Fast Interpolation Based Morphing of Whole Body Human Models

Esra Neufeld, ***Dominik Szczerba***, ***Barbara Bühlmann***, ***Marcel Zefferer***, and ***Niels Kuster***
IT'IS Foundation, ETH Zürich, Switzerland

Abstract

One of the demands for virtual anatomical models is parametrization, e.g., the same "base" model but varying height, pose, body mass index, muscle volume, organ shape, etc. in order to provide a better coverage of the concerned population. We have recently reported on the development of a finite element based framework to parametrize the *Virtual Population* models. While the solution proposed therein offers unprecedented realism, it suffers from long off-line processing times and required resources. In this study we evaluated a fast interpolation based method to realistically approximate required deformation fields interactively.

1 Motivation

Virtual anatomical models are becoming increasingly popular in applications such as virtual exposure assessments or device compliance and safety testing that are required by national and international regulatory procedures. The requirements for such models are constantly growing due to the rapidly developing market for medical devices. One of the demands of this market is to provide parametric models, e.g., the same "base" model but varying height, pose, body mass index, muscle volume, organ shape, etc. in order to provide a better coverage of the concerned population. We have recently reported on the development of a finite element based framework to parametrize the *Virtual Population* models. While the solution proposed therein offers unprecedented realism, it suffers from long off-line processing times and required resources. In this study we evaluated a fast interpolation based method to realistically approximate required deformation fields interactively.

2 Methods

A multi-domain triangle surface model is loaded into an application with a user friendly graphical interface (GUI). The imported model retains all the originally distinguished tissue types and can in addition contain user tags to, e.g., hierarchically assemble tissues into groups or mark certain tissues for fixation preventing their movement. Appearance and opacity of the tissues can be defined by the user to facilitate the efficient workflow. A series of interactive deformation filters based on cubic interpolation are available, including scaling, translation, rotation, multi-point box warp, free-hand warp and precomputed vector field warp. Each filter has its own dynamic user interface. Multiresolution representations are used to obtain real time interactivity on an average PC. Once the results are satisfactory, the transformation can be applied to the full resolution representation, which can take up to a few minutes. In addition to widget-based deformation fields, precomputed FEM based deformation fields (e.g., fat expansion, posing) can be interactively scaled and used to warp the model. The models can be checked for validity (element inversion/intersections) and the history of transformations can be tracked for undo/redo purposes.

3 Results

The procedure was evaluated on a few whole body models to approximately increase body fat and to fine-tune body postures. The final models are represented by multi-domain triangle surface meshes compatible with the *Virtual Population* CAD format. They can also be converted into segmented images (voxels). The procedure performs in real time on an average PC.

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4 Conclusions

We have presented an interpolation based method for interactive whole body morphing. The presented procedure preforms in real time, is robust, and does not require excessive computational resources. It can be combined with precomputed FEM based deformation fields.

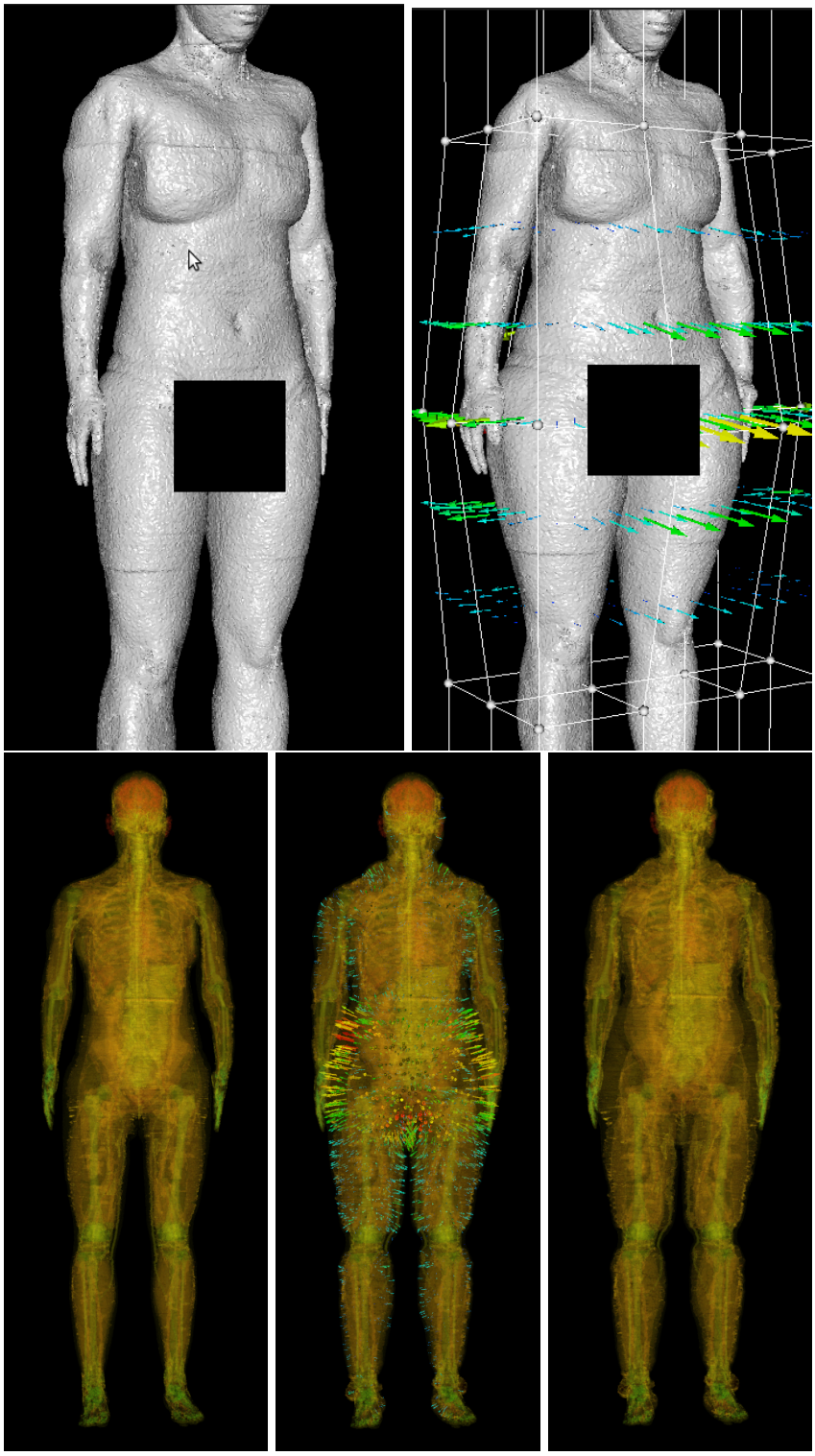

Figure 1: **Top:** An example of a fast interpolation based morphing of a whole body female model to achieve an approximate result of body fat gain. **Bottom:** An example of interactive procedure to apply precomputed deformation fields to a whole body female model to achieve physically correct result of body fat gain.