

Virtual Reality goes Physics

Realistic shading and physically
based simulation of the
Virtual Puppet



U N I V E R S I T Ä T
K O B L E N Z · L A N D A U

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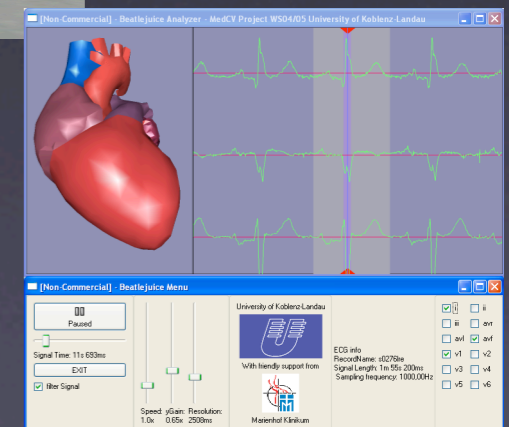
University of Koblenz-Landau, Germany

- Introduction
 - University and Institute
 - Course of study “Computational Visualistics“
 - Students‘ projects
- The Virtual Puppet
 - General information
 - Physics system
 - Shading architecture
- Discussion and Conclusion

- The City of Koblenz
- Campus Koblenz
 - approx. 5,500 students
 - new campus since 2002
- Courses of study (IT only)
 - Computer science
 - Information management
 - *Computational visualistics*



- CV Institute founded in 2001
- Six research groups focusing on:
 - Image processing/computer vision
 - Computer graphics
 - Software ergonomics
 - Computational linguistics
- CG group's topics include:
 - Real-time raytracing
 - Photorealistic image synthesis for real-time augmentation
 - Virtual and Augmented Reality
 - Visualization and interaction in medical contexts



- Course of study est'd 1998, one year after University of Magdeburg
- Degree: "Diplom-Informatiker/in"
 - diploma in computer science
 - "EU-redesign" to BSc/MSc around 2007
- Some facts about CV:
 - currently approx. 700 students
 - average duration 9-10 semesters
 - more than 25% female students

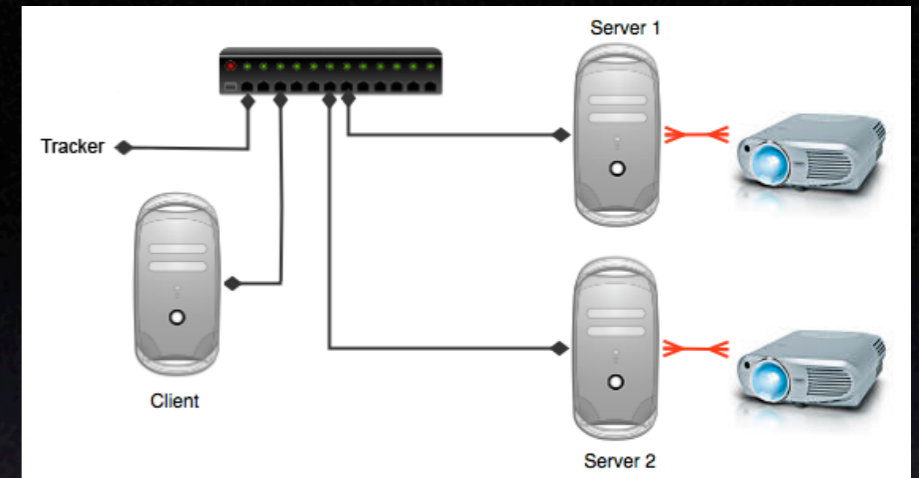
- Project with 6-30 students as part of curriculum
- During one semester (6 months):
 - becoming acquainted with chosen topic
 - planning/implementation/integration in teams
 - final presentation and (optional) deployment
- Projects cover wide range of topics like:
 - MedCV (medical applications in cooperation with local hospitals and medical staff)
 - Robotic systems (indoor and outdoor)
 - Mobile AR Game on portable devices
 - Virtual Reality...like the Virtual Puppet!

The Virtual Puppet

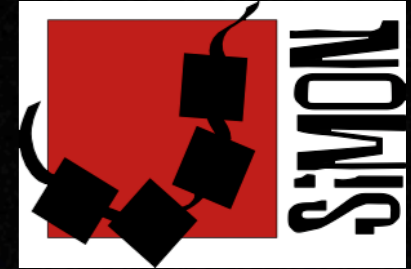
- VR application with physically simulated character
- Idea: Puppet (marionette) in different scenarios for playing and performing tasks
 - attractive and amusing application
 - both artistic and scientific content
 - challenging but still feasible
- 27 students gathered to put the idea into practice...

- Cross-platform (run on GNU/Linux and Microsoft Windows®)
- Network-based communication of events, even for physical simulation...
- Existing systems used
 - *OpenSG, Cg*: (stereo-)rendering, shading
 - *OpenAL, OggVorbis, SDL* : sound, input
 - *vrpn*: optical/electro-magnetical tracking
- Self-made exporter for 3ds max®
 - physical properties of objects
 - material library for shading system

- Typical setup
 - 2 render servers (for stereo)
 - 1 client for application and simulation
 - 1 tracking system
- Scales well, so virtually everything from 1 to n PCs is possible (e.g., for HEyeWall...)
- Two versions of the Virtual Puppet
 - extensive physics engine “Simon“
 - simplified showcase version



- OpenSimon: <http://opensimon.berlios.de/>
- Separate library, i.e., runs independently from VR application
- Implements physical simulation for real-time applications:
 - rigid bodies with constraints (joints, ropes, etc.)
 - collision detection and response
 - resting contact, friction
 - cloth simulation (partly...)
- Constraints and collision handling based on Baraff's and Fedkiw's algorithms



the virtual puppet

- Second physics “engine“ is limited, i.e., much more application-specific
- Uses spring-mass system only
 - visually convincing for moving parts (ropes, clothes etc.)
 - allows for gimmicks such as hair
 - but: problems with rigid objects like boxes, balls
- Very efficient implementation
 - focusing on this one case makes 24 simulation steps per frame (!) possible
 - stable computation despite limited model



- Basically, two shading architectures are implemented
 - shader programs on state-of-the-art commodity graphics hardware
 - advanced but standard OpenGL shading
- Build on top of OpenSG's infrastructure
 - powerful and efficient layer on top of OpenGL
 - several limitations for both systems (then...)
 - no real multipassing, number of lights etc.
 - somewhat complex handling of custom data used in shader programs

- High-level shading language: Cg
 - better known to students
 - however, somewhat limited interface to OpenSG/
OpenGL
- Extensive material library
 - handcrafted textures
 - advanced mapping techniques (bump, refraction, env, ...)
 - procedural displacement shaders
 - different lighting effects incl. maps
- Uses a more artistic style for overall setting

to the puppet...

Discussion

- “It’s gotta look good and behave right.”
- Definition of “look good“ ...
 - attractive, appealing setting
 - competitive visual quality
- Definition of “behave right“ ...
 - must not interfere with user’s world experience and expectations
 - needs to be “correct“ in terms of visual perception

- “Keep it as simple as possible, but as complex as needed.”
- Example: Input device...
 - Optically tracked wireless gamepad in first version of VirtualPuppet
 - control of strings etc. via joysticks
 - change of rooms via buttons
 - but: too complex for first-timers...
 - Showcase version: 6DOF tracked wooden “thingy”...



- In a nutshell: Making VR applications “physics aware” boils down to some major decisions
- Do it “the physics way” vs. faking reality
 - physics allows for easier interaction, more natural effects, no “workarounds” etc.
 - however, ties up a lot of manpower in your project
 - needs thorough knowledge to implement/integrate
- Complete, all-purpose physics engine vs. implementing application-specific only

- Usual trade-off between accuracy and speed
 - entertainment: real-time, but faked
 - simulation: precise, but hardly real-time
 - animation: combination of keyframes and simulation
- And this means for the Virtual Puppet...?
 - physics simulation with correct results w.r.t real-time applications
 - visually correct shading in the context of the somewhat comic style
 - indirect acting/control of character
 - interesting prospect: combination of animated sequences (mocapped?) with physics system...

Conclusion

- **Computational Visualistics**
 - course of study on computer science with interdisciplinary focus on images
 - two universities in Germany: Koblenz and Magdeburg
- **The Virtual Puppet as students' project**
 - amusing and attractive scenario
 - advanced VR technology combined with physics simulation and current graphics hardware
 - CV students combined their wide range of skills in successful project
- **Physics in VR allows for realistic and consistent behavior – but comes at a price...**

Thank you!

Questions? Comments?