# Building a Visible Man Atlas

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## ABSTRACT

In order to facilitate automatic segmentation and analysis of patient-specific full-body CT scans, we have begun to build an atlas of human anatomy from the Visible Man data set. As a first step, we have created a rough atlas which labels the major body parts (head, chest, pelvis, legs, and arms). As a second step, we have investigated techniques for segmenting bone, muscle, and brain tissue. These segmented structures were then used to create 3D anatomical models.

## INTRODUCTION

In 1989, the National Library of Medicine initiated the Visible Human Project and made available to the research community two sets of volumetric data representing complete, normal adult male and female anatomy: the Visible Man and the Visible Woman. The two data sets are available as CT, MRI and RGB images. For this project we use the CT images from the Visible Man data set.

The CT data set contains 1245 grayscale images representing a full body scan of an adult male. Each image (slice) has a size of 512x512 pixels and adjacent slices are 1mm apart.

## SOFWARE

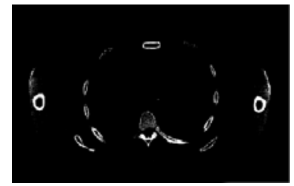
We use two open-source software systems specialized in image processing and data visualization: ITK and VTK.

## METHODS

To build the rough atlas, slices were grouped by visual inspection into four major sections of the body (head, chest, pelvis, and legs). The pixels in each slice belonging to the body were then assigned a label corresponding to the appropriate section. Slices containing the arms were further segmented and the arms were assigned their own label so that these slices contained two labels. The resultant atlas is in the form of a labeled 3D volume.

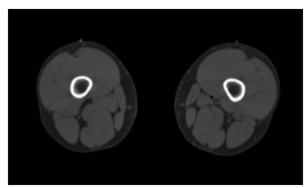
## BONE SEGMENTATION

Because bone is very dense, it appears white in CT images and can be segmented from other tissues using image thresholding. We used a standard windowed threshold to label pixels with CT numbers between 400 and 1024 as bone for each slice in the data set.



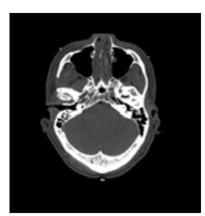
## MUSCLE SEGMENTATION

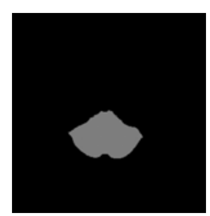
In the legs, muscles could be segmented from surrounding tissues using a windowed threshold. We labeled pixels in this region with CT numbers between -20 and 60 as muscle. In other regions of the body, the CT number alone was not sufficient to distinguish muscle from other tissues (such as organs in the chest and pelvis). In these regions, we combined thresholding with region growing initialized from a seed point placed inside the muscle.



## BRAIN SEGMENTATION

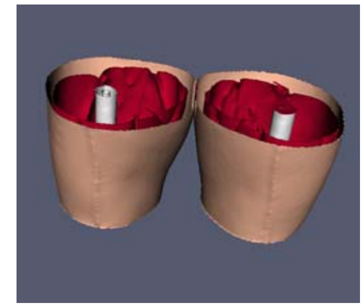
In the brain, we combined thresholding with region growing initialized from a seed point placed inside the brain. The thresholding range was set between 0 and 15. The region growing method expanded outward from the seed point to include neighboring pixels with CT numbers inside the threshold range.





## 3D MODELS

The labels we have created are used to build 3D models of the body. In the image below, we have used the labels for the skin, the muscle and the bone to create a 3D model of the thighs.



## FUTURE WORK

We plan to continue the work on the Visible Man data set and further refine our atlas. As a first step, we will add labels for the segmented bone, muscle, and brain tissues to the atlas.

The next step will be to segment the internal organs. This is a challenging step because very often adjacent internal organs have the same densities in CT images and the boundaries between organs are not always well defined. We anticipate that the techniques we have used so far are not powerful enough for this task. We plan to use more sophisticated boundary finding techniques (active contours and level-set methods) and to research on how we can best apply these methods.

The long term goal of this project is to create a detailed atlas that can be registered to patient-specific tomographic data, allowing us to extend knowledge encoded in the atlas to new data sets.

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