Evaluation and Optimization of Virtual Rigid Body

Project 14

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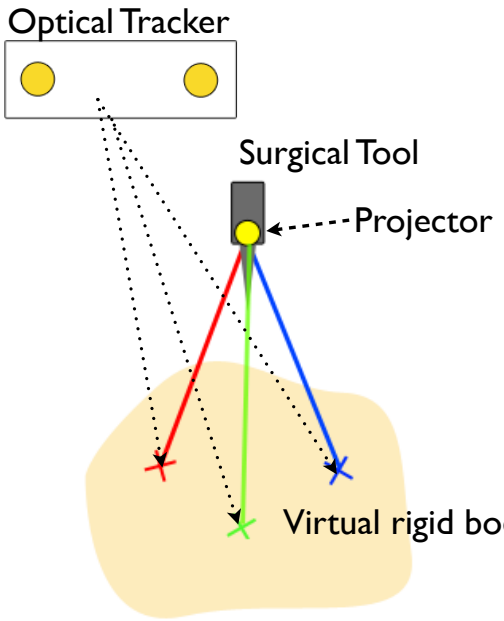
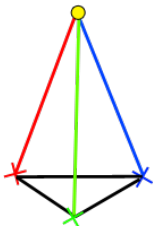
February 25th, 2014

"Virtual" Rigid Body

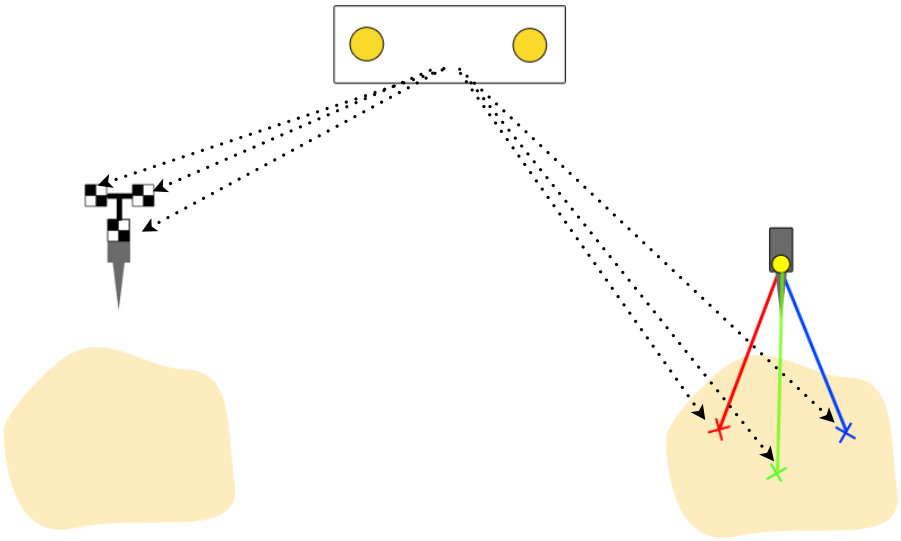


- A projector is attached to the surgical tool to be tracked.
- The projector shoots light beams.
- The virtual rigid bodies are detected by the optical tracker.
- The pose of the projector is recovered by fitting the detected points to a pyramidal model.



Figures redrawn from (Cheng et. al., 2014)

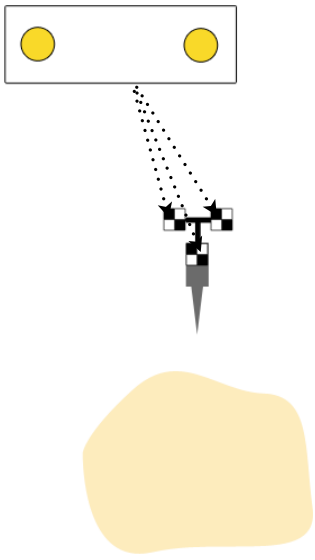
Comparison to Conventional Markers



Conventional Markers

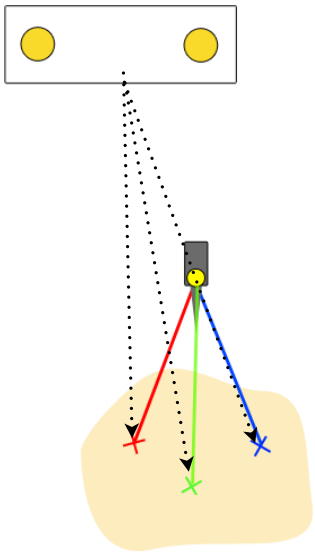
Virtual Markers

Limitations of Conventional Markers



- Limited marker size
  - Cannot be much larger than the tool, especially in crowded surgery settings
  - Limited accuracy
- Limited tool movement due to field of view (FOV)
  - Marker is distant from the surface of interest.
  - Tool must be in the optical tracker's FOV.
- Occlusions
  - If the surgeon gets in the way between the tool and tracker, the marker is occluded and cannot be tracked.

Benefits and Importance of Virtual Markers



- Freedom of marker size
  - Larger markers can be projected, allowing higher accuracy.
- Freedom of tool movement
  - Because projected, virtual markers lie on the surface of interest.
  - The tool does not have to be in the optical tracker's FOV.
- Robustness to occlusions
  - Less likely to be occluded.
  - Redundancy can be easily introduced.
  - If a marker falls on the surgeon's hand for example, the pose of the projector can still be estimated.

Current State, Goal and Approach

- Current state :
  - Accuracy is comparable to the conventional markers.
  - Design specifications are yet undetermined.
- Goal :
  - Test and evaluate factors related to performance of virtual markers.
    - Size of virtual markers
    - Shapes of virtual markers
    - Tool (projector) pose and motion
    - Number of virtual markers
  - Determine optimal design.
- Approach :
  - Evaluate and compare tracking accuracy using virtual and conventional markers

Approach

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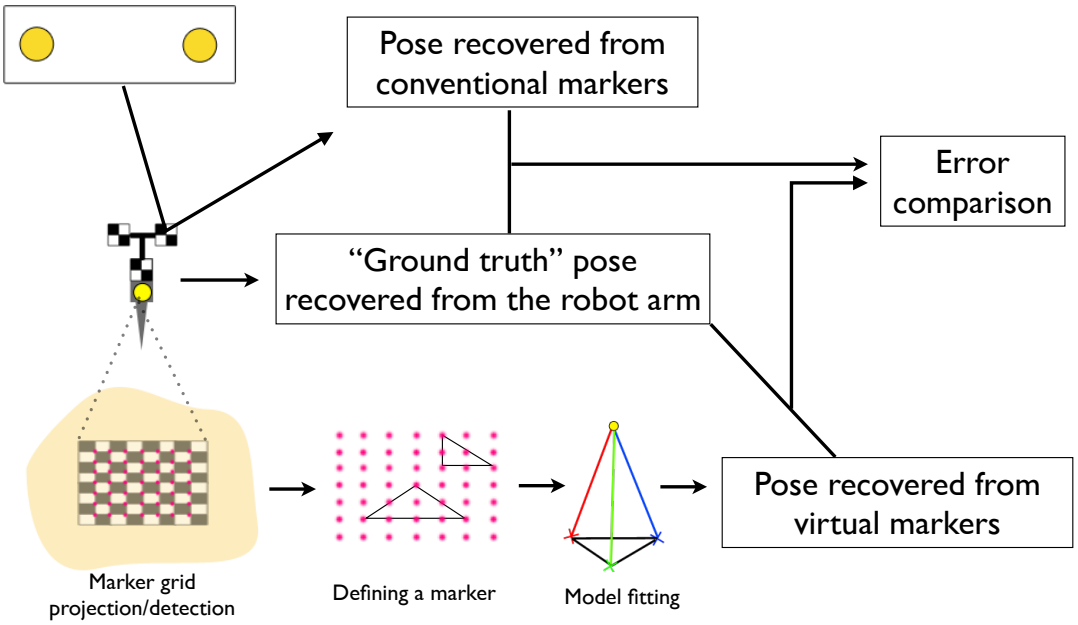
For a given pose,



Approach

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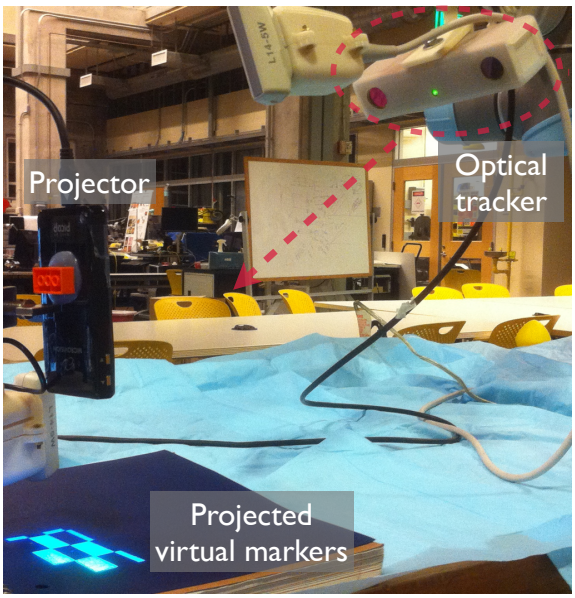
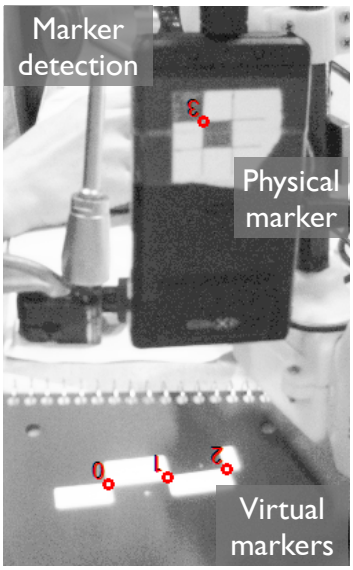


Overall Setting



View from Optical Tracker

Deliverables

- Minimum
  - Marker grid
  - Experimental routines in form of python or C++ codes
  - Experimental data
- Expected
  - Analysis and evaluation of different sets of virtual markers
  - Optimal design of virtual markers
- Maximum
  - Publication
  - Experimental data on non-level surfaces.
  - Introductory ideas on projector design.

Key Dates

- Feb. 28th :
  - Literature study, training for UR5 control
  - Virtual marker grid development
  - Resolve dependencies (to be explained in the following slide)
- Mar. 15th :
  - Develop and document a package of routines to acquire data from the MicronTracker and UR5 robot.
- Mar. 31st :
  - Experimental design (robot arm trajectories, marker shapes, etc.)
  - Data gathering for fixed pose and a trajectory of poses
  - *Minimum deliverables*
- Apr. 15th :
  - Analyze and determine optimal marker parameters.
  - *Expected deliverables*
- Apr. 31st :
  - Further experiments, such as on non-level surfaces, publication
  - *Maximum deliverables*
- May 9th : Poster presentation, final report

Dependencies

- Hardware
  - MicronTracker
  - Universal Robots robot arm and controller
  - Robot - projector adapter
    - ➡To be printed with a 3D printer.
  - Laptop
- Commercial Software
  - MicronTracker SDK
  - Universal Robots control system
- Internal algorithm and software
  - Pose estimation of the projector given the coordinates of markers
- Miscellaneous
  - Access to Hackerman hall Robotorium

*Unresolved

Management Plans

- Weekly meetings with Alexis at 16:30 on Tuesdays.
- Meetings with Dr. Boctor by appointment.
- Keeping a log
- Since working alone, probably a struggle with myself to balance the project with other coursework.
- The UR5 and MicronTracker system are shared with other groups. Prior scheduling and coordination will be necessary.

Reading List

- Cheng et. al., *Virtual Rigid Body: A New Optical Tracking Paradigm in Image Guided Interventions,* to appear in CARS 2014
- McIlroy et. al., *Kinectrack: Agile 6-DoF Tracking Using a Projected Dot Pattern,* ISMAR, 2012
- West et. al., *Designing Optically Tracked Instruments for Image-Guided Surgery,* IEEE Transactions On Medical Imaging, 2004
- Wieness et. al., *Sceptre - An Infrared Laser Tracking System for Virtual Environments,* VRST, 2006
- Wiles et. al., *Accuracy assessment and interpretation for optical tracking systems,* Medical Imaging 2004: Visualization, Image-Guided Procedures, and Display, 2004