

Interactive Multitouch Display

by [turkey tek](#) on June 26, 2007

Table of Contents

intro: Interactive Multitouch Display	2
Video	2
step 1: Theory of operation	3
step 2: screen frame	5
step 3: led rails	6
step 4: led mounting and wiring	8
step 5: prepare acrylic	9
step 6: screen sandwich assembly	10
step 7: modify webcam	13
step 8: projector mount	14
step 9: framing support	16
step 10: software and demos	18
step 11: enjoy	19
Related Instructables	19
Advertisements	19
Make Magazine Special Offer	19
Comments	19

intro: Interactive Multitouch Display

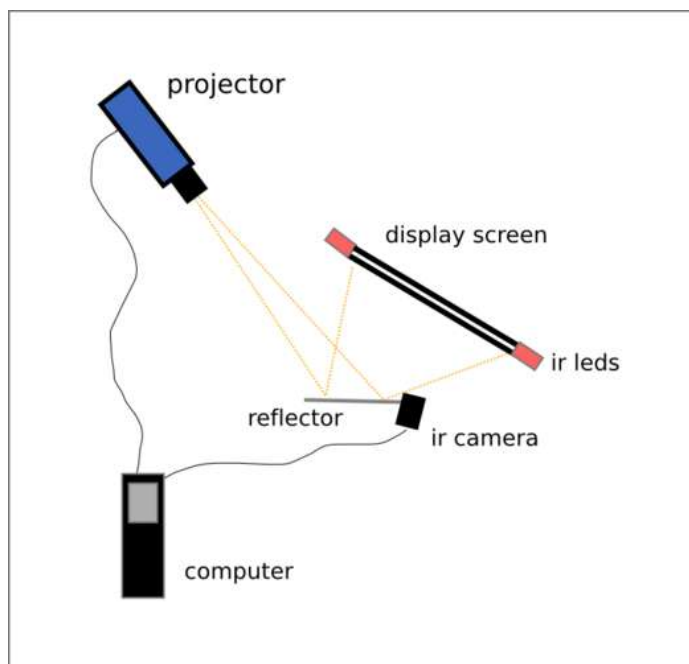
Between the Apple iPhone and Microsoft's interactive table, multi-touch displays are all the rage. This instructable will show you how to turn your lcd projector into an interactive multi-touch display table using a few cheap components readily available from the hardware store.

Here is a video of my display in action:



Image Notes

1. camera mounts here.



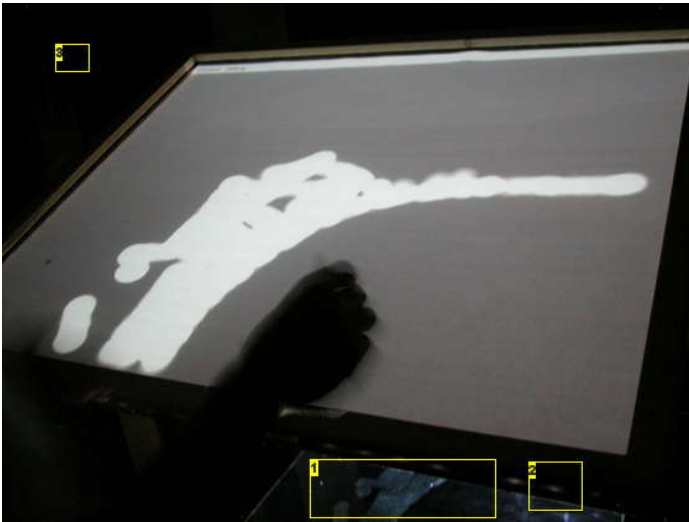


Image Notes

1. projector image visible on the dirty mirror
2. my camera responds a bit to the ir leds
3. touchlib fingerprinting demo

step 1: Theory of operation

This multitouch display screen design is based on the description in Jeff Han's paper,

Han, J. Y. 2005. Low-Cost Multi-Touch Sensing through Frustrated Total Internal Reflection. In Proceedings of the 18th Annual ACM Symposium on User Interface Software and Technology

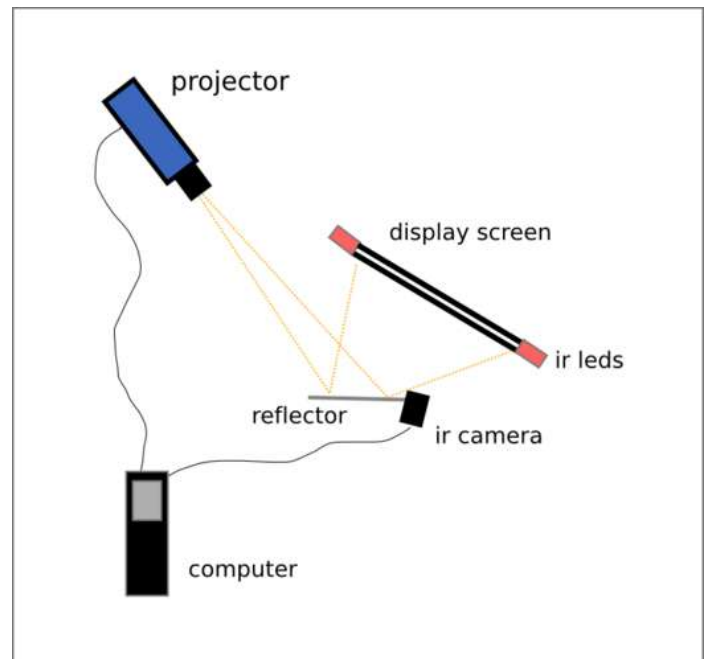
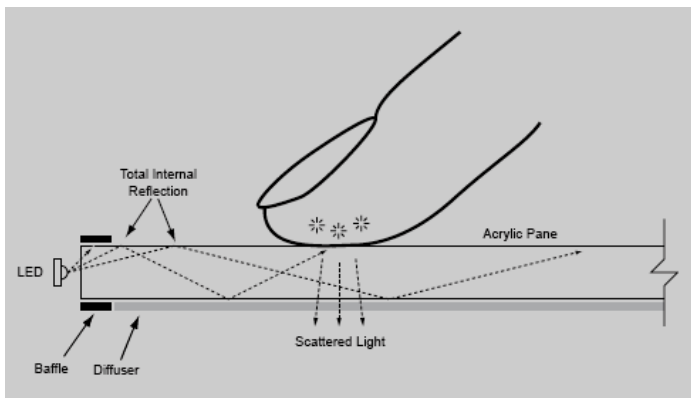
The figure below comes from his web site.

An acrylic panel is edge lit with infrared leds. When your finger comes in contact with the acrylic, it scatters infrared light out the back where it is visible via infrared camera. As long as nothing is touching the acrylic, very little of the light escapes, instead just reflecting around inside. Image processing takes care of detecting tips of fingers and relaying their location to application software. Since the camera "reads" the whole display in parallel, it is easy to detect multiple fingertips at once, even those belonging to multiple users. All this sensing goes on in the infrared spectrum, leaving us free to utilize the visible spectrum to display interactive software.

Since most hobbyists can't afford multiple projectors (i don't even own one, just borrowed it from [dr.eel](#)), my design uses a ceiling mount that swivels so that the projector can be used either in standard mode (say for watching movies) or can be aimed downwards, bouncing off a reflector and onto the multitouch display screen.

The screen itself can be constructed from hardware store materials and hand tools. Excluding the projector and modified webcam (commodity items these days), the only thing complicated is the software. Halfway through this project, I was happy to discover that there is thriving DIY community which has already undertaken the task of writing the image processing code and several cool open source demos which can be found here:

[touchlib](#)



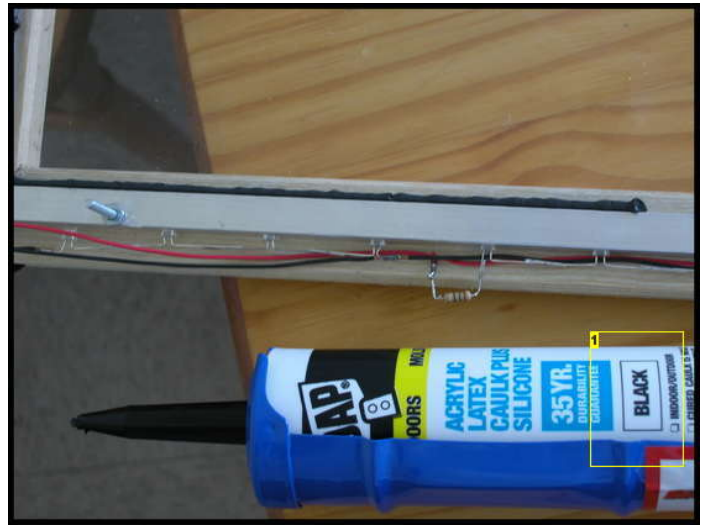
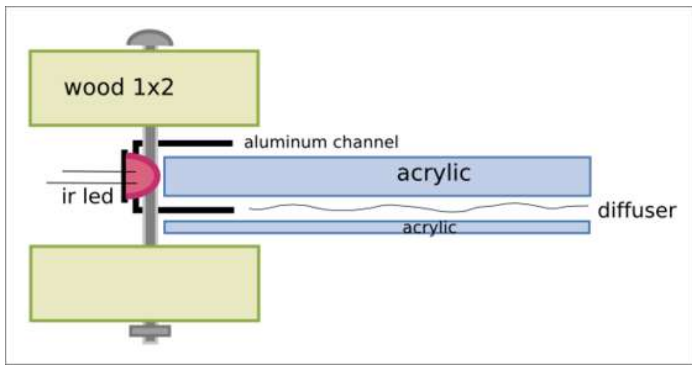


Image Notes

1. black seemed like a good choice for blocking light.



step 2: screen frame

The primary component to be constructed is the screen itself. This is a piece of acrylic, with a frame which holds the diffuser and IR leds in position. I opted for a sandwich style construction out of 1x2s and aluminum channel. My acrylic was 30x36x0.25 inches so I made two frames to match, mitering the edges and assembling with screws and construction adhesive. The sandwich design is simple and leaves plenty of room for wiring the leds.

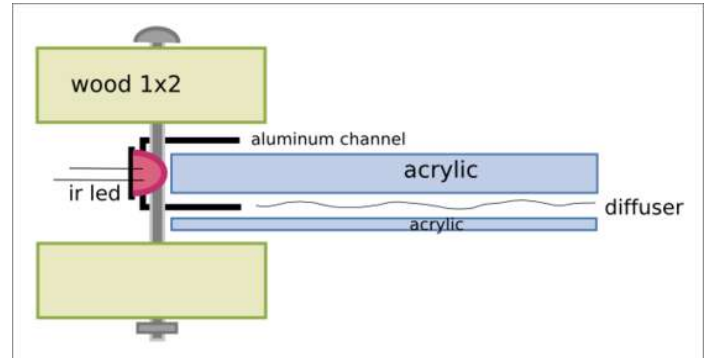


Image Notes

1. note the protective plastic...leave it on until the last possible moment to avoid scratches

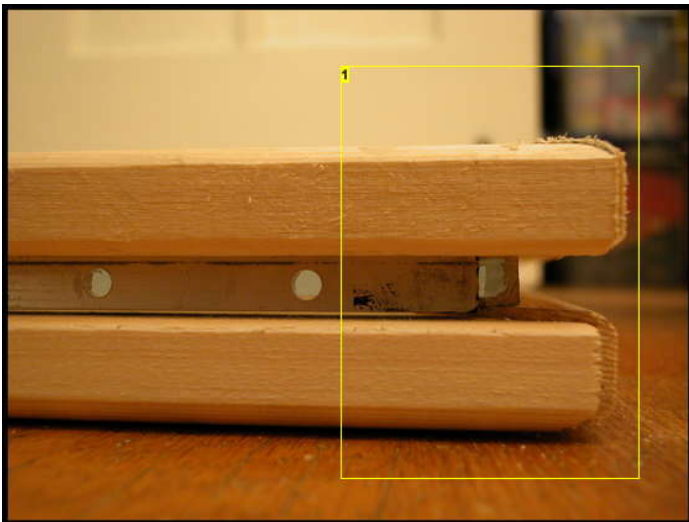


Image Notes

1. delicious sandwich. aluminum extrusion between two slices of pine.

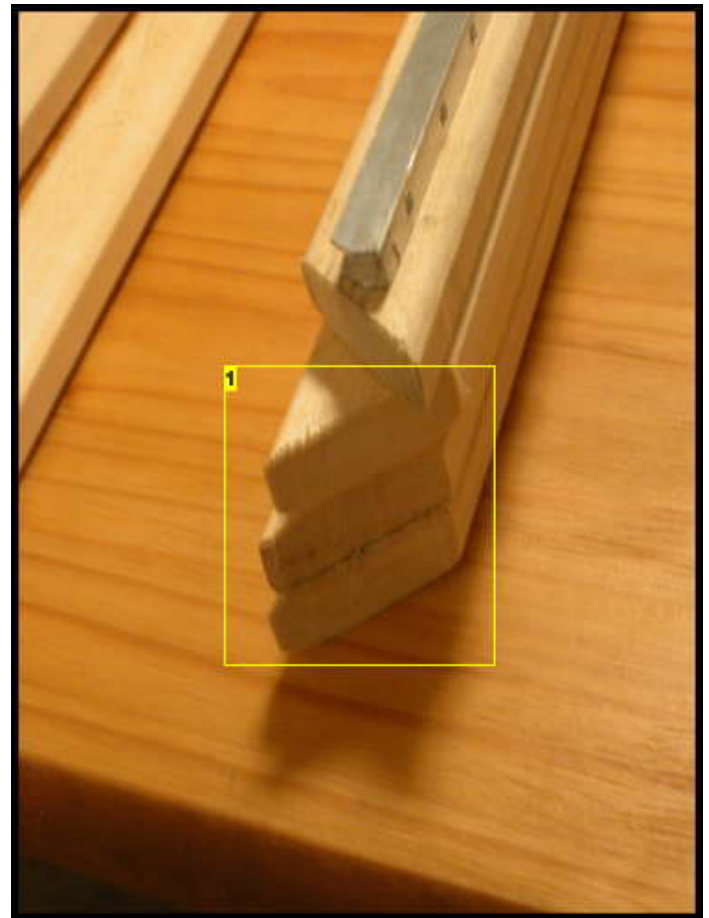


Image Notes

1. $\pi/4$ radians

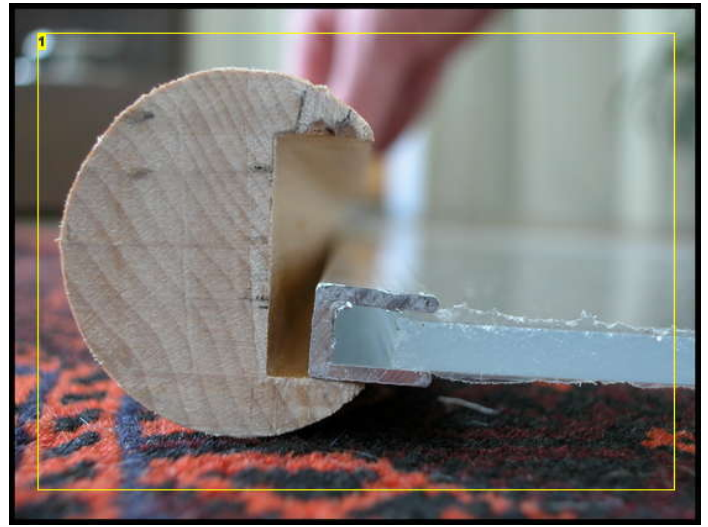


Image Notes

1. an earlier attempt to use some materials i had lying around...however, leaves little room for wiring up the leds meant i had to abandon this sleek, round material

step 3: led rails

The leds are mounted in extruded aluminum c-channel, pressed into holes. The channel serves to hold the leds in place as well as providing a baffle to direct the light into the edge of the acrylic. Additional spacer blocks cut from acrylic keep the panel from sliding around and pushing the leds out of their holes.



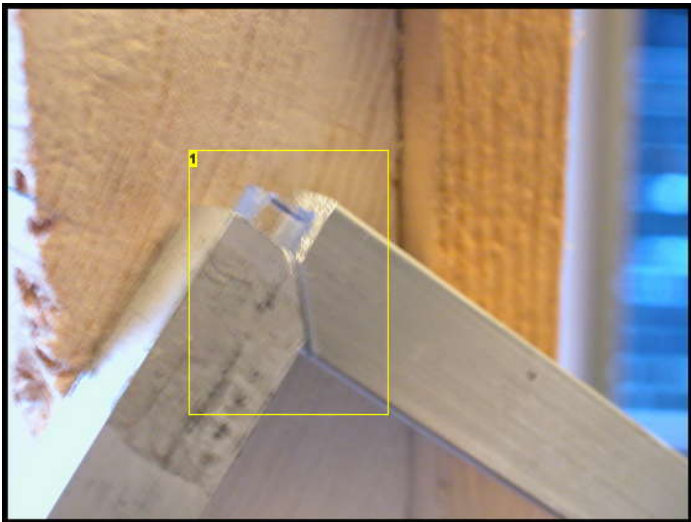


Image Notes

1. corner filed off to give appropriate clearance

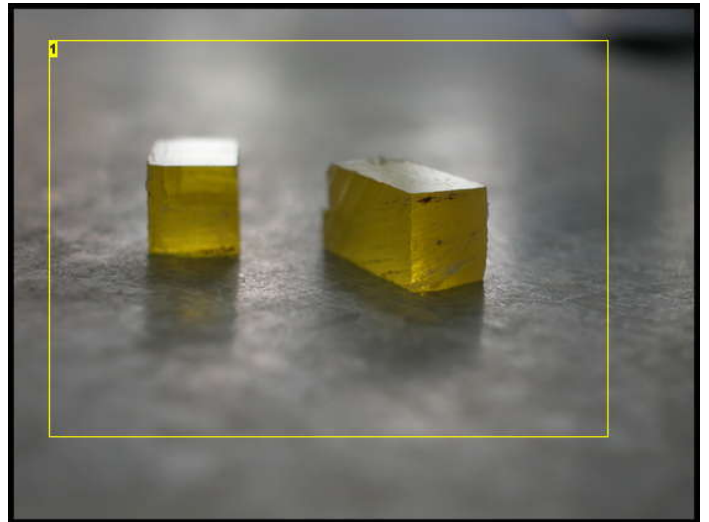


Image Notes

1. spacer blocks

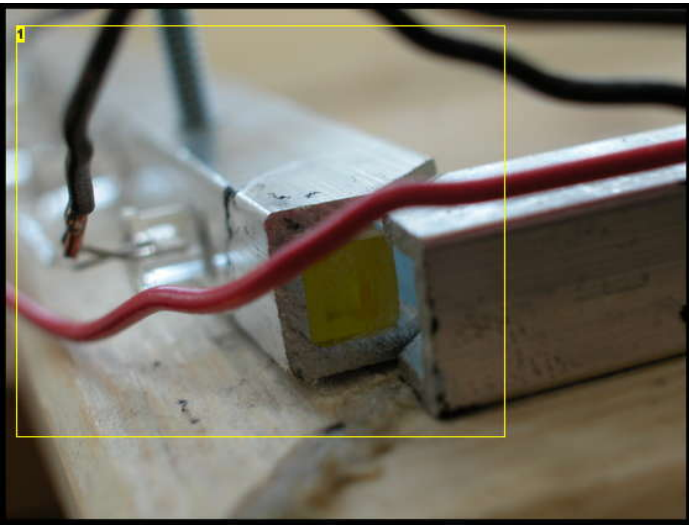


Image Notes

1. i am in ur extrusion, providing ur klearance!

step 4: led mounting and wiring

I used 88 infrared leds I ordered surplus online. Their maximum output was 10mW @ 940 nm. Each led needed 100mA at 1.45V so i wired sets of 8 in series along with a 5 ohm resistor. I wired these sets in paralell across the 12V rail of an old computer power supply I had lying around. Since the total current draw is over an amp, you can't get by with a wall wart.

Pour yourself a glass of whiskey and fire up the soldering iron...it will take a while to wire up 88 leds.

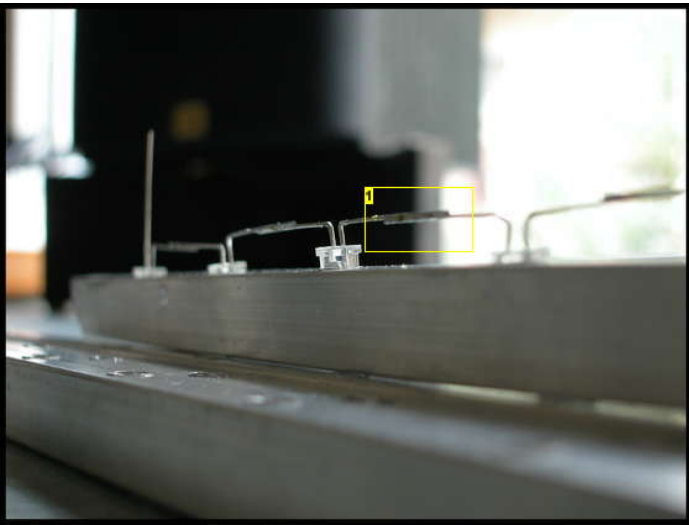


Image Notes

1. solder, solder, solder,.....



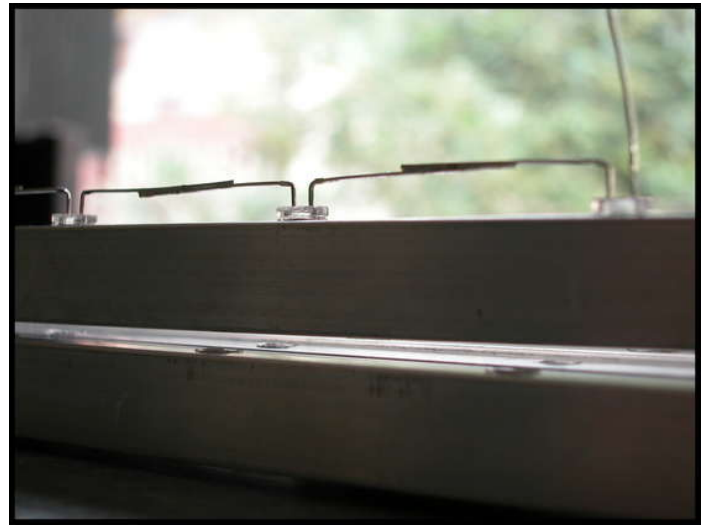
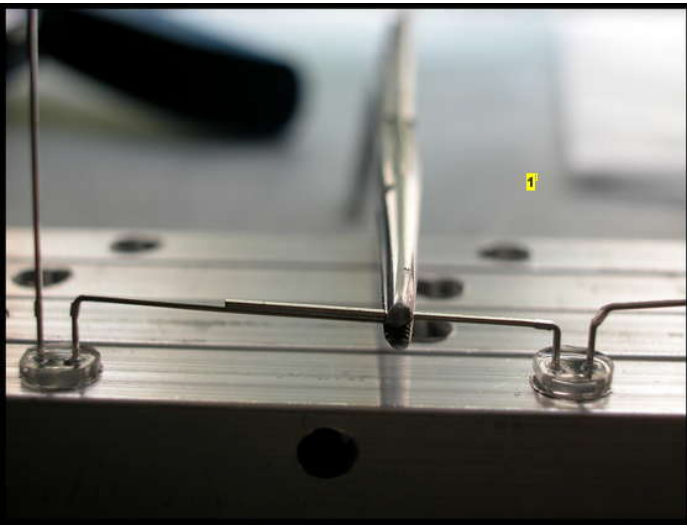


Image Notes

1. hemostats are teh rox

step 5: prepare acrylic

It is valuable to polish the edge of the acrylic to maximize the light that enters from the diodes. Some folks advocate drilling holes in the edge so the leds seat down in but they seem to work ok just butted up against the polished edge. Start with 200 grit sandpaper and work up to 600 or realms beyond. Sanding always takes longer than you think.



Image Notes

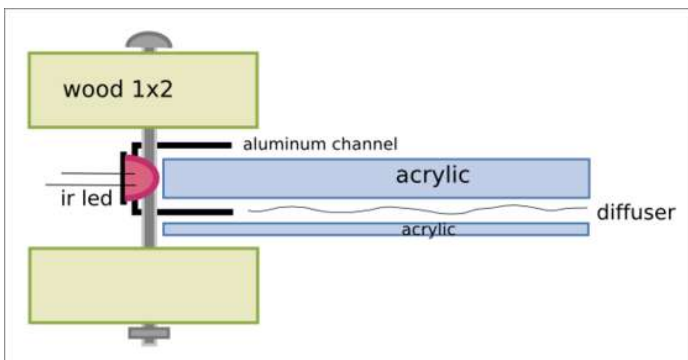
1. acrylic, available in large sheets at the neighborhood hardware store



step 6: screen sandwich assembly

Once the frame, rails and acrylic are prepared you are ready for the final assembly. Clamp the layers together for easy drilling and bolt them in place. Once the sandwich is assembled, it is necessary to caulk along the edge of the aluminum in order to block any light that might spill out thru the crack. We want it all nicely ducting along the inside of the acrylic instead.

In order for the projector to display on the surface it is necessary to also introduce a diffuser (not shown here). A sheet of thin drafting paper was included in the sandwich supported by a second thin layer of plexiglass.



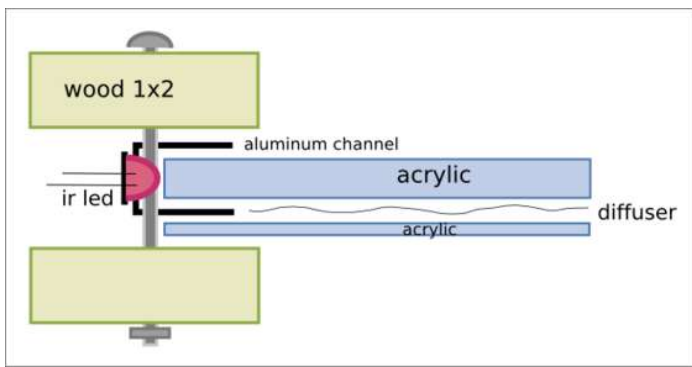


Image Notes

1. sheet of paper used as a diffuser



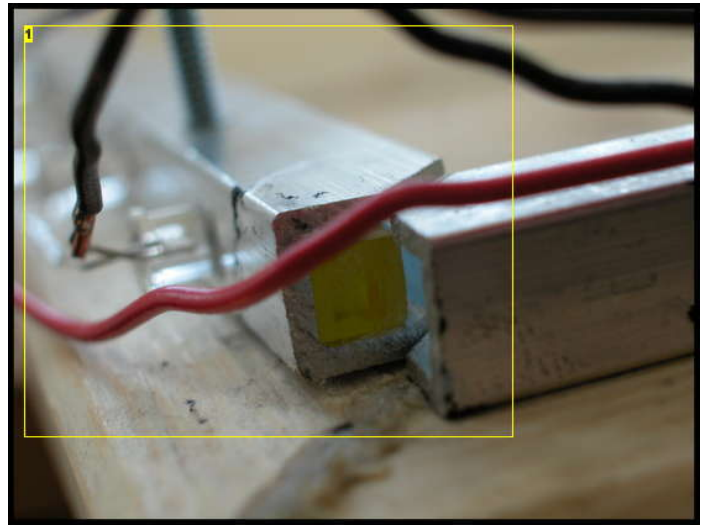


Image Notes

1. i am in ur extrusion, providing ur klearance!

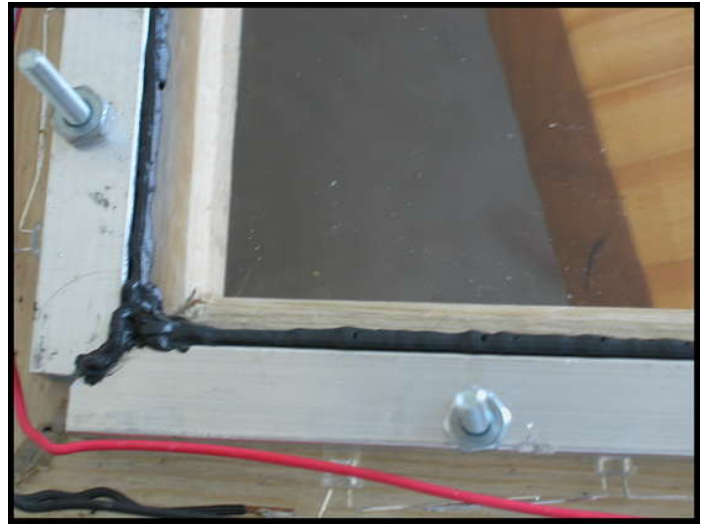
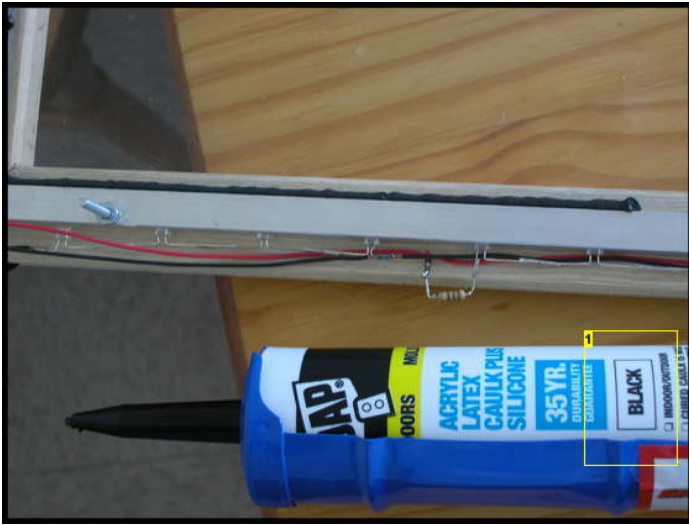
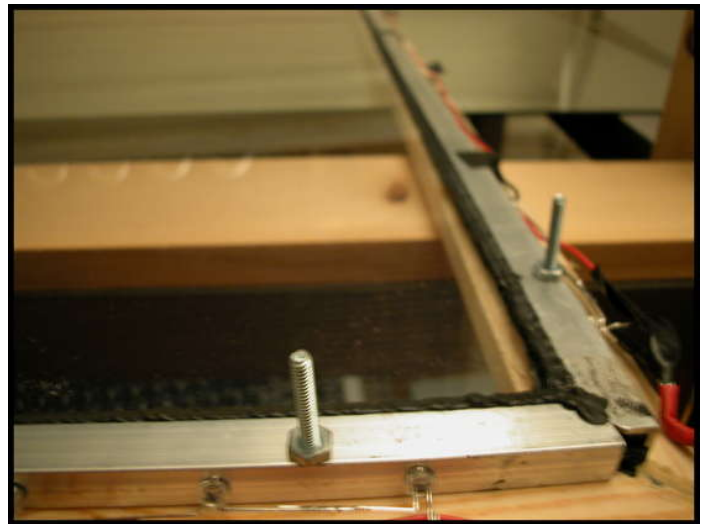
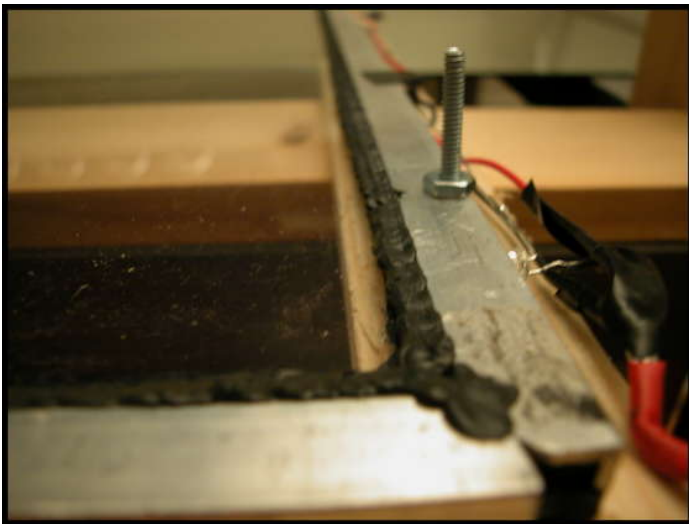


Image Notes

1. black seemed like a good choice for blocking light.



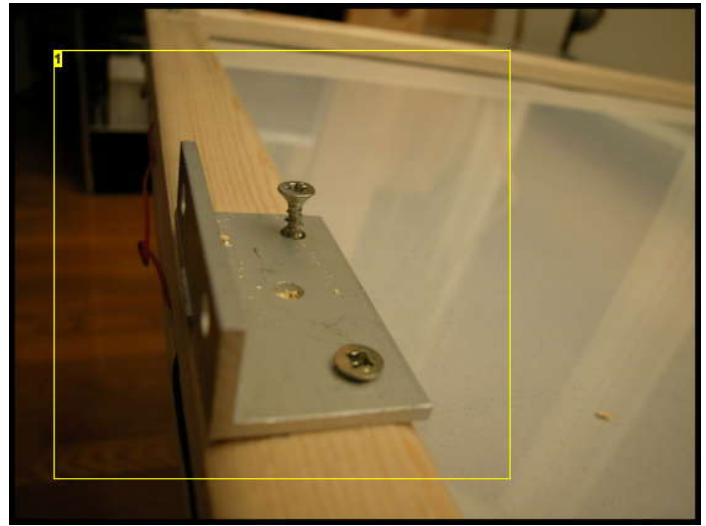
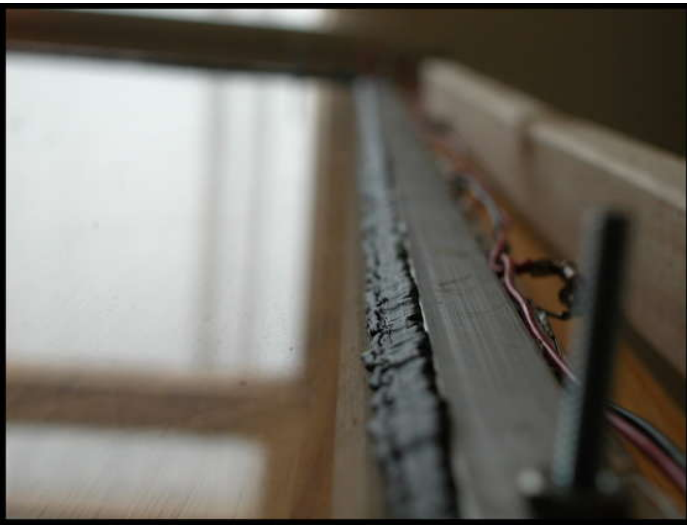


Image Notes

1. hinge point for attaching to the frame

step 7: modify webcam

In order to image the infrared light, we need an infrared camera. Fortunately CCDs in cheap consumer cameras are quite sensitive to IR, so sensitive in fact that it is necessary to filter out the ir in order to get good pictures. I got lucky and had an old intel web cam lying around in which the ir filter was a cinch to remove. Replace the ir filter with a visible light filter (so the camera doesn't see the projected display). I used the exposed end of a negative. See e.g., [this instructable](#) for more details.

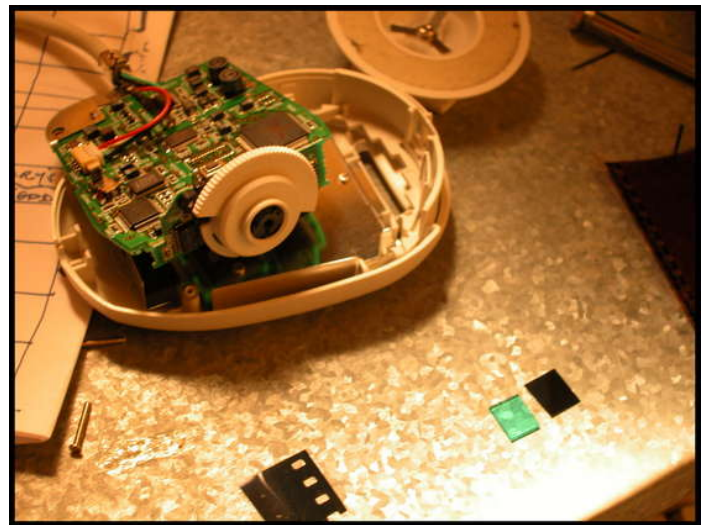
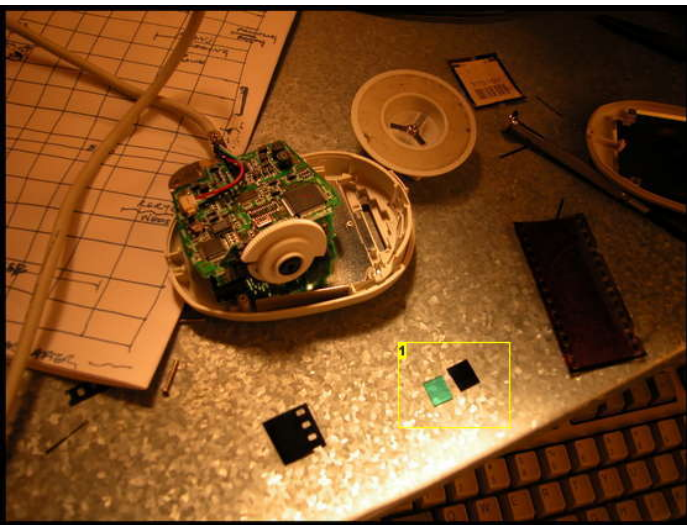


Image Notes

1. old infrared filter (green) alongside my new and improved visible light filter (black)



Image Notes

1. camera mounts here.

step 8: projector mount

A key aspect of my design is the projector mount. It allows dual use, whereby the projector can be used with a standard projection screen, or swiveled down for use with the multitouch display. I cobbled something together using scrap metal from the closet. A central support and cross piece with holes drilled to match the mounting holes on the bottom of the projector are attached thru a bolt to the wall. The bolt provides a natural place for the projector to hinge from.





Image Notes
1. hinge point.



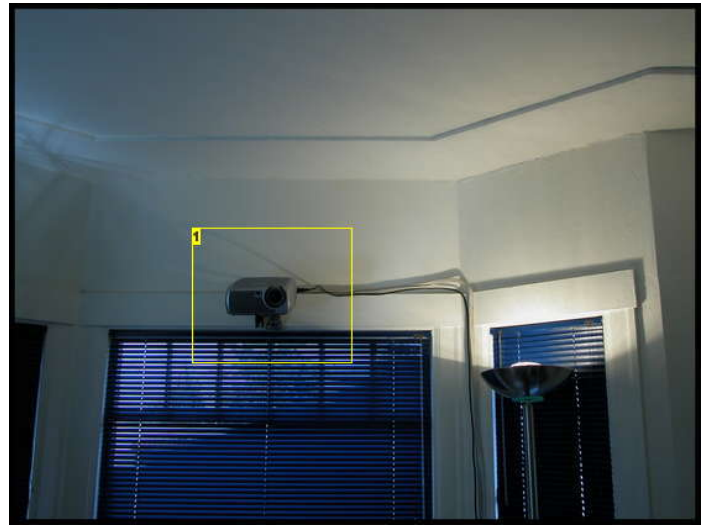
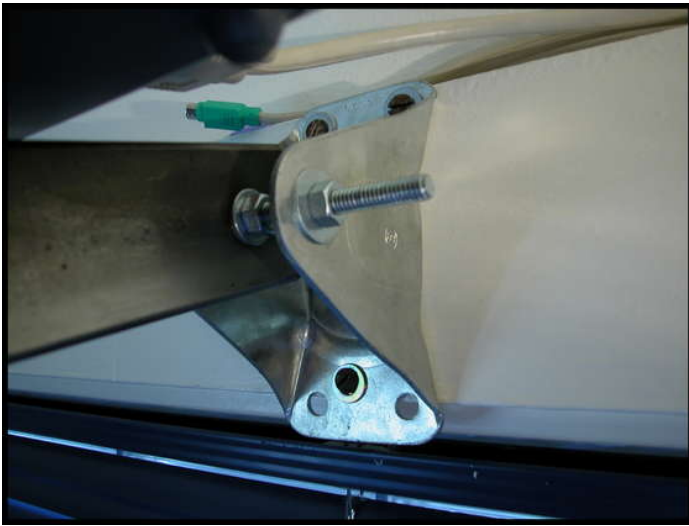


Image Notes

1. standard projection mode

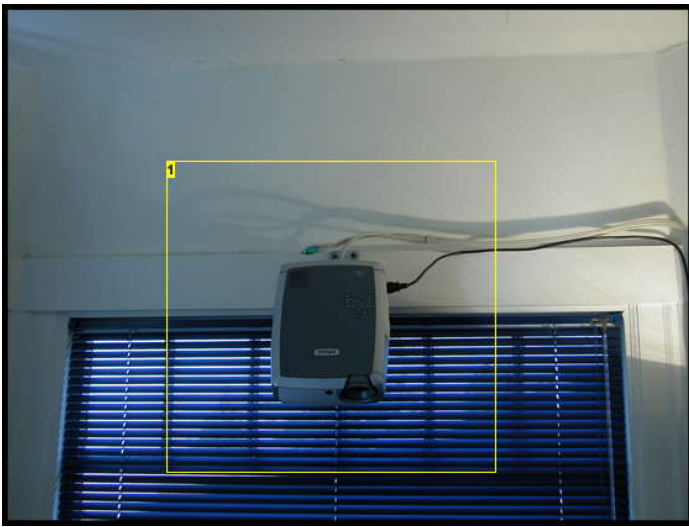


Image Notes

1. hinged down for touch screen use

step 9: framing support

Last but not least, build some framing to support the screen. I started from a coffee table frame as a base and a couple wood planks to get the screen up in the air. The exact geometry is dependent on the optics of your projector. The one I borrowed wouldn't focus at close distances so it was necessary to have the light follow a longer path, bouncing off the mirror and back up onto the display. The angle of the display surface matches that of the projector (angle of incidence = angle of reflectance) in order to minimize keystone distortion.

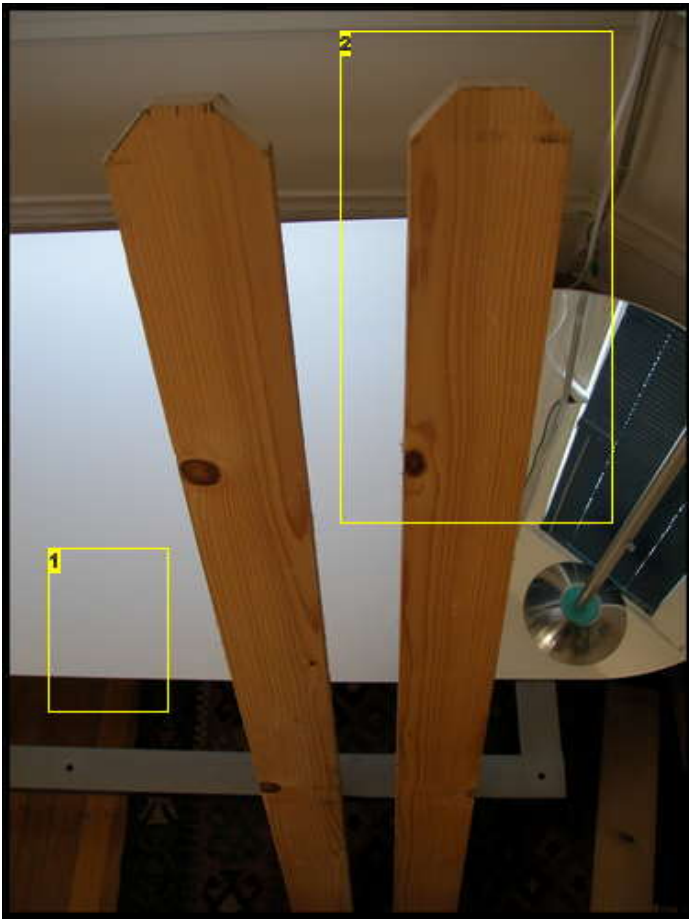


Image Notes

1. mirror...came with my apartment
2. left over wood planks from repairing the futon

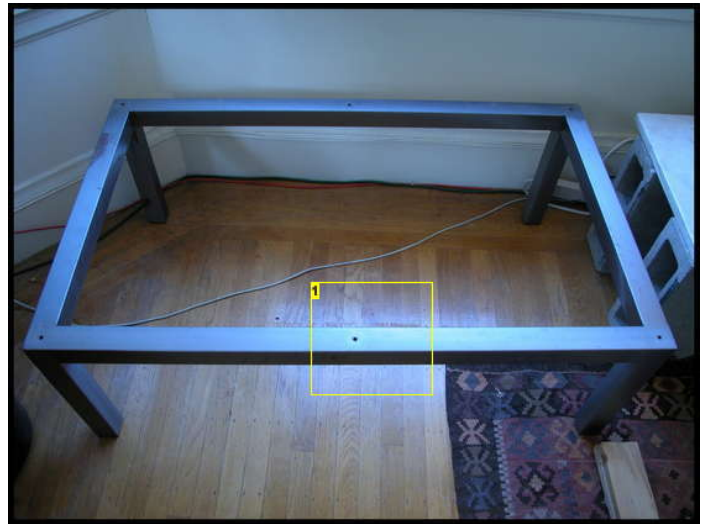


Image Notes

1. glass topped coffee table minus the glass top, found on the street in san francisco



Image Notes
1. haphazard attachment, surprisingly rigid.

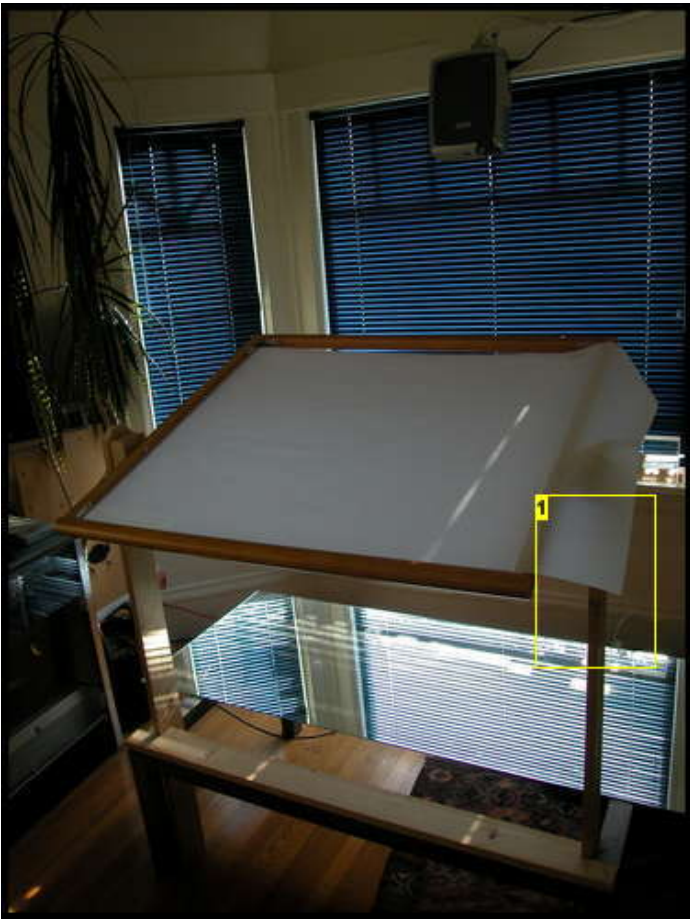


Image Notes
1. sheet of paper used as a diffuser

step 10: software and demos

The key thing to making this all work is really the software that converts the detected blobs of light where your fingers are into awesomeness...of course a good soundtrack also makes a huge difference. I used `touchlib` which basically just worked out of the box. There is a calibration utility which saves results to a configuration file that is shared among the other apps. I also downloaded some Flash apps, including the light-box shown in the video. These interface with `touchlib` via OSC, a neat protocol for relaying timestamped events which should provide a good starting point for building your own apps.



step 11: enjoy

Excluding the projector, the total material cost is on the order of \$100-200 depending on what you already have lying around. Construction time was around 15 hours, mostly soldering and sanding. There is a very active DIY/academic community which has started exploring this space; lots of reward and interesting things to be done for little work with very simple materials

touchlib
nui group
multitouch blog

Enjoy.



Image Notes

1. camera mounts here.

Related Instructables

Subscribe to MAKE and get 5 ISSUES for the PRICE OF 4! Build, Hack, Play, Make	SPECIAL OFFER FOR INSTRUCTABLES MAKE Magazine	BONUS ISSUE » Get a FULL YEAR plus a BONUS ISSUE for only \$29.95	 
---	--	--	---

Comments


[50 comments](#) [Add Comment](#)


[view all 207 comments](#)




crook17 says:
Would it be possible to use a ir pen (an old pen with a ir LED and a battery inside)
instead of using the large amount of LEDs


Apr 22, 2009. 9:34 PM [REPLY](#)

 **housewright30** says: Apr 20, 2009. 1:43 PM [REPLY](#)
i don't know if this is a dumb question or not but how well dose the IR pass though the paper? i mean i would think that it would be blocked by the paper.

 **automata** says: Apr 9, 2009. 8:16 AM [REPLY](#)
How far apart are the LED holes in the aluminum frame?
Do both vertical bars and horizontal have the same spacing or is it different.
I am assuming the IR's make a grid and the grid should have equal units between each IR.


Thanks in advance

 **turkey tek** says: Apr 9, 2009. 12:11 PM [REPLY](#)
weIIlll...the screen is 30x36 inches and there are 88 leds distributed around the perimeter so 1.5 inches.

 **Impatzer** says: Apr 7, 2009. 7:32 PM [REPLY](#)
Thank you for this great Instructable! I am going to attempt to build a small version and wonder if it is necessary to use aluminum channels to hold the LEDs and glass in place. Could I use wood or a different material and have the same effect? Any information is appreciated!

Lisa Marie


 **shadowninja31** says: Apr 1, 2009. 7:08 PM [REPLY](#)
Good Idea!

 **agent** says: Feb 5, 2009. 8:35 PM [REPLY](#)
Holy crap... This is exactly what I need. We are making a band where we use touchscreen synthesizers :D Thank you!


 **Fasteners** says: Jan 19, 2009. 9:21 AM [REPLY](#)
Nice stuff


 **jak06** says: Apr 11, 2008. 6:29 AM [REPLY](#)
is there any way to right click


 **hurtzmyhead** says: Nov 29, 2008. 6:26 PM [REPLY](#)
maybe two fingers?

 **Anthony Stark** says: Sep 10, 2008. 3:32 PM [REPLY](#)
Please! Please! Can anyone tell me if I can use glass instead of acrylic. I need the answer before Friday

 **hurtzmyhead** says: Nov 29, 2008. 6:24 PM [REPLY](#)
to late but yes you can sanding will be different though

 **junior2387** says: Nov 29, 2008. 6:48 AM [REPLY](#)
The sheet of paper.. that goes on top of the acrylic glass right? and if it does, do you put some kind of protector on the paper so it doesnt rip when using it..
or is it just the paper glued on to the glass... and u just touch the paper and thats it?

 **robert j loomis iii** says: Nov 1, 2008. 4:34 PM [REPLY](#)
is there a detailed set of instructions and/or a BOM? mouser/digikey have a lot of inexpensive ir leds. what material are you using to project the image onto?
do you do anything to block unwanted ir light?

 **human equivalent** says: Sep 7, 2008. 8:52 PM [REPLY](#)
i tried and succeeded doing this without building ftir. using lcd screens<removing a diffuser or two> from standard 19" monitors to 40" samsung lcd tv with vga. all i used was ir led's with a watch battery taped to my fingers<one for each finger> the contact for the led would be closed every time i touched the screen. worked good. accurate enough i'm gonna try trading touchlib for good old mouse tracking software.see which method uses less horsepower.



azmansami says:

hi,
i have been thinking of doing the same as my home project. Can you share your experience in more detail? do you have any blog?

Oct 27, 2008. 9:05 AM [REPLY](#)



addicted-2-weapons says:

is acrylic also called perspex?

Oct 18, 2008. 6:06 AM [REPLY](#)



rcamp004 says:

I've been so inspired by Turkey Tek and Jeff Han that I've been building my own FTIR display since June. I'm not finished but I am documenting the build on my blog - <http://polymathengineering.blogspot.com>.
I'd like to get comments from you guys out there.

Also- I've found an easier way to build the frame. Canvas stretchers sold at art stores allow you to quickly assemble frames - almost like wooden lego's or Knex. I have those on my blog as well.

Thanks again Turkey Tek!

Oct 8, 2008. 9:08 AM [REPLY](#)



WTHAI says:

You're pressing down on the thick sheet of acrylic, yes? Not the thin one?

Sep 30, 2008. 4:07 PM [REPLY](#)



turkey tek says:

yes. the thin one is on the backside just holding the diffuser (paper) in place

Sep 30, 2008. 6:09 PM [REPLY](#)



WTHAI says:

Alright. Thanks.

Oct 3, 2008. 9:52 PM [REPLY](#)



prestonC says:

If the projector is overhead, how are your arms not casting a shadow when they are stretched out over the center?

Shouldn't there be some occlusion from the light cast by the projector?

Sep 24, 2008. 3:15 PM [REPLY](#)



turkey tek says:

the projector is bouncing off the mirror so the screen is actually illuminated from behind

Sep 24, 2008. 4:10 PM [REPLY](#)



Pyrozz says:

Very awesome. Uhm, how is it that the projected image doesn't interfere with the IR light that the webcam is receiving? Does the filter on the camera filter ALL light except the IR?

Sep 12, 2008. 3:39 PM [REPLY](#)



Pyrozz says:

Never mind, I get it (after doing some research).

Sep 14, 2008. 3:47 PM [REPLY](#)



Llewner says:

If you want to skip the sanding on the acrylic, you can always flame polish with a blow torch.

May 5, 2008. 8:05 AM [REPLY](#)



Fivesevenx28 says:

how might i go about doing that?

May 8, 2008. 8:33 PM [REPLY](#)



Zinventor says:

get a blowtorch, carefully heat the edges till they are smooth... just be careful not to burn the edges... that would defeat the purpose... anyways, i prefer drilling little holes to seat the leds, it's easier, and faster...

-Z

Aug 28, 2008. 11:38 AM [REPLY](#)



redex777 says:

Greetings and thanks for this wonderful project!

Just one question/concern:

Judging from your video, the "Pictures" application especially, it seems to lose sensitivity as you put your fingers towards the center of the screen. Could this be because the acrylic pane was too large, and the infrared light wasn't able to reach the center as brightly?

...or maybe the light was too diffuse and therefore inaccurate towards the center?

...or maybe im just imagining things, ;-)

Aug 21, 2008. 2:34 AM [REPLY](#)



turkey tek says:

Hmmm. I didn't notice that effect myself but it could be the case.

A problem I did encounter with the middle of the screen is that there is a reflection of the bright lense of the projector off the back of the acrylic which the camera sees. You can get rid of this by subtracting an image of it from your input but if your fingers cross over the bright spot the tracker can get lost.

Aug 22, 2008. 9:25 AM [REPLY](#)



DenneyN says:

Check out this site <http://nuigroup.com/>.

They have a forum there that can answer all of your questions.

Aug 5, 2008. 1:52 PM [REPLY](#)



eevans says:

what projector did you use

Jul 21, 2008. 12:45 AM [REPLY](#)



Capm_Crunch says:

would it work if i built this whole touch screen over top of a regular monitor? i can't get a hold of a projector and i want this to be in a large coffee table that i am building. also, i just bought a brand new logitech web cam that has a 1.3 megapixel video capture size. would that work instead of gutting one like you did?

Jul 17, 2008. 2:30 PM [REPLY](#)



sambam2006 says:

For the people who are after IR leds then go here. I got mine from there. They come in strips. Easy installation took me five minutes. Shipping takes over a week. Contact him and leave him a message of your requirements etc.

<http://youshare.co.uk/iphoneworld/form1211626325.php>

Jun 30, 2008. 6:18 AM [REPLY](#)



human equivalent says:

does anyone know if an IR led is bright enough to show up on a webcam through an LCD screen? i dunno if the IR blocker on an lcd is one way or strong enough to block it. trying to build a work-around so fti is not required, allowing you to use a larger surface without a "deadspot" near the middle of the screen.

Jun 10, 2008. 11:29 AM [REPLY](#)



rcamp004 says:

I recently tried and was successful in seeing the IR led in the remote that came with my Mac Book Pro. I also saw the led from a tv remote light up. I have pics up at <http://polymathengineering.blogspot.com>.

It's my first blog and I'm documenting my build of an FTIR.
This only worked with the camera that came with my MBP though.

Jun 23, 2008. 1:43 PM [REPLY](#)



Aidin says:

Hi

Can i use glass instate of acrylic ?

Jun 20, 2008. 2:05 PM [REPLY](#)



rcamp004 says:

Jefferson Han states in his Paper that Glass has poor optical transmittance for this application. You have to pay for his paper \$10 from acm.org

Low Cost multi-touch sensing through Frustrated Total Internal Reflection.
You can also check out his site <http://cs.nyu.edu/~jhan>.

Jun 23, 2008. 1:41 PM [REPLY](#)



cba20k says:

This instructable is great!

Quick question though. I am not sure how you are attaching the channel to the acrylic. I see that the wood frame sections are bolted to channel, but that would not keep the four pieces attached to one another....would it? Sorry if I'm missing something obvious here.

Jun 17, 2008. 2:10 PM [REPLY](#)



sharath.sridhar says:
turkey tek,

Jun 5, 2008. 6:48 PM [REPLY](#)

Great work. I am planning a similar surface soon. It will be a little modified from your work though. I am more or less looking at a rear projected prototype. Have you tried that one before? I can foresee the projector throw distance as the potential problem and hence will need to use a mirror to shorten the distance. Another thing would be the modification of the sandwich type screen. I would have to remove the diffuser, but would it be as efficient without one? Any suggestions on this? Have you checked out the recent work of Microsoft, the TouchWall.. They are using such a short throw projector there. I assume they have a mirror arrangement there. Help me out there.



sambam2006 says:
What size acrylic did you use?, and what is the thickness of it?

Cheers

Jun 1, 2008. 7:36 PM [REPLY](#)



sambam2006 says:
What size acrylic did you use? And whats the thickness of it?

Cheers,

Sam

Jun 1, 2008. 7:34 PM [REPLY](#)



dunnos says:
i have a question: i wanna make a touch screen with an ir pen just like with the wii remote but i dont have software for a webcam (ir webcam mod) now i found touchlib but it only finds where you put your fingers on an mt mini (other project somewhere on this site) wich are shadows do you now anything to make it sensitive to light instead of shadows???
please reply fast im making a school prject and it needs to be finished by thursday

May 25, 2008. 12:43 AM [REPLY](#)



chaitanyamuppala says:
Someone commented that this could not be possible with an normal LCD screen.... What if we removed the backlight of the lcd screen and just used the non opaque screen as the thinner acrylic sheet in the sandwich?

Nov 2, 2007. 9:05 AM [REPLY](#)



mythbusterma says:
acttly you only need a lcd screen, and underneath it you put a normal light (this serves as the back light for the lcd screen and as the infrared light emitor!

Apr 6, 2008. 5:31 PM [REPLY](#)



human equivalent says:
i like this lcd idea. i don't have a projector, but i do have a 40" lcd tv. if the guts are similar to a computer lcd, could i remove the layers off the back, backlight it myself and throw a webcam behind it? it has a vga port already, sowhat do ya think?if it works, eventually i'll have a virtual ssl mixing console, less the obligatory mortgage.

May 23, 2008. 10:15 PM [REPLY](#)



mythbusterma says:
just remember to use a normal light bulb, NOT ENERGY EFFICIENT OR FLUORESCENT

May 24, 2008. 6:38 AM [REPLY](#)



lioncour says:
Hello!
Thank you for an great instructable.
There are a few things that I do not understand and was hoping you or someone could help me with.
Do you really need the second acrylic plate? Or can you just fasten the diffuser real good, like in a span?
I have seen several places that people uses silicon on top of the acrylic, does this act as a combined diffuser and touchscreen?

Good greetings from cold Norway!

May 20, 2008. 7:55 PM [REPLY](#)



turkey tek says:
I think you probably don't need the second plate if you have some other method for attaching/supporting the diffuser.

As far as silicon goes, people have reported that works quite well. I never got around to trying it though so I'm not sure of the details.

May 21, 2008. 9:34 AM [REPLY](#)



sasukeflaze says:
hey turkey, i'm new to this whole thing but i'm looking at making on of these multitouch setups.

you seem to have a bit of lag and maybe resolution problems (which i know can be fixed by getting a better webcam).
jeff han's demo of the multi touch setup seems to have...well, no lag at all.

so that leads me to conclude that your computer may be slow? Is that the only thing that effects the lag time?

most importantly though, what are the specs of the computer you use?

May 18, 2008. 3:36 PM [REPLY](#)

[view all 207 comments](#)