

The background features a large, faint watermark of the Stanford University seal. The seal is circular and contains a tree in the center, surrounded by the text 'STANFORD JUNIOR UNIVERSITY' at the top and 'DIE LUFT BRINGT FREIHEIT' on the sides. The year '1891' is at the bottom. The seal is surrounded by a decorative border of stars and diamonds.

CS225A : Experimental Robotics

Lecture 4 : Simulation & Graphics

(Aka.. All the details you (n)ever wanted)

Samir Menon

Oct 02, 2014

Supported Project : Robotic Control

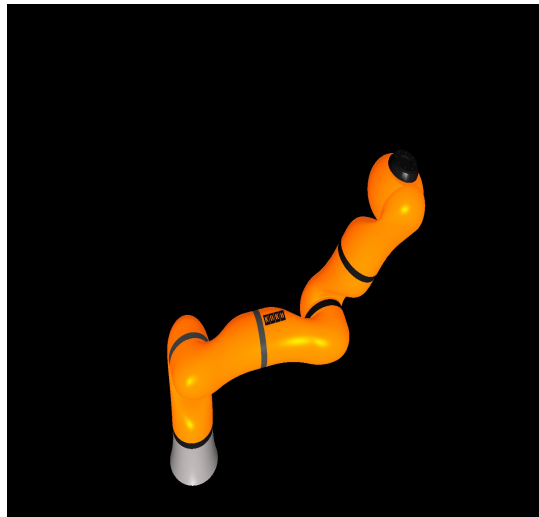
$$\Gamma = J_t^T (\Lambda(x)x + \mu(x, \dot{x}) + p(x))$$

Theory

Supported Project : Robotics Projects

$$\Gamma = J_t^T (\Lambda(x)x + \mu(x, \dot{x}) + p(x))$$

Theory

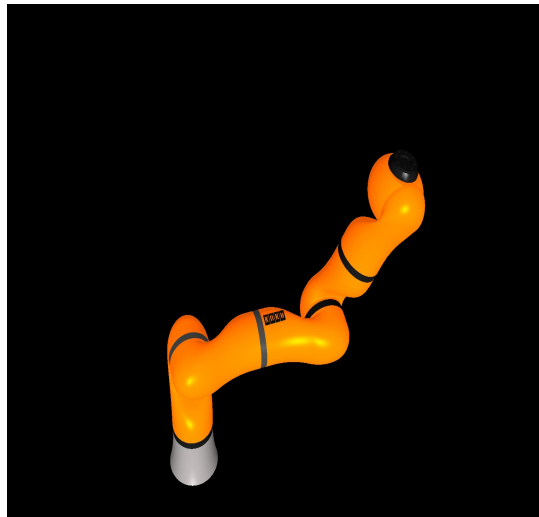


Simulation

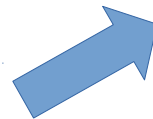
Supported Project : Robotics Projects

$$\Gamma = J_t^T (\Lambda(x)x + \mu(x, \dot{x}) + p(x))$$

Theory



Simulation



Testing (if feasible)

Supported Project : Haptics & Simulation

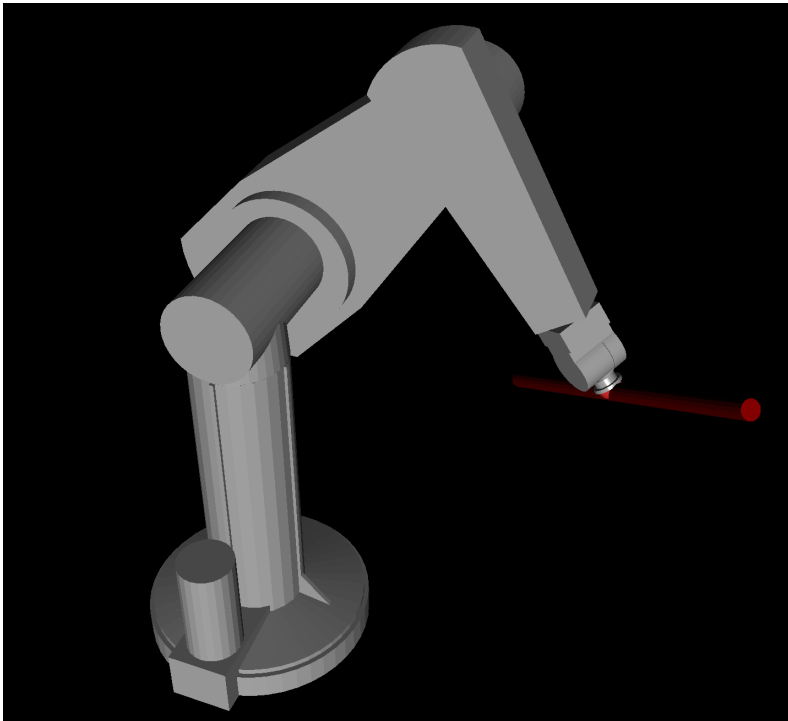
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Supported Project : Haptics & Simulation

$$\Gamma = J_t^T (\Lambda(x)x + \mu(x, \dot{x}) + p(x))$$

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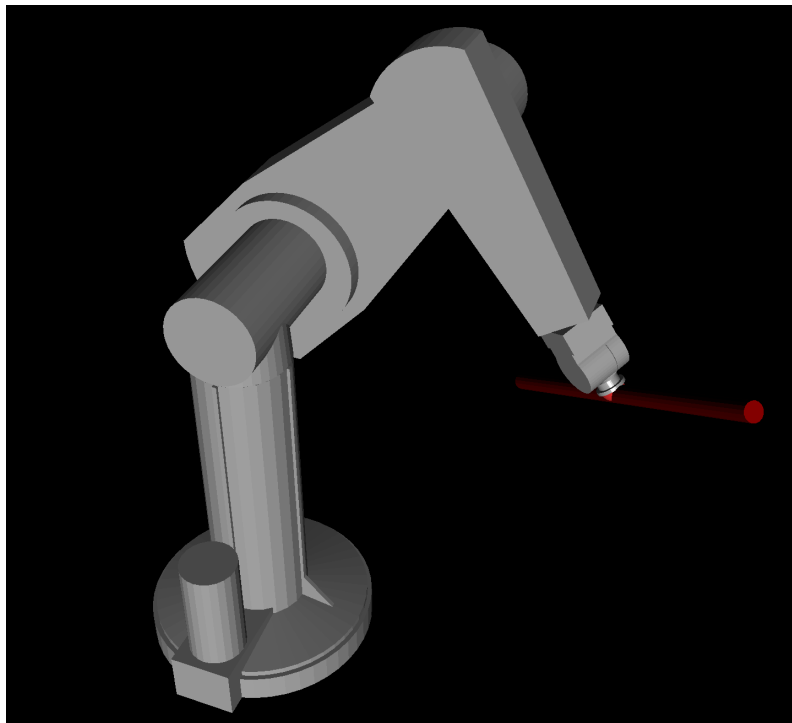


Keyboard/Mouse Control

Supported Project : Haptics & Simulation

$$\Gamma = J_t^T (\Lambda(x)x + \mu(x, \dot{x}) + p(x))$$

Theory



Simulation



Haptic control

Supported Project : Human Motion

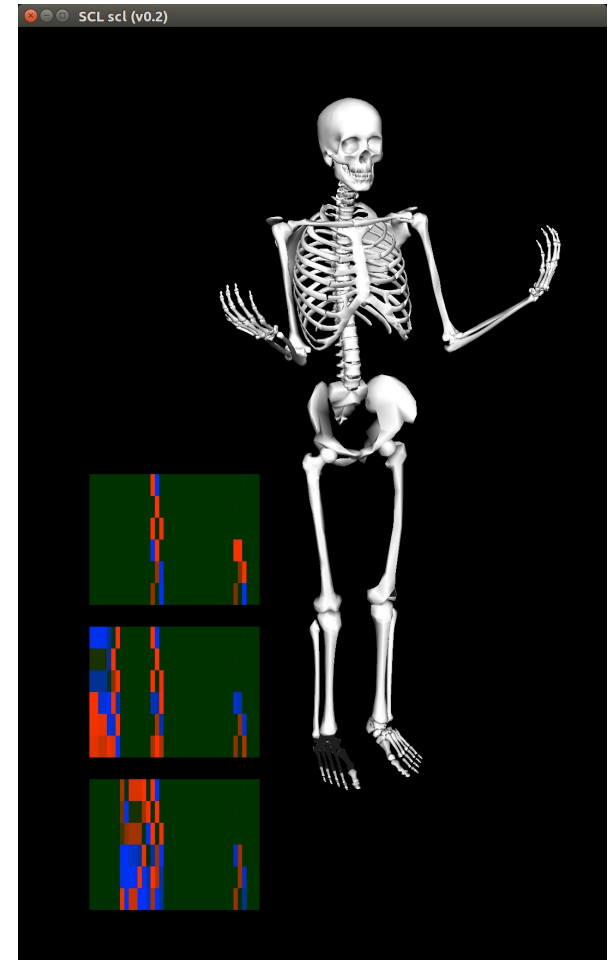
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Theory

Supported Project : Human Motion

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Theory



Whole body control

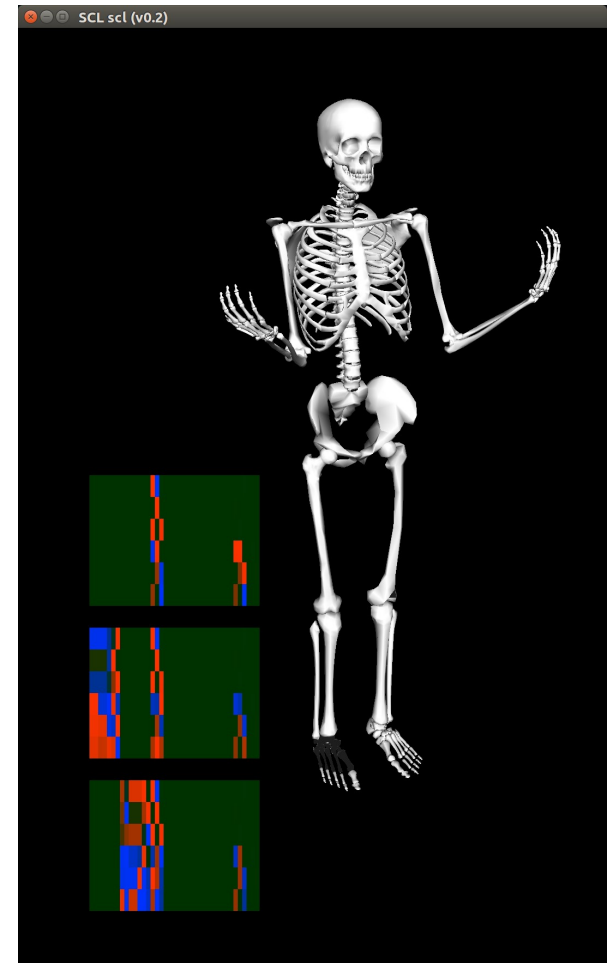
Supported Project : Human Motion

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Theory



Motion/Trajectory Mapping



Whole body control

Limited spots for each project class



** Rules and conditions apply

Limited spots for each project class

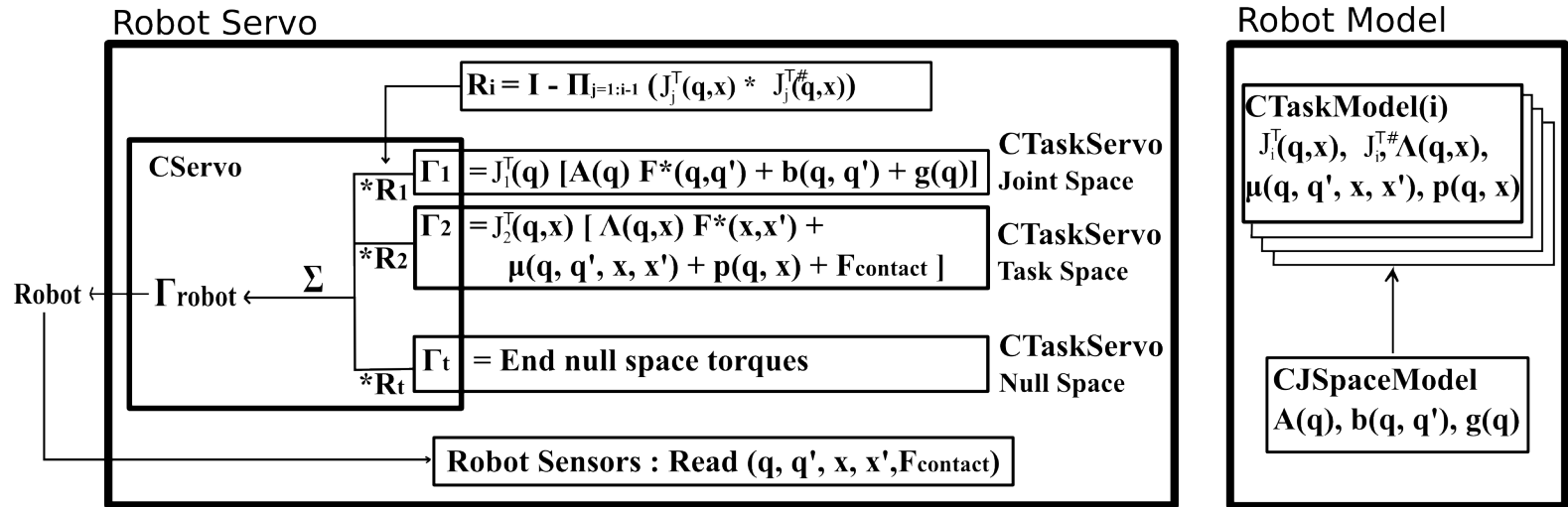


** Rules and conditions apply



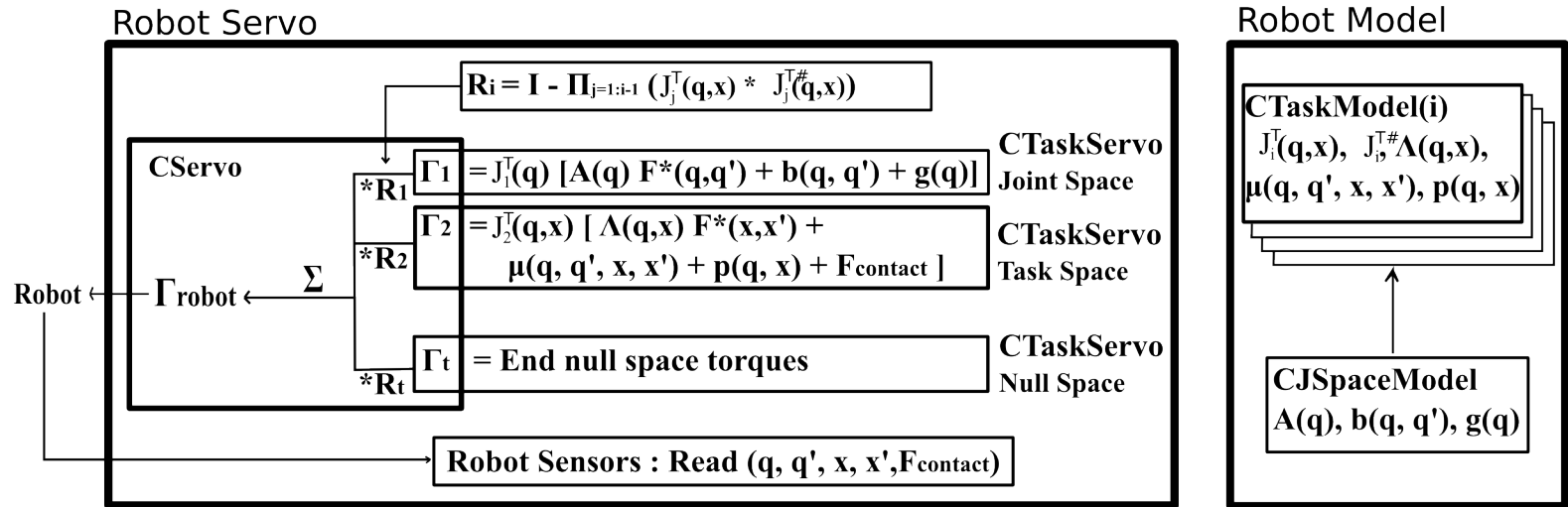
** Rules and conditions apply

Connecting theory to software....



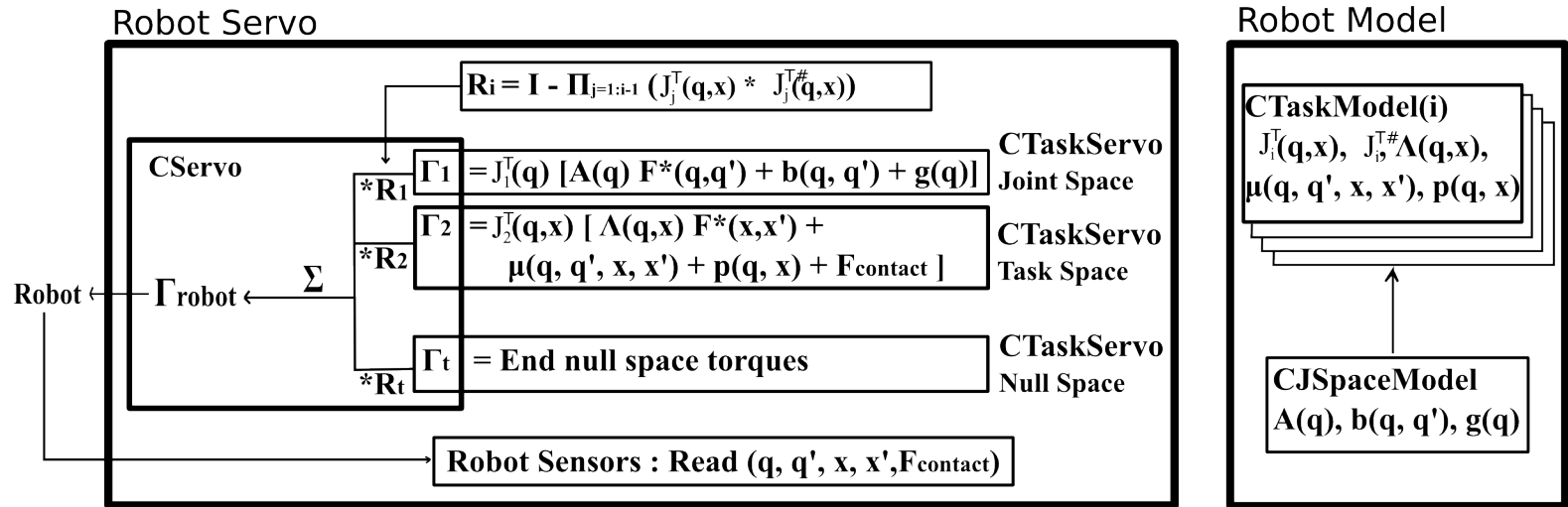
- Basic kinematics : $x_{ee}, dx_{ee}, J = f(q)$

Connecting theory to software....



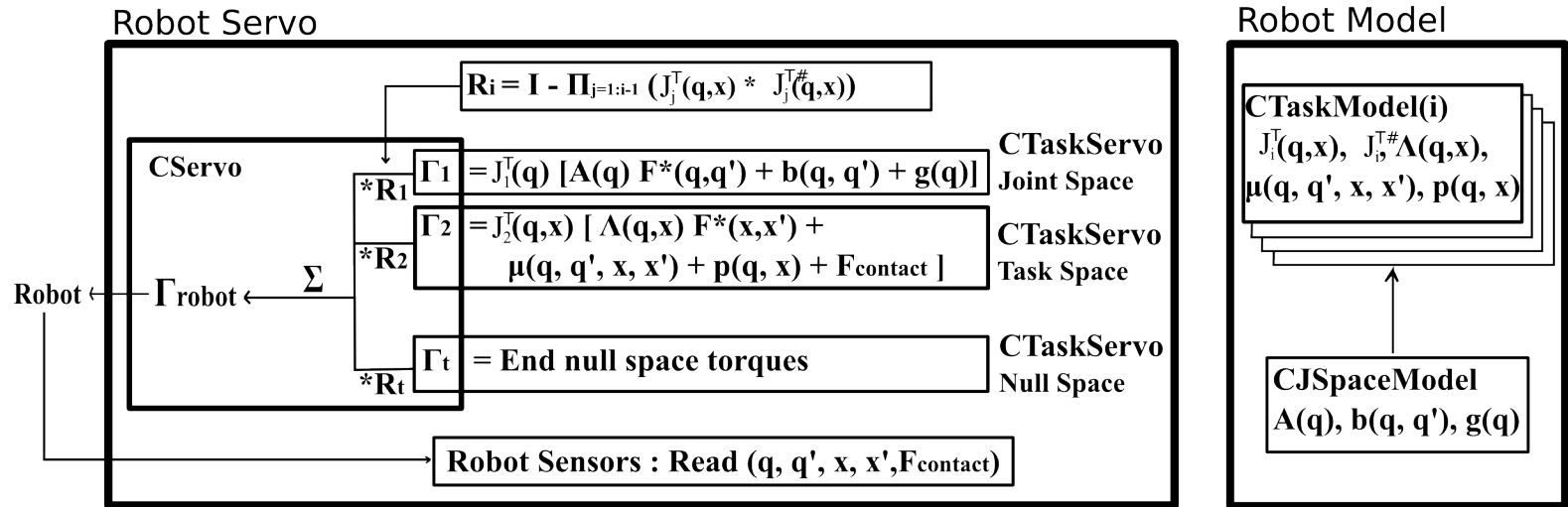
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Connecting theory to software....



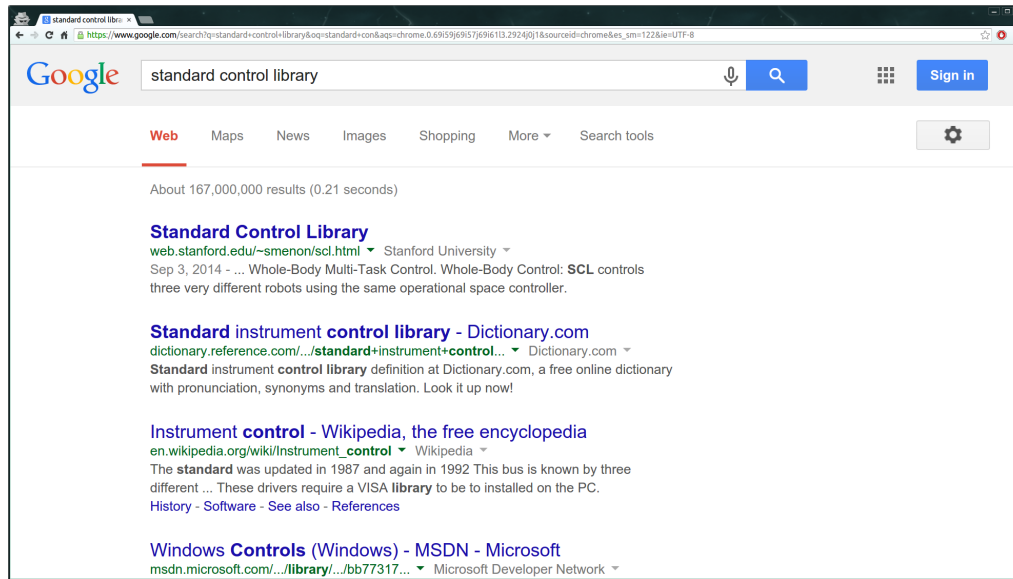
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- Inertias : M_{gc}, M_x

Connecting theory to software....



- Basic kinematics : $x_{ee}, dx_{ee}, J = f(q)$
- Forces and potential fields : $F_x = pid(x_{err})$
- Inertias : M_{gc}, M_x
- Subspace projections : $Null_J, J_{dyn_inv}$

SCL : Available resources....



SCL : Available resources....

The image shows a Google search for "standard control library" on the left and the Stanford University website for the Standard Control Library (SCL) on the right.

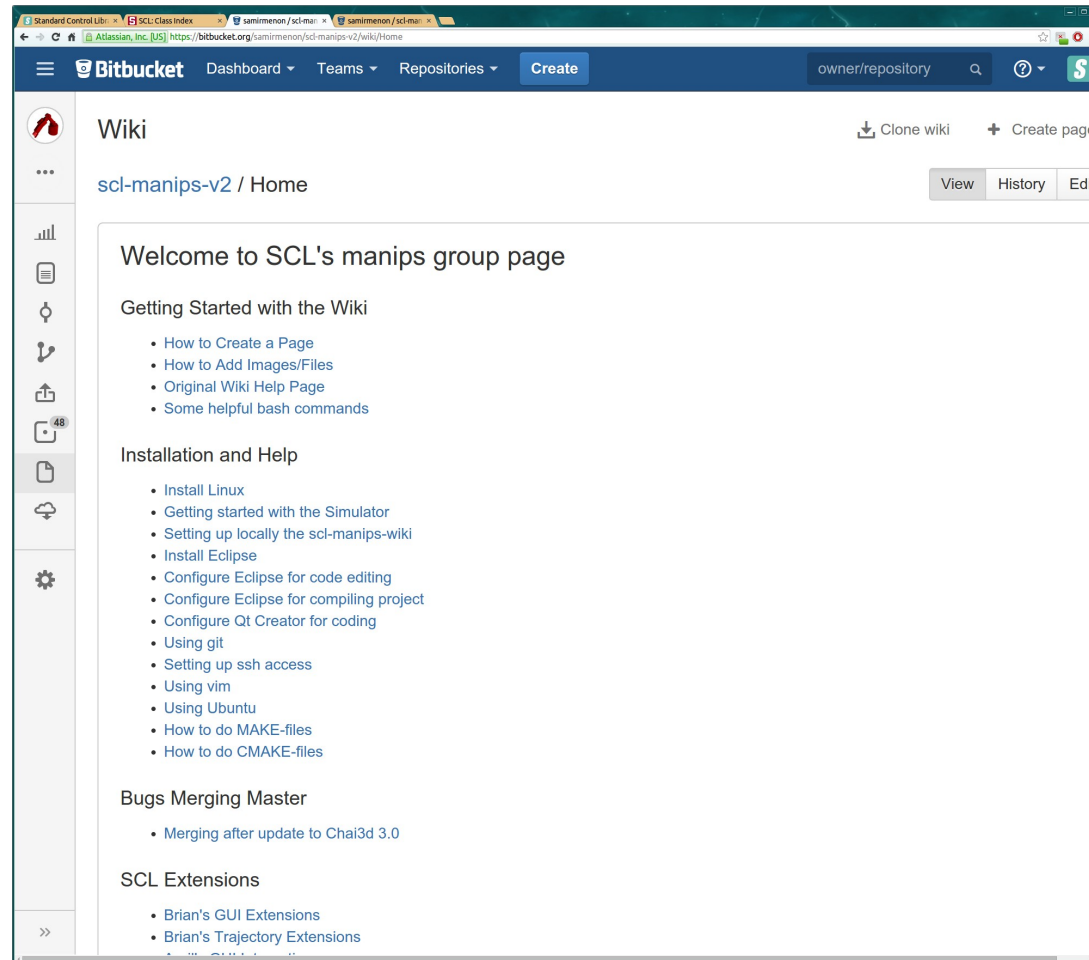
Google Search Results:

- Standard Control Library
web.stanford.edu/~smenon/scl.html - Stanford University
Sep 3, 2014 - ... Whole-Body Multi-Task Control. Whole-Body Control: SCL controls three very different robots using the same operational space controller.
- Standard instrument control library - Dictionary.com
dictionary.reference.com/.../standard+instrument+control... - Dictionary.com
Standard instrument control library definition at Dictionary.com, a free online dictionary with pronunciation, synonyms and translation. Look it up now!
- Instrument control - Wikipedia, the free encyclopedia
en.wikipedia.org/wiki/Instrument_control - Wikipedia
The standard was updated in 1987 and again in 1992 This bus is known by three different ... These drivers require a VISA library to be installed on the PC.
History - Software - See also - References
- Windows Controls (Windows) - MSDN - Microsoft
msdn.microsoft.com/.../library/.../bb77317... - Microsoft Developer Network

Stanford University Website (Standard Control Library):

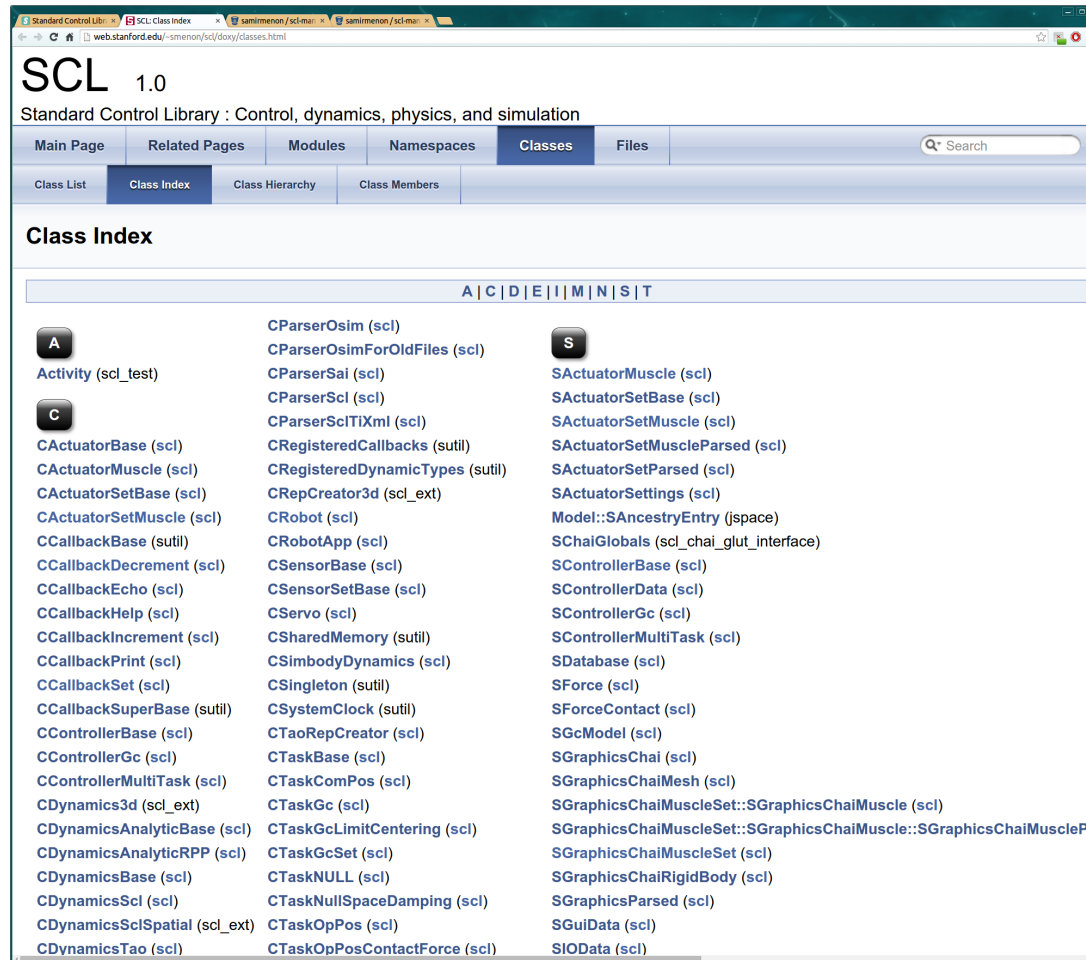
- Navigation: HOME, HAPTIC FMRI, HUMAN MOTOR CONTROL, SPIKING NETWORKS, SCL
- Section: STANDARD CONTROL LIBRARY
- Subtitle: A Control And Simulation Framework For Whole-Body Multi-Task Control
- Video: A video showing three different robots (an orange robotic arm, a white humanoid figure, and a yellow and blue humanoid figure) being controlled by the SCL framework. The video is titled "Whole-Body Control: SCL controls three very different robots using the same operational space controller." and has a duration of 0:31.
- Navigation Links:
 - SCL CODE REPOSITORY & WIKI
 - SCL CODE TUTORIALS
 - CONTROL MATH TUTORIALS : 3-DOF AND 6-DOF
 - SCL CLASS DESCRIPTIONS
- Section: OUR METHODS
- Text: Standard Control Library (SCL) is a control and simulation framework that aims to provide a generic implementation of robot agnostic control algorithms for use in simulation or on real robots. It achieves robot agnostic control by specifying closed loop control tasks in operational space, which can then be projected on to the articulated body dynamics for arbitrary robots. Multiple control tasks are readily accommodated using a prioritized control subspaces, which disallow competing control tasks from interfering and destabilizing the controller.

SCL : The Wiki



Feel free to edit it! Some links might be stale.
Also feel free to notify the TAs...

SCL : The Documentation



The S<Name> pages correspond to data structures
Do take a look! (no code; only data)

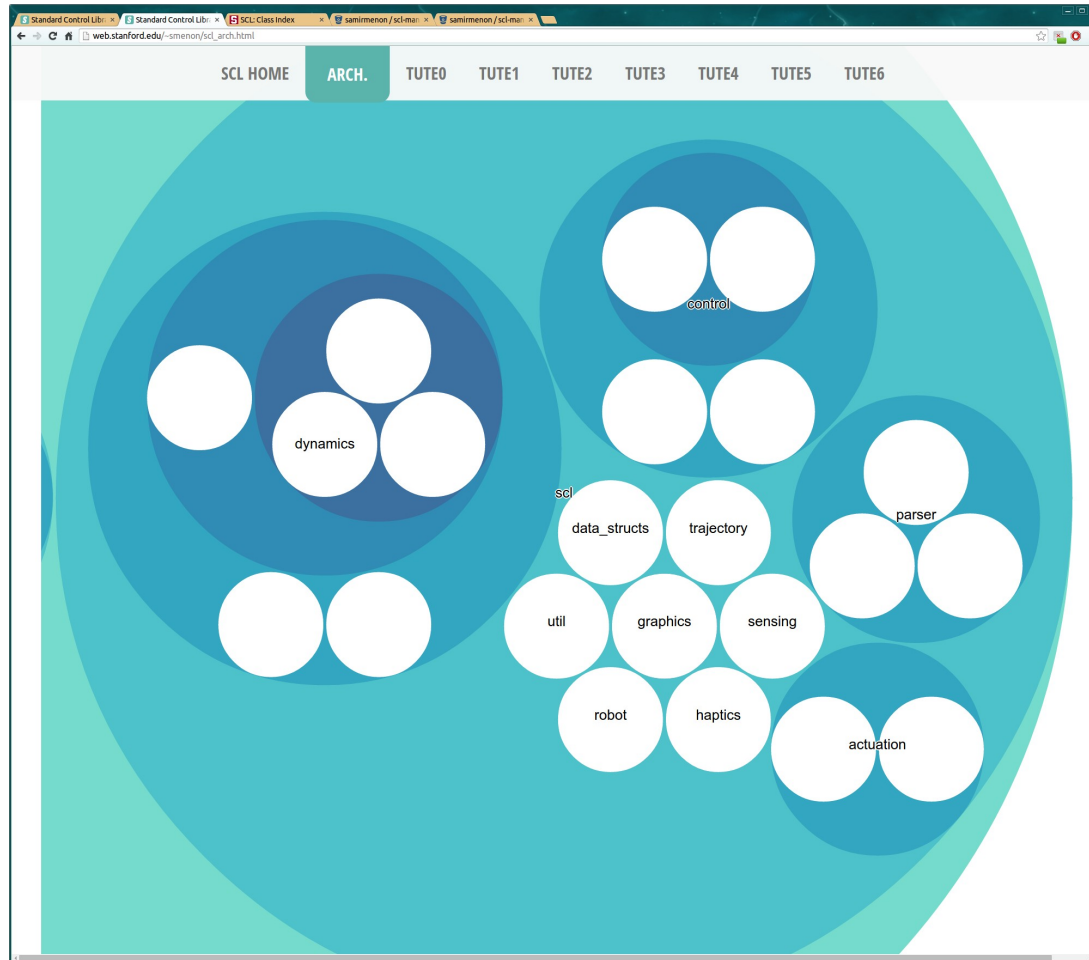
SCL : The Bug Tracker

Title	T	P	Status	Votes	Assignee	Created	Updated
#149: Add Romeo model	+	↓	NEW			2014-09-09	2014-09-09
#137: Energy Difference Between SCL and Dynamics3d	•	↓	NEW		Samir Menon	2014-03-21	2014-08-30
#146: Orientation specified in XML files does not work with prismatic joints	•	↑	NEW		Kenji Hata	2014-05-10	2014-05-10
#144: Joint Limit	•	↓	NEW		Kenji Hata	2014-05-10	2014-05-10
#142: SCL Documentation	↗	↓	NEW		Brian Soe	2014-04-17	2014-04-21
#34: Mouse force drag: graphics object metadata	↗	↑	NEW		Brian Soe	2013-01-07	2014-04-19
#19: Allow attaching a camera to any arbitrary link of the robot	↗	↓	NEW		Brian Soe	2012-08-11	2014-04-19
#141: Inconsistency with gravity signs in controllers	•	↑	NEW		Samir Menon	2014-04-16	2014-04-16
#140: Current CControllerGC is useless / incorrect	•	↓	NEW		Samir Menon	2014-04-15	2014-04-16
#139: Wrong sign in example controller	•	↓	NEW		Samir Menon	2014-04-09	2014-04-09
#138: Accessing link Pos/Rot in stepMySimulation	+	↓	NEW		Samir Menon	2014-04-01	2014-04-01
#130: CRobotApp name change	+	↓	NEW		Brian Soe	2014-02-17	2014-03-26
#131: combining initialization	+	↓	NEW		Brian Soe	2014-02-17	2014-03-26

If you find a bug. Report it!!

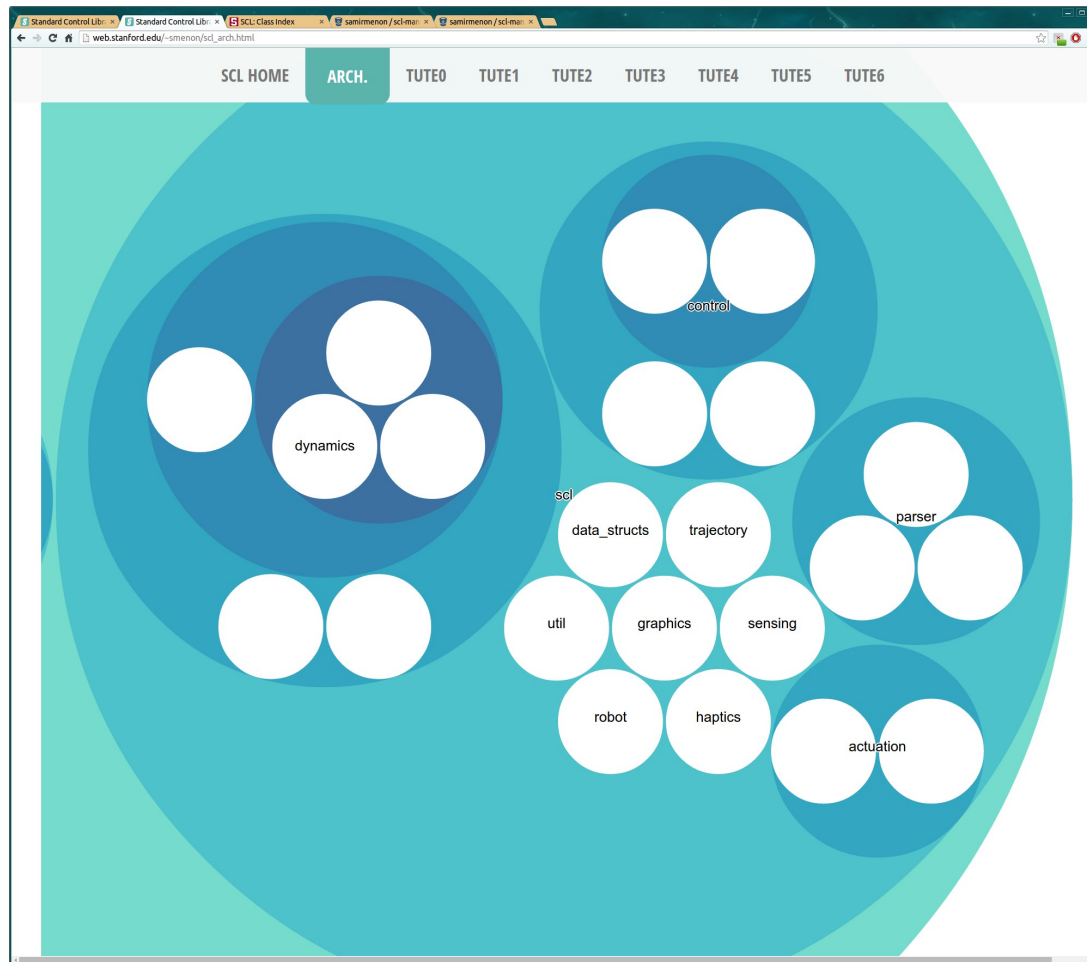
Valid and non-trivial bug reports will earn you extra credit!

SCL : Library Architecture



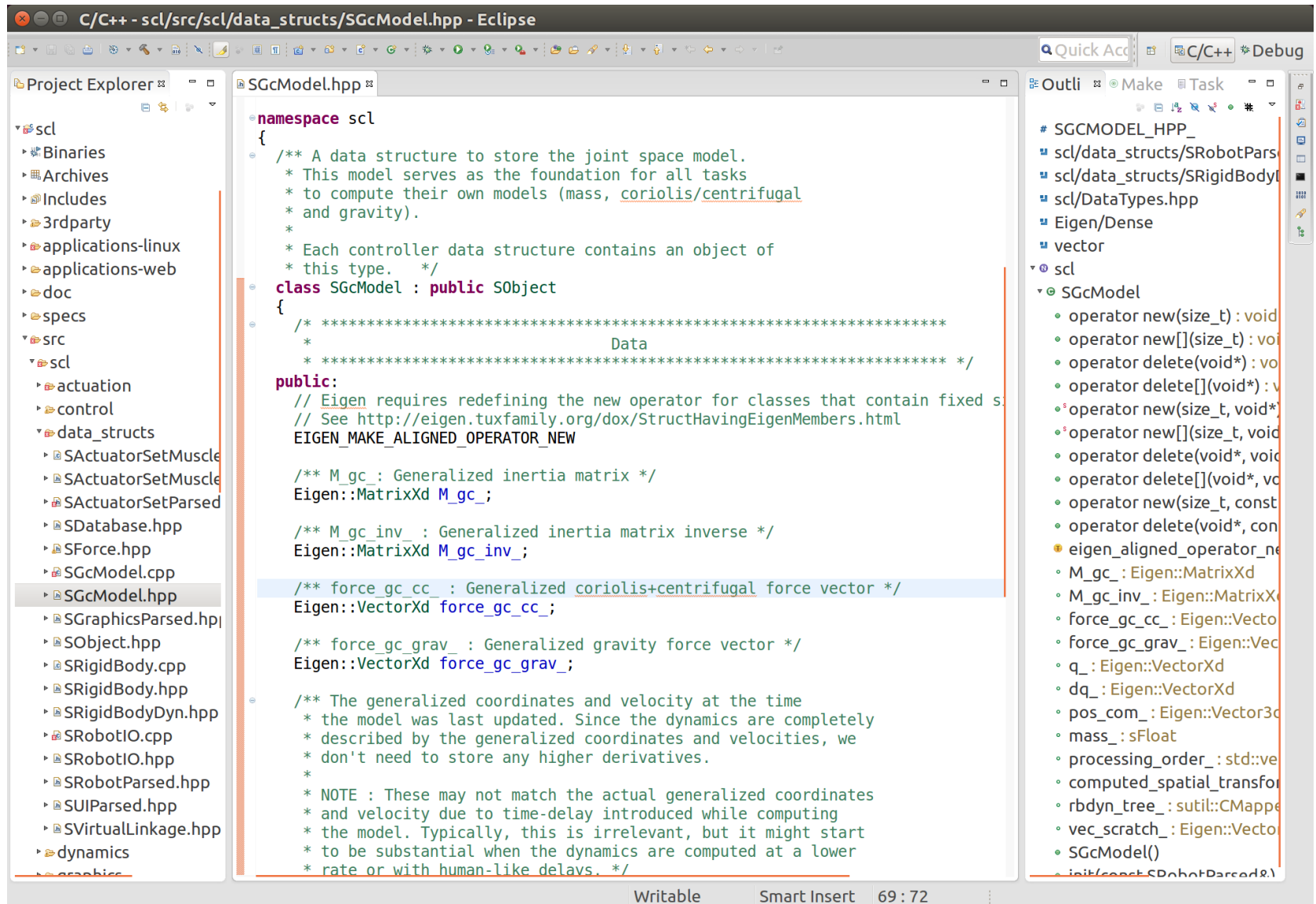
A lot of (almost) independent modules

SCL : Library Architecture



A lot of (almost) independent modules
(Tied together by shared data structures)

SCL : A glance at the code....



```
namespace scl
{
    /** A data structure to store the joint space model.
     * This model serves as the foundation for all tasks
     * to compute their own models (mass, coriolis/centrifugal
     * and gravity).
     *
     * Each controller data structure contains an object of
     * this type. */
    class SGcModel : public SObject
    {
        /** *****
         *                               Data
         * ***** */
    public:
        // Eigen requires redefining the new operator for classes that contain fixed s
        // See http://eigen.tuxfamily.org/dox/StructHavingEigenMembers.html
        EIGEN_MAKE_ALIGNED_OPERATOR_NEW

        /** M_gc : Generalized inertia matrix */
        Eigen::MatrixXd M_gc;

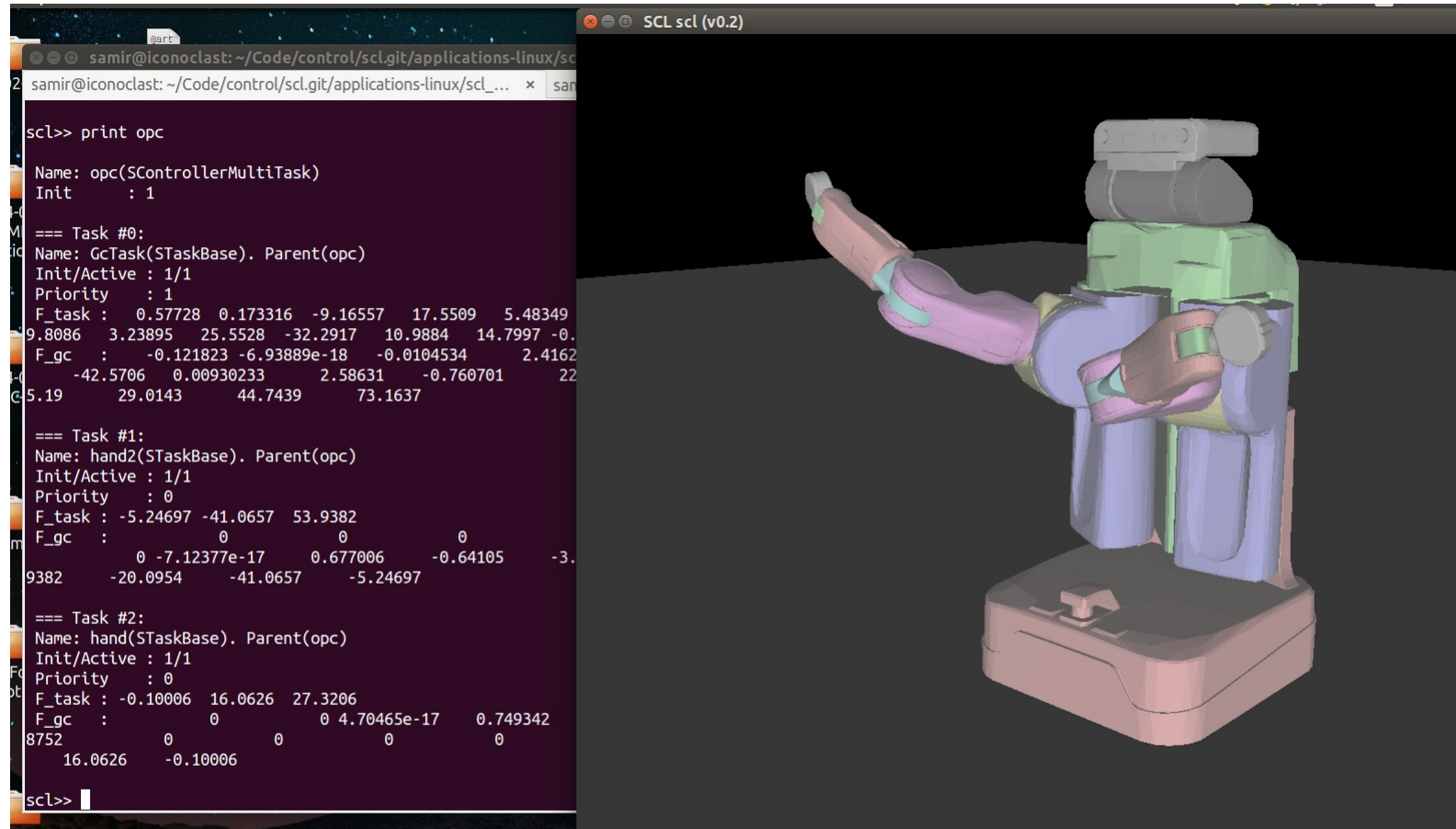
        /** M_gc_inv_ : Generalized inertia matrix inverse */
        Eigen::MatrixXd M_gc_inv;

        /** force_gc_cc_ : Generalized coriolis+centrifugal force vector */
        Eigen::VectorXd force_gc_cc;

        /** force_gc_grav_ : Generalized gravity force vector */
        Eigen::VectorXd force_gc_grav;

        /** The generalized coordinates and velocity at the time
         * the model was last updated. Since the dynamics are completely
         * described by the generalized coordinates and velocities, we
         * don't need to store any higher derivatives.
         *
         * NOTE : These may not match the actual generalized coordinates
         * and velocity due to time-delay introduced while computing
         * the model. Typically, this is irrelevant, but it might start
         * to be substantial when the dynamics are computed at a lower
         * rate or with human-like delays. */
    };
};
```

SCL : Building advanced controllers



CcontrollerMultiTask :: Specify your own tasks

https://bitbucket.org/samirmenon/scl-manips-v2/wiki/docu/additional_controllers

Project Discussion / Questions...

