

Smart-Cam CMM

Document Revision 25

Website: <http://www.smart-cam-mv.com/>

Sales: sales@smart-cam-mv.com

Support: support@smart-cam-mv.com

Copyright © Roland De Graaf 2008

Table of Contents

Chapter 1	Quick-Start Setup Guide	3
Chapter 2	A Quick Introduction to Machine Vision	5
Chapter 3	Using the Smart-Cam Software	7
Chapter 4	Auto Calibration	13
Chapter 5	Manual Calibration	15
Chapter 6	Manual Measurement	17
Chapter 7	Auto Edge to Edge	19
Chapter 8	Auto Hole Spacing	22
Chapter 9	Auto Hole Diameter	24
Chapter 10	Auto Surface Area	26
Chapter 11	Auto Distance	27
Chapter 12	Manual Distance	28
Chapter 13	Auto Radius of Curvature	29
Chapter 14	Comparator Grid	31
Chapter 15	Comparator Polar	33
Appendix A	Support	35
Appendix B	Camera Recommendations	36
Appendix C	Modular Extension	37
Appendix D	Features and Specifications	38

Chapter 1

Quick-Start Setup Guide

Thank you for purchasing Smart-Cam 2D CMM. While Smart-Cam has been designed to be a robust and intuitive imaging solution, please consult this documentation for tips to achieve best possible accuracy and repeatability, and to use the full wealth of features the program has to offer.

Program Installation

Installation is simple. If you received your copy on CD, insert the CD into your CD-ROM drive. Windows should automatically detect the CD and start-up the SETUP.EXE installation program. If not, you may run the SETUP.EXE program manually – simply browse to the main folder on the CD and double-click SETUP.EXE. Once SETUP.EXE has loaded, click Install.

SETUP.EXE will create the necessary folders, copy it's program files into those folders, and register Smart-Cam's presence in the registry. SETUP.EXE will not make any other alterations to your system or Windows installation. Once installed, you may use the icon on your desktop to launch your application.

Note: If you have a video device such as a video camera, webcam, or other video capture device that you wish to use with Smart-Cam, please install that device and make sure it is plugged in before you start Smart-Cam.

If you have a video device attached, you should be greeted by a live view at 320 x 240 resolution, when you launch Smart-Cam for the first time. The first-time default is 320 x 240 because that resolution is supported by almost video hardware so you are bound to get some video in right away. If by chance your device does not support 320 x 240, Smart-Cam should automatically select the next closest resolution that is reported as supported by your video device's driver.

To change resolution settings, as well as other general program settings, click the red Set-Up button. These settings should be relatively self-explanatory; for the full details please see chapter 3.

Note: For best possible system stability with a video device, it is recommended that you select a good resolution for your needs and stay with it. If you must change resolutions often, it is recommended that you exit and relaunch Smart-Cam. For recommendations on selecting a good resolution, please see chapter 2.

If you do not have any video devices attached when Smart-Cam is launched, then the software will function only in File mode, and only JPEG or BMP images loaded from disk or an ordinary digital camera (ie a non-video camera) can be analyzed. To load an image file when the software is in File mode, simply drag and drop an image file onto the Smart-Cam image display area.

Note: Don't be shocked if your image is converted to monochrome when you acquire an image from a

video camera, or load an image file. Each function has individually configurable color options, and some of the default function settings (which you can change) may perform a conversion to monochrome. For more details, please see chapter 2.

Important! Before you can use Smart-Cam's full functionality, you must go to general set-up and enter your license key. Once entered, the program will be fully unlocked.

Chapter 2

A Quick Introduction to Machine Vision

Achieving the best possible degree of precision and accuracy may be obtained by following some of the basic imaging advice contained in this chapter.

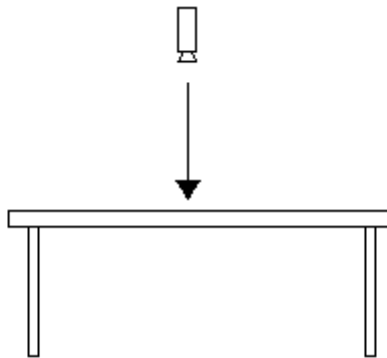
Resolution

When using a video device, usually the highest resolution supported by your device is best. This allows a standard unit of measure to be represented by a greater number of pixels. There are many fine low-cost and relatively low-cost webcams available today that support megapixel resolution. At a minimum, 640 x 480 resolution or higher is recommended.

When working with image files, the recommendation is the same. Obviously with old picture files you may not have a choice, but when taking new images with your digital camera you should use the highest resolution available.

Camera Distance and Orientation

Generally speaking, most machine visions systems orient the camera looking straight down at a table or fixture of some kind. The piece to be measured either sits on the table or is held in place by the fixture. The table or fixture usually also provides some type of uniform contrasting background to the piece under measurement.



Camera distance will have a direct impact along with resolution on the accuracy of the software. The general recommendation is that the camera be as close to the work as possible, but yet keep the work in the camera's field of view.

Background

The best background is usually either stark white or stark black and should be chosen to obtain

as much contrast to the piece or pieces under inspection as possible. Uniformity is important, but Smart-Cam does support regions of interest that allow you to specify tell the camera and software where to look without having to reposition the camera. So, you can tell Smart-Cam to ignore any “noise” in the background.

For some functions, you indicate to Smart-Cam what type of background is being used relative to the work under measurement. This allows Smart-Cam to distinguish the work from the background. If the object(s) to be measured are darker than the background, select Background “Light.” If the object(s) to be measured are lighter than the background, select Background “Dark.” A single threshold setting then allows you to set the split between your object(s) and the background.

Color and Monochrome Conversion

Most machine vision applications are strictly monochrome; color information isn't needed. Smart-Cam is configurable in this regard. You can choose to work in color, or you can choose to work in monochrome. Furthermore, if you choose to work in monochrome, then you can choose which color channel is used to generate the monochrome image representation.

Video cameras usually send image data to the computer in color. Image files are usually in color. A single pixel contains an intensity level of red, an intensity level of green, and intensity level of blue. Intensity is usually a value from 0 to 255, which 0 being darkest and 255 being brightest. The typical default for a function using monochrome conversion is to use RGB averaging to generate a monochrome image. But there are times when it may be beneficial to accuracy to use just the intensity from a specific color channel, and you may feel free to experiment in that regard.

Note: Live preview from a video camera is always shown in color. This is because Windows writes the live preview from the camera directly to your display for best performance.

Lighting

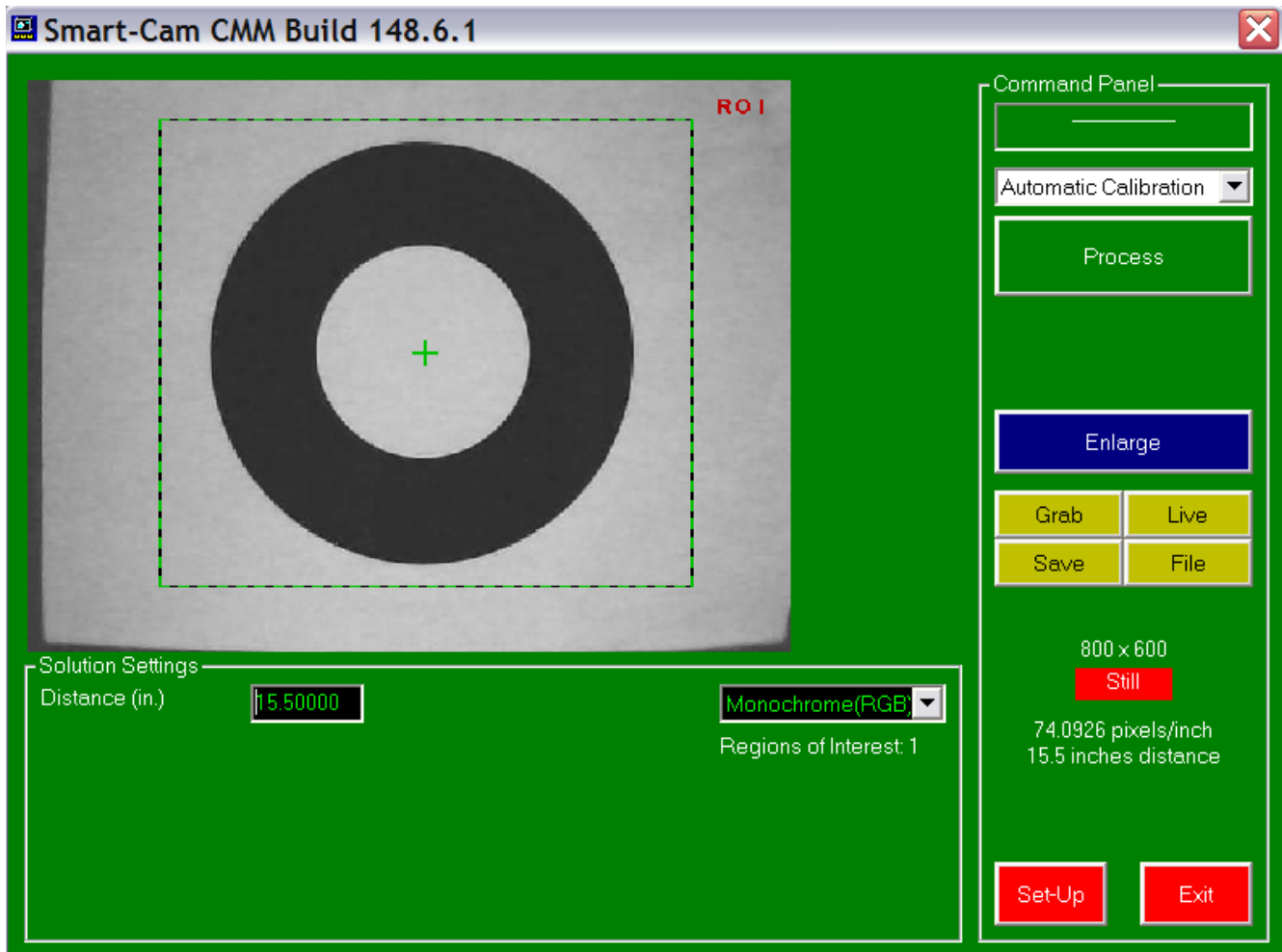
Usually, the best lighting is indirect and diffuse. Direct lighting often results in images which are uneven, or worse yet, specular – bright spots of white, typically reflecting off of metal parts. To avoid this, either [a] bounce the light off a wall or ceiling, [b] light from the side, [c] back-light, or [d] use the auto-exposure feature of your video camera and use ordinary ambient room lighting.

Fortunately, Smart-Cam CMM will work under a variety of lighting conditions, without requiring the best possible lighting. Partly this is due to the types of measurements it makes, and partly due to the robust nature of the program's design.

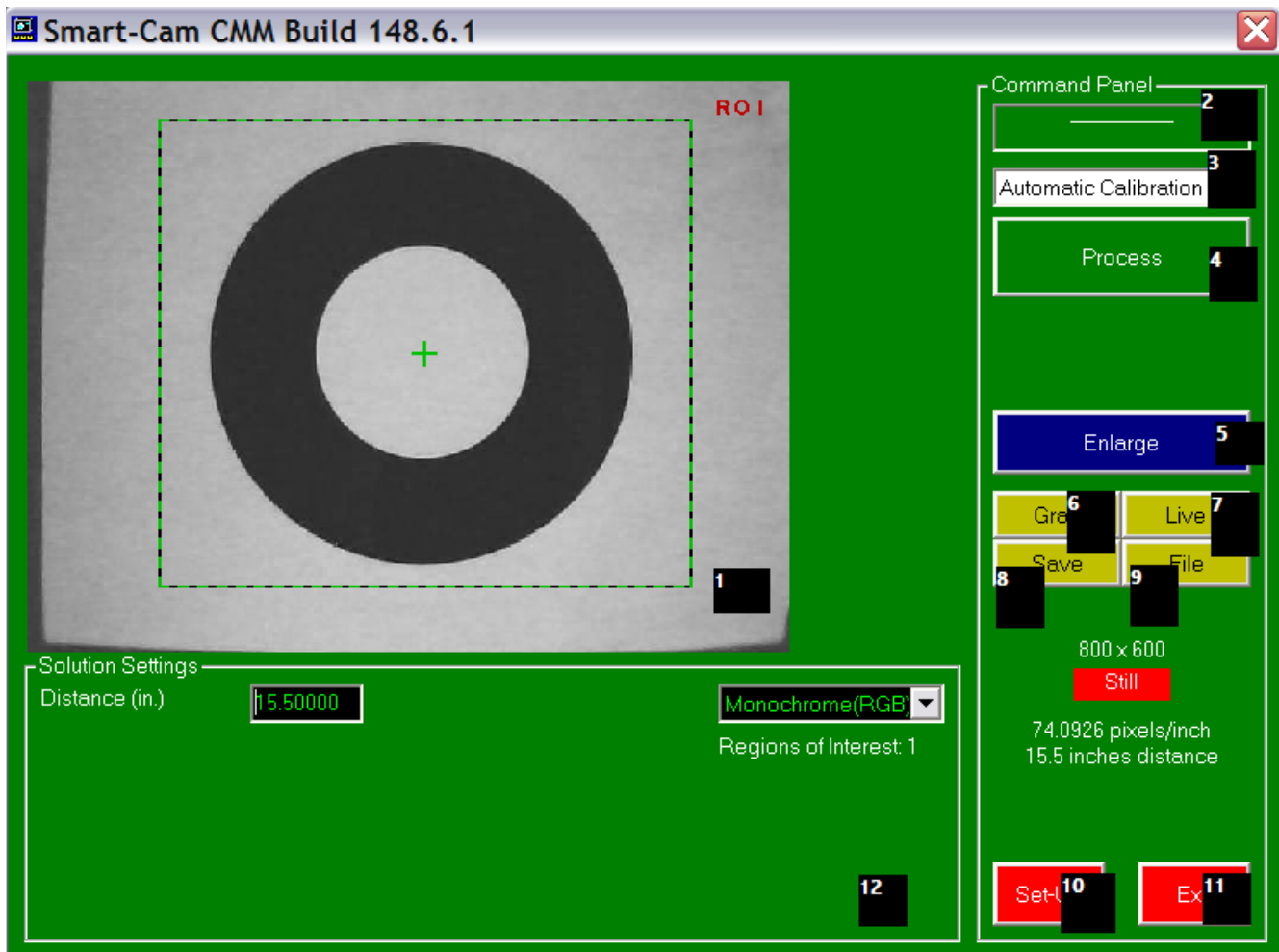
Chapter 3

Using the Smart-Cam Software

Smart-Cam has been designed to be as user-friendly and as intuitive as possible, but a brief description of the program's control screen couldn't hurt. In addition, it is possible to use the mouse to interact with the image and set-up each function's configurable settings.



The Smart-Cam control screen, when run on a system at 800 x 600 screen resolution, appears as shown in the example above. At higher screen resolutions, the program can expand and move controls in favor of a larger image viewing area. The Enlarge button provides yet another way to display a larger image by hiding the Solution Settings frame and expanding the image into the available space.



[1] **The image display area.** If you are using a video camera, both live previews and still image views as well as the results of processing are displayed in this space. The above example shows a shot of the calibration target and the region of interest drawn around the calibration target.

[2] **The results display area.** In addition to displaying on the image view, some results are also displayed in this text area.

[3] **Function select.** Select the desired function from this combo box.

[4] **Process.** Clicking this button causes the system to acquire a new image from your video camera or reload an image file and execute the function selected. Results are displayed on the image view after processing is complete.

[5] **Enlarge.** Clicking this button hides the settings and enlarges the image view for easier reading. Click again to return back to normal size.

[6] **Grab.** Clicking this button causes a new image to be acquired from your video camera, or reloads an image file. (If the video camera was in live display mode when Grab is clicked, the live is turned off and the acquired still image is displayed.) Grab is useful for acquiring or loading an image without any further processing, for set-up and configuration purposes, such as creating or editing regions of interest.

[7] **Live.** Clicking this button causes a live image preview to be displayed, instead of a still image. The live preview is active when the Live button glows green. (This button is disabled while in File mode.)

[8] **Save.** Saves the current image on display in the format as configured under general set-up. Images are automatically saved in a folder of their own ("Saved"), and with a unique sequence number, much the same way an ordinary digital camera saves photos. Depending on configuration, either the unadorned image can be saved, or the image plus results of processing can be saved.

[9] **File.** Switch the software back and forth between File mode and Video Camera mode. The software is in File mode when the File button glows green. (File mode is automatically enabled and this button is automatically disabled if no video camera is detected at software start-up. If you plug in a video camera after software start-up, you must exit Smart-Cam and restart the software for the video camera to be detected.)

[10] **Set-Up.** Access the program's general settings screen.

[11] **Exit.** Exit the program.

[12] **Function Settings Area.** Depending on the function selected, different configuration options will be displayed here. These are explained in greater detail in the chapters devoted to each function.

General Set-Up

The general set-up screen is used to set some for the program's general features to fit your preferences. These settings are saved to disk and are remembered by the software from one run to the next.

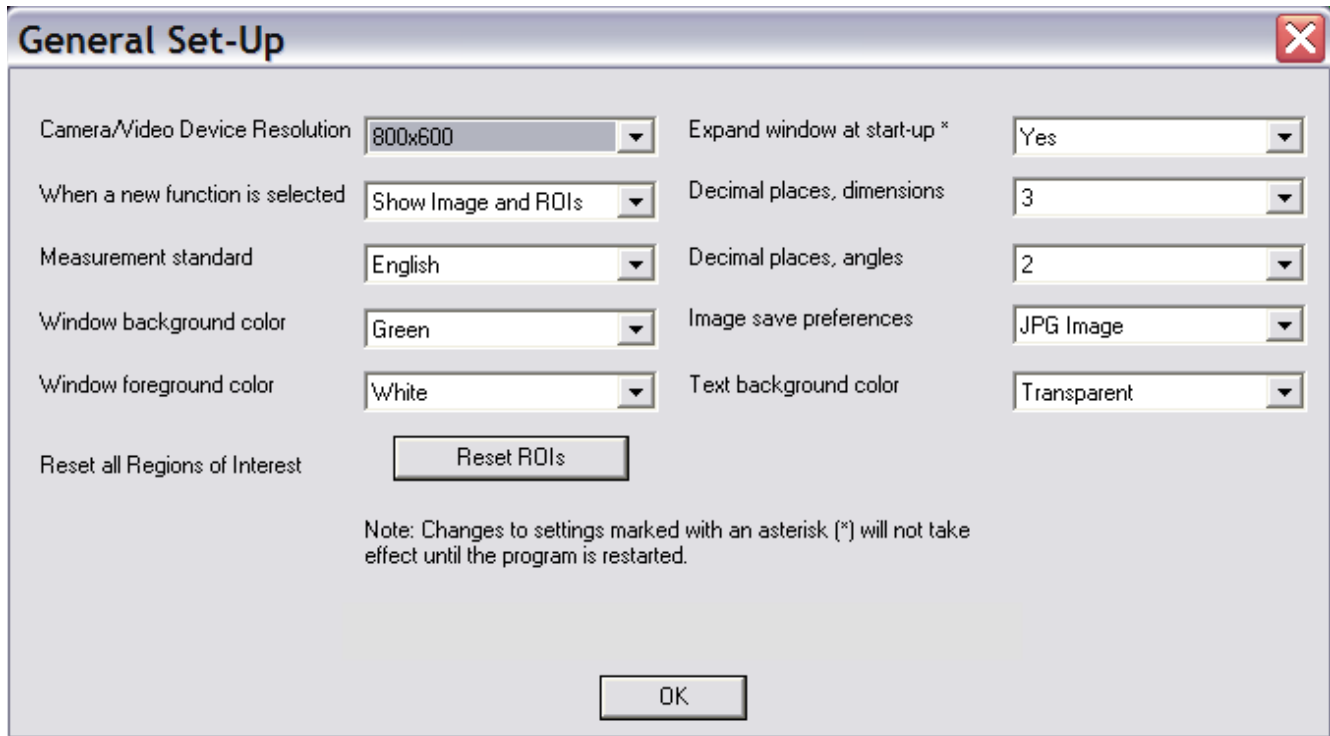
Camera/Video Device Resolution. Selects a resolution for your video camera or other video device. The available resolutions are obtained by the Smart-Cam software from the video device's driver, and you may select from the list here.

When a new function is selected. Sets the action to take when you navigate from one function to another. The choices are: Do Nothing, Show Live Preview, or Show Image and ROIs.

Measurement Standard. Selects either English or metric systems of measurement. For English measurement, the base unit is inches. For metric measurement, the base unit is centimeters.

Window Background Color. Select a custom background color.

Window Foreground Color. Select a custom foreground color.



The image shows a 'General Set-Up' dialog box with a title bar and a close button (X). The dialog contains several settings organized in two columns. The left column includes: 'Camera/Video Device Resolution' (800x600), 'When a new function is selected' (Show Image and ROIs), 'Measurement standard' (English), 'Window background color' (Green), 'Window foreground color' (White), and 'Reset all Regions of Interest' with a 'Reset ROIs' button. The right column includes: 'Expand window at start-up *' (Yes), 'Decimal places, dimensions' (3), 'Decimal places, angles' (2), 'Image save preferences' (JPG Image), and 'Text background color' (Transparent). At the bottom center is an 'OK' button. A note at the bottom states: 'Note: Changes to settings marked with an asterisk (*) will not take effect until the program is restarted.'

Setting	Value
Camera/Video Device Resolution	800x600
When a new function is selected	Show Image and ROIs
Measurement standard	English
Window background color	Green
Window foreground color	White
Expand window at start-up *	Yes
Decimal places, dimensions	3
Decimal places, angles	2
Image save preferences	JPG Image
Text background color	Transparent

Reset all Regions of Interest:

Note: Changes to settings marked with an asterisk (*) will not take effect until the program is restarted.

Expand Window At Start-Up. If enabled, the Smart-Cam software will automatically adjust itself to fit your full screen, and do so in favor of a larger image view. (This is separate and independent from the functionality that the **Enlarge** button provides, which even further increases view size.)

Decimal places, dimensions. Specifies the number of decimal places to display when printing out dimensional measurement data on the screen. *Note: Calculations are always performed at full double floating point depth; this setting merely affects the level of precision displayed on the screen.*

Decimal places, angles. Specifies the number of decimal places to display when printing out angular measurement data on the screen.

Image Save Preferences. Selects how images are stored to disk when you click the **Save** button. The choices are:

BMP Image, the unprocessed image in BMP format

JPEG Image, the unprocessed image in JPEG format at 95% quality

Hi-Q JPEG Image, the unprocessed image in JPEG format at 100% quality

BMP Image & Overlay, the processed image in BMP format

JPEG Image & Overlay, the processed image in JPEG format at 95% quality

Hi-Q JPEG Image & Overlay, the processed image in JPEG format at 100% quality

Text Background Color. Sets how text is displayed on the image view. Set to transparent, the image shows through as the background to any text printed on the image (such as measurements). Set to black, the background is erased with black before the text is printed for easier reading.

Reset ROIs. Normally, when you change resolutions, or load picture files at various resolutions, the Smart-Cam software automatically tracks the positions of your regions of interest relative to the overall image size, and makes adjustments. An ROI, for example, that is drawn around the middle of the image stays drawn around the middle and at the same relative size whether you are running at 640 x 480 resolution or 800 x 600 resolution or whatever. In the rare event that a configuration file is manually replaced or deleted by the user, Smart-Cam may lose sync with resolution changes. If this happens, click this button to reset all functions back to zero regions of interest, and then re-enter your regions of interest.

Interacting with the Image

When the image view is displaying a still image, it possible to interact with the image using the mouse. Some of the possibilities include retrieving pixel intensity information, creating and editing regions of interest, and making manually drawn measurements.

Depending on the mode of interaction, using the mouse on the image will produce different results. The possible modes are ROI, 2PT, and 3PT, and the current mode is displayed in the upper right corner of the image. *To switch between modes, with the pointer over the image, hold down the Ctrl key and click the left mouse button.*

ROI mode.

In ROI mode, the mouse pointer will be an arrow.

Pointing at a point on the screen and clicking the left button (without moving the mouse) will retrieve the pixel intensity information at that point, and display it on the Smart-Cam control panel. This is useful when trying to determine an intensity threshold.

To create a new region of interest, position the mouse pointer where you want one of the corners, click down and hold the left mouse button and drag the mouse to create and size a box that will be your new region of interest. When the box is where you want it, release the left mouse button.

To edit an existing region of interest, position the mouse pointer over one of the corners or sides, click down and hold the left mouse button and drag to the new size. Release the mouse button when the size is where you want it.

To move a region of interest without resizing it, position the mouse pointer over the center of the region of interest, click down the left mouse button and drag it to the new position. Release the mouse button when the region of interest is where you want it.

To delete a region of interest, follow the instructions for resizing and resize the region of interest to be zero or near zero width or height. Upon release of the mouse button, the region of interest is deleted.

Note: Each function individually has a limit to the number of regions of interest that may be created for that particular function. If you are trying to create a new region of interest, and are having difficulty doing so, you may be at the limit for that function.

2PT mode.

In 2PT mode, the mouse pointer will be a cross-hair.

2PT mode allows you to make manually drawn single-dimension measurements (ie from one point to another point). Up to 8 measurements may be made on screen at any one time. To place your first point, position the mouse pointer and click the left button. Then follow the same procedure to place the second point, thus completing the measurement.

3PT mode.

In 3PT mode, the mouse pointer will be a cross-hair.

3PT mode allows you to make manually drawn single-dimension and multi-dimension measurements with angle measurement. Up to 8 measurements may be made on screen at any one time. To place your first point, position the mouse pointer and click the left button. To place your second point, follow the same procedure. If there is to be a third point, repeat the procedure again, thus completing the measurement. The 3 points should yield 2 dimensional measurements, plus the angle between them. If there is not to be a third point, click the right mouse button to complete the measurement.

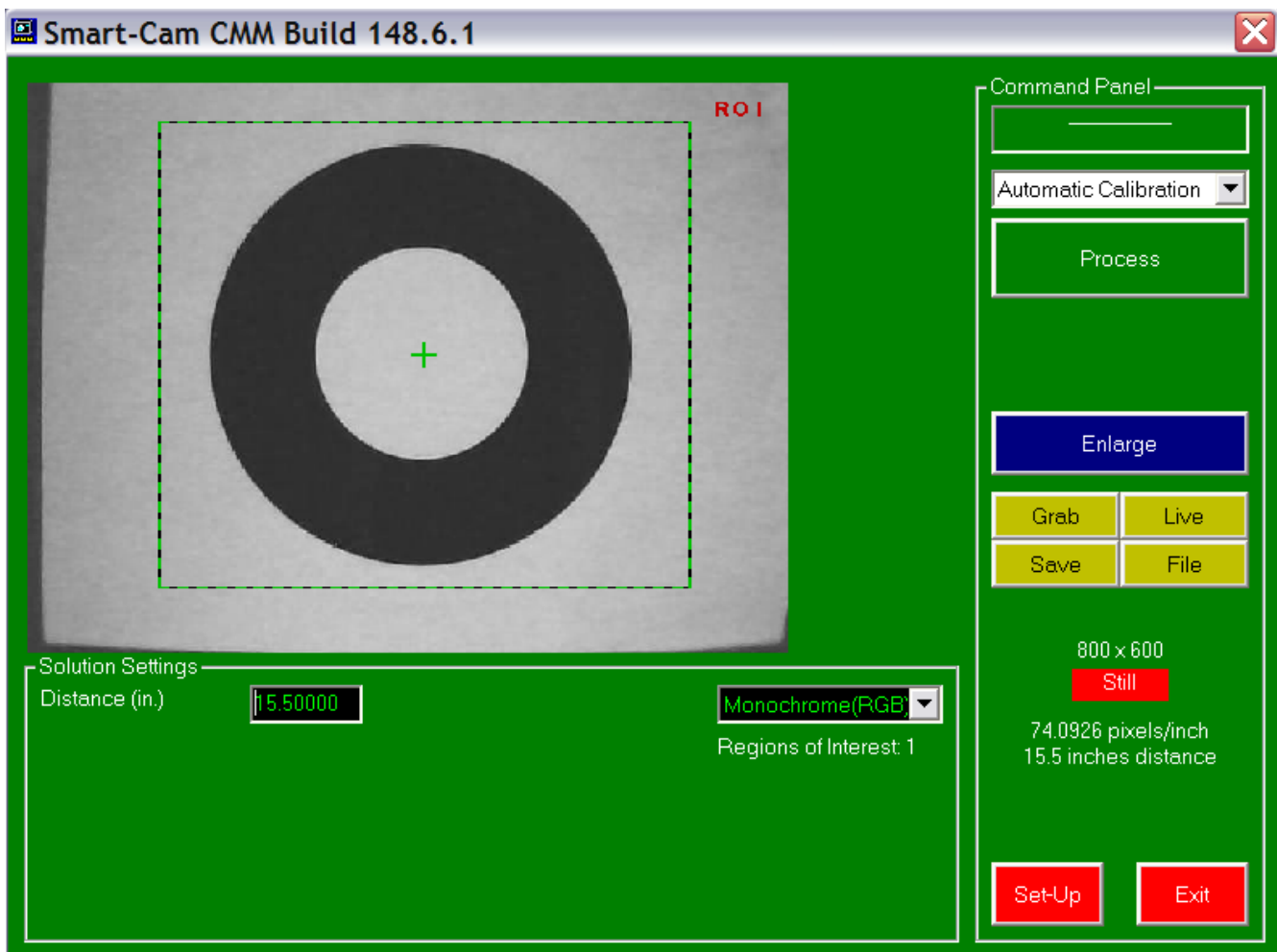
Note: In 2PT and 3PT modes, when the first point of a particular measurement is created, Smart-Cam will prompt you for the distance from the camera to the work where these new measurement points are being created. This distance value is used to correct the measurement for the camera distance when this image was taken versus the camera distance when the software was calibrated. In a system where the camera position and orientation is fixed, the work is relatively fixed into position, and the task is repetitive, this distance is more or less a constant.

Individual points in a measurement can be moved as desired; simply drag the point to a new location with the mouse.

Chapter 4

Auto Calibration

Calibration for real-world units (ie inches or centimeters) is part of what makes Smart-Cam so easy to use. Older machine vision applications worked in pixels. This meant you had to readjust all of your settings every time the resolution changed or guess how many pixels might be in a bolt you wanted to inspect. Once calibrated, Smart-Cam works in real-world units for both input configuration, and output display.



As you will find out when you get to the measurement functions, Smart-Cam has the optional ability to limit the objects it detects based on their size and intensity (brightness). This can be useful if want to measure some parts of an object, but not others, or if you need to exclude background noise from image processing. When specifying size limits, you'll be able to work directly in units of measurement that are native to you. Just enter the approximate value in inches/centimeters or square inches/cm² (as necessary), and Smart-Cam will do the rest.

Auto Calibration uses a special target that you print out with the included PRINTCAL utility. For best results, it is recommended that the calibration target be from 12 inches to 48 inches away from the camera, and that a region of interest be used to help guide the software to the target.

The calibration target is specially designed so that the software can automatically detect it, so you might not need a region of interest. However, without an ROI, processing time may take several seconds, versus a typical time of one second when an ROI is used.

Procedure (Video Camera):

- [1] Place the calibration target in view of the camera, middle image is best.
- [2] Set the region of interest around the target as shown in the example.
- [3] Set the distance equal to the distance between camera and calibration target.
- [4] Click Process, if successful, the system is now calibrated.

Procedure (Digital Still Camera/Scanned Photo):

- [1] Shoot a picture of the calibration target at some known distance from the camera, if your camera has zoom settings note those, as you will need to use these same settings when taking pictures for measurement.
- [2] Use File mode to load the calibration image into Smart-Cam.
- [3] Set the region of interest around the target as shown in the example.
- [4] Set the distance equal to the distance between camera and calibration target.
- [5] Click Process, if successful, the system is now calibrated.

Once calibrated, the software will not need further calibration, unless one or more of the following changes:

- different camera
- different optics

Function Limits:

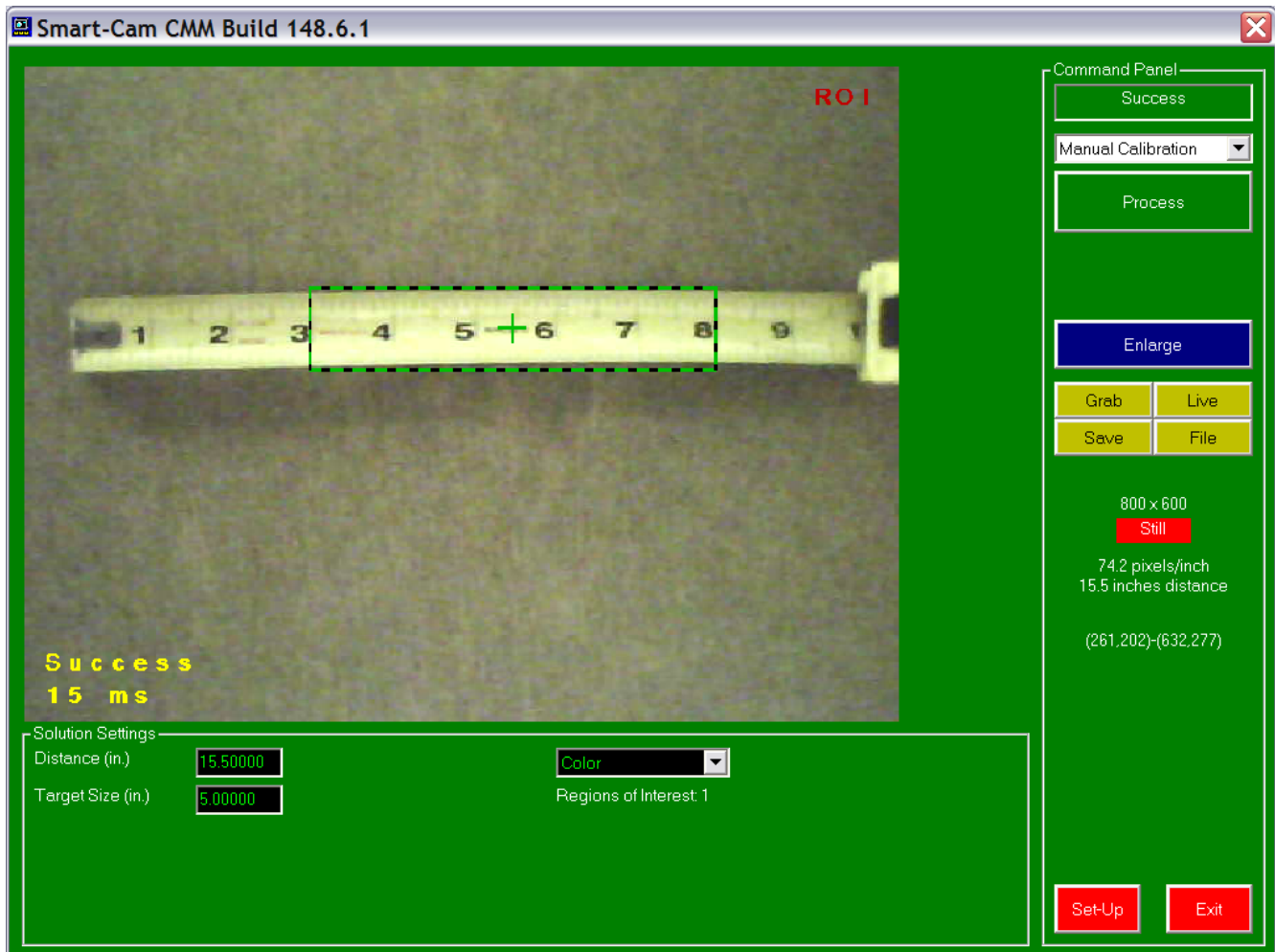
- Max Number ROIs: 1
- Available in Trial Version: Yes

Chapter 5

Manual Calibration

For instances where the automatic calibration mode isn't usable, there is manual calibration mode. For example, the auto calibration target may be too large to fit into the camera's field of view when the camera is less than 12 inches away. With manual calibration you could calibrate using a ruler or other object of known size, allowing you to calibrate the camera closer to the work, if so desired. Or, manual calibration mode may useful at times when your copy of the calibration target isn't handy available, and there is no printer nearby.

Manual calibration mode is also useful when you want to work with an old photograph. As long as some object or portion of the image is known, you can calibrate on that and then make measurements on other objects in the scene.



Procedure (Video Camera):

- [1] Place your ruler or other object in view of the camera, middle image is best.
- [2] Set the region of interest so that its width fits the ruler marks as shown in the example.
- [3] Set the distance equal to the distance between camera and ruler.
- [4] Set the reference width equal to width covered by the region of interest.
- [5] Click Process, if successful, the system is now calibrated.

Procedure (Digital Still Camera/Scanned Photo):

- [1] Shoot a picture of the ruler at some known distance from the camera,
if your camera has zoom settings note those, as you will need to use these same
settings when taking pictures for measurement.
- [2] Use File mode to load the ruler calibration image into Smart-Cam.
- [3] Set the region of interest so that its width fits the ruler marks as shown in the example.
- [4] Set the distance equal to the distance between camera and ruler.
- [5] Set the reference width equal to width covered by the region of interest.
- [6] Click Process, if successful, the system is now calibrated.

Once calibrated, the software will not need further calibration, unless one or more of the following changes:

different camera
different optics

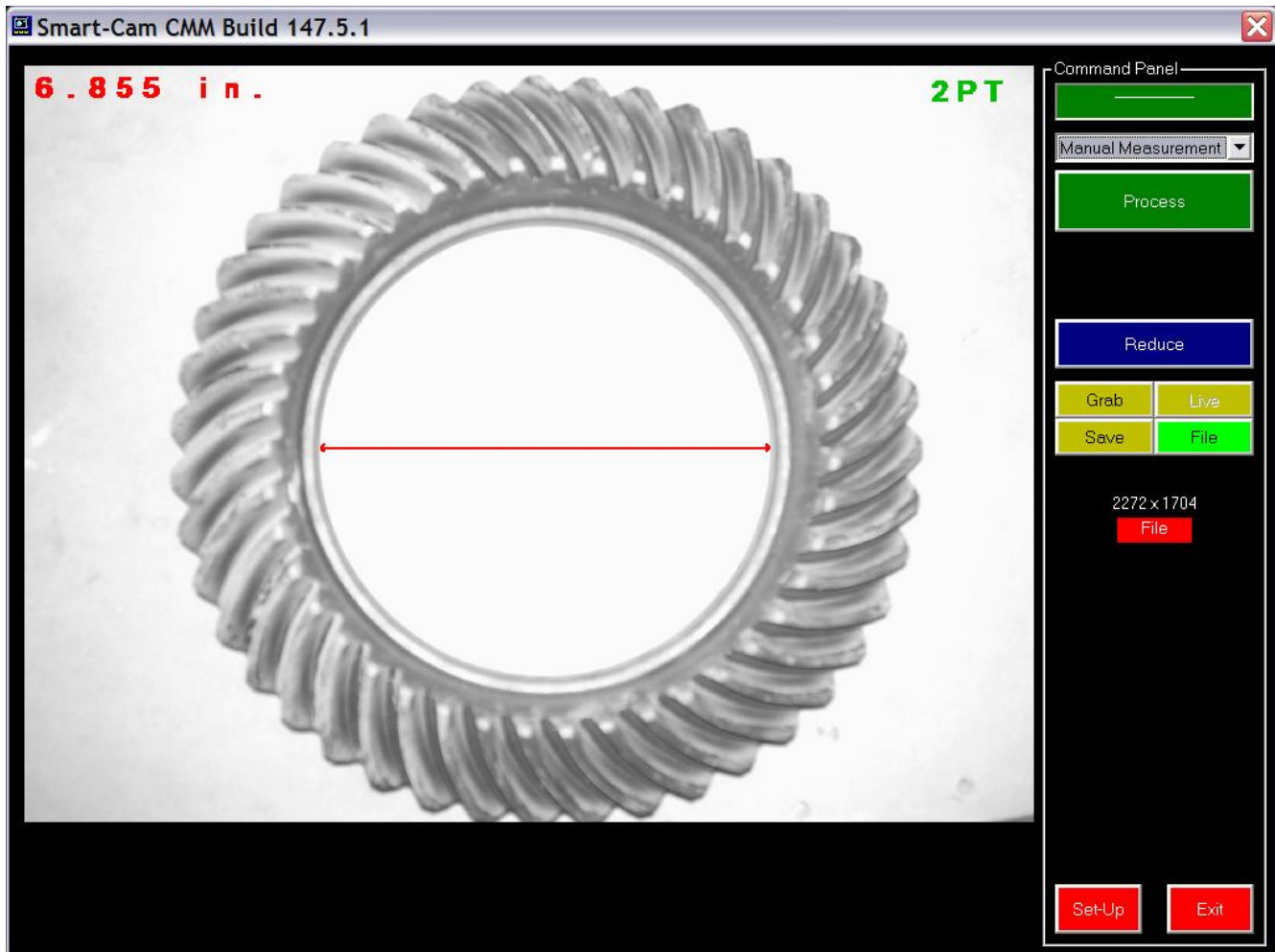
Function Limits:

Max Number of ROIs: 1
Available in Trial Version: Yes

Chapter 6

Manual Measurement

The manual measurement function is the simplest of the built-in functions. In terms of automation, it does practically nothing except acquire an image and let you use 2PT or 3PT mode (as discussed in chapter 3) to make dimensional and angular measurements.



Procedure (Video Camera):

[1] Click Process. Use 2PT or 3PT mode to make measurements right on the image.

Procedure (Digital Still Camera/Scanned Photo):

[1] Shoot a picture of the work to be measured at some known distance from the camera,

if your camera has zoom settings you will need to use the same settings used during calibration.

[2] Use File mode to load the image into Smart-Cam.

[3] Click Process. Use 2PT or 3PT mode to make measurements right on the image.

Function Limits:

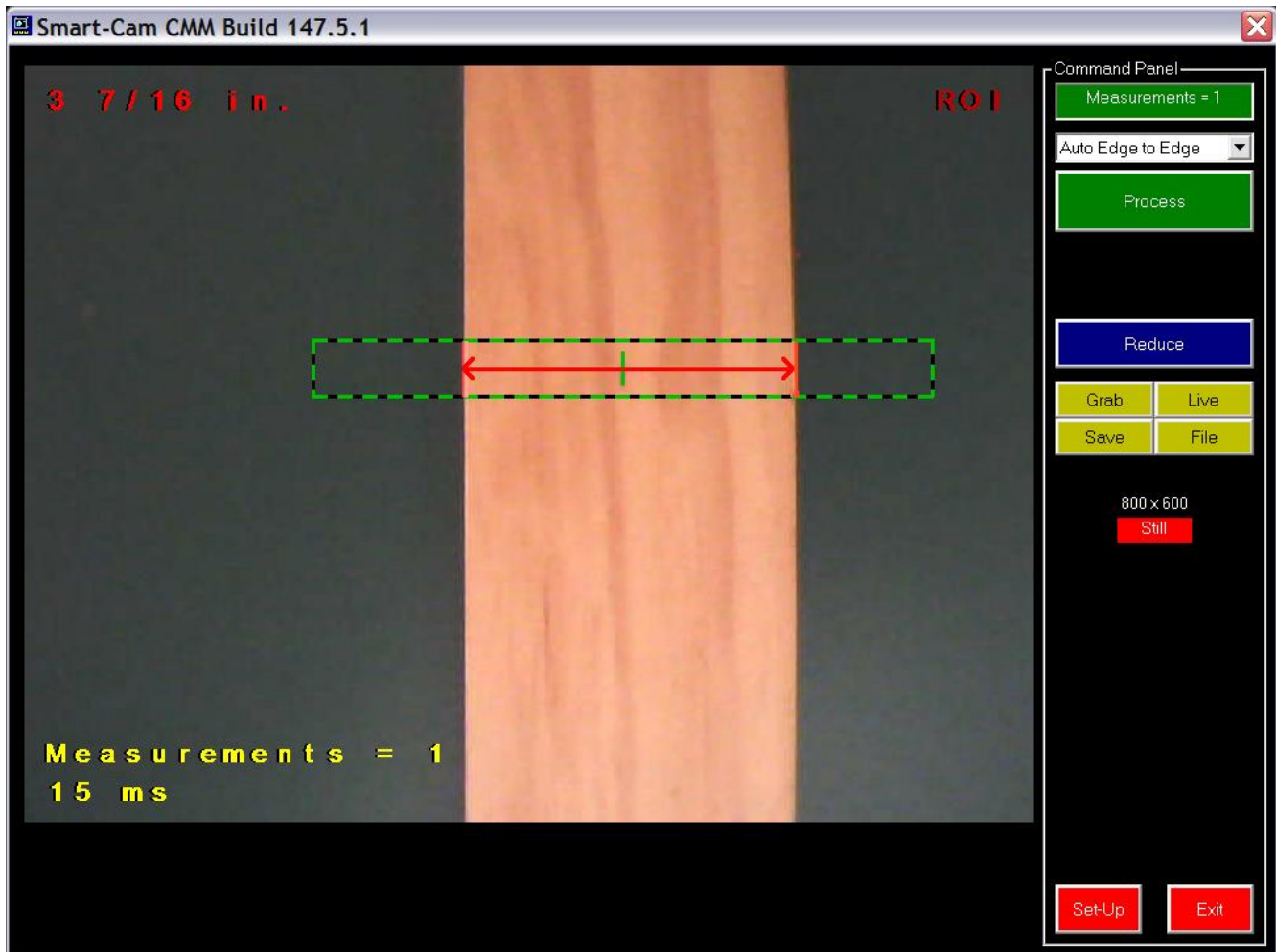
Max Number of ROIs: 0

Available in Trial Version: Yes

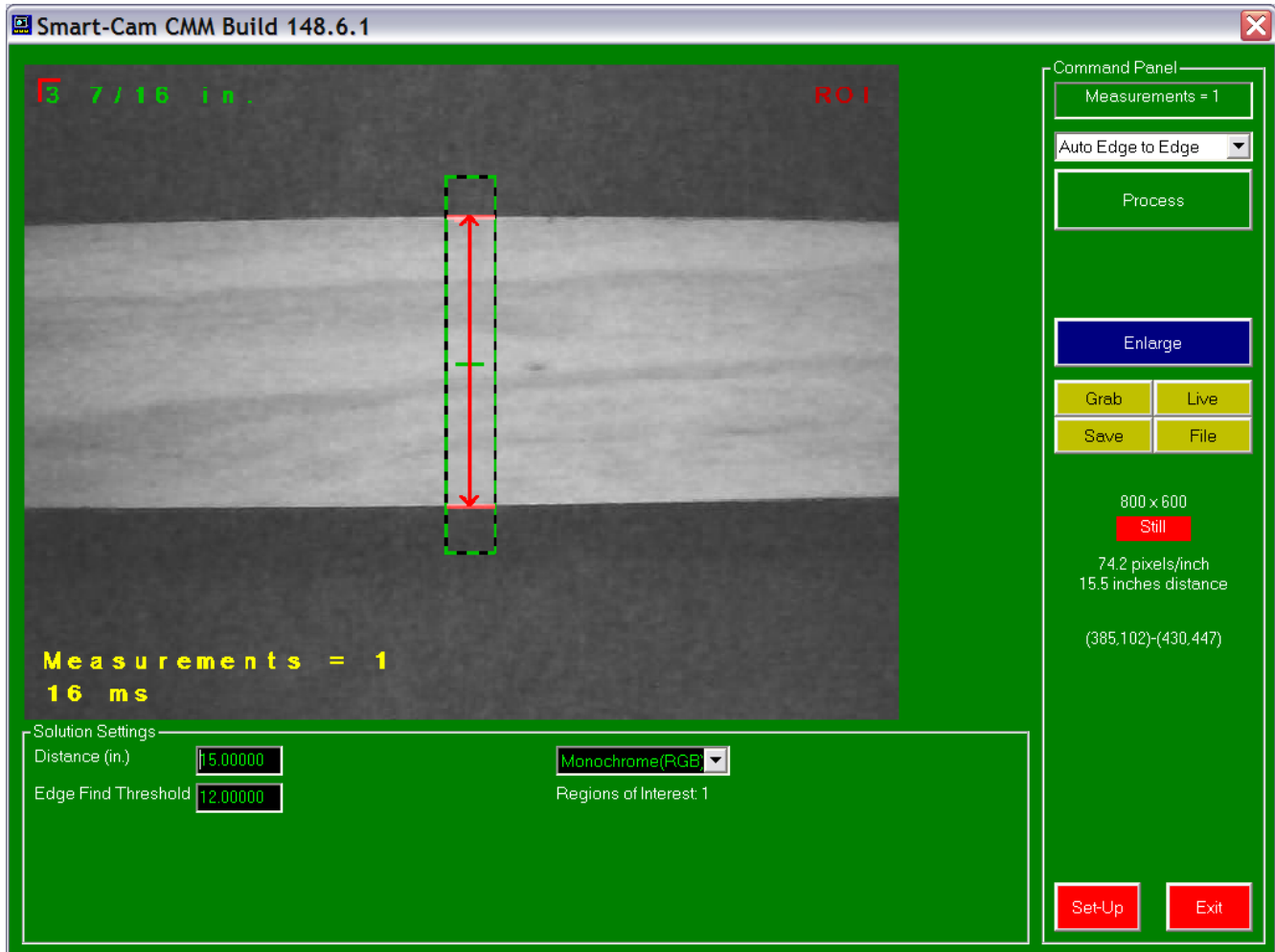
Chapter 7

Auto Edge to Edge

Making measurements manually is fine, but still too tedious in some cases. To that end, automatic functions have been developed that can assist in the process with your guidance. One of these is the auto edge to edge measurement function.



In the simple example shown above a region of interest guides the software to the area where the measurement is taken, and determines what kind of measurement is taken. The “short and fat” region of interest depicted above yields a horizontal edge to edge measurement. A region of interest that was “tall and skinny” yields a vertical edge to edge measurement, as shown in the next example.



Procedure (Video Camera):

- [1] Place your work in view of the camera, middle image is best.
- [2] Set the region(s) of interest as shown in the examples.
- [3] Set the distance equal to the distance between camera and work piece.
- [4] Set the edge find threshold accordingly – you want good thick edges, but not too thick.
Values between 4 and 36 seem to work best, but don't be afraid to experiment.
- [5] Click Process. The measurements are made and results shown.

Procedure (Digital Still Camera/Scanned Photo):

- [1] Shoot a picture of the work to be measured at some known distance from the camera, if your camera has zoom settings you will need to use the same settings used during calibration.
- [2] Use File mode to load the image into Smart-Cam.
- [3] Set the region(s) of interest as shown in the examples.

- [4] Set the distance equal to the distance between camera and work piece.
- [5] Set the edge find threshold accordingly – you want good thick edges, but not too thick.
Values between 4 and 36 seem to work best, but don't be afraid to experiment.
- [5] Click Process. The measurements are made and results shown.

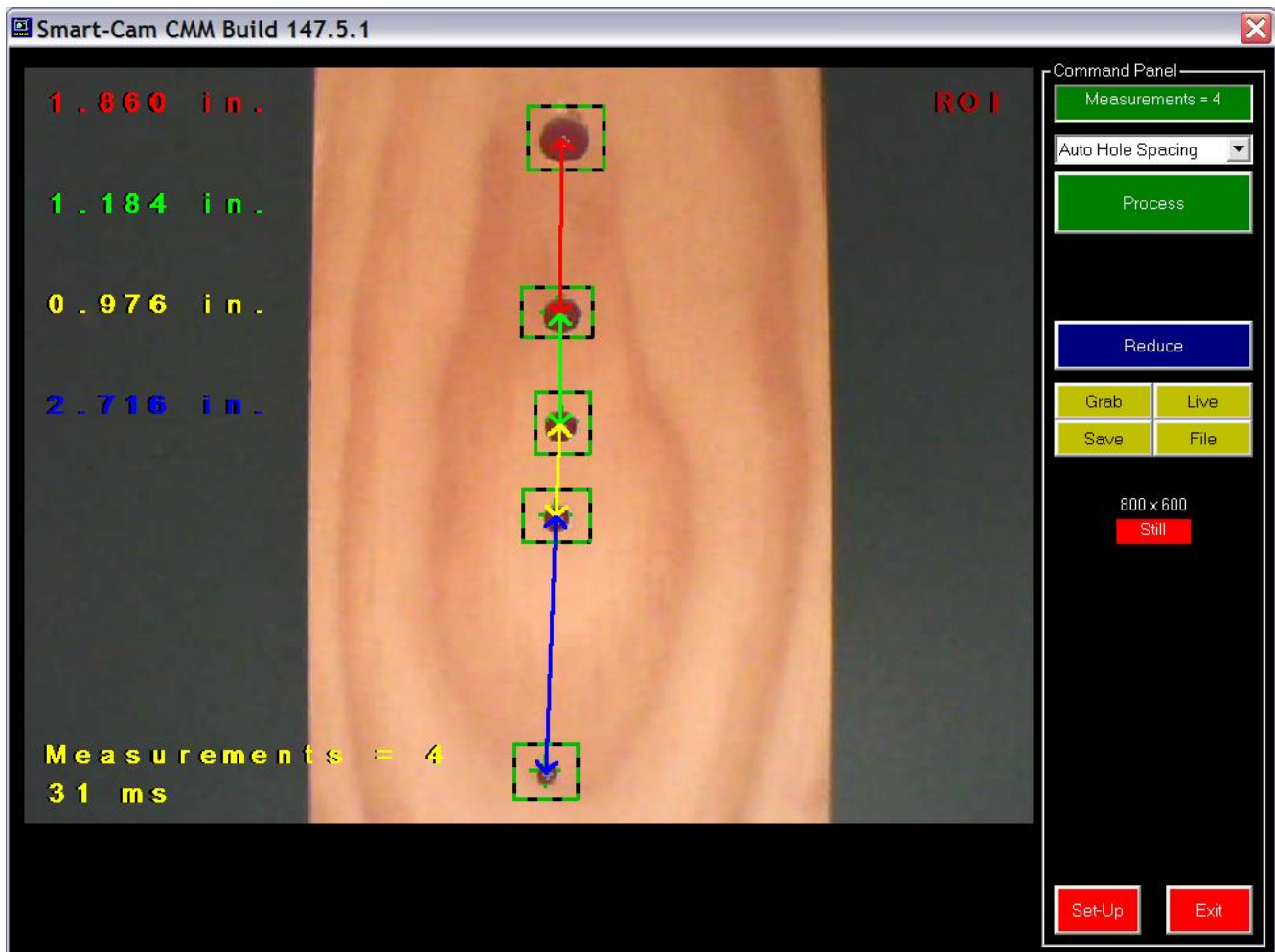
Function Limits:

Max Number of ROIs: 8
Available in Trial Version: No

Chapter 8

Auto Hole Spacing

The auto hole spacing function automatically makes measurements from one center to another, etc. Detection of the hole and finding of the exact center are done automatically for you.



As shown in the example above, each hole of interest has an ROI around it. Note that this function can measure other centers as well as hole centers. All that matters is that the hole or other mark of interest differ from the background.

Procedure (Video Camera):

- [1] Place your work in view of the camera, middle image is best.
- [2] Set the region(s) of interest as shown in the example, one ROI per hole.
- [3] Set the distance equal to the distance between camera and work piece.

- [4] Set the background type. If this is a dark hole on a light background such as depicted in the preceding example, select Light. If this is a light hole (perhaps back-lit) on a dark background, select Dark.
- [5] Set the threshold as necessary to separate your work from the background.
- [6] Set the minimum diameter – any holes smaller than this will be ignored.
- [7] Set the maximum diameter – any holes larger than this will be ignored.
- [8] Click Process. The measurements are made and results shown.

Procedure (Digital Still Camera/Scanned Photo):

- [1] Shoot a picture of the work to be measured at some known distance from the camera, if your camera has zoom settings you will need to use the same settings used during calibration.
- [2] Use File mode to load the image into Smart-Cam.
- [3] Set the region(s) of interest as shown in the example, one ROI per hole.
- [4] Set the distance equal to the distance between camera and work piece.
- [5] Set the background type. If this is a dark hole on a light background such as depicted in the preceding example, select Light. If this is a light hole (perhaps back-lit) on a dark background, select Dark.
- [6] Set the threshold as necessary to separate your work from the background.
- [7] Set the minimum diameter – any holes smaller than this will be ignored.
- [8] Set the maximum diameter – any holes larger than this will be ignored.
- [9] Click Process. The measurements are made and results shown.

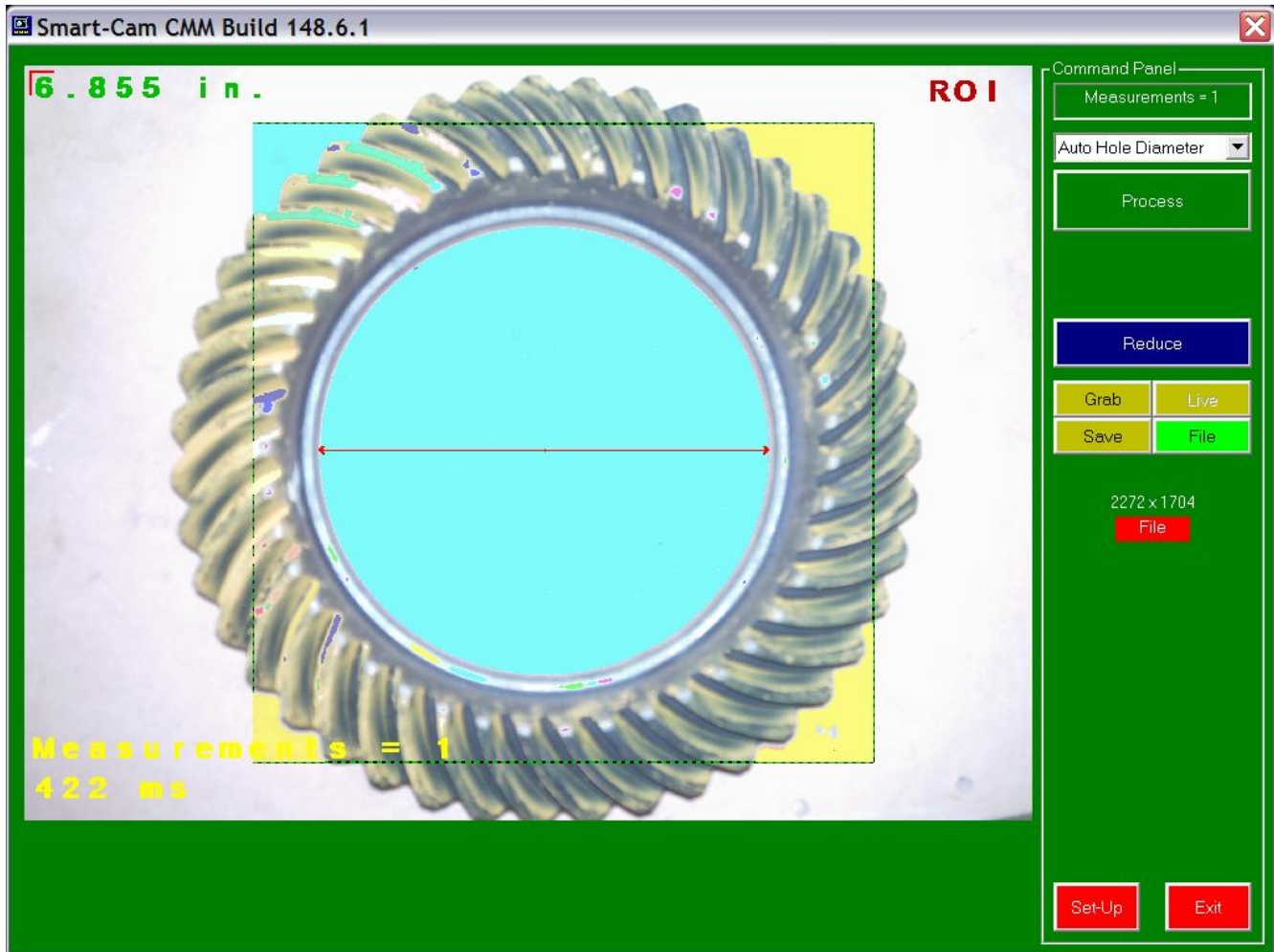
Function Limits:

Max Number of ROIs: 9
Available in Trial Version: No

Chapter 9

Auto Hole Diameter

The auto hole diameter function measures the diameters of one or more round holes, or other distinguishable round objects.



In the example shown above, the center of a ring gear is automatically measured. The region of interest guides Smart-Cam into the general vicinity of the center, and machine vision does the rest. As with the hole spacing function, you have some control over processing. Notice that although a flash was used to take this image and there is some specularity in the image (bright spots of white), the calculation completes normally, as Smart-Cam has automatically filtered out this noise.

Procedure (Video Camera):

- [1] Place your work in view of the camera, middle image is best.
- [2] Set the region(s) of interest as shown in the example, one ROI per hole.
- [3] Set the distance equal to the distance between camera and work piece.
- [4] Set the background type. If this is a light hole on a dark background such as depicted in the preceding example, select Dark. If this is a dark hole on a light background, select Light.
- [5] Set the threshold as necessary to separate your work from the background.
- [6] Set the minimum diameter – any holes smaller than this will be ignored.
- [7] Set the maximum diameter – any holes larger than this will be ignored.
- [8] Click Process. The measurements are made and results shown.

Procedure (Digital Still Camera/Scanned Photo):

- [1] Shoot a picture of the work to be measured at some known distance from the camera, if your camera has zoom settings you will need to use the same settings used during calibration.
- [2] Use File mode to load the image into Smart-Cam.
- [3] Set the region(s) of interest as shown in the example, one ROI per hole.
- [4] Set the distance equal to the distance between camera and work piece.
- [5] Set the background type. If this is a light hole on a dark background such as depicted in the preceding example, select Dark. If this is a dark hole on a light background, select Light.
- [6] Set the threshold as necessary to separate your work from the background.
- [7] Set the minimum diameter – any holes smaller than this will be ignored.
- [8] Set the maximum diameter – any holes larger than this will be ignored.
- [9] Click Process. The measurements are made and results shown.

Function Limits:

Max Number of ROIs: 8
Available in Trial Version: No

Chapter 10

Auto Surface Area

This automatic function provides a very fast and easy way to measure surface area on an object or work piece. This function can also be used to detect areas of holes, grooves, and other things that may be cut or routed into the work under inspection.

Procedure (Video Camera):

- [1] Place your work in view of the camera, middle image is best.
- [2] Set a single region of interest.
- [3] Set the distance equal to the distance between camera and work piece.
- [4] Set the background type. If this is a light surface or routed area on a dark background, select Dark. If this is a dark surface or routed area on a light background, select Light.
- [5] Set the threshold as necessary to separate your work from the background.
- [6] Set the minimum area – any surface smaller than this will be ignored.
- [7] Set the maximum area – any surface larger than this will be ignored.
- [8] Click Process. The measurement is made and results shown.

Procedure (Digital Still Camera/Scanned Photo):

- [1] Shoot a picture of the work to be measured at some known distance from the camera, if your camera has zoom settings you will need to use the same settings used during calibration.
- [2] Use File mode to load the image into Smart-Cam.
- [3] Set a single region of interest.
- [4] Set the distance equal to the distance between camera and work piece.
- [5] Set the background type. If this is a light surface or routed area on a dark background, select Dark. If this is a dark surface or routed area on a light background, select Light.
- [6] Set the threshold as necessary to separate your work from the background.
- [7] Set the minimum area – any surface smaller than this will be ignored.
- [8] Set the maximum area – any surface larger than this will be ignored.
- [9] Click Process. The measurement is made and results shown.

Function Limits:

Max Number of ROIs: 1
Available in Trial Version: No

Chapter 11

Auto Distance

The auto distance function measures the distance from camera to some surface, such as a wall, building, etc. A copy of the calibration target is “taped” to the object, and when the image is analyzed, a comparison to the distance at calibration allows the software to calculate the distance to object automatically.

Procedure (Video Camera):

- [1] Tape a copy of the calibration target to the object.
- [2] Point the camera at the target, middle image is best.
- [3] Set the single region of interest.
- [4] Click Process. The distance is calculated and displayed.

Procedure (Digital Still Camera/Scanned Photo):

- [1] Tape a copy of the calibration target to the object.
- [2] Shoot a picture of the target. If your camera has zoom features you will need to use the same settings used during calibration.
- [3] Use File mode to load the image into Smart-Cam.
- [4] Set the single region of interest.
- [5] Click Process. The distance is calculated and displayed.

Function Limits:

Max Number of ROIs: 1
Available in Trial Version: No

Chapter 12

Manual Distance

Manual distance calculation mode is useful when the object is so far away that the calibration target may not be seen, or for instances when it might not be possible to tape a copy of the target to the object. Manual distance mode does require that there be something in the image (scene) of known dimension so that there is some frame of reference for the calculation. For instance, if you wanted to measure the distance to a large building, all you would need to know is the width of a doorway or window, and the software can then calculate the rest. (And once you have the distance, then you can make manual measurements of the building and determine its size as well.)

Procedure (Video Camera):

- [1] Point the camera at the object, middle image is best.
- [2] Set the single region of interest so that its width lies over something with a known width.
- [3] Set the Reference Width setting to the real-world width of the known item.
- [4] Click Process. The distance is calculated and displayed.

Procedure (Digital Still Camera/Scanned Photo):

- [1] Shoot a picture of the target. If your camera has zoom features you will need to use the same settings used during calibration.
- [2] Use File mode to load the image into Smart-Cam.
- [3] Set the single region of interest so that its width lies over something with a known width.
- [4] Set the Reference Width setting to the real-world width of the known item.
- [5] Click Process. The distance is calculated and displayed.

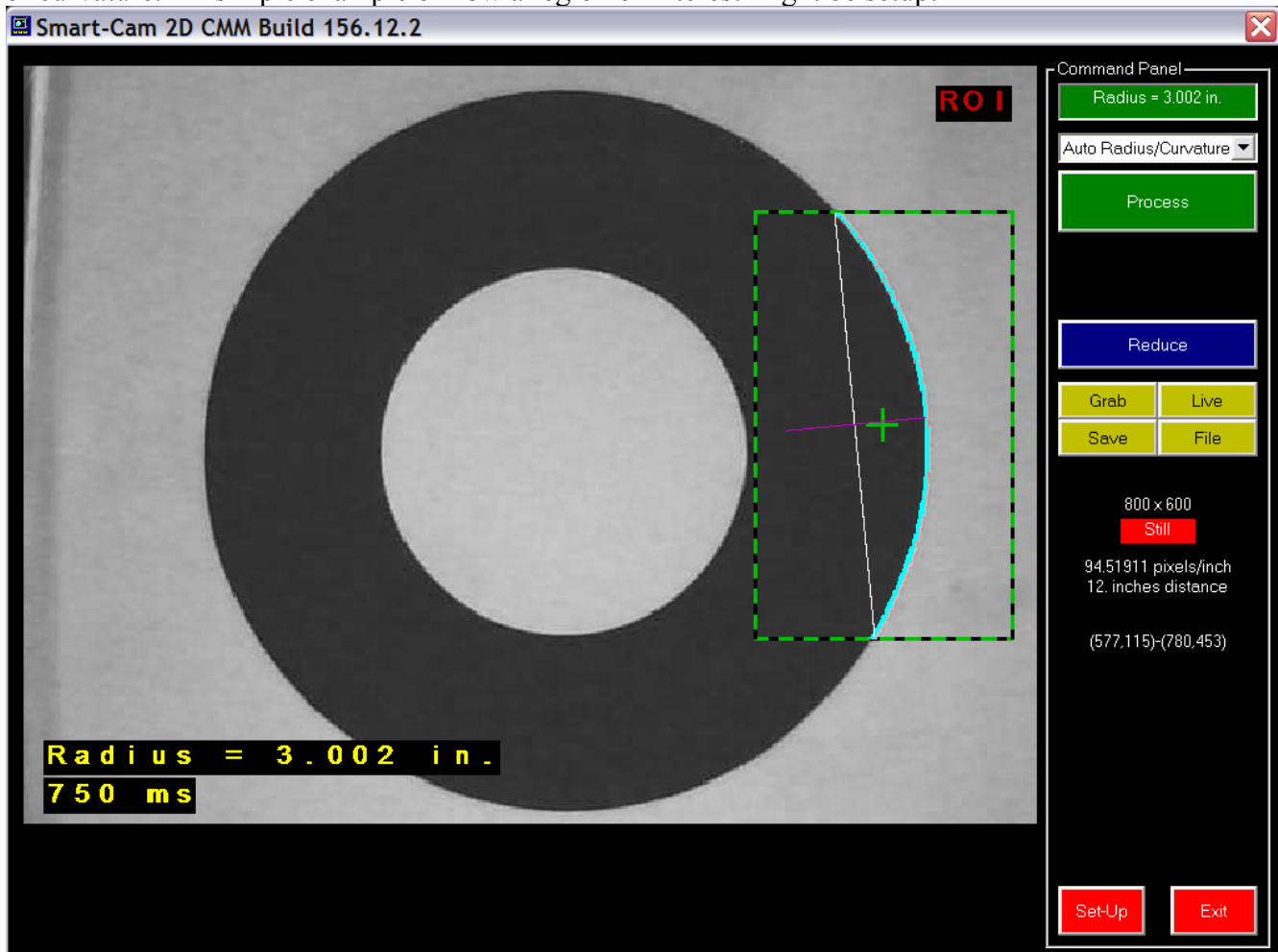
Function Limits:

Max Number of ROIs: 1
Available in Trial Version: No

Chapter 13

Auto Radius Of Curvature

This function takes a circle, or arc (portion of a circle), and automatically calculates the radius of curvature. An simple example of how a region of interest might be setup:



This function uses the chord length method to calculate radius of curvature.

Procedure (Video Camera):

- [1] Point the camera at the object, middle image is best.
- [2] Set the single region of interest to capture as much of the arc or circle as possible, without including any other circles or edges.
- [3] Set the distance equal to the distance between camera and work piece.
- [4] Set the edge find threshold to an appropriate value (typically around 12 to 16).
- [5] Click Process. The radius of curvature is calculated and displayed.

Procedure (Digital Still Camera/Scanned Photo):

- [1] Shoot a picture of the target. If your camera has zoom features you will need to use the same settings used during calibration.
- [2] Use File mode to load the image into Smart-Cam.
- [3] Set the single region of interest to capture as much of the arc or circle as possible, without including any other circles or edges.
- [4] Set the distance equal to the distance between camera and work piece.
- [5] Set the edge find threshold to an appropriate value (typically around 12 to 16).
- [6] Click Process. The radius of curvature is calculated and displayed.

Function Limits:

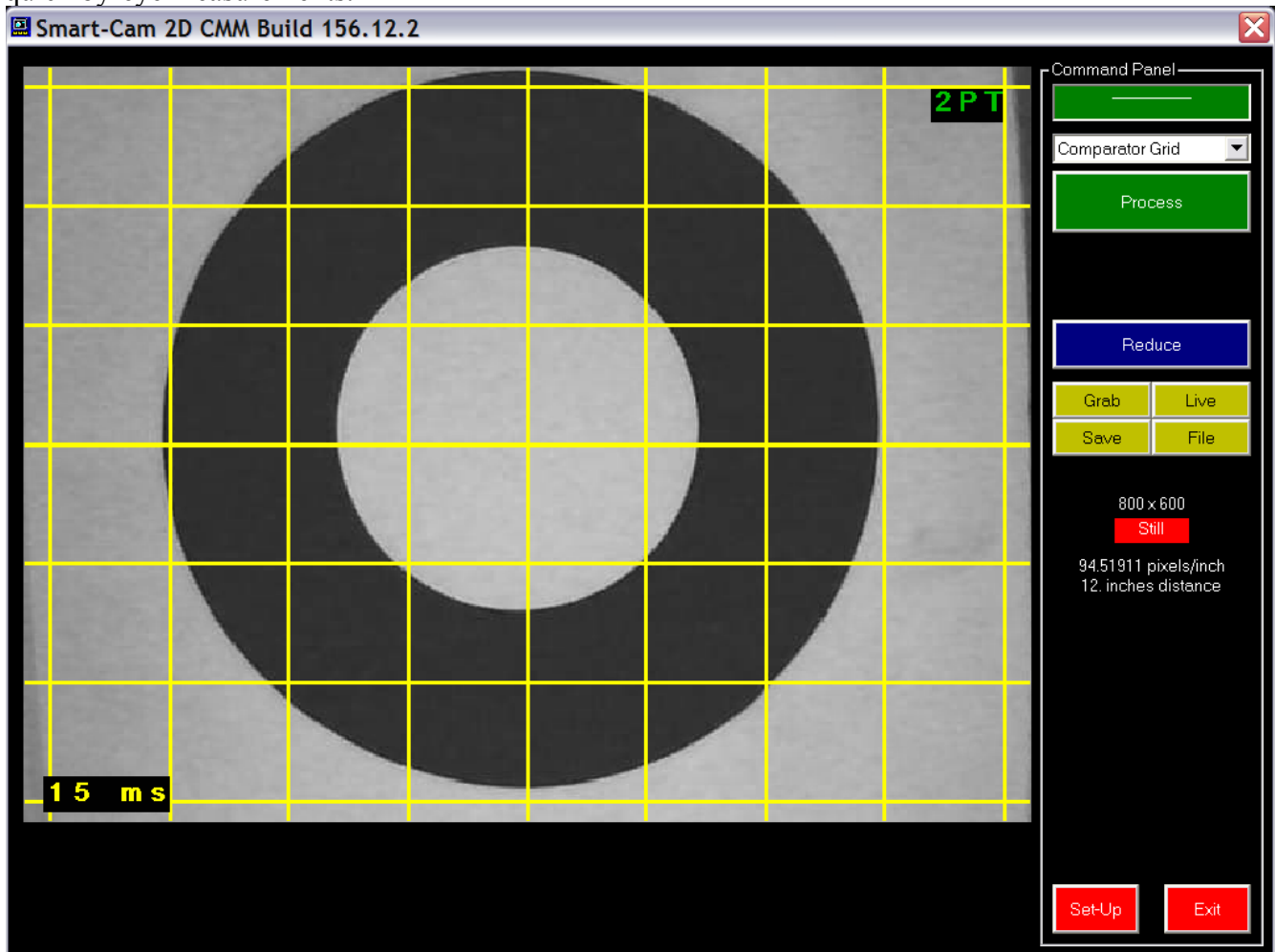
Max Number of ROIs: 1

Available in Trial Version: No

Chapter 14

Comparator Grid

This function simply overlays a square grid, whose spacing you can control, onto the image for quick by-eye measurements.



Procedure (Video Camera):

- [1] Point the camera at the object.
- [2] Set the distance equal to the distance between camera and work piece.
- [3] Set the spacing as desired.
- [4] Click Process. The image and grid are display together, and as with all functions, may be saved to disk.

Procedure (Digital Still Camera/Scanned Photo):

- [1] Shoot a picture of the target. If your camera has zoom features you will need to use the same settings used during calibration.
- [2] Use File mode to load the image into Smart-Cam.
- [3] Set the distance equal to the distance between camera and work piece.
- [4] Set the spacing as desired.
- [5] Click Process. The image and grid are display together, and as with all functions, may be saved to disk.

Function Limits:

Max Number of ROIs: 0

Available in Trial Version: No

Chapter 15

Comparator Polar

This function simply overlays a polar grid, whose spacing you can control, onto the image for quick by-eye measurements.



Procedure (Video Camera):

- [1] Point the camera at the object.
- [2] Set the distance equal to the distance between camera and work piece.
- [3] Set the spacing as desired.
- [4] Click Process. The image and grid are display together, and as with all functions, may be saved to disk.

Procedure (Digital Still Camera/Scanned Photo):

- [1] Shoot a picture of the target. If your camera has zoom features you will need to use the same settings used during calibration.
- [2] Use File mode to load the image into Smart-Cam.
- [3] Set the distance equal to the distance between camera and work piece.
- [4] Set the spacing as desired.
- [5] Click Process. The image and grid are display together, and as with all functions, may be saved to disk.

Function Limits:

Max Number of ROIs: 0

Available in Trial Version: No

Appendix A Support

Website: <http://www.smart-cam-mv.com/>

Sales: sales@smart-cam-mv.com

Support: support@smart-cam-mv.com

Customer satisfaction is extremely important, and your input is valued as an important asset for product development and improvement.

When writing to technical support for help, please include the following information:

Program (ie Smart-Cam CMM)

Version (ie 160-14-4)

Video Hardware (if any)

Digital Camera (if any)

Sample JPEG Images

Appendix B

Camera Recommendations

High-End

The main feature to look for in a high-end machine vision camera is software support for Windows built-in video capture API. In general, this means that the camera should come with a WDM driver, sometimes called a DirectShow driver.

In the old days, machine vision cameras usually required their own specific drivers and specific SDK software. This meant every application had to be coded to use their SDK, and every manufacturer had their own SDK, so things were quite a mess. This was just not efficient.

Fortunately, this is changing and it is possible to get some serious cameras that will work with Smart-Cam thanks to manufacturers finally providing proper Windows driver support. Smart-Cam can then leverage the Windows API to support a multitude of new digital video cameras.

One such suggestion for an industrial strength camera that runs on USB and has a WDM driver/Windows Direct Show, you may wish to check out the uEye from IDS Imaging.

Low-End

On the low-end, a camera from Creative Labs, Logitech, Microsoft, or HP may be your best choice, although Smart-Cam isn't that picky. Feel free to try any old camera you might have laying around the office or shop before you run out and buy a new one.

Appendix C

Modular Extension

The Smart-Cam software consists of several components, that are automatically installed by the Smart-Cam setup program.

They are:

MVBASE.EXE	The main executable and framework
MVSOLUTIONS.DLL	The replaceable module that implements functions
MVALGORITHMS.DLL	Common machine vision subroutines
MVLOADIMAGE.DLL	Load and save support for JPEG images

The standard MVSOLUTIONS.DLL that accompanies Smart-Cam CMM provides the definitions and code that implements the 7 measurement functions and 2 calibration functions that Smart-Cam CMM comes with by default as standard features.

A software developer's kit (SDK) is available that allows MVSOLUTIONS.DLL to be recoded, customized, and extended. Any *licensed Smart-Cam installation* may opt to use a replacement MVSOLUTIONS.DLL from another vendor. This makes Smart-Cam an open solutions platform for machine vision and imaging.

Appendix D

Features and Specifications

Video Camera Support	Yes
Video Capture Device Support	Yes
Video Live Preview	Yes
Video Image Acquisition	Yes
Load Digital Camera Files	Yes, JPEG or BMP standards
Load Disk Files	Yes, JPEG or BMP standards
Save Disk Files	Yes, JPEG or BMP standards
Still Image Display	Yes
Regions of Interest	Yes, Maximum varies by function selected
On-Screen Measurement	Yes, Maximum varies by function selected
Retrieve Pixel Data	Yes
English Measurement	Yes
Metric Measurement	Yes
Color	Yes
Monochrome	Yes
Minimum Resolution Supported	160 x 120
Maximum Resolution Supported	8192 x 6144 (48 megapixel)
Replacement Modules Supported	Yes

As with any software, specifications are subject to change as the software is improved and upgraded. Have an idea or suggestion? Send it to suggestion@smart-cam-mv.com.