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A Framework for Immersive VR and Full-Body Avatar Interaction

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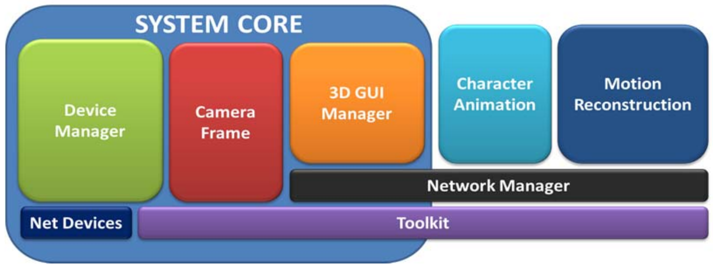
Abstract

We present a new software framework for the development of distributed immersive collaborative virtual reality applications with emphasis on full-body interaction with virtual humans.

- scalable to multi tiles, customizable and cross-platform.
- automatically distributed object replication.
- automatic state registration and maintenance.
- full-body synchronized character animation tools.
- real-time full-body tracking and retargeting.
- based on open source tools or with source code available.

The framework in a low-cost distributed multi-tile wall: Immersive object manipulation and 3D GUI interaction, virtual heritage reconstructions [2] and motion modeling [1].

System Architecture



Overall system architecture: framework modules organization

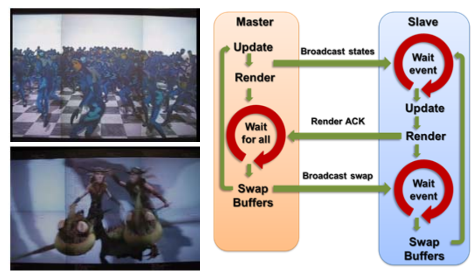
The framework is implemented in C++ and its main entry point is a derivable core class. Depending on the functionality required, different modules, instantiated as managers, can be requested. The core is highly flexible and application's instances can also be customized from a unified configuration file.

- **System Core**
Extends the OGRE rendering engine cycle. The application core is a monolithic entity orchestrating the requested managers, maintaining the shared states, handling the user's interaction events and providing to the developer a high-level abstraction of the system for fast application development.

- **Character Animation**
Handles the loading of high resolution skinned models. Supports distributed key-frame animation interpolations and distributed joint-values over-time animations. The character networked synchronization is bandwidth efficient and supports automatic determination of minimal updates.

- **Motion Reconstruction**
Allows real-time full-body tracking and retargeting to virtual characters of varied dimensions through Microsoft Kinect, inertial sensors or Vicon cameras. A motion retargeting calibration and real-time mapping algorithm from a reduced set of sensors is available based on inverse kinematics [1].

- **Camera Frame**
Creates the physical rendering window array (supporting user-perspective stereo rendering) and performs generic virtual camera manipulations. The system employs the "screen, window and viewport" model supporting many system configurations (CAVEs, Tiled Walls or simple 3D TVs).

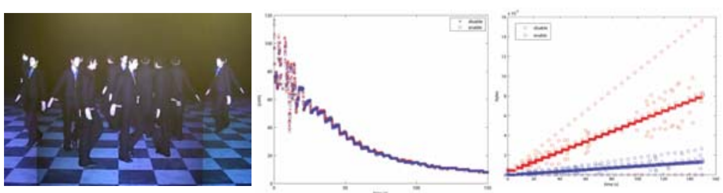


Right: Rendering cycle synchronization. Left: Sync tests with high-res video planes and key-framed skeletal animation crowd.

- **Network Manager**
The framework provides an internal cluster communication engine (master-slave interactions with a sliding window) for the cluster rendering/state synchronization and a general purpose communication channels (master-master interaction). Customized engines can be added.

- **Device Manager and the 3D GUI**
This manager handles interaction devices. Virtual devices are created on request and virtualized to a higher level format. A client-server extension handles platform-dependent devices. The 3D GUI manager includes primitives for distributed interactive widgets.

Evaluations



Comparison between applications with the bandwidth saving mechanism enabled (blue markers) and disabled (red markers) and preservation of the frame rate.
Left: test application: high-res characters are loaded every 5 seconds. Center: frame rate performances compared to non-distributed version of the system. Right: bytes transmitted

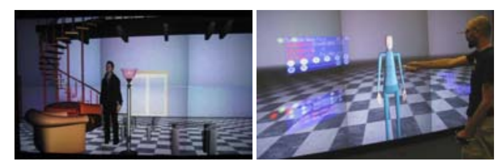
Hardware setup: Seven Linux-based rendering node Powerwall (P-Q9550 2.83GHz, GeForce GTX 280, 4Gb RAM), twelve projectors and an external windows device server with a 10-camera Vicon motion capture system.

Full-Body Interfaces Enabled by the Framework

Our framework has been successfully employed on a number of research projects for more than three years [1][2].

- **Motion Modeling**
User demonstrates to a virtual human how to perform motions. During the training phase the virtual human reproduces the motions in interactive training sessions with apprentice users learning the training subject [1]. The system includes new algorithmic solutions for motion parameterization [3].

- **Physical Therapy**
Allows therapists to create new upper-body exercises by direct demonstration, and then the autonomous virtual therapist provides automatic interactive exercise delivery and monitoring to users. The application also supports networked collaboration.



- **Interactive Motion Visualization**
Provides full-scale visualization for inspection of synthesized full-body motions. Inspected motions have been synthesized from a motion graph algorithm with obstacles, and then integrated with a multi modal motion planner.

References

[1] C. Camporesi, Y. Huang and M. Kallmann, ***Interactive Motion Modeling and Parameterization by Direct Demonstration,*** *IVA 2010.*
[2] S. Kenderdine, M. Forte, and C. Camporesi. ***Rhizome of western han: an omnispatial theatre for archaeology***. CAA, 2011
[3] Y. Huang and M. Kallmann, ***Motion Parameterization with Inverse Blending***, MIG 2010.

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