Virtual Dissection System of Cadaver Heart Using 3-Dimensional Image

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Abstract

For medical students and doctors, knowledge of the 3-dimensional (3D) structure of the heart is very important in diagnosis and treatment of the heart diseases. 2-dimensional (2D) tools (e.g. anatomy book) or classical 3D tools (e.g. plastic model) are not sufficient for understanding the complex structures of the heart. Moreover, it is not always guaranteed to dissect the heart of cadaver when it is necessary. To overcome this problem, virtual dissection systems of the heart have been developed. But these systems are not satisfactory since they are made of radiographs; they are not true 3D images; they can not be used to dissect freely; or they can only be operated on the workstation. It is also necessary to make the dissection systems incorporating the various races and tribes because of the organ's difference according to race and tribe.

This study was intended to make the 3D image of the heart from a Korean cadaver, and to establish a virtual dissection system of the heart with a personal computer.

The procedures for manufacturing this system were as follows.

1. The heart from a Korean adult cadaver was embedded with gelatin solution, and serially cross-sectioned at 1mm-thickness on a meat slicer. Pictures for 153 cross-sectioned specimens were inputted into the computer using a digital camera (756 ×504 resolution, true color).

2. The alignment system was established by means of the language of IDL, and applied to align 2D images of the heart. In each of 2D images, closed curves lining clean and dirty blood pathways were drawn manually on the CorelDRAW program.

3. Using the language of IDL, the 3D image and the virtual dissection system of the heart were constructed.

The virtual dissection system of the heart allowed for free rotation, any-directional sectioning, and selected visualization of the heart's structure. This system is expected to become more advanced, and to be used widely through Internet or CD-title as an educational tool for medical students and doctors.

Keywords:

Dissection; Cadaver; Heart; Three-Dimensional

Introduction

The heart is a vital organ, without which we can not survive. Heart disease is one of the leading causes of death. For the purposes of accurate diagnosis and treatment of the heart disease, it is essential for medical students and doctors to understand the anatomical structure of the heart. However, a 3-dimensional (3D) structure of the heart is so complex that it is impossible to get accurate knowledge from the anatomy books [1]. As a classical method, medical students study anatomy by dissecting a cadaver. But, dissection of a cadaver is not always guaranteed even for a medical person, and it is almost impossible for a non-medical person. A plastic model of the human organ is being widely used. But it is not detailed, and it does not permit free dissection.

Due to the popularization of the multimedia computer, a lot of anatomy software has been developed. However, most anatomy software includes only 2-dimensional (2D) images which do not permit free rotation and free dissection. To overcome this problem, virtual dissection systems including 3D images have been developed [2-6]. Most of these systems are made of radiographs [7,8]. Radiograph is not as realistic as sectioned cadaver because radiograph does not reveal true color and has a limit of resolution. The 3D image based on the sectioned cadaver is thought to be more realistic than that based on the radiograph. Many virtual dissection systems are operated on the workstation. It would be more desirable to operate on the personal computer which is popular world-wide [9].

The shape and size of the organ is different according to race and tribe. Therefore, it is necessary to make the dissection system incorporating the various races and tribes.

We attempted to manufacture a virtual dissection system on a personal computer using a 3D image of the heart from a Korean cadaver. The purpose of this study was to develop an educational tool for those interested in the anatomy of the heart.

Materials and Methods

The heart extracted from a 71-year-old Korean female cadaver was used. For the serial section, the heart was embedded with gelatin solution (8gm%), and frozen. After removing the embedding box, a heart block was acquired. The heart block was serially cross-sectioned using a meat slicer (HFS-330L, FUJEE™) at 1 mm-thickness. As a result, 153 serially-sectioned specimens were obtained.

Each specimen was inputted into the computer using a digital camera (DC40, KODAK™) with 754×504 resolution and true color. The color, brightness, and contrast of inputted images were corrected to appear natural on the PhotoEnhancer program (version 1.7) accompanied by the digital camera.

In this study, 2D images were not aligned properly. To correct this problem, an alignment system was required (Figure 1).

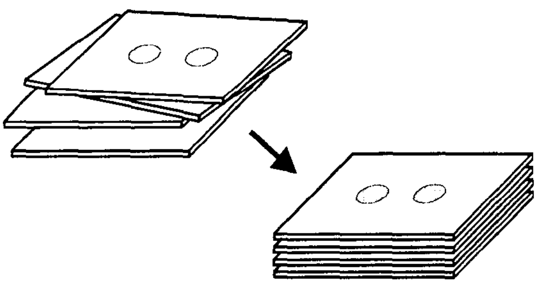

Figure 1 - Necessity of the alignment system

The alignment system was established by means of the language of IDL (version 5.0 for windows). The alignment system operated as follows: If two neighboring sections were selected, both outlines would be represented. While the left section remained stationary, the right section would move and rotate with the panel. Accuracy of alignment could be immediately verified by the two vertical planes (Figure 2).

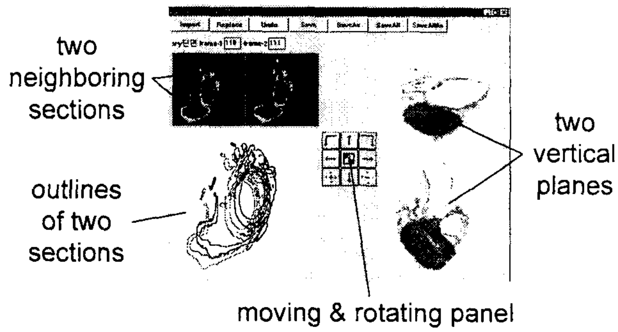

Figure 2 - Alignment system

Segmentation of the heart was performed on the principle that there were two pathways in the heart according to the partial pressure of oxygen. Clean blood pathway included pulmonary vein, left atrium, left ventricle, aorta, and coronary artery, while dirty blood pathway included vena cava, cardiac vein, right atrium, right ventricle, and pulmonary artery. In each of the 2D images, closed curves lining clean and dirty blood pathways were drawn manually on the CorelDRAW program (version 6.0) (Figure 3).

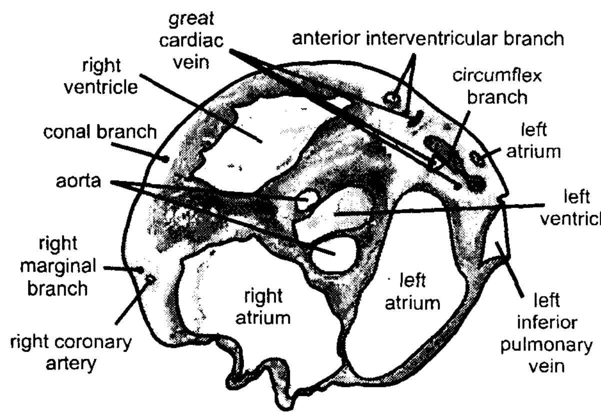

Figure 3 - Segmentation of components of the heart

After stacking the 153 images, a 3D image of the whole heart as well as the clean and dirty blood pathways were reconstructed by volume-based rendering. For the 3D effect, shading was added.

Using the 3D image, a virtual dissection system was established by means of the language of IDL. We named this system VIRDI HEART as an abbreviation of virtual dissection system of the heart. VIRDI HEART was composed of three windows. According to the commands in the command window, a 3D image was represented in the view window. Then, depending on the sectional direction in the view window, the sectional plane was represented in the slice window (Figure 4).

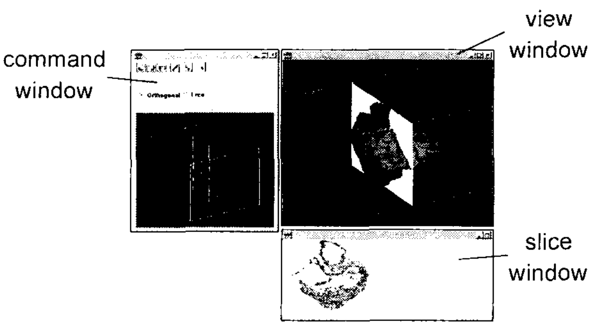

Figure 4 - VIRDI HEART (=virtual dissection system of the heart)

Results and Discussion

The alignment system developed in this study is expected to be applied to various fields of morphology. For example, this system can be used to align the serially-sectioned microscopic specimens for making a 3D image of the microscopic structure.

VIRDI HEART could rotate a 3D image of the heart (Figure 5).

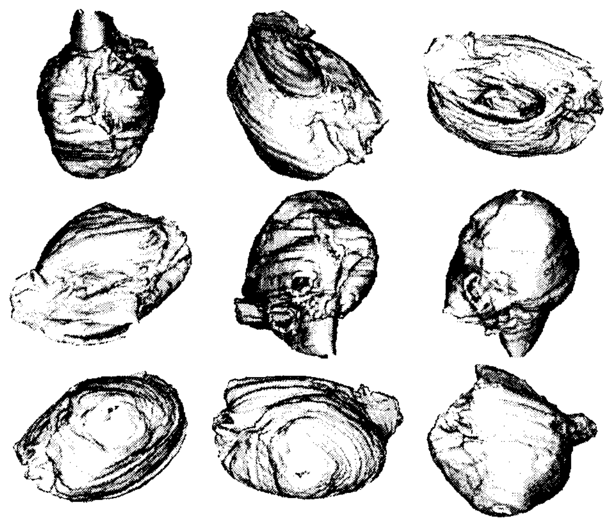

Figure 5 - Various views of the heart

The sectional direction could be placed orthogonally (horizontally, sagittally, coronally) or at any angle. And close-up view for any selected plane was possible. Figure 6 shows a free-angle section of the heart, and its plane (Figure 6).

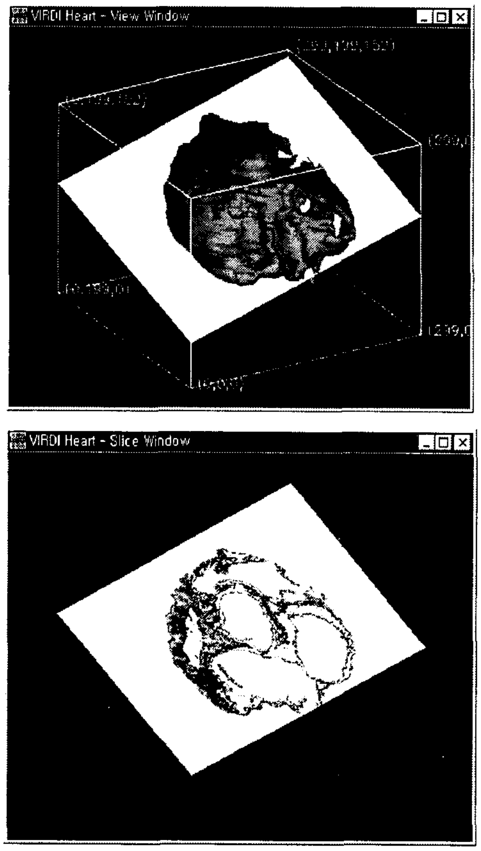

Figure 6 - Free-angle section of the heart (top), and its plane (bottom)

Three-dimensional image of clean and dirty blood pathways could be shown and rotated on VIRDI HEART (Figure 7).

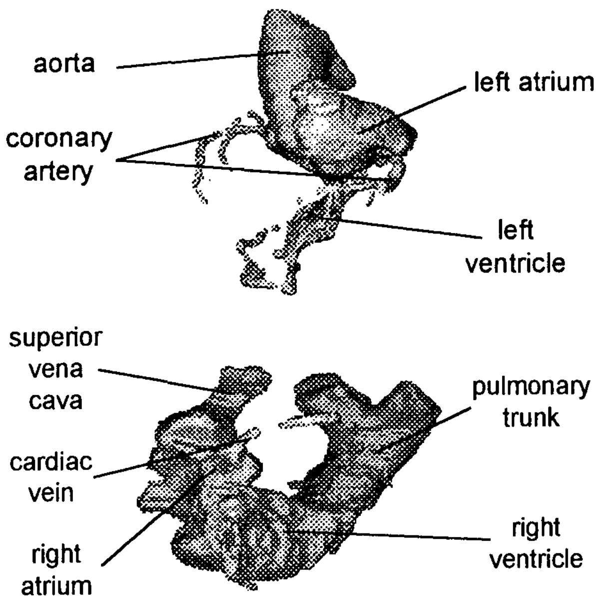

Figure 7 - Three-dimensional structures of clean (top) and dirty (bottom) blood pathways of the heart

VIRDI HEART will be further improved for the following aspects: first, raising resolution of the image; second, more segmenting components of the heart; third, adding and linking multimedia data of components including text and voice; fourth, operating virtual dissection system on LAN. This system is expected to be used widely through Internet or CD-title as an educational tool for medical students and doctors.

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