A Flight Simulator Approach to the Visualization of Dynamic Medical Data

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1 Introduction

Visualization of 3-D medical scan data (e.g.: MRI, CT, PET) is often performed using surface rendering or volume rendering. Volume rendering is well suited for applications where the assignment of color and opacity values is straightforward given the image voxel intensities. This is true of CT data where there is a strong correlation between Hounsfield units and tissue types. Surface rendering is well suited for applications where segmentation of key structures is a necessary step for good visualization, such as with MRI data, and a polygonal mesh can be wrapped around segmented structures to form a surface model.

Virtual reality approaches use haptic interfaces to associate force functions with segmented surfaces. These simulators let surgeons practice with patient-specific data [Neubauer et al. 2005].

Apart from photo-realistic volume rendering of CT data, systems tend to augment the data using non-photo-realistic rendering. For example, functional information (e.g.: fMRI of the motor cortex) is colorized and overlaid on gray-scale anatomical data, and 3-D graphical cues are added to guide trajectories during minimally invasive surgeries [Gering 2001]. Despite this departure from photo-realism, there has been a bias toward geometric realism.

Therefore, a method is proposed that relaxes the constraint for rendering scenes with geometric realism in order to exaggerate the contrast present in medical images using not only color, but also geometry. The method is based on the use of 3-D surface plots to graph a 2-D image as a surface whose height as a function of spatial location is determined by the image intensity. The proposed method extends this idea to enable the user to interact with surface plots of dynamic data, where there is an image for each of several time-points. The interaction mechanism is similar to that of a flight simulator. Cardiac MRI and dynamic contrast-enhanced MRI are applications that may be well suited to this approach, as a few slabs of temporally varying data are acquired.

2 Method

Consider a 4-D medical data set that consists of a handful of slices, and this stack of slices is scanned at each of many time-points. Process this dataset as follows to produce Figure 1:

1. Create a sheet, tessellated as a triangular mesh, such that there is a vertex for each pixel of a certain 2-D slice.
2. Assign a height value (above an otherwise flat sheet) to each vertex as a function of the brightness of the corresponding image pixel.
3. Assign a color to each vertex as a function of the brightness of the corresponding image pixel. The colors may be from a blended image, such as a segmentation or functional exam overlaid on the anatomical dataset.
4. For each time-point of the dynamic data, re-render the mesh using heights and colors associated with that time.

The transfer functions that govern the assignments of height and color may differ, and they can be edited using the conventional window/level interface with which clinicians are familiar.

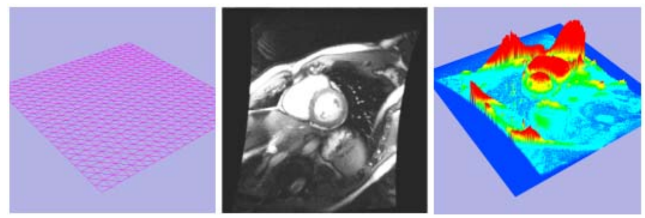

Figure 1: Left: initial mesh. Center: cardiac MRI input image. Right: the user "flies" over the terrain whose height is generated from image data, and whose color is assigned by anatomical and/or functional information. The terrain changes over time using the 20 phases of data acquired for the cardiac MRI.

Real-time user interaction is achieved through a mechanism similar to that of a flight simulator. The virtual flight is controlled using a joystick with a throttle, where one of the buttons determines whether the flight vehicle is allowed to penetrate the plotted surface. This gives the user the option of skidding along the surface when striking it inadvertently, as well as the power to effortlessly punch through a surface – but only when desired – en route to a different viewpoint.

Extending this paradigm to 3-D involves rendering the set of slices as either a vertical stack, or as a horizontal montage, of surface plots.

3 Conclusion

A method was presented for visualizing medical data by virtually flying through it as if the data represented dynamic terrain in a flight simulator. Contrast between data points is made apparent with respect to both color and elevation, thereby giving the user a different perspective than what can be shown using color alone.

References

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