Persepolis:Recovering History with a Handheld Camera

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We present new improvements to our novel pipeline for image based modeling of objects using a camcorder. Our system takes an uncalibrated sequence of images recorded around a scene, it automatically recovers the underlying 3D structure and camera path and then a volumetric scene reconstruction is performed using a hardware accelerated voxel carving approach. Finally a triangular mesh is obtained and the available information from the images is combined to generate a full 3D photo-realistic reconstruction. As an application, we use this system to reconstruct parts of the archeological site of Persepolis (Iran).

For more information: ibmrlab.ece.uci.edu, www-ma1.upc.es/~susin/contingut/labsid.html

The Reconstruction Pipeline

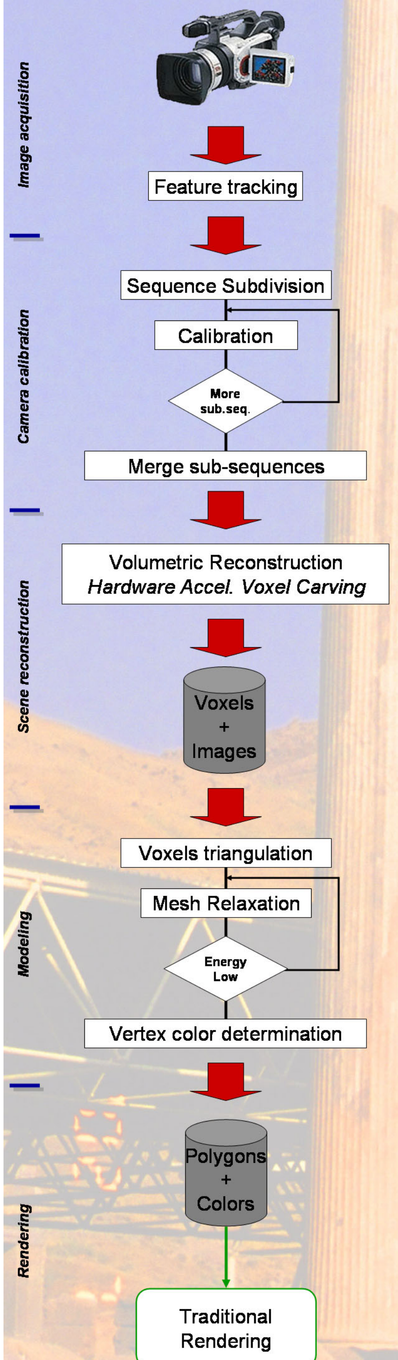
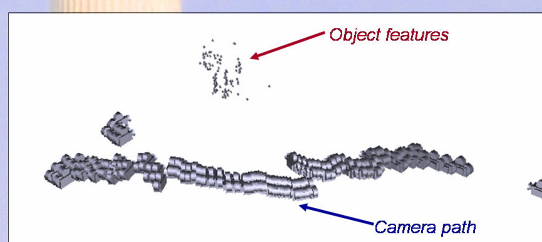


Image acquisition

During the image acquisition process we use a standard off-the-shelf camcorder and walk around the object to be reconstructed assuming no restrictions on the path, number of frames and camera parameters. Using a 2D tracking system, a set of significant features are extracted from the images.

Camera calibration

The second step is to automatically calculate the 3D position of the tracked features, the position and orientation of cameras and their internal parameters (such as the focal length). This is a very complex problem and we have successfully developed algorithms that perform these calculations automatically using a non-linear least squares numerical approach.



Scene reconstruction

Starting from the calibrated cameras and a subset of the images, we perform a spatial carving operation on a piece of virtual material (imagine an artist sculpting a raw block of marble). To do so we divide the space into small cubes (voxels) and iteratively remove those voxels that, when projected to each of the views, do not maintain a constant color value.

The carving algorithm is computationally very intensive and we exploit the hardware acceleration of the actual video-cards to reduce the run time, making this method a very attractive solution suitable for standard PC's.

Modeling

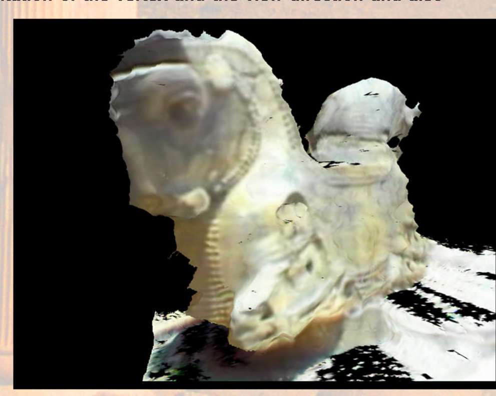
The final step of the pipeline is to generate a triangular mesh suitable to be rendered in a standard graphics pipeline. We generate a globally smooth surface model from the binary segmented volume data retaining the detail present in the original segmentation. A triangular mesh is constructed by linking nodes on the surface of the binary-segmented volume and relaxing node positions to reduce energy in the surface net while constraining the nodes to lie within a surface cube defined by the original segmentation. Finally a color per vertex is assigned by using a weighted average of colors from the reference images that see the vertex being colored. The weight for each view is calculated taking into account the relative orientation of the vertex and the view direction and also the proximity of the viewpoint to the vertex.

Rendering

The real-time rendering algorithm consists of rendering a colored mesh and re-lighting can be easily applied.

The example on the right is a model triangulated mesh of 203391 vertices and 409978 faces. The rendering time is 6.5 frames per second without any level-of-detail simplification.

The model has been reconstructed from an original sequence of 702 frame, using a final set of 12 frames during the volumetric reconstruction.



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