

Enhanced Simulation for the daVinci System



Group 6

Anand Malpani (Graduate, CS)

MENTORS

Anton Deguet

*Sr. Software Engineer
(LCSR)*

*Johns Hopkins
University (JHU)*

Prof. Taylor

*Professor (CS) & Director
(ERC-CISST)*

*Johns Hopkins
University (JHU)*

Simon DiMaio

Sr. Manager

*Research and Advanced
Systems Development,
Intuitive Surgical Inc. (ISI)*

Ashwin Prakash

Software Engineer

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)



daVinci S Surgeon Console (Master) ^[1]



daVinci S Patient Side Cart (Slave) ^[1]

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)



Space needs for set-up [2]



Anastomosis Task using daVinci S system and real phantoms

daVinci Skills Simulator

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



daVinci Skills Simulator [3]

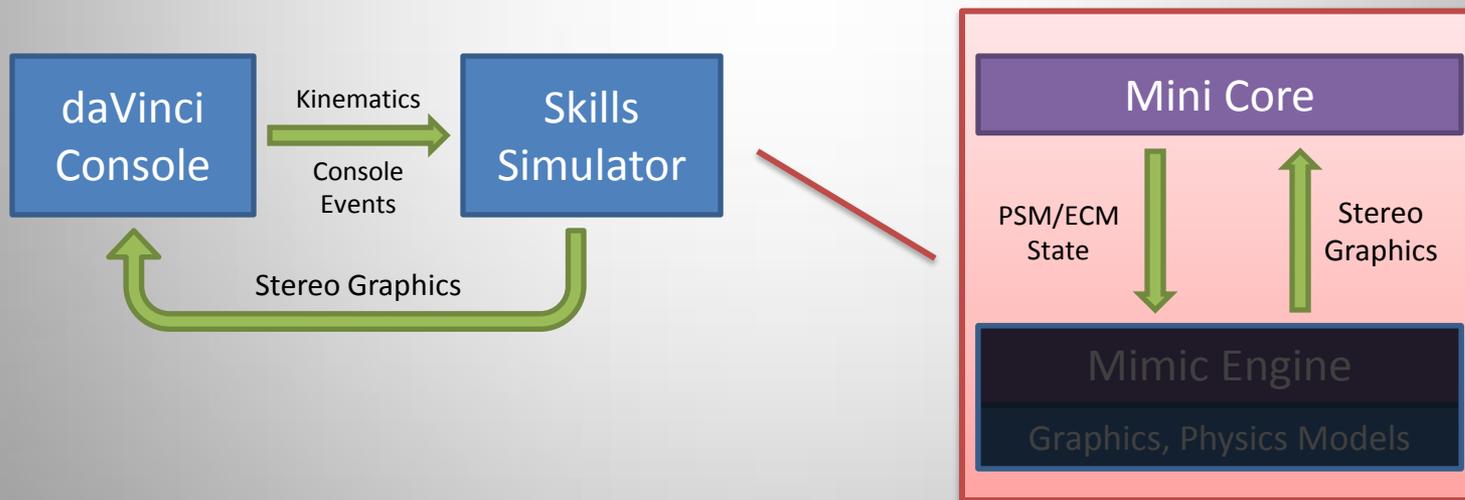


Anastomosis Task using daVinci Skills Simulator

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

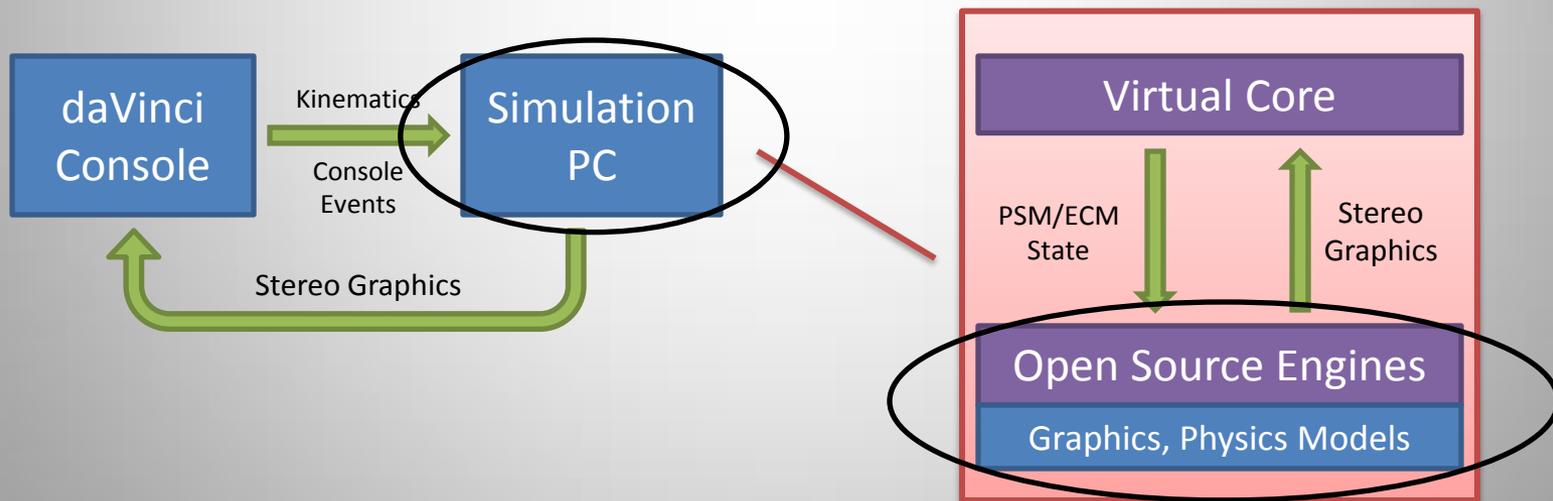
However,

- 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



daVinci Skills Simulator – Match Board



ISI Simulation Sandbox – Match Board

Technical Approach

- ISI API ^[4] – daVinci research interface
- Open source libraries – CISST-SAW, H3DAPI
- Extensions to existing components
- Framework flow

ISI API

Type	Read	Write	Setup	CISST-SAW component	daVinci Version support
ISI-API	Yes	No	No	Yes	Standard, S, Si
ISI-BB-API	Yes	Yes	No	Yes (lacks features)	S
ISI-SIM-API	Yes	Yes	Yes	No	Si

- 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

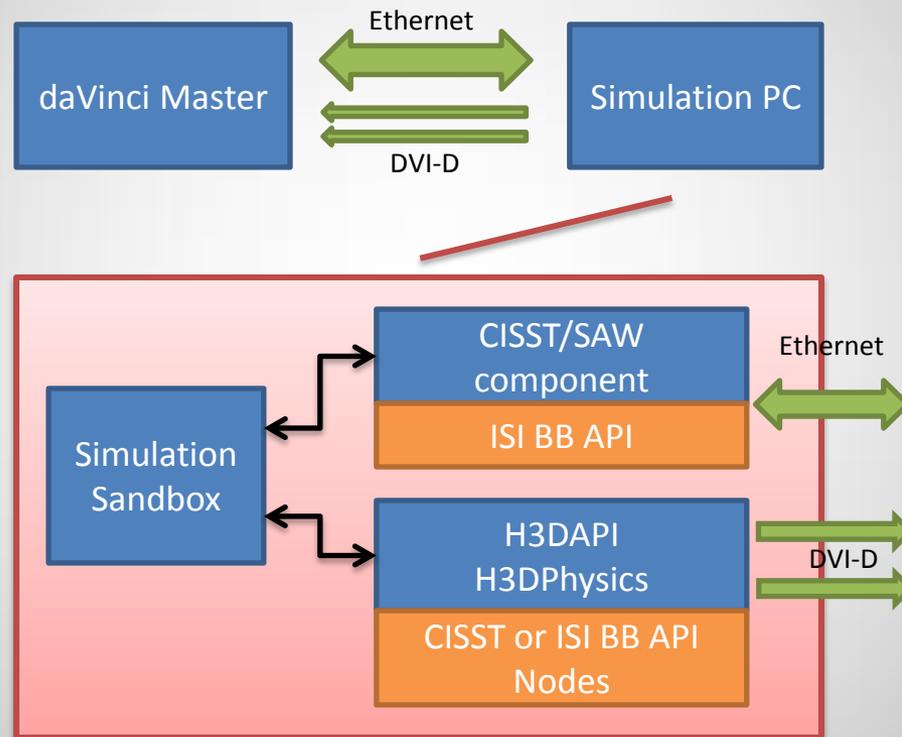
CISST-SAW Development

- *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

Proposed Framework



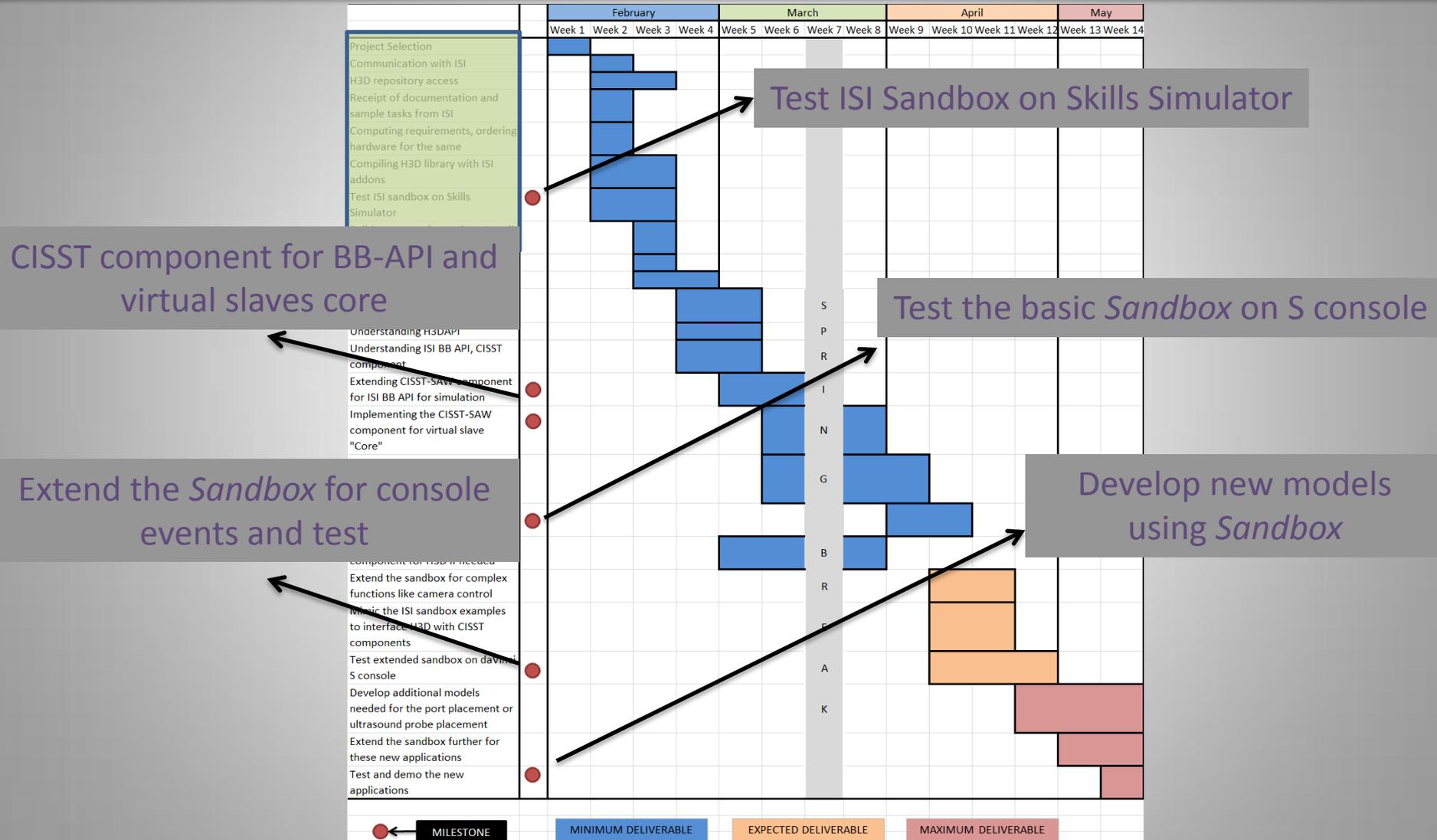
Deliverables

- 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

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

Timeline and Milestones



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*
2. Intuitive Surgical Inc., *daVinci S System User Manual*
3. Intuitive Surgical Inc., *daVinci Skills Simulator User Manual*
4. S. DiMaio and C. Hasser, *The daVinci Research Interface*, MICCAI Workshop on Systems and Architectures for Computer Assisted Interventions, Sep. 2008
5. A. Deguet and R. Kumar and R. Taylor and P. Kazanzides, *The cisst libraries for computer assisted intervention systems*, MICCAI Workshop on Systems and Architectures for Computer Assisted Interventions, Sep. 2008
6. B. Vagvolgyi and S. DiMaio and A. Deguet and P. Kazanzides and R. Kumar and C. Hasser and R. Taylor, *The Surgical Assistant Workstation*, MICCAI Workshop on Systems and Architectures for Computer Assisted Interventions, Sep. 2008
7. Sense Graphics A B, Open Source Haptics – H3D.org

Questions?

Thank you!