Interaction with Cultural Heritage using FTIR touch table

By: Kevin Nguyen

Host Site: NICT, Tokyo, Japan

8/20/10

Project Proposal

Initially the proposed project was to create a custom application on the Iphone or Ipad that would be able to control a CGLX application running on a Tiled Display Wall. Unfortunately several weeks in, it was made clear that the source code for the CGLX applications would not be available before the end of summer. As a result it was difficult to create a custom application that would incorporate multi-touch control to CGLX. In order to continue to exploring multi-touch interaction, the project was changed to creating a multi-touch table. The idea was to use a touch table to interact with cultural heritage at the NICT Nara exhibition. The table would use FTIR (Frustrated Total Internal Reflection) and computer vision software to allow multi-touch interaction with custom multi-touch applications. Unfortunnately, time would not allow development of a custom application for the Nara Exhibition, so open source MT applications would be customized to fit the needs of the exhibition.

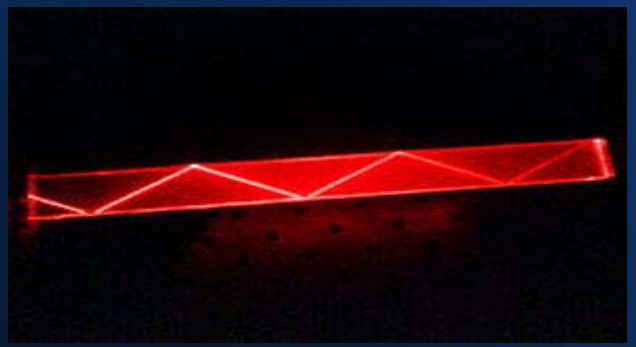
Preview of Table

Please Look at video titled “Nara Photo app demo”

Breakdown of Touch Table Technologies

This Touch table is basically made possible by two technologies:

- Frustrated Total Internal Reflection (FTIR)



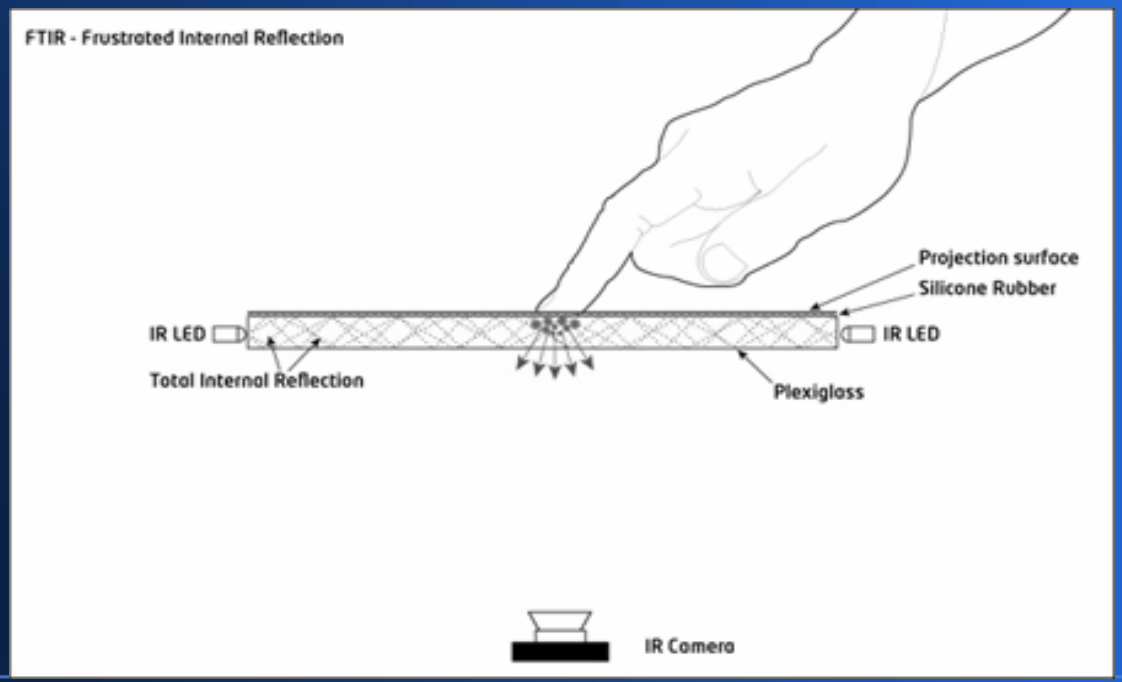
Example of Total internal reflection with lasers in acrylic.
Photo obtained from Wikipedia:http://en.wikipedia.org/wiki/Total_internal_reflection

- Emitting and Dectecting IR light

FTIR: How it Works

IR light is emitted into the sides of the acrylic and is totally internally reflected. When the surface is frustrated by a touch or any object pressing on it, the Total Internal Reflection effect no long happens at the location of the touch and the IR light escapes from the acrylic. This escaping light can be captured by an IR camera.

Diagram of FTIR effect courtesy of NUI group MT technology PDF->



Emitting and Detecting IR light

- Emitting IR light is taken care of by IR LEDs. The LEDs must be pointing into the sides of the acrylic and the angle must not be too wide or else it will not be Totally internally reflected and will escape the acrylic waveguide.
- Detecting IR light is taken care of by an IR camera placed under the acrylic waveguide. Usually IR cams are expensive and difficult to find, but fortunately some webcams can be converted to an IR camera.

< – Xbox Live Vision Webcam (30 FPS)

IR LED ribbon – > (850nm)

Components to Building a Touch Table

- Hardware:
  - Acrylic waveguide
  - Projection Surface
  - Compliant Layer (Silicone)
  - IR LEDs (850nm)
  - IR webcam
  - Front Surface Mirror
  - Projector
  - Power Supply
  - Frame to Hold everything together

Software:

Blob Tracking Software(CCV)

Multi-touch applicatons

Build Process

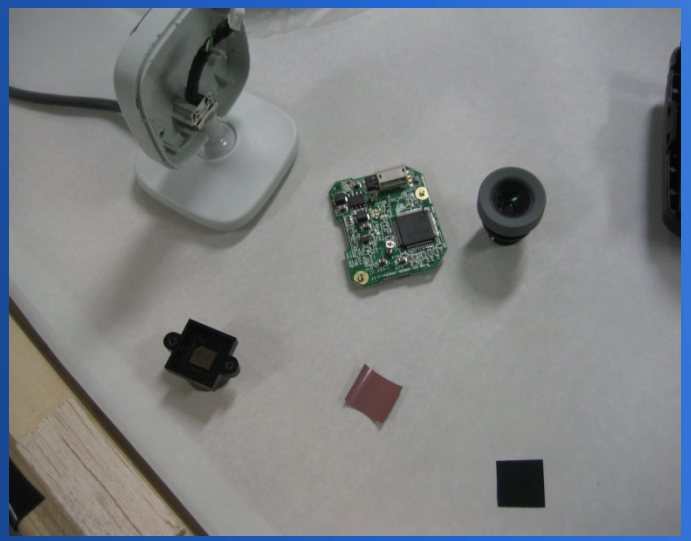
- Preparing the Acrylic:
  - 10mm thick acrylic was used (needs to not bend under pressure)
  - Cut to 900mm x 600mm using an endmill
  - Flame Polished sides to make it perfectly clear for IR light to enter more cleanly (minimizing refracted light)

Acrylic with the U-channels and IR LEDs inside the channels

Build Process Cont...

- Modifying Webcam:
  - Removed IR filter and replaced it with a visible light filter
  - Usually IR bandpass filters are expensive and rare, so magnetic tape from a Floppy disk was used instead. This gave decent results

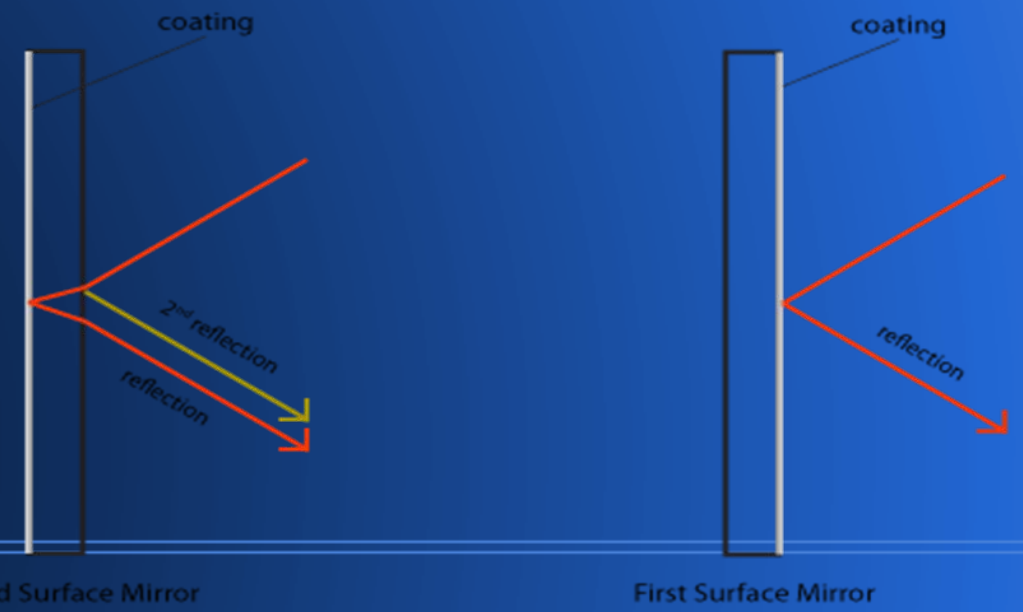
Right:Disassembled Webcam Cam. The small black square on the bottom right is the floppy disk magnetic tape and the grey ring is the lens. The small black plastic square is the lens mount.
Left: Image after IR modification



Build Process cont...

- Modifying a normal mirror into a First Surface Mirror:
  - A normal mirror can be made into a first Surface mirror by applying paint remover on the backside of the normal mirror. Afterwards, the coating on the back will peel off revealing the reflective material. This option was much less costly then buying a large front surface mirror.
  - A first surface mirror is needed to remove ghosting effects from the 2nd reflection from normal mirror.

Left shows how light enters and exits from a normal mirror. Right shows how light enters and exits a First Surface mirror.
Diagram obtained from: www.firstsurfacemirrors.com

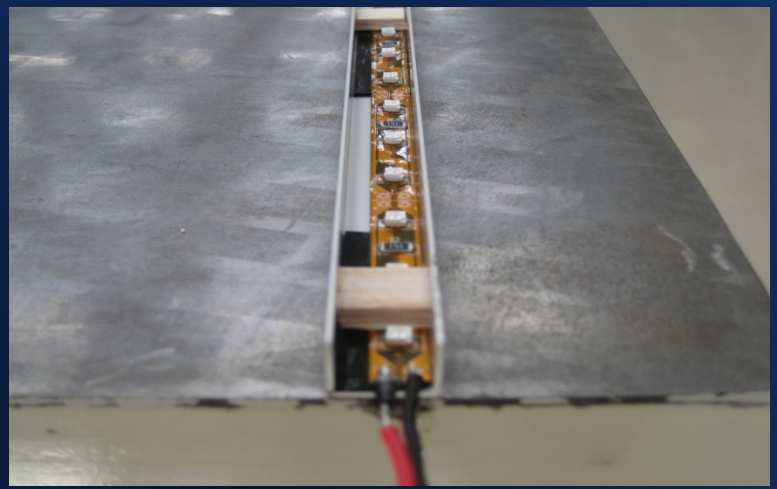


Build Process cont...

Preparing IR LEDs:

- LEDs needed to be mounted inside u-channels to keep the IR light pointing in the right direction and keep light from escaping the acrylic.

- 850nm IR LEDs were used rather than other wavelengths because 850nm is the wavelength best detected by webcams.



< – U channels with LED ribbon installed. The brown block is a balsa wood and it is used to keep the acrylic from crushing the LEDs when the u-channels are installed onto all 4 sides of the acrylic.

Finding a Suiteable Projection Surface and Creating a good Compliant Layer

Projection Surface:

- This is the material the the image from the computer will project onto. The material must not discolor the image and must block any IR interference above the table surface (such as lighting)

- Tracing paper happened to be a very good and cheap projection surface that blocks most of the IR interference from lights. However, it removes any FTIR effect when placed over the acrylic, which leads to the need for a compliant surface

Compliant Surface:

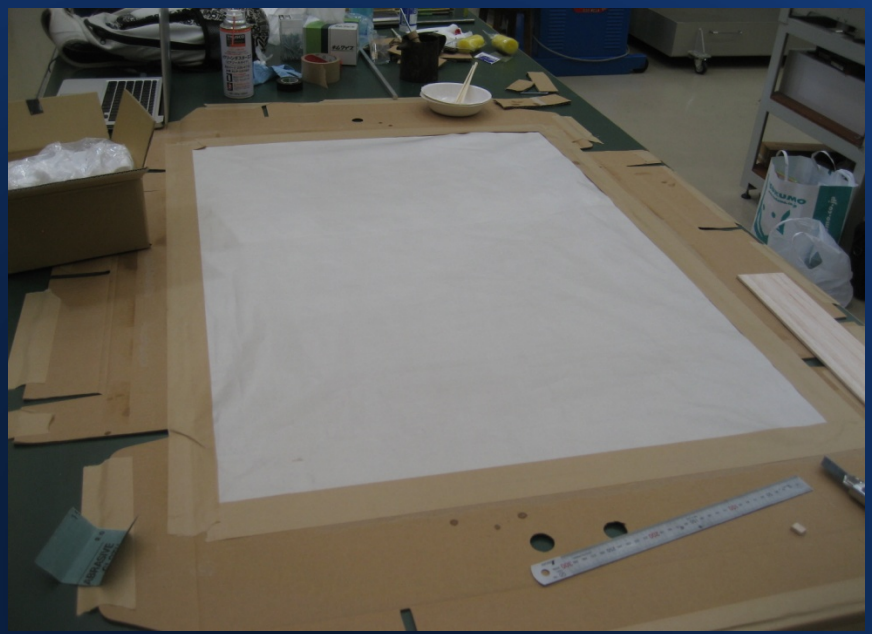
- a compliant surface sits between the projection surface and the acrylic. It serves as an link between touches on the projection surface and FTIR effect on the acrylic.

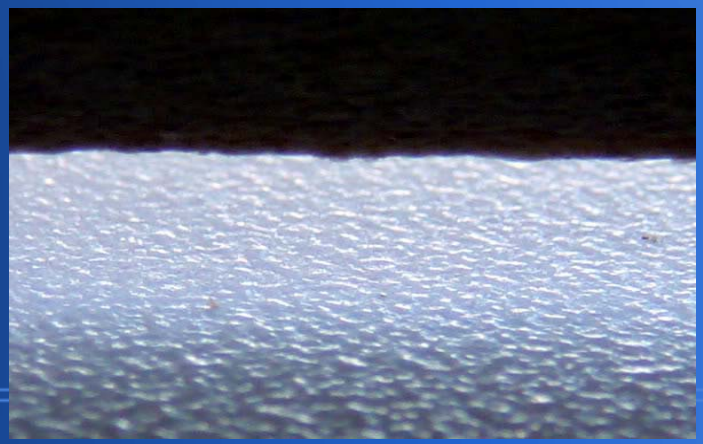
- in this project, Silicone was used as the compliant surface because it was clear and has a squishy texture which allows it to squish onto the surface of the acrylic causing the FTIR effect. Creating a good compiant layer was by far the trickiest part of constructing a touch table.

Problems Encountered with Compliant Surface

- getting ratio of paint thinner to silicone right was difficult. Too much paint thinner and the silicone would not dry correctly causing the compliant surface to stick to the acrylic which then causes false touches to appear all over the screen. Also rolling the silicone evenly onto the projection surface was difficult.

- I solved the problem by using only silicone with no paint thinner mixed in and rolled it evenly onto the projection surface with a dense foam roller





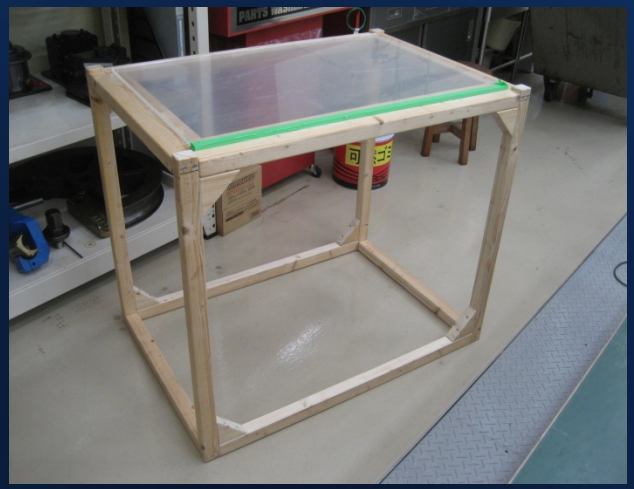
Left: Rolling silicone onto tracing paper
Right Top: Silicone and paint thinner used
Right Bottom: Correct compliant silicon layer should have this texture to it

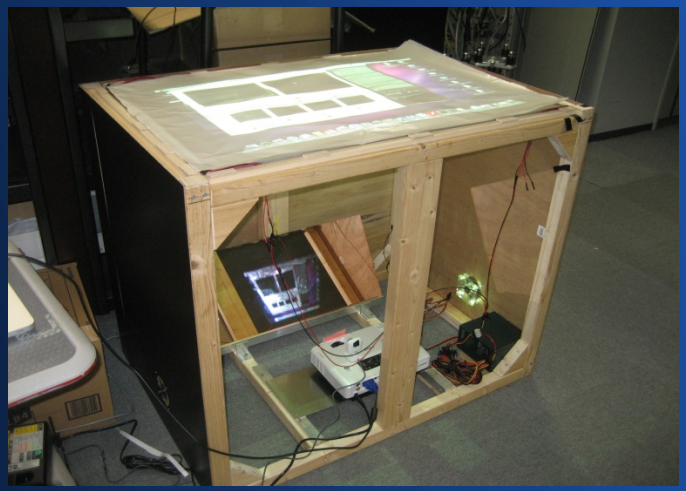
Photo Obtained from: http://peauproductions.com/compL.html

Building a Frame

- constructing a custom frame took up most of the time since everything had to be designed and made from scratch.

- the requirements of the frame are simple, it just has to hold everything together at the correct distances and it must be sturdy enough for heavy touches. In this project, wood was used as the main building material because it was readily avaialbe and easy to work with. Also it is inexpensive and light compared to aluminum and other metals.





Other Component Requirements

Projector:

-Used a short throw Epson projector to make the table a reasonable height without having to use 2 mirrors

Power Supply:

-to power the IR LEDs, a 12V DC power source was needed. Since computer power supplies had 12V connectors and had a wattage rating as well as a reasonable price, they were the best candidate for the job.

Software Used

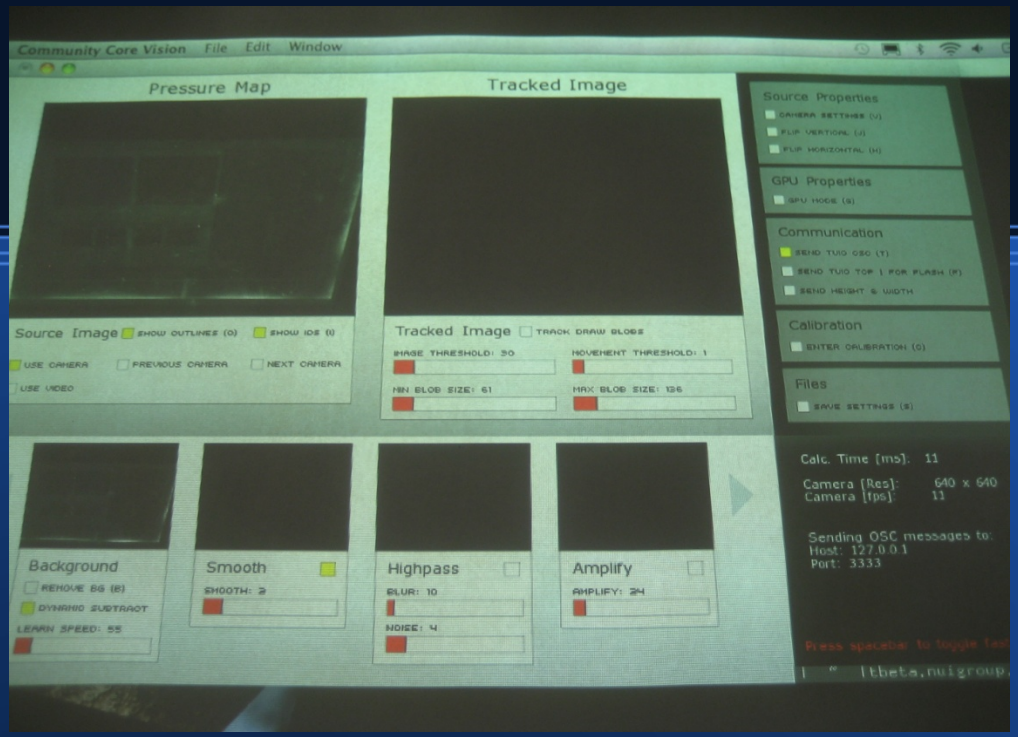
-CCV open source tracking software. It is based on OpenCV. Basically the tracker sends touch coordinates to the multi-touch application.

- tracking software first performs a background subtract

-then a thresh hold level is set so that only the brightest spots due to touches show up.

-the user then calibrates the IR cam to match with the projector coordinates and then the touches should be in the correct places.

- PhotoViewer and Puzzle Game developed by Laurence Muller of NUI Group. The developer of the apploader used was not specified, but it was a member of the NUI group.



< -- Tracking Software. The left picture is the source image with no filters on it and the left is after background subtract and thresh holding

Person Interacting with photoviewer application – >

Demo of CCV Calibration

Please watch videos titled “CCV calibration and after calibration”

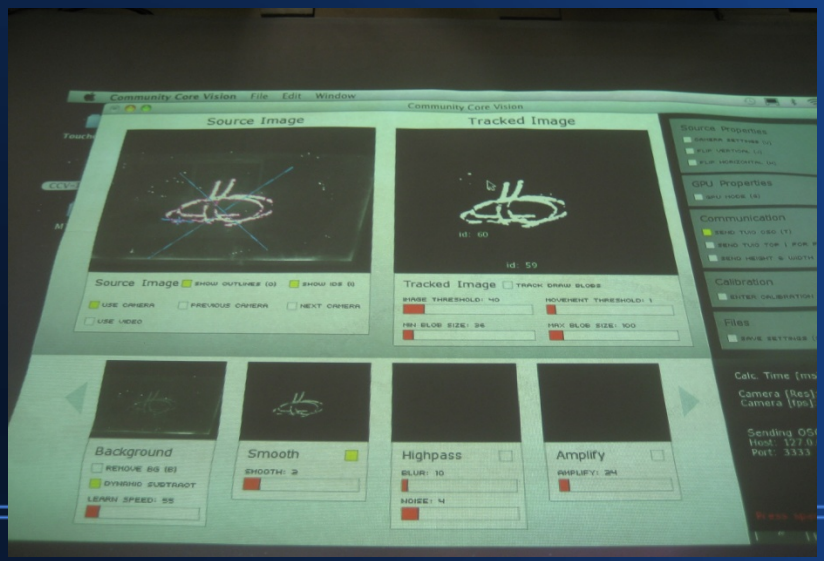
Problems Encountered

- false touches from a bad compliant layer

-slow camera frame rates (11 FPS)

- hot spot from projector since it emits IR as well (fixed with hot mirror)

- difficulty of finding necessary supplies in Japan due to not knowing the Japanese name of a component or item I needed.



Screenshot of tracking software having errors due to a bad compliant layer. You can see the trails of light left by the compliant layer.

Final Project Results

- Able to get all software and hardware working at Nara site.
- users were able to use the touch table to interact with photos of Nara and do picture puzzles of pictures relevant to Nara
- table was packed up and shipped to NICT site in Keihanna for further software development.

Future Plans

- plans have been made to develop software or use a version of CGLX compatible with touch tables to control a TDW.
- NICT intends create a second touch table to keep in Koganei (think of this one as a prototype.)
- Documentation of build process will be made to aid NICT staff in setting up and creating a touch table.

Resources

1. "Forum Home - NUI Group Community Forums." NUI Group - Natural User Interface Group. Web. 20 Aug. 2010. <http://nuigroup.com/forums/>.

2. Teiche, Alex, Ashish Kumar Rai, Chris Yanc, Christian Moore, Donovan Solms, Gorkem Cetin, and Justin Riggio. Multi-Touch Technologies. 11 June 2009. PDF.

3. Way, By The. "Making Your Own Fs Mirror - Lumenlab." MicRo Personal Fabricating Center - Mill, Drill, Engrave, 3D Print and More | Lumenlab. Web. 19 Aug. 2010. <http://lumenlab.com/forums/index.php?showtopic=21137>.

Acknowledgments

Special thanks to the following people:
- Gabriele Wienhausen, Division of Biology, UCSD
- Peter Arzberger, UCSD, PRAGMA
- Falko Kuester, Calit2 UCSD
- Shinji Shimojo, NICT
- Yoshinori Kobayashi, NICT
- Taku Morinobu, NICT
- Masaki Chikama, NICT
- Inoue-san (Machine Shop), NICT
- Hiroyuki Kimura, NICT
- Kazuyuki Yanai, NICT

Programs and Institutions:
- NICT, Tokyo, Japan
- Pacific Rim Undergraduate Experience, UCSD
- National Science Foundation
- Calit 2, UCSD

Questions?