1
⑦ Deltoid posterior part
⑧ Deltoid middle part 2

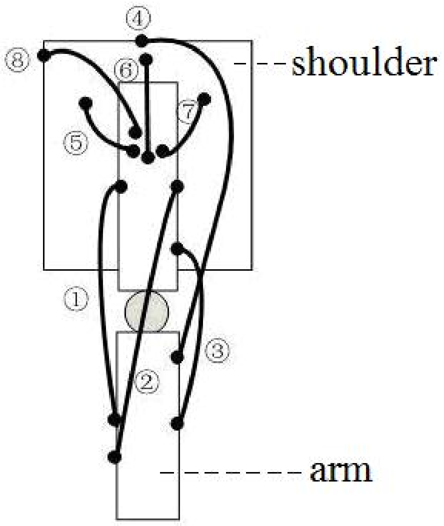

Fig.1 Configuration of the Mckibben mucles

3. Measurement and control system

The main characteristics of the artificial assistant suit are that it can sense the action intention of human arms and output forces to help the arm actions. To get the action intention of human arms exactly, the system uses both the SEMG signals and the gravity acceleration sensors to judge the action intention. Therefore the whole system should include at least the following parts:

① The compressor
② The electropneumatic volves
③ The artificial assistant suit actuated by pieces of Mckibben muscles
④ The SEMG signal detection device
⑤ The computer

The whole system is shown in Fig.2.

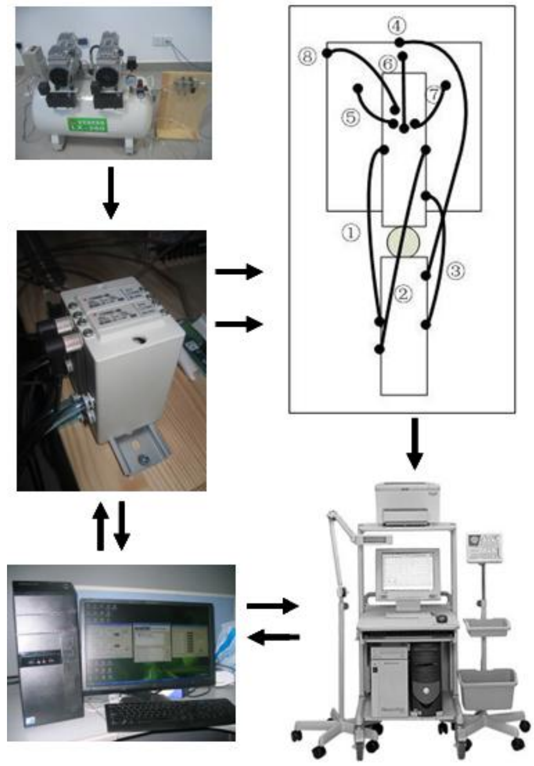

Fig.2 The whole system

The compressor is the source of the pressed gas. The Mckibben muscle needs pressed gas. Here the air is used. The electropneumatic valve is used to regulate the pressure of the air so that the Mckibben muscles can be input by the needed pressure of air. The SEMG signal device is used to detect the arm action by the SEMG signal of the arm. The computer is used as the center of measurement and control, which can control the electropneumatic valves to output the desired pressure of the air and sample the SEMG signals.

The compressor is a un-oil′s, the air from it must be passed through the air filter, the oil separator and the pressure-reducing valve, because that the air input into the electropneumatic valve have to be dry and pure. Otherwise the electropneumatic valve is easy to be damaged. The highest pressure of air must be lower than the highest pressure that the electropneumatic valve permits.

The electropneumatic valve in the system is made by SMC, Japan. The model is ITV0050-2ML. The permitted gas pressure varies from 0.1MPa-0.9MPa. So the highest output gas pressure of the compressor should be less than 0.9MPa. Its specification is DC24V/0.12A. So the max consumed power is 2.88W. The system has 16 valves. The whole power needed is 46.08W than which the source power of the electropneumatic valves should be larger. So we choice NES-200-24 made by Mingwei power source company as the electric power, shown in Fig.3. It can output 200W/24V, which can satisfy the requirement of the 16 valves. And the valve requires the input signal is DC0-5V. Its input impedance is about 10kΩ. Therefore, the max input power of the signal is about 2.5mW. The total input power of the signal is about 40mW. So the provided power from the signal input unit is larger than 40mW. Otherwise the voltage the valve got will be less than the required.

To satisfy the route number and the requirement for the input signal, The I/O card is selected as PCI-1724U which is 14-bit and has 32-channels' analog output, shown in Fig.4. Its output signal is DC0-10V. The required input signal voltage is 0-5V

Fig.3 The Power source (NES-200-24)

Fig.4 The I/O card (PCI-1724U)

To PCI-724U, the output current is 10mV, and if its output voltage is DC0-5V, the output power is 50mW. Fig.5 shows that the power requirement of the two valves can be satisfied by the I/O card.

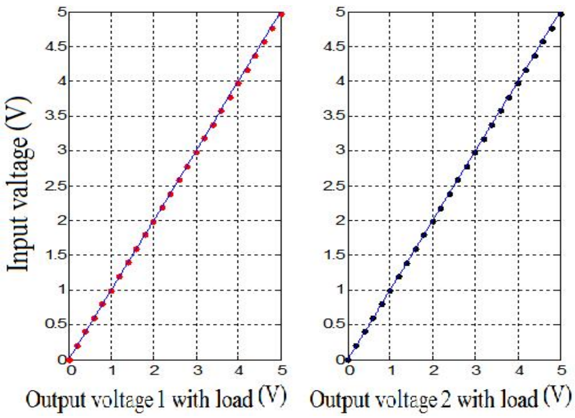

Fig.5 The voltage characteristics with loads

Fig 6 shows the good linearity of the electropenumatic valve. And Fig.6 indicates that the top voltage 5v is corresponds to the top pressure 0.9MPa. The highest pressure of air is 0.67MPa because that the compressor only provides the pressure 0.67MPa. It shows that the pressure gets its highest 0.67MPa when the input voltage is 3.8v. Therefore the input voltage 0-5v corresponds to the output pressure 0-0.9MPa instead of 0-0.67MPa.

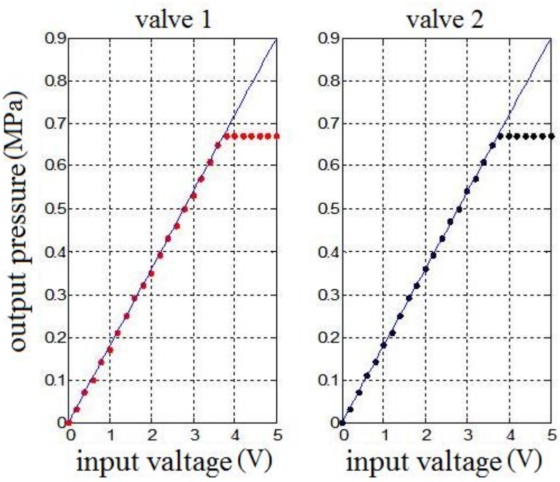

Fig.6 The linearity of the valve

The SEMG signal is used to detect the action intention because it can inform the muscle contraction[4]. We put six pairs of the SEMG signal electrodes on the arm, shown in Fig.7, which are used to detect the action intention of the related muscles. After analyzing, the computer can judge the action intention of the arm by the electrode distribution. A neural network is used to analyze the relationship between the SEMG signals and the action intention.

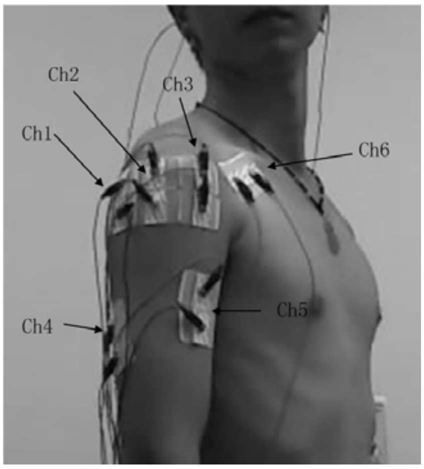

Fig.7 The distribution of the SEMG electrodes

4. conclusion

This paper introduced the whole system including the configuration of the Mckibben muscles in the artificial assistant suit, the integration of the system hardware, and the detection method of action intention of human arms. Of course some research still hasn't been finished including the software and the final experiments.

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