Real-time 3D reconstruction: applications to collision detection and surgical workflow monitoring

Nassir Navab
Alexander Ladikos, Nicolas Padoy, Diana Mateus and Cedric Cagniart

Presented by Nicolas Padoy
Computer Aided Medical Procedures (CAMP)
Technische Universität München, Germany
Motivation

Due to safety concerns: 
*Medical Robots are not used at their full speed & functionality:*

- Need to predict and avoid collisions

Siemens/Kuka Angiographic robot (Zeego)
Motivation

Due to safety concerns: *Medical Robots are not used at their full speed & functionality:*

- Need to predict and avoid collisions
- Need to reconstruct & recognize objects in dynamic, complex environment
- Need to recover and monitor surgical workflow
Multi-view Real-time Reconstruction
Shape-from-Silhouette: Real-time 3D reconstruction Systems

- There are many real-time systems today
- It is comparatively easy to build such a system due to increase in computational power and its availability at reasonable price
- Most systems use the volumetric approach due to its simplicity
- One notable exception is the GrImage platform at INRIA Rhône-Alpes
Shape-from-Silhouette: CAMP system

- 16 synchronized cameras mounted on the ceiling
- Working volume 3.5m x 3.5m x 2.5m
- Runs at 30 Hz
Shape-from-Silhouette: CAMP system

- Camera images
- Silhouette images
- Local Reconstruction

Slave 1
Slave 2
Slave 3
Slave 4

Network

- Local Reconstructions
- Global Reconstruction
- Secure Hulls
- Visualization

Master
Shape-from-Silhouette: CAMP system
Collision Avoidance System: CAMP system
Shape-from-Silhouette: Summary

• Advantages
  – Only silhouette images are required
  – No need for correspondences or texture
  – Robust
  – Efficient and easy to implement

• Disadvantages
  – Cannot recover concavities not seen in the silhouette images
  – Artifacts for complex scenes and low number of cameras
  – Needs calibrated input images
  – Silhouettes need to be recovered
Additional applications of real-time 3D reconstruction:

Increasing the safety for interventional radiology crew:

Real-time 3D reconstruction
 +
Recognition and 3D surface path tracking
 +
Radiation distribution and scattering modeling/estimation
 +
Estimation of individualized accumulated radiation to body parts
Additional Applications of real-time 3D reconstruction:
Recovering and monitoring surgical workflow for predicting the need and triggering/controlling events

Acquisition of training data
+
Recovery of workflow based on signals (see next talk)
+
Recovery of workflow based on 3D flow
+
Monitoring of workflow and use for UI & robot control (see next talk)
Workflow Monitoring based on Multi-view Reconstruction

Nicolas Padoy, Diana Mateus (CAMP, TUM, Munich)
Daniel Weinland (CVLAB, EPFL, Lausanne)
Scenario & Data

- Dataset of 22 sequences
Methods: 3D-flow

- Capture global activity pattern
- Lucas-Kanade in 3D
- Spatial histograming
  - Smooth voting with RBF
- Orientation quantization
  - Uniformly in 12 directions
- Observation vectors
  - Size 216
  - Dimensionality reduction
Methods: Workflow-HMM

- Temporal process modeling
- Hierarchical HMM with 2 levels, augmented with phase probability variables
- Dynamic Bayesian Network representation:
Recovery of workflow based on signals
Recovery of workflow based on signals
Follow up project at TUM:

• Joint DACH project with:
  - EPFL (P. Fua, V. Lepetit)
  - TU Graz (H. Bischof)

- Five researchers over three sites
- Multi-camera systems in OR
- + Kinect, TOF, Inertial Sensors, …
- Development of advanced workflow based Surgical interfaces …

Looking forward to national and international research collaboration …
Thanks to CAMP@TUM

2009/11pubs : 9 TMI, 4 MedIA, IJCV, PAMI, 29 MICCAI, 12 CVPR, 3 ICCV, 3 ECCV, 9 ISBI, 7 ISMAR, 8 BMVC, 2 IPMI, 2 IPCAI, …
Thank You

For more information

visit:

campar.in.tum.de