ME425 · Sensing Technology

Thesis Proposal

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1 Introduction

Blackground overview

Tracheal intubatuib(usually called intubation) is a operation to put the tract tube into the tracheal by passing the upper respiratory tract. It can keep the patient's airway unobstructed. In general anesthesia surgery, paitents lost consious and can't breath themself. Tracheal intubatuib becomes the principal method to to build the artifical breath channel which can maintain the breath of paitents. Under normal circumstances, anesthetist is responsible for inserting the intubation tube from the mouth into the trachea.However, the patients with poor airway evaluation result need to be intubated through the nasal cavity. If the operation failed serval times or in emergency situations, anesthetist will cut off the cricothyroid cartilage to expose trachea, and to the tracheal tubu through the wound. If failed over three times, the tracheal spasm will caused. The difficulty of intubation increases exponentially, which may delaying the time of ventilation and causing suffocation. At this time, a more professional anestheists are required to continue the tracheal intubatuib.

Significance and difficulties

We want to reduce the work burden of the anestheists. According to the reseaches, the current number of anestheists in China is 76,000 and the number of hospitals (including private hospitals) is 34,534. There is currently a shortage of 300,000 professional anestheists. Many departments share an anestheist and the hard work burden leads the death of them. And Down' s children, patients with facial tumors, with natural throat exposed, are difficult to successfully insert the tracheal tube. They need a efficient method. About the patients with loose tongue muscles or obesity, the tongue tends to droop and block the throat. Patients with poor grades of difficult airways cannot insert a laryngoscope during intubation.

Methodological Design

The key of endotracheal intubation lies in the positioning and control of the end. In the aspect of localization, this project plans to use the magnetic dipole to locate the terminal. In the aspect of control, the pneumatic muscle can achieve this goal well.

2 Design

The robot consists of two parts. One is the expander part, is responsible for extenting tracheal. Another is the locator part, is responsible for locating the location in tracheal.

Expander part

Pneumatic muscle

Figure 1 shows the structure of the pneumatic muscle. As valve pumping out the air in the muscle, it be compressed, and the support be compressed. As the air be pumping into the muscle, it be stretched, and extend the support part. We will use silicone injection molding or 3D printing to print the muscle. When it be compressed, the length of it should no longer than π cm, which is the size for opration with these special patient allowed. As it be stretched, the length of it should no less than 2π cm.

Figure 1: muscle structure

Support

As show in Figure 2, this part include four TPU cylinders with length of 40 cm and diameter of 3 *mm*. The part is responsible for enlarging the passage from the mouth to the trachea, which can make sure the tracheal tube can be put into tracheal correctly, and take out the locator part.

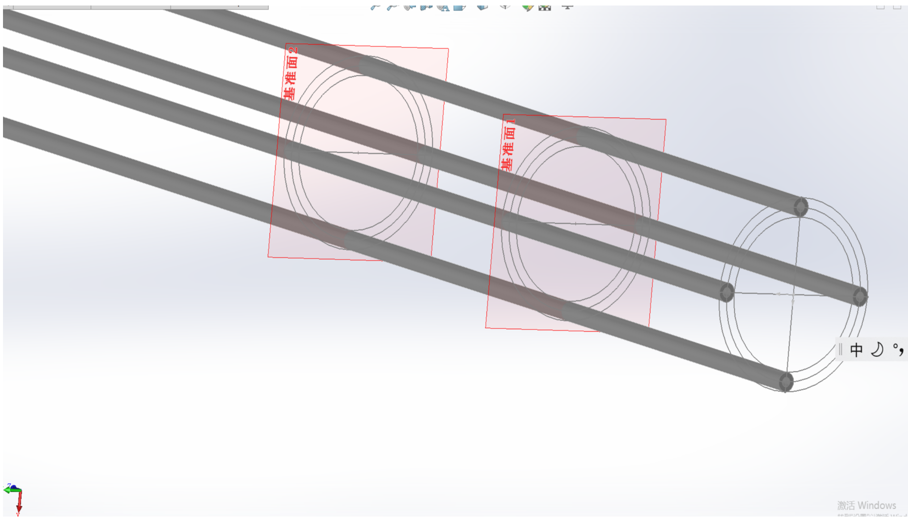

Figure 2: support part to enlarge the tracheal

Locator part

Mathematical Model

As shown in Figure 3, the system uses three-axis generating coils and the 3-axis sensor coils, which are along with the related electronic circuitry. The signals from the three-axis generating coils can be detected by the three-axis sensor coils by using time-sharing or frequency-coupling methods. By defining the

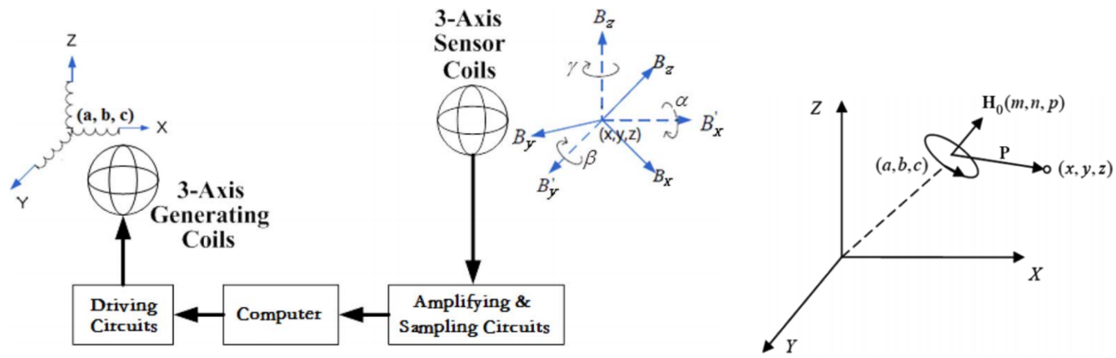

Figure 3: mathematical model of electronic dipole

coordinate frame, the position of the three-axis generating coils can be defined by (a, b, c); the position and orientation of the three-axis sensor coils can be defined by $(x, y, z, \alpha, \beta, \gamma)$, where (x, y, z) is the center position of the sensor coils and (α, β, γ) represents the rotation angle of the sensor coils with respect to the global coordinate frame.

And after a series of mathematical and physical deductions, finally we reach this.

$$x = \pm \frac{\sqrt{B_1^2/B_T^2 - B^2/(6B_T^2)}}{\sqrt{3}[B^2/(6B_T^2)]^{\frac{2}{3}}}$$

$$y = \pm \frac{\sqrt{B_2^2/B_T^2 - B^2/(6B_T^2)}}{\sqrt{3}[B^2/(6B_T^2)]^{\frac{2}{3}}}$$

$$z = \pm \frac{\sqrt{B_3^2/B_T^2 - B^2/(6B_T^2)}}{\sqrt{3}[B^2/(6B_T^2)]^{\frac{2}{3}}}$$

Where M_T is a constant defining the magnetic intensity of the dipole, and

$$B_T = \mu_r \mu_0 M_T / 4\pi$$

$$B = \frac{6B_T^2}{R^6}$$

$$R = \sqrt{(x-a)^2 + (y-b)^2 + (z-c)^2}$$

Structure Design

In order to achieve this goal, we designed a positioning shuttle and a set of receivers.

As shown in Figure 4 the khaki-colored part is a shuttle-shaped main body made of engineering plastics, used for coil support. The body is wound with a two-dimensional coil to position the shuttle from two dimensions (the third dimension is controlled by the depth of the tube insertion).

An optical camera can be mounted on the front of the positioning shuttle, with a speculum function.

When working, the positioning shuttle sends out signals, and four external positioning coils receive signals, and the positioning is completed by reference to the algorithm mentioned above.

After positioning, the system finds the trachea by controlling the pneumatic muscles of the expanded part to move in a direction.

Schedule

Figure 5 shows the schedule of out project.

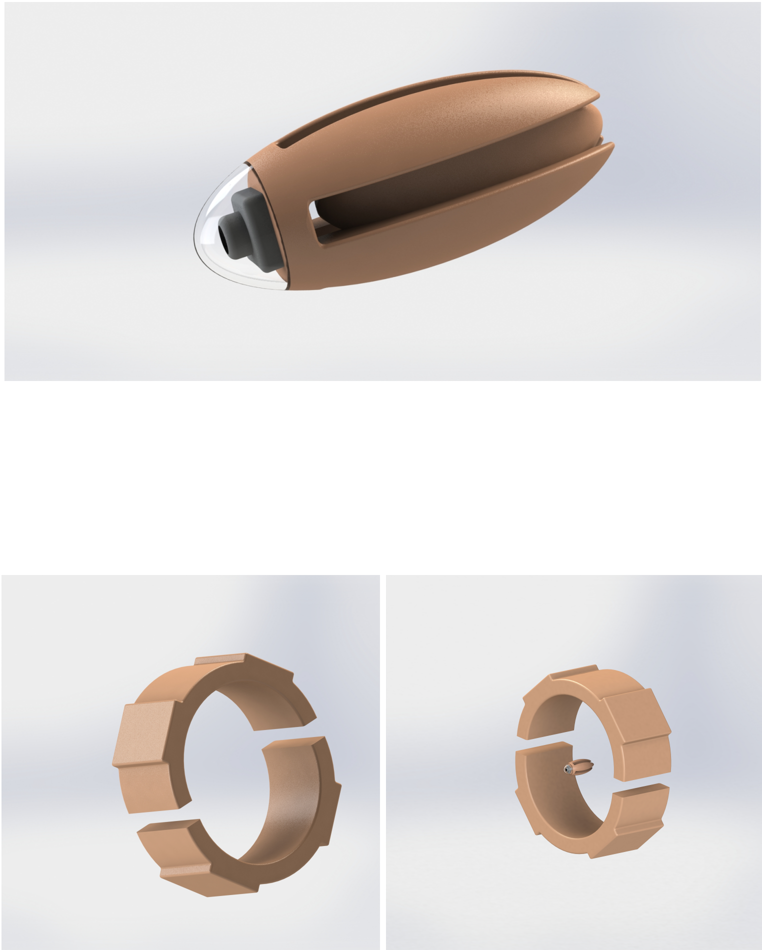

Figure 4: Structure design of locator part

Figure 5: schedule of project

References

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