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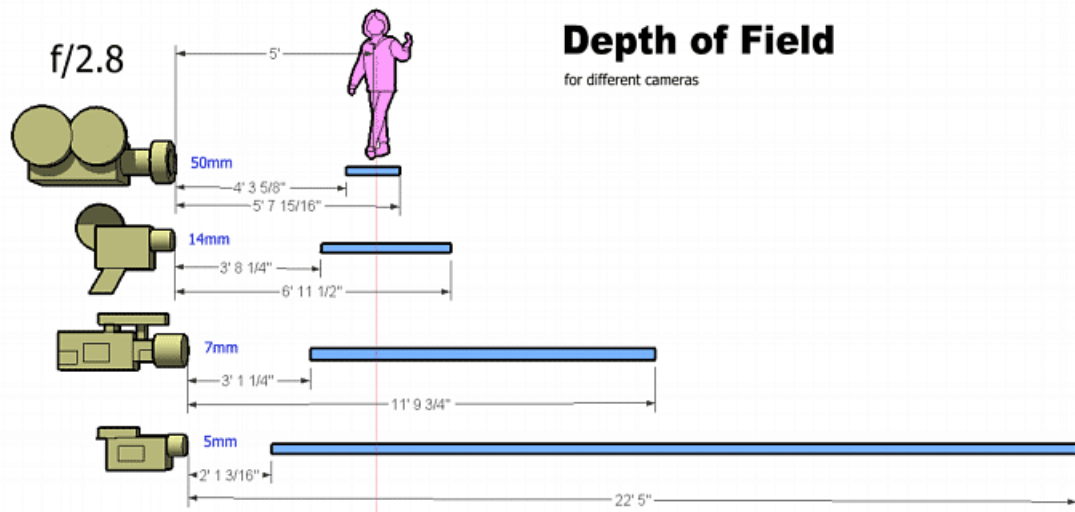


(A tool for guerrilla movie makers to make their video more film-like by reducing the depth of field)

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**What is Depth of field**

DOF is simply said a distance range in which the objects appears to be in focus. Large DOF means that area is larger and more of the scene will appear in focus, shallow DOF means the range will be smaller and objects closer or further will appear blurred.



The image above explains this better than any text. All cameras are 5 feet from the object and all cameras are taking the same shot. All have F set to 2.8. The blue number shows the actual focal length of the lens for each camera (so each camera frame the subject the same way)

- First is a 35mm movie camera.
- Second is a 16mm movie camera (or a 2/3 inch broadcasting camera).
- Third is a 1/3 inch professional DV or mini-DV camera used for ENG (Canon XL1, Sony VX2000).
- Forth is a consumer or prosumer 1/4 inch mini-DV camera (Canon GL1, TRV900)

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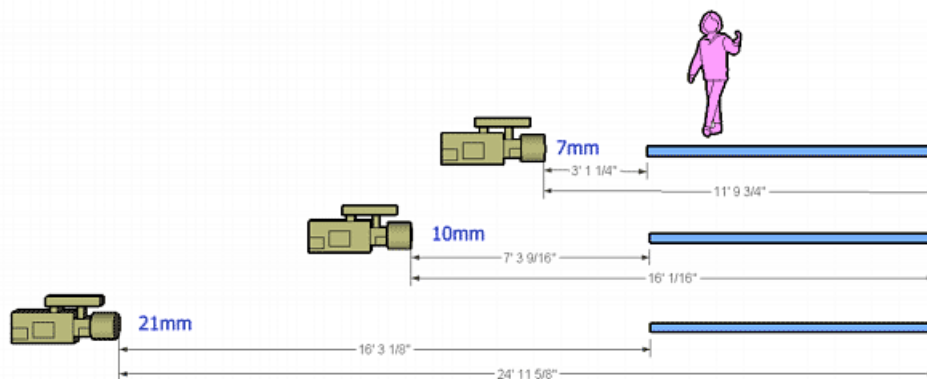
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Some people think that the major technical difference between shooting video and shooting 35mm film is a progressive scan or 24fps. But that's not true, the most visible and obvious difference is shallow/deep DOF. If our scene is a close-up of person in front of a building, video will have most of the scene in good focus. 35mm film will show face in sharp focus and the building behind will be blurred.

This is also called **selective focus** and it is used by film makers to keep attention of the viewers on the main subject.

As you can see the difference in the above cameras is the size of CCD chip or film frame, also called a target size.

You can simulate selective focus a little, by pushing your camera back and zoom in. Many people would think that changing focal length will change the DOF - but that's wrong! The DOF will stay in fact the same (see image below). A zooming shortens the distances and that apply for DOF as well. But the image will also appear loosing its depth and looking flat.



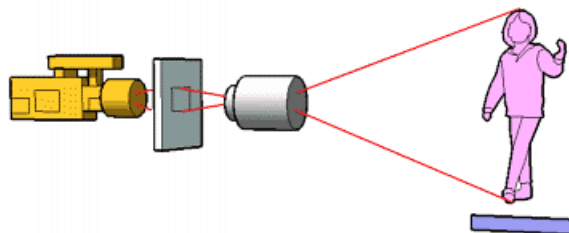
On the image above we use same three cameras, all f/2.8 and each moved further back and zoomed-in so the subject appear the same on each viewfinder. The DOF doesn't change, because it doesn't depend on the focal-length (opposite what many people think). It depends only on F-stop (aperture) and that stays the same. However, thanks to the perspective, longer distance from object also virtually shortens the DOF. Zooming-in may look like it produced shallower DOF but any other distances are shortened as well so the image is loosing its depth.

#### What is the bottom line?

You can never achieve DOF of 35mm camera with a video camera unless you are able to change the target size (the size of CCD chip).

#### Changing target size.

Here is the question: How to change the target size of your video camera? Obviously you are not going to replace CCD. But there is a trick that comes from telecine devices. Such device is used to transfer the film to video. We will simply skip the film part and combine the telecine directly with the 35mm lens.



Lets the 35mm lens capture its image and project it to a 35mm target size. Then we will capture this projected image with our video camera in macro mode. The projected 35 mm image will have all the DOF characteristics of a 35mm camera. Our Video camera is a mere telecine device to record this projection.

#### Will this work?

Yes, of course, many devices works on this principle. We need something like a ground glass to project the image so we can capture it from the other side by our video camera. The ground glass. At the 35mm frame size, a ground glass will more or less show its grain unless we can get some space-age superfine ground glass. Here comes a rescue again from a optometry laboratory devices that use ground glass for projection - we need to shake or rotate the glass somehow so the grain will become invisible to our camera.

#### Upside down issue.

One biggest trouble with this setup is that the image projected on the ground glass is upside down. Of course, every photo or video lens project the image upside down, just the electronics in the camera will make it flip. But now we have 2 lenses - the 35 mm and the camera lens so the image is also recorded upside down. And because we are capturing the projection from back, it is also horizontally reversed. Well, we can't have everything these days. You can either tun the camera upside down and the image will be just horizontally flipped (and you may even make a few friends using the camera like that) or simply swallow it and turn everything the right way in post-production.

To turn the image the right way optically before the camera captures it would be troublesome You need to use a mirror to turn flip it vertically and then pentaprism or pentamirror to flip it horizontally. This is out of the reach of most home-improvement guys. Especially that these things are not easy to find in VAL-MART or Home Depot.

So for our design we will simply make it flip at post-production. The easiest way is in fact to forget the flipping right now and add a small hood and a mirror to the LCD screen of the camera so we see the image correctly during shooting.



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Please note: Our goal is to build this in a fun and educational way, reusing things that you probably have at home. It is not a plan for professional or commercial device.

### The Design.

The biggest and hardest part of the design is the ground glass shake or rotate in order to minimize the grain. Some optometry laboratory devices and laser devices use rotating ground glass diffuser. There are of course many ways how to do this, most of them quite expensive, but our goal is to do this in guerrilla way - that is with minimal spending, preferably using things found in the basement or attic. One clever idea is to grind a clear CD (such is used in a CD-R spindles as top and bottom CD to protect the CD's between them) and use a broken CD player mechanism to rotate it. Many people trying to solve such problem come independently to the same conclusion so it is officially the easiest way.

### Pre-production

To work smart and to minimize mistakes, let's design this first on computer.

### What we need

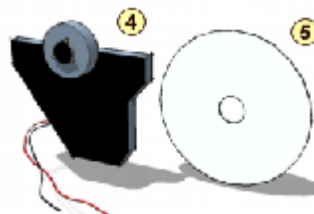
#### The optical part



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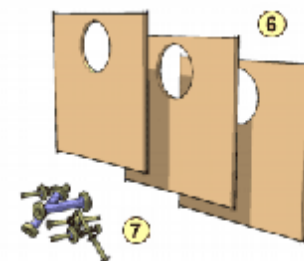
- 1 - a closeup macro lens
- 2 - the 35 mm lens
- 3 - lens bottom lens cap

#### The mechanical part



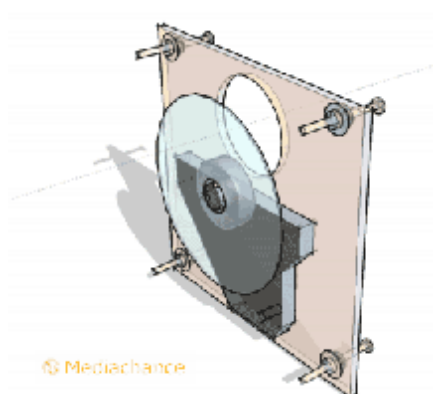
- 4 - Motor from broken CD player
- 5 - CD dummy

#### The things that holds this together



- 6 - particle boards
- 7 - bunch of screws.

Since the distances from ground glass and lens matters a lot we need a design where we can move all parts back and forth until we find the best position. Otherwise we will very easy make a device that cannot be focused. I decided to have three boards holding lens, CD and macro lens.



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The first step is to mount the CD chassis from broken portable player on the first board. Then use large screws to distance the attached board for the macro lens and the 35mm lens.

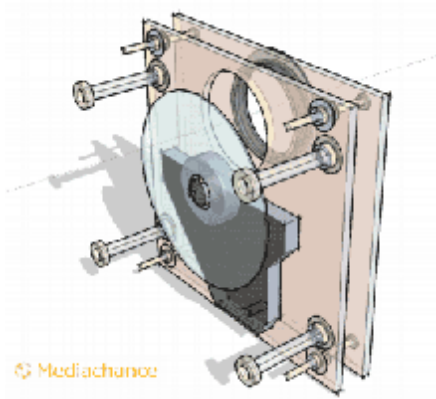
The CD which is a ground dummy CD will work as a ground glass. This is cheap and the plastic CD still has quite reasonable optical parameters.

The CD will rotate so we will minimize all the grain and scratches on the CD.

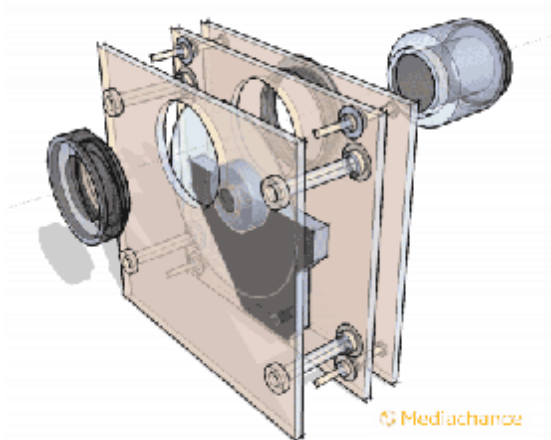
Here is the part with attached second - lens plate.

To attach the lens I will use the bottom lens cap, create a hole in it and then optionally glue it to the board.

The large screws will work like spacers and I will be able to space the two boards precisely to the

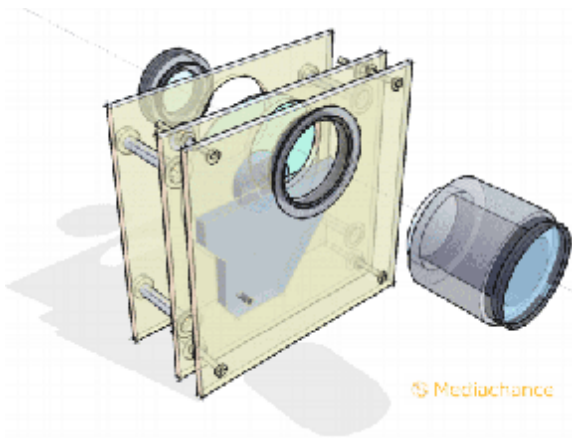


distance I will need. The rough distance I measured on my SLR is 50mm. I should be able to move these boards closer or further from this distance to set the exact distance where the lens is focusable.

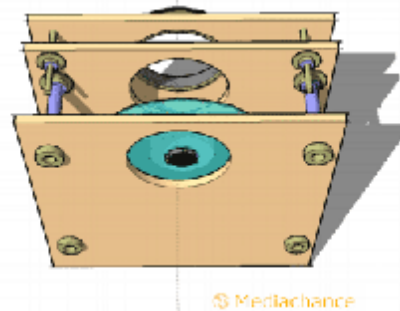


The third board is the part where will be the macro lens attached. Again I use long screws so I can later position the boards to the exact place for the best focus.

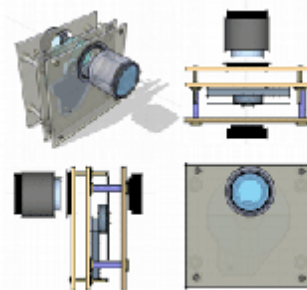
The macro lens is needed so I can attach my video camera to this side and then zoom in, focus on the ground glass (CD). Without the macro lens I will be able still focus on the ground glass but not zoom in, which will result in large vignetting. Every lens project a circular image with large vignetting on edges. The camera then simply crop the middle part of it.



Here is a view from other side.. The design will allow me to change the distances between boards to find the exact position.



This is the first prototype and at this moment I don't want to think about any enclosure since I still don't know the exact distances that will be clear once I build the device.



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## Building the first prototype

So far it is clear what we want to build. Now lets gather the parts.



It come to my attention that maxell CD-r have the dummy CD already frosted from one side - creating nice uniform ground glass.



This was lying in my basement for ages. Even if you don't have any CD player to salvage yet, ask your friends or buy some for five bucks in a pawn shop.



A good helper is always a welcome addition and much more fun. Try to get one who is not constantly stealing parts and screws when you are not looking.



Finally the player will have second chance!



Here is the motor piece that was held to the body by 3 screws.



I took out the laser and lens and this is what I need.



Lens cap from the bottom part of the lens will be used to hold the lens to the board and still to be able to take it off.



Of course I need to create a hole in it so the light can pass through.



I need three boards as designed in previous page each with large hole.

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We have what we need so let's put it all together.



First step as designed on the previous page is to attach the motor piece to the board. Not much science here, I also reused the rubber silencers.



Second board is attached with the lens cap and lens in the position.

By looking through the lens you already see mirrored image on the ground glass...ehm... the frosted CD.



I attached the bottom third board that will go to the camera through MACRO lens. (the macro lens is not yet added to the device).

I attached the battery and all is ready for first experiments.





The goal is to find the distances so I can use the whole focus range of the lens.

This is determined by the lens distance from ground glass. This should be very carefully set so I can reuse the whole focusing range of lens. Here is a simple way to find the correct distance: Focus the lens to infinity and then point the whole device to far away objects such as far buildings, trees etc. and look from the back side on the ground glass. There is no chance that the image is already in focus. We have to adjust the distance between the lens and ground glass with the screws so the projected image gets in focus. With this we calibrated the device so we know we can focus on infinity.

Since we have zoom in our camera the distance from ground glass to the macro lens is not that sensitive once we make sure we can focus with the camera on the ground glass from that distance. We can always zoom in or out to cover the best area to avoid vignetting. The problem is if you can't focus at all, then you have to move the camera away from ground glass until you can focus. The MACRO lens has the function to shorten this distance.

This took me 2 hours to build in one evening, and it is already dark outside so I can't really set the focus on infinity today.  
Let's leave it for tomorrow.



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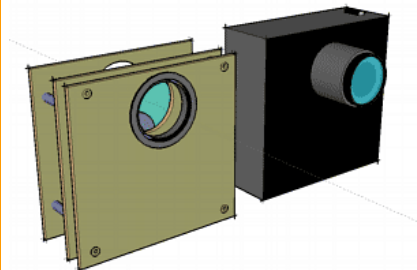
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## Enclosure design

OK, last evening I did the first prototype - a proof of concept. It seems to work, so during the day I set the distance from ground glass to lens so I can get focus at infinity.

Once all distances are set, I can think about enclosure. As I looked at the prototype it seems all to fit to a 6x6x? project box that can be found in RadioShack or any component store. In worst case you can always build the enclosure from a cereal box :-)

Here is what I want it to look:



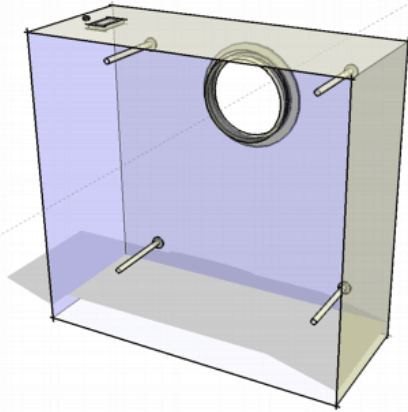
## Prototype Design

Again to look more professional and impress my two years old daughter I designed the thing in CAD first. The goal is to reuse everything I did last night, but this time build it inside closed box.

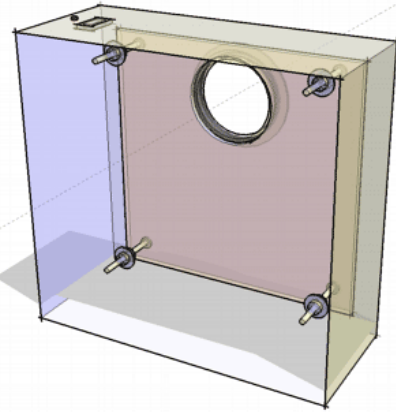
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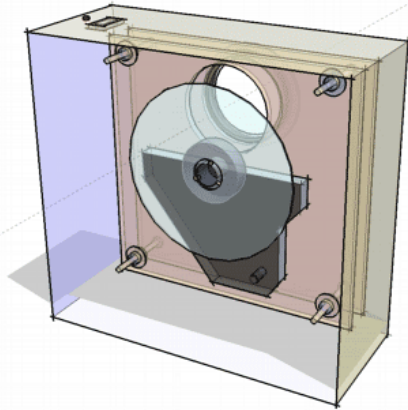
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Since I will be using the RadioShack project box which is quite sturdy, I will use the body to hold the screws itself.

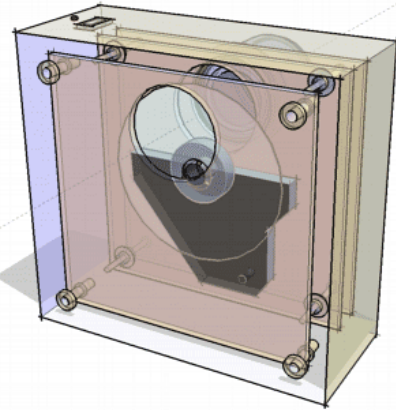


Never trust a plastic so I will took the "lens" board from yesterday project and attach it from inside of the box to hold the shape.

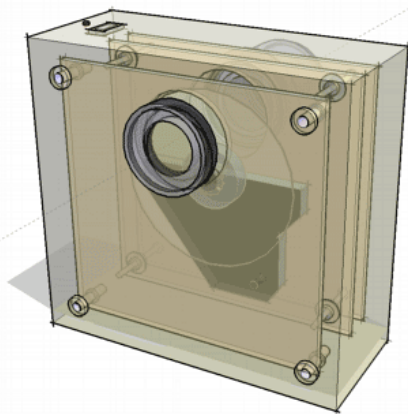


Now take the middle part with the CD motor and place it on top of the lens board and secure it with screws in the distance I measured earlier.

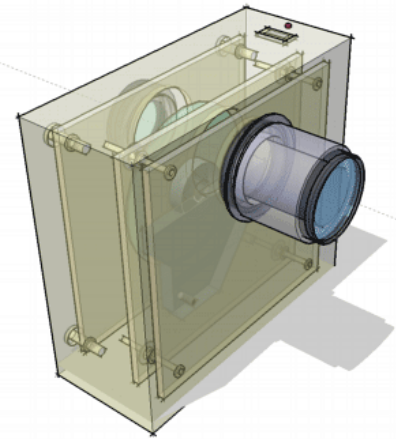
Well to be honest, I will probably have to re-calibrate it anyway.



The last part will be the macro board part. But see the change, I will not screw it to the CD motor part as yesterday, but I will attach it the same way as the lens board above to the back part of the enclosure box. As we determined before, the distance from ground glass to the macro lens is not that critical.



Here is the look from back side - from the MACRO attachment lens side. Here goes our camera.



This is a view from the front - the lens side. See the switch on the top for the motor.

This looks easy, so let's build it!



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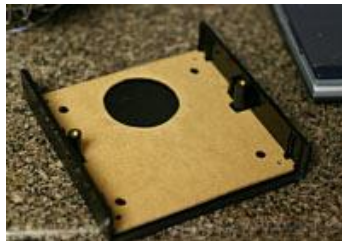


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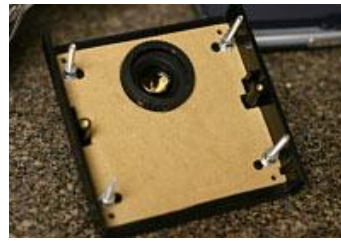
## Enclosure finish

Working in CAD is a cushy job, warm feet and stuff...but now it is the screwdriver time again.

Not a big problem for a handy man.



The lens board will go to the first enclosure part.



Here it is attached with screws, the hole was created in plastic and the hollow lens cap is attached and glued if needed.



Silence is golden. To isolate the motor noise inside the box I added a foam - this is from a craft store, they have it in many colors. Kids use this for art projects.



I added foam also under the motor board.



Here is the macro board attached to the other half of the project box also with foam.



Closed all together. I put the battery box (RadioShack) outside the box for better access. Since all I need is one AA battery - I could put it inside.



Another view. Plain and



The view of the switch. I



Now attached to the TRV900

simple. Very sturdy.

added a low voltage LED (I use one 1.5 V battery so you need LED that runs below 2V) camera.

### The first test

I really overdid the foam part and the thing is whisper quiet. In fact if I have no LED I wouldn't know it is running.

The first tests were quite great. Apart the fact that everything is upside down... the camera can now produce really shallow DOF. I used the inexpensive Canon F1.8/50mm and the F1.8 does really show. Now when autofocus is out the way, it does require some training especially to get the grip and to remember which way to turn the focus wheel :-).



Here are the first observations:

- | the DOF is now really as I am used to from my SLR
- | the rotating ground glass has also some subtle diffusion effect which softens the contrast and the footage looks actually more film-like
- | having camera taking upside down pictures is not much fun - you really don't know how to follow the scene
- | it takes time to learn how to follow focus
- | I can now actually use pattern filters such as Pro Mist and they do (finally) work. They didn't previously work on the video camera unless you really zoom-in to blur the filter pattern.



A nice rack! (focus).

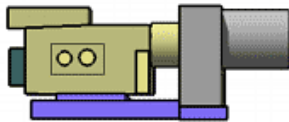
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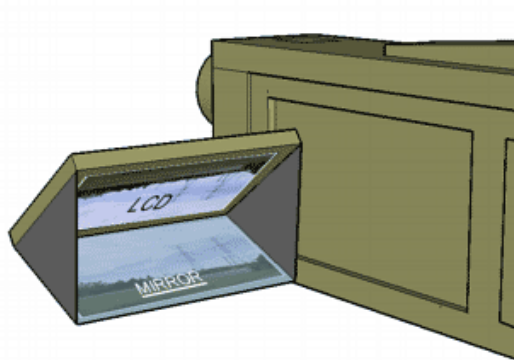
#### The next step (I didn't do this yet)

The next step is probably to attach securely both the camera and the device on some kind of rail (blue on picture below) that can be mounted on tripod so it is not joined just by the lens which is a very fragile way.



What with the rotated image upside down on your LCD?

I think instead of figuring out how to rotate the image from lens to camera (mirror and a pentaprism - expensive!) the easiest way is to add a normal mirror and a small hood to LCD so we can at least see it feet down (still left-right will be reversed) and then simply rotate it (flip & mirror) in post-production.



I will post some more shots as soon as I made them.

#### The final word (for now)

OK, after spending about 4 hours in total on the DOF device and about \$18 CAD for the project box and LED (everything else was found in my basement), I think it does work pretty good. One thing for sure, it is not for ENG or anywhere you need fast action. But a guerrilla film-maker may really benefit by using such device and adequate lens for each scene. The image after flipping and mirroring looks much more film-like, one would be surprised how much the 35mm lens changes the whole feel and how the rotating ground glass softens the image in a good way.



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