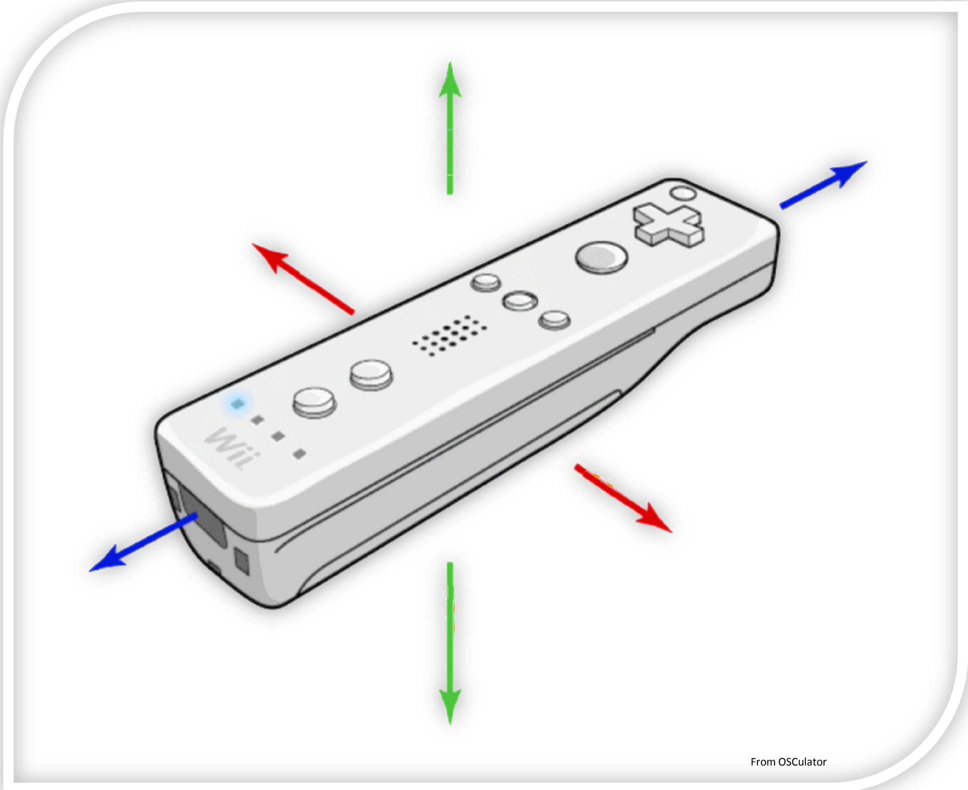
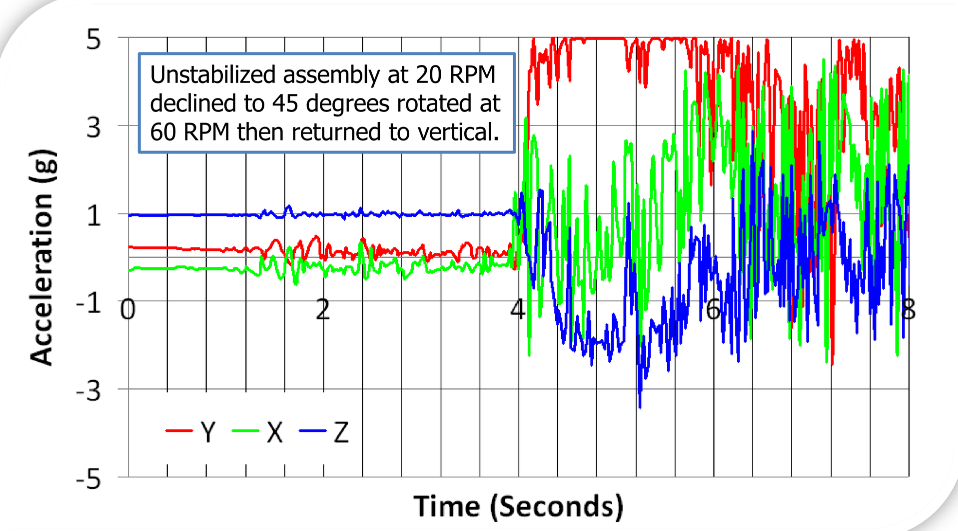
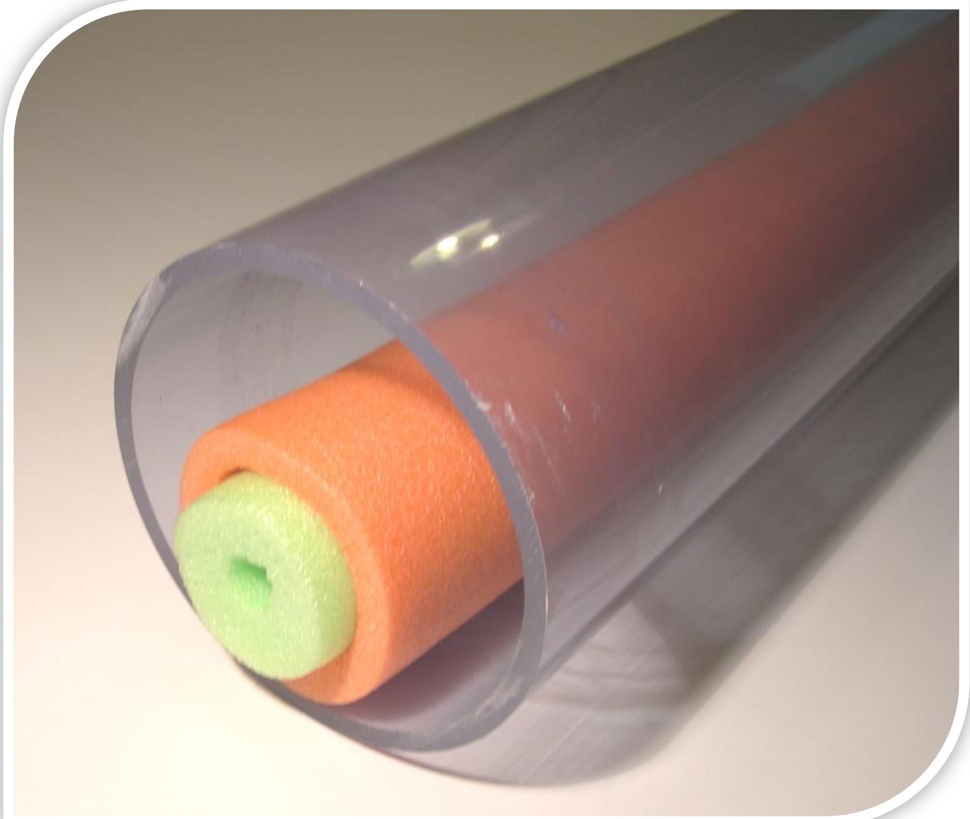
Drilling Lab

A Sensor and Computation Grid Enabled Engineering Model for Drilling Vibration Research

Richard Duff, <rduff@chevron.com> Chevron, Louisiana State University , Society of Petroleum Engineers
Yaakoub El Khamra, <yye00@cct.lsu.edu> Center for Computation and Technology, Louisiana State University, Society of Petroleum Engineers.







Abstract

Across many fields of science and engineering computers now play a significant role in scientific discovery through both large scale simulation and real time data acquisition. As these scientific simulations increasingly require new levels of complexity and fidelity,and leveraging increasing computational capabilities, scientists are migrating their applications back and forth from workstations to supercomputers, high performance clusters, and new distributed grids of computers. For applications which depend on live real world data, the migration to varied and distributed resources provides additional challenges.

Drilling Dynamic Dysfunction, or inefficient motion phenomenon in drillstrings is a complicated, expensive and time consuming challenge for drillers seeking energy resources in the earth. A sensor enabled physical analog model for the drillstring system will help drillers and scientists acquire new information about motion phenomenon such as stick slip and whirl, and be a knowledge transfer tool for demonstration, because unlike actual drillstrings deep in the earth the model can be seen, touched, and felt right in front of ones eyes. Sensor enabled, computationally aided decision making is critical to mitigating drilling dynamic dysfunction, improve the economic cases for discovering and developing energy sources. The Cactus Code drilling dynamics toolkit provides research and production applications for grid computing enabled scientific processes tailored to the challenges of drilling geothermal, oil or gas wells. The tool kit seeks to provide robust modular tools for scientists and engineers to build real-time drilling applications utilizing state of the art sensor platforms in a grid computing paradigm.

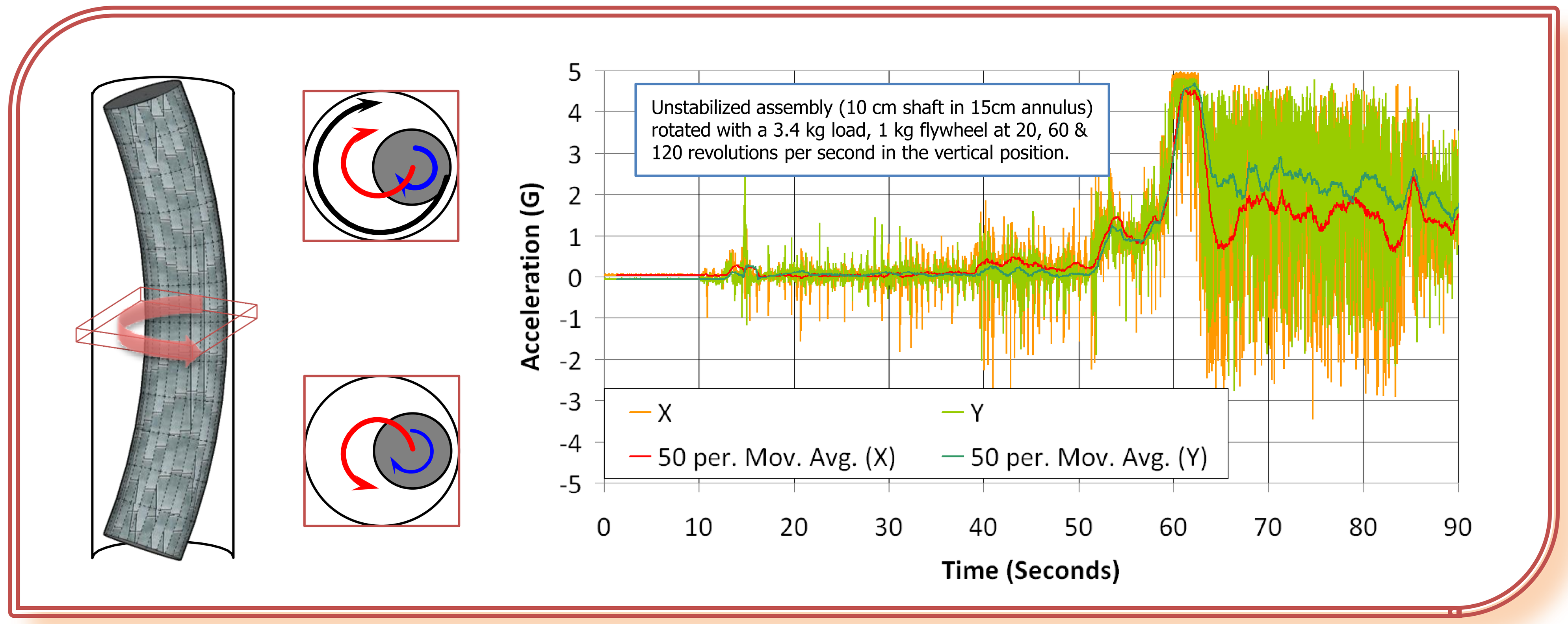
The grid computing simulation code modules, data relay component examples, and sensor platform modules have been previously reported on.* This poster shows the development of a grid enabled physical experiment, with a focus on real-time sensor, reporting, and computation integration. For our application, we will use the Cactus Code (www.cactuscode.org) open-source high performance scientific computing framework as the simulation framework, LabVIEW (www.ni.com/LabVIEW) as the data acquisition software, and include the Nintendo Wii Remote as a sensor node.

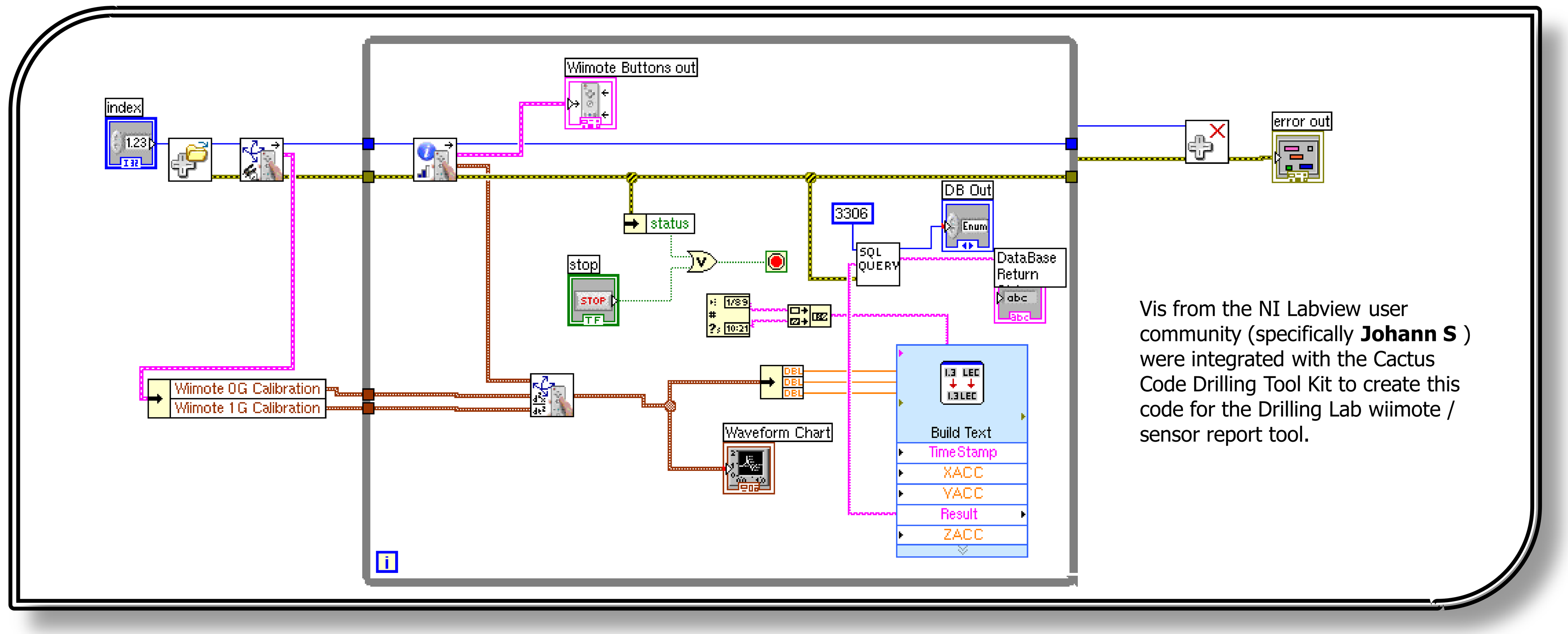
The creation of a physical analog model of the drilling assembly is a research component of a petroleum engineering dissertation focusing on drillstring dynamics and vibration. The goal was to create a new analog model to the complex behavior of the drilling bottom hole assembly system. The opportunity to develop this analog model with real time sensor grid computation also facilitated accelerated development and experimentation.

The authors' contributions to this effort include developing the original Cactus Drilling toolkit application. New work leveraging community momentum in the area of wireless sensor connectivity to the sensor platform was necessary for the experimental models connectivity to the relay. The system of the physical analog model necessitated adjustments to the Cactus Drilling thorn, documentation of how to properly modify this style of modular code are addressed.

The result of this work is that a new physical analog model has been created, and a successful demonstration of the process of instrumenting and enabling real-time grid computation. The Grid enabled dynamics model is the first physical product of the efforts of the Cactus Drilling Application toolkit originally developed for the Ubiquitous Computing for the Discovery and Management of Energy Resources UCoMS project.

*Richard G. Duff and Yaakoub Y. El-Khamra, Louisiana State U., Real Time Simulation in Grid Environments: Communicating Data from Sensors to Scientific Simulations, Digital Energy Conference and Exhibition, 11-12 April 2007, Houston, Texas, U.S.A., 2007.

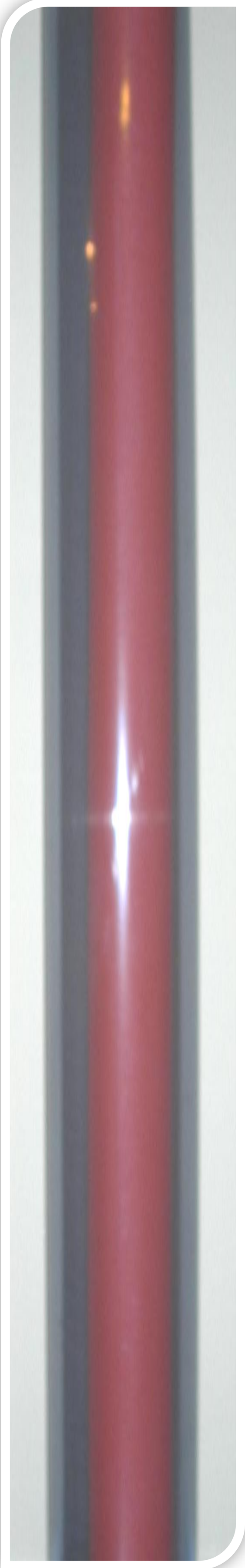




Vis from the NI Labview user community (specifically **Johann S**) were integrated with the Cactus Code Drilling Tool Kit to create this code for the Drilling Lab wiimote / sensor report tool.

For more information and short movies of Drilling Lab in action join us at YouTube!

http://youtube.com/drillinglab



Computational Framework

Framework

- Nominal computation
- Module manager
- Automatically "glues" code from modules to perform specific tasks

Relay to Simulation

Module CommMySQL interface: framework to relay.
- Application has control of when to schedule calls to the relay
- Storage at the relay while waiting on frame query
- Archive

SOCI

Code Modules

- Computational grid
- Decomposition for parallel tasks
- Coordinate systems
- Boundary and initial conditions
- Interprocessor communication
- Solvers
- I/O
- Visualization streaming

Computational Framework, Cactus:
- Central portion :flesh:
- Code Modules :thorns:

Each code module communicates with the manager.
Thorns do most tasks.

The use of the SOCI abstract relational database access library as an underlying mechanism of communication between the sensor platform, the relay and the computational framework allows the use of a large number of replicated data bases of hybrid types **(Oracle, MySQL etc...)** without compromising data integrity or security.

Relay

Relational Database

Sensor Measurement to Database

Middleware : MySQL communication libraries for sensor platform Interface to the common operations required to stream data
- Various sampling rates (w or w/o multiplexing)
- Modular communication module
- Relay arguments: address, database, user, password & data
- Arguments passed to a shared library function
- Calls static system library functions

SOCI

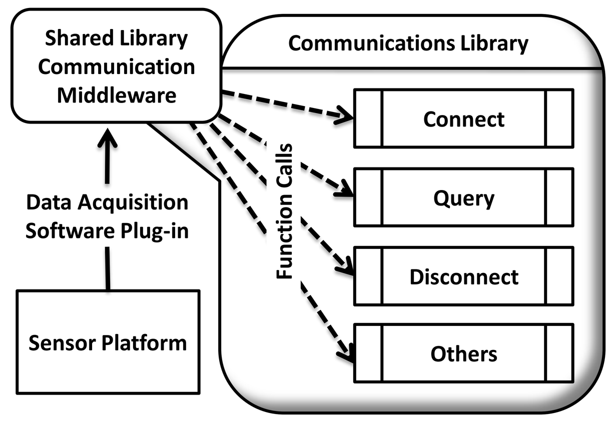
This choice of underlying infrastructure allows a broader range of flexibility in terms of database replication (sensors transmitting to several real-time operations centers) and hardware resources for simulation (simulations running on single computers, computers, several supercomputers , on a Grid).

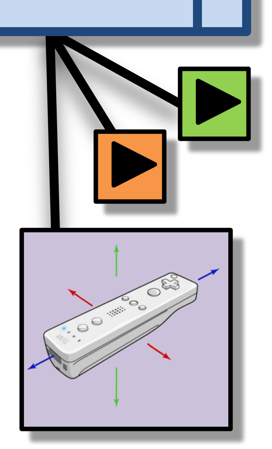
Sensor Platform

Data Acquisition Unit

Design

DAQ side communication calls





Sensors