MRI Visual Analyzer System

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1.Abstract

The problem is to design and implement a friendly platform for MRI visual analysis to be used by medical professionals. The application should enable doctors to see the result of MRI as three-dimensional objects. It also provides them the opportunity to access various parts of the organ and study it from different points of view. There are more features such as measurement, opacity, and coloring that make the application useful by achieving a more precise, fast, effective, and easy to understand vision of the organ's cells.

2. Background

When you put the nervous system cells in a magnetic field their polar molecules rearrange to point in the same direction as the magnetic field. Physicians refer this phenomenon as the magnetic resonance that occurs with different speeds in different types of cells.
Magnetic Resonance Imaging (MRI) system provides the two dimensional (2D) images of organs in the nervous system by measuring and showing the resonance speeds when the patient's body is in a magnetic field with monotonous changing direction. Each image shows a horizontal picture of a particular height. It provides forty pictures with 0.4 Cm vertical distances of human brain, for example. Any issue in the organ would be presented in several consecutive pictures. So the problem will be found by studying all of pictures carefully. The diagnosis colors the images to allow a distinction between the cells with different level of magnetic resonance. It helps the doctors distinguish normal cells from the problematic ones.

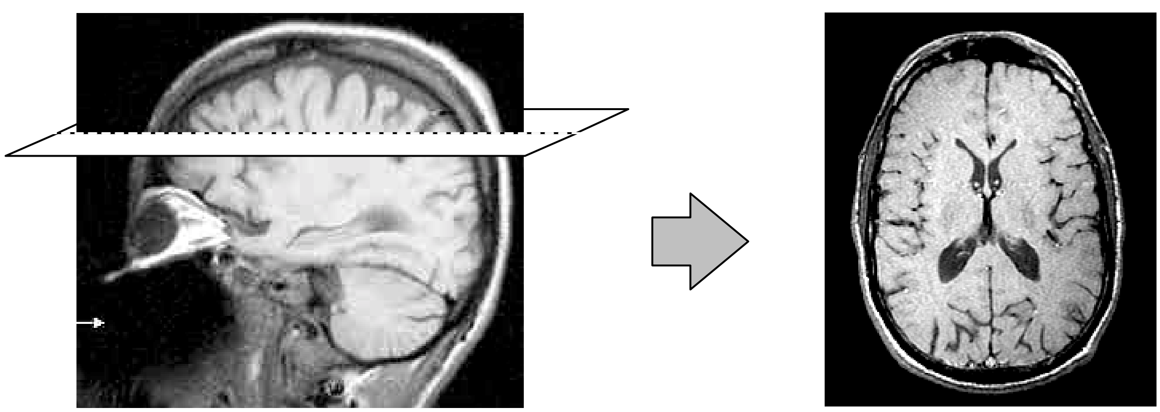

Figure 1. The original images are horizontal slices of the organ

3. Desired program description

'MRI Visual Analyzer' system is a computer application to help doctors have a better understanding of the pictures. It makes a three-dimensional (3D) object using the image information. It also let doctors access desired points of the organ by rotating and slicing it in different directions. Coloring and contrast adjustments allow doctors have a precise view and precise measurements of area, height, distances, or 3D volume and surface areas of objects and defined regions are other good opportunities provided by the system that make surgery plans easy and accurate. Another useful feature of the system is Opacity that is necessary when doctors want to study inner layers as 3D object. The system also provides a archive option that stores original images as well as process results for later uses.

Here are some advantages of the system versus traditional manual studies:

- Accuracy: the system provides doctors the opportunity to study the tissues precisely. The coloring and contrast adjustment helps them concentrate on a specific group of cells.
- Speed: the system will work in a proper speed so the required time for study will be decreased.
- Effectiveness: when the doctor is able to see the different places of the organ from various points of view, the chance of mistakes will be reduced.
- Availability: the system can save the results. They are always available to be discussed and/or reviewed
- Ease of use: the MRI Visual Analyzer is easy to use. This can help the medicine professionals use it without undergoing extensive training. It also can be used for educational goals in medical schools.

4. Detailed requirements

- Doctors and hospital personals that are not necessarily computer experts will use MRI Visual system. So it should be very user friendly. It needs a complete online help as well as a tutoring example set to train the staff. There also should be a help section with a separate icon on the screen.
- Proper process speed is another quality parameter for the system. Any single process for less than sixty horizontal images (this is the actual range of image numbers) shall be done in less than two minutes.
- As they are the most popular operating systems, the system shall work both on windows (ME/9X/2000/NT) and UNIX (V4.0 and above). It also should work on any computer with 32 MB of RAM or more and a processor with a minimum speed of 133MHz.
- The system should resist any mistakes made by user and it should not lose any information because of misuses. After any error situation, the system will be at the same state as it was before the wrong data/command was entered. Image errors and file

incorrectness shall be reported as warnings. However, the user may ignore the false data if the user wants to continue the process.

- The usecases (described in section 5) can be performed in any order. It is possible to perform any usecase process in any valid status. There shall be an undo command for each usecase also. This would cover several back stages based on the system's available memory. That number will be set in the installation phase.
- As we have vertical distances between the original images, the information has some gaps between the layers. So we would have only a net of pixels in any slice of the organ as well as the 3D object's picture.
  The system will use logical cubes or voxels to determine the color of the 3D area to be constructed. The first step is to read slices of data such that each slice is stacked one on top of another to form a large 3D vector. The result would be a 3D volume made by voxels as shown in figure 2.

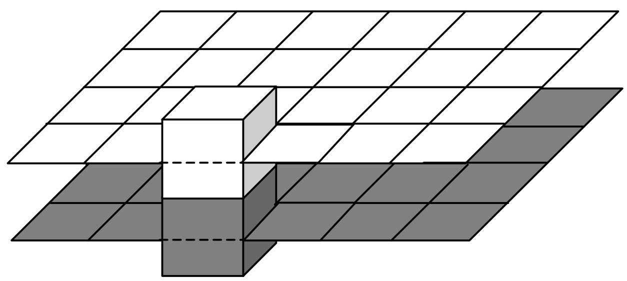

Figure 2. Pixels and Voxels

We will have a mosaic picture of 3D object including a set of colored squares that do not change constantly. There are several approaches to solve this problem. One popular technique is using the following formula to assign a gray level to each pixel based on the gray level (GL) of the closest up/down pixels that we know their color for sure:

GL = ∑(known pixel's GL* it's distance) / layers' distance

The result would be a softer and more natural picture:

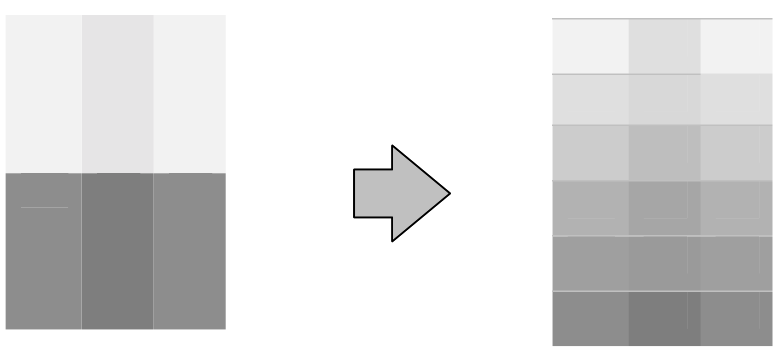

Figure 3. Smoothing the pictures

The technique is applicable similarly for the results of the slicing process that have the same information gaps between the layers.

- The system shall have file transportation options such as open, close, save, save as, print, send to, and exit. These options will be provided by the operating system and the system will inherit them naturally.
- Doctors should be able to do any process in the system both by clicking on the proper icon and by using the hot keys. All hot keys should be defined in the help section.

5. Use case description

5.1) Provide pictures

2D pictures shall be fed in the system directly by the MRI scanner, by the hospital archive, or by a patient who brought ready images. Pictures' permitted formats include Jpeg, GIF, Tiff, PnP, CFX, and BMP. If the images have been zipped, the system should unzip them first. All of the files and no extras should be saved in a separate directory. The file names should follow the standard format: patient name plus a sequence number starting at one. The system should check the validity of received picture and alters the provider if the name formats or image information has errors.

5.2) View files

2D pictures should be available in any part of program. The system should provide an environment to show them individually or as a set of comparable pictures. Doctors should also have access to the other images or text files stored in the system.

5.3) Create 3D object

2D pictures' information should be combined to make a 3D object. The dimensions of the object should be adjustable by the doctor. Doctors also need to drag and drop the final picture. It is useful especially when the picture is bigger than the screen.

5.4) Rotate

The system shall provide doctors the ability to rotate 3D object around horizontal and vertical axes as much as necessary. Rotation axes can move in the screen to have a broad range of rotation. It is necessary to have rotations in a constant manner and the doctors should have proper control over it so the desired view can be easily obtained.

5.5) Create slice

The doctors should be able to view any desired cross-section of the 3D object. They will define the section orientation and well as its position. The system should remove the part selected by the doctor and show the cross-section.
The combination of this feature and object rotating will provide full access to any organ's cell.

5.6) Adjust contrasts

The nervous system organs include several types of cells. They will be presented with different gray levels in the original MRI images. Because some of these gray levels are so close together it is useful to have the optional contrast degree. The option will adjust the picture's contrast so the desired group of cells will be distinct enough for medical studies.

5.7) Color

Original and result pictures can be colored with a certain rule provided by the doctors. This rule will assign each range of gray level to a particular color. That will be useful for doctors to distinguish different types of cell carefully.

The following figure shows a 2D slice before and after coloring:

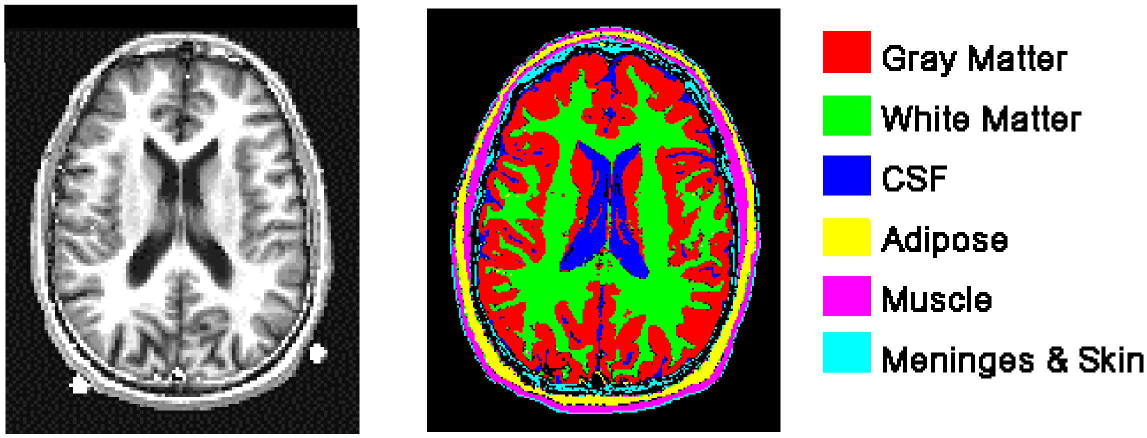

Figure 4. Colored pictures provide more precise diagnosis

5.8) Smoothen pictures

As explained before, the 3D-object picture and the results of slicing would be in the mosaic shape because we don't have the information of every cell in the organ. The mosaic pictures are more precise and do not have approximated pixel colors. However they are not natural and soft. The system should provide an option for the doctors to smoothen the results of the processes if they want.

5.9) Measure

Doctors also need the measurements of areas, heights, distances, or 3D volume and surface areas of objects and defined regions. That would make them comfortable to prepare for the accurate surgeries as well as important diagnosis.

The results of measurements should be available in both metric and British systems.

5.10) Transparent

As you can see in the above colored picture, there are different types of cells in any organ. Sometimes it is necessary to study inner layers as 3D objects. The system should enable doctors to make a definite range of gray levels opaque so the next cells would be visible.

5.11) Archive results

Doctors should be able to archive results of image processes and also the original 2D image files for later uses. The system shall zip the image files In order to use memory space effectively. Each stored folder should have a label that is both given to the patient and stored in his/her medical folder for later references.

Interfaces

The main interface of the system is with the MRI scanner that makes 2D image files. The files have to be prepared and organized in the certain way described in part 5.1.The system also has an interface with the 'Hospital Archive' system. This will follow the archive standards mentioned in appendix A.

References

[1] www.cis.rit.edu/htbooks/mri/inside.htm
[2] www.cosc.brocku.ca/Project/info/grossi/detback.html