Computer graphics in medicine

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ABSTRACT

In the article, the main difficulties that surgeons face when performing laparoscopy are Limited camera field of view , the fact that the monitor reflects a mirror image of the real movements of surgical instruments, tactile effects (force feedback) of surgical seals are significantly reduced due to the distance from the end of the instruments to the hands of the surgeon, The fact that surgical instruments most of all rotate around a fixed point, which makes movement difficult.

Keywords: graphics, laparoscopy, Filtering and segmentation, Algorithms and methods

Introduction

Computer graphics is playing a growing role in adding value to a wide range of medical applications. Today, medical professionals use a variety of imaging techniques for diagnostic purposes, and these techniques represent a rich source of data for further processing using computer graphics. Surgical training simulators are very important equipment for the surgical resident who needs to practice complex procedures. One procedure that is very often performed in advance, but is very complicated and can lead to serious problems if performed incorrectly, is laparoscopy. This allows the surgeon to perform delicate operations with small surgical instruments by operating the instruments while viewing the video screen.

One of the most common laparoscopic procedures is cholecystectomy (removal of the gallbladder). The gallbladder is attached to the liver and stores bile, which aids in digestion. When gallstones form between the gallbladder and the bile duct (where bile enters the intestines), it can cause serious problems that require surgery. One of the most difficult parts of cholangiography is the examination of the cystic duct before surgery by inserting a small catheter directly into the duct.

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1. Limited camera field of view;
2. the fact that the monitor reflects a mirror image of the real movements of surgical instruments;
3. tactile effects (force feedback) of surgical seals are significantly reduced due to the distance from the end of the instruments to the hands of the surgeon;
4. The fact that surgical instruments most of all rotate around a fixed point, which makes movement difficult.

One of the urgent tasks of the application of information technologies is the modeling of the human heart. The relevance of this topic is caused by two main factors. The first of these is the extreme importance of the problem of cardiovascular diseases. According to statistics, they confidently hold the first place among the causes of death and disability of the population. The second factor is the widespread introduction of information technologies, when modeling and analysis of the functioning of individual systems have become the norm today. And as the history of science shows, at least since the middle of the last century, very often breakthroughs occur precisely when working at the junction of various industries. Many scientists and entire branches of science have successfully developed the subject of the heart, individual aspects of its activity, but often quite isolated from each other. The current level of development of information technology, modeling and visualization allows you to use these developments for research purposes, training and diagnostics.

Algorithms and methods

This section discusses some of the main algorithms and methods for imaging medical volumes. The section is divided into four parts. First, it describes the filtering and segmentation steps that act as pre-processing of medical image data before applying the imaging technique. Secondly, the main approaches to the visualization of volumetric data in medicine are discussed.

It then provides an overview of the main techniques used to combine two or more image modalities of the same patient - often referred to as image merging or registration 3D images. Finally, it summarizes the algorithms used for soft tissue modeling, an important component of the medical virtual environment.

Filtering and segmentation

Images received from a scanner will inevitably contain noise. Many filtering methods have been proposed to remove noise, usually smoothing by replacing the value in each voxel with some averaging over the local neighborhood. However, in medical applications, this smoothing can blur the boundaries of anatomical features. The best approach to medical data is to use an anisotropic diffusion method, where image intensity values are repeated. to the equilibrium state controlled by the partial differential equation of anisotropic diffusion. The diffusion function depends on the magnitude of the intensity gradient, and therefore diffusion occurs within regions where the gradient is small, and not across the boundaries of regions where the magnitude of the gradient is high. This approach was first proposed by Perona and Malik and now widely used. It was applied to MRI data in Gehrig's seminal paper, and the algorithm is included in many software libraries, providing a robust means of image enhancement. For example, it has recently proved successful when applied to ultrasonic data, which typically contains speckle noise.

The next step is to apply a segmentation algorithm to identify the different parts of the anatomy of particular interest. This will label the voxels with an ID indicating the material type. Usually this process remains semi-automatic and a user manual is required for correct identification. Indeed, segmentation is often a major bottleneck in clinical applications - it is time consuming and results are often difficult to reproduce due to user involvement. Segmentation is an important area of research supported by a significant body of literature and only a very brief overview is provided here. A typical strategy is to use simple methods first, and if unsuccessful, look for more complex ones. Perhaps the simplest method is thresholding, in which the image is split according to the intensity of the pixels. A single threshold will divide the image into two classes: pixels above and below the threshold intensity, making it a useful technique, for example, in applications where two different tissue classes are present (eg, malignant and non-malignant).

Volume visualization

A simple approach to visualizing a volume is to render a series of slices that are parallel to one of the volume's faces, or oblique. This is often referred to as multiplanar reformation and is perhaps the most popular imaging modality in clinical practice. Radiologists are trained to navigate slices and recognize branching patterns in the process. Their experience in moving through 2D slices in this way allows them to build a 3D mental model of the actual anatomy. One difficulty with this approach is that branching structures of interest, such as blood vessels, are not planar and therefore difficult to track. Recently, the idea has come up to use a planar transformation of curvilinear structures, which represents a "curved" slice following the ship's trajectory. Note, however, that this requires prior identification of the vessel's center line, and therefore significant effort is required to generate CPR imaging.

Although MPR is widely used in practice, there are situations where the 3D image provides the radiologist with valuable information - for example, when patients have unusual or complex anatomy or pathology. This has sparked a very active area of research among computer scientists to develop fast and efficient ways to represent 3D medical imaging. This is the subject of the remainder of this section, which assumes that the data is presented in the form of a three-dimensional volume, more specifically, a rectilinear grid of voxels.

Soft tissue modeling

The goal of soft tissue modeling is to model the behavior of tissues. This is required in a variety of applications, including surgical simulators for training, intraoperative deformity simulation, and surgical planning. In general, soft tissue modeling algorithms can be divided into geometric or physical ones. In geometric modeling, the shape of an object is adjusted by changing the position of some control points or by adjusting the parameters of an implicit function that defines the shape.

A typical example of such a technique is free-form deformations, in which an object is embedded in a lattice of a simple shape. Lattice deformation causes subsequent deformation of the object. These methods are often fast, but the deformation of an object is done indirectly and may have little or nothing to do with the physically plausible deformation. Recent research has focused on improving user interaction with objects to allow direct manipulation.

Conclusion

So, the role and importance of computer graphics in medicine is currently considered to be very large. The use of video screens in the delicate operations of the surgeon brings great relief. This section discusses some of the main algorithms and methods for imaging medical volumes.

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