



# 3D Reconstruction, Content Extraction, Human Motion Tracking Using Video

Department of Computer Science

University of North Carolina at Chapel Hill

August 2007

Our work aims at fast and accurate 3D reconstruction and information extraction and human body motion tracking using video streams. Since 2005, we have been working on real-time 3D reconstruction of urban environments using videos captured by 8 cameras mounted on a vehicle. Our processing pipeline is able to generate detailed, textured models that can be used for effective visualization of very large areas. We are also working towards achieving the same performance and results on videos captured by unknown hand-held cameras. In order to be able to recognize previously reconstructed scenes, we employ a recognition module based on invariant features. The recognition can then be used for detecting changes and displaying location based information. We are also investigating methods for making high-level inferences about the scene, such as whether it is indoors or outdoors.

## From video to 3D models

The key enabling technology for our research is Structure from Motion which is based on the fact that 3D properties of the world that have been lost during projection to the 2D images can be recovered. This is possible if there was relative motion between the camera and the scene during the recording of the images or video streams. Processing begins by detecting pixel correspondences in consecutive frames of the video. These correspondences and auto-calibration techniques allow us to estimate the intrinsic parameters of the camera and its pose at each frame.

3D reconstruction can effectively summarize the static parts of a large scene in a detailed model that can be perused in a few seconds. At the core of the framework lies an adjustable 3D reconstruction engine that generates complete, textured 3D models of the observed surfaces in real-time utilizing the GPU. Once 3D models of the scene and potentially the objects have been computed, tasks such as mensuration and context inference can be performed.



## Highlights

**We have recently obtained very satisfactory results in several domains related to 3D reconstruction at processing speeds that are orders of magnitude faster than the previous state-of-the-art.**

- **Under the DARPA UrbanScape program, we have achieved faster than real-time reconstruction of urban scenes from videos captured on a vehicle which is equipped with a GPS and INS unit. The reconstructed models have been measured to be within a few cm of surveyed buildings.**
- **We have achieved encouraging preliminary results in the registration of images of the same location downloaded from the Internet despite different viewpoints, imaging and illumination conditions.**

## Technical Challenges

Performing 3D reconstruction and context inference on arbitrary videos captured by unknown cameras presents several challenges to the processing system. Key challenges include the following:

- Unknown cameras
- Unknown pose for each frame
- Determining the feasibility of reconstruction
- Fast and accurate 3D reconstruction
- Recognition of observed landmarks and change detection
- Mensuration
- Selection of cues for context inference



## Markerless Human Motion Capture

We are working on approaches to track human body motion from vide. Our group developed a factorization-based approach for analyzing articulated and non-rigid motions. An important result that we have obtained is that the linear motion subspaces of articulated bodies intersect and that their intersection corresponds to the motion subspace of the joints.

### People

**Marc Pollefeys**, Associate Professor

**Jan-Michael Frahm**, Research Assistant Professor

**Brian Clipp**, Graduate Research Assistants

**David Gallup**, Graduate Research Assistants

**Seon-Joo Kim**, Graduate Research Assistants

**Xiaowei Li**, Graduate Research Assistants

**Sudipta Sinha**, Graduate Research Assistants

**Changchang Wu**, Graduate Research Assistants

### For More Information

Marc Pollefeys, [marc@cs.unc.edu](mailto:marc@cs.unc.edu) (919) 962-1845

Jan-Michael Frahm, [jmf@cs.unc.edu](mailto:jmf@cs.unc.edu) (919) 962-1703

