

IBM Research Report

PupilCam Construction Instructions

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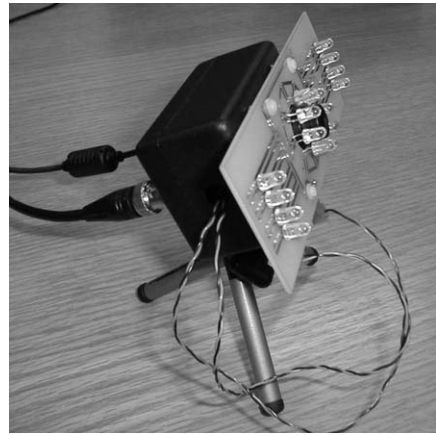
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PupilCam Construction Instructions



This manual describes the step-by-step construction of a PupilCam pupil-detecting camera. The PupilCam uses a simple structured lighting scheme that synchronizes the illumination of two sets of near-IR LEDs to the field rate of a B&W NTSC board camera. The resulting video output is standard NTSC with the distinction that pupils in the first/odd field will appear bright and the same pupils in the second/even field will appear dark. A simple differencing operation reveals the location of pupils in the video image.

I. Parts overview

II. Modify plastic enclosure/box

- Drill holes in enclosure top
- Drill holes in enclosure bottom

III. Electronics and cables

- Build cables
- Populate pupilSX board
- Program pupilSX microcontroller
- Populate LEDillum board

IV. Modify camera

- Insert Wratten filter in lens housing
- Mount lens

V. Final Assembly

- Connect cables and test
- Mount cables in enclosure bottom
- Mount camera, pupilSX and LEDillum
in enclosure top
- Close box and add tripod

VI. Appendix

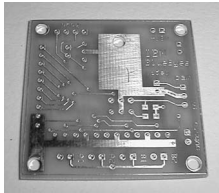
I. PARTS OVERVIEW



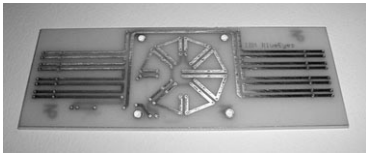
C-mount B&W high-resolution board camera (NTSC)
C-mount 50mm F/4.0 lens and spacer set
Mini tripod with ball socket
ABS plastic enclosure



BNC female bulkhead (video out)
2.5mm male power jack



Printed circuit boards
The two boards for the pupilCam are fabricated by expresspcb.com using proprietary layout software. Refer to files “pupilSX.pcb” and “LEDillum.pcb”.



II. MODIFY PLASTIC ENCLOSURE/BOX



Refer to Hole Template.
Drill holes in enclosure top

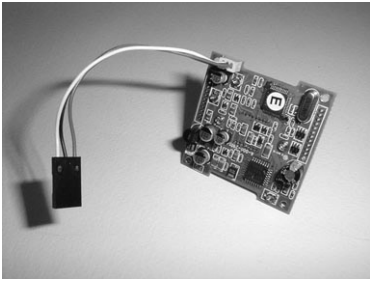


Drill holes in enclosure bottom

Build cables

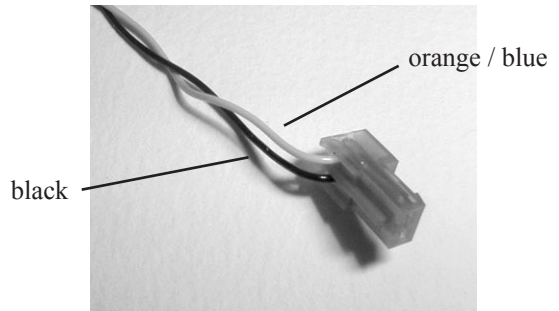
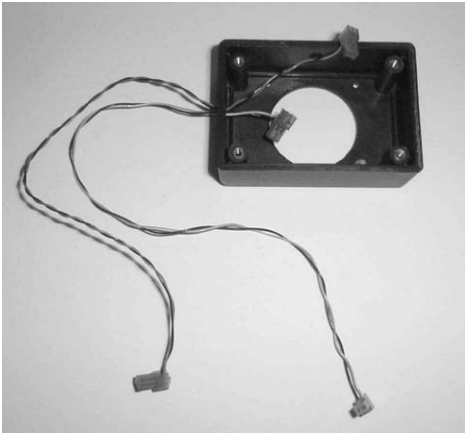
Camera cable

Supplied with the board camera is a 3-wire cable with micro connector. Cut the cable to approximately 3" and add a non-polarized 3-conductor 0.1" connector housing. Maintain the order of colors on the micro connector: red, black, white.



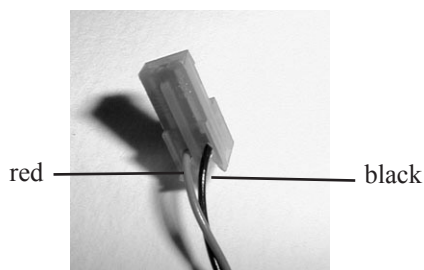
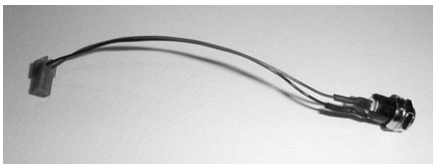
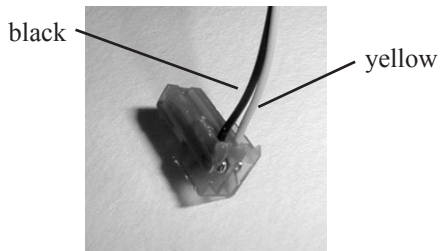
LED cables

Build two 10" 2-wire cables (orange/black and blue/black) with MTA connectors on both ends. For each cable: attach the MTA connector to one end, thread the cable through the hole in the side of the enclosure top, and finally, attach the second MTA connector



Video cable

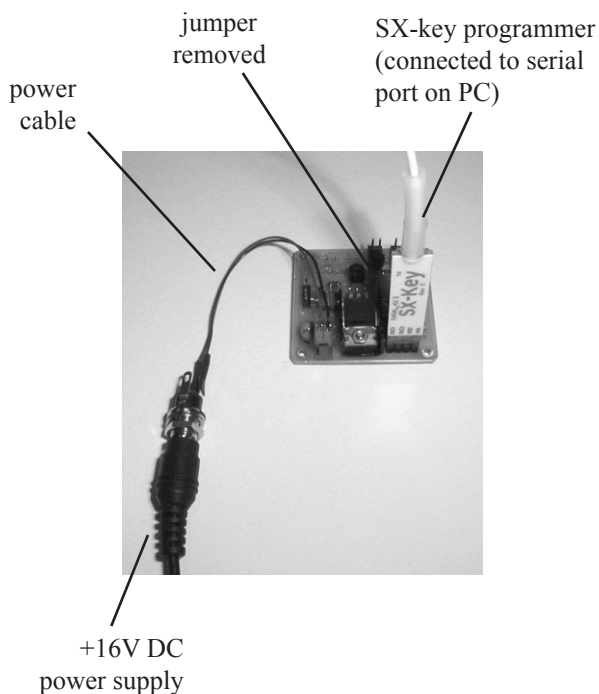
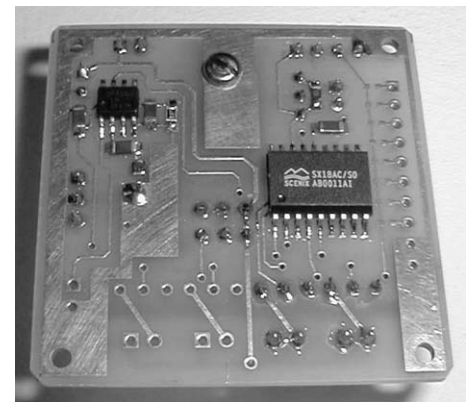
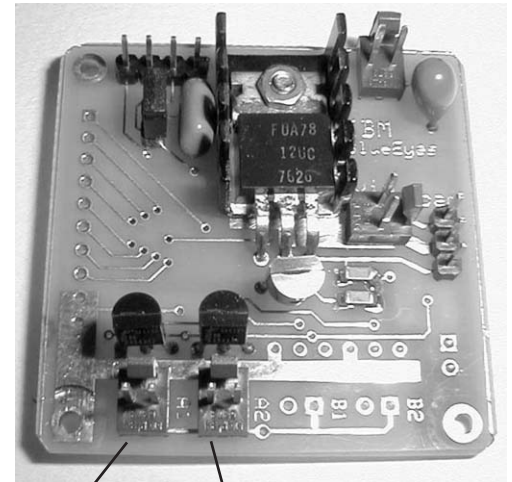
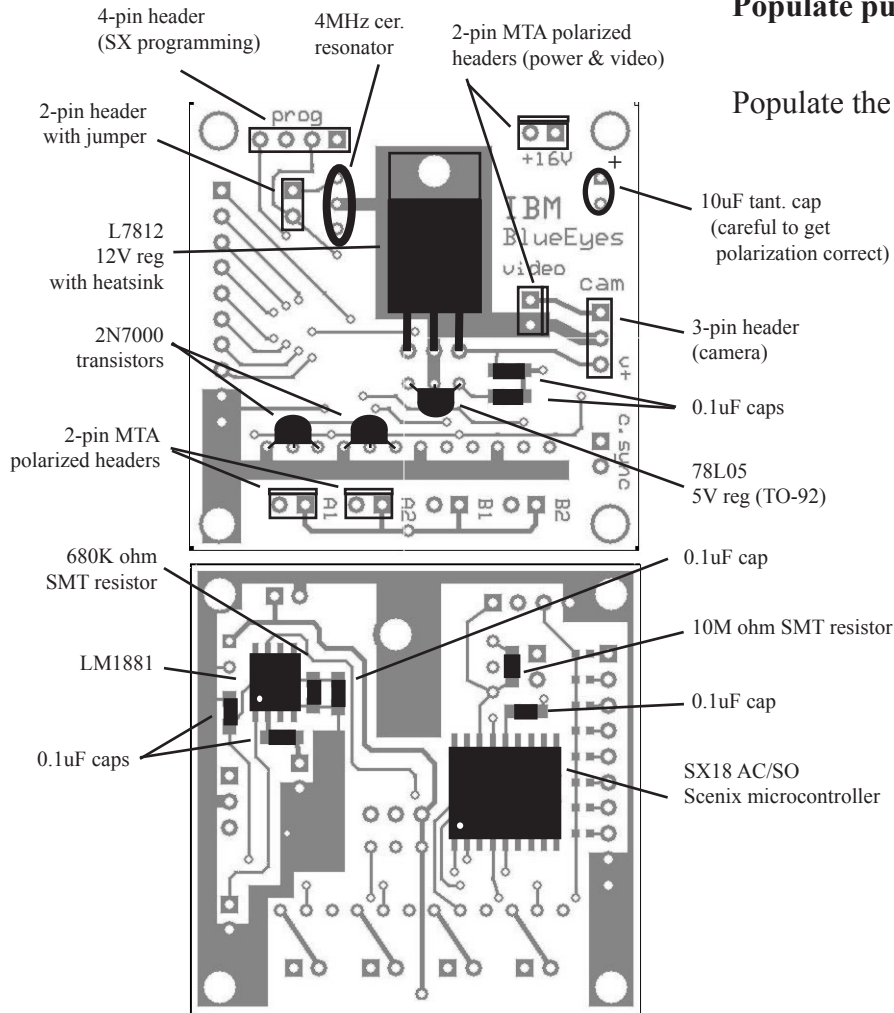
Build a 3" two wire cable (yellow/black) with the BNC female bulkhead (center = video signal, yellow) and a MTA connector.



III. ELECTRONICS AND CABLES

Populate pupilSX board

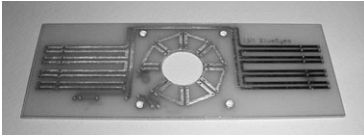
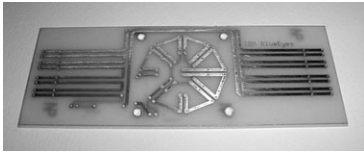
Populate the PupilSX board with these components.



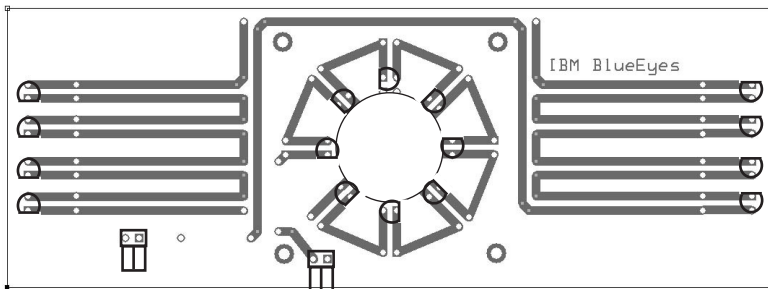
Program the Scenix microcontroller

Attach the SX Key to the 4-pin "programming" header on the pupilSX board. Remove the jumper that is adjacent to the header and save it in a safe place. Connect the power cable to the pupilSX board and plug in a +16V power supply (ThinkPad power module). Using the SXkey assembler application assemble and download the "pupilSX.asm" code to the SX microcontroller.

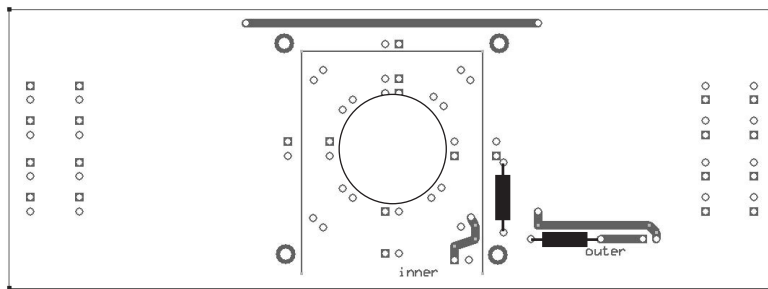
Populate LEDillum board



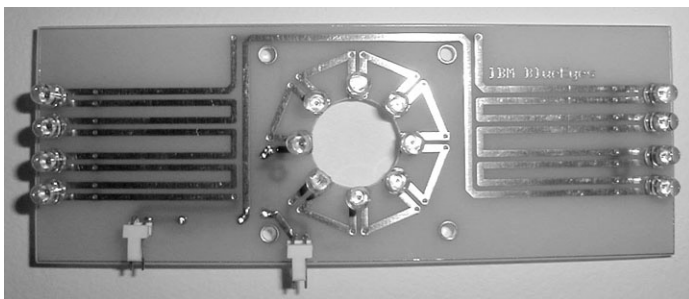
The LEDillum board is a simple 2-layer pcb that allows a variety of LED configurations. For the pupil-Cam, begin by drilling out a 3/4" hole to allow the lens to pass through the LEDillum plate (test the fit on the lens barrel before proceeding to the next steps).



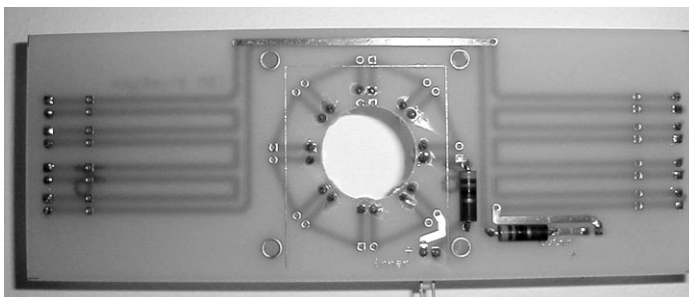
On the front surface of the LEDillum board solder the eight inner-ring LEDs and the eight outer-bar LEDs in this configuration. Also on the front surface, solder the two 2-pin right-angle MTA headers in the positions shown here.



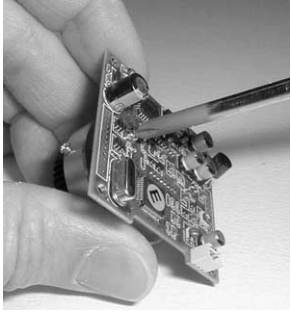
On the back surface of the LEDillum board solder the two current-limiting 2-watt resistors into these locations. With a 16 VDC power supply, a 38-ohm resistor will allow approximately 75mA through each 8-LED circuit.



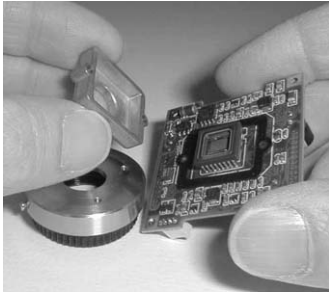
The completed LEDillum board.



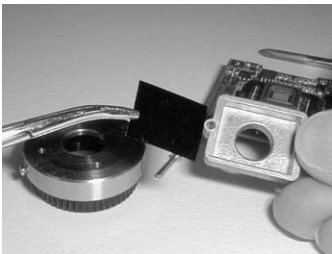
IV. MODIFY CAMERA



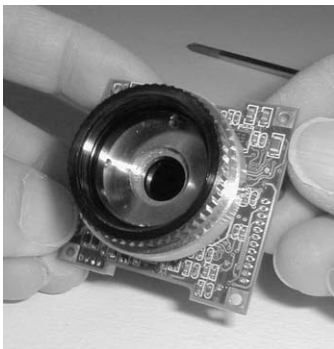
Remove the two small screws holding the lens housing onto the PCB of the camera.



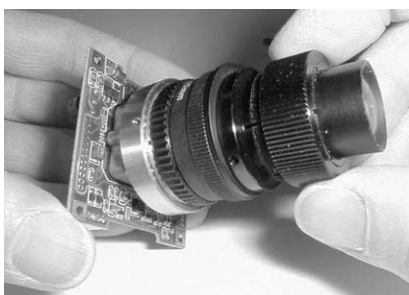
Remove the lens housing. Be careful not to scratch or damage the exposed CCD on the front of the camera PCB.



Cut a small rectangle of Wratten No.87 filter to fit inside the lens housing.

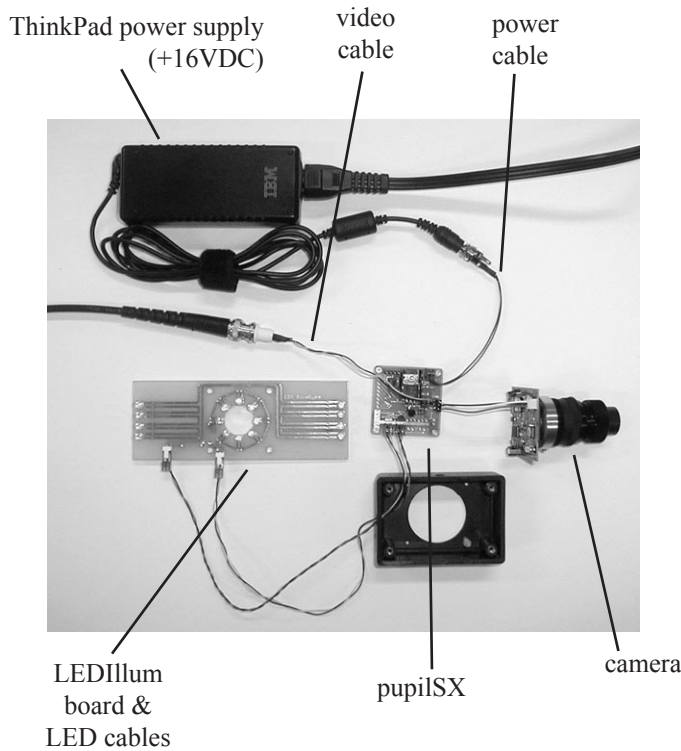


Carefully insert the Wratten filter inside the lens housing and reinstall the housing on the camera PCB with the two small screws.



Build the lens assembly with the C-mount lens holder and two lens spacer rings: 10mm and 5mm. Screw the lens assembly onto the C-mount on the board camera.

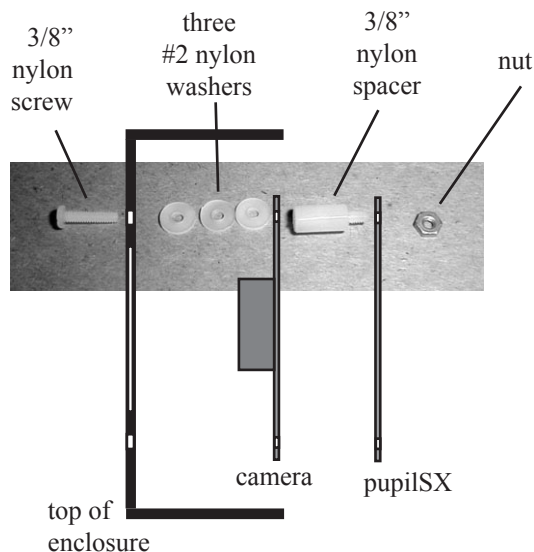
V. FINAL ASSEMBLY



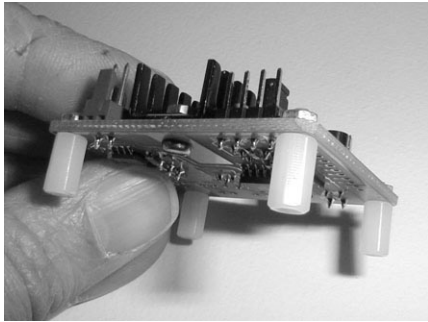
Before mounting everything in the ABS enclosure, test the electronics and cables by connecting everything together. Connect the camera to the pupilSX with the short 3-wire cable. Connect the inner and outer LED cables between the pupilSX and LEDillum boards. Connect the video-out cable to the pupilSX and feed the video line to a NTSC monitor or to your computer's frame grabber input. Finally connect the power cable to the pupilSX and connect a +16VDC power supply (IBM ThinkPad power module) to the power jack.



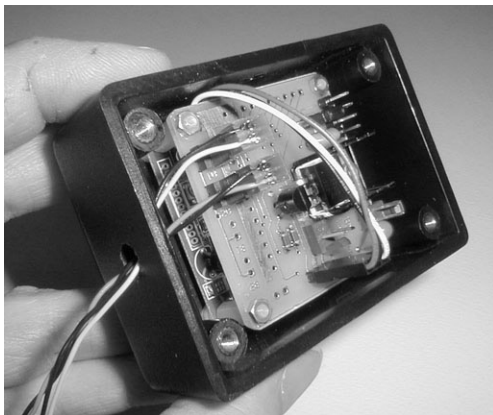
Mount video and power cables in enclosure bottom



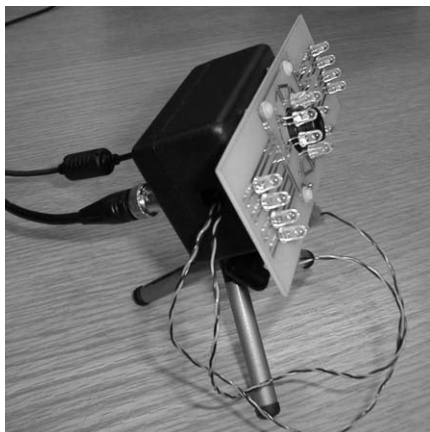
Mount the camera and pupilSX board in the enclosure top using the following hardware. If the 50mm lens (20mm diameter barrel) is replaced with a wide-field micro-lens this mounting configuration must be modified to allow the LEDillum board to be mounted to the box (instead of slipping over the lens barrel). Four 1" 2-56 screws and additional washers and nuts can be used in place of the 3/8" screws shown here to extend beyond the front surface of the box and hold the LEDillum board at the required distance.



A view of the 3/8" nylon spacers mounted on the pupilSX board. Note that it may be easier to first mount the camera in the box by passing the 3/8" screws through the mounting holes in the front side of the box, through the 3 nylon washers, through the camera mounting holes and finally screwed into the 3/8" spacers.



The pupilSX board can now be mounted on the threaded pins of the 3/8" spacers and secured with four 2-56 nuts. Connect the camera-pupilSX cable and the two LED cables to the connectors on the pupilSX board.



Connect the power and video cables (mounted on the box bottom) to the connectors on the pupilSX board and carefully close the box. Slide the LEDillum board onto the lens and attach the LED cables to the connectors on the front of the board. Finally, add the micro-tripod on the 1/4"-20 threaded hole in the bottom of the camera box.

VI. APPENDIX - PARTS AND SUPPLIER LIST

PupilSX parts list:

ExpressPCB [expresspcb.com]

1	pupilScenix.pcb		\$10.73
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Parallax, Inc. [SXTech.com, (888) 512-1024]

1	SX-18 microcontroller	SX18AC/SO	\$3.81
1	4MHz thru-hole cer. Reson.	250-04050	\$1.50

Jameco Electronics [jameco.com, (800) 831-4242]

1	5V regulator TO-92	51182	\$0.29
1	12V regulator TO-220	51334	\$0.29
1	TO-220 heatsink	158051	\$0.29
2	2N7000 MOSFET transistor	119423	\$0.29
1	10uF tant. Cap	33689	\$0.59
1	2-pin header	108337	\$0.10
1	jumper	19140	\$0.10
1	3-pin header	109575	\$0.10
1	3-pin housing	157382	\$0.15
1	4-pin header	117559	\$0.10
10	female pin	100765	\$0.10/10

DigiKey [digikey.com, (800) 344-4539]

1	LM1881M video sync SO-8	LM1881M-ND	\$5.11
4	2-pin MTA header	A1921-ND	\$0.10
4	2-pin MTA housing	A19132-ND	\$0.19
6	0.1uF SMT cap (805)	PCC1828CT-ND	\$0.16
1	680Kohm SMT res (603)	P680KGCT-ND	\$0.076
1	10M ohm SMT res (603)	P10MGCT-ND	\$0.08

PupilCAM parts (eye-tracking optics):

Jameco Electronics [jameco.com, (800) 831-4242]

1	BNC female bulkhead	111561	\$1.75
1	RCA-BNC adapter	114753	\$1.25
1	75ohm BNC cable	85542	\$2.95
1	2.5mm male power jack	151562	\$0.89

Edmund Industrial Optics [edmundoptics.com, (800) 363-1992]

1	Kodak Wratten filter 87	K54-518	\$46.45
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Mintron [mintron.com, (888) 383-9386]

1	Hi-res B&W (C-mount) camera	MTV-365	\$179.00
1	*6mm miniature lens (replaces the 50mm Univ. Kogaku lens - for wide field imaging)	MTL-0006	\$12.00

Video Streaming Solutions [vccsales.com, (888) 991-5000]

1	Osprey-100 framegrabber	Osprey-100	\$199.00
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Universe Kogaku (America), Inc. [ukaoptics.com, (516) 624-2444]

1	50mm F/4.0 lens C-mount	MT49S	\$79.50
1	C-mount spacer set		

DigiKey [digikey.com, (800) 344-4539]

1	ABS plastic box	HM227-ND	\$6.59
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IBM [ibm.com]

1	72W ThinkPad Power supply	IBM 02K6699	\$55.00
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Illuminator board parts list:

ExpressPCB [expresspcb.com]

1	LEDring.pcb		\$18.46
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Newark Electronics [newark.com, (800) 4-NEWARK]

16	HSDL-4220 IR LED - T 1 3/4	06F6934	\$0.81
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DigiKey [digikey.com, (800) 344-4539]

2	2-pin MTA header (right-ang)	A1926-ND	\$0.10
2	2-pin MTA housing	A19132-ND	\$0.19
2	1-watt 36ohm res	P36W-1BK-ND	\$0.24