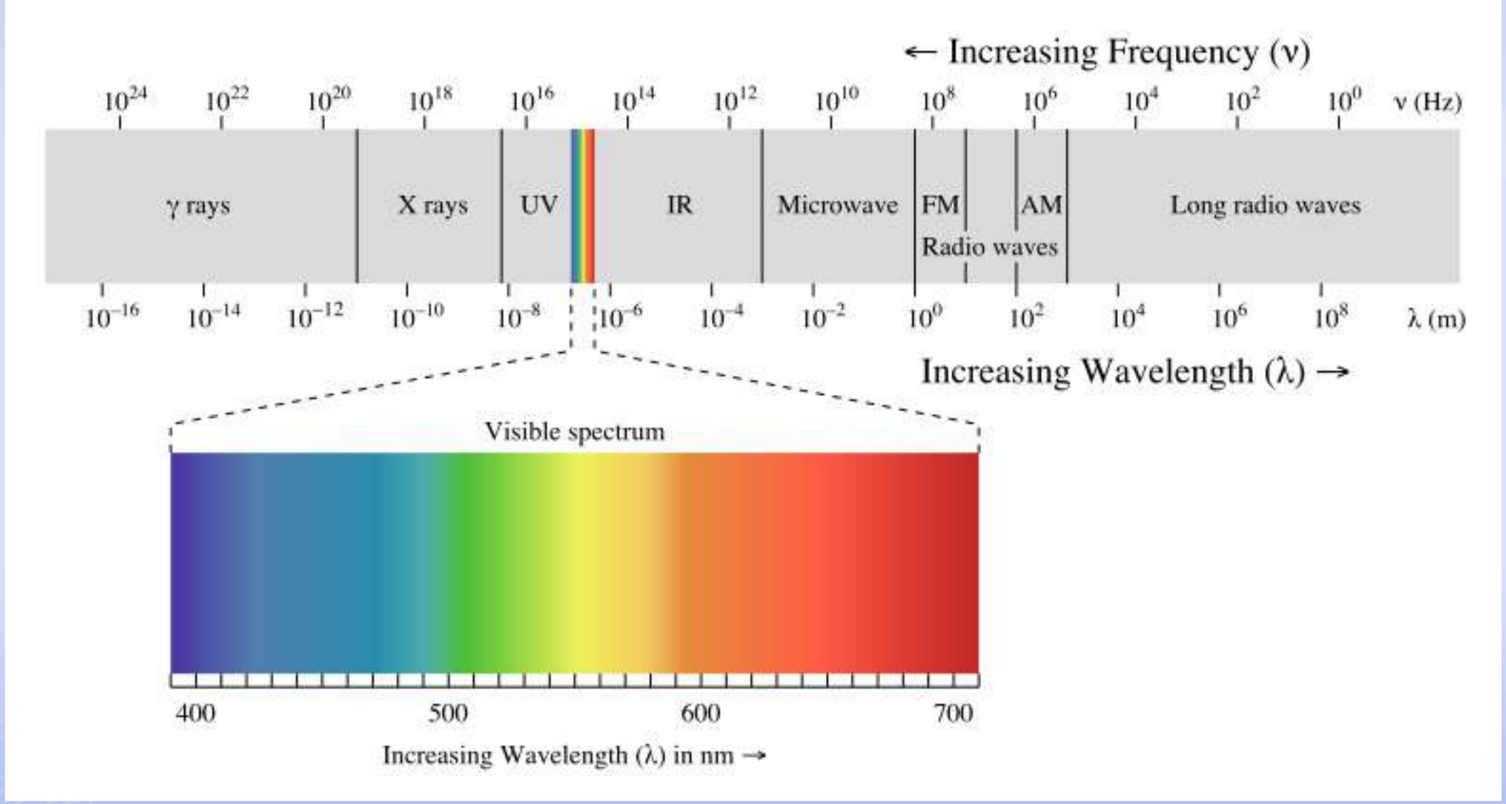
Magic Wall
(working title)

David Croft
SCOPE Sessions, 18.08.2011

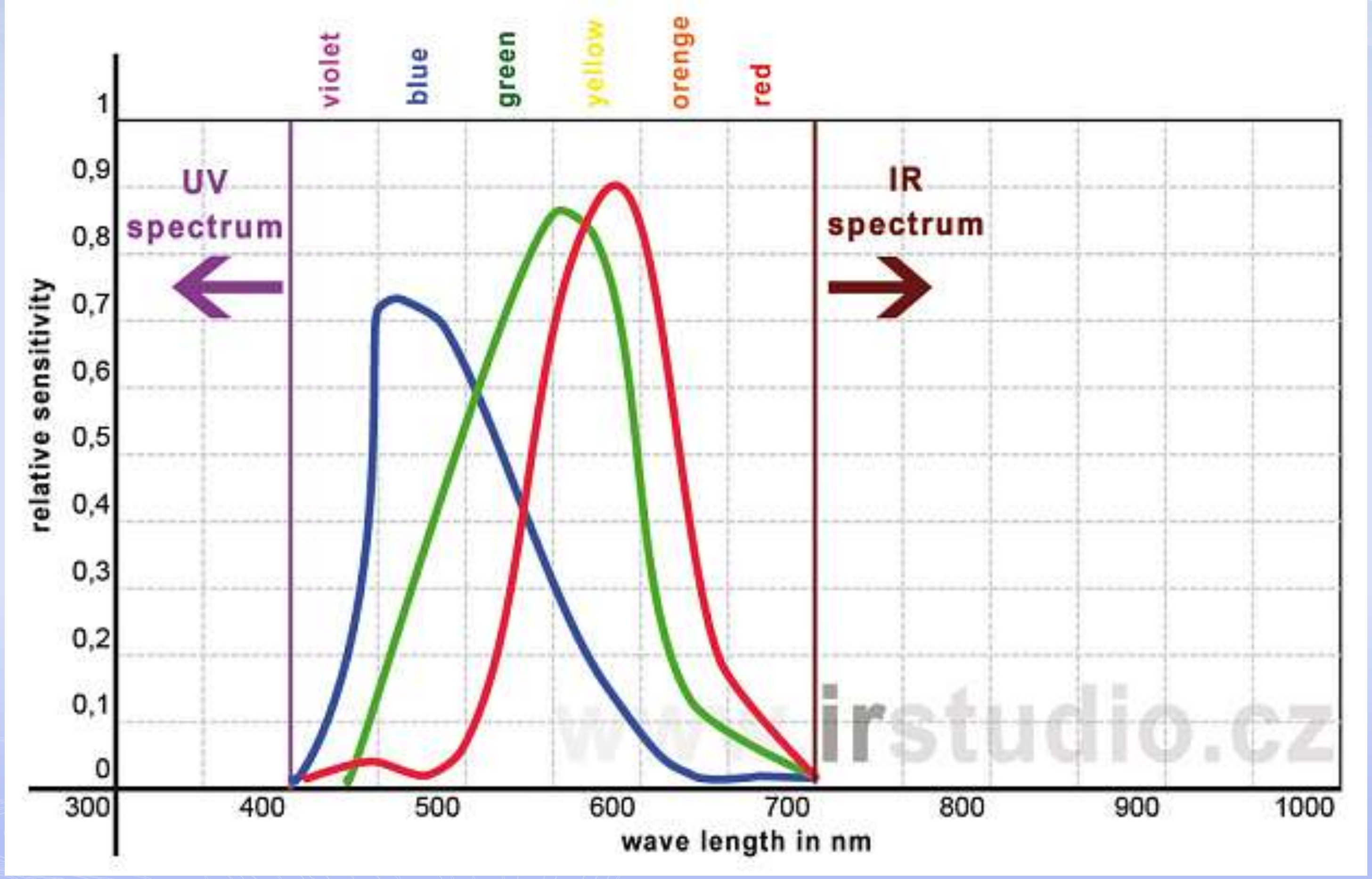
Magic Wall

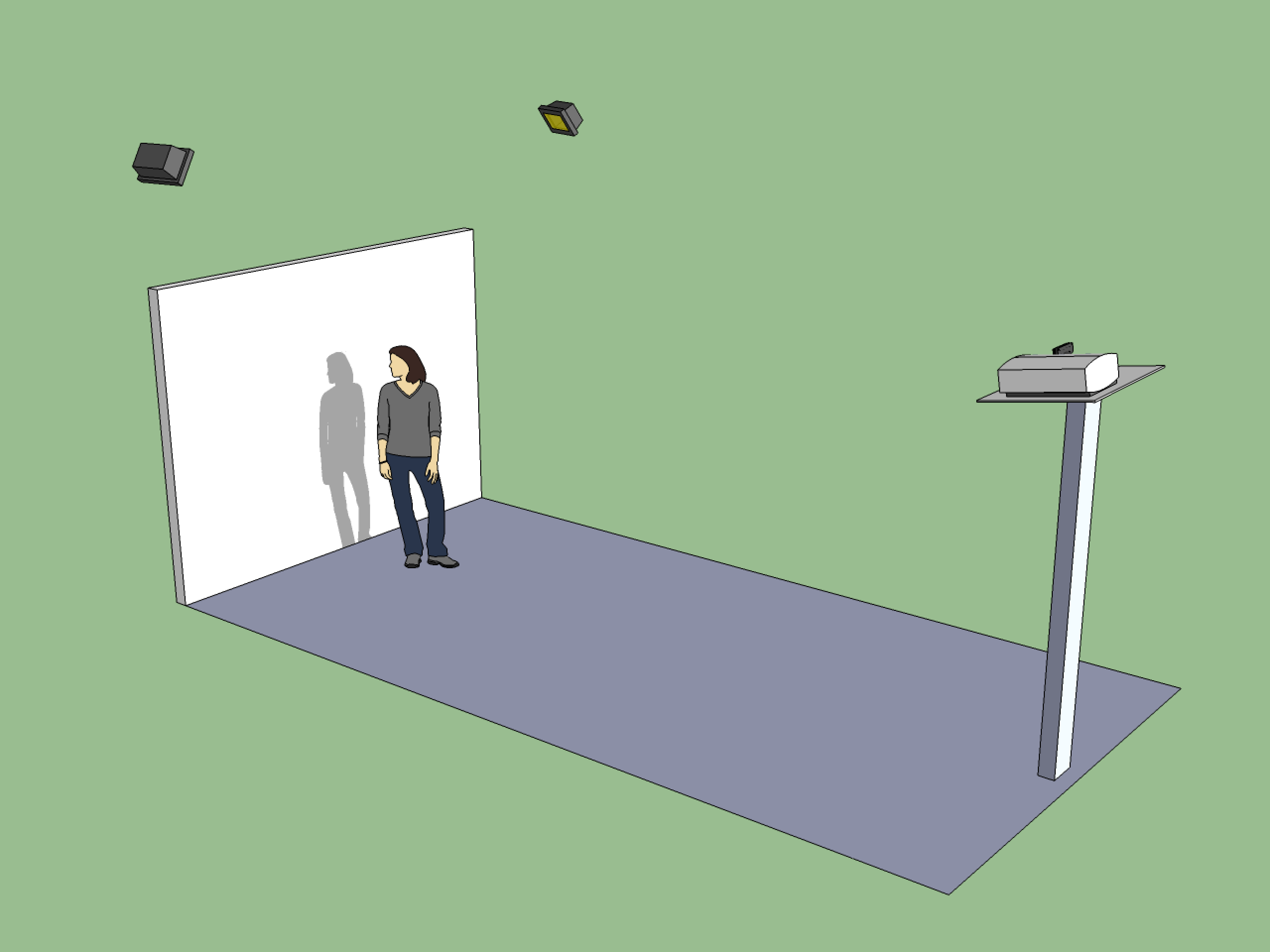
THE PRINCIPLE

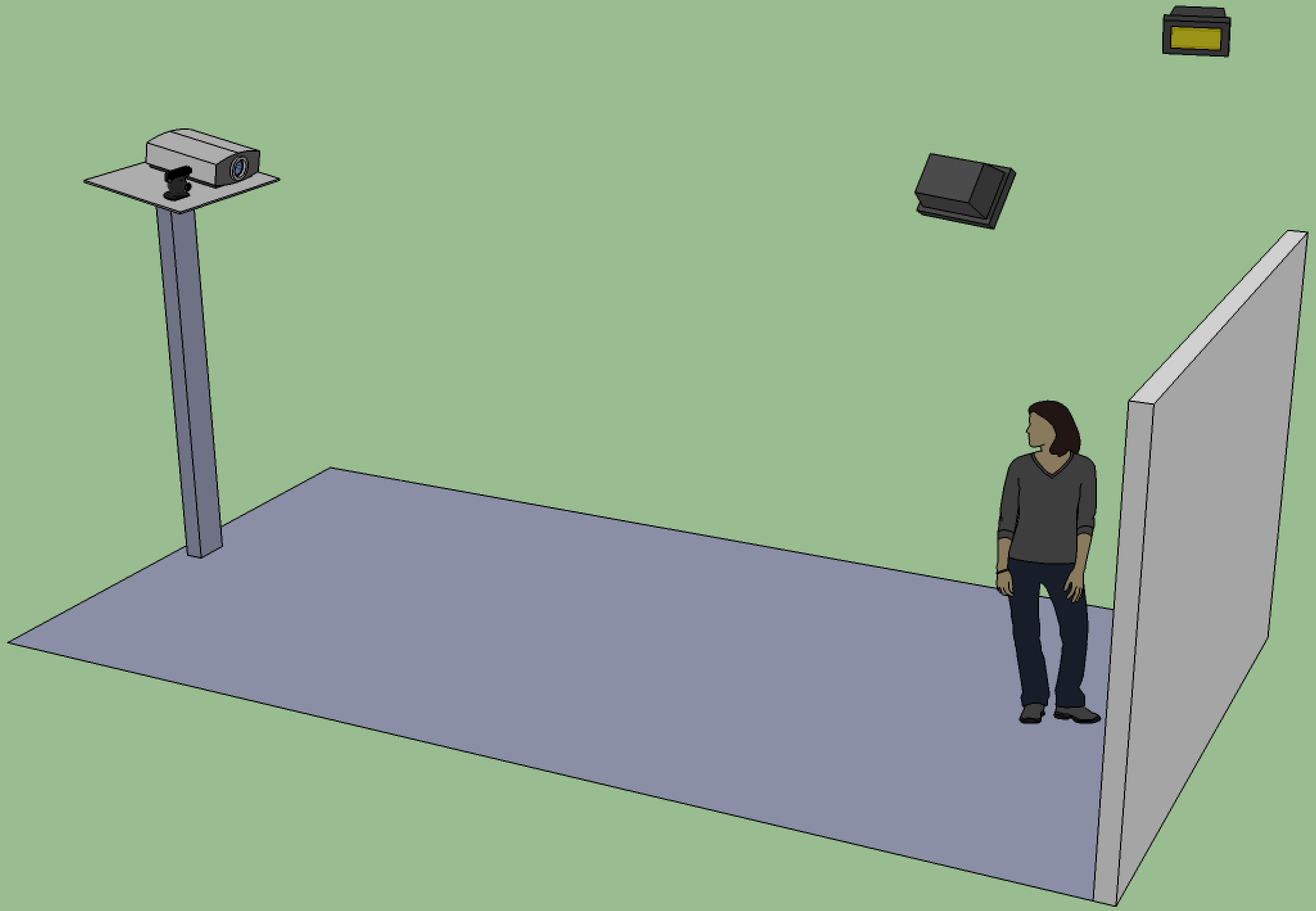
Electromagnetic Spectrum

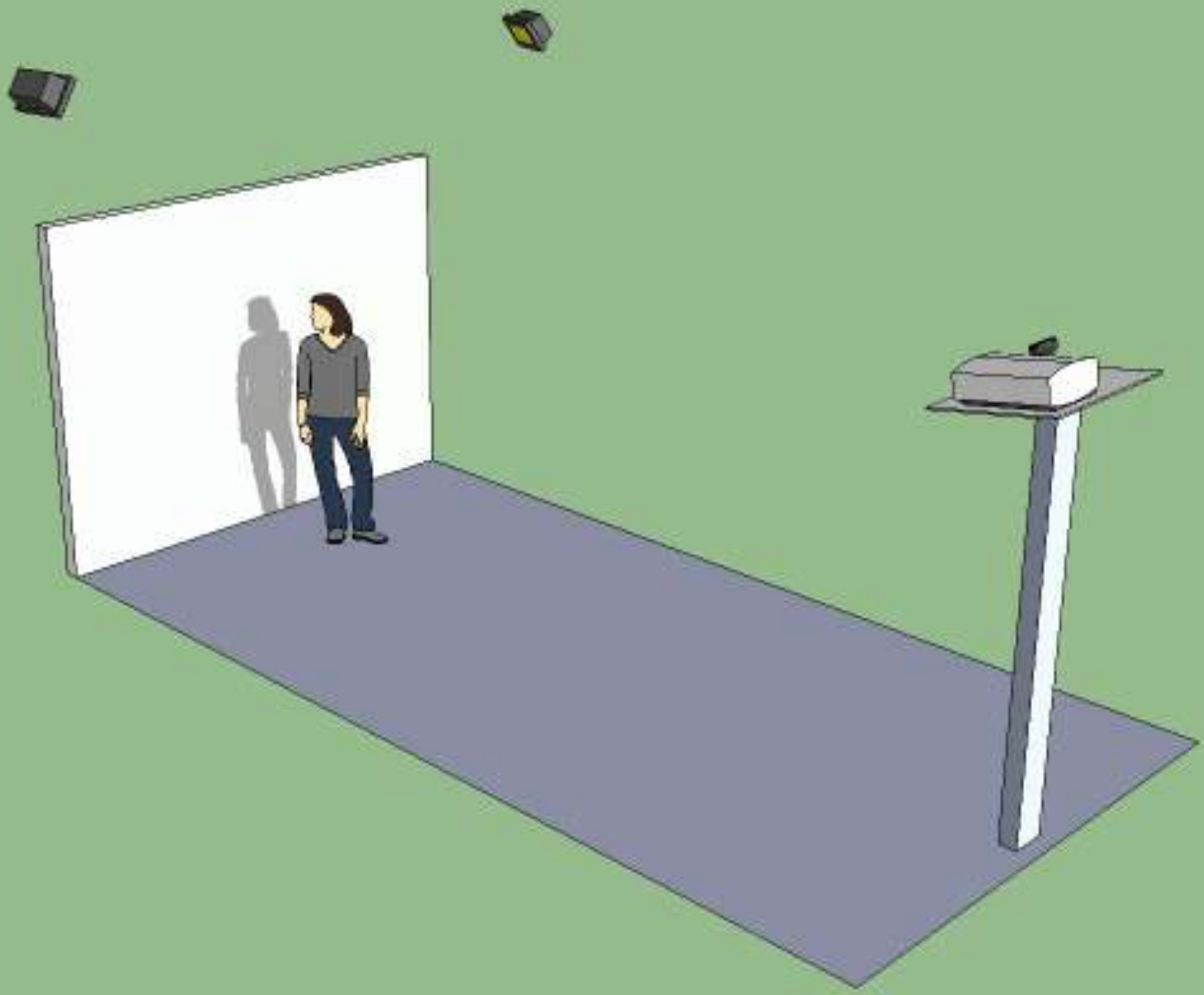


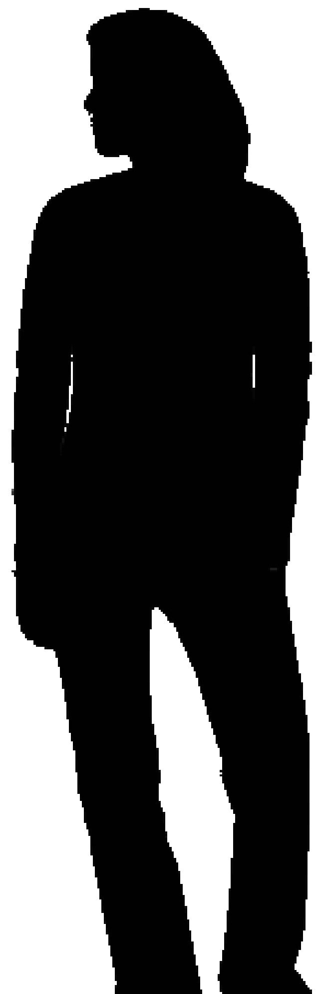
Human Eye Model











Magic Wall

THE HARDWARE

It’s not a Kinect (Damnit)

- Has built in IR laser projector
- Only outline needed, not depth
- Minimum range 1.2m, maximum range 3.5m
- Intrusive
- Proprietary connector
- 640×480 @ 30fps (only)
- Most functionality is within the Xbox
- Expensive (100€+)

Inaccurate even at short range

Camera

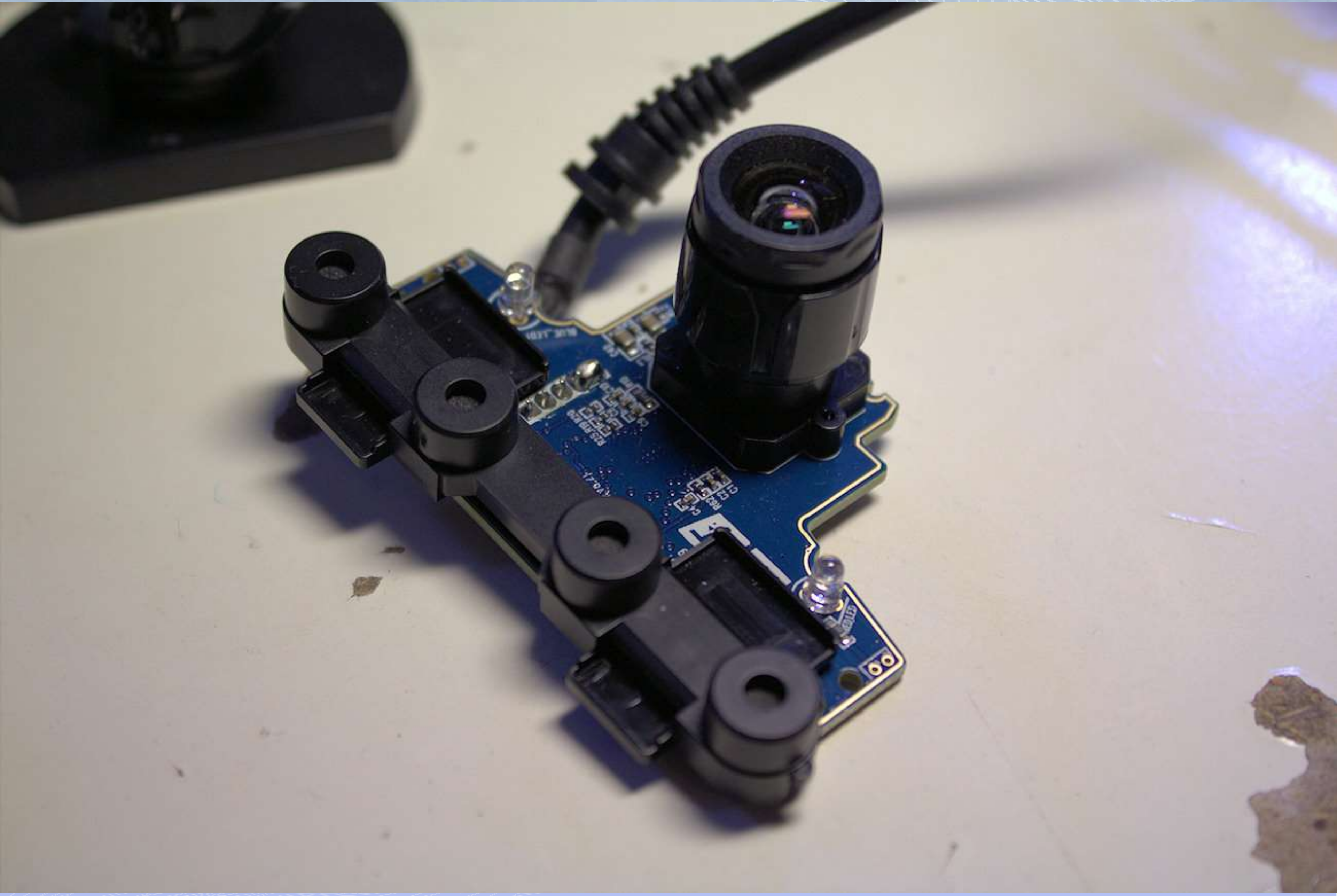
- Cheap
- Fast frame rate
- Good resolution
- “Hackable” – to remove IR-blocking filter and add IR band-pass filter
- Cross-platform drivers

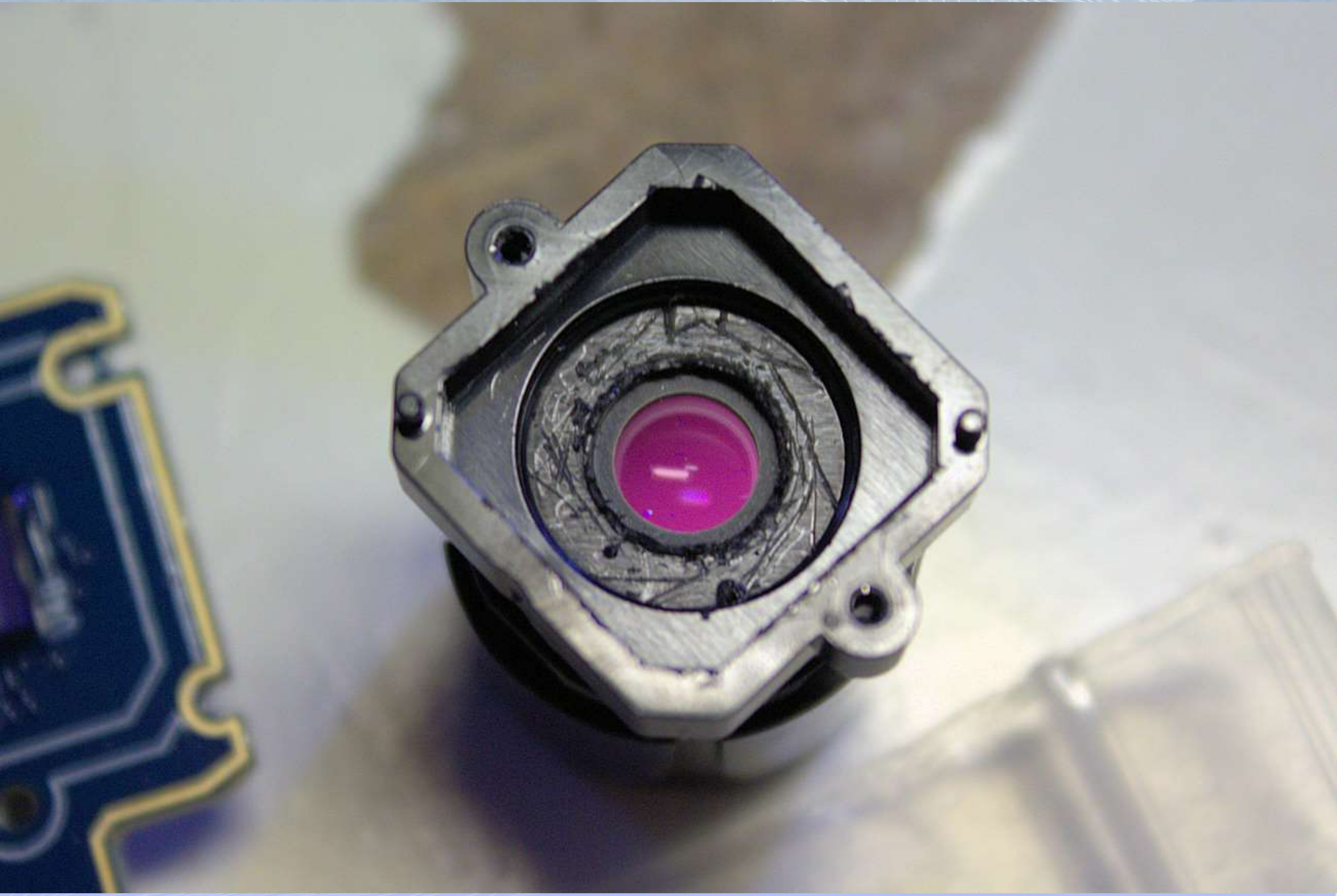
PlayStation Eye Camera

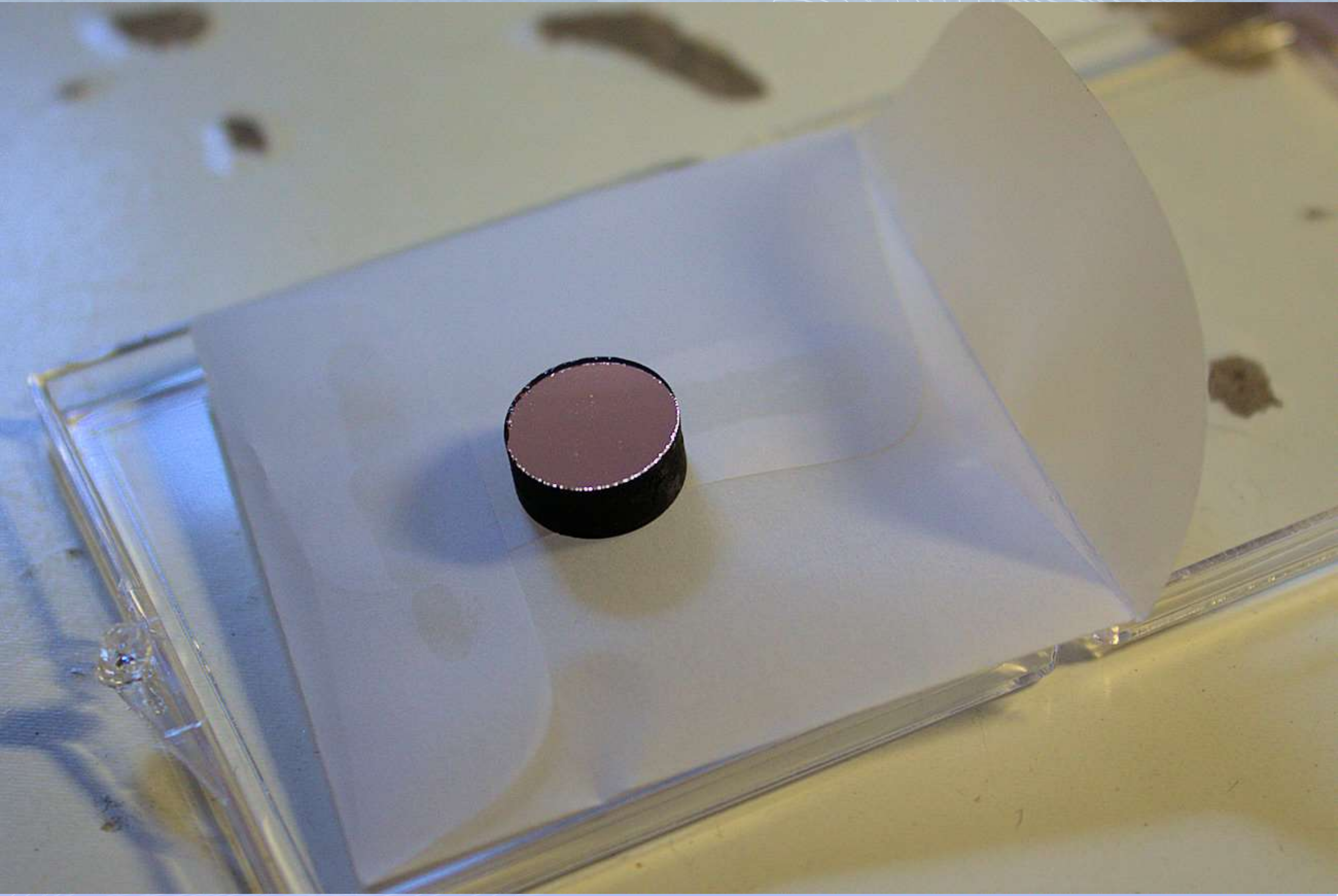
- 640x480 @ 60fps (320x240 @ 120fps)
- Free community-written drivers for Windows, Mac, Linux (from 2.6.29)
- Already in use for open source multi-touch tables
- IR hacking well documented
- Very cheap for its quality (15€)

Hacking the PS3 Eye

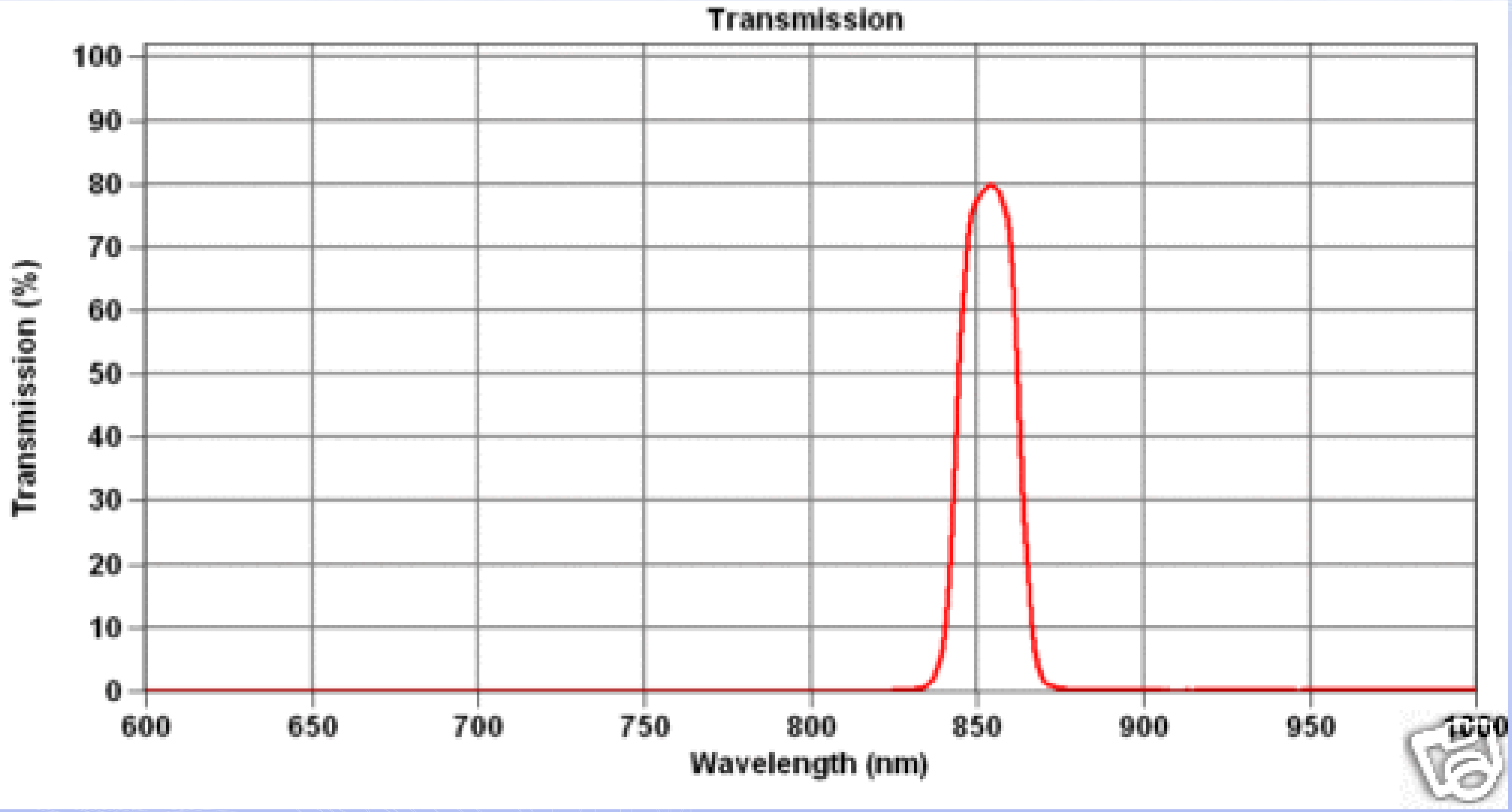
- Get it open (hard!)
- Remove built-in IR-blocking filter
- Fully-exposed and developed camera film, or floppy disk, work OK as visible light filter
- Better: specialised IR band-pass filter
- Get it closed without smashing the CCD sensor (even harder!)

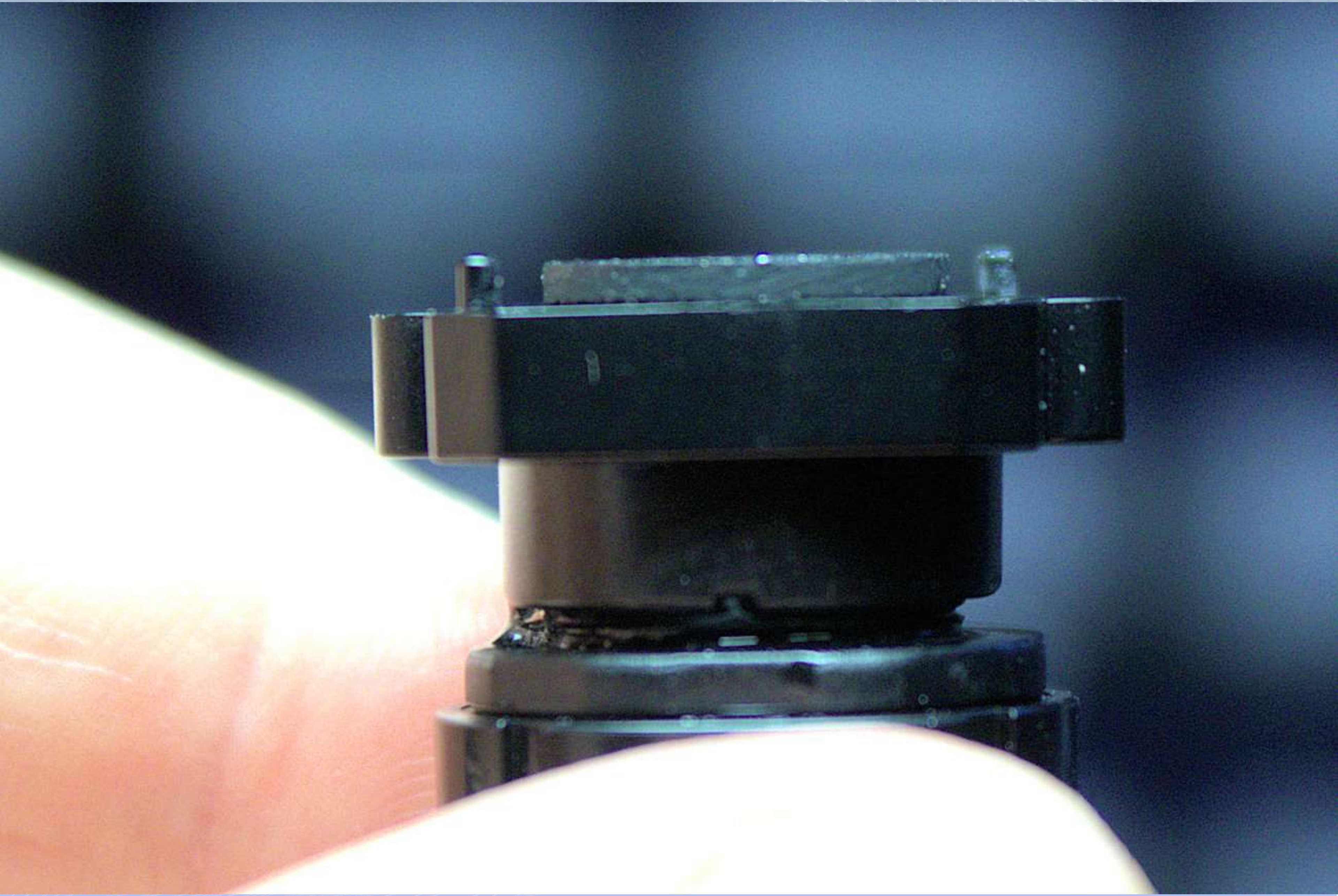


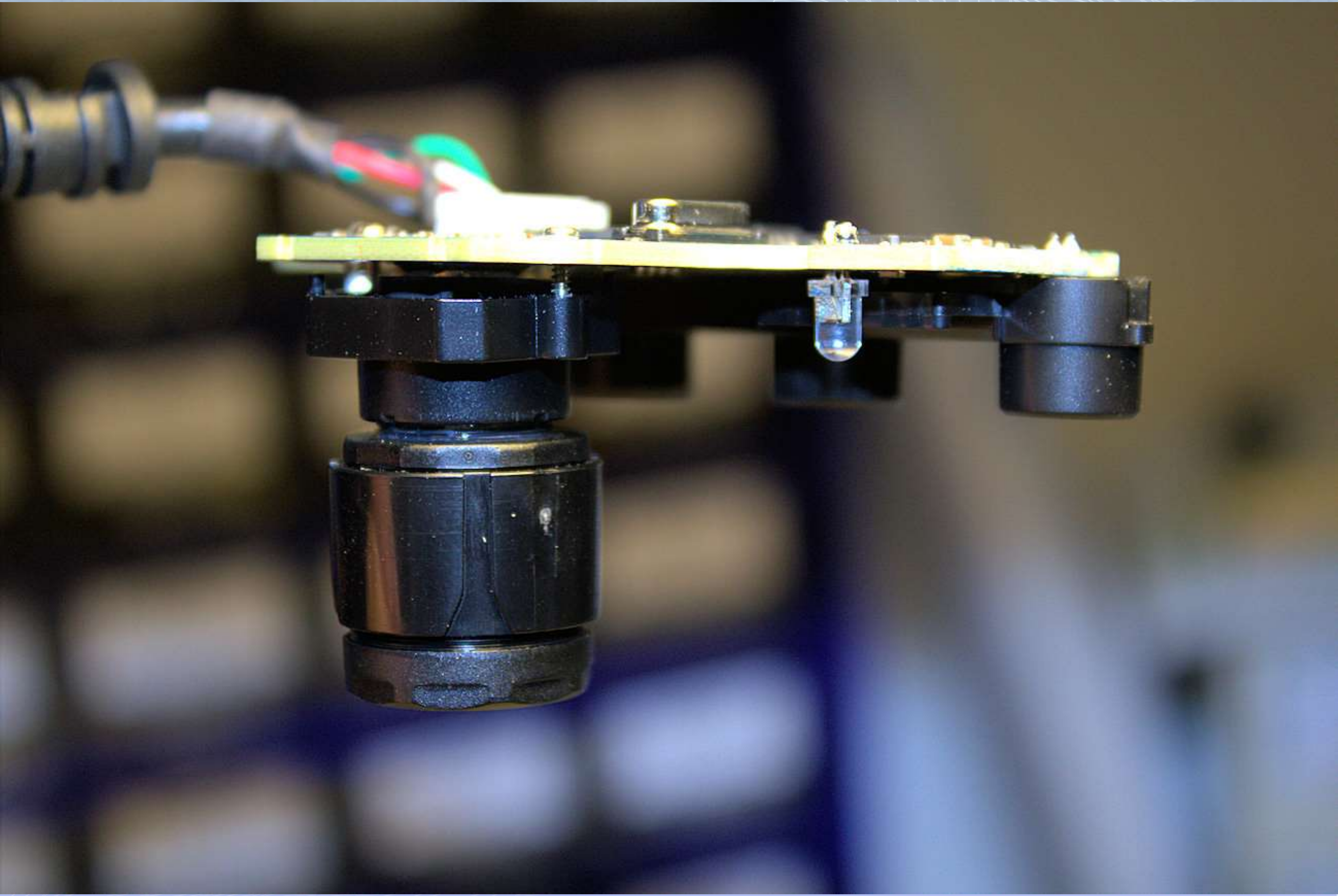


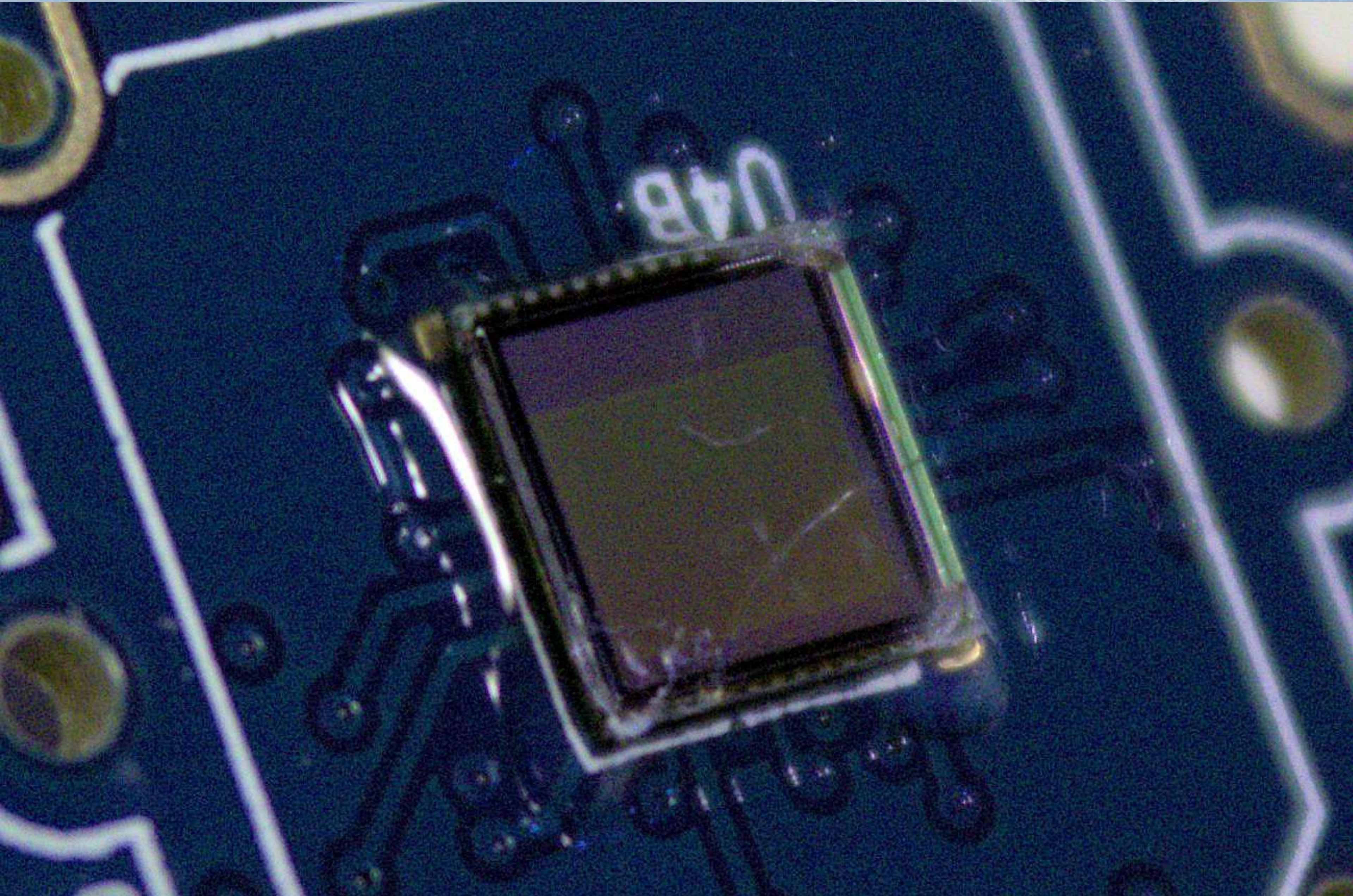


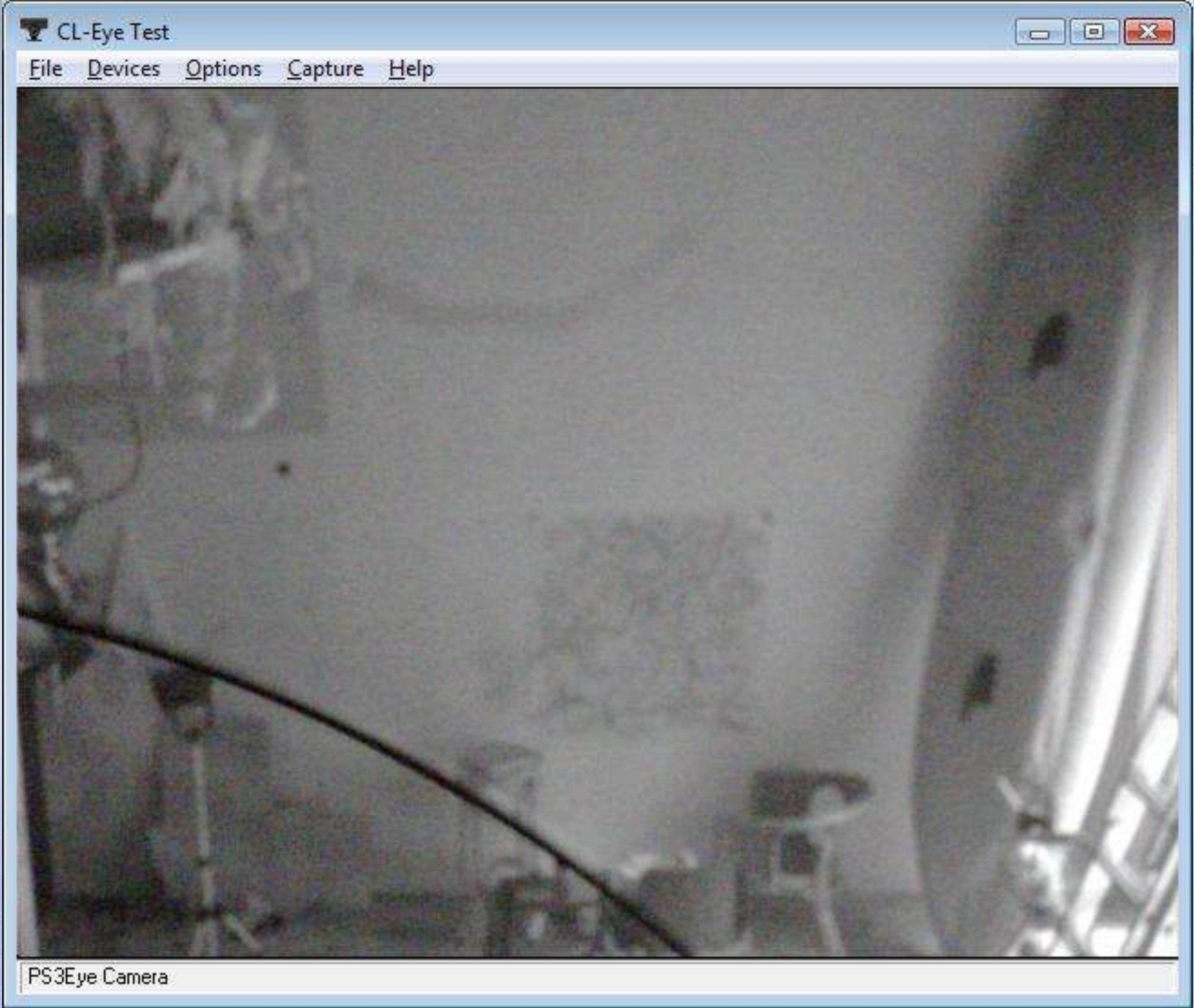
IR Bandpass Filter








U4B


CL-Eye Test
File Devices Options Capture Help
PS3Eye Camera

Infrared Emission

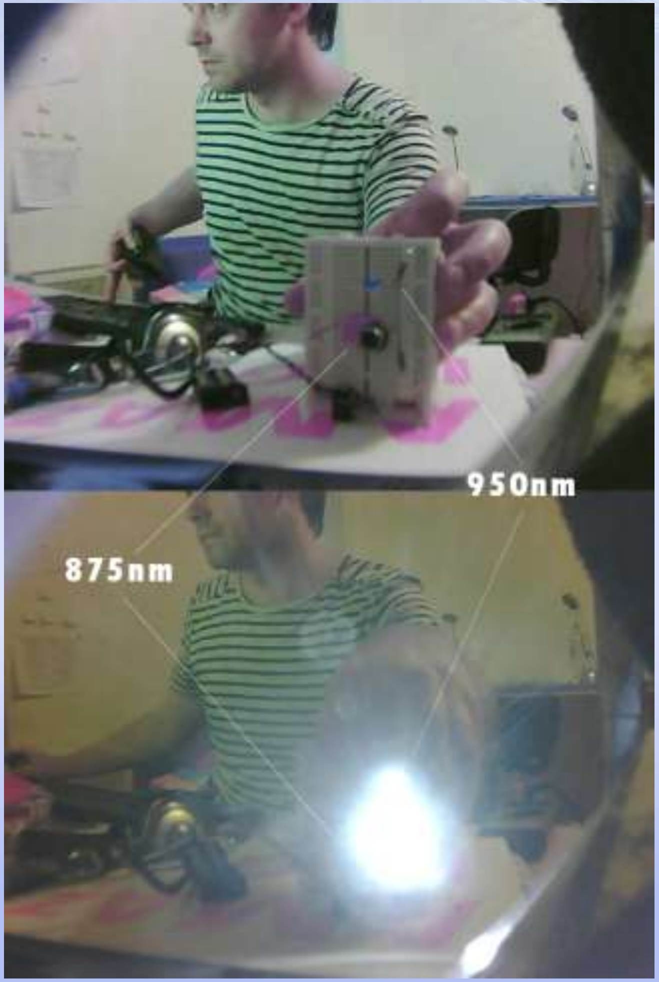
- Filtered incandescent lamps
- “IR” heat lamps (but also heat and light, and expensive)
- Lasers
- LEDs

Infrared floodlight

- Contrast between wall and ambient IR requires powerful emitters
- Position behind viewers requires unusual angle
- Should scale well to larger areas
- Still looking for a good source

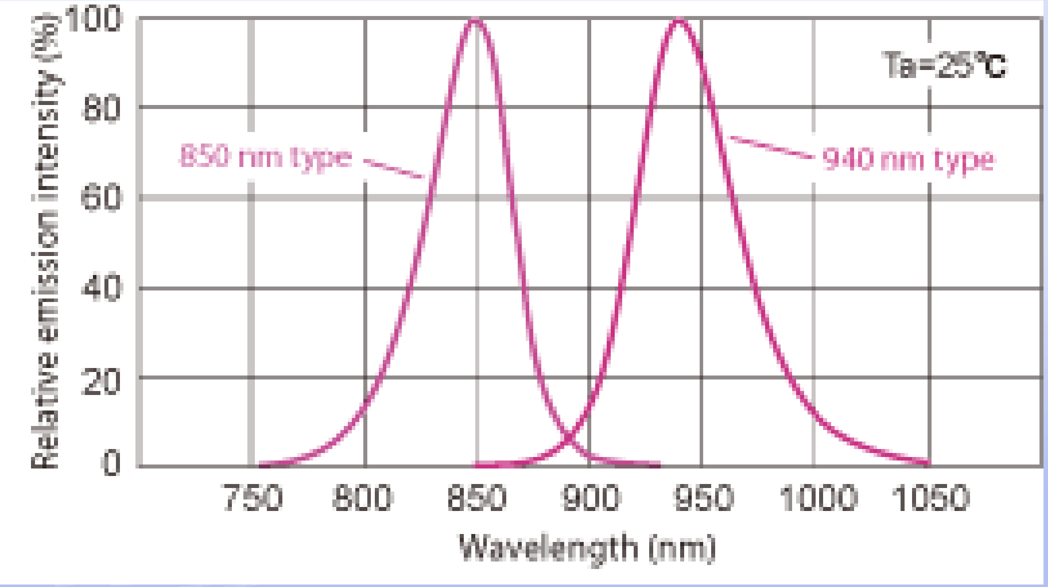
What wavelength?

- 850-875nm seems best with the cameras I tested
- Also the cheapest
- Minor visible red glow, but only if you look at the LEDs
- Filter will depend on this too



850nm

- Bleeds slightly into visible spectrum
- Doesn’t seem visible on reflection – but need to test with a child!



Magic Wall

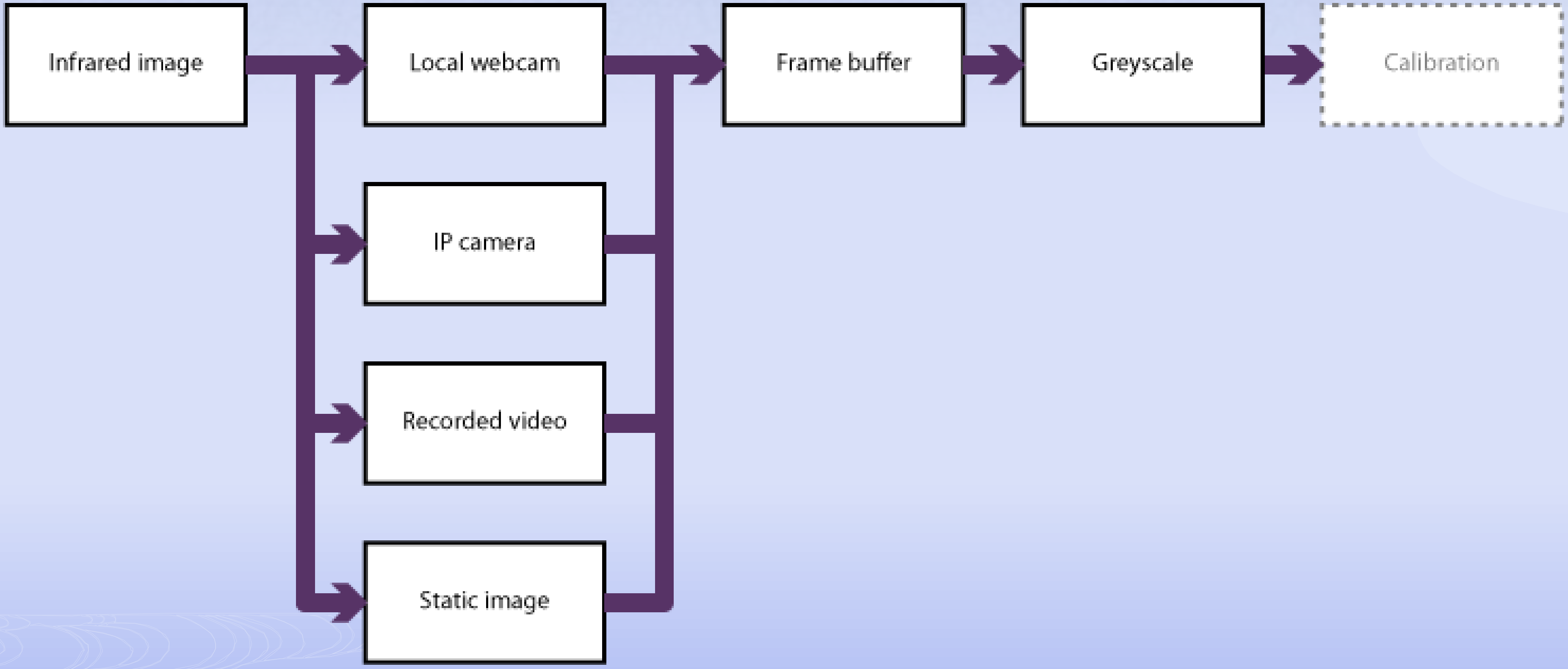
THE SOFTWARE

Requirements

- **OpenCV** (Open Computer Vision) library
- Much useful but cryptic real-time computer vision functionality
- **Processing**
- Simplified programming environment for visual artists
- **My library**
- Wraps all of the above.
- Will be released soon at www.davidc.net

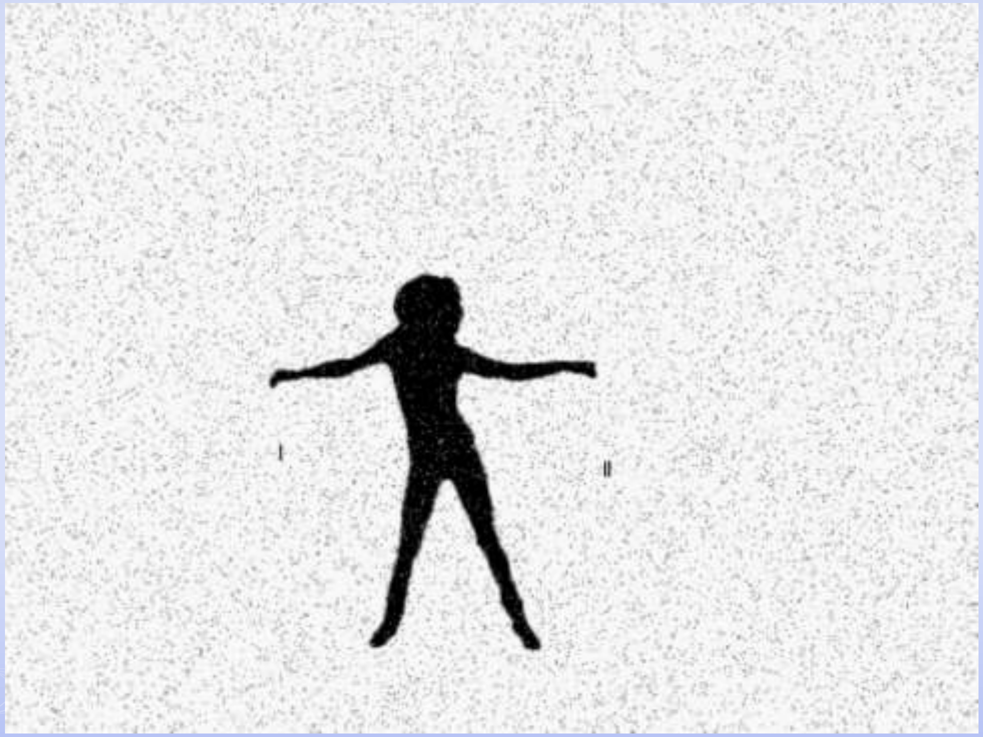
Software Flow

Source

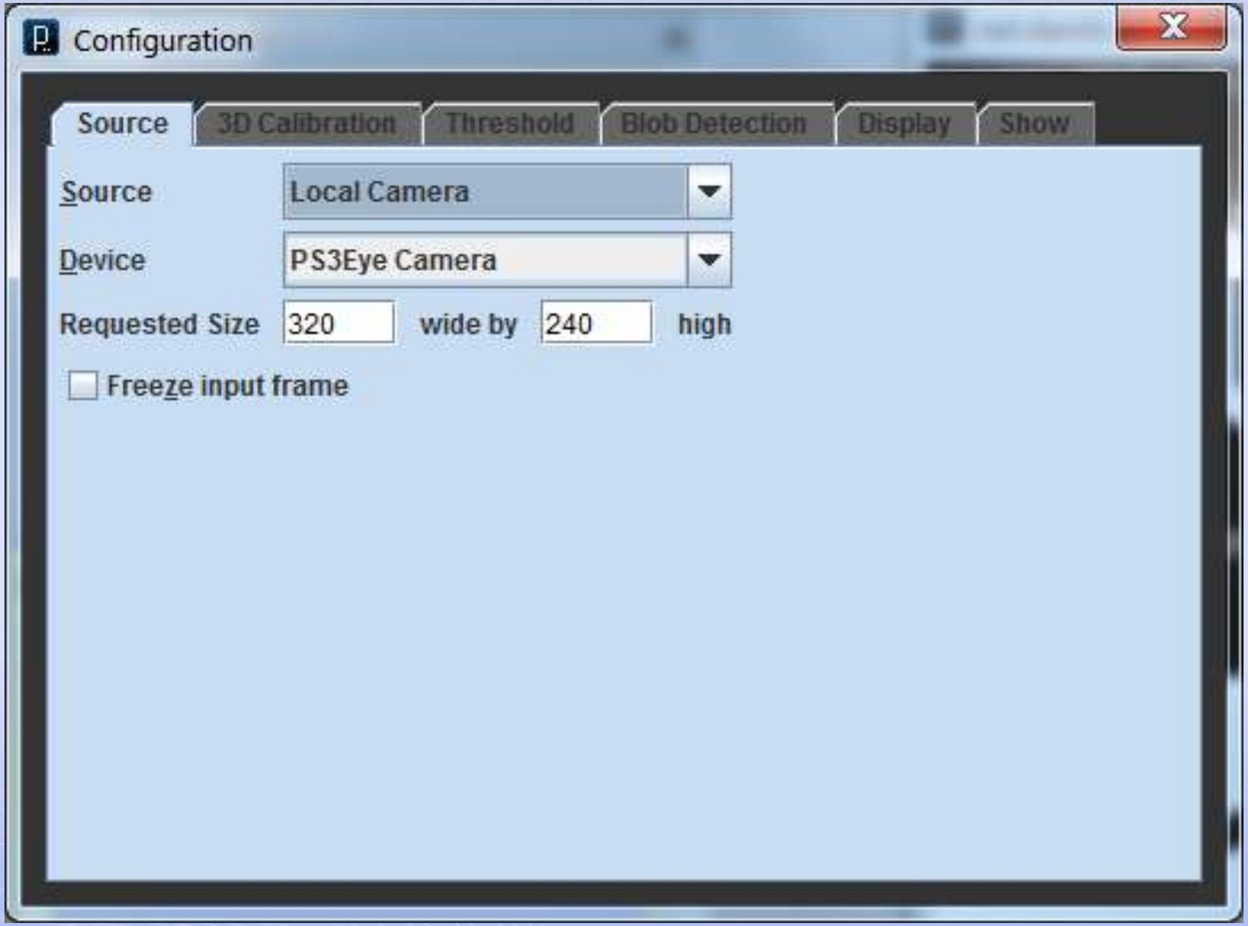


Infrared image
Local webcam
IP camera
Recorded video
Static image
Frame buffer
Greyscale
Calibration

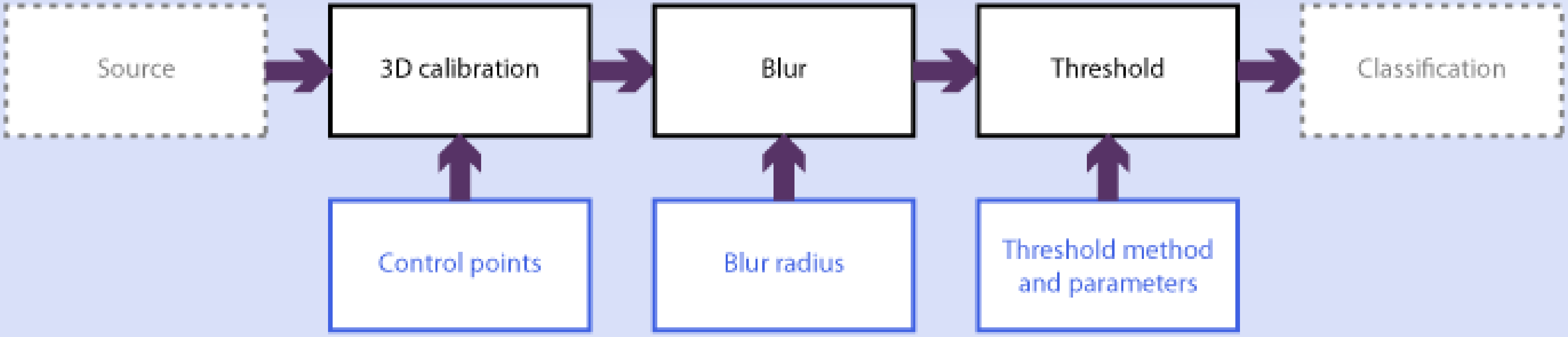
Source



Source Controls



Calibration



3D Calibration

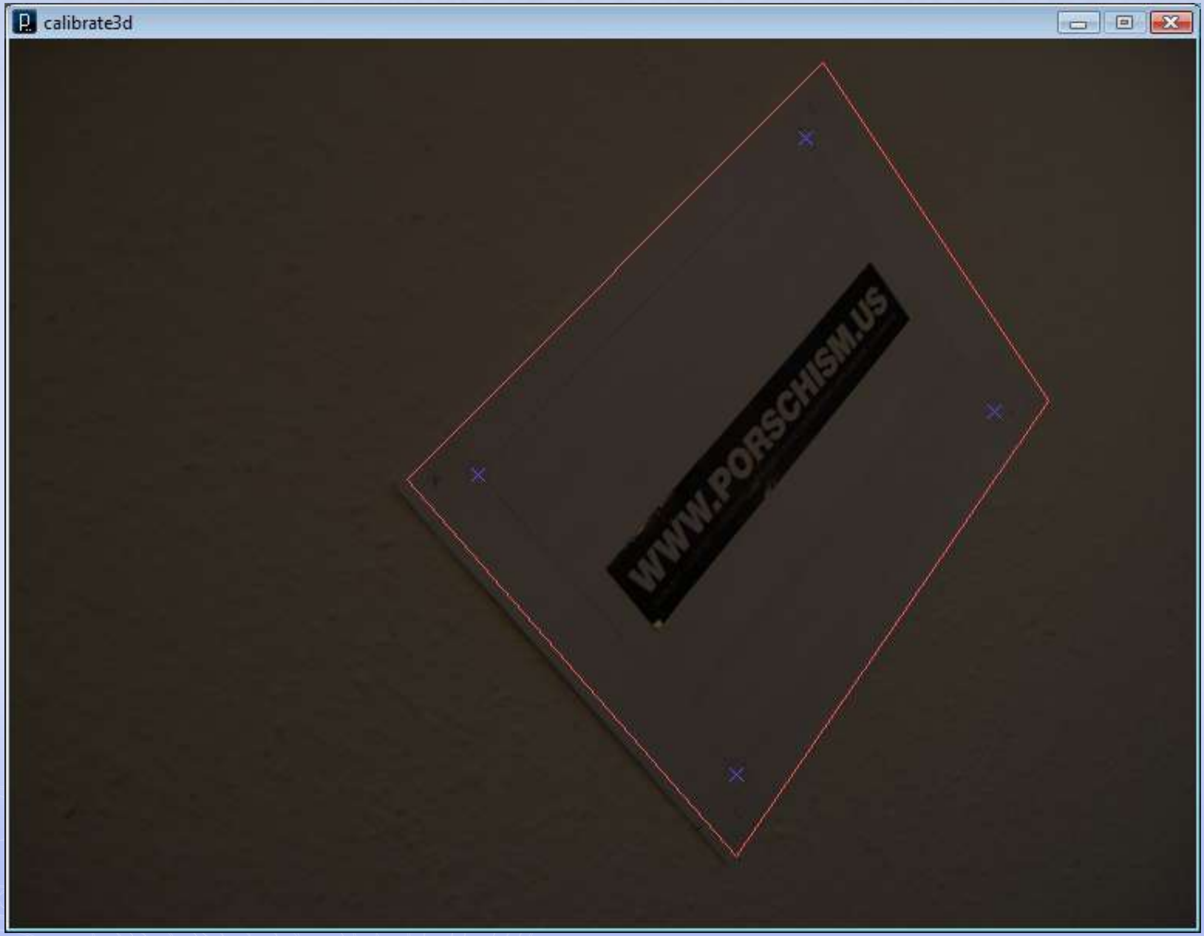
- Camera and projector are not at the exact same position
- Lenses and FOV are different anyway
- Need to recalibrate so that the final projected image lines up with bodies

3D Calibration

- Similar principle to touchscreen calibration, but in 3D space
- Correlate points in both projector and camera space
- Naïve implementation ignores perspective, but is fast and sufficient for not
- OpenCV has calibration routines

Calibration – Source Image

Calibration – Control Points



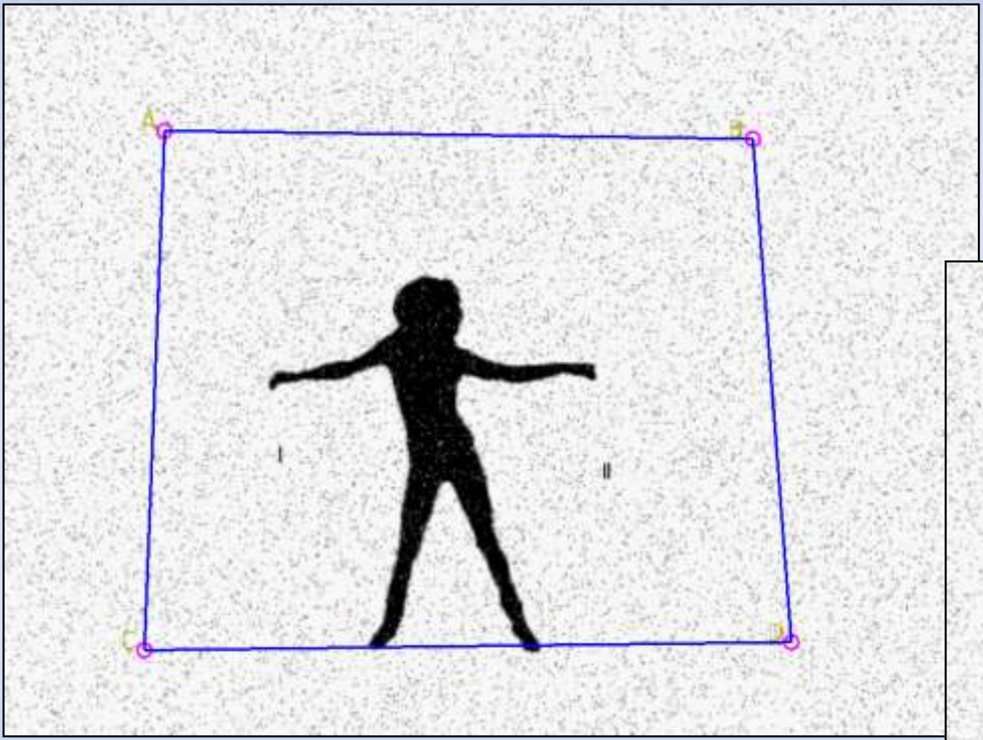
Calibration - Output

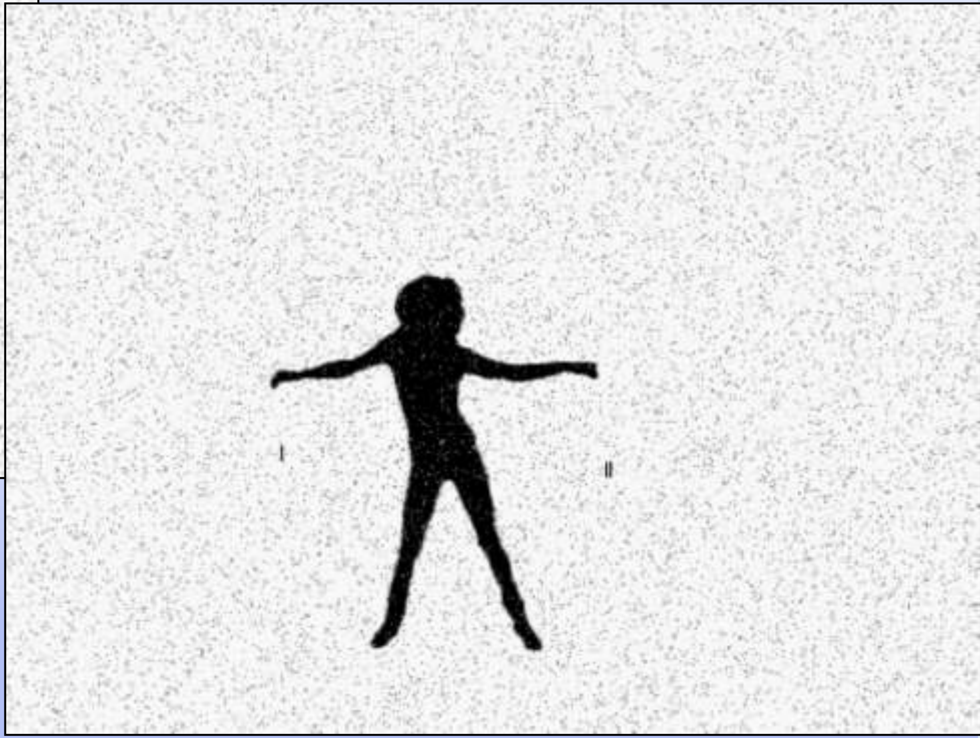
Calibration Method

- Turn off floodlights
- IR LED on a stick
- Search for a single blob of a given size range
- Take the average of its centre of gravity over a period of time
- Repeat for other points
- Run calibration routine
- Then re-project each source frame

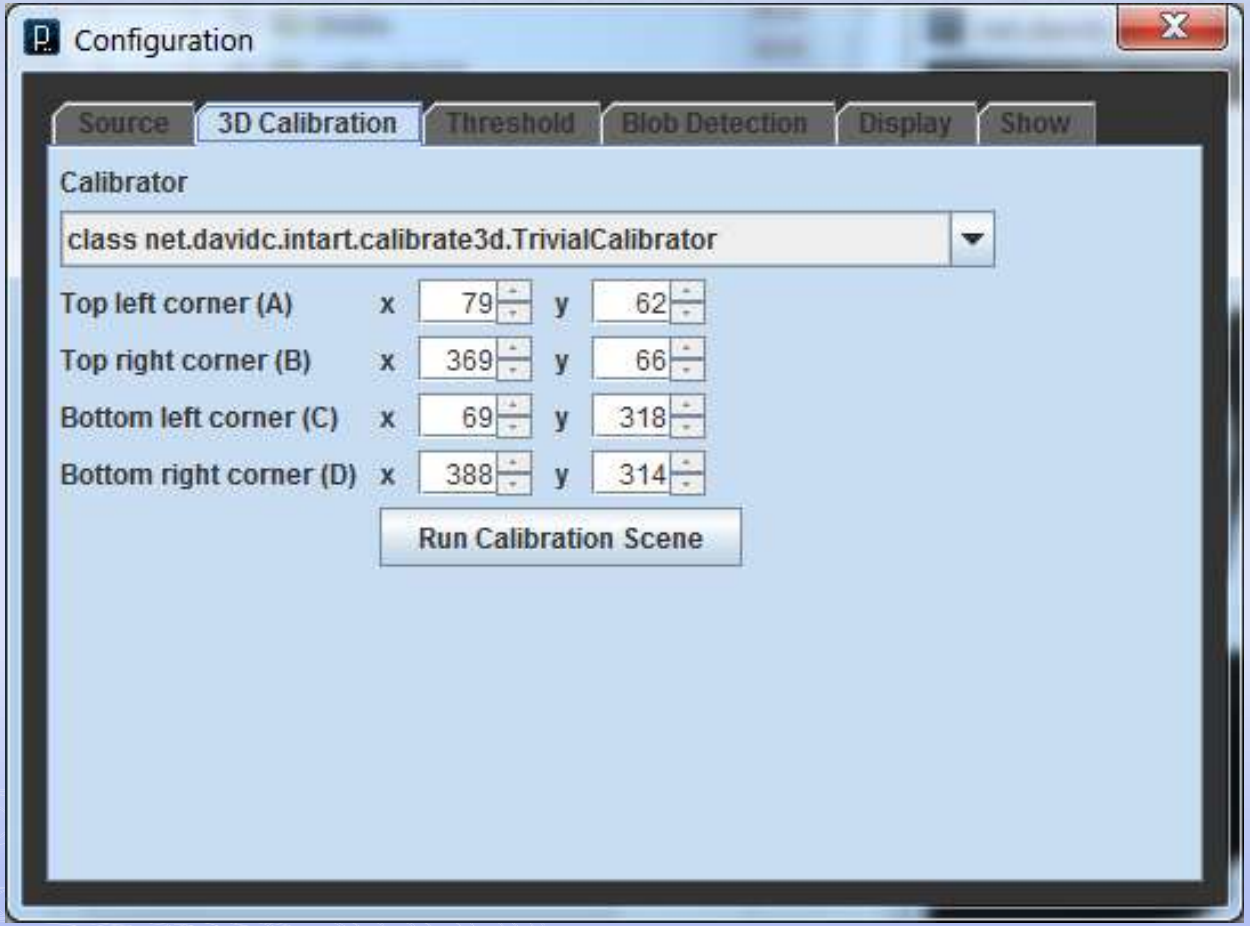
Calibration Markers

Calibration

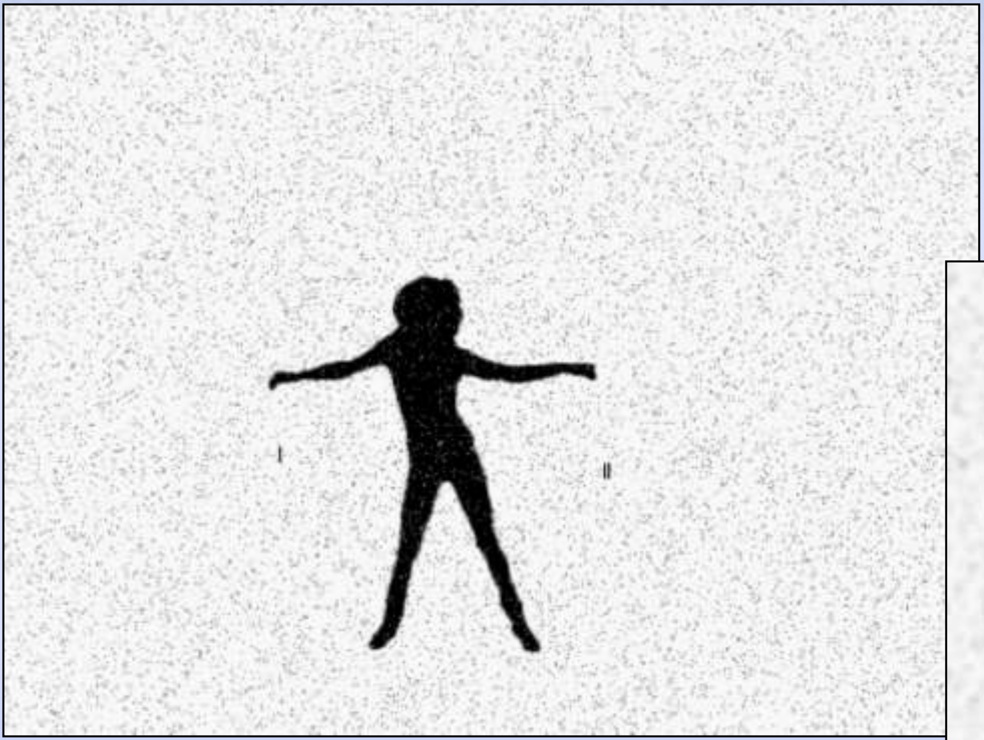




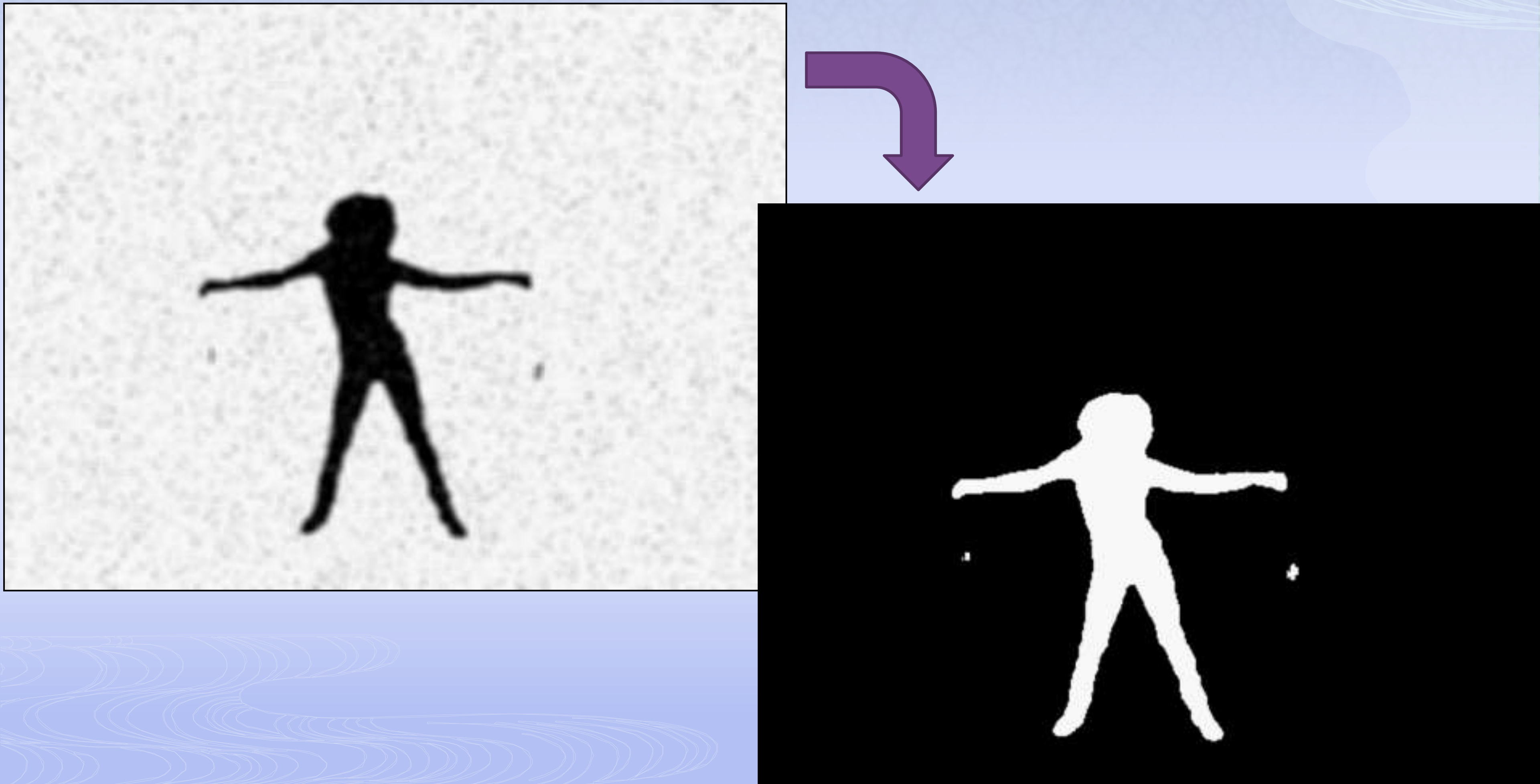
Calibration Controls



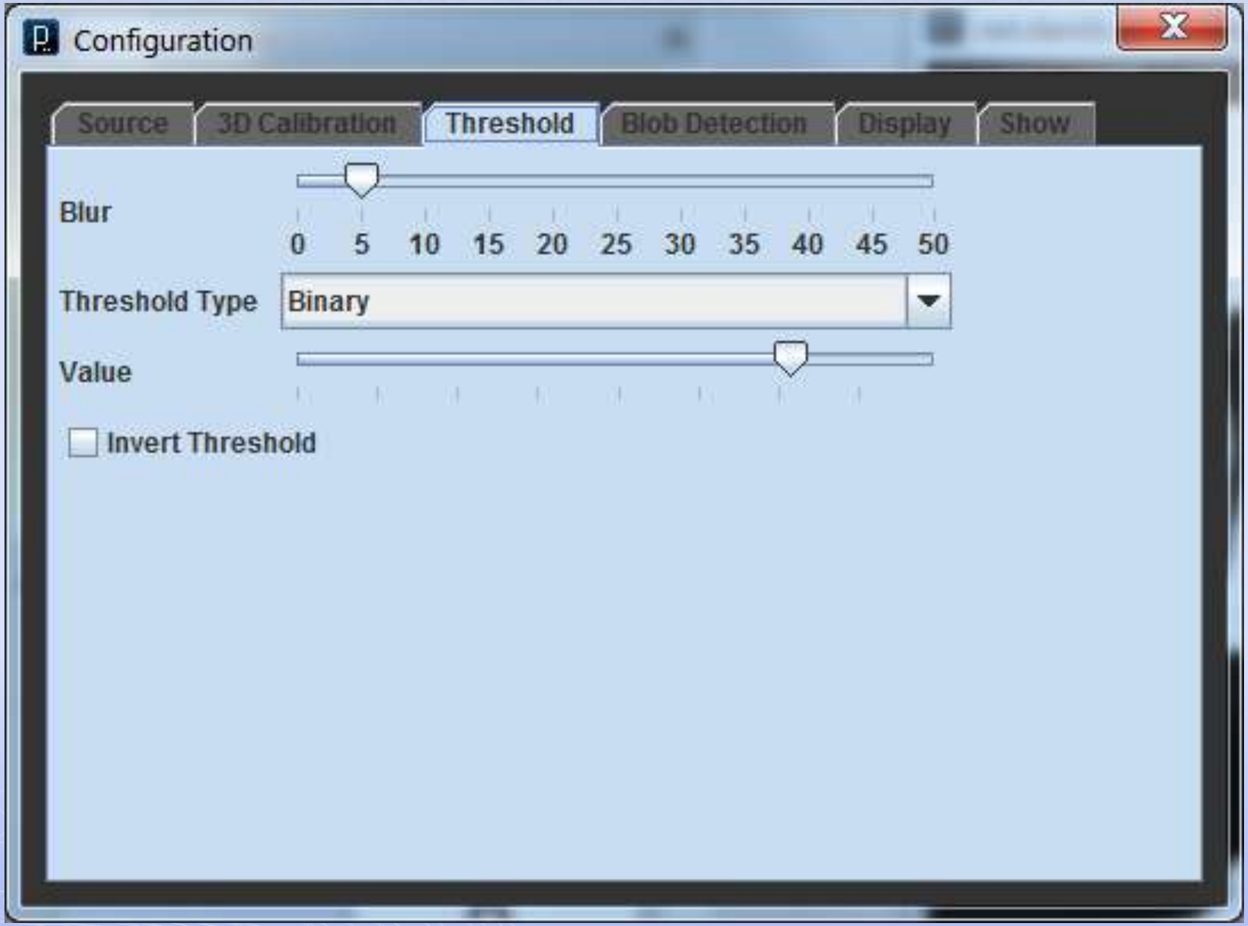
Blur



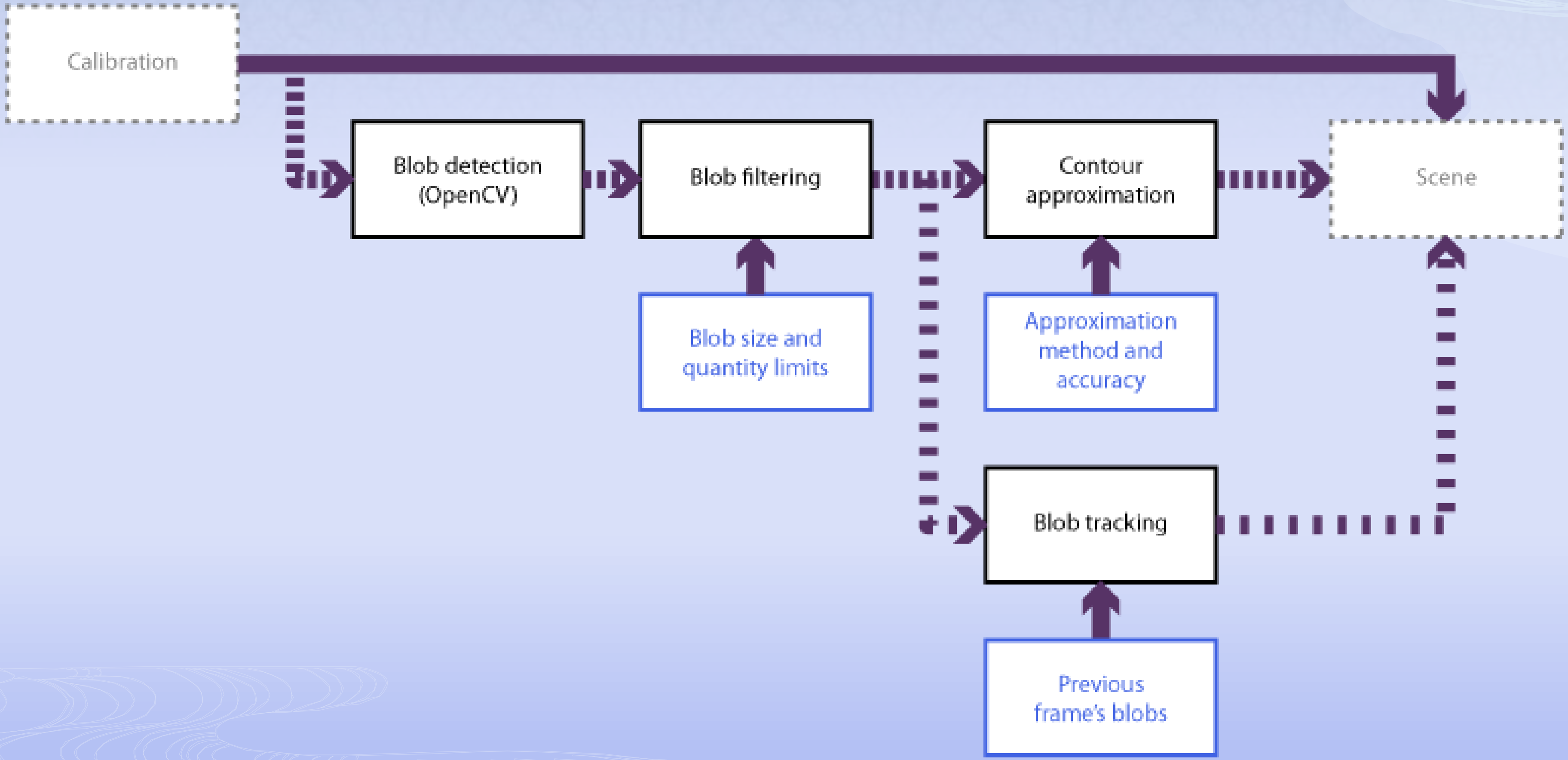
Threshold



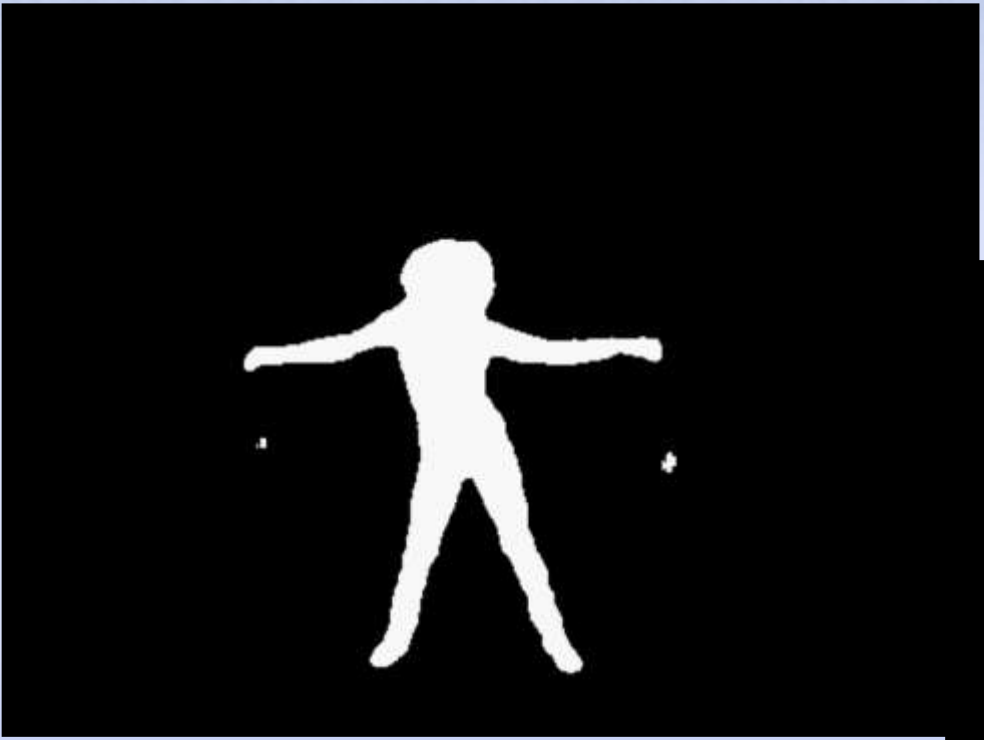
Blur and Threshold Controls

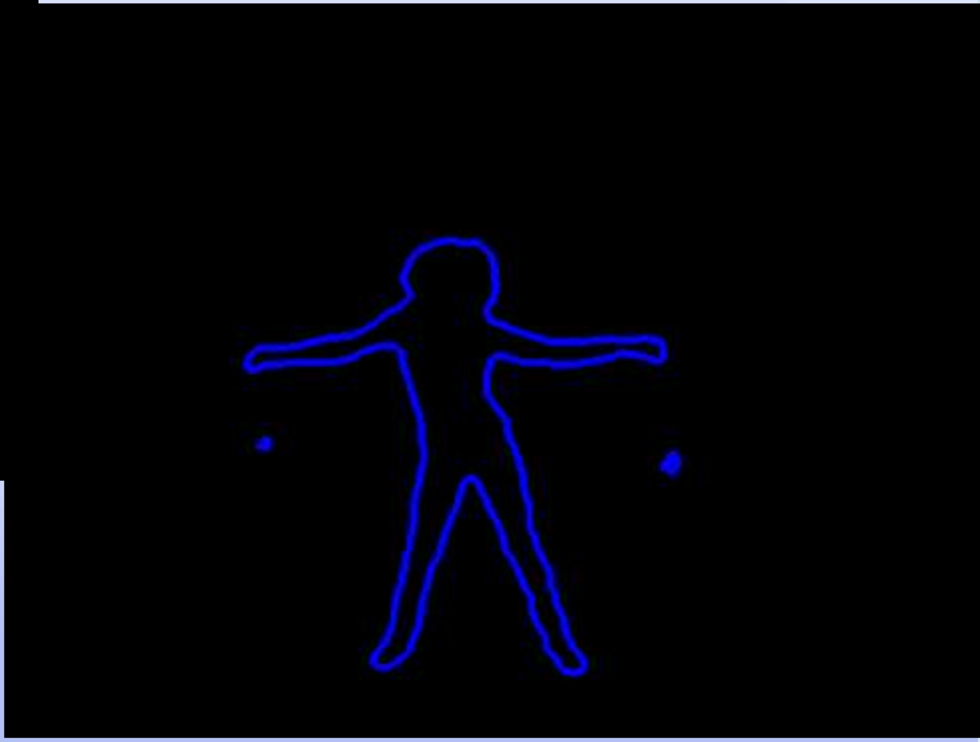


Classification

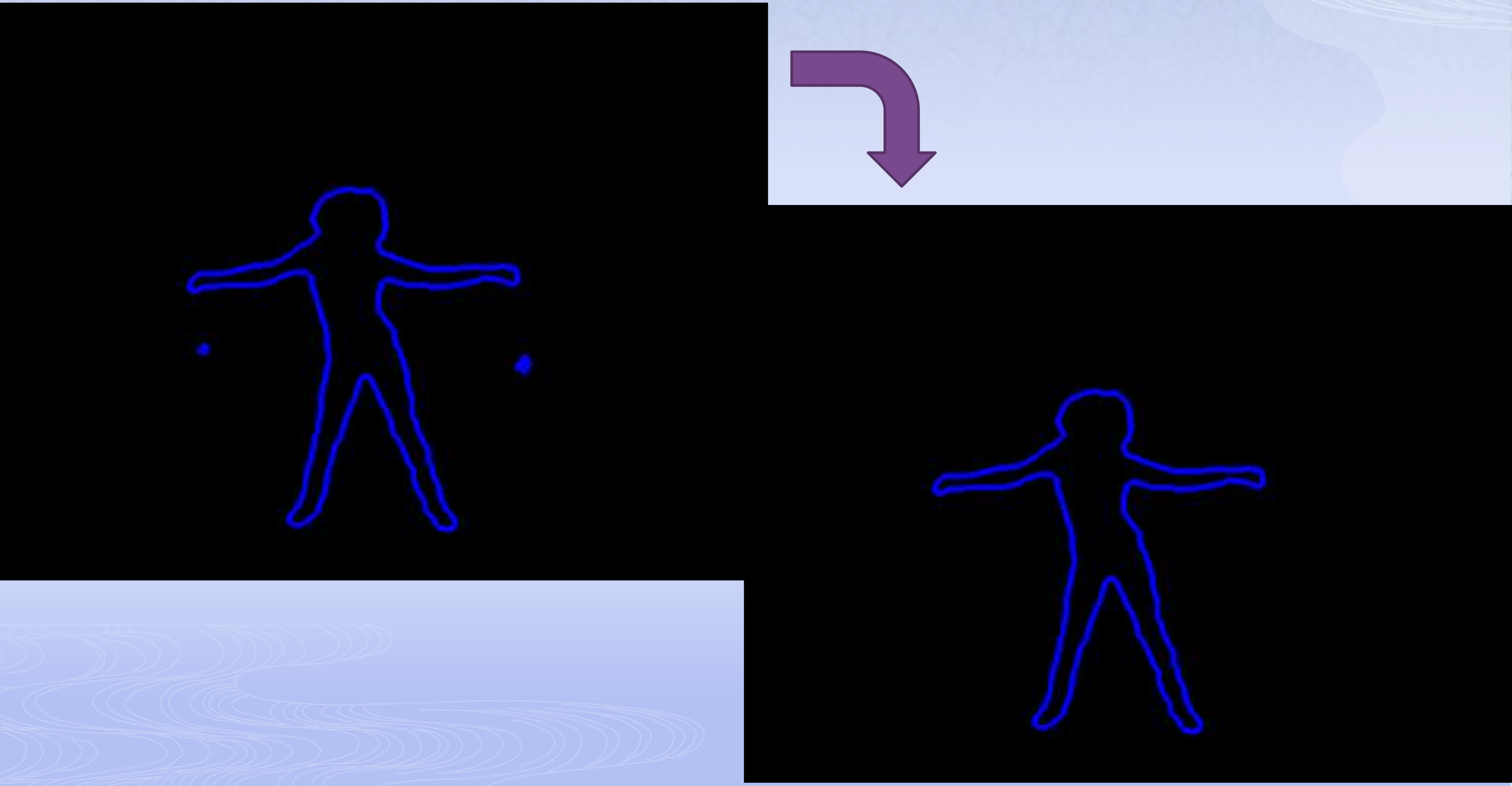


Blob Detection

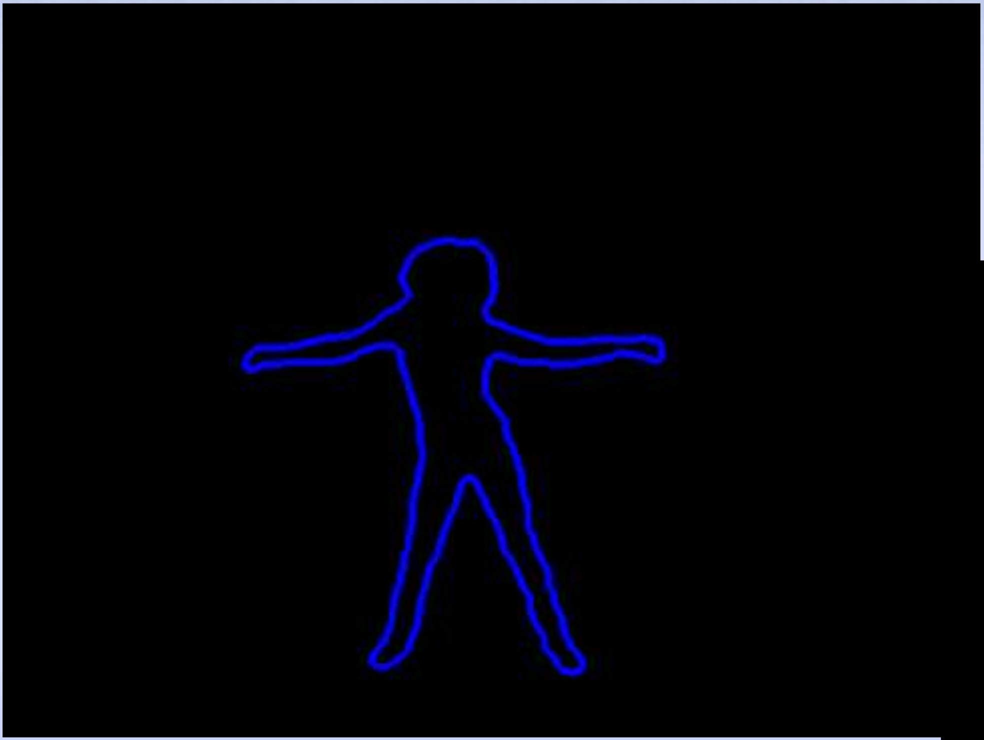


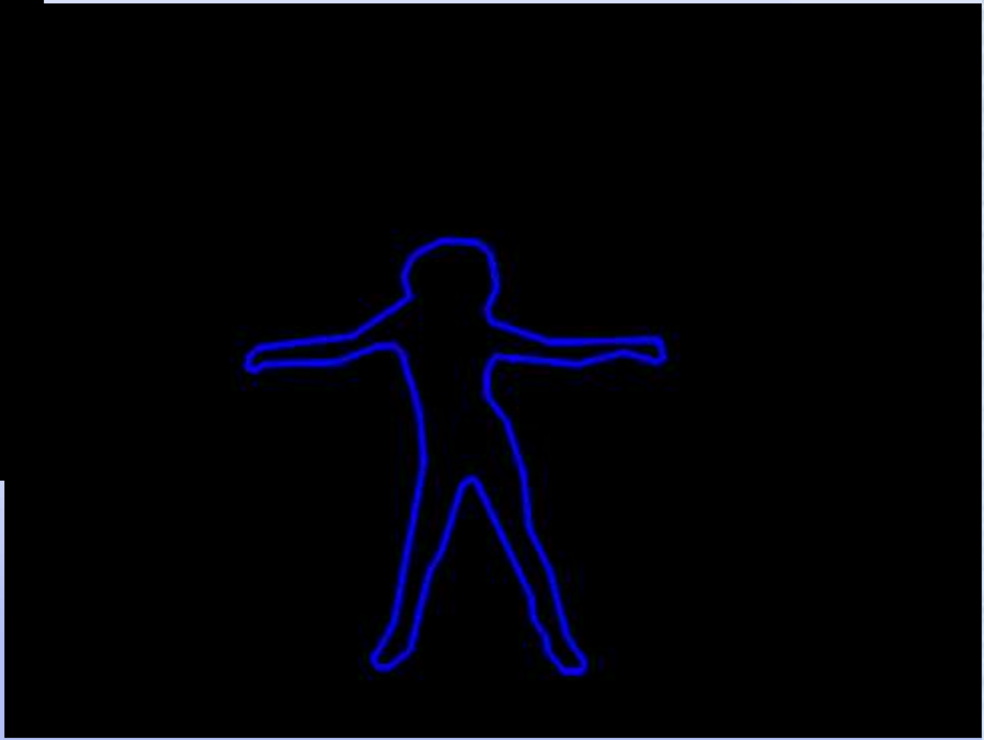


Blob Filtering

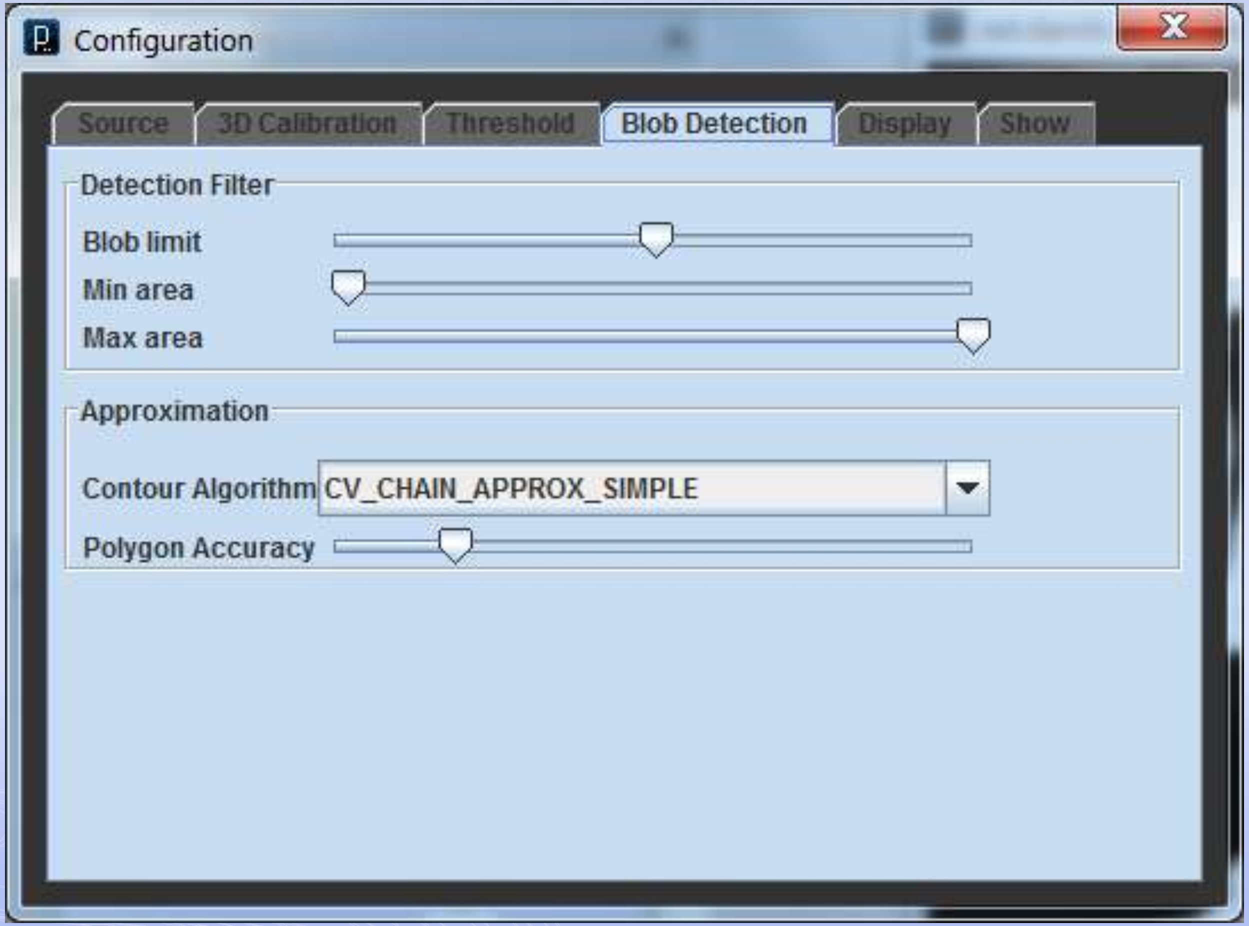


Contour Approximation

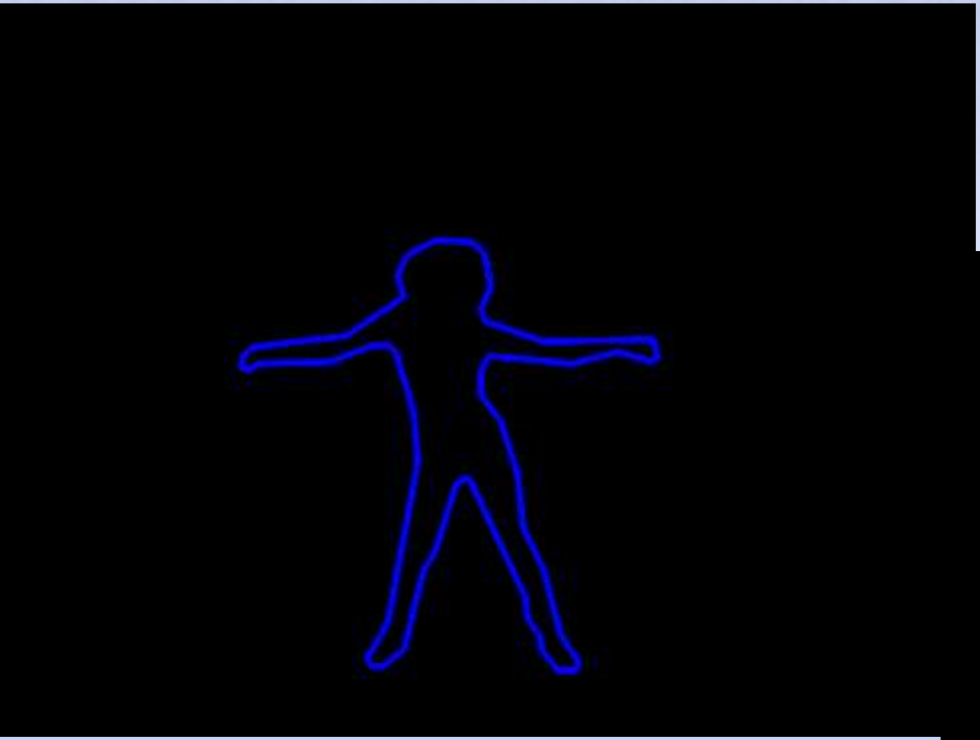


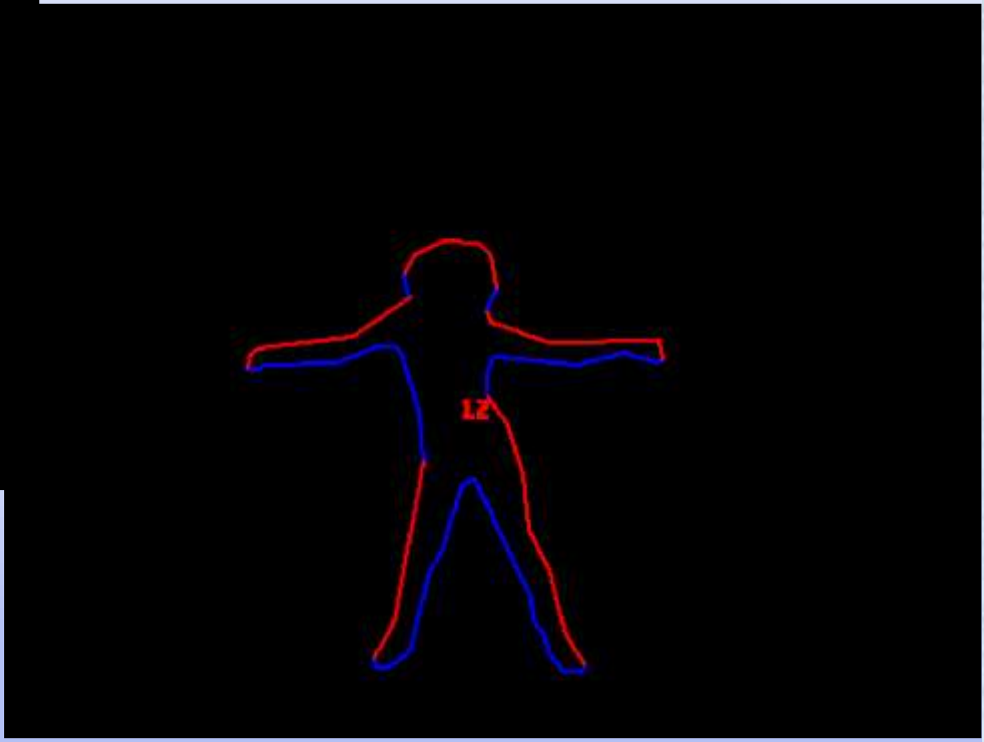


Blob Detection Controls

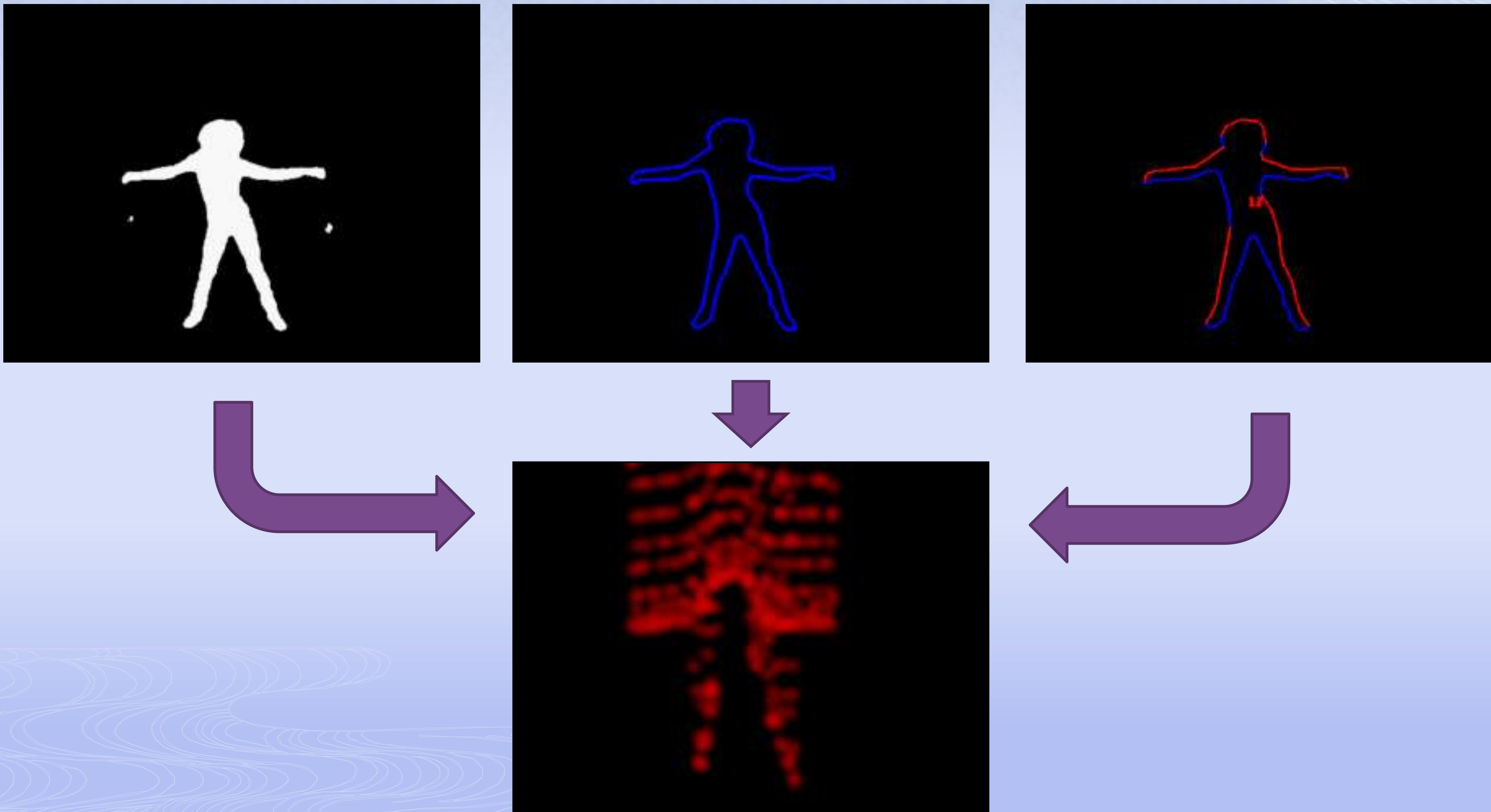


Blob Tracking

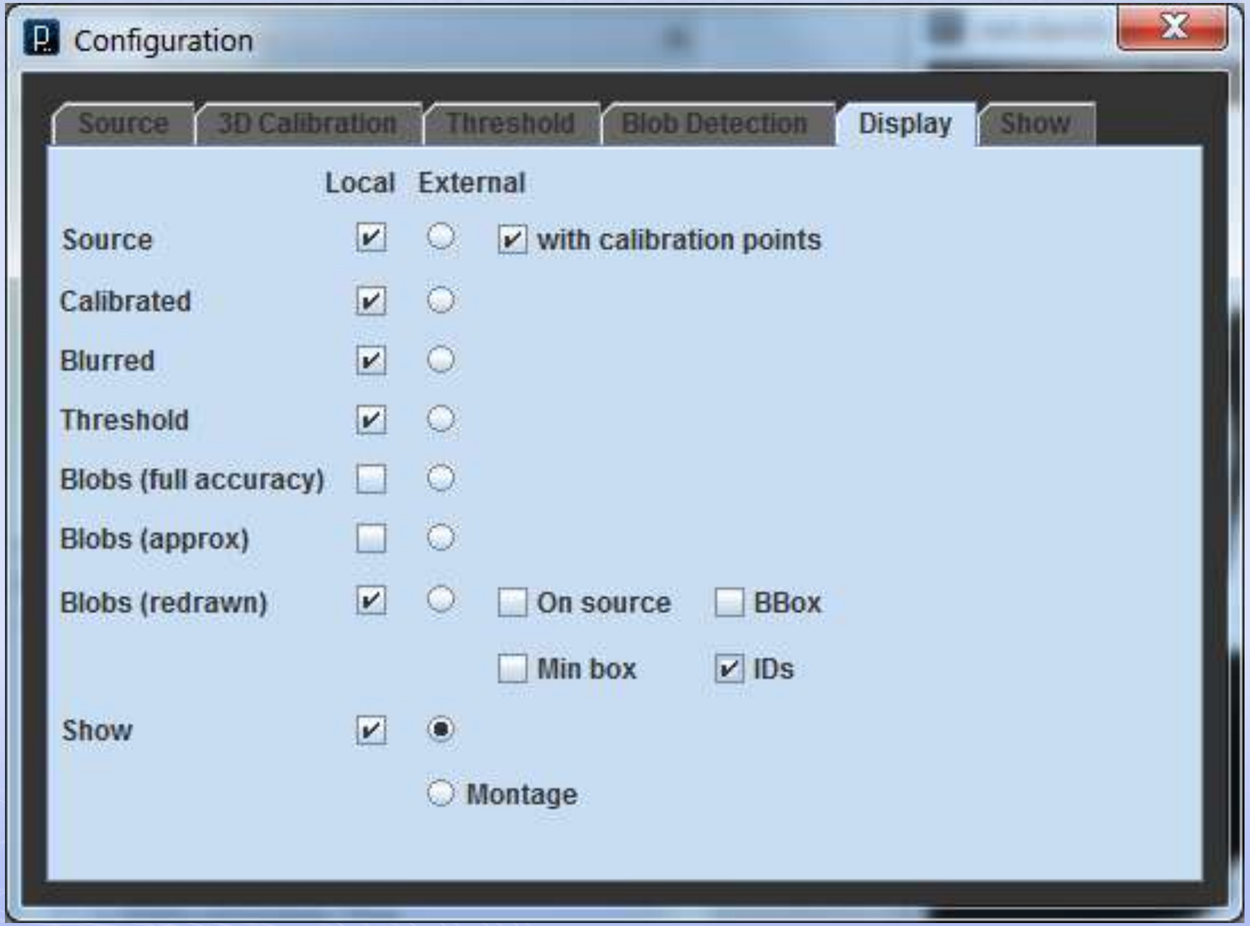




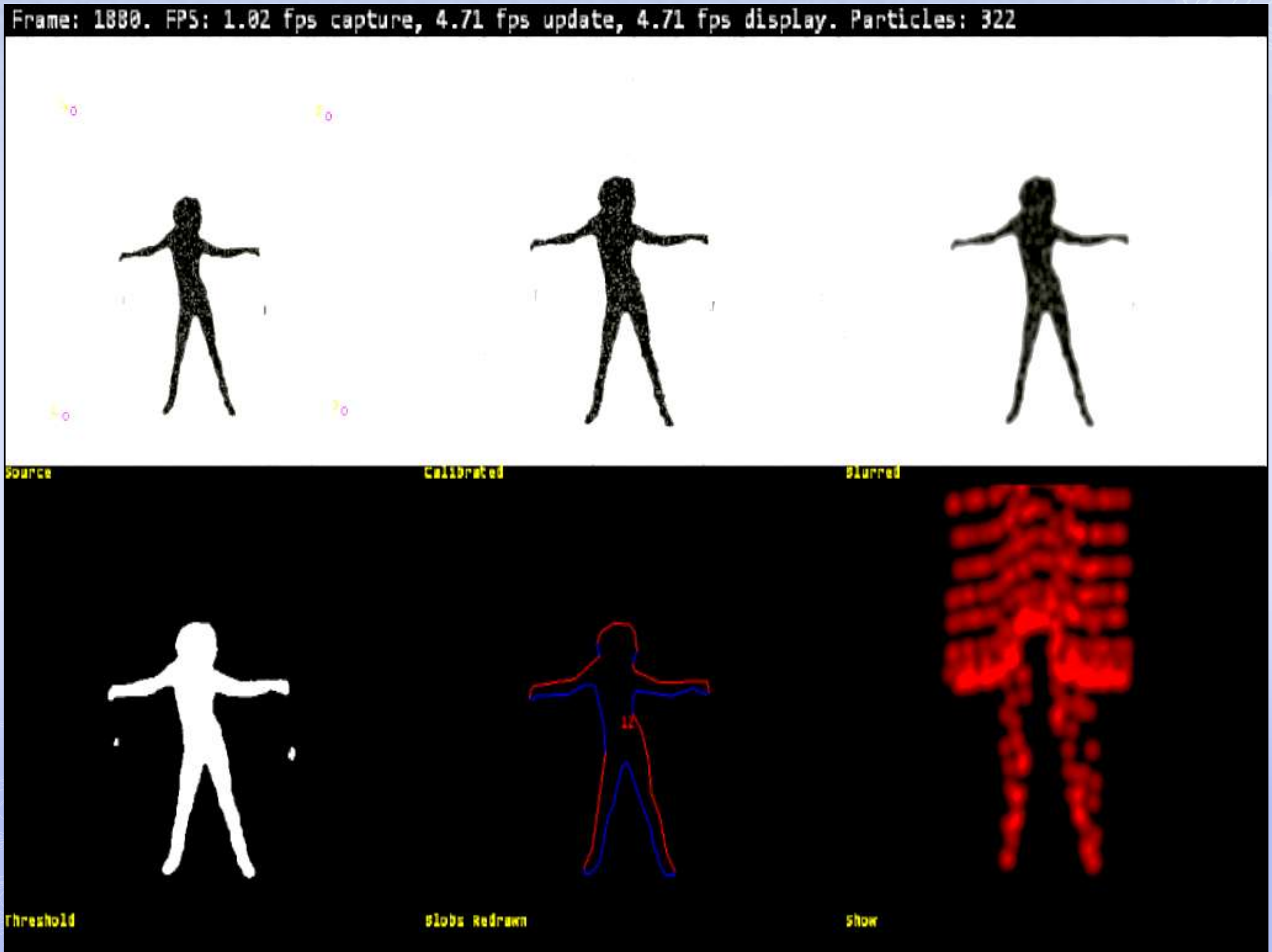
Scene



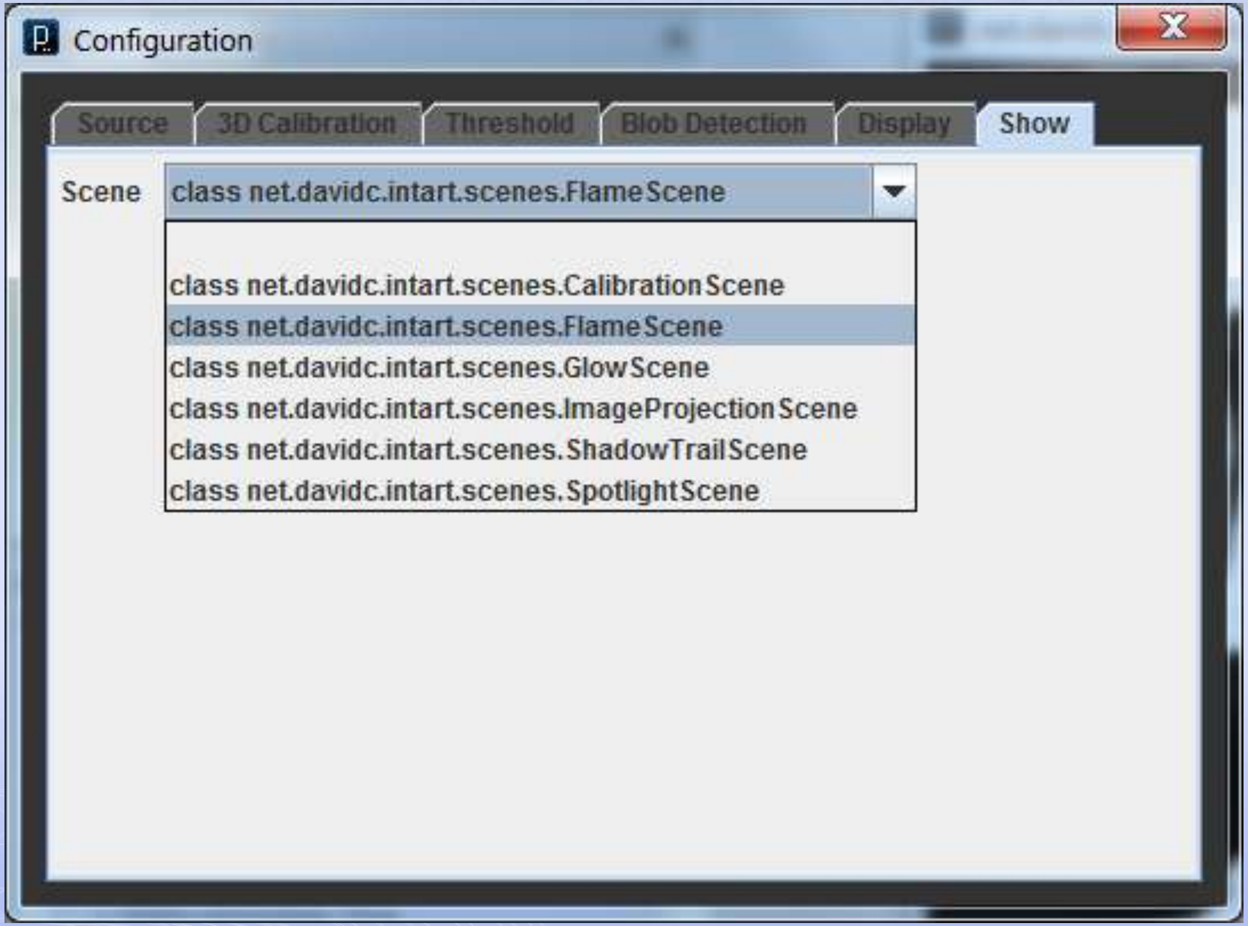
Display Controls



Montage


Frame: 1880. FPS: 1.02 fps capture, 4.71 fps update, 4.71 fps display. Particles: 322
Source
Calibrated
Blurred
Threshold
Blobs Redrawn
Show

Scene Controls



Example Scenes

- Spotlight
- Glow
- Image projection
- Shadow trail
- Flames

Example Scenes

- Video projection
- Insects/flocking
- Rain
- Beach ball game
- Forest

Example Scenes

- Develop a reference hardware design
- Finish and release software as open source
- Invite others to develop scenes

Next Steps

- Find better floodlights
- Improve, finish and optimise software
- Write more demos
- Turn it into a Processing library
- Release it as open source software with a hardware reference design
- Regions of interest
- Camera and projector tiling

Further information

- Documentation will appear over the next few weeks at **www.davidc.net**
- david@davidc.net