

Introduction  
to  
**Ultra Fractal**



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# Introduction

Ultra Fractal is a sophisticated program for the generation of fractal images. With this material, you'll have a *brief* introduction to its capabilities. Like any other powerful program, Ultra Fractal can take years to master. Fortunately, there are resources available to help new users, such as an email list of over 300 users, web-based tutorials, and several online galleries of images. For more information, see the Ultra Fractal website at [www.ultrafractal.com](http://www.ultrafractal.com).

## Assumptions

- This material assumes that you are familiar with the Windows operating system, and are comfortable with things like finding files and folders, menus, and basic keyboard operations.
- While fractals are fundamentally mathematical objects, this tutorial is written with minimal math. It is assumed that the reader is comfortable with basic concepts from algebra and geometry.

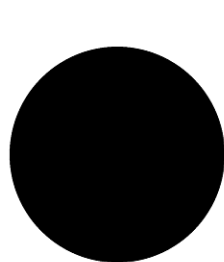
## Conventions

- Hierarchical menu items are represented using the “|” character. Thus, “File | New | Fractal” means to click on the “File” menu, choose “New,” and then to pick “Fractal” from the submenu.
- When available, keyboard shortcuts are listed. For example, “Ctrl+B” means to press the “B” key while holding down the control key (“Ctrl”).
- The fractals discussed here are based on complex numbers, which are numbers that have two parts. Many of the program's inputs are complex numbers. In this text, the real and imaginary parts of complex numbers will be represented like this:  $1-3i$  means a complex number with a real part of 1 and an imaginary part of -3.

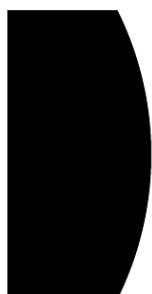
# What are Fractals?

## Shapes with Infinite Detail

Fundamentally, fractals are shapes, just as circles, squares, and triangles are shapes. However, fractals are very different from other, more common shapes. Right away, you can tell that fractals are different. A circle, for example, is smooth. We can see that more precisely by looking at smaller and smaller pieces of a circle:



circle magnified 1x



edge magnified 3x



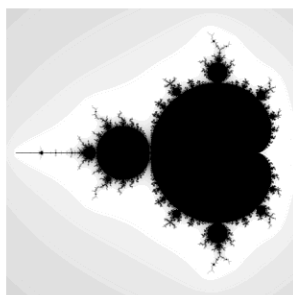
edge magnified 10x



edge magnified 100x

As the magnification increases, the edge of the circle flattens out and eventually becomes indistinguishable from a straight line. This is characteristic of any smooth shape--if you zoom in enough, the edge will look like a straight line.

Fractals are different in that, no matter how much you zoom in, the shape never flattens out. Here we see this with a fractal called the Mandelbrot set:



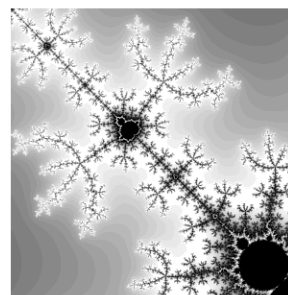
Mandelbrot set 1x



edge magnified 3x

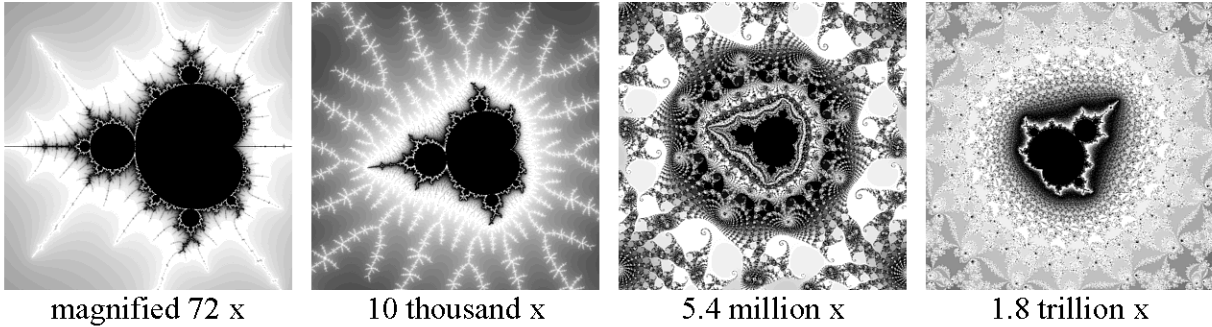


edge magnified 10x



edge magnified 100x

With fractals, no matter how much you zoom in, you never run out of detail. There is literally an infinite amount of detail in every fractal. That detail is usually made up of small copies of the overall shape. For example, if we zoom in to the right spots on the Mandelbrot set, we see small copies of the set buried inside:



## Defined by Iteration

The differences between smooth shapes and fractals arise from how the shapes are generated mathematically. Smooth shapes can often be described by relatively simple equations, such as  $x^2 + y^2 = r^2$  for a circle, or  $Ax + By = C$  for the side of a triangle. Fractals are generated in an iterative process, where the result from one step is used as the input for the next.

In Ultra Fractal, each pixel in the image represents a complex number (a number with 2 parts),  $z_0$ , like a pair of map coordinates. Every fractal has its own characteristic formula, and the number  $z_0$  is used with this formula to generate a sequence of numbers:

iteration	input	output
1	$z_0$	$z_1$
2	$z_1$	$z_2$
3	$z_2$	$z_3$
	...	
n	$z_{n-1}$	$z_n$

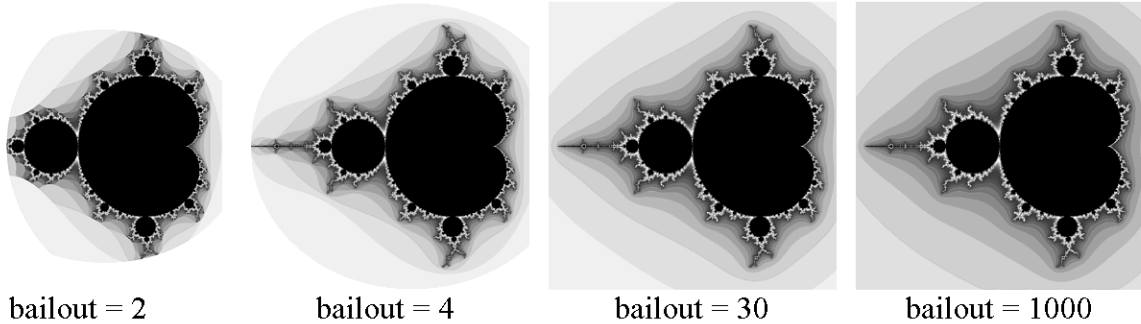
At each iteration, the previous result is fed back into the formula as the new input.

Depending on the formula and the numbers chosen, different things will happen to the sequence. With the Mandelbrot set, some numbers (pixels) will lead to a sequence that gets bigger and bigger, never turning back. These pixels are termed “Outside” points and are shown in white and gray above. Other numbers begin sequences that settle down into repeating patterns, or meander about without ever getting too big. These pixels are termed “Inside” points and are shown in black above. The boundary between the “Inside” and “Outside” points is the actual fractal, and is where most of the interesting detail lies.

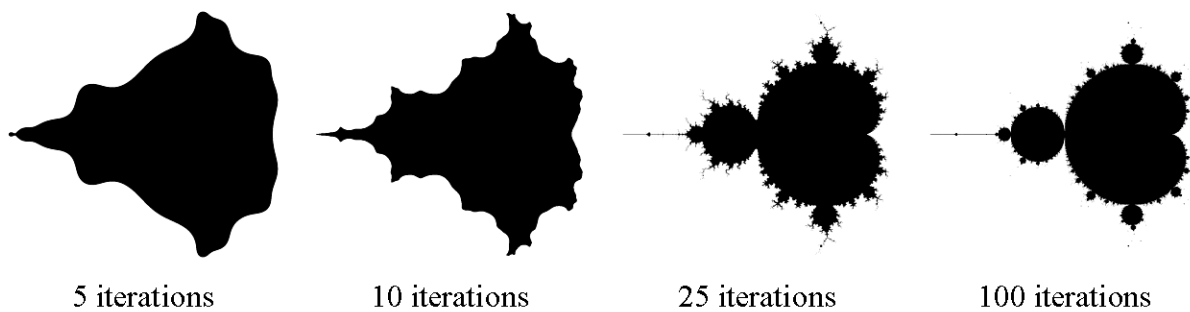
## Approximating Infinity

Mathematically, the outside points are those pixels such that the numbers in their sequence become infinitely large, and the inside points are everything else. For example, the point (1, 1) is an outside point, and its sequence is: (1, 1), (1, 3), (-7, 7), (1, -97), (-9407, -193), (88454401, 3631103), (7810996147272190, 642374081668607), etc. The numbers are getting larger and will continue to infinity. However, we can’t iterate a point infinitely to see what happens, but we don’t need to. For a given fractal, we can tell when a sequence of numbers is going to continue

to grow to infinity. Once the sequence crosses a certain threshold, it will never come back and we know that point is an outside point. In Ultra Fractal, that threshold is typically called the “Bailout value.” Setting the bailout value too large generally doesn’t matter, but setting it too small can cut off some of the fractal. Here is the Mandelbrot set shown using various bailout values; the smallest value that can be used without cutting off any of the image is 4.



But what happens if the sequence never grows larger than the bailout value? We stop iterating when we’ve had enough, by specifying how many iterations we will allow for each pixel (say, 100 or 1000). If the sequence doesn’t bailout by then, we can consider the point an inside point. Some care must be taken though: many pixels that appear to be inside are really outside points when given enough iterations. Increasing the maximum iterations will add detail to an image if that image has some inside points in it. However, that increase in detail comes at the expense of increased calculation time. Here is the Mandelbrot set shown with various numbers of maximum iterations:

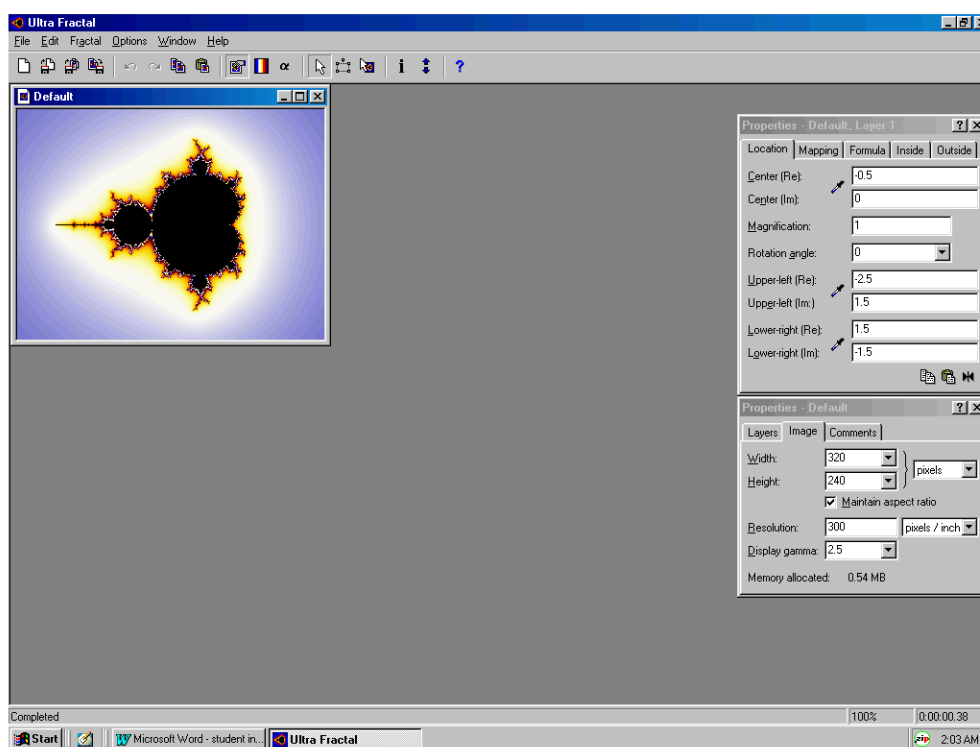


# Using Ultra Fractal

Now that you know what a fractal is and have seen some examples, we'll see how to use Ultra Fractal to create some basic Mandelbrot and Julia fractal images.

## Starting Ultra Fractal

To start Ultra Fractal, click on the "Start" menu in the lower left corner of the screen. From there, choose, "Programs | Programming Apps | Ultra Fractal | Ultra Fractal 2.04." Click through the opening splash screens until you see something like this:



This screen shows the image window (the small window in the upper left corner), and the two properties windows (on the right). We'll use the properties windows to specify the formula and the location parameters for the fractal, and see the result in the image window. We'll start with the basic fractal, the Mandelbrot set.

## Formula

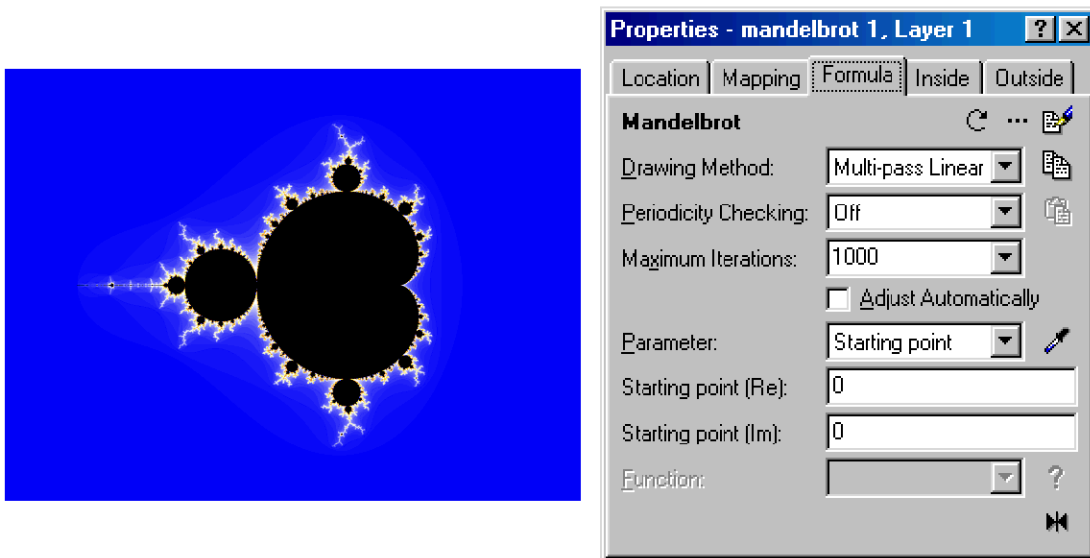
- Close any open images by clicking the "X" icon in their upper right corners. Don't bother to save them; we'll figure that out later.
- In the "File" menu, choose "New | Fractal," or press Ctrl+N. This opens the "Select Formula" browser. You can also click on the "New Fractal" icon on the left of the toolbar.

- Click the “+” on the left of the folder icon labeled “standard.” This shows the files in the “standard” folder, including “Julia” and “Mandelbrot.”
- Click on “Mandelbrot.” A small image will appear in the browser window, and the formula’s code will be shown beneath the image.
- Click “OK.”

A computer can only approximately represent a fractal, since a true fractal would require an infinitely long time to compute and an infinity of pixels. Here, we’ll make some adjustments to the formula to improve that approximation:

- If the Properties windows are not open, open them by choosing “Fractal | Properties,” or by pressing Ctrl+P.
- In the larger (usually, top) Properties window, click on “Formula” to bring the Formula tab to the front.
- Using the drop-down menu in the “Drawing Method:” box, choose “Multi-pass Linear.” The “Guessing” method is quicker, but less accurate. “One-pass Linear” has the same accuracy and speed as multi-pass, but multi-pass allows you to get a idea of the image quickly, then more details with each pass.
- Using the drop-down menu, set the “Periodicity Checking” to “Off.”
- Set the “Maximum Iterations” to 1000, either by typing in the value or using the drop-down menu.

Your image and the Formula tab of the Properties window should look something like this:



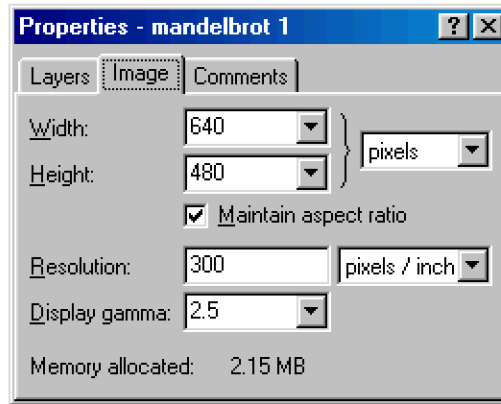
## Size

Now that we have an image, let’s make sure that it’s large enough to see:

- Click on the word “Image” in the smaller (usually, lower) Properties window, to put that tab on top.



- Set the “Width” to 640 pixels by typing the number in the box or using the drop-down menu (click the arrow on the right of the Width window). Set the “Height” to 480 pixels. If the “Maintain aspect ratio” boxed is checked, then setting the width or height will automatically adjust the other parameter. The smaller Properties window should resemble this one:

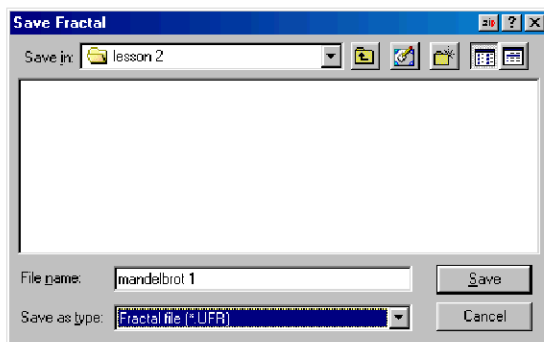


## Saving the Fractal File

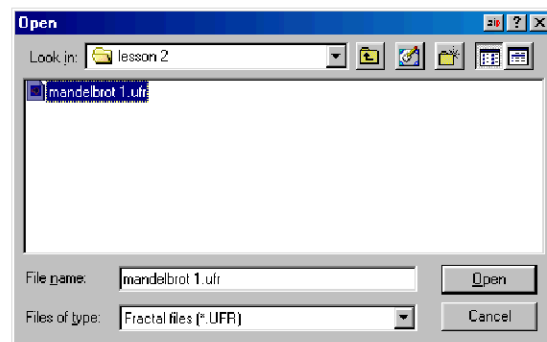
Before continuing, let’s save our work. Ultra Fractal has two methods for saving a fractal. The first method saves a copy of the image and all the information needed to regenerate it in a “fractal file,” which has the extension “.ufr.” When you save a fractal as a .ufr, you can open it later and the finished fractal will be there, just as it was when you saved it.

To save a fractal as a fractal file, choose “File | Save As...” if this is the first time you’ve saved the file, or “File | Save” (Ctrl+S) to re-save a modified file. You’ll see a “Save Fractal” dialog box, where you can specify the folder and name for the file. The “Save as type” box only has one option, “Fractal Files (\*.UFR),” to remind you that you’re saving a fractal file.

Save your fractal as “mandelbrot 1.ufr.”



“Save Fractal” dialog box



“Open” dialog box

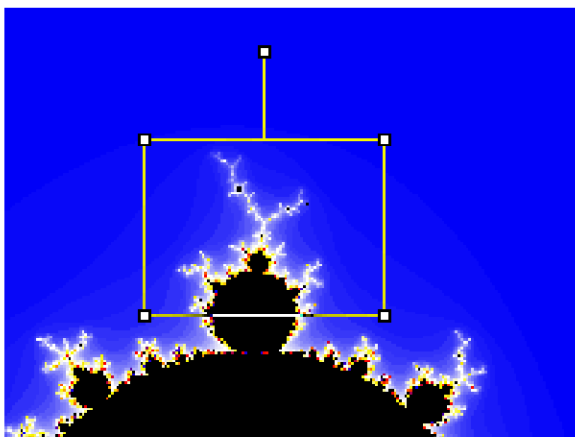
You can open a fractal file from the “File” menu. Choose “File | Open...” or press Ctrl+O. The “Open” dialog box will display any fractal files (\*.UFR) in the current folder. If you file lies in another folder, use the directory tools to find and open it.

Open the fractal you just saved to verify that it was saved correctly.

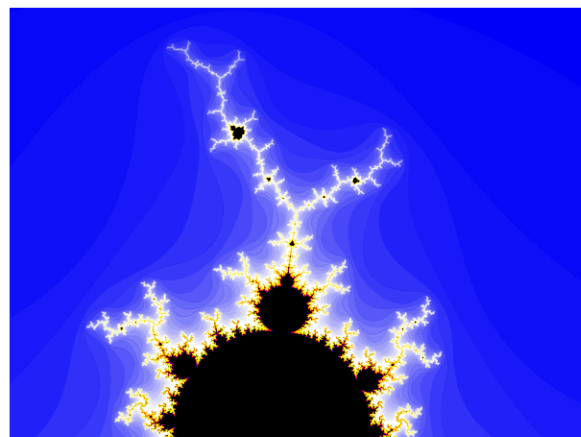
## Location

Much of the joy of fractal exploration comes from zooming into a fractal. The easiest way to zoom in is to use a zoom box. Here, we'll use a zoom box to magnify the disk at the top of the set:

- Open "mandelbrot 1.ufr" if it isn't already open.
- Move the mouse so that the tip of the cursor is that the place where you want to zoom. For this example, place the mouse tip near the Y-shaped branch near the top of the image.
- Click the left mouse button and drag. This creates a zoom box, a rectangular outline with a handle on the top. The box shows the region of the image that will be magnified.
- Double-click inside the box or press the F9 key to zoom in. You can also zoom in by clicking on the icon containing the "+" and the magnifying glass in the "Select" pop-up window.



zoom box



zoomed image

## Saving the Fractal Parameters

This is a good time to see the second way of saving a fractal, saving the parameters. The parameters for an image are all the formula settings, locations, and coloring information needed to recreate the image. Here are the parameters for the zoomed image, above:

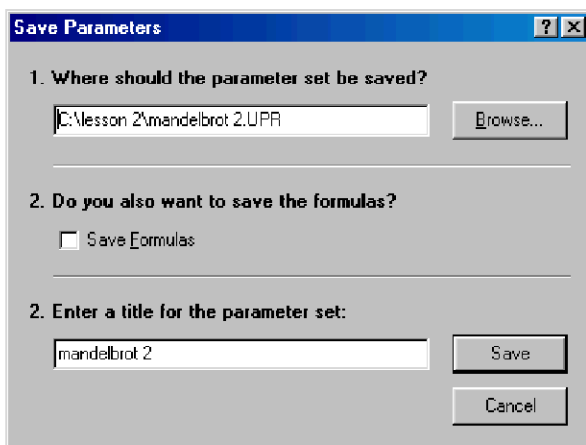
```
mandelbrot2 {
fractal:
  title="mandelbrot 2" width=640 height=480 author="Kerry Mitchell"
  created="October 5, 2001" numlayers=1
layer:
  method=multipass caption="Layer 1" visible=yes alpha=no
mapping:
  center=-0.0999999999999999744/0.9437500000000000128
  magn=7.11111111111111104 angle=0
formula:
```

```

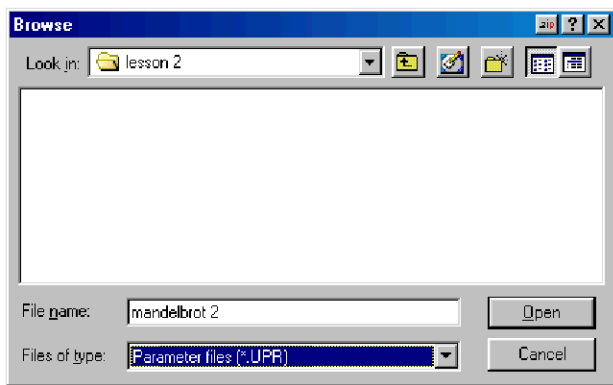
filename="standard.ufm" entry="Mandelbrot" maxiter=1000 percheck=off
p_start=0/0 p_power=2/0 p_bailout=4
inside:
  transfer=none repeat=yes
outside:
  transfer=linear repeat=yes
gradient:
  smooth=yes numnodes=4 index=0 color=16711680 index=100 color=16777215
  index=200 color=65535 index=300 color=255
}

```

The parameters are stored as text, so they are very easy to share with friends who use Ultra Fractal. Also, the parameters take up much less space than a .ufr file. To save the parameters, choose “File | Save Parameters...” or press Ctrl+A, opening the “Save Parameters” dialog box.



“Save Parameters” dialog box

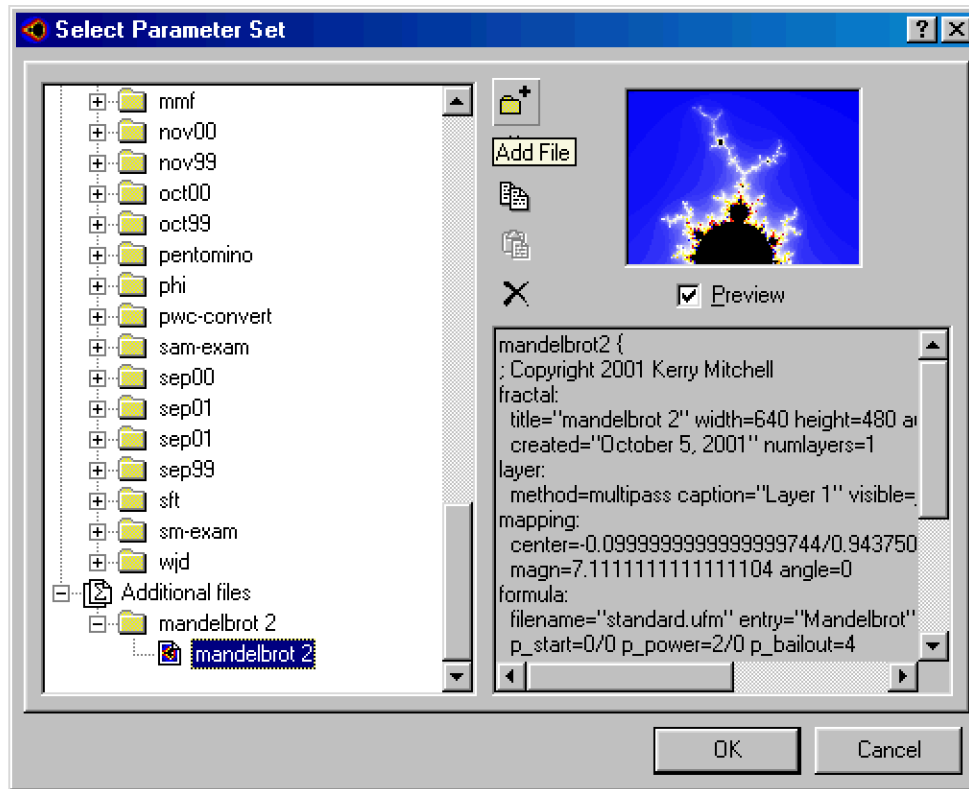


“Browse” dialog for “Save Parameters”

Click on the “Browse” button to open the “Browse” dialog box, where you can specify the folder and name for the parameter set. The parameters for many images can be saved in the same file. By default, Ultra Fractal uses the extension “.upr” to refer to parameter files. They are text files and can be opened in any word processor or text editor (like Word or Notepad). For now, leave the “Save Formulas” box in the “Save Parameters” window unchecked. If you have previously saved the fractal, its title will be entered automatically, but you can change it if you like.

Save the parameters for this image in the “mandelbrot 2.upr” file, and name the fractal, “mandelbrot 2.”

You can open a parameter file from the “File” menu. Choose “File | Browse | Parameters...” or press Ctrl+B. The “Select Parameter Set” browser will display the names of parameter files (\*.UPR) in Ultra Fractal’s parameter folder. If the desired file is not in this folder, click the “Add File” icon (the folder with the + to the right of it), to open the “Add File” dialog box and locate the file.



Once the file has been located, click on the “+” on the left of the folder icon to expand the folder and show the names of the parameters sets included in the file. Click on the name of a set to load its code into the lower browser window. If the “Preview” box is checked, then a small version of the fractal will generate in the upper browser window. Click “OK” to the parameters. When you load a fractal from the parameter set, Ultra Fractal has to re-compute the image, which can be quite time-consuming for complicated images.

Load the “mandelbrot 2” parameter set, to verify that you saved it properly.

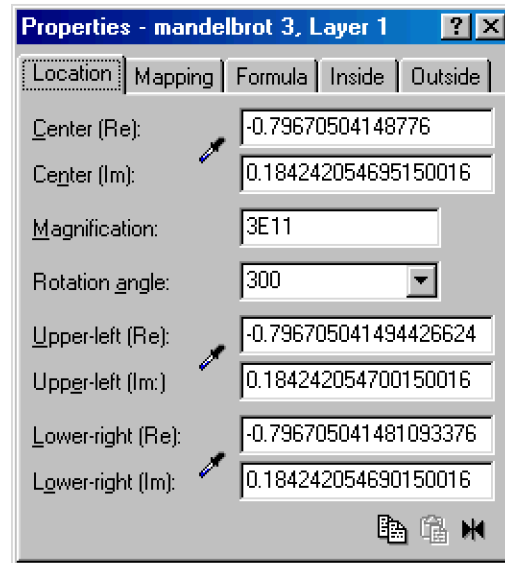
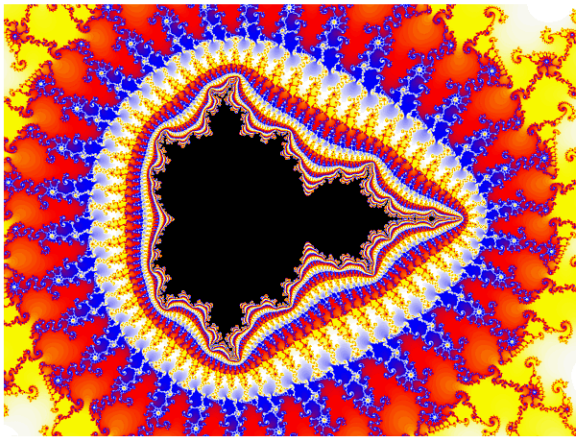
## More Location

If you know exactly where you want to go in a fractal, then you can enter the location directly:

- Open the “mandelbrot 2” if it isn’t already open.
- Click on the word “Location” in the larger Properties window, to bring that tab to the front.
- In the “Center (Re):” box, type -0.79670504148776. This is the real part of the complex number representing the center of the screen. After you change any parameter, Ultra Fractal begins redrawing the image.
- In the “Center (Im):” box, type 0.18424205469515. This is the imaginary part of the complex number representing the center of the screen.
- For the “Magnification,” type 3e11. The larger the magnification, the deeper into the fractal you’re zooming. Ultra Fractal can handle zooms up to about 1e16, or  $10^{16}$ , or

10,000,000,000,000,000. The program accepts scientific notation for entering very large or very small numbers.

- For the “Rotation angle,” type 300. Ultra Fractal uses degrees as its units of rotation.
- Save this image as “mandelbrot 3”, either as a fractal file (“mandelbrot 3.ufr”) or as a parameter set (“mandelbrot 3” in “mandelbrot 2.upr”--use the same .upr file as before).
- Your image and the Location tab should look like this:

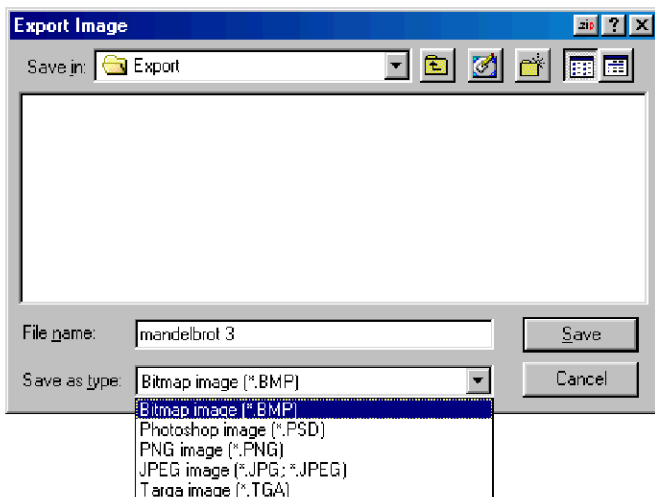


You can (and should!) zoom out by repeatedly pressing F10 to see how this zoom relates to the overall set.

## Exporting the Image

When you save a fractal, either as a fractal file or as a parameter set, you can later recreate the image exactly. Ultra Fractal also allows you to export the fractal as an image (e.g., JPEG or Windows Bitmap) for use in another program or on a web site. In exporting, only the pixel colors are saved, not the underlying fractal recipe. So, once you export an image, you can't reload the exported image into Ultra Fractal.

To export the finished fractal image, choose “File | Export Image...” or Ctrl+E. This opens the “Export Image” window.



“Export Image” dialog box



“JPEG Export Options”

Choose the folder and enter the file name. You can save the image in a variety of 24-bit formats: Windows Bitmap (.bmp), Photoshop (.psd), PNG (.png), JPEG (.jpg), or Targa (.tga). If you choose JPEG, you will be prompted for the quality setting. The higher the quality, the less the image is compressed. You can either accept the default or choose another quality setting.

Export “mandelbrot 3” as a JPEG (.jpg), then view it in a web browser or image processor to verify that you exported it correctly.

## Switching to a Julia Set

The Mandelbrot set contains an infinite amount of detail, but it is only one type of fractal. Related to the Mandelbrot set are the Julia sets. For each point in the Mandelbrot set, there is a separate Julia set fractal. To see them, we’ll use Ultra Fractal’s “Switch” mode.

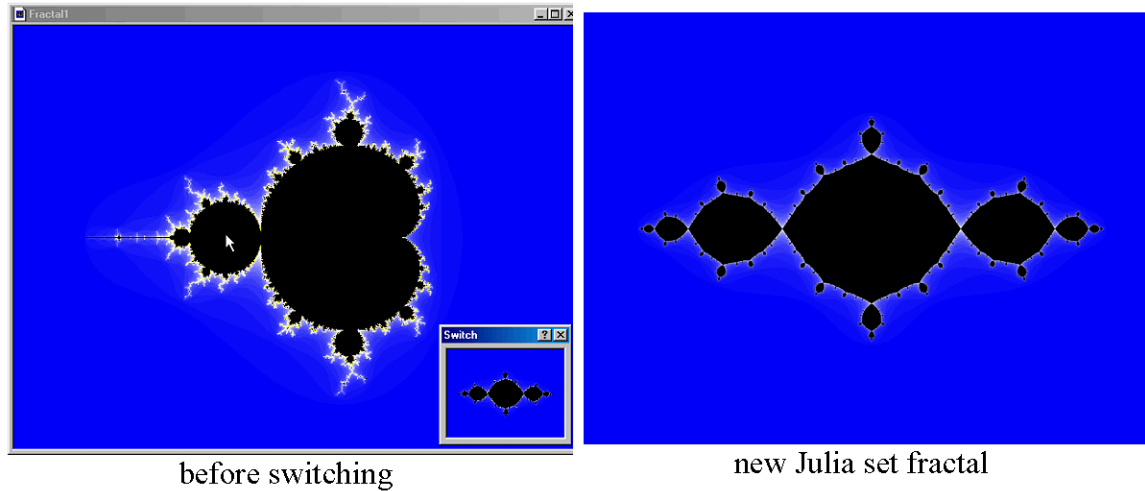
Start from scratch and make a basic Mandelbrot set image:

- Close any open fractals.
- In the “File” menu, choose “New | Fractal,” or press Ctrl+N.
- Choose the “Mandelbrot” formula from the “standard” folder, and click “OK”.

Now, open a “Switch” window to preview the Julia sets:

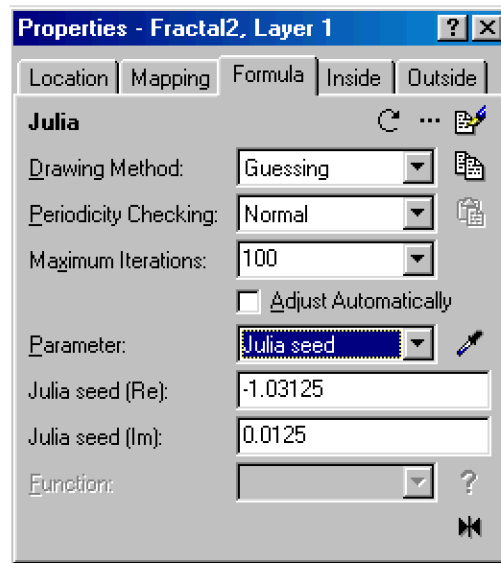
- Choose “Fractal | Switch Mode” or press Ctrl+J. This will open a small window titled, “Switch.” Click in the title bar of that window and drag it to some convenient part of the screen where it doesn’t block the Mandelbrot image.
- Move the cursor around the Mandelbrot image. As you do, you should notice that the contents of the Switch window change. This window is showing a preview of the Julia set associated with the point where the cursor is.

- Place the cursor at the center of the large circular disk on the left of the Mandelbrot set. Without moving the mouse, single-click and a new window will open, containing the Julia set for that point. The “before” and “after” should look something like this:



Look at the “Formula” tab for this image. The name of the formula should read, “Julia.” The top 3 parameters are the same as for the Mandelbrot image; they are standard for all images. The bottom parameters are specific to this formula and are:

- “Julia seed”: should be approximately -1 (Re) and 0 (Im). Changing this parameter will create a different fractal. If you know the seed values for a particular Julia set, you can type them in directly.
- “Power”: the default setting is 2/0 (Re/Im).
- “Bailout value”: defaults to 4.



## Other Fractal Types

You can create different types of fractals by using different calculation formulas. To change the formula you're currently using, click on the "Select" icon (three dots) on the "Formula" tab in the larger "Properties" window. There are thousands of formulas from which to choose; here we'll see a sample of some of the most popular and easiest to use.

### Mandelbrot and Julia

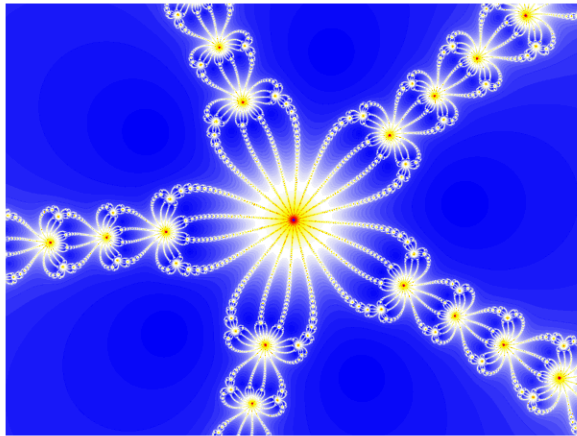
By far, the most frequently used formulas are the Mandelbrot and Julia from the "standard" folder. They have spawned hundreds of formulas which modify the basic idea in one way or another. In your explorations with them, be sure to investigate the effects of changing the "Power" parameter. In particular, see what happens when you use a non-real value--set the "Power (Im):" parameter to something other than zero. Remember, you can always switch between the Mandelbrot and Julia formulas by using the Switch mode (Fractal | Switch mode, or Ctrl+J. If a pair of formulas offers this feature, they will generally have the same name except for "Mandelbrot" and "Julia". For example, in the "lkm" folder, the "Fibonacci Mandelbrot" formula switches to the "Fibonacci Julia" formula, and vice versa.

### Newton

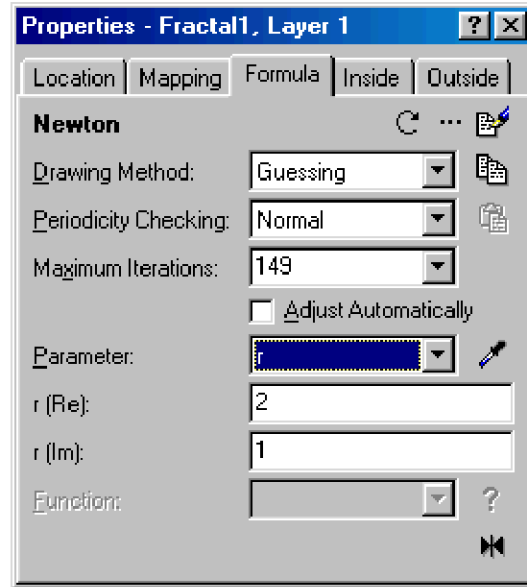
Newton's method is a technique for solving equations, and was developed by Isaac Newton, one of the inventors of calculus. The method works very well in general, but when it doesn't work, it gives fractals. Generally, fractals made with Newton's method solve the equation,  $z^n = 1$ , finding the  $n^{\text{th}}$  roots (cube roots, fourth roots, etc.) of 1.

To create Newton's method fractals, select the "Newton" formula from the "Fractint" folder inside the "Compatibility" folder. This formula uses Newton's method to solve  $z^{\text{degree}} = r$ , where you input the degree and the constant  $r$ . The defaults for the degree and  $r$  are 3 and 0/0. Using 0/0 for  $r$  won't generate anything interesting, so change  $r$  to 2/1 and the degree to 5 to get something like this:



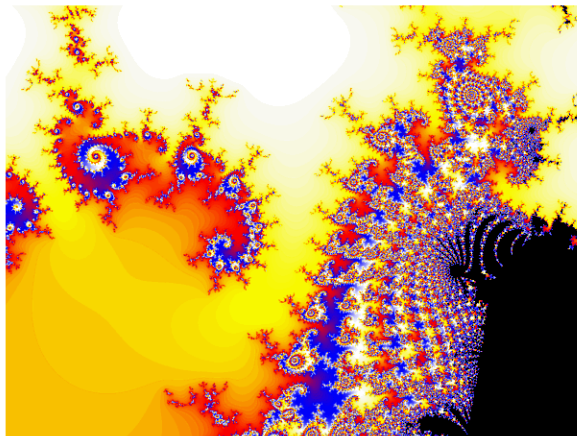


Newton fractal, degree = 5

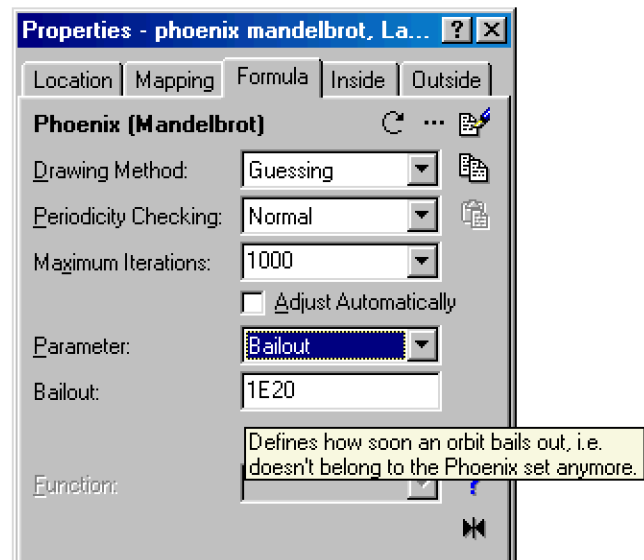


## Phoenix (Mandelbrot | Julia)

The original Phoenix formula was developed Shigehiro Ushiki, and many variations were created by Damien Jones. The image below uses the “Phoenix (Mandelbrot)” formula from the “dmj” folder. The center is at  $-0.8118/0.0353$  and the magnification is 350. This formula, like most in the “dmj” folder, incorporates additional parameters to give you more flexibility. Hints help you learn what the parameters do and how to set them. To see the hints, place the cursor in the entry box for a given parameter. If the formula author has put hints in the formula, the hint will show up briefly in a pop-up window. Here, we see the hint for the “Bailout” parameter.

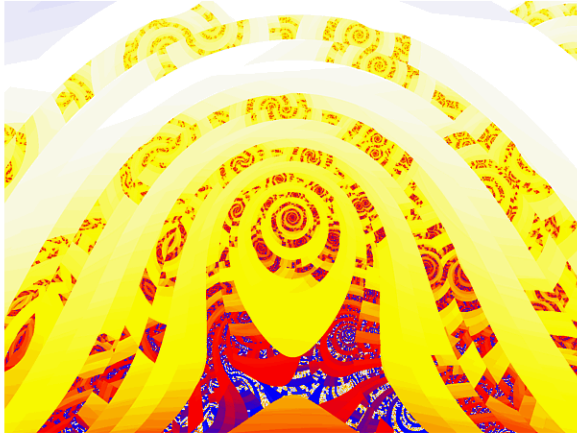


Phoenix (Mandelbrot) zoom

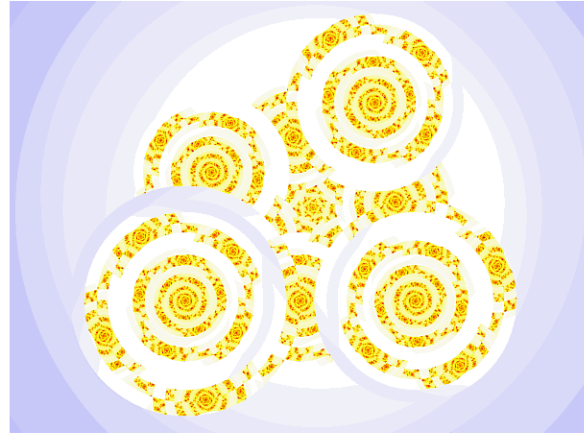


## General Tent Mandelbrot | Julia

The Tent map is a formula used in the study of chaos. The “General Tent” formulas generalize the idea of the Tent map for use in creating fractals. They were written by Kerry Mitchell and are located in the “lkm” folder. The General Tent Mandelbrot offers several fundamentally different types of fractals, through the “r type” and “rotation type” drop-down menus. Here are examples of a zoom into a General Tent Mandelbrot image, and the General Tent Julia corresponding to the center of the Mandelbrot zoom.



General Tent Mandelbrot



General Tent Julia

# Rendering Images

The calculation formula (Formula tab) determines the basic shape of the fractal, but its final appearance is also affected by the coloring formulas (Inside and Outside tabs) and the gradient.

## Coloring Formula

The coloring formulas communicate with the calculation formulas to transform the sequence of numbers into a final color. You can use separate colorings for the inside and outside points; they both work in the same basic way. Select a coloring by clicking on “Outside” (or “Inside”) to bring that layer to the front of the Properties box. Click on the “Select” icon (three dots) and choose the desired file and formula, just like choosing a calculation formula.

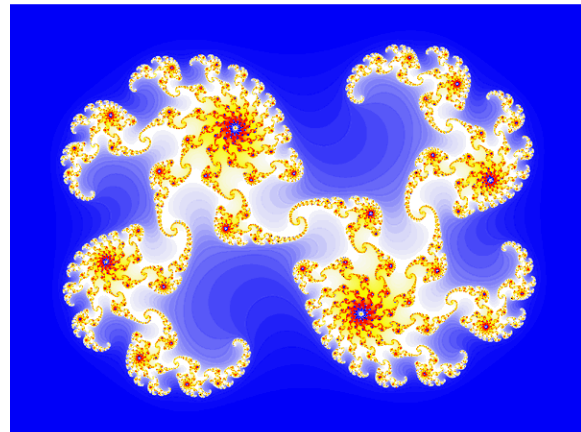
Let’s see the effect of using different colorings using a Julia set. This fractal has no inside points, so we’ll just use the Outside tab. Create the following fractal from scratch.

On the Formula tab:

- Formula = “Julia” (“standard” folder)
- Drawing Method = Multi-pass
- Periodicity Checking = Off
- Maximum Iterations = 1000
- Julia seed (Re/Im) = 0.329417/0.04202
- Power (Re/Im) = 2/0 (default)
- Bailout value = 4 (default)

On the Location tab:

- Center (Re/Im) = 0/0 (default)
- Magnification = 1.5
- Rotation angle = 90

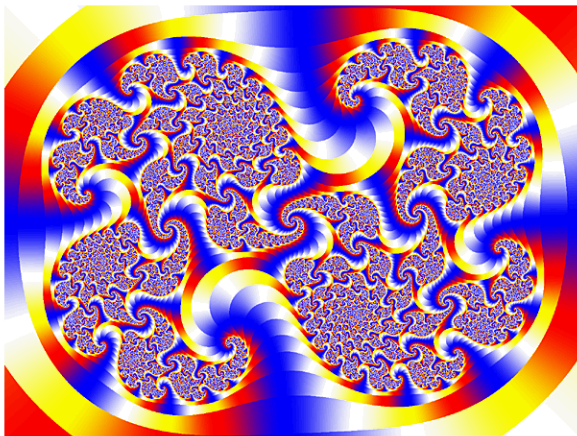


Your image should resemble the one shown on the right.

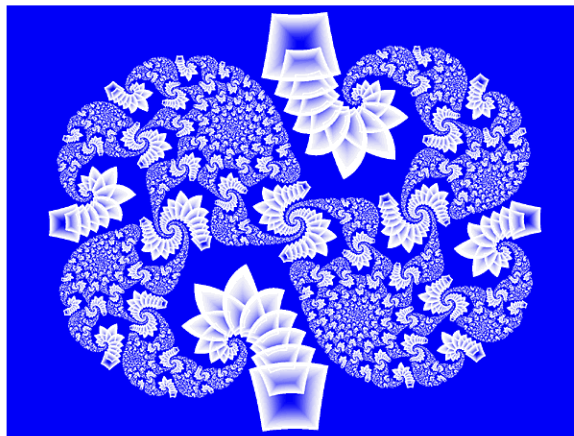
## Basic

The “Basic” coloring is so called because it uses some of the basic, or traditional, means of coloring a fractal. You can color by how many iterations are required before the bailout value is reached, or by the magnitude, angle, real part or imaginary part of the last complex number (when the iteration stopped). On the Outside tab, load the “Basic” formula from the “lkm” folder. When the coloring is loaded, you may not notice a difference. That’s because the “color by” parameter defaults to “iteration,” which is the same coloring that Ultra Fractal uses by default. Notice how the image is composed of bands, each band being the same color. We can fill those bands with color by changing the “color by” parameter to “polar angle.” Now, each pixel is colored by the angle of the last complex number. Remember that complex numbers can be thought of as map coordinates or as a distance and heading from the point (0, 0). Here, the

image is colored according to the last heading. Save this image as “polar angle.ufr.” Try the other settings and see how they change the coloring of the fractal, but not its basic shape.



“Basic”



“Orbit Traps”

## Orbit Traps

“Orbit Traps” is a coloring with many, many more choices than “Basic.” It was written by Damien Jones, and you can find it in the “dmj” folder. As the iteration proceeds for any given fractal, the sequence of complex numbers (the orbit) can be viewed as points on a plane. The orbit can be “trapped” by seeing how close it comes to a shape embedded in the plane. Then, that distance away from the shape can be used to color the image. That is the basic idea behind “Orbit Traps.” When you consider the number of possible shapes (circles, rectangles, etc.), the location and size of the shapes, and how the orbit can relate to the shapes, you have a tremendous amount of flexibility with this coloring.

Here is one example: Load the “Orbit Traps” coloring. Using the drop-down menus in the “parameter” box, choose:

- Trap Shape = rectangle
- Trap Mode = farthest
- Trap Center (Re/Im) = 1/0

and leave everything else at the default setting. The image should resemble that shown above.

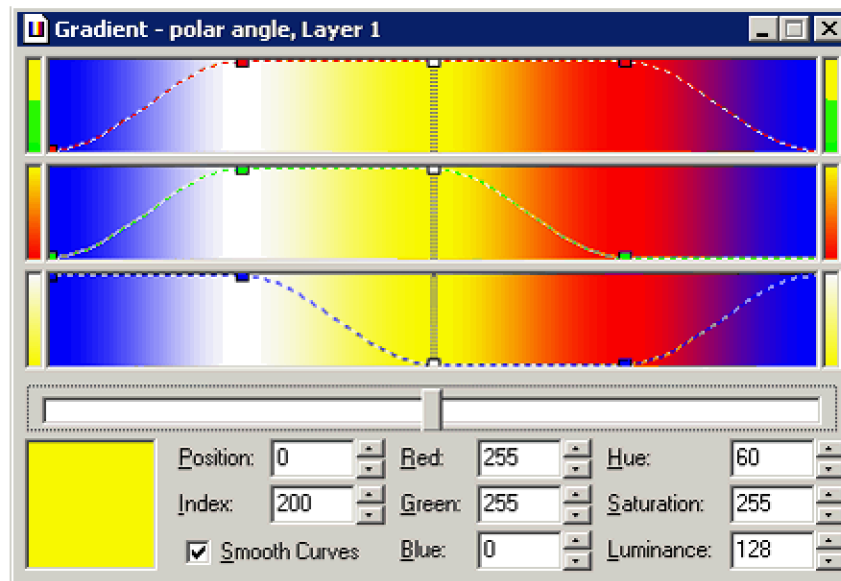
(Hint: if you change something and don’t know what you changed, click on the “Undo” icon in the menu bar (counter-clockwise curved arrow). Or, you can reset all of a formula’s parameters to the default settings by click on the “Reset” icon (two black arrowheads pointing at each other) in the lower right corner of the Properties menu.)

## Gradient

The coloring formula doesn’t determine the actual colors, but the distribution of the colors, like assigning the numbers to the regions in a “paint by number” set. The actual color palette used is provided by the gradient. You can adjust the current gradient, change to a new, pre-created gradient, or change to a new, random gradient.

## Gradient Editor

Load the “polar angle” image from above, and let’s begin by looking at the current gradient. In the “Fractal” menu, choose “Gradient” or press Ctrl+G. Alternatively, click on the “Gradient” icon in the toolbar. This opens the gradient window:



The three horizontal bands of color show the current gradient in the background. The dotted lines in each band indicate the amounts of red (top window), green (middle), and blue (bottom) amount in the gradient.

Below the component windows is a slider bar. Click on it and drag it to the left or right to rotate the entire palette. As you do, you should notice the colors in the fractal changing, as well as the numbers in the “Position” and “Index” boxes. The position indicates the relative rotation of the gradient, from  $-200$  (half a cycle left) to  $+200$  (half a cycle right). For fine adjustment, you can change the position by clicking on the up and down arrows.

## Control Points

The “control points” determine the amounts of red, green, and blue in the gradient. In the screen shot above, there are 4 squares in each of the top, middle, and bottom windows. These squares indicate the position of the control points. The third one, in the middle of the gradient, is highlighted. The vertical line running through the squares indicates that this is the active control point. Click on a square to activate it. Once a control point is active, its components are shown in the windows. Each control point has red, green and blue components that can vary from 0 (none) to 255 (full). You can change the color of the control point by typing in the red, green, and blue values, or by dragging the squares up and down with the mouse.

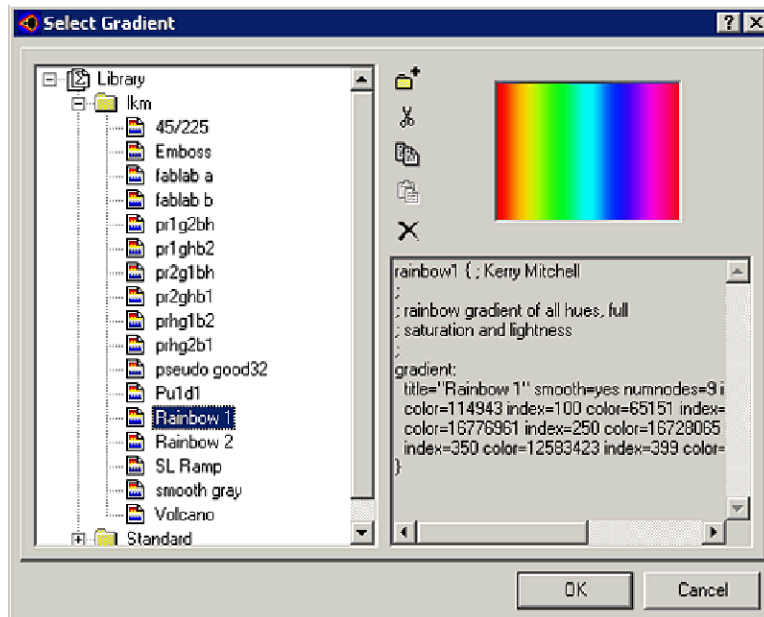
A gradient can have up to 400 control points. To add a new control point, click on the “Insert” icon in the toolbar (note that the toolbar changes when the gradient window is active). In the

gradient window, the mouse cursor is replaced by an arrow with a “+” next to it, indicating that Ultra Fractal is ready to add a control point. Click on a spot in the gradient where there isn’t already a control point, and a new one will be created.

The colors between control points are interpolated by Ultra Fractal. For example, between a black control point and a white one, the gradient would be shades of gray. You can control how the colors are interpolated by checking or clearing the “Smooth Curves” box. When the box is cleared, the lines between control points are straight; checking it makes the lines curved.

## Loading Gradients

Instead of altering your gradient, you can load one that has already been created. With the gradient window open, choose “Edit | Paste Special...” This opens the “Select Gradient” browser, which functions like the formula and coloring browsers. Click on the “+” left of a folder icon to show the contents of that folder. Then, click on the name of the gradient. This shows the gradient in the upper right corner of the browser window and the code for the gradient in the lower right. If that’s the gradient you want, click “OK.” Otherwise, click “Cancel” and pick a new one. Here is the browser showing the “Rainbow 1” map in the “lkm” folder:



## Random Gradients

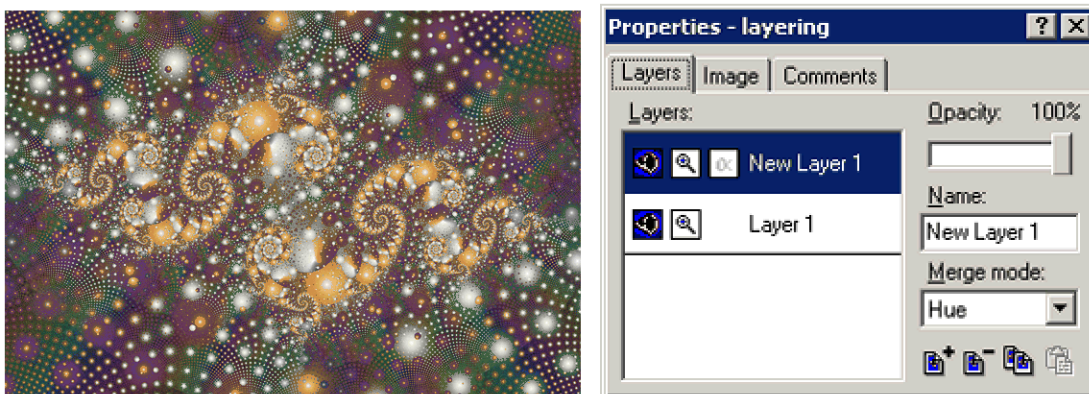
Finally, you can have Ultra Fractal create random gradients for you. With the gradient window open, select “Gradient | Randomize” or press Ctrl+1. If you want a bright gradient, try “Gradient | Randomize Bright” (Ctrl+2), or “Gradient | Randomize Misty” (Ctrl+3) for a misty palette.

## Layers

A great deal of Ultra Fractal’s power and appeal comes from its ability to create images in layers. Before Ultra Fractal, most fractal programs created single-layer images—just one fractal. Ultra



Fractal allows you to combine several fractals into one final image, each fractal being its own layer. With layering, you can create effects that aren't possible (or at least, aren't easy) using only one layer. Layers are controlled through "Layers" tab in the smaller (lower) Properties window. Here we see an example of an image with two layers and its corresponding Properties window:



For an image with multiple layers, the important aspects are the layer's name, its opacity, and how it is merged with the rest of the layers. By default, every image starts with "Layer 1," and new layers are named, "New Layer 1," "New Layer 2," etc. Type the layer's name into the "Name:" box, and it is duplicated in the layer listing. Each new layer is merged with the stack of previous layers to compose the image. The "Merge mode:" drop-down menu provides a variety of options for merging the active layer with the stack below. See the help files for more information on the specific merge modes. Finally, the opacity determines how strongly the active layer is used in the merging process: 0% opacity means that the layer is ignored and 100% means that the layer is fully utilized. Set the opacity with the slider and the percent value is shown.

## Layering Tutorial

Now, let's see how to create a two-layer image like the one above. Create a new fractal using the specifications below. If something isn't specified, then leave it at its default value.

Create the first (bottom) layer:

Formula tab:

- Formula = "Julia" ("standard" folder)
- Drawing Method = "Multi-pass"
- Periodicity Checking = Off
- Maximum Iterations = 1000
- Julia seed (Re/Im) = -0.8/ 0.2
- Bailout value = 1e12 (1 with 12 zeroes following)

Location tab:

- Magnification = 1.3

Outside tab:

- Formula = "Gaussian Integer" ("lkm" folder)

- Color Density = 2
- Transfer Function = “Sqrt”
- Image tab (clear the “Maintain aspect ratio” box):
- Width = 600
- Height = 400

Gradient:

- Gradient = “SL Ramp” (“lkm” folder)
- Position = 200 (move the slider to the far right)

Create the second (top) layer:

Layers tab:

- Click on the “Add” icon (with a “+” at the bottom of the tab). This creates a new layer named “New Layer 1” which is a duplicate of the bottom layer.

Gradient:

- Reset position to 0
- Gradient = “Rainbow 1” (“lkm” folder)
- Position = 160 (move the slider to the far right)

Outside tab:

- Color Density = 1
- Transfer Function = “Linear”
- color by = “angle @ min” (in the “Parameter:” drop-down menu)

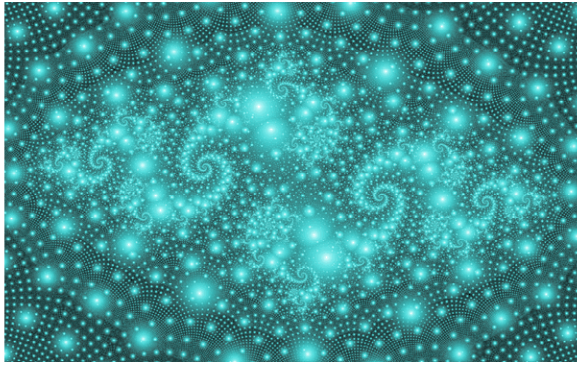
Merge the two layers, using the Layers tab:

- Click on “New Layer 1” to activate that layer.
- Set the opacity to 100%
- Set the Merge mode to “Hue.”

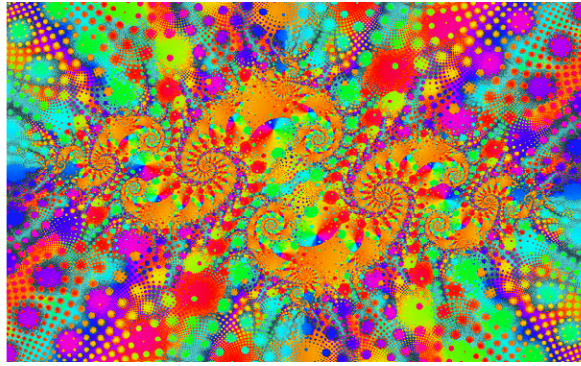
Save this final image as “layering.ufr.” It should resemble the one above. To see what each of the layers looks like by itself:

- Go to the Layers tab:
- In the list of layers on the left of the tab, click on the layer’s name to activate it.
- If the layer is the bottom one, there will be two icons left of the name. If the layer isn’t the bottom, then there will be three icons left of the name. Hold down the Shift key and click on the leftmost icon (looks like a small Mandelbrot set). Each layer is shown below.
- Release the Shift key and click on that icon to toggle each layer on or off.





Bottom layer



Top layer

## Rendering to Disk

Ultra Fractal affords you the opportunity to create very large renders of your images, well over 10,000 pixels on a side. You can't manipulate an image that size, but you can design the image at a smaller scale and have Ultra Fractal generate it at any size you want. The "Render to disk" feature renders any fractal to a disk file, freeing you up to do other things. The primary advantage to disk rendering is the ability to create an image in practically any size.

## Anti-Aliasing

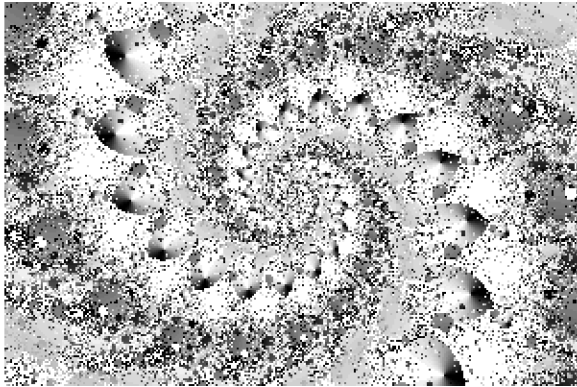
The other major benefit of rendering to disk is anti-aliasing. Fractals contain small details that are too small to be resolved by an individual pixel. A common example is the "jaggies" that appear when an image contains a smoothly curved line. When you look at small details in something far away, your eye blends them together. Ultra Fractal does this by anti-aliasing the image: when the color difference between two adjacent pixels is larger than a certain threshold, sub-pixels are calculated between the two original pixels. Then, the final pixel colors are obtained by averaging together the colors of the sub-pixels. This improvement in quality comes at a price: anti-aliasing can increase the time needed to render the same size image by a factor of 10 or more, depending on the image and the settings.

## Example

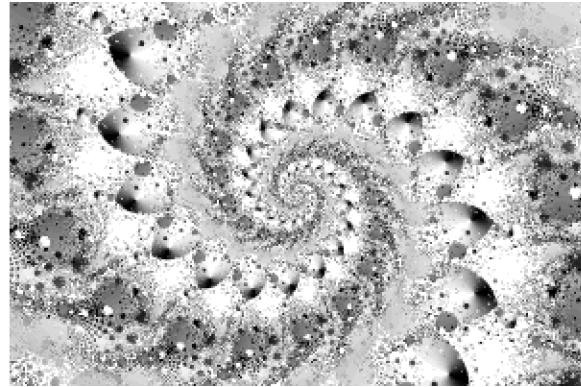
Let's see how this works by rendering to disk a zoom from the "layering.ufr" image:

- Open "layering.ufr" if it isn't already open.
- In the Layers tab, delete "Layer 1." Click on "Layer 1" to activate that layer, then click on the "Remove" icon (with a "-" at the bottom of the tab).
- In the Location tab, make the Center  $-0.5292905 / 0.0971543$  and the Magnification 1875.
- Load the "smooth gray" gradient from the "lkm" folder.

Your image should be fairly grainy and should resemble the one of the left, below.



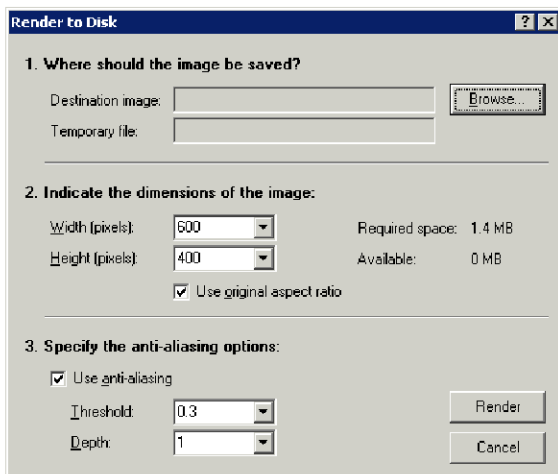
Without anti-aliasing



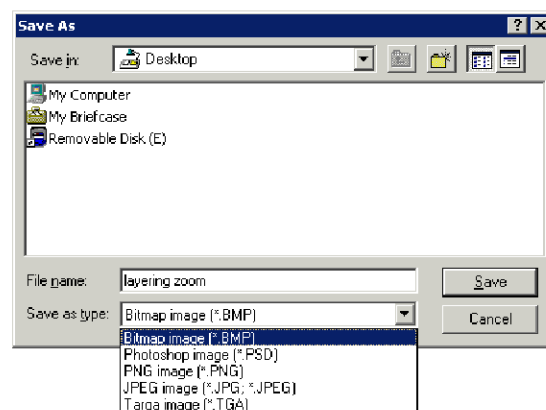
With anti-aliasing (default settings)

To render the image to disk with anti-aliasing:

- Select “Fractal | Render to Disk...” or press Ctrl+R. This opens the “Render to Disk” dialog box.
- Click “Browse” to open the “Save As” dialog box. Specify where you want to save the image, and in what format. The supported formats are, Windows bitmap (.bmp), Photoshop (.psd), PNG (.png), JPEG (.jpg), and Targa (.tga). Click “Save”.
- In the “Render to Disk” dialog, specify the size of the image, in pixels. If the required space is more than that available on the desired drive, you’ll get an error message.
- Specify the anti-aliasing options. Check the “Use anti-aliasing” box and use the default settings of 0.3 for the threshold and 1 for the depth. The threshold is how different adjacent pixels must be before sub-pixels are used; smaller numbers lead to more refinement and a longer render. The depth is how many times the pixels are sub-divided. Roughly, the calculation time increases by a factor of nine with each increase in depth.
- Click “Render” and wait. A status box will show how much time has elapsed, how much of the image is completed, and an estimate of how much time is remaining.



“Render to Disk” dialog box



“Save As” dialog box