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Master's Thesis

Informatics
Computer Graphics
2022/2023

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A system for editing triangle mesh sequences with time-varying connectivity

Abstract

Time-varying mesh (TVM) sequences are a common product of modern 3D scanning methods, which are used to represent animated 3D models. Processing TVM sequences can be challenging due to a lack of temporal correspondence between consecutive frames, which is required by many algorithms. In this work, a method for editing TVM sequences is designed and implemented using an existing system for tracking volume elements.

Introduction

Recently, the demand for realism in 3D modeling and animation has grown and the modeling process has become extremely time-consuming. This has made the possibility of 3D scanning surface geometry and motion attractive.

Unlike traditional 3D modeling methods, 3D scanning produces mesh sequences in which vertex counts and connectivity change between frames. However, most existing methods for processing mesh sequences rely on these properties remaining constant throughout the sequence. This creates a demand for new TVM sequence editing methods.

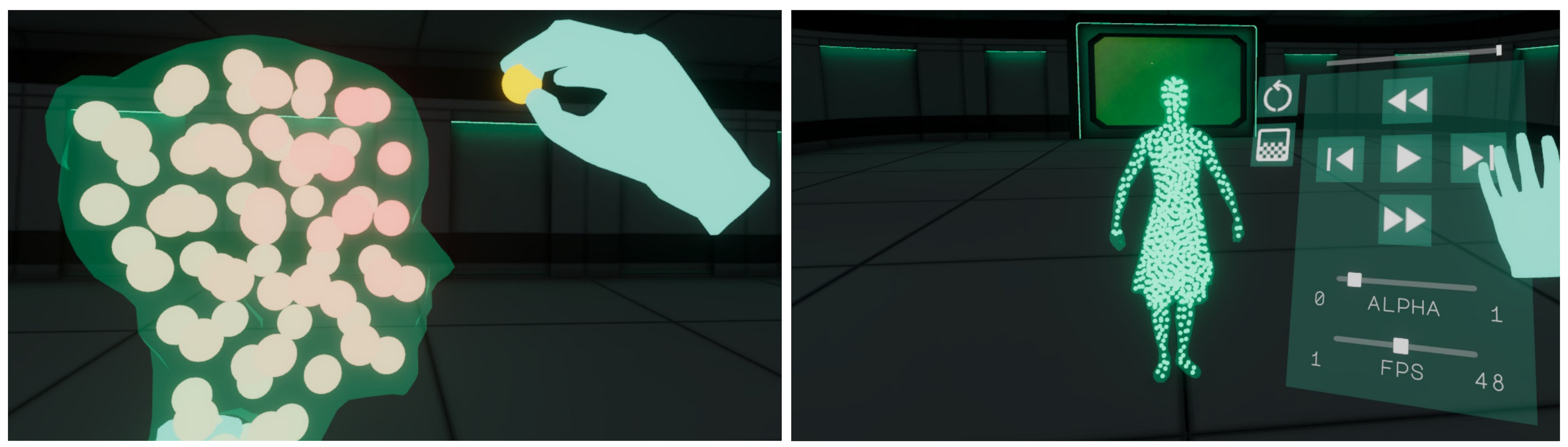
This work utilizes a volume element tracking system, which was recently developed at the University of West Bohemia. Based on its output, a system for editing TVM sequences with a virtual reality interface is implemented. The properties of the implementation are evaluated and future directions are suggested.

The volume element tracking system, as well as the foundations of this work, were developed as a part of the project GAČR 20-02154S Representation and processing methods for three dimensional dynamic shapes.

Goals

The main goal of this work is to design and implement a TVM sequence editing method, which would distribute changes made to one frame of the sequence to the entire sequence. When changes are introduced to the model by a transformation of a single volume element in one frame, the method can be executed in the following three steps:

- distributing the transformation of a single volume element to surrounding volume elements within one frame using the Gaussian distribution in the editing area of effect,
- distributing the deformation of one frame to the rest of the sequence by transferring the local coordinate system using an optimal rotation of the neighborhood of the effector
- and deforming the surface vertices in all frames using the combined translation of nearby volume elements.



Editing process

Main implementation features

The application was implemented in the Unity engine, which provides tools for advanced graphics rendering as well as user interface creation and virtual reality integration. The XR Interaction Toolkit was used to provide VR support. Within the application, the user can load TVM sequences into a virtual environment, where they can be viewed and manipulated.

The editing tool is configurable, which allows the user to choose the editing area of effect and the size of the effector neighborhoods used by the algorithm. Once the user is done editing the sequence, they can choose to save the editing results, which can be loaded into the application at a later date and viewed or edited further.

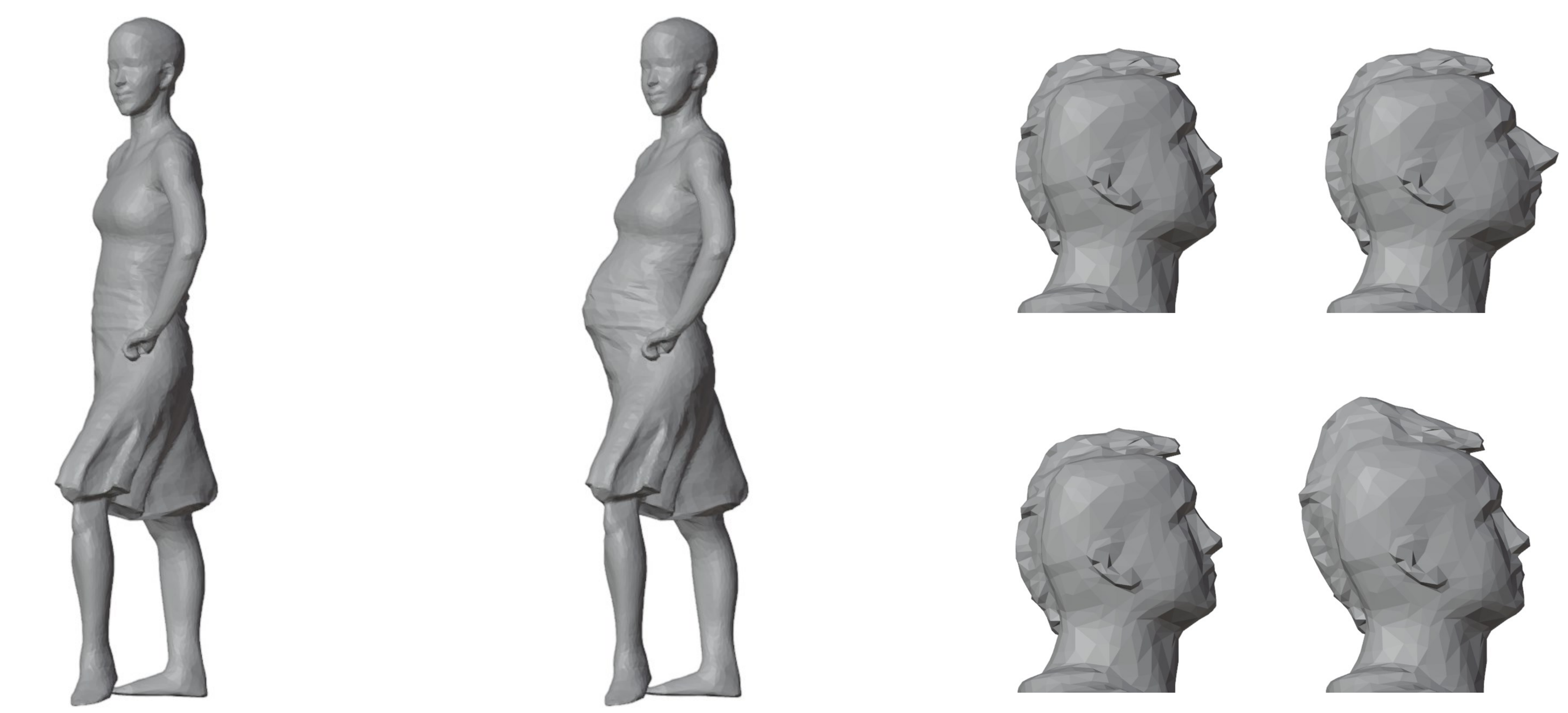
The implementation of each part of the editing pipeline is independent and easy to replace, which allows for creating a diverse set of editing tools, each suitable for different editing scenarios. Alternative editing tools are suggested as a part of the work.

Results

The designed method was tested on sequences of humans in motion and shown to provide good editing results for a certain class of editing operations, which can be modeled well using the Gaussian area of effect. Such operations include deformations of body shape or facial features.

The method is currently not well suited for large scale deformations, such as bending the limbs of the models. However, possible approaches to extending the system to support such operations are discussed in the text.

Currently, the surface deformation stage of the algorithm prevents the method from running in real time due to each volume element being affected by the editing action. This is a result of using the Gaussian area of effect without a cutoff parameter and would be improved by limiting the area affected by editing.



Input sequences (left of pair) and editing results (right of pair)

Future work

Directions for further development of the method were proposed as a part of the work. Among other suggestions, they include implementing effect weight painting, adding a rotation tool, and optimizing the surface deformation phase by using compactly supported functions to model the area of effect.