Project 16: Da Vinci Intelligent Surgical Assistance

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Mentors: Kel Guerin, Jon Bohren, Prof. Greg Hager
Robotic Tasks

- Grab a needle
- Cut a thread
- Move the camera
- Manipulate small objects or tissue
Example: Transfer object from top to bottom, avoiding knocking over the marker.

Why should users have to do this every time?
Case 1: Peg Transfer Task
Case 2: Grabbing a needle after suture throw
Prior Work

• Language of Surgery project
• Partial automation work by Dr. Nicolas Padoy and Sebastian Bodenstedt
• Learning from Demonstration research with Amir Masoud
Specific Aims

- Formalize methods for modeling tasks and predicting user intentions
- Extract scene information from Da Vinci data
- Develop software to model portions of tasks
- Apply methods to simple test example
- Apply methods to Da Vinci example
Technical Approach: Three Key Components

- Inverse Optimal Control to model performance of a specific task within a procedure
- Features extracted from 3D data (stereo video) or object information (simulation)
- Temporal logic describing the relationship between components of a procedure

Work will require a simulation for software development and use the ISI BB API to write commands to the Da Vinci for suturing case.
Inverse Optimal Control

Finds a *reward function* relating an observed change in state to changes in observed features of the environment.

\[
P(a_0|s_0) = \frac{1}{Z} \sum_t r(s_t, a_t)
\]
Stereo Video Processing
Registration Based on Tooltips
Temporal Relationships

- Develop a task model to determine when a robot should take over control from a human.
- When are certain components of a task complete?
Gazebo and ROS Integration
Simulating a WAM Arm in Gazebo
Minimum Deliverables

- **Simple stereo** registration and reconstruction for collected Da Vinci video data
- **Formal approach** for modeling components of a procedure
- **IOC software** for computing task models
- **Simulation** peg transfer task set up, performed by human users
Expected Deliverables

- Partial automation of peg transfer task, running in the simulation environment.
- Tooltip-based stereo registration to automatically register and extract visual features from collected Da Vinci data.
Maximum Deliverables

- Partial automation of suturing task
- **Semi-automation toolkit** for use on other problems and on different robots
Dependencies

- Access to Da Vinci robot for experiments
- Access to surgical data, with video, camera positions, and robot kinematics
- Workstation with simulation capabilities for developing software
Software Dependencies

- OpenCV
- Gazebo
- ROS
- NLOPT (or other numerical optimization toolkit)
- ISI BB API
Milestones

- Formal Algorithmic Approach: 3/14/2014
- Tooltip-based Stereo Registration and Reconstruction: 3/7/2014
- Model Task Components: 3/14/2014
- Peg Transfer Task: 4/11/2014
- Suturing Task: 4/25/2014
Management Plan

- Weekly meetings with mentors at 11 am on Monday
- Biweekly meetings with Prof. Hager at 9:30 am on Wednesdays
- Weekly discussions with graduate student mentors on Wednesday at 1 pm
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References


Image References


- Slide 5, 9, 10 images from: Language of Surgery data set, public release version. Available online at https://cirl.lcsr.jhu.edu/Research/HMM/


- Slide 14 image from Jon Bohren

Questions?