DESKOTHEQUE DISPLAY SYSTEM

Multi-projector displays have been regularly employed in the domain of information visualization and interactive multi-user environments for years. Projector-camera systems ([1], [2]) enable the usage of consumer hardware for the construction of multi-projector displays on irregular surfaces within an environment.

The Deskotheque[1] display system [3] supports the deployment of interactive room-adaptive installations and multi-projector displays. Multi-planar projection surfaces are detected by means of locally mounted cameras and a virtual three-dimensional model of the environment is created. This 3D display model is used for compensating projective distortions and illumination effects of overlapping projectors as well as for the computation of interactions between multiple users and the input and output periphery.

A spatial interaction frame can be established by registering various coordinate systems (e.g. external tracking systems, spatial audio systems) with the virtual room model. The artist or programmer is thus enabled to handle user actions with respect to their position and orientation within the frame. Deskotheque manages the rendering of OpenGL scenes on multi-projector output displays in a perspective-neutral way suited for multiple users.

PROJECTION ENVIRONMENT

The multi-projector display of the TIYF installation is located in a 10x10x3 meters (WxHxD) space. Six projection canvases have been constructed. Each canvas is tilted by 10 to 20 degrees towards the room center and seamlessly connected to its neighboring canvases.

The resulting projection surface has a perimeter of almost 20 meters and features a roughly circular shape around the room centre thereby spreading an angle of approx. 270 degrees. The entire surface is lit by eight overlapping projectors. For the detection of the projected geometry, eight cameras are required. Projectors and cameras are all connected with a single PC.

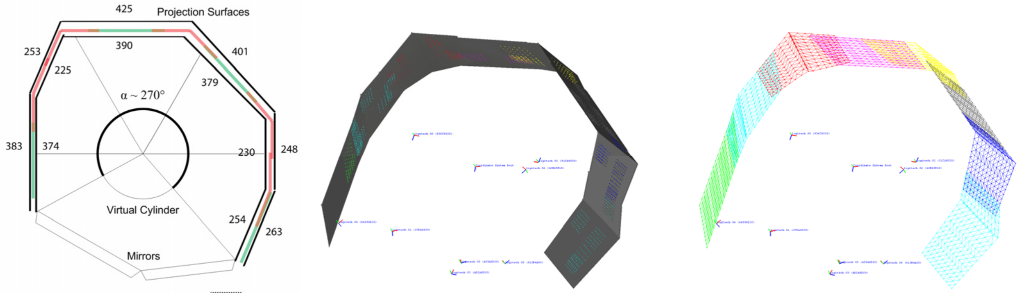
SOFTWARE FRAMEWORK

The Deskotheque framework is essentially composed of two software components. The first component is the interactive GUI application for the camera-based calibration of multi-projector displays. The outcome of the off-line calibration is stored in XML format for later retrieval. The second component is the runtime library which is initialized with an existing XML dataset and provides a programming interface for the TIYF OpenGL Pd/GEM[2] applications.

The calibration procedure is composed of three major sequential steps: 3D reconstruction, projector plane fitting and texture parameterization. In the following a brief overview is given while the interested reader may refer to Waldner et al. [4] for details.

---

[1] http://studierstube.icg.tu-graz.ac.at/deskotheque/
[2] http://gem.iem.at/



The 3D reconstruction step launches by showing structured light (e.g. checkerboard) patterns on the individual projections and capturing these patterns with all available cameras. Within the captured images, 2D points are detected. Corresponding points between pairs of cameras are employed to register camera poses and the 3D position of detected points in space.

The reconstructed point cloud is then converted into a polygonal plane model. Deskotheque assumes that each projection is potentially located on multiple planes within the environment. Hence, planes are fit into the point cloud and – since projections are finite – clipped at their borders. The resulting polygonal patch model reflects the projected room geometry and the boundaries of the individual projections.

At runtime, the projection imagery is given as 2D image located in an OpenGL frame buffer. During the texture parameterization step, 2D coordinates are mapped onto the 3D display model in such a way that distortions from oblique and overlapping projections are removed. For that purpose, a vertically aligned virtual cylinder is inserted into the center of the 3D scene. The unreeled cylinder represents the 2D frame buffer image. The actual mapping takes place by parallel projection: from the center axis of the cylinder parallel rays run out which hit the cylinder surface (2D point) as well as the display geometry (3D point). For the compensation of color gradients in the overlapping projection areas, alpha masks are computed for each projector.

The Deskotheque runtime library provides the application programmer information about the spatial distribution of displays and other entities. Among others, spatial relationships of user interactions with display or audio systems can be established. Within the TIYF installation, the users' lines of sight are intersected with the display geometry. The resulting 2D coordinates are used to place graphics content in the scene which is finally rendered in front of the users "eyes" on the projected display. The inverse mapping from 2D to 3D can for instance be used to invoke sounds in space relative to some graphics content on the display via some external spatial audio system.

REFERENCES

[1] R. Raskar, J.V. Baar, P. Beardsley, T. Willwacher, S. Rao, and C. Forlines, "iLamps: geometrically aware and self-configuring projectors," ACM Trans. Graph., vol. 22, 2003, pp. 809-818.

[2] O. Bimber, A. Emmerling, and T. Klemmer, "Embedded entertainment with smart projectors," ACM SIGGRAPH 2005 Courses, ACM, 2005, p. 8.

[3] C. Pirchheim, M. Waldner, and D. Schmalstieg, "Deskotheque: Improved Spatial Awareness in Multi-Display Environments," Virtual Reality Conference, 2009. VR 2009. IEEE, 2009, pp. 123-126.

[4] M. Waldner, C. Pirchheim, and D. Schmalstieg, "Multi projector displays using a 3D compositing window manager," Proceedings of the workshop on Immersive projection technologies/Emerging display technologies. ACM, 2008, pp. 1-4.