Augmented Reality

Augmented Reality as Tool in Architecture

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This project describes a way to combine real-world images with graphical representations of three-dimensional objects.In architecture the combination of physical and virtual spaces is a traditional approach to propose the design of a building. Presenting a virtual design as it appears in relity requires either an unsatisfying level of abstraction while being on-site, as with sketches, or the performing of several ardous tasks. While in this case the quality is appropiate, it is now unlikely to get immediate results.Combining an interactive modeler as the primary designing instrument with a augmented reality system as mixture of cameras, GPS-devices and fiduciary features the system can demonstrate how augmentation as tool in architecture might work.

Keywords: *Augmentation: augmented reality; interactive modeler; OpenGl; GPS..*

Introduction

Virtuality, as virtual reality or virtual architecture, is the tool of choice for architects in computation, and it suits their requirements perfectly well. Even though architecture could be totally virtual, absolutely pure virtual architecture is uncommon. Even as virtual, architecture has to happen on a specific location. This is already reflected by the fact that almost every project in architecture is somehow attached to a building site. It is not likely that an architectural project is created without an associated site. At least in part virtual worlds as models presented by architects are reproductions of the real world, and these parts are real or derived from real sources. Therefor architecture is part of the real world.

It is conclusive that composite images as combination of an existing and a virtual scene are one of the most desired form of visualization. Therefor augmented reality rather than virtuality should be the tool of choice in architectural computation.Generally an augmented reality system generates a composite view in real time. The composition is a combination of a real scene viewed by a user and a virtual scene generated by a computer, where the real scene is submerged with additional information in order to enhance the perception of the user. To generate the

virtual part in order to match the image of the real scene according to the eye-point of the user it is necessary that this position is known at any time. For this purpose the eye-point must be tracked by a tracking device, the distinguishing feature of augmented reality systems.The virtual presentations itself can be two-dimensional, as written informations in an exhibitive environment and as simple graphics, common and well known in targeting devices, or three-dimensional. In this case a fixed three-dimensional model is created in advance and used as source for the real-time rendering according to the position of the user.To establish augmented reality as tool in the hand of an architect, only one aspect is missing: it has to be a tool. Therefor as additional feature an interactive modeller is introduced. Although the real-time computing allows real-time modelling by definition, interactive modelling is usually not considered as technique in augmented reality. Designing a building in real-time while on-site is the most challenging part of the project, and even though the interactive modeler is usable this part of the system is still not nearly complete.

Interactive modeler

Core of the project is the interactive modeler. It consists of two parts, a video input device or camera as source for the input from the real world, and the modeler to establish the additional virtual component to be augmented.

Video

The only adequate image input for a real-time application is live-streaming video from different points of view. While video-input is generally established, the support of multiple cameras is still an uncommon task, because usually only one camera is attached to a single computer. Although this constraints are not all overcome yet, partly because of hardware and bandwidth issues, the system is designed to access different types of cameras like DV-cameras, USB- or firewire-cameras simultaneously. The use of several cameras from different locations and for different tasks allows the evaluation of a design from different point of views and opens a wide range of yet unknown possibilities.

Additionally the input size is adjustable in pixel by the frame grabber to align the rendering to the desired size, because later adjustments may result in unpredictable losses.As a final step the video input is directly transferred into memory on the graphic card as soon as it is delivered from the camera through the frame-grabber.

OpenGl

OpenGL has become the standard for almost every graphic application in real-time. The only exceptions

Figure 1
Simultaneous input from three videos or web-cameras (indoor). (70_lonsing_fig01.jpg).

are still some renderers supplied with CAD-programs or high-quality renderers like 'RenderMan' from Pixar. In all other cases the combination of graphic-cards and the OpenGL standard languages is without alternatives, because the delegation of graphical tasks to the graphic card relieves the CPU substantially.

However, using the OpenGL standard languages implies the use of a set of specific functions with special data-types. This was taken into consideration, but to ease and simplify the development the modeler is written from scratch with its own data structure completely based on OpenGL.This part of the application is based on a simple object-oriented design utilizing threedimensional geometric primitives like boxes, cubes, spheres or cylinders. As shapes these objects are applicable to all kind of geometrically transformations like moving, resizing or rotating, and attributive variations like color changing, texture mapping or light features. As benefit of this approach all graphical changes are immediately shown onscreen as rendering, and if cameras are installed and feeding, as part of the augmented reality.

Also the abdication of a commitment to a dedicated file format for three-dimensional graphics allows
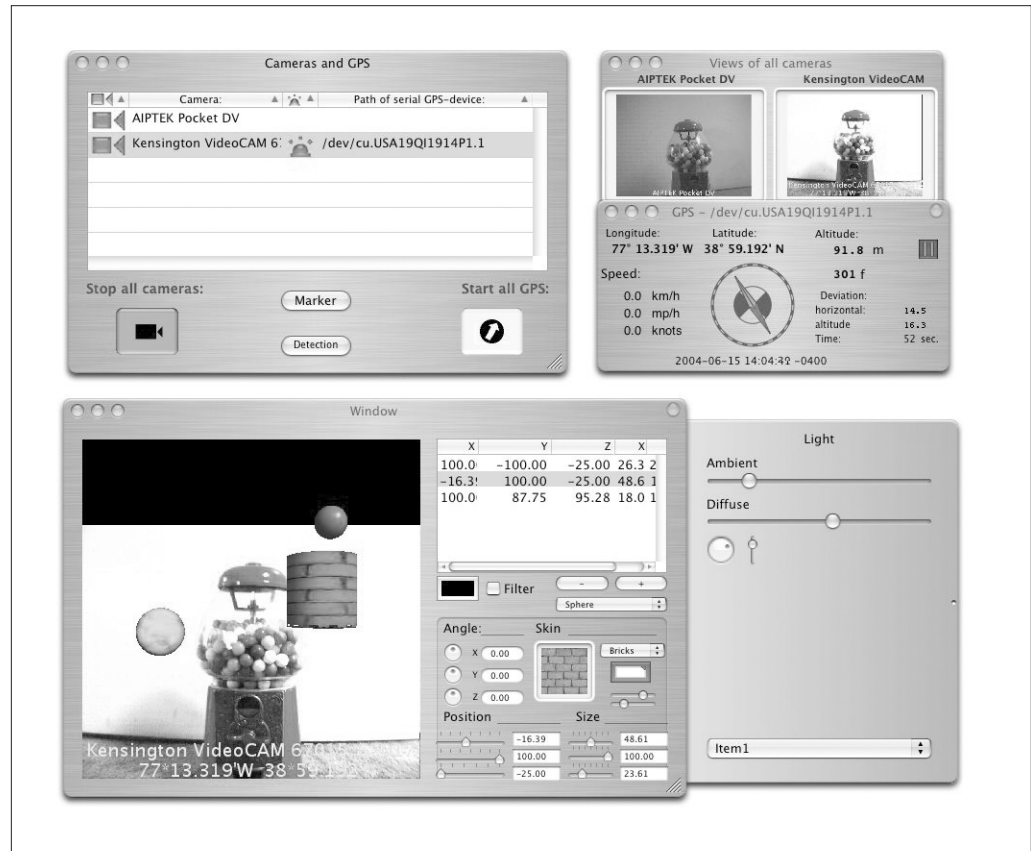

Figure 2
User interface of the application; connection-panel; multiple video and GPS input; composition of live stream video and interactive modeler with immediate results. (70_lonsing_fig02.jpg).

greater flexibility through the use of importers and exporters. This is not doen yet. As so far no attempt has been made to integrate any of the existing standard formats or addressing any of the standard CAD-programs directly through plug-ins. Therefor the import of models generated with other applications is presently not possible. This limitation will be addressed in the future.With the use of the interactive modeler the three-dimensional virtual scene is constructed and rendered using only OpenGL procedures, and the final image is already in place in memory on the graphic card. With these technique the former bottleneck 3D-rendering is overcome.

Composing

Composing the captured and generated images into a composite scene is a comparatively simple matter of combining two buffers in the right order and displaying the results on-screen. Because of the uninterrupted flow of the process nothing can be corrected; the quality of the final composite is directly related to the quality of the video stream and generated images.

Still not added is the use of the sun's position determined by the GPS and additional atmospheric values applied during the examination of the fiduciary features.

Conclusion

This example of computational augmentation demonstrates, that the idea of using augmented reality with three-dimensional objects in real-time while being on-site is not wishful thimking, and that the use of techniques from several different areas of computation can still lead to new application and unexpected results. Although not fully functional yet, the concept of this application is already proven. Utilizing strictly live and outdoor equipment results as instant visualizations with fixed camera positions are expected in the nearby future. The remaining obstacles are more related to appropriate hardware then to the application's programing itself.

One major task is the physical connection between several computers, cameras and GPS-devices on site. While GPS can be connected via Bluetooth, and as alternative as GPS-over-IP with support from a wireless network, the demanding bandwidth

of video presently permits no other than fiber-optic connections without significant reductions to the quality, and/or the camera's range. As alternative stuttered images and cameras with close range may still be acceptable.Therefor intentionally all presented images are indoor images, because the demonstration of the working concept is more important than some handcrafted results for an ambiguous presentation, with the following exception.To demonstrate the expected final results a digital photo and a composite image from a predecessor program are shown,

This results were produced using measured values from a map to generate the rendering. Also the idea was developed to create an interactive modelerand use it like an overlay on several photos from different point of views.The idea of designing with a computer while being on-site similar to sketching forces the programing of an application to deliver immediate results with overall performance from the beginning. Utilizing strictly live and portable equipment instead of fancy goggles the realization of this idea is in reach.

Acknowledgements

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