Instructions for using ImageJ to obtain measures from an image file

Project: Accuracy and precision, dart board

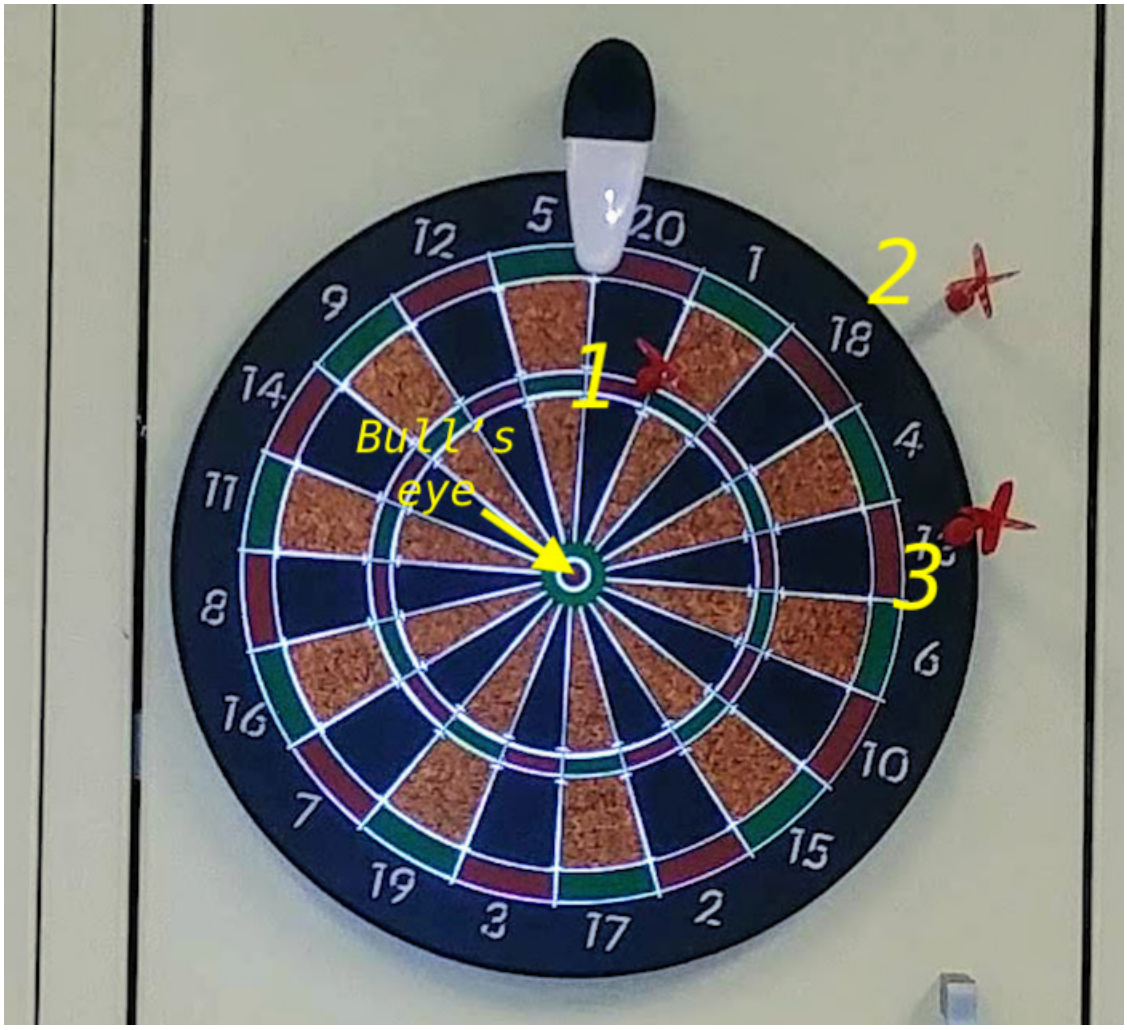

Figure 1. Image file of dartboard, Toysmith model 3121, with darts labeled by order.

SOP
Mike Dohm
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Overview

- Load the image into imageJ
- Set measurements to record, the coordinate system, and identify the origin (center)
- Set scale, number of pixels to distance
- Record darts
  - distance from origin (*r*)
  - coordinates (*x, y*)
  - angle relative to origin

Load the image into imageJ

6. If you have installed imageJ (or FIJI), skip this step and got to 2. If you have not already installed ImageJ (or FIJI), proceed to install imageJ (or FIJI) now.
   a) Which to choose? FIJI is just ImageJ, but comes with more features – If space is not an issue for you on your computer, then install FIJI. Choose one or the other – you don't need both.
   b) For ImageJ, go to https://imagej.nih.gov/ij/download.html and follow the instructions for your operating system; I recommend that you download the version with Java bundled.
      - You will download and archived (zip) file. Once it is downloaded to your computer, double-click to unarchive the file.
      - Double click on the installation app and follow the installation instructions.
        - Should install and work fine for Windows 10 users
        - Mac users may run into some problems: instructions to fix are provided at the ImageJ website.
   c) For FIJI, go to https://fiji.sc/ and download the file bundled with Java for you operating system. Repeat instructions from step 2 above.
7. Start ImageJ (or FIJI) app – I will simply refer to ImageJ; instructions are the same
8. Load image file
   a) **Menu bar: File → Open**
      - Browse to file

Set measurements to record, the coordinate system, and identify the origin (center)

4. Set measurements: **Menu bar: Analyze → Set Measurements**
   a) Check Area, Centroid, Invert Y Coordinates (Fig. 2)
      - A quick word about imageJ and coordinate system. If you remember your geometry, the coordinate system provides a way to uniquely identify location of any point in an Euclidian space. Each point in the space may be identified by its position on the X axis and the Y axis relative to a point of origin.
      - By default, imageJ sets the origin at top, left (Fig. 3).
5. Identify the origin and update the image
   a) Hover the cursor over the area of the image where you want the origin to be located. In our case, that's the Bull's eye of the target (Fig. 1). Once the cursor

is over the origin, note from the indexing the X, Y location of the cursor in pixels (Fig. 5).

b) Go to **Menu bar: Image → Properties** and enter in pixels the location of the origin: In this example, replace 0,0 with 356,355.

Set scale, number of pixels to distance

6. Draw line between known distances on the target
   a) **Menu bar**: Select the "straight" line button
   b) Point mouse to where you want to start the line, click-hold left mouse button and drag to where you want to end the line.
   c) Release mouse button.
7. Relate length in number of pixels to known distance – I chose the diameter of the outer ring, which for this model of dart board is 9.5 inches (24.13 cm). Diameter of the entire board is 11 inches (27.94 cm).
   a) **Menu bar: Analyze → Set scale**.
   b) Change the following options in the popup menu (Fig. 6)
      - known distance: 9.5
      - units of length: inches
      - Check Global box
        - Click OK button
      - Leave the other settings unchanged

Record darts

Estimate accuracy *

8. Measure distances between darts and center of target (the bull's eye, Fig. 1). For each dart, repeat steps 9 and 10
9. Draw a line from dart to center of target (see step 6 above)
10. Get length of the line
    a) **Menu bar: Analyze → Measure**
    b) Length, in inches, will be displayed in Results window (Fig. 7): first dart: r = 2.2.916, x = 0.515, y = 1.373, angle = -109.714
    c) Second dart: r = 6.654, x = 2.723, y = 1.899, angle = -144.233
    d) Third dart: r = 5.493, x = 2.688, y = 0.263, angle = -174.503
11. Record your numbers and get statistics summary – Click on Results window, then select Summary from **Menu bar.**
    a) Mean: 5.021 (Fig. 8)
    b) SD (standard deviation): 1.913 (Fig. 8)
    c) By hand calculation, get the coefficient of variation (CV = SD/mean) as estimate of accuracy: 0.3809998
    d) Report CV in percent, e.g., 38%, as estimate of accuracy (the smaller the CV, the more accurate the estimate)

Estimate precision *

1. Clear results window (**Menu bar: Results → Clear results**).
2. Select Polygon tool
3. Point mouse to first dart, click and release left mouse button to begin.
    1. Draw cursor to second dart, click-release
    2. Drag cursor to third dart, click-release
    3. And finish by dragging mouse back to first dart, click-release.
    4. You should now have a closed triangle
4. Measure area of triangle
    1. **Menu bar: Analyze → Measure**
        1. Area, in inches squared, will be displayed in Results window: 7.434
5. Report area of the triangle as estimate of precision; the smaller the area, the more precise the estimate.

* A disclaimer: The procedures above to estimate accuracy and precision are crude. For one, we would want the X Y coordinates of each point (dart) on the target (circle). Perhaps unsurprisingly there is a large literature on accuracy/precision of target shooting. If you are interested, then explore the package shotGroups. This package provides a number of functions and graphics specifically for target shooting. One nice summary graphic from this package is shown in Figure 9 for a larger data set.

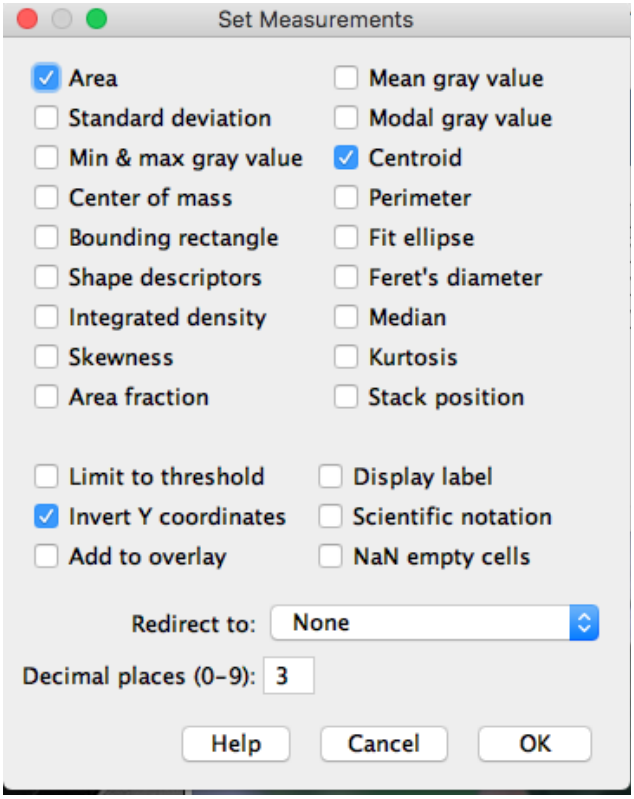

Figure 2. Available options for measurements. Menu bar: Analyze → Set Measurements.

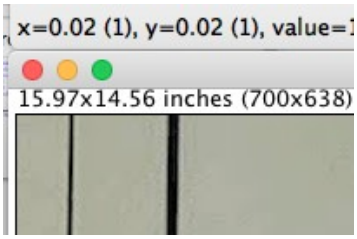

Figure 3. Cursor placed at top left of image x = 0.02 (1), y = 0.02 (1). ImageJ displays in real time the X,Y coordinates of the cursor. By default, imageJ sets the origin, 0,0, a the top left – the cursor position captured was at (1, 1).

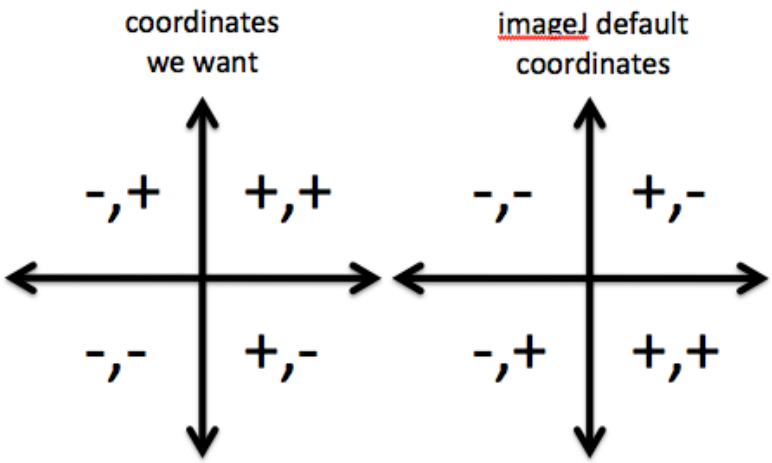

Figure 4. Coordinate system. The graph at right shows imageJ default locations after changing the origin. The system we want is shown on the left; Select Invert Y coordinates in the Set Measurements options to change from the default to the standard coordinate system.

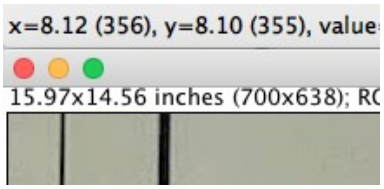

Figure 5. Cursor moved to "bulls eye" center (target not not shown); the true center of the image was X = 8.12 inches (356), Y = 8.10 inches (355). To change the origin, ***Menu bar: Image → Properties*** *and enter in pixels the location of the origin. (In this example, replace 0,0 with 356,355.)*

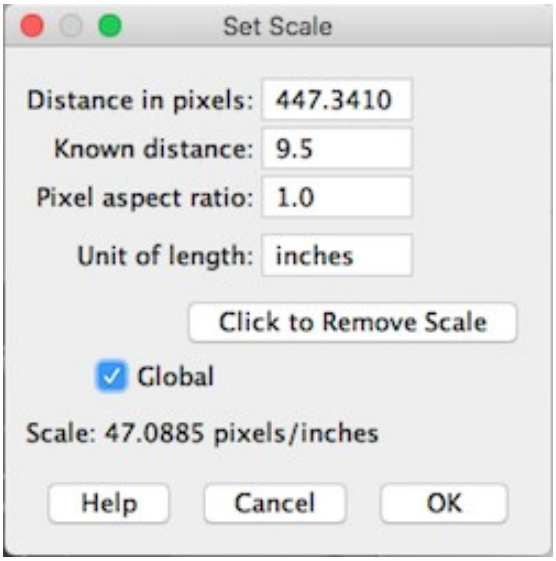

Figure 6. Screenshot of Set Scale menu. The distance of the drawn line, measured by ImageJ, is showed in pixels (447.3410). The user enters the actual distance (9.5) and the Unit of Length (inches). Click the check box next to Global – the scale will now apply to all distances measured.

Results

	Area	X	Y	Angle	Length
1	0.067	0.515	1.373	-109.714	2.916
2	0.153	2.723	1.899	-144.233	6.654
3	0.126	2.688	0.263	-174.503	5.493

Figure 7. Results window for each of the three lines drawn between the center and darts.

Results

	Label	Area	X	Y	Angle	Length
1		0.067	0.515	1.373	-109.714	2.916
2		0.153	2.723	1.899	-144.233	6.654
3		0.126	2.688	0.263	-174.503	5.493
4	Mean	0.115	1.975	1.178	-142.817	5.021
5	SD	0.044	1.265	0.835	32.418	1.913
6	Min	0.067	0.515	0.263	-174.503	2.916
7	Max	0.153	2.723	1.899	-109.714	6.654

Figure 8. Results window with Summary statistics.