Animating the Visible Human Dataset

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In this work, we describe a method to animate the visible human dataset. The animation is done using a volumetric skeleton *which is computed directly from the visible human dataset. The skeleton is then imported into a commercial animation package and animated using existing toolkits. The volumetric skeleton can be used for many other applications since it act as an advanced data structure for referencing all of the voxels in a volumetric model.*

Traditional computer graphics animation is generally done with commercial animation packages such as Maya (Alias/Wavefront) and Character Studio. Polygonal models are designed, and then a skeleton is constructed and attached to the polygonal models. Limbs and joints are designated on the skeleton. Limbs are then rotated about these joints or the entire skeleton is translated and rotated (usually by a professional *animator*). This is known as "skeletal animation". To achieve realistic movements in computer models, motion capture techniques are used in which "live actors" are wired with sensors and the movements of their joints are recorded by computer and assigned to the corresponding joints in the skeleton model. However, this methodology can not be used for "volumetric models" such as the visible man dataset, since there are no methods to rotate and move arbitrarily shaped groups of voxels, which correspond to limbs, in a realistic manner.

In this work, we present a methodology to animate volumetric objects. The methodology creates a bridge between volumetric objects and polygonal objects and allows all of the commercial animation tools (such as motion capture, key framing, etc.) to operate on volumetric data. The first step of the animation process involves thinning the visible human dataset using a parameter controlled thinning algorithm[1]. The thinning process creates a thinned version of the dataset (a small set of unconnected voxels) which are then connected either algorithmically or manually by an animator. Once connected, these skeletal-voxels can be manipulated like standard articulated-skeletons in any animation package. The key to this whole process is the reconstruction phase in which the volumetric objects are regenerated from the skeletal-voxels. Each frame of the deformed skeleton is reconstructed into its own deformed model, and is then volume rendered. There are three steps in skeleton-based volume animation: computation of the volumetric-skeleton (volume thinning), animation of the volumetric-skeleton (deformation) and, finally, regeneration of the deformed volume from the deformed skeleton (reconstruction).

We demonstrate our method by applying a motion capture sequence to the Visible Male Dataset. The photo dataset is used at a resolution of 290x169x940 voxels (purchased from Gold Standard Multimedia Inc.), which is half of the full resolution in each dimension. We resampled each slice to match the resolution in the "z" dimension. Volume thinning the data produced a skeleton with 42,298 voxels. Twenty-five points were chosen from this volumetric-skeleton and connected into an articulated skeleton by an animator. The articulated-skeleton conforms with the Biped model in Character Studio. The motion sequence data was obtained from Viewpoint Digital and Kinetix (available on their website). We applied a skipping and running sequence to the articulated-skeleton and exported each frame. The transformation for every bone in the articulated skeleton was applied to all voxels connected to that bone. The resulting animations and full references, can be seen on our web site at

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[1] see N. Gagvani and D. Silver, "*Parameter Controlled Volume Thinning*", GMIP, 61(3), 1999.

Some frames from a jumping rope sequence are shown in Figures 1 and 2 below.

There are many other uses for the volumetric skeleton, these include:
- Data registration: the skeleton manipulates the voxels and can be used to register data from different modalities since it is easier to match up skeletons than to match up entire volumes. Matching can be done either manually or using some of the existing Computer Vision techniques for skeleton manipulation.
- Targeted Volume Morphing: The skeleton can be used to precisely transform one volume to another, i.e. by specifying which sections of the volume should get transformed to where.

- Collision Detection: The skeleton can be used to detect collision, i.e. for use in virtual surgical applications
- Virtual Navigation: Since the skeleton is a centerline, it can be used to specify a centerline through a volume for automatic virtual navigation (i.e. virtual colonoscopy)
- Volume Manipulation: The skeleton can be used to specify and remap voxels for better visualization, i.e. moving sections of voxels, unwinding a colon MRI, etc.
- Simplified Muscle Deformation: Enhancements to the distance transform could simulate muscle deformation (contraction and expansions).

Figure 1: The Visible Man Jumping Rope (see http://www.caip.rutgers.edu/vizlab.html)

Figure 2: Close-up of one volume rendered frame from the animation