WHOLODANCE

Whole-Body Interaction Learning for Dance Education

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Deliverable 2.5

3D Avatar scenes

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Index

Introduction

The creation, development and optimization of the 3D avatar scenes for the WhoLoDancE project was dependent on several guidelines and requirements that emerged from discussions with the consortium dance partners. Those guidelines pertained to the type of functionality an avatar should have in a dance teaching context in general, and specifically, what kind of avatar would best fit to assist in immersive teaching of different movement principals of dance.

There are several additional guidelines that were determined by the project's target. Detailed explanation and listing of those is in section 2 of this document.

Avatar creation analysis and functionalities

Each avatar that was created, was designed to cater for different principles of movement in dance. The movement principles that were defined at the start of the project served as the primary guideline for the types of avatars created. We decided to develop 3 types of different avatars.

- Directional guidance (The “Arrowman” avatar)
- Time based motion volume (The “blob” avatar)
- Articulated visual (The “robot” avatar)

In addition, all 3 avatars were programed to have the capacity to display particle trails from any chosen body part throughout the dance sequence.

1: “Arrowman” avatar:

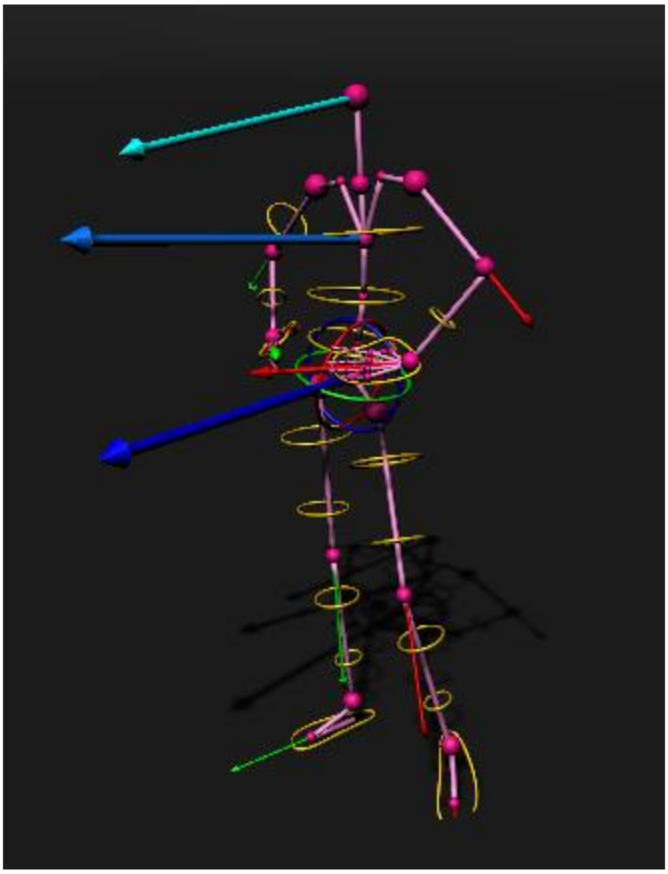

Fig1: Arrowman avatar

This avatar was designed with the following functionalities in mind:

- To give real-time visual guidance to the dancer about the direction in space of each body-part (Head, Torso, Pelvis, Elbows, Hands, Knees and Feet). This was achieved by implementing the arrows emanating from the center rotational pivot of the respective body parts.

- To give visual cues of the perpendicular place of rotation of each body part. This was achieved by modeling circular objects around the limbs, where the radius of the torus's mimicked the actual limb thickness. This assists in intuitive understanding of the segment (body part) rotations in real-time.

- Creating rotational manipulator around the hips to assist in the visualization of the global direction of the dance in space.

2: The "Blob" avatar:

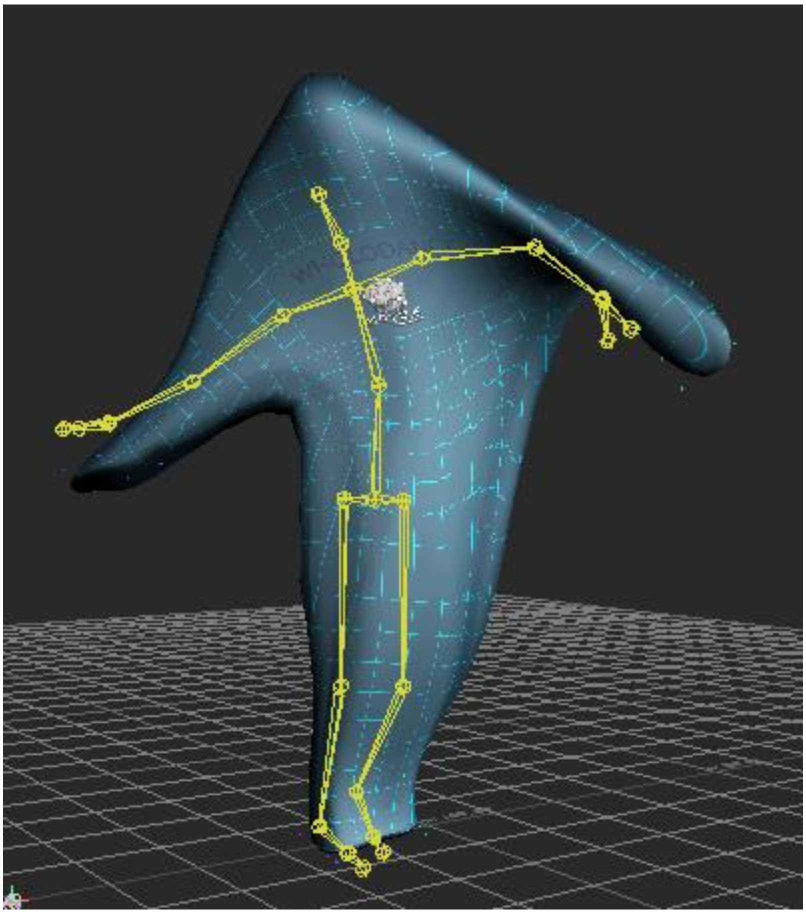

Fig2: The "Blob" avatar

This avatar was designed with the following functionalities in mind:

- To create clear and intuitive time based feedback of the volume that the dancer occupies in space while moving. The main target of the WhoLoDance project is to let a dance student be immersed inside an avatar that is driven by the motion of the dance master. For this purpose, we created 5 different variations of this avatar. Those different variants, present different levels of difficulty to the student who tries to "Stay inside" the virtual body represented by the avatar.

The levels of difficulty were based on allowing greater volume around the physical dancer.

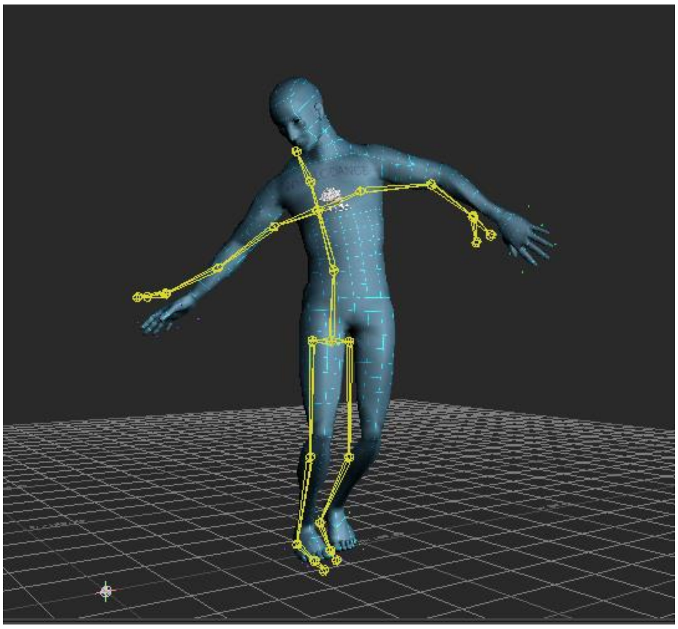
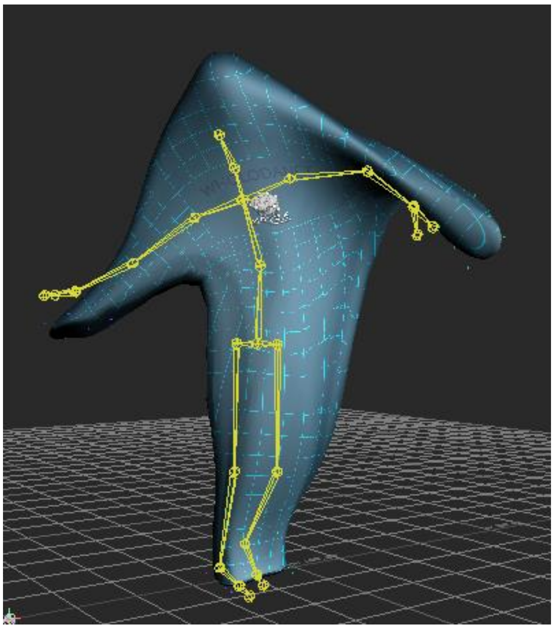
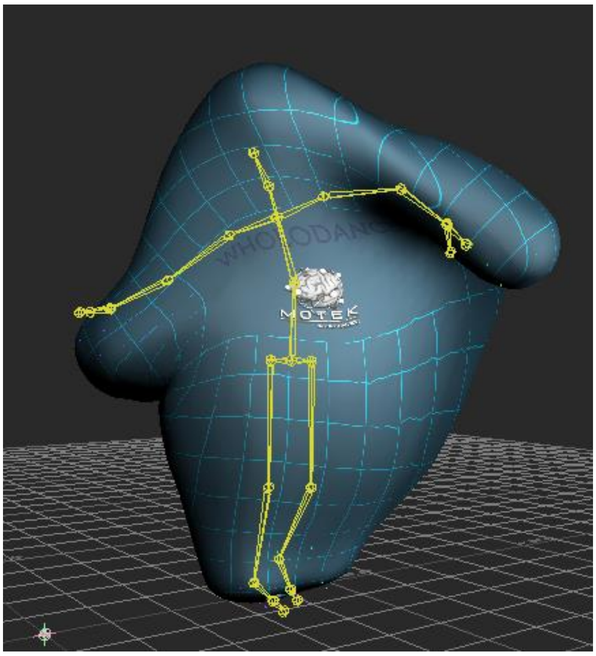
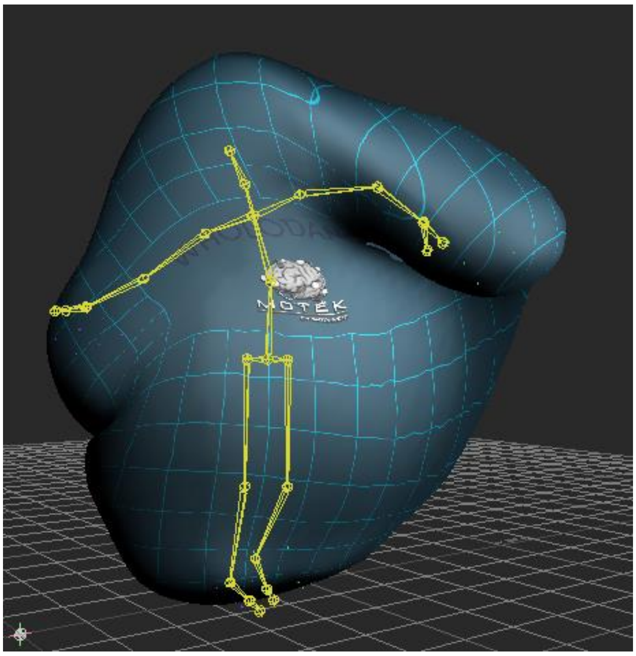
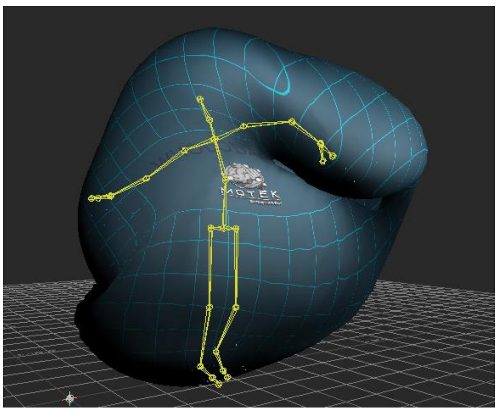

Fig3: The "Blob" avatar's levels of difficulty

3: The “robot” avatar

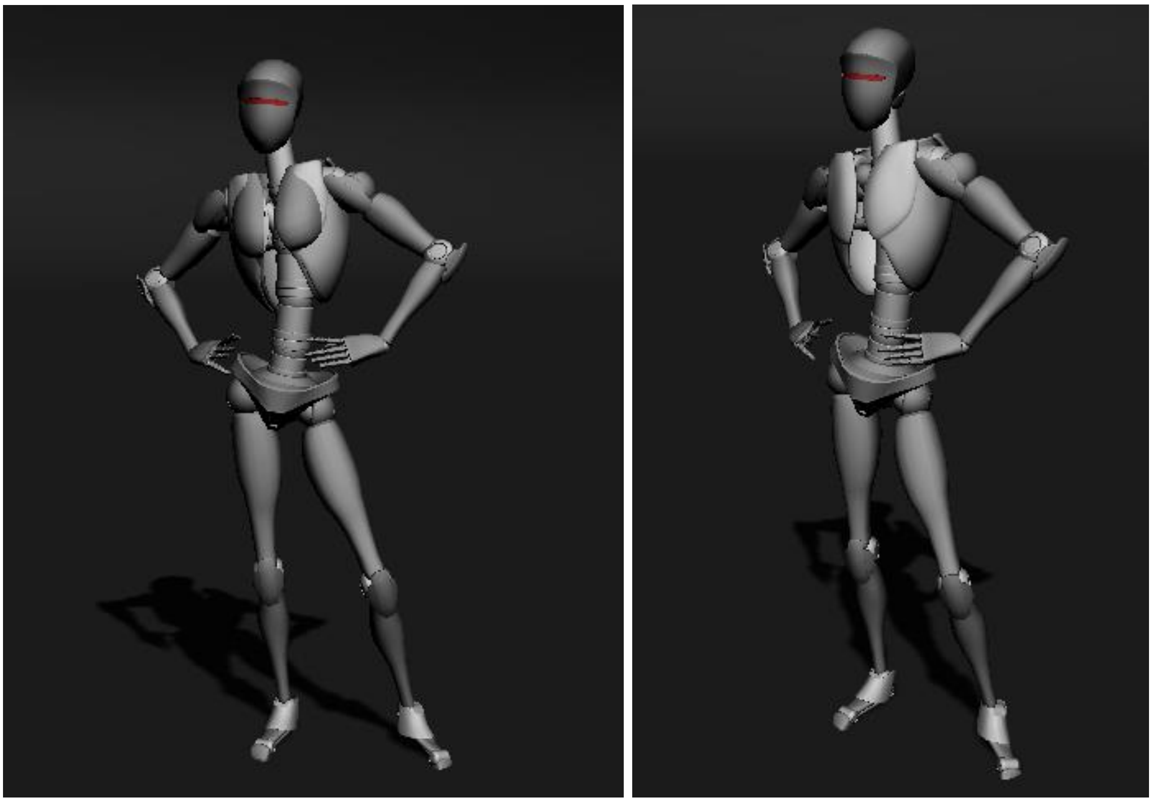

Fig4: The “Robot” avatar - Female Male

This avatar was designed with the following functionalities in mind:

- Create an avatar in a way that will be visually appealing and at the same time will bring out the articulation in the joints of every part of the body.
- Make a figure that will be gender agnostic, with the ability to associate male or female gender with very slight modifications to the avatar.

Avatar creation pipeline

The creation of the avatars demanded a pipeline that would be generic and adhere to 3D modeling standard used in CGI for real-time robust performance.
Real time 3D is the science (and art) of implementing 3D objects in software and display them afterwards on a screen as immediately as possible depending on the performance of the machine. The rendering is said to be "real time" because the computer makes the rendering without delay time, at each movement or modification of the 3D model. Contrary to the image rendering for the 3D "classical" animation or the "real time" realistic movie, all the rendering is calculated while the user is manipulating the object or is travelling into the project, thus the calculation of the images is hyper fast. (In our case we set a target of achieving at list speed of 60FPS (Frames per second).
Non-real-time graphics typically rely on ray-tracing where the expensive operation of tracing rays from the virtual camera to the world is allowed and can take as much as hours or even days for a single frame. On the other hand, in the case of real-time graphics, the system has less than 1/30th of a second per image. Or in the WhoLoDance project, 1/60th of a second. In order to do that, the current systems cannot afford shooting millions or even billions of rays; instead, we rely on the technique of z-buffer triangle rasterization. In this technique, every object is decomposed into individual primitives - the most popular and common one is the triangle. These triangles are then 'drawn' or rendered onto the screen one by one. Each of these triangles get positioned, rotated and scaled on the screen and a special hardware.
We chose to customize the avatar creation pipeline to be oriented toward providing as much quality as possible for the lowest performance cost possible for a given class of hardware. This was done to enable the avatar scenes to run in robust realtime even on standard laptops present in most Dance schools and centers. We created the real-time graphics in ways that they would be optimised on standard GPUs (graphics processing units). These GPUs are capable of handling millions of triangles per frame and within each such triangle capable of handling millions or even billions of pixels (i.e. generating these pixel colors).

<u>Chosen software packages used in pipeline creation</u>

The motion capture sessions were done with highend Optical systems (www.vicon.com) using their in-house software package “BLADE”. The raw data was processed and brought into “Motionbuilder” software (www.autodesk.com) for further processing and retargetting to the avatars.

The modeling took place in “MAYA” and “Xsi”; both are packages are used for 3D modeling, texturing, lighting and offline rendering.

The models were also imported in Motionbuilder where the merging of the 3D avatars and the motion capture data was done.

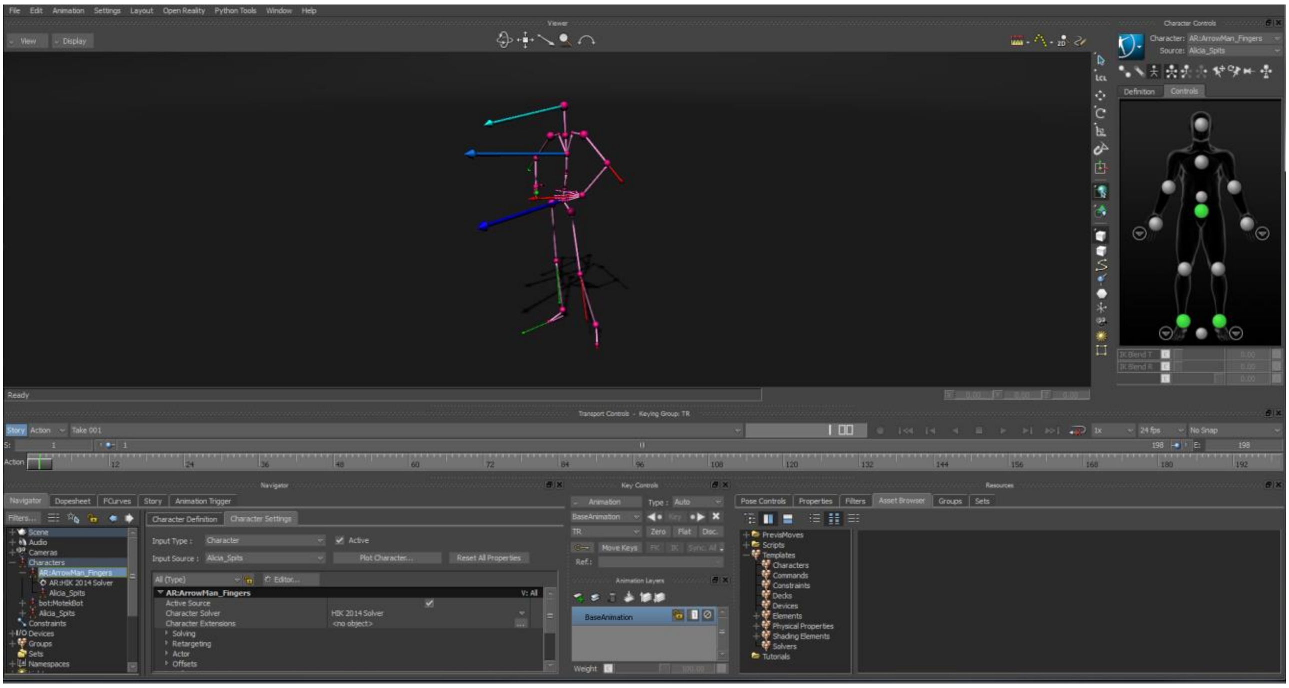

Fig5: Motionbuilder UI for the “arrowman” avatar

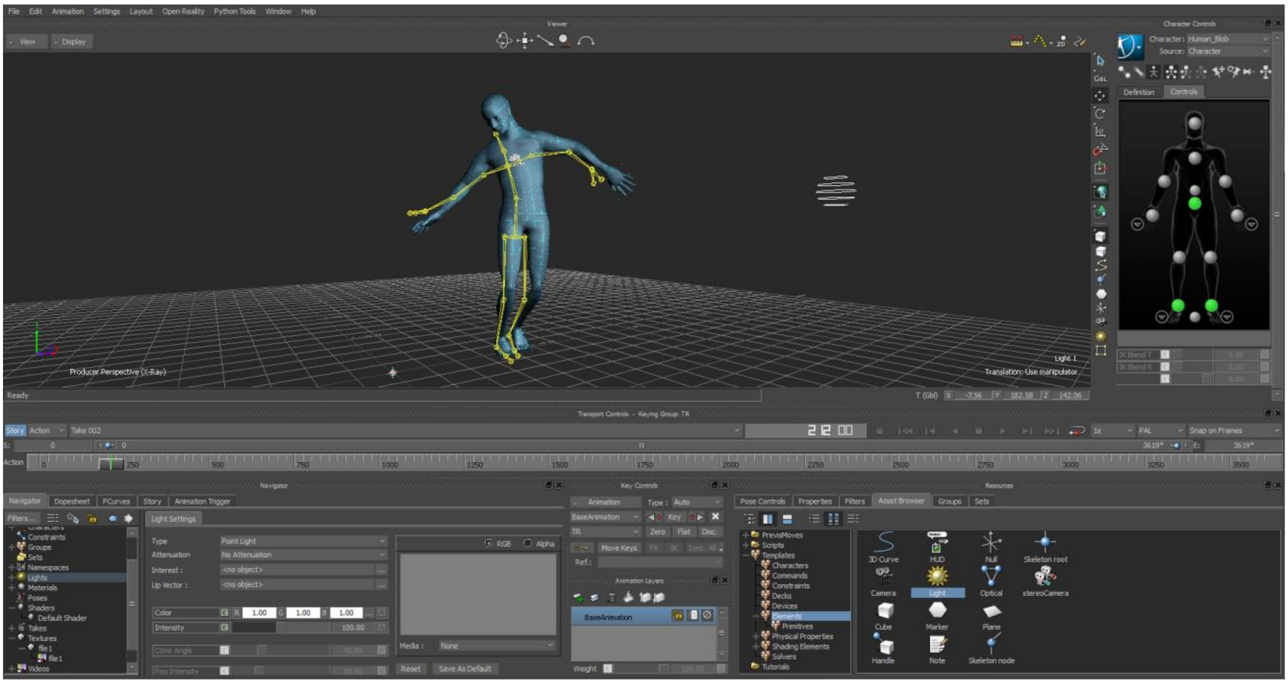

Fig6: Motionbuilder UI for the “blob_Level5” avatar

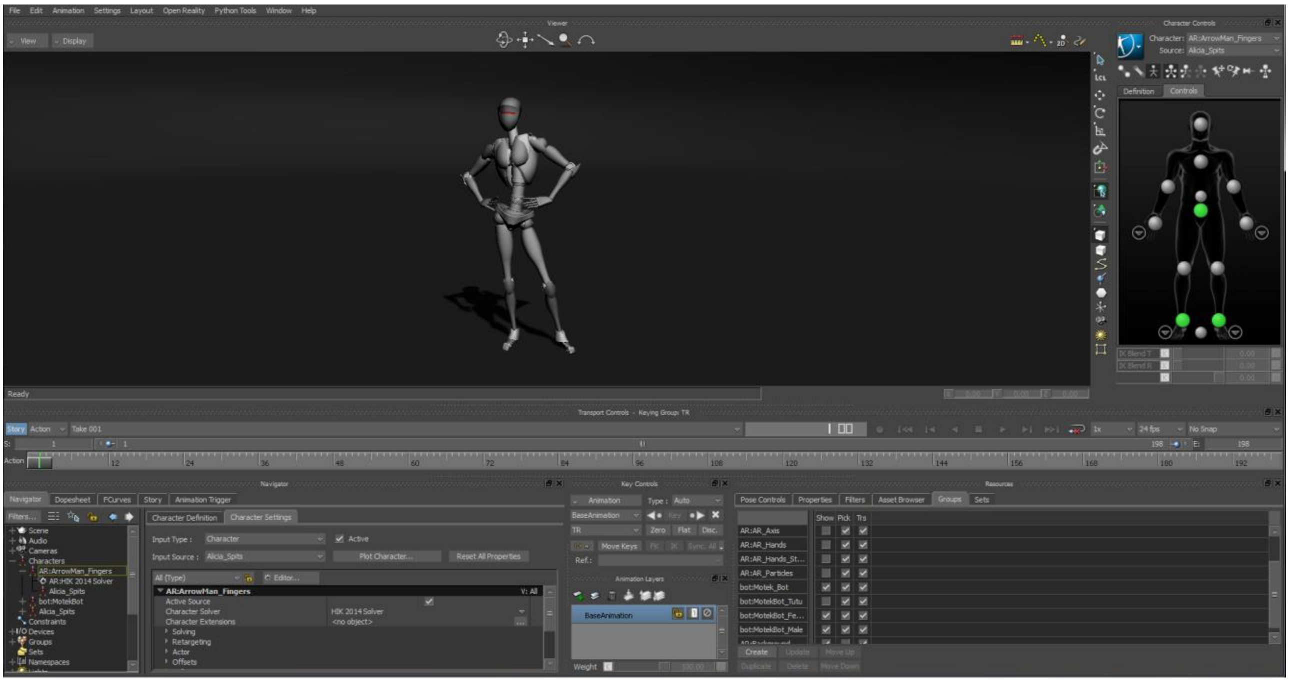

Fig7: Motionbuilder UI for the “robot” avatar

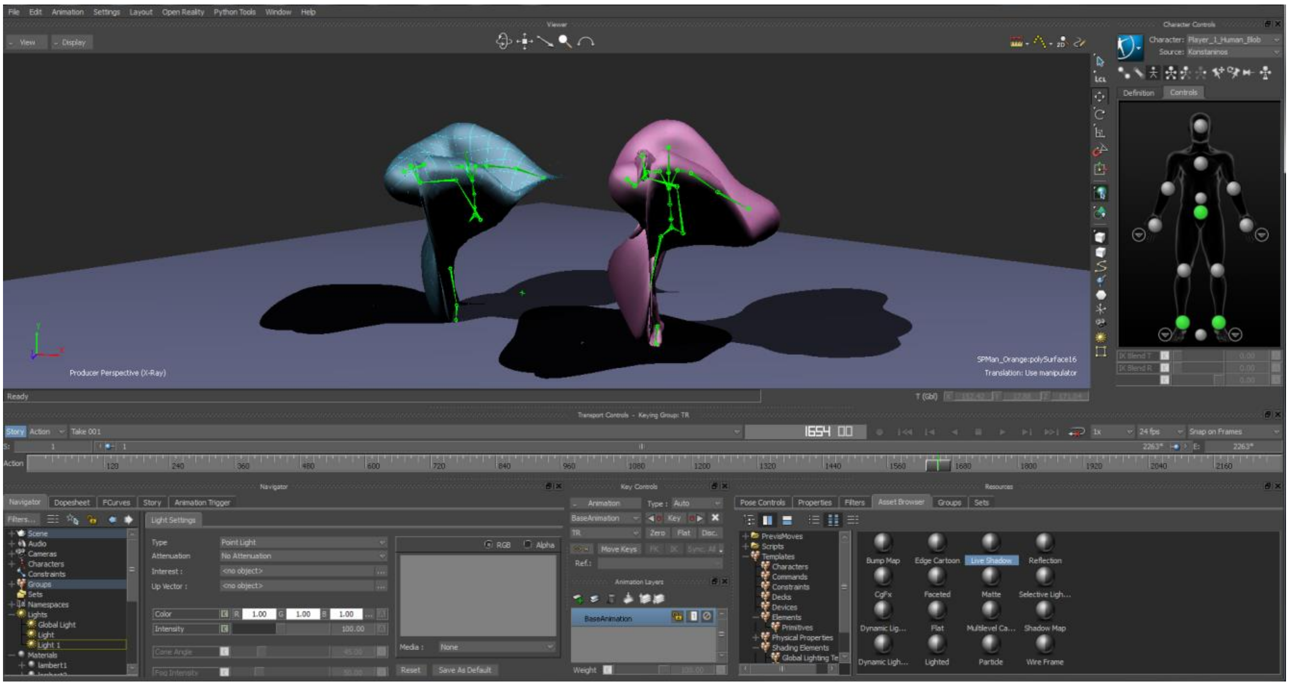

Fig8: Motionbuilder UI showing 2 dancers connected to and immersed in the “blob_level3” avatars

Scene constraints

One of the aims of the WhoLodance project is to achieve a dance teaching paradigm where a dance student is immersed inside the 3D avatar, and the teacher or choreographer can see both the dancer, and the avatar engulfing the dancer. To achieve this, the ultimate goal is to use life-size volumetric holography. Currently, due to the lack of such device, we have explored using AR (Augmented reality) and VR (Virtual reality) techniques to achieve this goal. These media techniques present several unique scene constraint relating to optimize real-time immersive displays and synchronization constraints between the physical dancer and the virtual avatar.

Augmented Reality (AR) constitutes a very powerful three-dimensional user interface paradigm for many "handson" application scenarios in which users cannot sit at a conventional desktop computer.

Current AR research fans out into several different activities, all of which are essential to generating a system which eventually will be able to sustain a truly immersive AR-experience in extended practical applications rather than short laboratory demonstrations: Virtual objects need to be presented as realistically as possible, integrated physically correctly into the real world. This means that occlusion and light reflection properties between virtual and real objects must be established and maintained, as well as physical laws such as nonpenetration, gravity and friction. Furthermore, users must be free to roam an extended area, without being tethered to a stationary system. Thus, AR-systems must be wearable and mobile, either by carrying all information "on-board" or by being wirelessly connected to distributed sources of information. At the same time, the system should facilitate synchronization and collaboration with other AR users (in our case the dancer and the teacher / choreographer), allowing them to work together. Finally, in order to make all augmentations worth their while, AR systems must be able to correctly track user motions and in some cases, even predict future motions ahead of time in a manner that virtual objects are rendered according to the user's changing perspective.

The current state of technology cannot yet provide simultaneous support for an optimal solution to all aspects of AR. Most critical in this respect is the real-time performance of the overall demonstration system. Today's AR systems have to balance a wealth of trade-offs between striving for high quality, physically correct presentations and user modelling on the one hand, and making short cuts and simplifications on the other hand in order to achieve a real-time response.

In the work in WhoLoDance, we have selected two different complementary principles among many possible trade-offs. We emphasize the real-time immersive impression that can be generated with today's technology. The current solution gives the dancer immediate feedback to his actions and thus generate a very tight, immediate interaction scheme. The second principle is intended to present a hint of the future, forecasting what quality might be achievable with continuously increasing processing power and data bandwidth.

The augmentation of the physical dance student with virtual avatars can be performed live on a high-end graphics computer. AR provides the means for bringing a wealth of information into the dance teaching situation in the form of up-to-date 3D motion capture sequences of steps to be performed or choreographed.

The avatars that were built for the project had to be on one side, simple enough in order to be able to be rendered in robust real-time on standard computers, and on the other side effective enough to achieve the sense of synchronised immersion.

Fig9: Views through the AR Hololens device of the avatars and physical dancer

Related research

Dynamic 3D models with local and global deformations: deformable superquadrics. D. Terzopoulos ; D. Metaxas

http://ieeexplore.ieee.org/abstract/document/139605/?reload=true

3D Modeling and Animation: Synthesis and Analysis Techniques for the Human Body. Nikos Sarris, Michael G. Strintzis
https://books.google.co.il/books?id=GUaFGxQI8gwC&lpg=PP2&dq=3d%20character%20modeling%20related%20research&lr&pg=PP1#v=onepage&q=3d%20character%20modeling%20related%20research&f=false

Automatic rigging and animation of 3D characters. Ilya Baran Jovan Popović

http://dl.acm.org/citation.cfm?id=1276467

Mapping optical motion capture data to skeletal motion using a physical model. Victor Brian Zordan Nicholas C. Van Der Horst. http://dl.acm.org/citation.cfm?id=846311

Augmented Reality: A Balance Act between High Quality and Real-Time Constraints Gudrun Klinker (1), Didier Stricker (2), Dirk Reiners (2) Technical University of Munich, Germany Fraunhofer Project Group for Augmented Reality at ZGDV, Germany http://far.in.tum.de/pub/klinker1999ismr/klinker1999ismr.pdf

Real-time human pose recognition in parts from single depth images. Jamie Shotton Toby Sharp Alex Kipman Andrew Fitzgibbon Mark Finocchio Andrew Blake Mat Cook Richard Moore
http://dl.acm.org/citation.cfm?id=2398381