An Efficient Data Structure for 3D Image Registration
Computer Science research expo poster abstract

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Abstract

Computed Tomography (CT) scans of rock samples can yield high resolution three dimensional (3D) images. One property of rock that is particularly interesting to Geologists is its diffusion coefficient which can be obtained by observing the propagation of an iodide solution over time. Repeated CT imaging of the rock sample (for example at 4, 8, and 24 hours) shows how the iodide solution has moved throughout the sample over time. The challenge is to properly register the multiple images with some reference image so that the same location in the rock is compared at different times to properly compute the diffusion coefficient. The main motivation for this research is how to accurately determine the 3D rotation and translation components (assuming a rigid body) of multiple CT scans of the same rock sample. Currently, a small number of two dimensional (2D) image slices are used to estimate a rotation without statistical accuracy estimates.

An efficient method to register high-resolution 3D images would be useful in many areas including Computer Vision, Medical Imagery Analysis, Remotely Sensed Data Processing, and, in the case of this specific project, geological CT image registration[1]. Although many methods to register images currently exist such as correlation and sequential methods, Fourier methods, elastic model-based matching, to name a few [1], they are most often found to be in 2D, and even 3D image registration in most cases seems to be accomplished by simplifying a 3D problem to one that can be solved "reasonably" with 2D techniques. One example of this, as presented earlier, is taking a small number of 2D slices and registering them accordingly with slices from the same location in another image, then allowing our estimates to govern the registration of all slices.

Octrees are spatial data structures that allow compact representation of 3D data. They allow us to consider some unique color (or group of colors) within an image and represent them in a compact form, while not losing spatial information (such as location) of the color(s). Samet [3] presents a way to construct octrees from raster data that is directly applicable in this case. We construct octrees for all unique frequencies of color within each image. Once the octrees are constructed, they are used in the registration process.

By linearizing the model that represents the rotations and translations in all three dimensions, we then can apply standard least squares methods [2]. This is accomplished by using points from both images, one image being a "reference image" that is assumed constant, and the other being an image at some time that we need to resample to match the first image, as well as the partial first derivatives of the model. Another benefit of using this method is that statistical error residuals can be derived during the least squares calculation.

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References

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