Enhanced Simulation for the daVinci System

Group 6
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MENTORS

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Intuitive Surgical Inc. (ISI)
Outline

• Background, Introduction
• Motivation, Goal, Significance
• Proposed Approach
• Deliverables
• Dependencies
• Management
• Resources
Background

- Intuitive Surgical Inc. (est. 1995)
- Three generations of robotic systems
  - daVinci Standard
  - daVinci S (upstairs in the Mock OR)
  - daVinci Si (currently in use at most OR’s)
- Over 2000 systems in circulation worldwide
- Around 360000 procedures in 2011
daVinci Surgical System

• Surgeon Console (Master)
  – Stereo Viewer
  – Joysticks with 7 DOF’s (MTM’s)
  – Foot Pedals

• Patient Cart (Slave)
  – 4 Telerobotic Arms
    • 3 Instruments (PSM’s)
    • 1 Endoscope (ECM)
Limitations to Training

- Scarcity of robot time for training (overbooked for cases)
- Huge space requirements (if dedicated for training)
- Constant need for replenishing phantoms (most are not reusable)
daVinci Skills Simulator

- Simulate the patient side cart!
- Removes the need for vision cart and patient side

Anastomosis Task using daVinci Skills Simulator

- Repeatability
- Structured environment for training assessment
- More wider applications ...
However,

- Simulation exercises outsourced to *Mimic Simulation Inc.* (which acts as a **black box**)

- Developer has no access to the graphics rendering and the environment
Goal

• Develop a simulation framework for the daVinci System using Open Source dependencies (except ISI API)
  – CISST-SAW [5,6] (developed at ERC-CISST, JHU)
  – H3DAPI [7]
Significance

- Enable researchers to design their own environments using graphics and physics models
- Enable developers to add new object models for new applications
- Prove to be a great source for ground-truth data
- Be the testing ground for learning approaches to model task performance
- Allow simulating patient specific anatomical data to plan a surgical procedure
Current Work

- ISI (Ashwin) implemented a sandbox
  - Interfaces to the Si console (Skills Simulator) only!
  - Object models (graphics + physics)
    - Instruments
    - Manipulation objects
  - Some exercises
Technical Approach


• Open source libraries – CISST-SAW, H3DAPI

• Extensions to existing components

• Framework flow
### ISI API

<table>
<thead>
<tr>
<th>Type</th>
<th>Read</th>
<th>Write</th>
<th>Setup</th>
<th>CISST-SAW component</th>
<th>daVinci Version support</th>
</tr>
</thead>
<tbody>
<tr>
<td>ISI-API</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Standard, S, Si</td>
</tr>
<tr>
<td>ISI-BB-API</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>Yes (lacks features)</td>
<td>S</td>
</tr>
<tr>
<td>ISI-SIM-API</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>Si</td>
</tr>
</tbody>
</table>

- Only *closed* component of the framework [4]
- Used to communicate with the daVinci systems
- ISI-BB-API requires a slave ‘*core*’ for sending commands to the system
- Need features from both SIM-API as well as BB-API
Open Source Libraries

• CISST-SAW [5,6] (developed by ERC, LCSR, JHU)
  – Libraries for computer assisted interventions
  – Based on component-interface model
    • Every component needs some ‘required’ and offers some ‘provided’ interfaces
    • Two components can talk when these are met
      – e.g. a master and a slave

• H3DAPI [7]
  – Open source scene graph API
  – Built using OpenGL (graphics) and HAPI (haptics)
  – Contains H3DPhysics toolkit for physics engines
CISST-SAW Development

- `sawIntuitiveDaVinci` component exists for the ISI-API
- Separate component for BB-API exists with lesser features (merging soon with `sawIntuitiveDaVinci`)
- Extend the BB-API to incorporate features from SIM-API
- Implement a `virtual core` similar to the slave core on S, Si or the mini core on the Skills Simulator for state maintenance
H3D Development

• Mimic existing custom nodes to work with CISST-SAW components for the BB-API and the virtual core

• Existing sandbox uses the ODE (Open Dynamics Engine) – rigid body physics only!

• Use PhysX engine implementation for future incorporation of anatomical models
Deliverables

- **MINIMUM**
  - Extend CISST-SAW component for BB-API
  - Create a ‘virtual slave core’ component for the simulation
  - Demo *sandbox* using a basic example

- **EXPECTED**
  - Extend sandbox to incorporate camera control, clutching
  - Demo using an application like Match Board task

- **MAXIMUM**
  - Extend *sandbox* by developing new models
  - Demo an application using these models
# Dependencies

<table>
<thead>
<tr>
<th>Dependency</th>
<th>Resource</th>
<th>Alternative</th>
<th>Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>daVinci Skills Simulator assess</td>
<td>Other projects usage</td>
<td>None</td>
<td>Not much, project can move forward</td>
</tr>
<tr>
<td>Development Drive for Simulator</td>
<td>Anton</td>
<td>None</td>
<td>Not much, project can move forward</td>
</tr>
<tr>
<td>daVinci S System assess</td>
<td>Other projects usage</td>
<td>Make sure to reserve on calendar</td>
<td>Slow down!</td>
</tr>
<tr>
<td>Funds for using the daVinci S</td>
<td>Prof. Taylor</td>
<td>None</td>
<td>Need this!</td>
</tr>
<tr>
<td>Computer for simulation</td>
<td>ISI (info), Prof. Taylor (approval)</td>
<td>None</td>
<td>Need this!</td>
</tr>
<tr>
<td>Test hardware pipeline</td>
<td>New GPU</td>
<td>Other GPU</td>
<td>Project heavily depends on this</td>
</tr>
<tr>
<td>H3D library svn assess</td>
<td>Network Security</td>
<td>Use network outside Hopkins</td>
<td>Not much, unless bugs get fixed in future revisions</td>
</tr>
<tr>
<td>CISST BB-API component</td>
<td>Anton</td>
<td>Do myself</td>
<td>Crucial for communication with robot</td>
</tr>
<tr>
<td>ISI-BB-API assess</td>
<td>Anton</td>
<td>None</td>
<td>Need this!</td>
</tr>
<tr>
<td>Existing Sandbox from ISI</td>
<td>Ashwin, Simon</td>
<td>None</td>
<td>Slow down!</td>
</tr>
</tbody>
</table>
Timeline and Milestones

2/26/2013

Enhanced Simulation for daVinci System - Group 6
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- Test ISI Sandbox on Skills Simulator
- Test the basic Sandbox on S console
- Develop new models using Sandbox
- Extend the Sandbox for console events and test
- CISST component for BB-API and virtual slaves core
Management Plan

• Weekly meeting with Anton – Wednesdays at 2pm
  – Might change to accommodate Prof. Taylor at the meeting

• Fortnightly meetings with ISI already set for the JHU-ISI group – Thursdays at noon

• Standing meeting time – tentatively Thursdays at noon (Anton, Simon, Ashwin)
Acknowledgements

• Swirnow Family Foundation
  – Mock Operating Room and related equipment
  – Funds for the project

• Intuitive Surgical Inc.
  – daVinci S Surgical System
  – daVinci Skills Simulator
  – Funds for the project
References, Reading

1. Intuitive Surgical Inc., daVinci Si System User Manual
Questions?

Thank you!