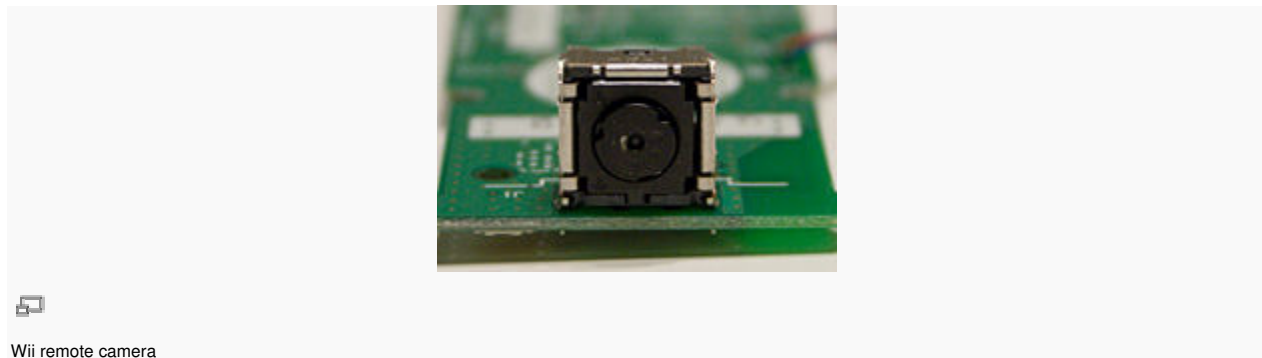# IR Camera (Source: http://wiibrew.org/wiki/Wiimote#IR_Camera)

Wii remote camera

The Wii Remote includes a 128x96 monochrome camera with built-in image processing. The camera looks through an infrared pass filter in the remote's plastic casing. The camera's built-in image processing is capable of tracking up to 4 moving objects, and these data are the only data available to the host. Raw pixel data is not available to the host, so the camera cannot be used to take a conventional picture. The built-in processor uses 8x subpixel analysis to provide 1024x768 resolution for the tracked points. The Sensor Bar that comes with the Wii includes two IR LED clusters at each end, which are tracked by the Wii Remote to provide pointing information. The distance between the centers of the LED clusters is 20 cm (as measured on one unit).

The IR Camera is enabled by setting bit 2 on output reports 0x13 and 0x1a:

```
(a2) 13 04
(a2) 1a 04
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The first enables a 24MHz pixel clock on pin 7 of the camera. The second pulls pin 4 low - probably an active-low enable.

Mechanical Characteristics

The camera component is mounted on the bottom surface of the circuit board. The camera module itself is mounted in a socket perpendicular to the circuit board; to remove just the camera module, no desoldering is required. The process is as follows:

First, orient the camera so that you are looking into the lens with the PCB horizontal and below the lens.. There are four metal clips, two on each of the vertical sides of the socket. Use something tiny to slide between each metal clip and the camera module: maybe wire wrap wire? Then look at the back of the camera module, opposite the lens. There is a small rectangular hole in the middle of each vertical side of the socket. Use a pin or something to pry/press the camera module out.

Once the camera module is free of its socket, it may be further disassembled by gently prising up the tiny PCB with gold contacts; this is gently glued to the module's structure, but will come loose without damage. At this point you have three pieces: the camera socket, still attached to the Wiimote PCB, the camera module housing, complete with lens and dichroic filter (of unknown optical properties), and a tiny PCB with the camera chip and eight gold contacts on the bottom.

Optical Characteristics

The IR camera has an effective field of view is about 33 degrees horizontally and 23 degrees vertically (as measured on one unit). With the IR-pass filter intact, 940nm sources are detected with approximately twice the intensity of equivalent 850nm sources, but are not resolved as well at close distances. If the filter is removed, it can track any bright object. However, the IR filter referred to here is not only the dark plastic window of the wiimote but also a teensy slab of dichroic-coated glass inside the camera module. One may operate the wiimote having installed neither, one or the other, or both filters.

Initialization

Reminder

Remember to set bit 2 (0x04) on the first byte of the Output Reports to write to registers!

The following procedure should be followed to turn on the IR Camera:

1. Enable IR Camera (Send 0x04 to Output Report 0x13)
2. Enable IR Camera 2 (Send 0x04 to Output Report 0x1a)
3. Write 0x08 to register 0xb00030

4. Write Sensitivity Block 1 to registers at 0xb00000
5. Write Sensitivity Block 2 to registers at 0xb0001a
6. Write Mode Number to register 0xb00033
7. Write 0x08 to register 0xb00030 (again)

After these steps, the Wii Remote will be in one of 3 states: IR camera on but not taking data, IR camera on and taking data and half sensitivity, IR camera on and taking data at full sensitivity. Which state you end up in appears to be pretty much random. Repeat the steps until you're in the desired state. To avoid the random state put a delay of at least 50ms between every single byte transmission.

The Wii preforms these steps slightly different, differences in bold:

1. Enable IR Pixel Clock (send **0x06** to Output Report 0x13)
2. Enable IR Logic (send **0x06** to Output Report 0x1A)
3. Write **0x01** to register 0xb00030
4. Write Sensitivity Block 1 to registers at 0xb00000
5. Write Sensitivity Block 2 to registers at 0xb0001a
6. Write Mode Number to register 0xb00033
7. Write 0x08 to register 0xb00030 (again)

Adding bit 0x02 to reports 0x13 and 0x1a is a request for acknowledgement (if set, wiimote will respond with report 0x22).

Sensitivity Settings

Sensitivity is controlled by two configuration blocks, 9 bytes and 2 bytes long. The following settings are known to work:

Block 1	Block 2	Notes
00 00 00 00 00 00 90 00 C0	40 00	Suggested by Marcan
00 00 00 00 00 00 FF 00 0C	00 00	Suggested by Kestrel (max sensitivity)
00 00 00 00 00 00 90 00 41	40 00	Suggested by inio (high sensitivity)
02 00 00 71 01 00 64 00 fe	fd 05	Wii level 1
02 00 00 71 01 00 96 00 b4	b3 04	Wii level 2
02 00 00 71 01 00 aa 00 64	63 03	Wii level 3 (Suggested by Cliff)
02 00 00 71 01 00 c8 00 36	35 03	Wii level 4
07 00 00 71 01 00 72 00 20	1f 03	Wii level 5

The last byte of Block 1 determines the intensity sensitivity, with increasing values reducing the sensitivity. Both bytes of Block 2 must be zero for the full sensitivity range to be available. Setting the sensitivity as high as possible, without unwanted light being tracked, is recommended to achieve the highest subpixel resolution. As the sensitivity is reduced, the subpixel resolution also reduces, approaching the true sensor resolution of 128x96.

Data Formats

The IR Camera can return different sets of data describing the objects it is tracking. When the IR camera identifies an object, it assigns it to the first available object slot. If an object moves out of view, its slot is marked as empty (returns 0xFF data), but other objects retain their slots. For example, if the camera is tracking two objects and the first moves out of view, the data returned will be [empty, second object, empty, empty]. With more than four objects visible, the camera is prone to rapidly switching between some of them. This could allow perception of more than four objects, at a reduced response speed and reliability.

Mode	Mode Number
Basic	1
Extended	3
Full	5

The data format MUST match the number of bytes available in the Reporting Mode selected. Even choosing a mode with space for more bytes than necessary will not work, it has to be an exact match.

Basic Mode

In Basic Mode, the IR Camera returns 10 bytes of data corresponding to the X and Y locations of each of the four dots. Each location is encoded in 10 bits and has a range of 0-1023 for the X dimension, and 0-767 for the Y dimension. Each pair of dots is packed into 5 bytes, and two of these are transmitted for a total of 4 dots and 10 bytes.

This is the data format for a pair of objects:

Byte	Bit							
	7	6	5	4	3	2	1	0
0	X1<7:0>							
1	Y1<7:0>							
2	Y1<9:8>		X1<9:8>		Y2<9:8>		X2<9:8>	
3	X2<7:0>							
4	Y2<7:0>							

Extended Mode

In Extended Mode, the IR Camera returns the same data as it does in Basic Mode, plus a rough size value for each object. The data is returned as 12 bytes, three bytes per object. Size has a range of 0-15.

This is the data format for each object:

Byte	Bit							
	7	6	5	4	3	2	1	0
0	X<7:0>							
1	Y<7:0>							
2	Y<9:8>		X<9:8>		S<3:0>			

Full Mode

In Full Mode, the IR Camera returns even more data, 9 bytes per object for a total of 36 bytes for all four. The data is split up between two input reports of 18 bytes each (see Data Reporting Mode 0x3e/0x3f). The first three bytes of each object are the same as the extended mode, and are followed by the bounding box of the pixels included in the blob along with a deeper intensity value. The data format of each object is:

Byte	Bit							
	7	6	5	4	3	2	1	0
0	X<7:0>							
1	Y<7:0>							
2	Y<9:8>		X<9:8>		S<3:0>			
3	0	X min<6:0>						
4	0	Y min<6:0>						
5	0	X max<6:0>						
6	0	Y max<6:0>						
7	0							
8	Intensity<7:0>							