Real-Time Relighting of Video Streams for Augmented Virtuality Scenes

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Introduction

Application area: Virtual production, Augmented reality, and Augmented virtuality

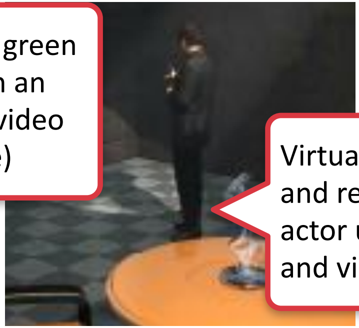
Video captured real persons (or objects) ingested into virtual or real scenes in real-time

Several productions with relighting at the virtual studio of the Hochschule Düsseldorf (Picker et al. 2018, Mertens et al. 2019, Davin et al. 2020)

Development of real-time relighting systems

Best case: real, relighted object is not distinguishable from a virtual counterpart

(Davin et al., HSD, 2020)

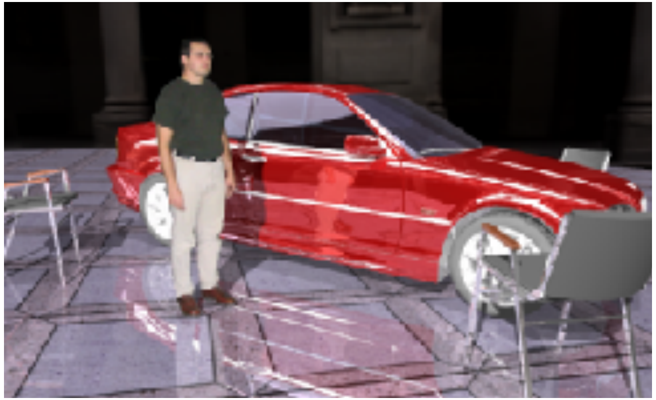


(Mertens et al., HSD, 2019)

(Picker et al., HSD, 2018)

(Picker et al., HSD, 2018)

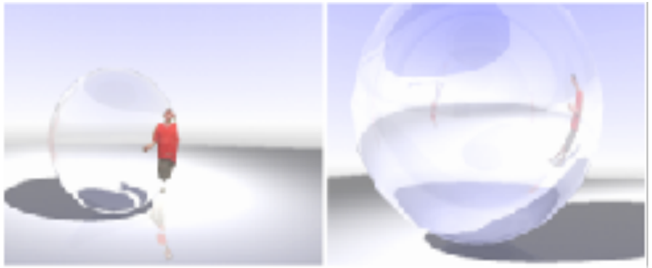
Related Work



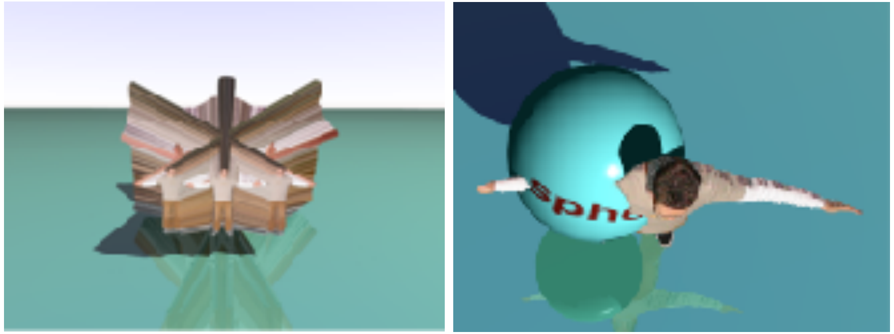
(Pomi & Slusallek 2005)

Interactive Ray Tracing for Virtual TV Studio Applications (Pomi and Slusallek 2005)

- Ray Tracing System with computer cluster
- Recording of a person in front of a green screen
- Visual hull of a person using several cameras, enabling occlusion, shadow, reflections and free virtual camera moves
- Real-time rendering for interactivity



(Pomi & Slusallek 2005)



(Pomi & Slusallek 2005)

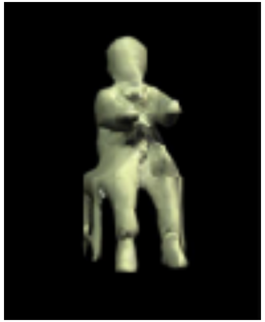
Related Work

Multi-camera Radiometric Surface Modelling for Image-Based Re-lighting (Grau 2006)

- Relighting of a video sequence in video studio
- Using a diffuse lighting model and person geometry captured by a multi camera system
- Convex hull from chromakeying
- Environment map from the recording for neutralising the studio lighting


(Grau 2006)


(Grau 2006)


(Grau 2006)


(Grau 2006)

(Guo et al. 2019)

(Guo et al. 2019)

The relightables: volumetric performance capture of humans with realistic relighting (Guo et al. 2019)

- Light Stage, Sphere with 58 RGB- und 32 depth cameras including 331 LED rings
- Camera recording processed with neuronal networks for volumetric reconstruction of actor
- High resolution textures including sophisticated lighting model
- Realistic relighting of 3D model of actor in any environment
- Incredible high processing demand and huge data set

Early Tests & Experiments

Avatar matching: Strong shift between the tracking systems, difficult or even impossible to compensate in three-dimensional space (1). Adjusting the mesh by shifting the vertices destroys the structure of the mesh (2). Skeletal structure is difficult to adapt universally to different sizes and proportions.

Normal Mapping: Use the normal map of the avatar as the normal map for the video image, but creates ghost images (3).

Delaunay triangulation: extraction of the person's contour and subsequent triangulation and mesh creation (Shewchuk 2002). Depth information is missing, but the mesh is congruent (4).

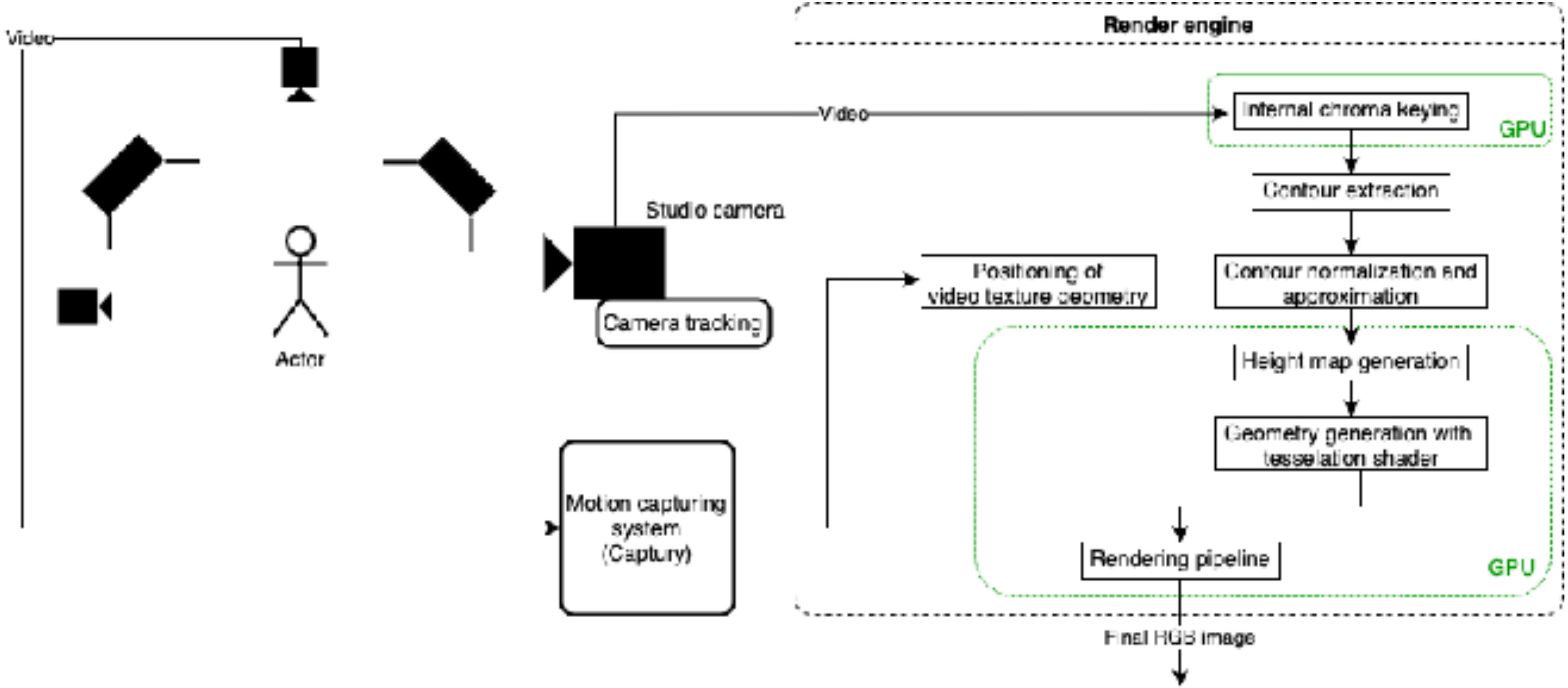

(1)


(2)


(3)

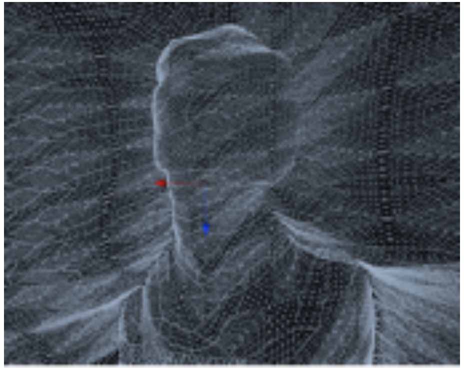

(4)

Relighting System



Relighting System


(1)


(2)


(3)

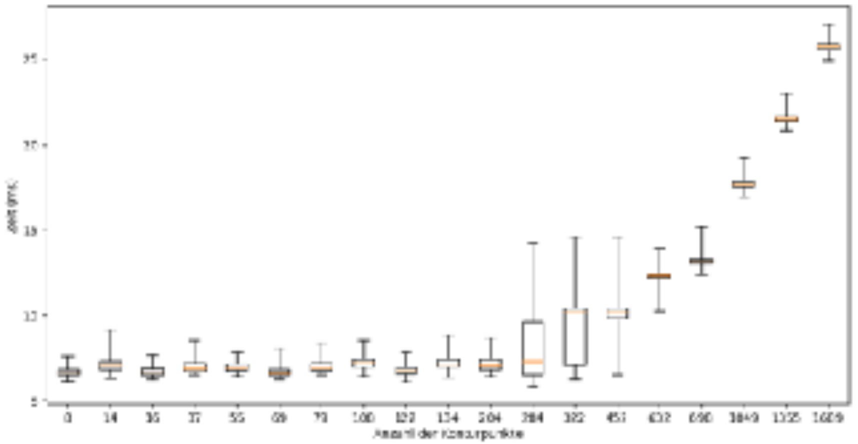
Compute Shader: In parallel, the distance to each contour point is calculated for each texture pixel. The smallest distance gives the strength of the pixel in the height map. (1)

Tesselation Shader: Additional geometry generation from level. Protrusion of the plane based on the height map. (2)

Evaluation

Performance measurement:

The system is real-time capable. Performance depends on the level of detail of the contour. Compression can prevent too high a level of detail.

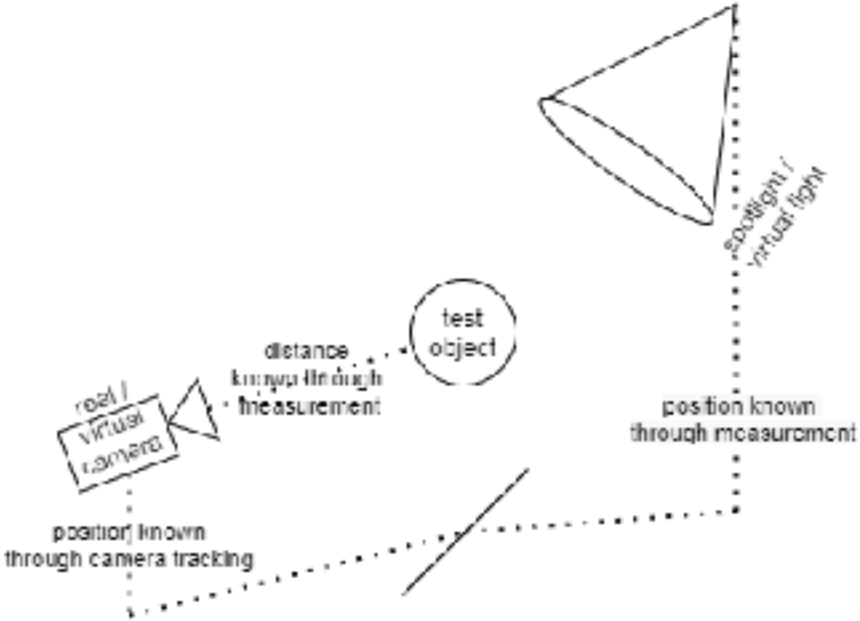


Delay measurement:

Additional delay of 0-1 frame is created by asynchronous loading of the texture from the GPU to the CPU. But also more for large contour data.

Anzahl Konturpunkte	Mittlere Verzögerung in ms
Isolierte Messung	10.69
16	15.60
55	15.98
122	15.71
284	19.38
632	32.30
1355	60.25

Evaluation



Evaluation recordings:

Comparative recordings between real and virtual lighting of a test object with a spotlight
Light measurement of the real ambient light and the headlight
Measurement / tracking of the position of all objects involved
Replication of all measured parameters in the virtual scene

Evaluation

Qualitative image evaluation:

No relation to reality and also no improvement towards realistic representation, neither after subjective evaluation nor after evaluation with metrics.

Relighting provides additional information about the light through self-shading and specular highlights.

Relighting System

Real Light

Relighting System

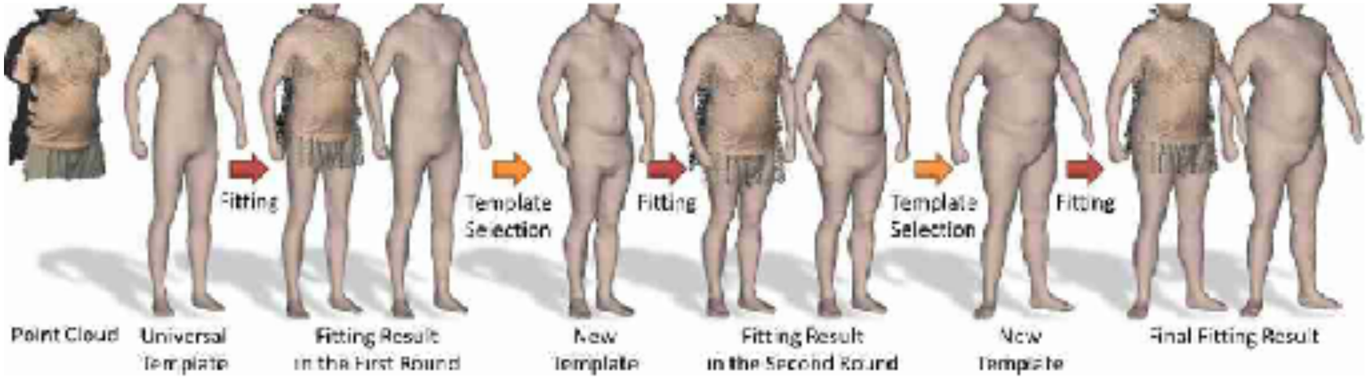
Simple 3D Plane

Conclusion

Expansion with depth cameras for the actual representation of reality. Note the different projection and position, noise components and level of detail of depth cameras.

The use of a multi-camera setup to generate the visual shell enables the generation of a geometry that is specific to the person.

With the help of a continuous adaptation of the geometry volume to the volume of the person, a congruent geometry could also be generated. An artificial neural network is likely to be necessary to solve adaptations of this more complex type.



(Kwok et al. 2014)

Conclusion

Relighting System:

The video stream is expanded in real time by a geometry with depth information

Correct positioning through markerless person tracking
Depth information is represented by a generic function and has no relation to the actual surface geometry of the real scene.

Enables a better representation of the virtual lighting in the video image, through self-shading and highlights

Full integration of the textured geometry into the lighting calculation of a virtual scene

Literature / References

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