Realistic Skeleton Based Deformation of High-Resolution Anatomical Human Models for Electromagnetic Simulations

Emilio Cherubini\textsuperscript{1}, Nicolas Chavannes\textsuperscript{1}, Niels Kuster\textsuperscript{2,3}

\textsuperscript{1}SPEAG Software R&D, Zeughausstrasse 43, 8004 Zurich, Switzerland
emilio@speag.com and chavannes@speag.com

\textsuperscript{2}IT'IS Foundation, Zeughausstrasse 43, 8004 Zurich, Switzerland, kuster@itis.ethz.ch
\textsuperscript{3}Swiss Federal Institute of Technology (ETHZ), 8092, Zurich, Switzerland

Abstract

Several techniques have been presented to deal with skeleton driven deformation of 3D skin models for visual purposes only. The work presented here extends and combines these techniques to deal with high-resolution anatomical full-body models, including deformation of all tissues and organs surrounding the rigid bones in an efficient way. This work focused also on a visual system to setup the hierarchical system of bones that drive the anatomical deformation in an easy way.

1. Introduction

The goal of this work was the development of a system which takes a high-resolution anatomical model and allows a visual setup of the influencing bones. It furthers allows positioning of the underlying bone structure taking into account user-defined joint constraints. The next step is the actual computation of the deformation with immediate visual feedback to the user. The posed anatomical models are finally used to simulate exposure to and interaction with electromagnetic radiation.

2. Method

The crucial part of the skeleton based deformation of anatomical models is the setup of the influence regions of the bones. For this a tool has been developed and integrated into the existing electromagnetic simulation platform SEMCAD X. The user defines a set of bones as a hierarchical structure. Such a structure consists of a set of rigid bones connected with joints.

Every bone defines a volume of influence and a spatial weight distribution attached to it. The tool allows the user to manipulate the influence volume such that it matches the bone and the tissues surrounding it. Bones may have regions with overlapping influences. Every vertex in the model has a set of weights for every bone with an influence on it. The resulting transformation of the vertex is computed using a method called Spherical Blend Skinning described in \cite{2} which computes the interpolation of a set of transformations in the quaternion space. To ensure a more realistic deformation, the rigidity of the bone is considered and a simple spring correction is used on the non-rigid parts of the model. This correction takes into account the actual shape of the bone model.

The bone hierarchy allows propagation of transformations through a whole limb if the user moves the parent bone, on the other side the tool makes use of known methods to solve the Inverse Kinematics problem to achieve a desired pose of the bone structure while satisfying defined joint constraints. This work uses a non-iterative method based on Lagrange multipliers described in \cite{1} to simulate the articulation of the bone system which gives to the user a fast and intuitive way to define a pose.
3. Results

All the methods described in this work have been implemented and integrated into the software package SEMCAD X. Models with millions of triangles have been imported and posed, e.g. high resolution anatomical human whole body models from the Virtual Family project [3]. A lot of effort was spent on the user interface for setting up the bone influence regions since this step resulted to be the most crucial part and the most time consuming one from a user perspective. This step still requires a lot of tweaking regarding the influence volumes, especially at complex joints like hand bones or the whole torso.

![Fig. 1: Interactive posing of a hand.](image)

4. Conclusion

This work presents methods inspired by computer graphics based animations applied to the physiological postures of high resolution inhomogeneous anatomical human models. Whereas in computer based animation the sole purpose is usually to deform an empty skin, this novel approach was implemented in the context of electromagnetic simulations with anatomical models.

In particular addressing complex exposure situations, it resulted to be highly valuable to put the anatomical model of interest into the posture being addressed in the investigation, e.g., standing, sitting, operating or being exposed to an EM radiation emitting device, e.g., the influence of a hand holding a mobile phone. Application of the novel methods presented in this work to a variety of inhomogeneous high resolution models in different exposure situations have proven to be successful.
5. References