Pioneering in Object Recognition

FALCON Object Recognition System

User's Guide:
For System Configuration
and Set up

FALCON
Object Recognition Systems

FALCON Object Recognition Systems Users Guide Revision 1.2
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Table of Contents

Chapter 1 Introduction to the FALCON Object Recognition System

The FALCON Object Recognition System is a fast, accurate color object tracker. It can track up to 12 objects simultaneously, at a rate of over 6 frames per second.

There are three modes of operation:
1. Simultaneous tracking of 6 objects: Three colors; two objects per color.
2. Simultaneous tracking of 12 objects: Six colors; two objects per color.
3. Simultaneous tracking of 12 objects: Two colors; six objects per color.

These modes are configurable through the use of the slide switches on the FALCON system.
See Chapter 2 for configuration instructions.

Chapter 2 Basic Hardware Set Up

Refer to the following diagram of the FALCON system board for the steps below:

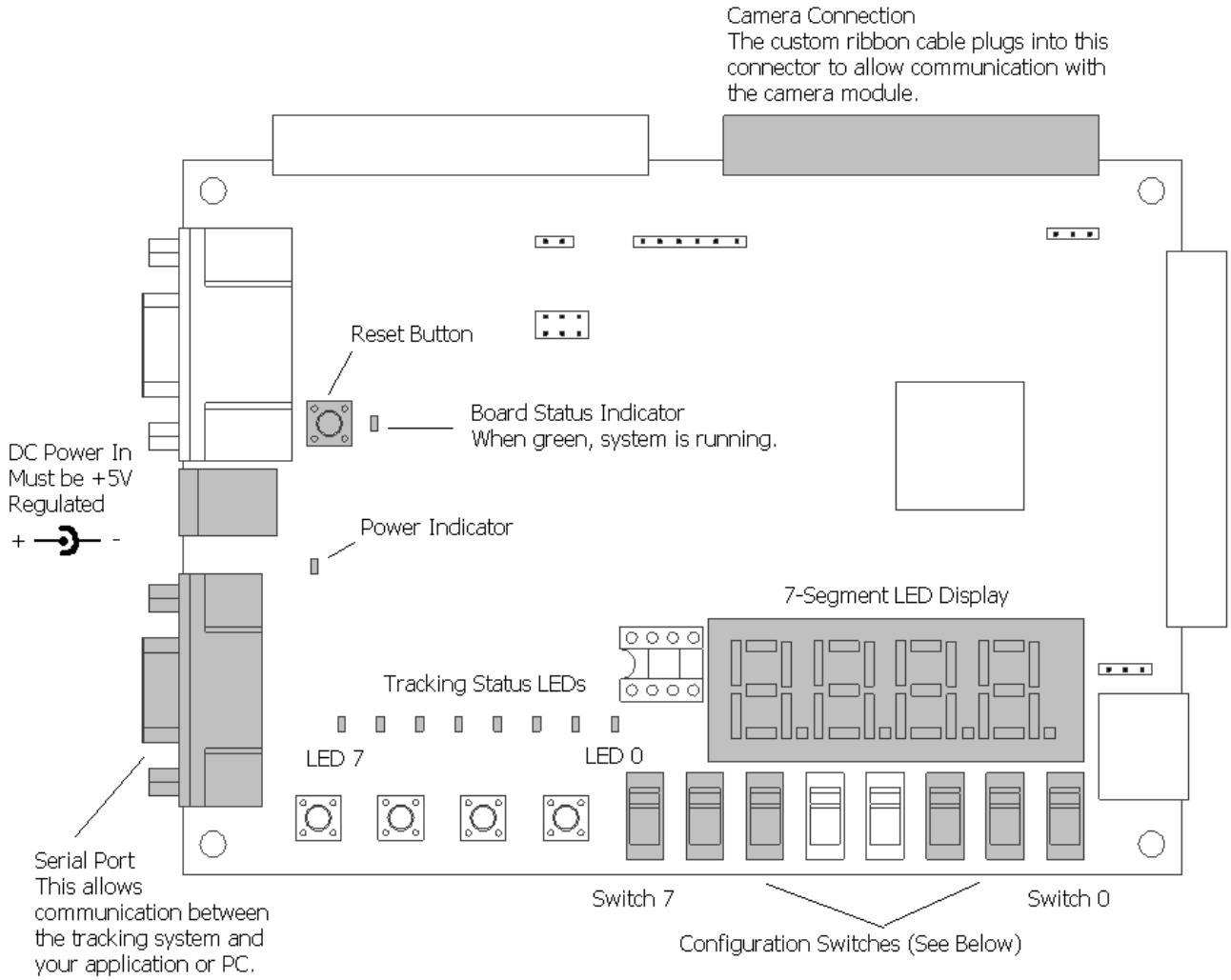

Fig. 2.1 Diagram of FALCON system

Camera Module:
It will be necessary to connect the camera module to the FALCON system board through the use of the custom ribbon cable provided. Simply plug the wide end of the cable onto the header labeled "Camera Connection" above, then plug the camera module into the other end.

Power Supply
You will need to provide the system board with a regulated +5V power supply as shown in Figure 2.1. For setup purposes, you may use the included universal +5V DC power supply.

Null-Modem Serial Cable
You will also need a null-modem serial cable to interface with the setup computer and your application.

Configuration Switches
There are several configuration switches on the FALCON system board. Please use the following table in order to set up the FALCON system to meet your specific need:

Tracking output mode (Switches 0 – 2)	
Mode 1 (Default)	SW0 down; SW1 down; SW2 down
Mode 2	SW0 up; SW1 up; SW2 up
Mode 3	SW0 up; SW1 up; SW2 down

Display mode (Switches 5 – 7)	
Current frame processing time (seconds) (default)	SW5 down; SW6 down; SW7 down
Firmware Version	SW5 down; SW6 down; SW7 up
Last Received Serial Byte	SW5 down; SW6 up; SW7 up
Custom Value	SW5 up; SW6 up; SW7 up

Tracking Status LEDs
These 8 LEDs display the current tracking status of the system while in online recognition mode. LEDs 7 and 6 will flash once with every frame processed. LED 5 lights up if a purple object is in view, LED 4 if a blue object is in view, LED 3 if a green object is in view, etc.

Chapter 3 The FALCON Client

Introduction

The FALCON Client is the software you will use to configure the FALCON system. It includes features such as:

1. The ability to grab frames, so that you can view what the camera is seeing.
2. The ability to save and restore profiles that contain tracking parameters and color information.
3. The ability to view the tracking data to ensure the tracking parameters are correct.
4. The ability to set the tracking parameters for objects to be tracked.
5. The ability to set up various camera parameters, including colorspace, saturation, and brightness, and view the results.

You will need a computer with the following system requirements to run the FALCON Client:

1. The Microsoft .NET Framework v1.1 installed.
2. A serial port capable of 115200 baud or higher.
3. A 500MHz or faster processor is recommended.

Usage

The following diagram illustrates the various controls on the FALCON Client and their typical usages:

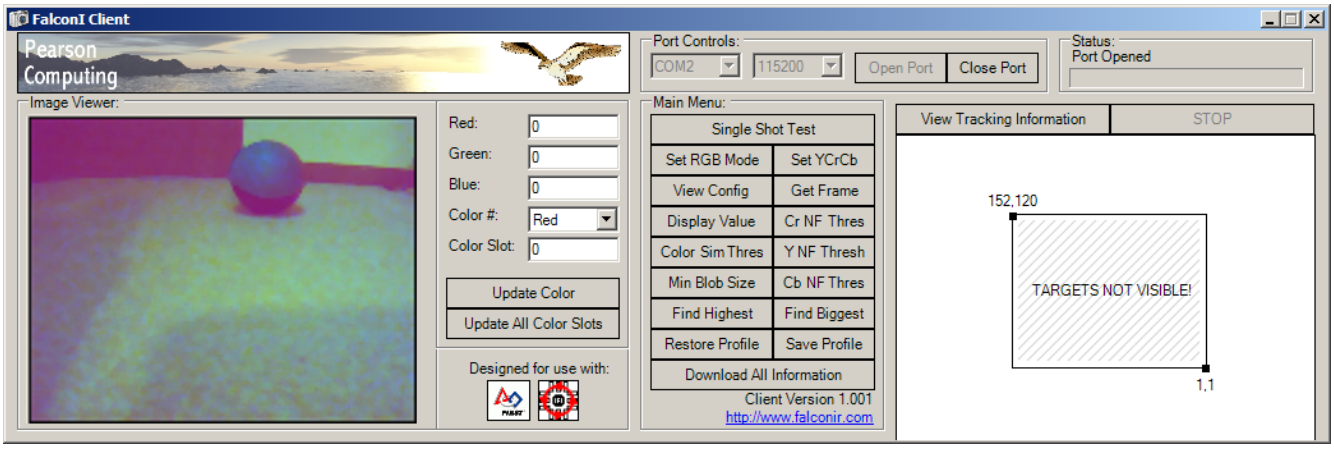

Fig. 3.1 FALCON Client controls

1. Image Viewer. This is where any captured images are displayed
2. Color Addition Controls. This is where the color values for a new object are entered. Clicking on the object in the Image Viewer will fill these textboxes with the appropriate color information. Clicking Update Color will add the color to the next color slot and increment the Color Slot field; clicking Update All Color Slots will load all color slots with that color.
3. Serial Port Controls. This is where you will select the serial port the FALCON system is connected to and the desired baud rate.
4. Main Menu. This is where all of the camera and tracking configuration options are. Find Lowest will find and track the lowest object visible, whereas Find Biggest will find and track the largest object visible. Min Blob Size sets the minimum object size the system will find. Single Shot Test gets, processes, and displays an image, whereas Get Frame simply displays an unprocessed frame. Colorspace selection is accomplished through the use of the Set RGB and Set YCrCb buttons. Auto-Brightness can be controlled through use of the Enable Auto-Brt and Disable A-B buttons.

5.Tracking Verification Interface. Clicking View Tracking Information will place the system into tracking mode, and display the tracking results in the tracking window to verify correct setup of the tracking parameters. Clicking STOP will return you to setup mode.

For setup purposes, you will need a computer with a serial port and the .NET Framework installed. This guide will assume you have already installed the appropriate version of the FALCON Client.

Connect the FALCON system to the serial port via a standard null-modem serial cable, and apply power. Start the FALCON Client software and select the serial port you have connected the FALCON system to. Click connect. The status display should now read “Port Opened”. If you receive an error, make sure that you have selected the correct serial port and try again.

Example 1: Tracking a single object

Start by downloading the default profile into the system. This is accomplished by clicking “Restore Profile” and selecting the “default_profile_ycrcb.fpr” file. For this example, we will use the YCrCb color space. This will provide a greater range of options, such as allowing adjustment of color saturation and image brightness. In addition, this profile will enable auto-brightness adjustment.

You will need an area that matches the desired working environment's lighting. Set up the object you wish to track in the camera's field of view, approximately 10 feet away. Click “Grab Frame” and ensure that the object is visible. If it is, click “Single Shot Test”.

You will now have to adjust three parameters until the white lines correctly segment the objects. An example of good segmentation follows (see Fig 2.1):

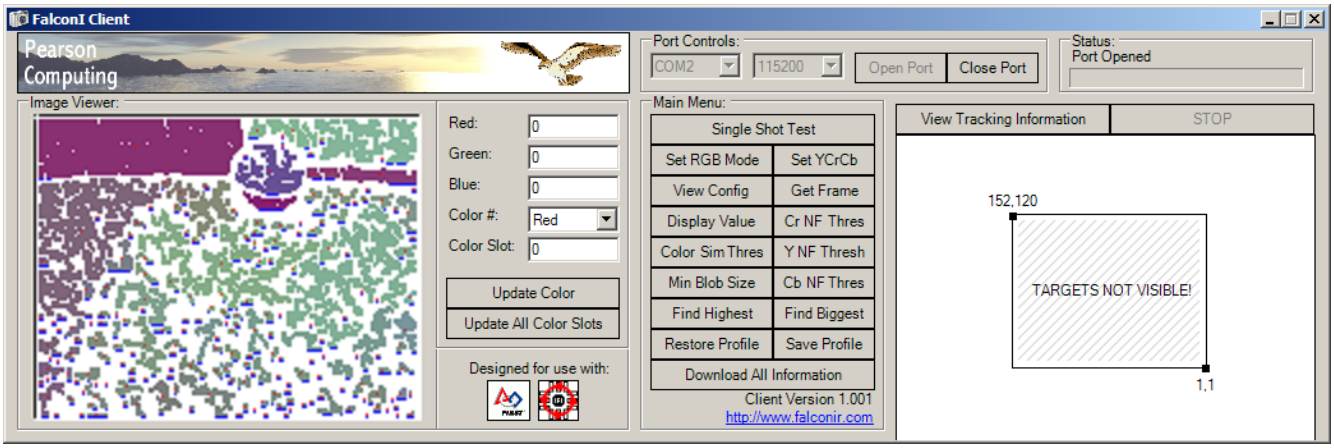

Fig 2.1

And an example of poor segmentation (oversegmentation) (see Fig 2.2):
Note that the object is broken up into several small areas, as opposed to one large area.

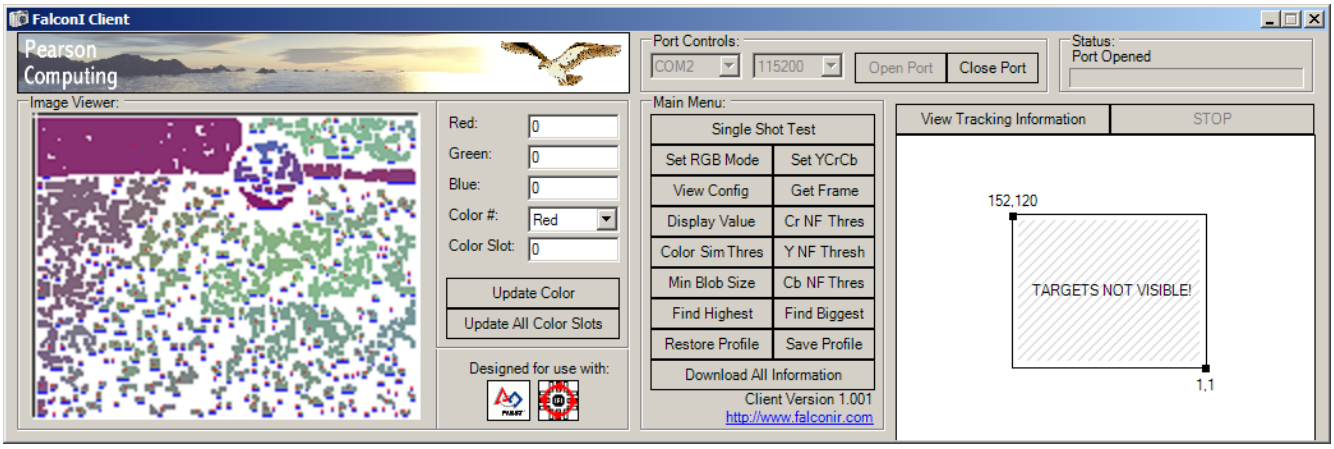

Fig 2.2

Finally, an example of undersegmentation (see Fig 2.3):
Note that in this case the object has merged with the background.

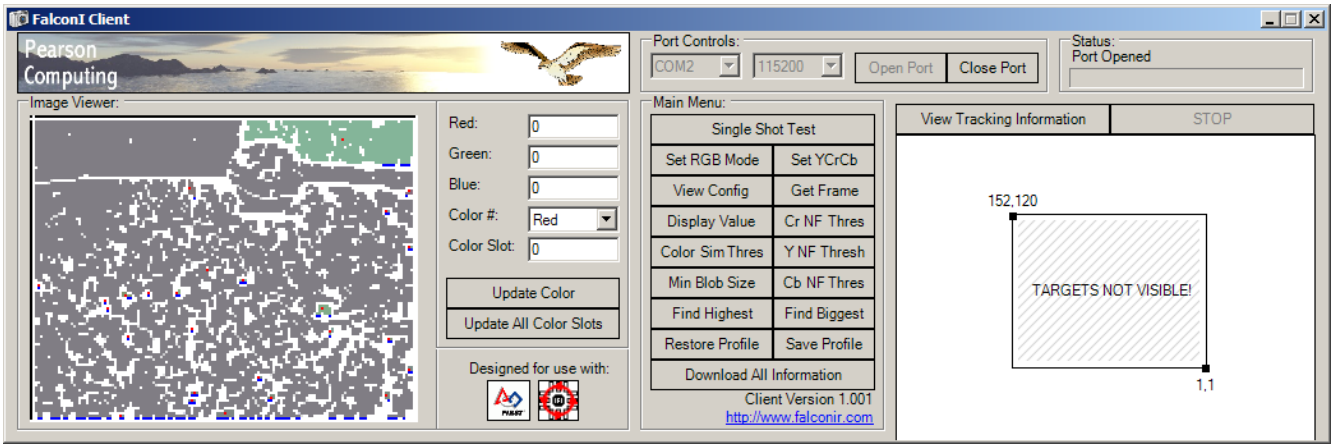

Fig 2.3

The parameters that must be adjusted are:
“Cr NF Thres” (Red noise floor threshold)
“Y NF Thresh” (Green noise floor threshold)
“Cb NF Thres” (Blue noise floor threshold)

Lowering the values increases the amount of segmentation (increases the thickness of the white lines); increasing the values decreases the amount of segmentation.

When the image has been properly segmented, you can add the object's color to the database:

1. Click on the object in the Image Viewer. This will update the color fields to the right.
2. Select the desired tracking color for this object from the drop-down menu on the lower right.
3. Click “Update Color”. The object's color has now been entered into the database.

Now you can test the system's tracking by clicking “View Tracking Information”. This will place the

system into tracking mode, and display the results in the tracking window on the right. If all is well, you should see dots appear on the Tracking Verification Interface that correspond to the objects that you are tracking.

Congratulations! If you were able to track the objects above, you have successfully configured the system to track your objects. You may now place the object in various lighting conditions, and continue adding color slots to your profile. The color slot field will auto-increment with every click of the “Update Color” button.

Please note that the system will lose all configuration information upon loss of power. For this reason, all configuration settings should be saved using the “Save Profile” option and restored before use through the “Restore Profile” option. If you are planning to use the FALCON system in a specific application with a host microcontroller, you will need to reference the command table in Chapter 4 to develop a power-on configuration routine for the FALCON system. You may view a listing of all current settings by clicking on the “View Config” button.

Chapter 4 The FALCON Tracking Protocol and Configuration

The Tracking Protocol:

When the FALCON system is placed into tracking mode, it will output a constant stream of serial data. The format of the serial stream differs based on the current tracking mode, and is outlined below.

Mode 1: Simultaneous tracking of 6 objects: Three colors; two objects per color.
This mode features a smaller serial data stream than the other two modes, making it the ideal choice for a processor that cannot keep up with large amounts of serial data.

Byte Number:	0	1	2	3	4	5	6	7
Description:	Marker ASCII 176	Protocol Version (1)	Red 1 X	Red 1 Y	Green 1 X	Green 1 Y	Blue 1 X	Blue 1 Y

8	9	10	11	12	13	14	15
Red 2 X	Red 2 Y	Green 2 X	Green 2 Y	Blue 2 X	Blue 2 Y	Red 1 Size High	Red 1 Size Low

16	17	18	19	20	21	22	23
Green 1 Size High	Green 1 Size Low	Blue 1 Size High	Blue 1 Size Low	Red 2 Size High	Red 2 Size Low	Green 2 Size High	Green 2 Size Low

24	25	26	27
Blue 2 Size High	Blue 2 Size Low	LineFeed ASCII 10	Return ASCII 13

Mode 2: Simultaneous tracking of 12 objects: Six colors; two objects per color.
This mode features the ability to track up to six different colors, making it the best general-purpose mode.

Byte Number:	0	1	2	3	4	5	6	7
Description:	Marker ASCII 176	Protocol Version (2)	Red 1 X	Red 1 Y	Orange 1 X	Orange 1 Y	Yellow 1 X	Yellow 1 Y

8	9	10	11	12	13	14	15
Green 1 X	Green 1 Y	Blue 1 X	Blue 1 Y	Purple 1 X	Purple 1 Y	Red 2 X	Red 2 Y

16	17	18	19	20	21	22	23
Orange 2 X	Orange 2 Y	Yellow 2 X	Yellow 2 Y	Green 2 X	Green 2 Y	Blue 2 X	Blue 2 Y

24	25	26	27	28	29	30	31
Purple 2 X	Purple 2 Y	Red 1 Size High	Red 1 Size Low	Orange 1 Size High	Orange 1 Size Low	Yellow 1 Size High	Yellow 1 Size Low

32	33	34	35	36	37	38	39
Green 1 Size High	Green 1 Size Low	Blue 1 Size High	Blue 1 Size Low	Purple 1 Size High	Purple 1 Size Low	Red 2 Size High	Red 2 Size Low

40	41	42	43	44	45	46	47
Orange 2 Size High	Orange 2 Size Low	Yellow 2 Size High	Yellow 2 Size Low	Green 2 Size High	Green 2 Size Low	Blue 2 Size High	Blue 2 Size Low

48	49	50	51
Purple 2 Size High	Purple 2 Size Low	LineFeed ASCII 10	Return ASCII 13

Mode 3: Simultaneous tracking of 12 objects: Two colors; six objects per color.
This is a specialty mode, designed to track the red and blue lights in a FIRST robotics competition. It may find use in any situation where only two colors need to be tracked, and it is desirable to track six objects of each color simultaneously.

Byte Number:	0	1	2	3	4	5	6	7
Description:	Marker ASCII 176	Protocol Version (3)	Red 1 X	Red 1 Y	Red 2 X	Red 2 Y	Red 3 X	Red 3 Y

8	9	10	11	12	13	14	15
Blue 1 X	Blue 1 Y	Blue 2 X	Blue 2 Y	Blue 3 X	Blue 3 Y	Red 4 X	Red 4 Y

16	17	18	19	20	21	22	23
Red 5 X	Red 5 Y	Red 6 X	Red 6 Y	Blue 4 X	Blue 4 Y	Blue 5 X	Blue 5 Y

24	25	26	27	28	29	30	31
Blue 5 X	Blue 5 Y	Red 1 Size High	Red 1 Size Low	Red 2 Size High	Red 2 Size Low	Red 3 Size High	Red 3 Size Low

32	33	34	35	36	37	38	39
Blue 1 Size High	Blue 1 Size Low	Blue 2 Size High	Blue 2 Size Low	Blue 3 Size High	Blue 3 Size Low	Red 4 Size High	Red 4 Size Low

40	41	42	43	44	45	46	47
Red 5 Size High	Red 5 Size Low	Red 6 Size High	Red 6 Size Low	Blue 4 Size High	Blue 4 Size Low	Blue 5 Size High	Blue 5 Size Low

48	49	50	51
Blue 6 Size High	Blue 6 Size Low	LineFeed ASCII 10	Return ASCII 13

Configuration Commands:

NOTE: A Carriage Return (ASCII 13) MUST be sent after EVERY byte!

For example, to set RGB mode you would send this string to the FALCON system:
"J<CR>" where <CR> is a carriage return.

Decimal ASCII value:	Next Data Expected:	Command Description:
52	None	Place system into online tracking mode. Note that configuration commands can still be sent while the system is tracking, and changes to the tracking parameters will be reflected immediately.
53	None	Stop online tracking.
74	None	Set RGB mode.
75	None	Set YcrCb mode.
87	None	Track the highest centroids within the window.
88	None	Track the largest centroids within the window.
65	The desired threshold	Cr Noise Floor Threshold
73	The desired threshold	Y Noise Floor Threshold
66	The desired threshold	Cb Noise Floor Threshold
72	The desired threshold	Color Similarity Threshold
78	Minimum blob size	Minimum blob size (up to 255)
89	Lower byte, upper byte	Value to show on the 7-segment display.
59	I2C Register, I2C Data	Custom camera configuration parameter
91	R, G, B values	Desired color for red color slot 1
92	R, G, B values	Desired color for red color slot 2
93	R, G, B values	Desired color for red color slot 3
94	R, G, B values	Desired color for red color slot 4
99	R, G, B values	Desired color for orange color slot 1
100	R, G, B values	Desired color for orange color slot 2
101	R, G, B values	Desired color for orange color slot 3
102	R, G, B values	Desired color for orange color slot 4
107	R, G, B values	Desired color for yellow color slot 1
108	R, G, B values	Desired color for yellow color slot 2
109	R, G, B values	Desired color for yellow color slot 3
110	R, G, B values	Desired color for yellow color slot 4
115	R, G, B values	Desired color for green color slot 1
116	R, G, B values	Desired color for green color slot 2
117	R, G, B values	Desired color for green color slot 3
118	R, G, B values	Desired color for green color slot 4
123	R, G, B values	Desired color for blue color slot 1
124	R, G, B values	Desired color for blue color slot 2
125	R, G, B values	Desired color for blue color slot 3
126	R, G, B values	Desired color for blue color slot 4
131	R, G, B values	Desired color for purple color slot 1

132	R, G, B values	Desired color for purple color slot 2
133	R, G, B values	Desired color for purple color slot 3
134	R, G, B values	Desired color for purple color slot 4
67	None	Request Frame Dump. This command will send 230400 bytes of data in the format R_1, G_1, B_1, R_2, G_2, B_2, etc. Data will be sent across the image and then repeating each row down.
48	None	Request Single Shot Test. Data will be sent in the same format as the Frame Dump.

Chapter 5 Troubleshooting

TROUBLESHOOTING:
Q. The objects show up in the display, but they are unstable or fluctuate excessively in the tracking window.
A. This is most likely caused by a slightly fluctuating lighting color. You should use additional color slots to “train” the system to recognize the objects despite the fluctuations. Alternatively, you could open the color window by clicking “Color Sim Threshold” and entering a bigger value; however this could cause the symptoms below to appear.

Q. The objects “dance” around the tracking window.
A. This might be caused by an excessively wide-open color window. Try narrowing the color window by clicking “Color Sim Threshold” and entering a smaller value.

Q. The objects that I am trying to track are very dim / I cannot see the object's colors.
A. Try using a different color space. For example, if you are using the RGB color space, switch to YcrCb and see if the object is more easily detected. Please note that when using the YcrCb color space, the objects’ colors will look distorted compared to the RGB color space.

If you are encountering a technical difficulty that is not described here, please contact us at kb9vqf@pearsoncomputing.net with a detailed description of your problem. Alternately, you may use the Falcon forums at http://www.falconir.com/forum.