

How to Use St. Norbert College's “Multi-Touch Desk #1”

A Projected, Rear Diffused Illumination, Optical Multi-Touch System



The Comprehensive Quick Guide Collection and User's Manual

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About This Document

This collection of guides was prepared in the spring of 2009 by Ryan Pavlik <ryan.pavlik@snc.edu> to accompany the Projected Rear DI multi-touch desk produced during a CS460 Senior Capstone project. The St. Norbert College computer science professors have access to PDF versions for printing additional copies, as well as the Apple Pages original version and a Microsoft Word exported copy for adaptations and updates.

Additional information on this specific hardware and the original software is available on the project website which can be found starting at:

<<http://www.snc.edu/computerscience/>>

Additional information on the hardware operating principles and the community components (tbeta/Community Core Vision, PyMT, etc.), as well as assistance in further development, can be found through the NUIGroup community at:

<<http://www.nuigroup.com>>

Table of Contents

System Power On	2
Hardware Tuning and Tracker/Application Use	2
Switching Between Dual-Screen and “Clone” Modes	2
Hardware Shutdown	2
Removing the Projector and Anchoring the Camera	2
Securing and Transporting the Desk	2
Appendix A: Hardware Specifications	2
How To Use These Guides	2

Multi-Touch Desk #1 Quick Guides

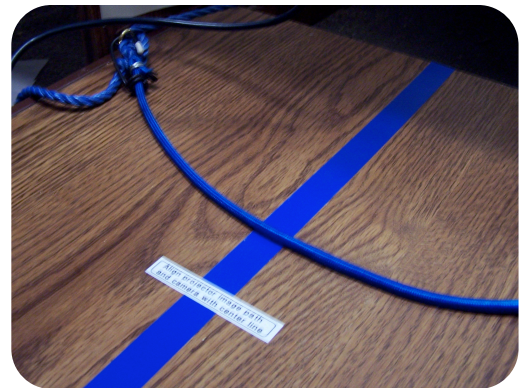
For help in using and interpreting these guides, please see the back cover.

System Power On

1. **Open the drawer.** Slide the deadbolts and open it most of the way.
2. **Connect and secure the projector and camera by following these steps.** If you need to connect the projector, it's usually best to turn off the computer before continuing.

2.1. **Align the projector on the drawer.**

Place the projector on the shelf, being sure to align the "image path" (the lens and behind it) with the blue center line on the drawer, and with the lens of the projector near the furthest edge of the drawer. Generally the projector needs to be fairly close to that furthest edge.



- ### 2.2. **Remove camera and its wooden mount from the bolt in the drawer.**
- Remove the nut holding the camera to its storage anchor in the drawer, slide the camera and mount off that bolt, and put the nut back on for safekeeping. **DO NOT** remove the actual camera from the bolt holding it to the wooden mount!



- ### 2.3. **Center the camera (on its mount) on the projector.**
- Set the camera on top of the projector, facing forward, centered above the

blue line. The black cable wrap outside the drawer also is a center marker, as is the storage anchor bolt.

2.4. **Plug power into the projector.** Use the power cable running next to the camera cable - this cable stays with the desk.

2.5. **Plug the projector into the video card.** Use the projector's own cable to connect it (usually on the port labeled RGB 1) to the DVI-VGA adapter on the add-in video card on the computer: see the picture to know which of the several identical ports to use. You can secure these cables through the black cable wrap and the remaining twist tie lengths.



2.6. **Bungee the camera and projector down.** Stretch the blue bungee cord from one drawer hook, over the projector, over the camera's wooden mount (behind the camera and under the cable), and down to the other hook on the other side. If this does not hold it securely, either use a shorter bungee, or be careful to remove the projector and anchor the camera in the drawer when moving the desk.

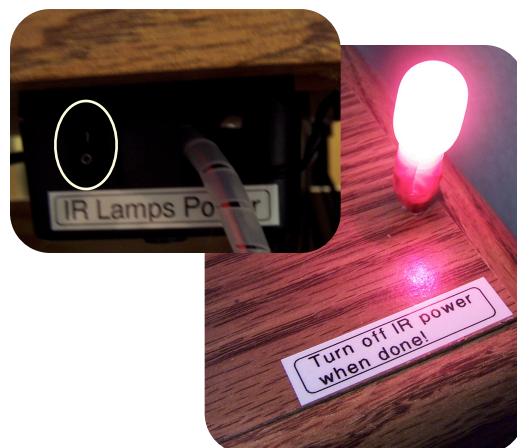


3. **Remove the square touchscreen protector.** Be careful not to scrape or tear the touchscreen surface with an edge or corner of the protector

or with any other object. Use only the flat pads of your fingers when using the multi-touch screen for safety and best results.



4. **Power on the projector and the monitor**, if not already on. Everything should be plugged into the power strip mounted under the desk, so you can just plug in that one power cable.
5. **Power on the computer**, if not already on.
6. **Align and focus the projector.** Once an image is displayed both on the monitor and the touch surface, adjust the drawer depth, projector position (forward/backward) and aim (using the projector's built in tilt feet), and zoom until you can fill the desired area on the screen with a projected image. Focus the image, and if you can't focus it, try changing the drawer depth and/or zoom first. Normally, you want the camera and the hooks a few inches inside the chamber, for an optimal mirror angle and distance, but you might need to make it a little closer or a little further away. If the projector has it, you can use the keystone function to make the projected image more square.
7. **Turn on IR.** Turn on the IR illuminator power switch beneath the desk surface on the right hand side (below the red light, box labeled "IR Lamps Power") when you are ready to use the camera.



Hardware Tuning and Tracker/Application Use

NOTE: You should not adjust the focus knob on the camera - it has been taped in place to keep the surface clearly in focus throughout the normal range of camera-screen distances.

These instructions require the “rp-mt-scripts” to be installed and configured, with the “default install” completed. They are designed for the graphical interface. If you are using the command line, `cd` to the `rp-mt-scripts/scripts` directory and run `./run_tbeta_1.1.sh` or its successor for Community Core Vision to start the tracker directly using the `rp-mt-scripts`.

1. Go to the directory where

you installed rp-mt-

scripts. In the

screenshots in this

example, I installed them

to `~/multitouch` (the

“multitouch” directory in

my home folder) but

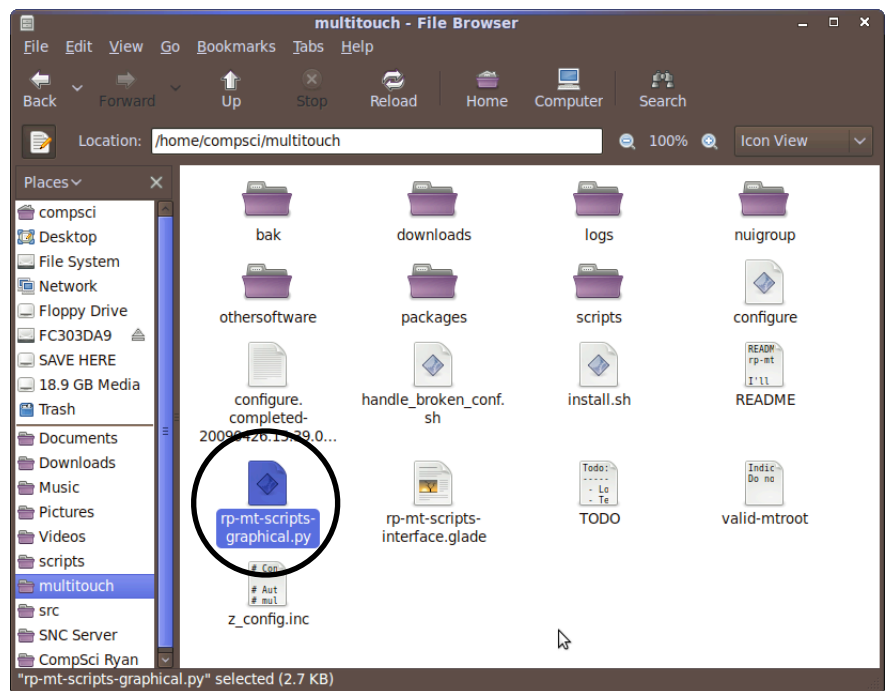
yours might be in `~/rp-mt-`

`scripts`. Click on the

Places menu in the top

panel to find the home

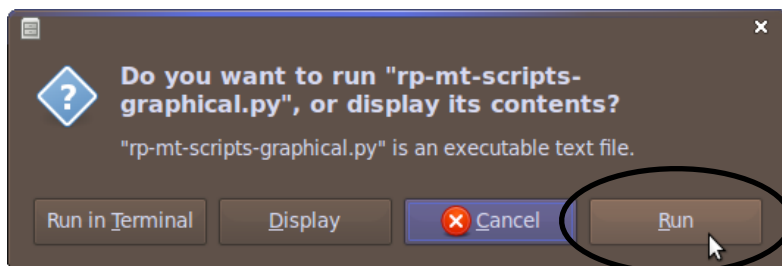
folder. Double-click the directory with your install.



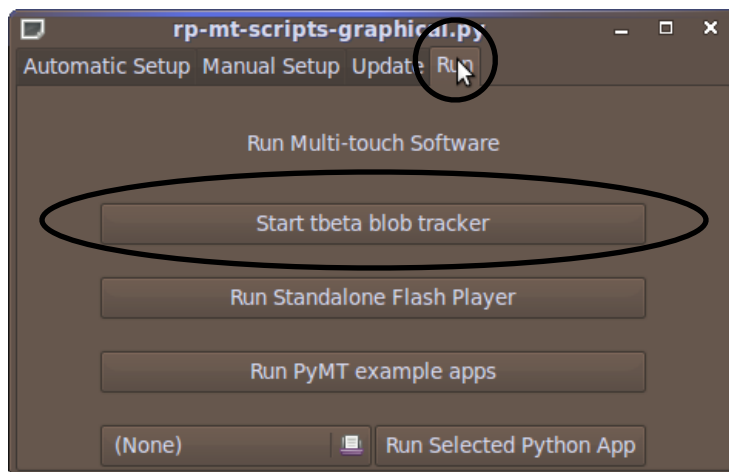
2. Double-click the `rp-mt-scripts-graphical.py` file. See the image of the file browser for an example: it might show up somewhere else in that

window based on your settings, but the name will be the same, and the icon will likely be the same as well.

3. **Click “Run” when prompted.** You could click Display here to see the source code for the graphical interface, though it’s a bit dull since it is a basic front-end to the files (mostly in the `rp-mt-scripts/scripts` directory) that actually get the job done.



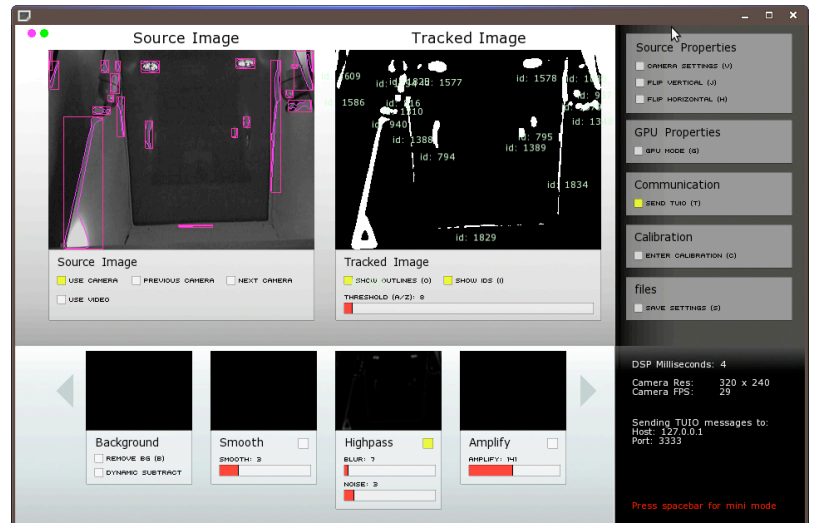
4. **Click on the Run tab.**
5. **Click the “Start tbeta blob tracker” button.** A new terminal window will open - you can ignore its contents if everything works correctly. The tbeta software will start, and once you exit tbeta the



terminal window will close automatically 10 seconds later. Do not close the terminal window! You can minimize it, however.

6. **Align the camera to see the screen.** The tracker software has a “source image” display (see next page). Remember that it is seeing it through the mirror, so some adjustments will feel backwards. Normally, if you’ve followed the steps to set up the projector and camera before starting up, this should be very close if not good enough already.

7. In *tbeta*, press **b** to perform an initial background clear. This will remove the false detected blobs (outlined in magenta) that are stationary (caused by the hardware design), so make sure to keep the space above the screen clear (don't touch or lean over the desk) when doing this.



8. Fix IR or mirror alignment (hotspots), if necessary.

Red boxes indicate detected

blobs - hit *b* every time you make changes to reset the background subtraction. **If you see hotspots**, (very bright areas that look like the front of the IR emitters being seen by the camera directly or reflected off the acrylic), you either need to adjust how far you pulled out the drawer (and thus the angle of the mirror) or adjust the aiming of the two illuminators closest to the opening. Screenshots in this section explain the difference between the two hotspot causes and show an example of a setup without hotspots.

- 8.1. The image on this page shows mirror-related hotspots (before pressing *b* to remove the extra highlighting: the pair of bright circles near the top of the camera's view are the hotspots from the illuminators. If you see these, that means the drawer is pulled out the wrong amount: adjust it until the illuminators leave the view of

the camera, then move your projector on the drawer to change the image size and location.

8.2. This image is part of a screenshot with an IR aiming-related

hotspot circled - caused by one of the front emitters being aimed up too far so it reflects directly off the acrylic and into the camera (via the mirror). Remember that the mirror and camera mean that the emitter to move is



probably not the one you think - have a helper look at the screen while you cover the emitters up with your hand one-by-one until you find the correct one. Adjust it slightly so that it doesn't shine directly at the acrylic - usually it needs to be pointed directly across the chamber or even a bit downward.

8.3. This image shows a correct setup - you can see

where the emitters are shining on the chamber lining on the sides, but it's diffuse and not reflecting off the bottom of the acrylic directly.



9. Touch the screen and see if the blobs are recognized. If they are, all you will see on the left image is white areas where you touch and only where you touch. Move your fingers and make sure the directions are correct - there are image flip options. The various settings should all be approximately correct for the desk already, but if they aren't, or if you need to start over, a good general technique is reset background subtraction with b, decrease all levels to nearly 0 so you see a lot of false blobs and noise, and then slowly adjust the sliders until you get

good clear blobs and no false blobs. The desk usually just needs the high-pass filter and optionally a little smoothing before the last “rectify” step. Rarely, amplify might be needed if there is very low contrast.

9.1. Adjusting tbeta filters: If only large areas of contact are seen, and are seen as small areas, your High Pass Filter:Blur is too low. If it is creating a blob for your palm as well as your fingers, your High Pass Filter:Blur is too high. If there is a lot of noise everywhere, your High Pass Filter:Noise is too low. If there are a few false blobs or noise that doesn’t dance around like the noise removed by the high pass filter, your Threshold is too low. If nothing is detected on a touch, either the IR illuminators are off (check the indicator lamp - you might also be able to faintly see a red dot in each LED with your eyes if you look in the drawer opening), your threshold is too high, your High Pass Filter:Noise is too high, or perhaps you need some Amplify turned on. If extra blobs are added when you touch, you’re touching too hard (flexing the acrylic and changing the pattern of reflection) and/or the illuminators need to be aligned again. Don’t forget to reset the background often by pressing *b*, and make sure that nobody is touching or standing over the screen when you do this!

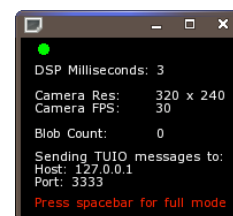
10. Start calibration of tbeta by following these steps if the drawer, projector, camera, or desk have been moved since last use. Press *c* to load the calibration screen, and move it to the correct display if needed. Then, press *b* again to reset background tracking, and *c* to start the calibration procedure. Tap on each circled point in order - if it

skips a point (false touch), press *r* as many times as needed to return to the missed point. Once you have touched all those points, touching the screen should place a colored shape beneath your fingers. If it is not quite right, re-calibrate. More complicated settings involving screen shape or improved precision are explained on the calibration screen.

11. Leave calibration mode by pressing the x key on your keyboard.

12. Change to mini mode by pressing the space bar. This

is a toggle: if you need to adjust beta settings, you can do so after pressing space again.



13. Run multi-touch software. You can use the other buttons

on the Run tab of the graphical rp-mt-scripts interface, or run other

Python multi-touch software

directly (like the tactus-

navigator) the same way you

started the rp-mt-scripts-

graphical.py interface: finding

the main source file in the file

browser (for example, tactus/

py/mainpymt.py), double-

clicking, and choosing Run

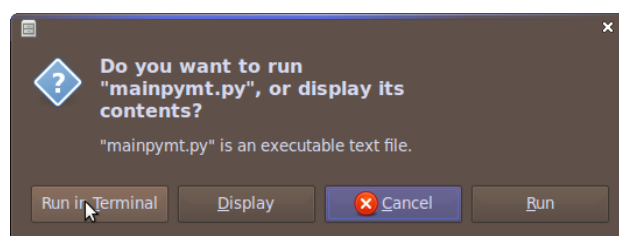
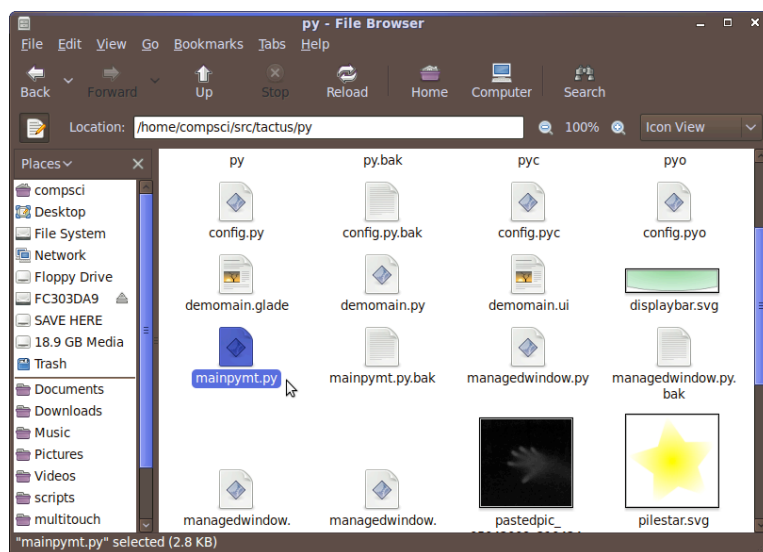
(or Run in Terminal if you

want to see any output to stdout).

14. When you are done, exit the

multi-touch software. Usually

there is an obvious way to quit



each application - if not, try pressing *esc*. Exit one multi-touch application before starting another. However, you do not normally need to quit and restart *tbeta* for each app, just leave *tbeta* open and start your new application manually or with the *rp-mt-scripts* GUI.

- 14.1. Note that most third-party demos assume that your touch surface is on your primary screen or that you only have one screen, which is not accurate for this desk, while *tactus-navigator* prefers dual-screen mode for normal operation. See the guide to switch between dual-screen and “clone” (single-screen duplicated on monitor and projector) mode for best results.
- 14.2. If you are having problems, check what the blob-count in *tbeta* is when you are not touching the screen - if it is not zero, press *b* with the *tbeta* window selected to reset the background subtraction.
- 14.3. If touches are no longer received, but there are correct blobs detected in *tbeta*, one of your programs probably did not correctly release their access to the touch data. If you did not run a multi-touch application in the standalone Flash Player, try quitting your application, quitting *tbeta* using *esc*, and starting *tbeta* and your application again.
- 14.4. If you are having problems and you ran a Flash app, it's likely that the FLOSC gateway did not shut down properly afterwards, which is not your fault unless you closed the terminal window for the Flash player before it finished. The script tries to quit it, but it can't always do it right, so if you know how, manually kill the Java

process running the FLOSC gateway from the terminal or system monitor then quit and start tbeta again.

14.5. If these steps do not work, try restarting the system and starting tbeta and your application again.

15. Exit tbeta by pressing `esc` with its window selected. You do not need to leave mini mode. Do not just close its window, since this might not save its settings.

Switching Between Dual-Screen and “Clone” Modes

These instructions are written for the nVidia dual-head graphics cards using the (proprietary) nVidia drivers that was installed in the computer during the project. They will apply to any other recent nVidia dual-head graphics card using the proprietary drivers on Linux.

1. Start the nVidia Settings Tool. If

you want to set the settings temporarily, just go to the System

menu, Administration, NVIDIA X

Server Settings. If you want to

set up dual-screen for the first time (already completed) or set

the default settings for startup,

press *Alt-F2* and type *gksudo nvidia-settings* and press enter. You'll be

asked for the password, and then

will be shown the same screen as

if you were temporarily changing a

setting.

2. Choose “X Server Display

Configuration.” You'll see the

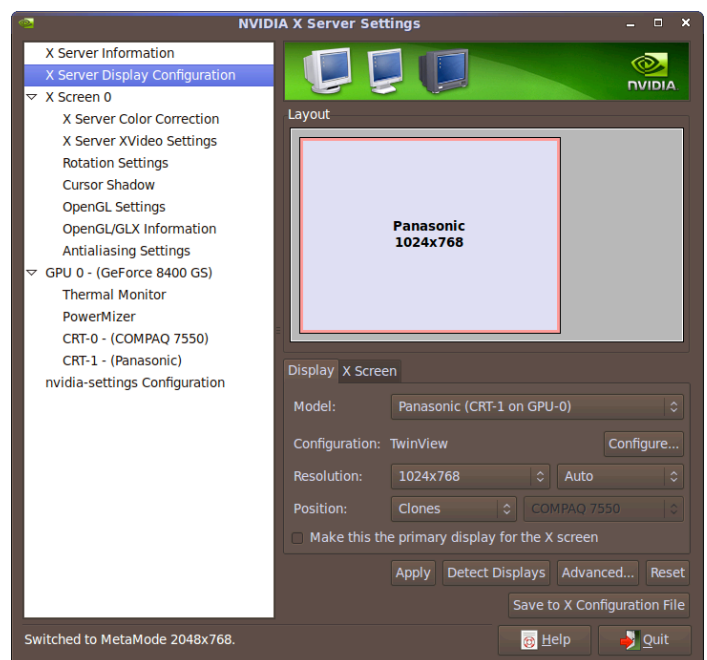
following screen - if you don't see

“Configuration: TwinView” then

either you are using a new

installation or the settings were

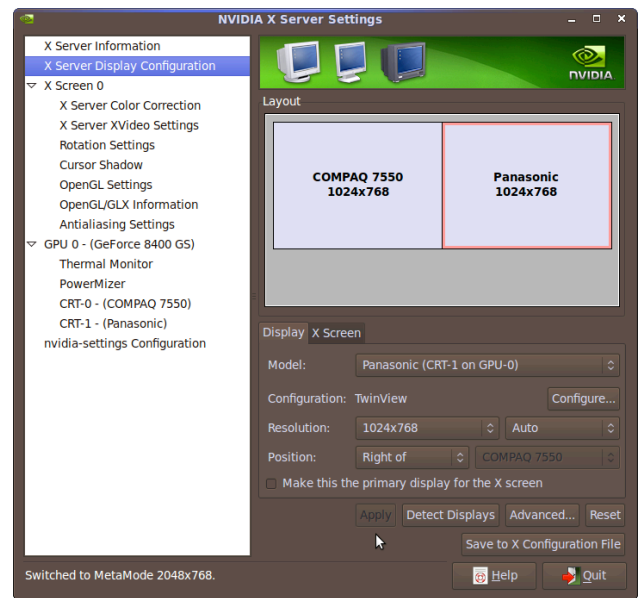
damaged - click the Configure



button and choose TwinView in that case. You might need to start this tool as a superuser - see the previous step for how to start the tool to make permanent changes.

3. **Change screen position for the projector - display #2.** In the

“Model:” drop-down menu, choose the second entry, which should correspond to your projector. Make sure you see “Configuration: TwinView”, then under Position, choose your desired option: “Clones” to run most third-party demos and software that assume you only have one screen and that it’s your touch screen, or another option (such as “Right Of”) to run dual-screen-aware

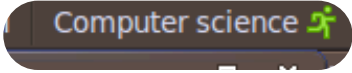


software such as tactus-navigator. If you don’t see an entry for your second screen, try clicking Detect Displays, and if that doesn’t work, reboot: you probably plugged your second display in after the computer booted up with just a single screen.

4. **Apply the changes, and save if applicable.** If you are just making a temporary change, click the Apply button so it takes effect. If you are making a permanent change, click the Save to X Configuration File option, leave the settings as they are, and confirm - you will need to close all your applications and either press *Ctrl-Alt-Backspace* or restart the computer.

Hardware Shutdown

Shut down at least the projector and the IR illuminators when finished working with the system. Shut down at least the projector (and probably also the IR) before closing the drawer. You must shut the entire hardware system down before moving the desk. Complete whichever steps are needed in your situation.

1. **Turn off the IR illuminators.** The switch is on the right-hand side of the desk, underneath the desktop near the red IR power indicator light.
2. **Shut down the computer safely.** First, close all software. Then, click in the upper-right corner of the screen (on the  username Computer Science next to either the running-person icon or your status icon) and choose to shut down the computer from the menu. Confirm the shutdown in the window that pops up.
3. **Turn off the monitor.**
4. **Turn off the projector.** Usually this involves pressing the power button once, then pressing it again to confirm. DO NOT remove or unplug the projector or slide the drawer in until the projector is cool and its fan has shut off!

Removing the Projector and Anchoring the Camera

You must complete this process if you need to remove the projector. You must also go through this process before securing the desk and transporting it, unless you accept the risks of moving the desk with the projector in it.

1. Power down at least the projector using the correct instructions.

Simply unplugging the projector or switching it off before it is correctly shut down and cool can damage the bulb, which costs hundreds of dollars to replace.

2. Unhook the blue bungee from the hooks. Only unhook one side, and be careful not to affect the ropes tethering the mirror to the same hooks.

3. Secure the camera and mount to the anchor bolt.

Remove the nut from the anchor bolt inside the front panel of the drawer (circled), then slide the camera mount over that bolt and replace the nut. See the startup instructions for a photo of the camera correctly connected to the anchor bolt - the same nut is circled.



4. Disconnect the video cable from the computer and projector. You only need to disconnect the projector's video cable (leaving the monitor plugged into the computer) unless you have a special reason.

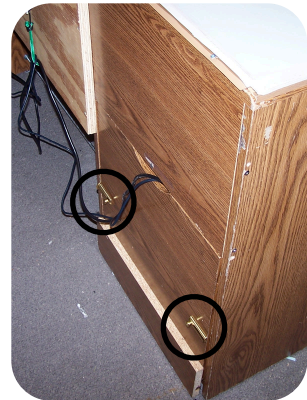
5. Remove the power plug from the projector, and remove the projector. The power cable stays with the desk.

6. Connect the bungee to the hooks again for safekeeping.

Securing and Transporting the Desk

You must at least turn off the projector and allow it to cool completely (fan off) before following these steps!

1. **Make sure the bungee and loose rope ends are not in the way.** The bungee should be connected to both hooks whether or not the projector is mounted, and the loose ends of the rope should be laying on the drawer shelf, away from the glide rails and the open floor by the mirror.
2. **Slide the drawer back in.** The cables still remaining should go through the black cable wrap above the center of the drawer opening, and when the drawer is closed should pass through the open area directly below that cable wrap.
3. **Secure both deadbolts.** They are a little finicky, especially depending on your floor surface, but if you wiggle them around and shift the drawer front a bit, they do both close all the way.
4. **Cover the touchscreen if possible/logical.** Leave the cover off if it would be likely to shift around and cause damage to the surface during transport. Place the protector on the touchscreen, smooth side down. Be careful of the edges and corners, and set it down all at once rather than sliding it on.
5. **Unplug the power strip and network cable.** Leave everything plugged in to the power strip.



6. **If you are removing the computer tower, disconnect the IR power and other cables.** The screw terminal stays with the power box beneath the desk, so you would unscrew the computer side of the terminal. Most cables stay with the desk and are secured using a number of velcro cable ties or twist ties permanently attached to the desk - leave them neatly tied as-is if it is at all possible.
7. **Move the desk if desired.** When you can't slide the desk, lift slightly using both end handles - the desk has glides (beneath all three parallel vertical support boards and the drawer front) for use on smooth surfaces. When you lift it, it will probably tip toward the drawer-opening side, so be careful if there are components still on the desk. Beware of floor gaps, bumps, and surface changes, as well as the gap entering/leaving elevators. Long distances require a cart and probably the removal of the projector, monitor, and CPU tower.



Appendix A: Hardware Specifications

Computer System:

- 2.4 GHz Pentium 4 processor
- 1 GB SDRAM
- 20 GB hard drive for Windows XP Pro (Tech Support Services)
- DVD drive
- Additional 20 GB hard drive from the computer science department with Ubuntu Linux 9.04 installed (bootloader installed to primary hard drive)
- BFG nVidia GeForce 8400GS 512MB PCI dual-head video card, purchased by the computer science department, lifetime warranty
- Logitech QuickCam Pro 4000 USB webcam from the computer science department, modified to remove IR filter and add visible light filter created with two layers of developed, over-exposed negative film. Runs at 320x240px and 30fps for multi-touch use.

Touch Hardware:

- 6mm clear acrylic sheet, approx. 23"x17", mounted on chamber providing approx. 22"x16.5" maximum viewable area
- Off-white, thin shower curtain material (from Dollar Tree) covering acrylic sheet to serve as diffusion layer and projection surface, attached to plastic mounting rails with double-sided tape - replaceable in case of damage/wear
- Chamber lined with projection screen material to reflect/diffuse IR light.
- Four 48-LED pre-built IR illuminators with light sensors covered
- Hinged mirror tethered to sliding projector/camera drawer for projection and camera input

How To Use These Guides

The bold sentences at the beginning of each step are intended as summaries for experienced users. The text in regular print that follows is a more-complete description intended for new users or those who want more information on the details.

The guides reflect the most updated information in early May of 2009 on how to use the desk and the software installed on its computer. While the photos and screenshots are cropped and annotated to directly illustrate the steps they match, hardware and software changes since the creation of those images might mean that what you're working with looks slightly different. Regardless, the process should be similar.