

Welcome to the Circle Detection (Circled) software!

This software program uses computer vision to detect circles in images by finding “edges”. For auto-detection mode, a technique called 'Circle Hough Transform' (CHT) is used. Circle candidates are produced by 'voting' in the Hough parameter space and selecting the local maxima in the accumulator matrix. Depending on the image quality, not all circles may be detected and the parameters have to be optimized to prevent over-detection/under-detection of circles.

A manual circle detection mode is also available which allows the user to selectively trace out individual circles one at a time.

More Suggested Readings:

https://en.wikipedia.org/wiki/Circle_Hough_Transform

Description of Hough Circle parameters:

https://docs.opencv.org/3.4/d3/de5/tutorial_js_houghcircles.html

A “How To Use” Guide

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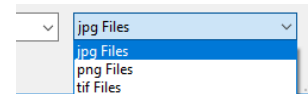
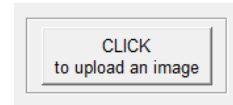
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1) Opening the Software:

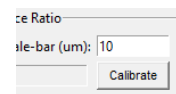
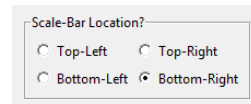
- a) Begin by double clicking on the “Main.exe” application program in the folder.
 - i. It should take 10-30 seconds to load up
- b) Ensure the software displays correctly. (The software has a resolution of 1200x700, so older computers/laptops that do not have 1080p resolution may have a hard time viewing it.)

2) Uploading Images:

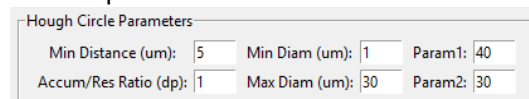
- a) To upload an image, click on the button “CLICK to upload an image”.
 - i. Click on the drop-down arrow to see options for different image types. Several image types can be used with this software (e.g. jpg, png, tif).
- b) Click “open” once your desired image is selected.
- c) Images that are too large or too small can be problematic for the software.
 - i. The images will be resized to 1000 pixel resolution for circle detection.

**3) Calibration of Scale-Bar:**

- a) Images uploaded must have a scale-bar in order to obtain accurate measurement values reported in units of microns (um) instead of pixels (default).
- b) The scale-bar location has to be at one of the four corners in the image and selected in the box.
- c) When the “Calibrate” button is pressed, a small window will pop up showing the corner of your image.
- d) Drawing mode is now active.
 - i. Use your mouse to left-click and drag from one end of the scale-bar to the other, then let go of the left-click mouse button.
 - ii. A green line should have been drawn over/next to the scale-bar in the image.
 - iii. If a mistake is made, simply press “d” on the keyboard to delete the drawing.

**4) AUTO DETECT MODE:**

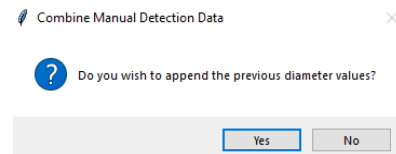
- a) Auto-detection mode is based on the “Circle Hough Transform” technique to find “edges and contours” in order to find the existence of circle shapes.
- b) The “Hough Circle Parameter” values need to be optimized in order to detect as many circles and as accurately as possible.
 - i. Min Distance (um) = The minimum distance between the center of each circle. False detection of smaller circles may occur within a larger circle, so the “Min Distance” value should be large enough to avoid these false detections.
 - ii. Accum/Res Ratio (dp) = This is the inverse ratio of the accumulator resolution to the image resolution. The Hough transform converts the input image into a 3-D space (x, y, radius). Each edge pixel in the image votes for all possible circles on which the pixel could lie. Hence, the bigger the matrix relative to the input image, the higher the resolution of the voting. Higher resolution (smaller “dp” value), leads to more accurate circle detection. However, more accurate detection may sometimes lead to detecting degenerate circles or multiple circles within a big circle. Default value = 1.



- iii. Min Diam (um) = The minimum diameter value to detect. All detected circles smaller than this value will not appear. Increase this value to reduce false detection of small circles.
- iv. Max Diam (um) = The maximum diameter value to detect. All detected circles larger than this value will not appear. Decrease this value to reduce false detection of grossly large circles.
- v. Param1 = The parameter used in the “Canny edge detection” algorithm. This is the “edge threshold” that determines whether the pixel gradients detected are considered an edge or not. Values higher than this (upper threshold) will be considered an edge and values lower will be rejected. Hence a lower value (<40) will allow for the detection of more edges but may also inaccurately label edges. If an image does not have many circles to detect, it would be best to leave this value high (>40).
- vi. Param2 = This parameter is the accumulator threshold. The smaller the value, the more circles will be detected but false circles may also be detected if the value is too low (<25). Recommended to use values >40 if less than 20 circles are expected to be detected. Use values 20-40 if several hundred circles are expected to be detected.

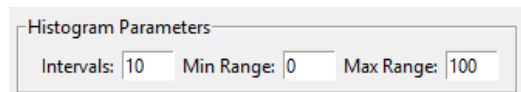
5) Manual Detect Mode:

- a) The software also allows for manual detection mode by using the user’s mouse to trace circles on the image.
- b) In manual detection mode, the image in a new window will pop-up and the user can use the left-mouse button to click, hold, and drag from one side of the circle to the other side.
- c) Letting go of the left-mouse button will draw a circle with a diameter equivalent to the length of the mouse dragged distance.
- d) If a mistake is made, simply press “d” on the keyboard to delete the previous green circle drawing.
 - i. The diameter values of each circle drawn will be displayed on the output box. Deletions will remove values from the output box.
- e) After the user is done drawing, closing the window will populate the diameter values in the spreadsheet table.
 - i. If the user wants to combine the previous detected circles image (either auto or manual), the user must upload an image with the word “detected” in the filename. (This image should have been automatically generated in the same folder as the original image after auto/manual detection mode was used.)
 - ii. A pop-up window will ask the user if they would like to combine the manual detected circle diameters with the previous list of diameter values.



6) Histogram Parameters:

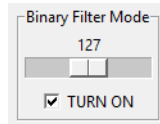
- a) The histogram parameters can be modified before running Auto/Manual mode
 - i. Intervals = The incrementation number. A value of 10 means the x-axis will increment 10 values at a time
 - ii. Min Range = The minimum value of the histogram range.
 - iii. Max Range = The maximum value of the histogram range.



- b) The histogram image will automatically save after running Auto/Manual mode to the same folder where the image was uploaded. The image will be named "YOUR_IMAGE_NAME_histogram.png". The image will overwrite itself each time the "START" button is pressed.

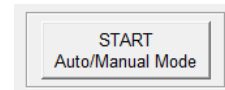
7) Binary Filter Mode:

- a) Binary filter mode turns the image to black and white.
- b) The advantage of this filter is that the detail between the foreground and background will contrast very distinctively since only two colors black or white is used (unlike a gray or colored image).
- This contrast allows for the edge detection of objects to be more accurate.
- c) The adjustable slider value is the threshold of the binary filter. The image is first automatically converted to gray-scale and pixel values higher than the gray threshold value will turn white and values smaller than the threshold will turn black.
- The range is 0-255 and 127 is the default 50% binary threshold value.
 - The threshold of 0 is a completely white image and the threshold of 255 is a completely black image.



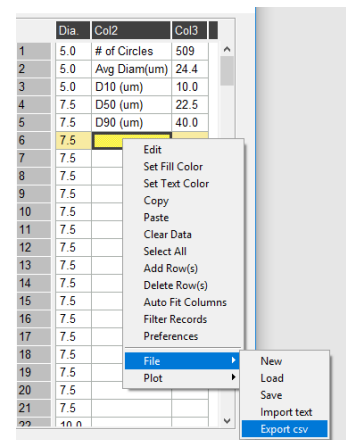
8) START Auto/Manual Mode:

- a) Once manual or auto mode is selected (if auto mode, input "Hough Circle Parameters" first), pressing the START button will begin running the software.
- A new window of the image with detected circles will pop-up once the circle detection algorithm is done running.
- b) If too many circles are detected, the computer may slow down or freeze due to the CPU working hard to detect all the circles. In this case, wait for the program to finish or restart the program and please use higher "Param1/Param2/Min Distance/Min Diam" values for auto-detection mode.
- c) The number of circles detected, the average diameter, the D10 (smaller than the bottom 10% of the circles), the D50 (the median), D90 (larger than the top 90% of circles) will be reported in the output white box. The raw diameter values of each circle will also be populated in the spreadsheet table.



9) Exporting the Data:

- a) After running the Auto/Manual Mode and obtaining the desired data in the spreadsheet table, one can export or manipulate the data in the table.
- To export the data, move the mouse cursor to the table and right-click using the mouse.
 - Go to down to "File" and left-click.
 - Then go to "Export csv" to obtain a .CSV file that can be opened using Microsoft Excel or other softwares.
 - The exact values and layout you see in the spreadsheet table will be the same in the .CSV file exported.



10) Closing the Software:

- a) To close the software, simply press the top-right (X) button in the program window.
- b) A pop-up window will ask you to confirm quitting the software application.
- c) Click “OK” to close the program.

