Towards a unified approach to 3D environment capture and rendering.

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Two technologies for reconstruction of environments have emerged in recent years: active scanning with a laser rangefinder, and passive photogrammetry. While these techniques have taken great strides in realism in recent years we believe the best solution for 3D capture ultimately lies in the integration of these two methodologies. To this end we have developed a software framework to handle the different data types and integrate two capture methods.

Our chosen capture techniques are the Façade photogrammetric modelling system, developed by Paul Debevec et al from UC Berkeley, and Laser scanning techniques developed by Lars Nyland and his colleagues at UNC, now commercialised by 3rd Tech as the Deltasphere 3000 scanner.

Debevec et al. in [1996] recovers a geometric proxy based on the perspective of marked lines. To generate models, photographs are required that exhibit strong perspective – the corners of buildings or rooms. In viewing these models look quite realistic, we believe partly because they are geometrically complete and free of holes that cause distracting artefacts. The method begins to fail where geometric complexity increases and the scene starts to become more cluttered.

The hybrid point and polygon-based is shown rendered with shading.

Nyland et al. in [2001] develop a realistic capture and modelling system using a scanning laser rangefinder. Colour images are employed to derive the colour of the surface only, no 3D geometry recovery is attempted. The resulting models reproduce detail very well but holes result from occlusions or dark surfaces. In a built environment such as a room, many scans and many millions of points are required to produce a model with good realism, however many of the recovered points will be co-planar.

To facilitate integration we have created a framework for handling polygonal and point data using the object-oriented visualisation toolkit, or VTK. VTK is readily extensible and already contains many relevant methods to this problem. For image-based rendering we have adopted the Renderman standard and have developed custom light source shaders to produce view dependent effects. We have used the Blue moon rendering tools for the images in this paper.

Our methodology is to use the proxy recovered from façade as a framework for the model. We use the laser-derived points to represent detailed geometry such as furniture and remove points that lie on the surface of the proxy. We improve on the technique in [Stamos and Allen 2000] to achieve planar segmentation of range images. The planar regions in the range data are aligned to those in the proxy via a two-stage alignment: a closed approximate quaternion-based alignment stage followed by an accurate transformation via the iterative closest point algorithm. This results in up to an 80% reduction in the size of the point cloud. Use of the proxy automatically fills any holes that would be present in the point cloud when rendering and allows for easy registration of multiple scans. We have found use of this proxy considerably simplifies the process of producing a model from laser scan data.

The model set shown left is rendered with view-dependent texture mapping. Areas occluded from the laser are shown in red.

In conclusion we have seen some of the benefits from integration of these two techniques. Our future plans include a better global treatment of the errors in the two sensing modalities and a real-time renderer using pixel shaders.

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