# JMorph Quick-Start Tutorial

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This tutorial is meant to give you a fast introduction to the basic functionality of JMorph. We have tried to design the application to be as intuitive as possible so hopefully you can figure out the functionality not explained here through your own exploration.

Please note that Java applications look different on different platforms so there may be minor inconsistencies between what you see in this tutorial and what you see when running JMorph.

## Contents

# 1 About JMorph

JMorph is a dedicated digital morphometrics package, designed for fast measurement of many specimens from digital photographs. The major design criterion has been to allow processing of a huge number of photographs as quickly as possible.

JMorph allows you to load images and measure lengths, angles, curvatures, separations, areas, define outlines and landmark points, and count things, all with a few simple clicks of the mouse. The measurements can be exported to load into whatever spreadsheet or data processing software you choose to work with. Some processing is built-in, e.g. Fourier outline analysis, and adding further processing routines is certainly possible.

JMorph has grown from the needs of a single researcher: while it meets her needs, your needs may differ. Therefore, **we encourage users to suggest additional functionality or other general improvements that would help you with your research needs:** please contact the primary developer at plelievre@mun.ca.

# 2 Policies

The following policies should not discourage use of JMorph but, rather, are meant to clarify the conditions of use and to protect our significant investment in code development. In the following, "I" refers to the primary developer, Peter Lelièvre.

## 2.1 (Dis)claimer

While the software in this package can not be guaranteed in any way, I provide the following assurances:

- I will keep this document up-to-date with the current version of JMorph.
- JMorph has been thoroughly tested but nothing is perfect. I am happy to run further tests with any specified parameters as requested.
- I value direct and constructive feedback: please contact me at plelievre@mun.ca for any questions, suggestions or requests with respect to the JMorph application or this documentation.
- I will deal with any reported bugs or issues in a timely manner.
- I will provide basic user support for JMorph, provided users have first reviewed this documentation thoroughly.

## 2.2 Conditions of use

JMorph is freely available under the MIT License. Use of JMorph requires that the developers will not be held responsible for any damages, monetary or otherwise, to the user caused directly or in part through the use of JMorph.

User responsibilities:

1. properly cite usage of JMorph in any publications resulting from its use (see suggested citation below)
2. promptly inform the developers of any such publications
3. **promptly inform the developers of any bugs or issues encountered while using JMorph**
4. promptly inform the developers if the user changes institutional affiliation or email address
5. users agree that their name and institution or company position may appear on the developers' academic websites in a list of users of JMorph.

Suggested citation:

- P. G. Lelièvre and M. Grey, 2017, JMorph: Software for performing rapid morphometric measurements on digital images of fossil assemblages, Computers & Geosciences, 105, pp120–128.

# 3 Installing and running JMorph

Make sure you have the latest version of the Java SE Runtime Environment installed on your machine. Because the JMorph application is written in Java, it should in theory run on any platform that can run Java. We make efforts to test the application on various operating systems but without direct access to users' computing systems we can not guarantee that the application will execute flawlessly on your system.

**In the instructions below, I use `"jmorph"` to indicate the directory that contains all of the JMorph files, e.g. that I emailed to you or that you obtained from GitHub.**

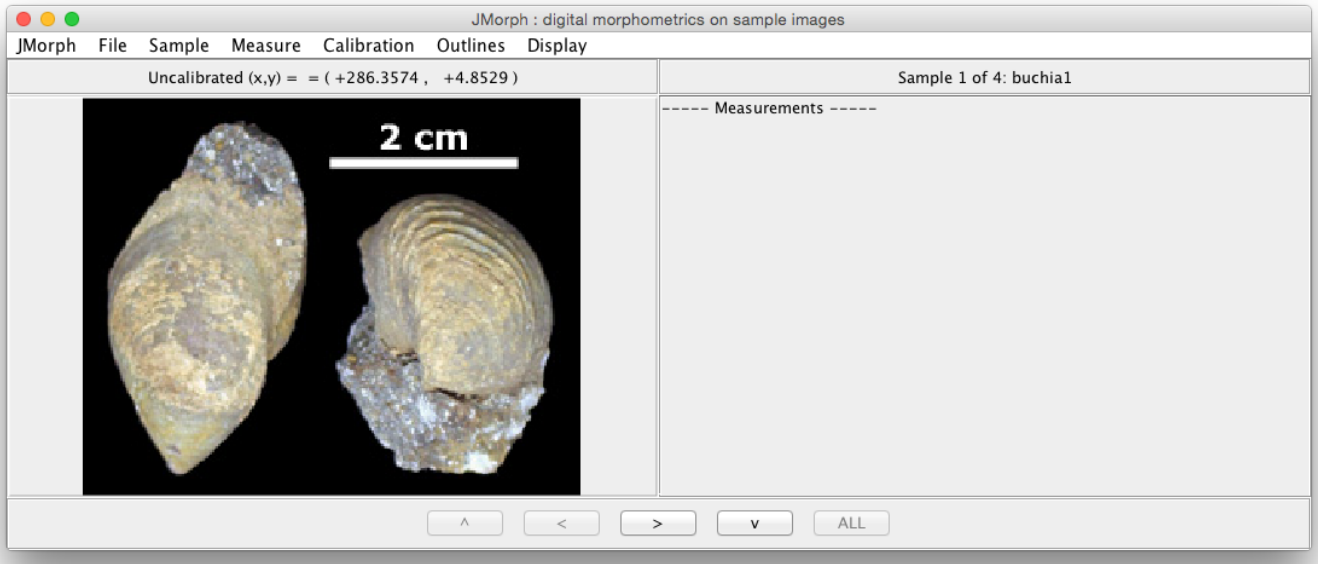
To launch JMorph,

1. Run the `JMorph.jar` file located here
   `jmorph/dist/JMorph.jar`
   by double clicking it, or from a terminal/command window using
   `java -jar JMorph.jar`
2. Read and close the `About JMorph` dialog window.

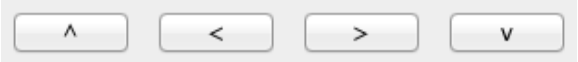
# 4 Loading your image files

3. Select the menu item
   `File > Load sample images`
4. Navigate to
   `jmorph/example/`
   and select all the image files named `buchia*.jpg`
5. Press the `Open` button.
6. Close the subsequent confirmation dialog window.

You should now see the first image in the left panel:




You can cycle through the images by using the arrow buttons on the bottom of the window:




You can try those buttons now if you like but navigate back to the first image before continuing below.

# 5 Defining your measurements

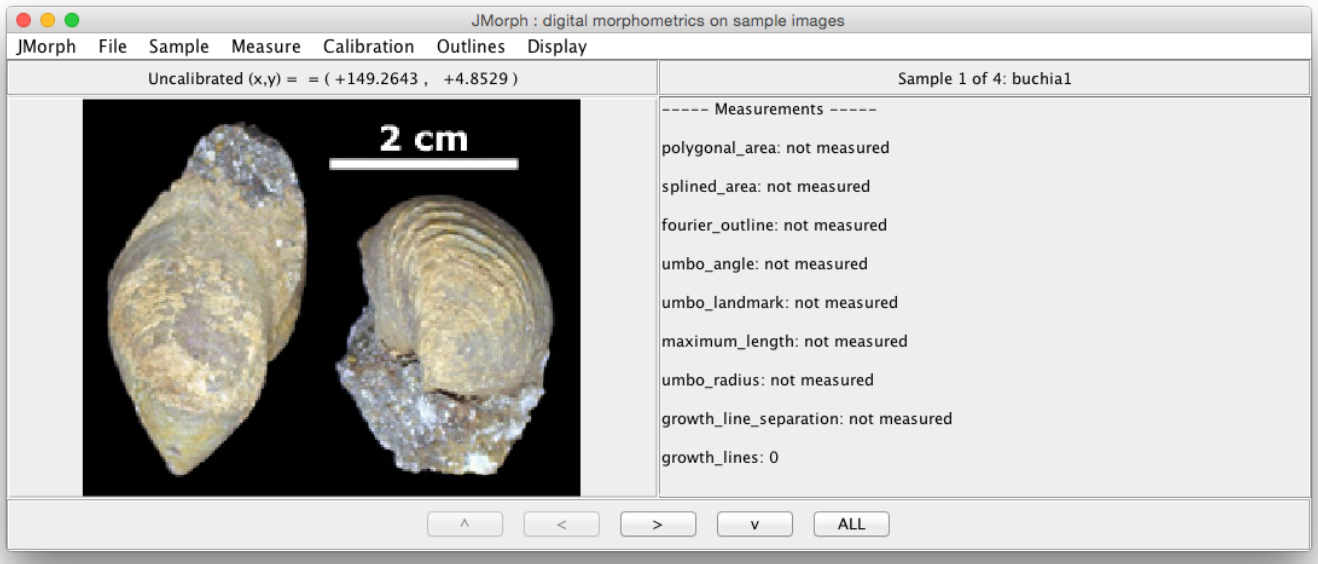
7. Select the menu item
   `Measure > Define a new measurement`
8. Select `outline` from the pull-down menu and press `OK`.
9. Enter a name for the measurement when prompted. Here you can simply enter `outline` because we'll only use one outline per sample image.

If you want to try other measurements (e.g. polygonal area, splined area, angle, landmark, length, radius, separation, count) then you need to repeat those same steps for each. If you have many measurement types then it may be faster to define those in a simple text (ascii) file. We will do this now. The first line of the file should specify the number of measurement definitions. Each of the lines following the first should contain a measurement type description followed by a name. The names should not contain spaces. Only certain measurement type descriptions are recognized. Here is an example file containing all the measurement types (this is the file you will be using in this tutorial):

```
9
area          polygonal_area
spline        splined_area
outline       fourier_outline
angle         umbo_angle
landmark      umbo_landmark
length        maximum_length
radius        umbo_radius
separation    growth_line_separation
count         growth_lines
```

10. Select the menu item
    `File > Load measurement definitions`
11. Press `Yes` on the confirmation dialog.
12. Navigate to
    `jmorph/example/`
    and select the file named `measurements.txt`
13. Press the `Open` button.
14. Close the subsequent confirmation dialog window.

You should now see all 9 measurements listed in the right panel:



# 6 Taking your measurements

15. The fastest way to perform all the measurements on all the samples is to use the menu item
`Measure > Perform all measurements on all samples`
The `ALL` button at the bottom of the window also activates this functionality. Select that menu item or press that button now. You will now be guided through each of the required measurements as well as calibration steps for each sample image. The enumerated items below will help you with this process. Be sure to click on the `Continue` button on the dialogs, unless the instructions below direct you otherwise.

16. When prompted to define the calibration length, click[1] on the two ends of the 2 cm scale bar in the first sample image. Enter 2 when prompted for the calibration distance.

17. When prompted to define the origin used for landmarks and outline points you can click anywhere (for the purposes of this tutorial, the location of the origin is arbitrary).

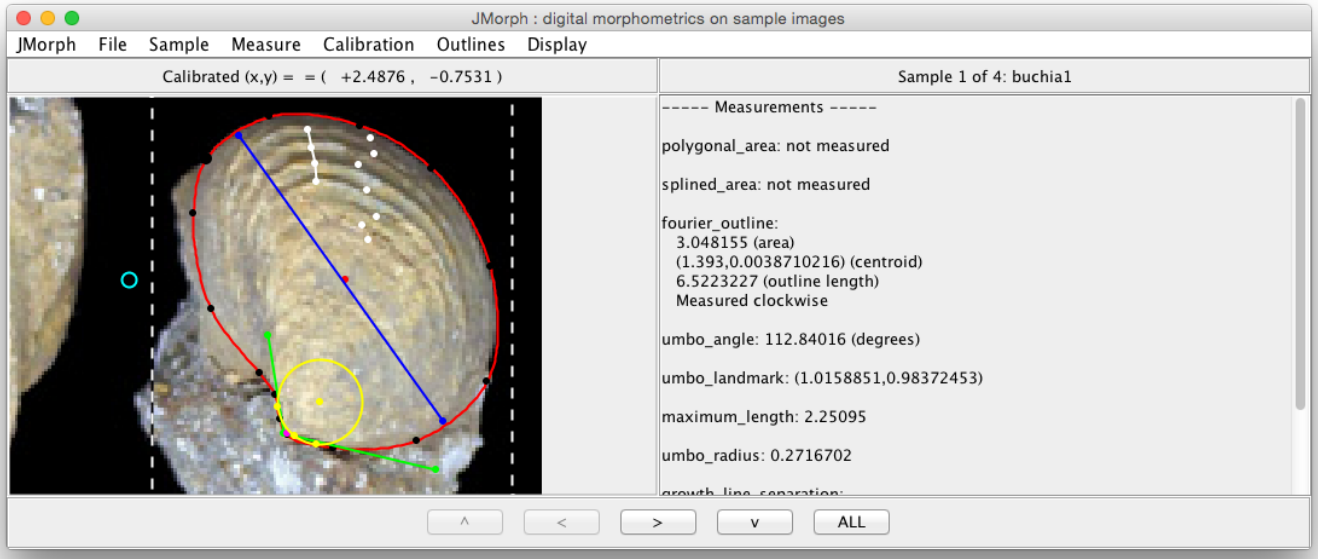
18. When prompted to define the zoom box, you could skip because the first photograph is zoomed into the specimen well enough. However, I suggest you try defining a zoom box for this sample so you can see how it works: press `Continue` and follow the dialog instructions to zoom in on the valve on the right.

19. You can `Skip` the next two measurements, named `polygonal_area` and `splined_area` (they are defined similarly to the next measurement named `fourier_outline`).

20. When prompted to define the measurement named `fourier_outline`, click `Continue` and following the instructions on the prompt dialog. Make sure you hit the space bar to finish the outline: this will close your outline by connecting the first and last points clicked so there is no need to try to click near the first point again.

21. Continue with the other measurements, as instructed in the dialogs, until you are asked if you want to re-measure the current sample. At that stage, click `Cancel`. If, instead, you had continued then JMorph would have displayed the next sample image and continued with the measurement instructions. If at any later time you wish to continue where you left off, you simply need to navigate to the required sample and click the `ALL` button again.

You should now see something like the following:

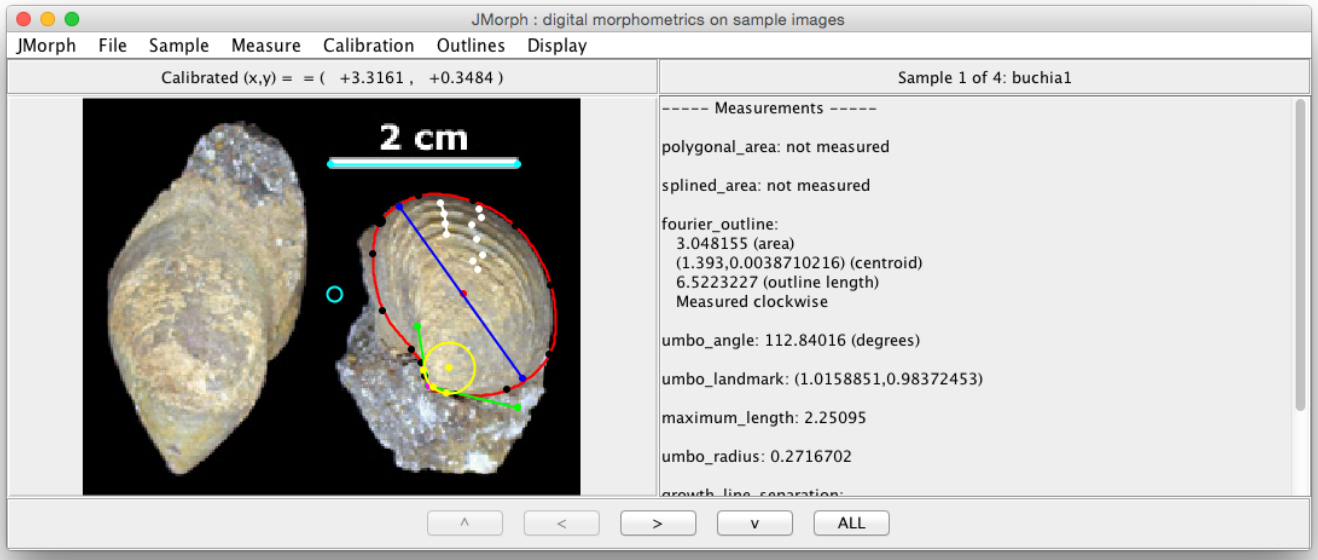



The zoom box is indicated by a black and white dashed line (the black blends with the background for this sample image).

22. You can clear the zoom by selecting the menu item
`Display > Clear zoom`

[1] If using Apple's Magic Mouse or another similar device, mouse clicks may not register if your finger moves too much, i.e. scrolling while clicking.

You should now see something like the following:




The calibration length is painted as a cyan line and the calibration origin is a cyan circle (seen above in the centre of the image). For the outline measurement, the clicked points are painted black and the spline through them is a red line. We will discuss this Fourier outline measurement in more detail in the following section. The angle measurement is the angle between the two green lines defined by the three points you clicked. The landmark is painted as a magenta dot. The length measurement is a blue line between the two points you clicked. The radius measurement is plotted as a yellow circle that passes through the three points you clicked: the measurement is the radius of this circle. The separation measurement is indicated as white connected dots: the measurement is the average of the distances between the points. The count measurement is indicated as unconnected white dots (the count measurement is simply the number of times you have clicked the mouse, i.e. the number of unconnected white dots). These default painting colours can be changed in the `Display` menu.

# 7 Fourier outline analysis

23. To perform the Fourier analysis, select the menu item
`Outlines > Select Fourier analysis method`
and choose the `Tangent-vs-ArcLength` option.

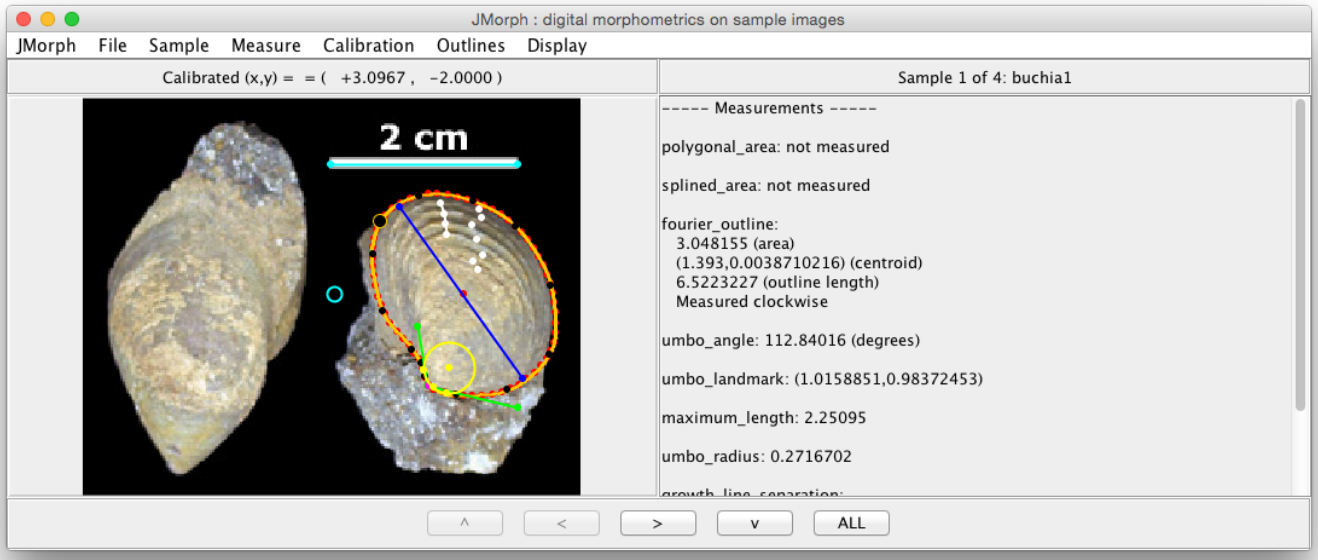
The `Tangent-vs-ArcLength` option is the method of Crampton and Haines (1996): software program HANGLE[2]. **Make sure you cite that work as required.**

The `Radius-vs-Theta` option calculates the centroid of the spline (painted as a red dot) and then calculates the distance (radius) and angle (theta) for each spline point with the centroid as the origin. This option can not be applied when a radius-vs-theta relationship contains a double-valued point, i.e. two radii values for a single theta value, which can occur for more highly sinuous outlines.

**WARNING! We have yet to implement HMATCH in JMorph. In general, Fourier methods are sensitive to the starting position of the digitized outline. The HMATCH program removes any variation in the samples that can be explained by small offsets in the starting positions. When using JMorph, you may be able to avoid the use of HMATCH if you start all of your outline digitizations at a homologous landmark and digitize the outlines in the same direction (clockwise or counterclockwise). However, if the homologous landmark is rather broad or poorly defined then this may not be sufficient. In such cases, the HMATCH program should be used. Please contact James Crampton for access to his software or ask us to implement the HMATCH program into JMorph. To use the HANGLE, HMATCH and HCURVE programs directly, you can export your sample outlines from JMorph using the menu item `File > Export outlines`. Those files will be in a format that the HANGLE, HMATCH and HCURVE programs can work with.**

[2]Crampton, J. S., Haines, A. J., 1996. Users' manual for programs HANGLE, HMATCH, and HCURVE for the Fourier shape analysis of two-dimensional outlines. Institute of Geological & Nuclear Sciences science report 96/37. 28 p.

You should now see something like the following:




The red dots indicate the resampled splined outline, resampled to some power of 2 for Fourier analysis. The yellow line indicates the reconstructed outline after throwing away higher Fourier coefficients. There are other options in the `Outlines` menu that I won't explain here but you can experiment with them as you like: for example, you can change the resampling power and the maximum Fourier coefficient.

The panel on the right gives you information about the measurements performed on the current sample being viewed. By default the Fourier coefficients are not shown. To show them, use the menu item

```
Display > Show FFT coefficients
```

# 8 Saving your work

24. To export your measurements to a `.csv` file (e.g. for viewing in your preferred spreadsheet program) use the menu item
    `File > Export to CSV file`
25. To save your work to a JMorph session file, that can be opened to continue your work later after closing JMorph, use the menu item
    `File > Save session`