Mandella 6.2

0: Contents

I. About Mandella

Mandella is a graphics program for color Macs. It draws mathematical objects called fractals. These fractals can be extraordinarily beautiful and complex. Mandella requires a Mac with an FPU and System 6.0 or later. It also needs to have 32-Bit QuickDraw inside the System Folder if it's used with System 6 (System 7 has 32-Bit QuickDraw built in). The name "Mandella" comes from the title character in the science fiction novel Forever War by Joe Haldeman.

Mandella draws fractals using a palette of 200 colors. It works best with the main screen set to 256 colors. If there are fewer colors the fractals will be dithered yielding an approximation of what the fractal would look like with 256 colors. If the screen has more then 256 colors the fractals will look as they do in 256 colors but animation will be disabled and palette editing will be slightly slower.

This version is a complete rewrite of Mandella 5.6. There have been a lot of changes and improvements. Section XIV has a list of the major changes. I'll be releasing one or two more versions this summer. If you have any suggestions please let me know. My address is at the bottom of this file. If you find any bugs definitely let me know. I can't fix them if I don't hear about them!

I'll be graduating from the University of Washington in March 1993 with a bachelors in Mathematics and a minor in Computer Science. If anyone has a programming position opening up then I'd be delighted to hear from you. I'm also interested in a part-time programming job while I'm still in school.

After you register for Mandella I'll send you two copies of the latest version. One will have the shareware notice the other will not. Feel free to give copies of the one with the shareware notice to your friends. The copy without the shareware notice should be used only by the person who registered. Upgrades are five dollars to registered users.

Mandella cannot be used for any commercial purpose without my express written

permission. This would include the program being sold by for-profit organizations. Bulletin-board systems that charge by the hour are OK as are not-for-profit organizations. Images generated by Mandella may be used however you please.

If you're interested in buying fractal posters, tee-shirts, videos, etc. there are several companies to chose from. Strange Attractions [24] is using Mandella 5.6 to create all kinds of stuff including some really cool posters and tee-shirts. Art Matrix [3] uses a mini or mainframe computer. I've heard good things about Art Matrix but they seem to have a more limited selection then Strange Attractions. If you want a quick and dirty way to print fractals a company named MicroSpot [14] sells a utility called MacPalette that allows you to print full color images on an ImageWriter II.

II. Just what are fractals?

Euclidian geometry is concerned with objects such as points, lines, circles and 3-D shapes like spheres or planes. Classic geometry can be useful but it doesn't describe the real world very well. As Mandelbrot says, "Clouds are not spheres, mountains are not cones, coastlines are not circles, and bark is not smooth" [12].

Fractals, on the other hand, do model reality. Like natural objects fractals are not smooth and they are often self similar. As an illustration consider a mountain. It is obviously not a smooth object. And it is self similar: if we examine part of the mountain we will see peaks and hills that are similar in appearance to the whole mountain.

Fractals vary in their degree of self similarity. For example Julia fractals (figure 3) are very self similar (and therefore rather boring). The Mandelbrot fractal (figure 2) is not nearly as self similar. If you examine it under magnification you can find an amazing number of different shapes including spirals, whirlpools, and stars. Here and there you will also find distorted replicas of the original fractal!

Fractals are quantified using the concept of dimension. Euclidian objects have an integer dimension. For example a line has a dimension of one, the plane has a dimension of two, and a sphere has a dimension of three. Fractals have either a fractional dimension or a dimension greater then their topological dimension.

As an example consider the space filling curve in figure 1. This curve will eventually cover every point in the plane so it has a dimension of two. On the other hand lines have a topological dimension of one so the curve is indeed a fractal. Figure 1 was drawn using a program called Hilbert [9].

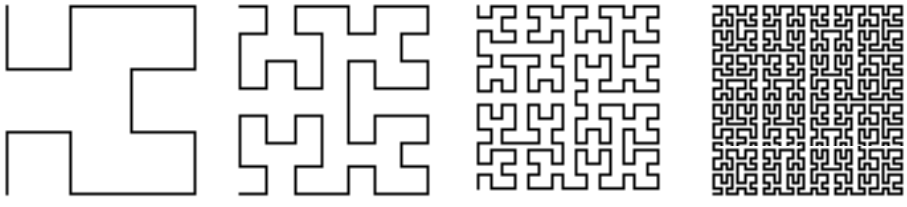

Figure 1: An example of a Space Filling Curve

Fractals are used everywhere the natural world needs to be modeled or described. Scientists are using fractals to model nature [10], and computer scientists are using fractals to produce "natural" images. Some simple examples include the IFS fern and fractal mountains [6, 27]. Many of the special effects in movies are based on fractals. Barnsley is using fractals in a new image compression scheme. He has achieved

compression ratios in excess of 10,000 to 1 [5].

III. Computing Fractals

Most fractals are calculated using complex numbers. Complex numbers are numbers that have both a real and an imaginary component. Real numbers are the standard floating point numbers. Imaginary numbers are multiples of the square root of -1. Complex numbers are usually written as 3+5i where 3 is the real component and 5i is the imaginary component. “i” represents the square root of -1.

Complex numbers can be thought of as number pairs. In other words 3 + 5i can be written (3, 5). If we write them in this way it is natural to use a plane to represent the complex numbers. This is called the complex plane. Each point on the plane corresponds to a complex number. The fractal windows in Mandella can be thought of as windows into a section of the complex plane.

All of the standard arithmetic, trigonometric, and logarithmic functions can be extended so that they work on complex numbers. New functions can also be defined. One of the more important returns the magnitude of a complex number. If z = x + yi then Mag(z) = Sqrt(x^2 + y^2). This is a measure of the “size” of a complex number. It’s also the distance from the origin to the point.

This version of Mandella draws two types of fractals: escape time and dynamical systems (or “orbital” fractals). Escape time fractals are what most fractal programs draw. The algorithm is very simple:

```
count := 0;
REPEAT
   z := z^2 + c;
   count := count + 1;
UNTIL (Mag(z) > 2) OR (count = maxCount);
```

This procedure can be used to determine whether a point is outside the fractal. The fractal is, by definition, the set of all points where Mag(z) is never greater then two. If Mag(z) > 2 then z will increase without bounds, i.e. it will “escape” to infinity. Points in the set typically fall into a loop and so never escape. Points within the set are, by convention, colored black. Points outside the set are colored according to either the count value or the final z value.

It’s important to notice that the algorithm above cannot be used to determine if a point is within the set. Since the loop is executed a finite number of times we can never be sure that the point won’t escape. However if we increase maxCount the image will become a better and better approximation to the fractal. To determine if a point is really in the set we need to somehow check the z values to see if they have fallen in a loop.

The procedure above draws either the Mandelbrot Set or a Julia fractal. For the Mandelbrot Set z is set to zero and c is set to a point in the window (see figure 2). For Julia fractals z is set to a point in the window and c is set to a constant. There are therefore an infinite number of Julia fractals: one for each constant. Julia fractals can be either connected or disconnected. A connected fractal is contiguous (figure 3). A disconnected fractal may be nothing more than a collection of dots. A Julia fractal is connected if the constant c is within the Mandelbrot set. So the Mandelbrot set can be considered a "dictionary" of Julia fractals! Mandella will allow you to pick a point in a Mandelbrot fractal and then draw the corresponding Julia fractal.

Other formulas will produce different fractals. This version of Mandella has 21 Mandel/Julia fractals. There are also 13 “Other” fractals. These work like the Julia fractals but don’t have a corresponding Mandelbrot fractal.

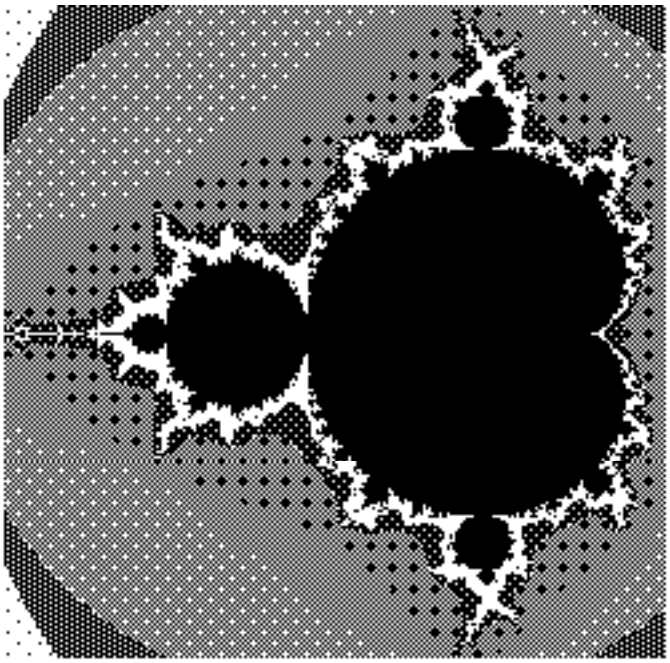

Figure 2: The Mandelbrot Set

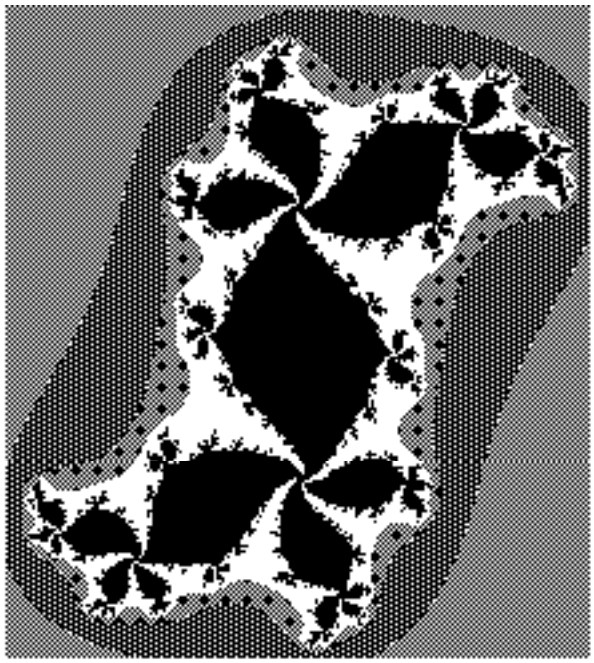

Figure 3: A Julia Fractal

Dynamical systems are a bit different: instead of checking each point in the window to see if it’s in the fractal we plot the trajectory followed by points as the formula is iterated. This trajectory is called an orbit. We can plot the orbits of one seed point or overlay the orbits of several seed points. The result is, strictly speaking, not a fractal. Dynamical systems are related however. When the orbits are plotted the result is often a strange attractor (the Ikeda fractal is a good example of this). The procedure used to plot dynamical systems looks like this:

```
x := seed.r;                    (* real component *)
y := seed.i;                    (* imaginary component *)
count := 1;
REPEAT
   newX := y - Sin(c.r*x);      (* Hopalong3 formula *)
   newY := x - Cos(c.i*y);
   x := newX; y := newY;        (* get next orbit *)
   Plot(x, y);
   count := count + 1;
UNTIL count = maxCount;
```

Note that the formula used real numbers instead of complex numbers. This is usually the case with dynamical systems. Also note that maxCount is used to control the number of orbits that are plotted. Figure 4 shows an example of a typical dynamical system. The original image was in color. Each point was colored according to how often it had been plotted. Mandella has 10 orbital fractals. Pickover [20] has more details on dynamical systems.

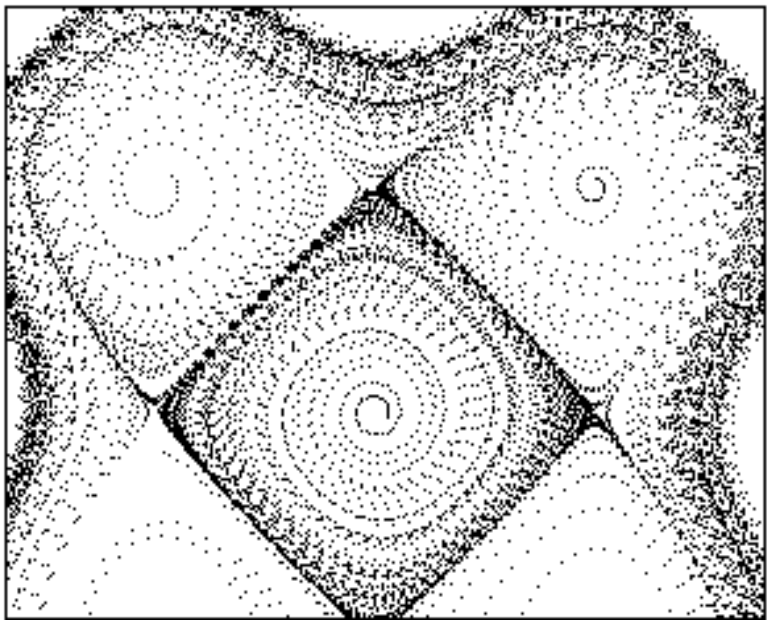

Figure 4: A Dynamical System

IV. Drawing the Fractals

Mandella lets you open as many fractal windows as you have memory for. The frontmost fractal window will be the first to be drawn. After it has been finished the window immediately behind the frontmost window will be drawn. This process will continue until all the windows have been drawn. The frontmost fractal window is marked with a checkmark in the Windows menu. If a window behind the front window is being drawn it will be marked with a hollow diamond (◊).

Mandella will still draw the fractal windows when it is placed in the background. The Draw For sub-menu in the Draw menu can be used to adjust how long Mandella spends calculating points before yielding time to the foreground application. The time Mandella spends drawing is measured using “ticks”. One tick is equal to 1/60 of a second. If Draw For is set too high the foreground application will be slow in responding to the user (e.g. a word processor may take a moment to display text after the user types it in).

Mandella draws escape time fractals using three different methods: Multiple Passes, One Pass, and Line by Line. Multiple Passes is the best method to use when you’re exploring a fractal. It draws a crude representation of the image and successively refines it. Line By Line is the fastest method: it calculates and then draws an entire line before handling any actions by the user (like the mouse and keyboard). One Pass looks similar to Line By Line but uses the Draw For menu so is more responsive to the user.

There’s one problem with Multiple Passes: it’s just about the worst possible way to draw a fractal on a Quadra. The 68040 processor in the Quadra includes a huge data cache that accounts for a large part of the Quadra’s speed. Unfortunately Multiple Passes makes very poor use of the data cache. If you’re running Mandella on a Quadra I’d recommend you use either One Pass or Line by Line. If you still want to use Multiple Passes set the cache to “write-through”.

Multiple Passes uses seven passes to draw images. The first pass calculates the count value for points in a grid with each point being separated by a gap of 32 pixels. The corresponding color is then used to fill a block of 32x32 pixels in the window. The next passes uses a gap of 16x16 pixels, then 8x8, 4x4, and 2x2. After the 2x2 pass is

completed one quarter of the pixels in the image will have been calculated (see figure 5). The next pass is the 2x1 pass it will calculate half the pixels in the odd rows. When it finishes half the pixels in the image will have been calculated. The last pass, 1x1, calculates the remaining points. The effect of all this is to let the user quickly get an idea of what the image will look like when it finishes.

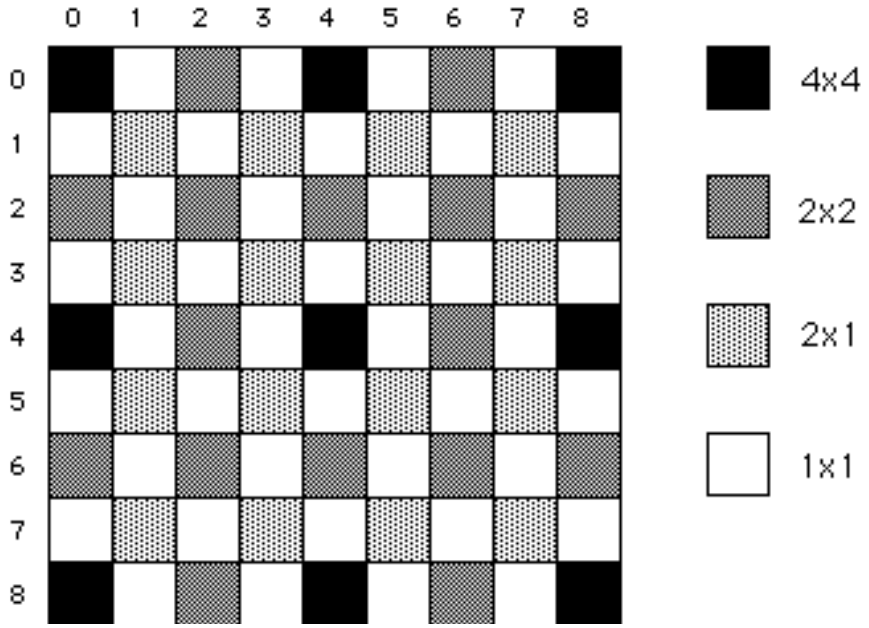

Figure 5: Multiple Passes

There is also another advantage to drawing in this manner: we can use solid guessing. For example while the 1x1 pass is being drawn we can examine the four neighbor points. If they all have the same count value we can simply guess that the center point has the same count value. This will be considerably quicker then calculating the count value. It will also, in general, be a good guess. An even faster route is to do the guessing in the 2x1 pass. Here we examine the four diagonal neighbors. If they all have the same count value we we set the center and its four neighbors to that count value. This won't be as accurate as the 1x1 guessing but it will be faster.

The speed improvement will vary with different images. It will be greatest for images with large sections with the same count values. The improvement is typically around 8% to 15% for 2x1 and 6% to 10% for 1x1. Solid guessing can be controlled using the options dialog for the fractal window (see the Windows section). The default behavior can also be set using the Preferences command in the File menu.

Mandella has one more trick to speed drawing: it does period checking. This catches the points that fall into a loop and hence never escape to infinity. This is a big help when drawing fractals with high values for maxCount. The Mouse window will display count = ∞ for points that are caught by the period checker. Period checking can be turned on or off using the option dialog. There are a few fractals that have problems with the period checker (e.g. Potts1 and Potts2). These fractals have period checking permanently disabled.

Mandella provides ten different ways to draw Escape Time fractals. These methods color the fractal according to the count value and/or the final value of z. There are also five different ways to draw Orbital fractals. The Escape Time methods can be divided into two groups: those that use the final z value to return a floating point number between 0 and 1 and those that simply return the count value. The floating point options are

marked with *. The Escape Time draw styles are as follows:

Level Sets This is the fastest method and the one most fractal programs use. Colors are chosen according to the count value. To get the most out of the palette Mandella uses three numbers called Cutoffs to map counts to colors. The high Cutoff is used for maxCount. Count values between the middle and high cutoffs use the last color in the palette. Counts values between the low and middle cutoffs use the palette. Count values below the low cutoff use the outside color.

Continuous Potential This method generally produces the best looking images. It results in images where the colors shade very smoothly into each other. Most of the color plates in The Beauty of Fractals and The Science of Fractal Images use this method. However, it's slower then Level Sets and is a little more difficult to use since it uses a parameter called "slope". The slope is used to control how quickly colors change in the image. The potential is calculated using the formula: pot := Ln(Mag(z))/(2^count).

Stalks This is a rather cool method. It draws stalks that curve and twist about the image. These stalks are drawn for points where z passes near the origin when the formula is iterated. The user can adjust the size of the stalks by specifying how near the origin z must be for a stalk to be drawn.

Color Inside In this method the interior of the fractal is colored using the magnitude of the final z value. The points outside the set are colored using the background color. This method works best for Julia type fractals.

Decomposition This is a rather weird method where pixels are colored according to the angle z makes with the origin. The result is very strange and occasionally even interesting. The Newton3 fractals look very nice when drawn using decomposition.

Distance Estimator This method does some extra computation to determine how close a point is to the fractal. If the points are nearly in the set they are colored using the filament color. The user can adjust the size of the filaments to make them larger or smaller. This is the slowest method and seems to work best when the image is drawn at a high resolution. The Beauty of Fractals and The Science of Fractal Images have some excellent black and white pictures of fractals drawn using the Distance Estimator.

Biomorph This method was developed by Pickover [20]. It works well for images with low maxCounts. The results look a bit like invertebrates. It works by coloring points using the filament color if both the real and imaginary components of the final z value are large.

Brainy Smurf This is a variation of a method suggested by Richard Hughes (who goes by the name "Brainy Smurf"). The images are colored according to the size of the real component of the final z value.

Ratio This method uses the ratio of the real and imaginary components of the final z value to color the image. The results are similar to decomposition but usually look a little better.

Periodic Here points in the set are colored according to how long they take to become periodic. Points outside the set are colored using the background color. This method doesn't produce very striking images but it's kind of neat to see how the period checker works.

The Orbital fractals use the following draw styles:

Number of Hits Points are colored according to how often they have been plotted. It's usually works fairly well.

Number of Points Colors are chosen according to how many points have been plotted. The first points are colored using the first colors in the palette. The last points plotted use the last colors in the palette.

Displacement Points are colored according to the distance between the new point and the last point. The user can enter a fudge factor to adjust for fractals that have small or large displacements.

Angle Points are colored according to the angle formed by the new point and the last point.

Orbit Number This method works only for multiple seeds. The orbits for each seed are given different colors.

V. Tweaking Images

To get the best results you'll have to adjust the cutoffs, the color map, and pick a good palette. All three are critical to getting the best looking images. Unlike other programs Mandella makes it easy to set these parameters.

To get the most detail from an image the cutoffs must be set properly. The high cutoff should be large enough to ensure an accurate image but not so high as to wash out the colors in the image. The middle cutoff should be set so that there is a small amount of the LastColor around the fractal. The easiest way to do this is to set the LastColor to something noticeable and adjust the middle cutoff until you're satisfied. The low cutoff should be set to the smallest count value in the image. The Info window can come in handy when you are adjusting the Cutoffs. It will optionally display the smallest and largest counts in the image.

The color map is used to map count values into colors. The simplest mapping is linear: counts equal to the low cutoff use the first color. And counts halfway between the low and medium cutoffs use the color in the middle of the palette. The default color map maps the first 1/3 of the counts into 2/3 of the palette. This is usually the best map since most of the points in the image will have low count values.

The color map can be changed using either Bezier curves or root scaling. If Bezier curves are used the color map is changed by dragging the two control points around (the little black squares). If root scaling is used a floating point number is used to create the map. To make it easier to see what's going on a graph is drawn in the Color Map dialog. Root scaling tends to work best once you've zoomed in a bit and there's a large gap between the middle and low cutoffs.

The color map can make a big difference in the appearance of the image. The Info window optionally shows the number of colors used by the image. Changing the color map can cause more or fewer colors to be used. By experimenting with different maps you can maximize the number of colors used or emphasize part of the image.

Finally different palettes can make a dramatic difference in the palette. To begin you can try a number of random palettes (using the Random Palette command) or you can

try one of the built-in palettes in the Palette menu. If you find a palette you like save it using the Add Temp command. When you’re tired of looking at new palettes you can go back through the temporary palettes (via command-number-key) to pick the best one.

You can adjust the way the Random Palette command works by using the Random Options command in the Color menu. There are five options: complexity, saturation, value, palette wrapping, and randomize alternate. Complexity controls how “wild” the palette appears. A high complexity results in a palette with a lot of very different colors. A low complexity results in a palette where the colors change very slowly. Saturation and value work as in the Color Picker (HSV colors). If value is set to a large number the colors in the palette will tend to be very bright. If palette wrapping is enabled the first and last colors in the palette will be the same. This can make palette animation look smoother. If randomize alternate is enabled the alternate colors (see the next section) will be changed whenever Random Palette is selected.

VI. Palette Editing

There are three places where you can change the palette: the image itself, the Palette window, and the Palette Editor (figure 6). Colors in the image (or anywhere else) can be changed using option or command-click. Option-click changes the color to a random value. Command-click allows you to choose a color using the Color Picker.

The Palette window has two arrows to either side. These arrows can be used to rotate the colors in the palette. The Palette window also has two little triangles beneath the palette. These are called markers. They define a range of colors for the Palette Editor. The markers can be dragged with the mouse or they can be moved with the arrow keys. Option arrow moves the left marker. And command arrow moves the right marker. The Palette Editor can also be used to type in the range.

If you option-click in the palette between the markers Mandella will do what I call a "three-way" shade. In other words Mandella smoothly shades from the color at the left marker to the new color and from the new color to the color at the right marker. This feature was inspired by Dave Platt's program MandelZot 2.0 [21].

The buttons in the Palette Editor all operate on the palette range. The color boxes allow you to set the left and right colors. Shade Short and Shade Long do a "two-way" shade: the left color is smoothly shaded into the right. Shade Long will take the long way around the color wheel so that if the left and right colors are close together you will get a rainbow effect. The Random button randomizes the range using the same algorithm as the Random Palette command.

The Shade and Random buttons normally will keep the left and right colors the same so that the palette doesn’t have any discontinuities. If you want to forego a smooth palette you can hold down the option or command keys. The option key will randomize the left or right colors. The command key allows you to choose the left and right colors.

In the middle of the palette editor is a popup menu. If Smooth is selected colors will be smoothly shaded from one to the other. If Alternate is selected every other color will be the alternate color. A color box will appear above the popup menu so that the alternate color can be changed. The last option is Interleave. In this case two alternate colors are used. The color used as the alternate color will be shaded from the first alternate to the second. The alternate options seem to work better with root scaling.

The Invert button inverts all the colors in the palette range. Pressing it twice will

return you to the original colors. The black arrows to the right allow you to adjust either the RGB or HSV components for a range of colors in the palette.

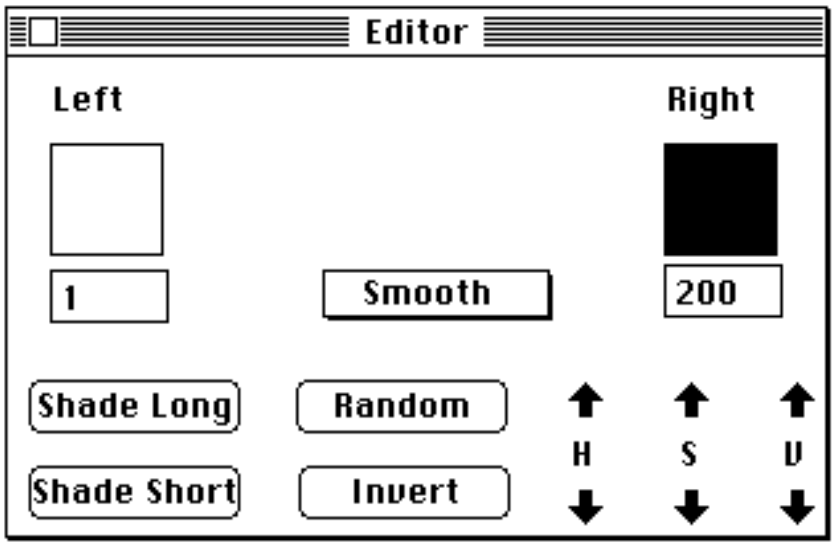

Figure 6: The Palette Editor.

VII. Transforming the Image

After an image is drawn it may be transformed by one of the options in the Convolve or Transform sub-menus. These options use the count values in the image to create a new window which can look very different from the original image. My favorites are the Sobel convolve option, the Delta transform, and the 3D transform.

The Convolve options use a technique from image processing called convolution. Convolution uses an array of numbers called the convolution kernel. To see how it works consider the kernel:

```
-1   -1   -1
-1    8   -1
-1   -1   -1
```

A count value in the new image is produced by multiplying the corresponding count value in the old image by 8 and then adding -1 times each of its neighbors. The above kernel will act as an edge detector: solid areas will wind up with zero count values. Points whose neighbors are very different will generate large count values.

Some of the kernels I've provided (e.g. Edges and GradientW7) will look much better if the low cutoff is set to one and the color map adjusted. For example GradientW7 can produce some really strange looking images. Try setting the low cutoff to one and using root scaling for the color map. For the root value try a number between six and eight.

The Transform sub-menu provides a variety of different ways to change fractal images. Unlike the Convolve images you can't add new options or change old options. There are eight transform options:

Delta This is one of the best transforms: it's fast and produces excellent results. It colors pixels according to how many of its neighbors have count values different from the pixel.

Bands... The Bands transform allows you to specify how many colors you want to use

in the image. For example if you used two colors the image would consist of two alternating bands. If you used sixteen all sixteen would be used for the lowest count values and then they would be reused for the higher count values. This is the method IBM PC programs usually use to color fractals.

Full Color This transform produces a true color image using twenty times the number of colors as the standard windows. If you're using a monitor with 256 colors you'll see a dithered approximation of the true image. It works by interpolating the colors in the palette to construct a large color table.

Color Sobel This is another true color transform. The Sobel convolution kernel is a simpler version of this transform. The colors in the new image are chosen using hue controlled by the orientation of edges in the original image, saturation fixed at 50000, and value high in regions where the count values change quickly. This is a slow option but can look kind of cool. Try it with Continuous Potential.

Blur This transform averages out the image so that edges get blurred. It uses a 3x3 convolution kernel consisting of all one's. After a point is convolved the result is divided by nine to get the average.

Evert The Evert transform everts an arbitrary circle. In other words every point within the circle is mapped outside. And every point outside the circle is mapped inside. To evert an image select Evert and then draw a circle in the fractal window.

Log This is probably the worst transform but it can, on occasion, produce interesting results. It uses Ln(count)/Ln(maxCount) to smoothly shade the image. It also uses the pixels coordinates to produce a tiling effect.

3D... The 3D transform is based on an algorithm outlined in The Science of Fractal Images. It's by far the slowest and most complex transform (see figure 7). The idea is to treat a pixels count value as a height. So, we then have a rectangle with each point having some height and color associated with it. To show the data we use a view angle to render the image in two dimensions in the window. A view angle of 0° corresponds to an edge on view. And a view angle of 90° corresponds to a view from directly above the rectangle.

There is one problem with this method: a gap will develop below the pixels in the bottom row (since in general they will all have different heights). There are several ways to handle this. One possibility is to pull down each column by whatever its gap is. However this can result in a distorted image. The best approach is to calculate new count values for points below the bottom row so that all the gaps are filled. This is the method Mandella uses. However this can take some time. To get a quick look at the 3D image Mandella has a "Preview" option. When this is used any gaps are colored black. When "Draw" is selected new count values are calculated. Mandella will remember these values so they don't have to be calculated again.

Mandella can color your 3D image with any of three different methods. The simplest is to just use the old pixels color. This will give you a 3D image with no shadows. Or you can color the image using a light source. The light source assigns to each pixel an "intensity" that corresponds to how deeply the point is in shadow. This works better with a smooth palette. The third lighting option uses a true color window to combine the first two methods. Each pixel is colored with its original hue and saturation but the value is decreased if it is in shadow.

For best results draw your fractal using Continuous Potential with the slope set to a very small value. This will give you an image that smoothly increases in height. Once you have an image you will need to adjust the Gradient and Scaling parameters. Gradient controls how quickly the image rises up. Large values will tend to flatten out the image. Scaling controls how much of the window the image occupies.

The 3D transform can take a long time to finish. The Status window will display messages as the transform grinds away so the user can gauge the progress it's making. The user can also abort the transform by pressing the command and period keys simultaneously. When the Draw button is selected keep an eye on the number of new lines calculated. If it keeps going up an up you may have to increase the Gradient. Try aborting the transform (via cmd-.) redoing the transform. Some images will require very large gradients...

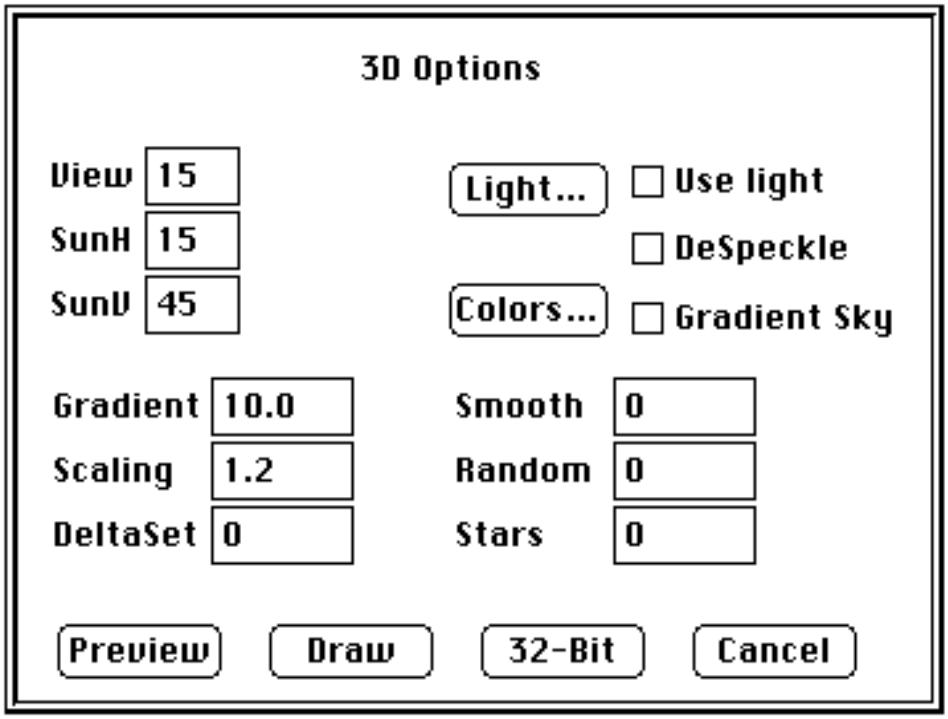

Figure 7: The 3D Transform dialog box.

3D commands and options:

The **view** angle controls how far the image is tilted. 0° means the 3D image will be viewed edge on. 90° means the 3D image will be viewed from directly above.

The **sun** controls the location of the light source. The sun is considered to be infinitely far away. SunH controls the horizontal location of the sun. 0° means the sun is directly in front of the image. 90° means the sun is to the left of the image. SunV controls the height of the sun. 0° means it is in the xy-plane. 90° means it is directly above the image.

Gradient controls how much weight is given to differences in count values. If the gradient is large the 3D image will have little variation in height. If the gradient is small the image may have extreme height differentials.

The **scaling** number is multiplied to each height to scale the image. You can use this to control how much of the window the image covers.

Delta Set allows you to offset points in the set by any value. If it is negative the interior of the fractal will look sort of like a lake. (Especially if the SetColor is blue).

The **Light** button controls the way shadows are calculated. The formula Mandella uses is:

intensity := Ambient + Diffuse*Cos(theta) + Specular*RaiseInt(Cos(alpha), Shiny)

Theta is the angle between the surface normal and the light vector. Alpha is the angle

between the view vector and the reflected light vector.

The **Colors** button can be used to change the colors for the Set, Stars, and Sky.

If **Use light** is on the image will be colored using the light intensity. If it is off intensity is ignored and each point is given its original color.

Despeckle is used to eliminate isolated points that have counts equal to maxCount.

Gradient Sky is used when generating 32-bit images. It smoothly changes the sky color from the top of the sky to the bottom.

Smooth uses averaging techniques to reduce the jaggies. The higher the number the smoother the image.

Random randomizes the intensity for each point. This can sometimes be useful to reduce banding problems.

Stars controls the number of stars in the “sky”.

VIII. Automated Drawing

The Automated drawing options allow the user to automatically draw and save to disk a sequence of images. The Options dialog allows the user to control which pass drawing will stop after. It also lets the user specify the formats the image will be saved in. The images will be placed in a folder with the program. Each folder will have a unique name. For example if Randomize is used twice Mandella will create folders named “Random ƒ 1” and “Random ƒ 2”. The automate options are as follows:

Randomize As the name suggests Randomize generates random fractals by randomizes constants. The user can choose to randomize any or all of Constant, Lambda, and Perturb. This option is a bit different then the other options in that the user can choose not to save each image. If the user decides to go this route the Status window will display this message after the fractal finishes, “Hit any key. A-aborts S-saves”. Hitting the “A” key will terminate Randomize. The “S” key will save the image. Any other key will cause the next fractal to be drawn.

Interpolate This option allows the user to draw the fractals that result as one of its constant is changed. The user chooses either Constant, Lambda, or Perturb; the start and stop values; and the number of images.

Zoom Into This option creates a sequence of zooms into a point in the complex plane. The point it zooms into is the center of the front fractal window. This option will be disabled if the front window covers more of the complex plane then the first preset. The user can specify either the number of zooms to be used or the percent to zoom by. For example, if the user entered %10, each zoom would be %10 smaller in both the x and y directions. The user can also optionally draw a white outline around the area to be zoomed into.

Blow Up This option can be used to create posters of a fractal. The idea is to divide an image into nxn images. Each new image will be the same size and have the same aspect ratio as the original image. So, if the user entered 5 for the side length he would get 25 images that could be pasted together to form the original image.

IX. Short Cuts and Special Keys

Mandella provides a large number of short cuts. They are listed below:

Keys

Option-arrow	moves the left marker left or right.
Command-arrow	moves the right marker left or right.

Command-J	randomizes Constant (which is used by Julia sets).
Command-L	randomizes Lambda.
Command-P	randomizes Perturb.
Command-1 to 9	selects a temporary palette.
Command-0	clear all of the temporary palettes.
1-9	speeds up scrolling. 1 is normal speed. 9 is 9x faster.
Command-Esc	quit without saving changes. The user is asked to confirm that he wants to discard all changes.
Space-Bar	allows a fractal to be scrolled by dragging the mouse.
Escape	is equivalent to pressing Cancel in a dialog or alert.
Command-.	is also equivalent to pressing Cancel in a dialog or alert.
‘y’ and ‘n’	are equivalent to pressing Yes or No buttons.

Mouse

Option-click	randomize a color.
Command-click	select a color using the Color Picker.
Control-click	change the options for a window.
Shift-click	get information about a point in the fractal or edit a preset in the Browser window.

File menu

Option-Close	closes all windows. If a window is dirty the user is asked if he wants to save it.
Command-Close	closes all windows without saving. The user must confirm that he wants to close all the windows without saving.
Option-Save	saves all windows.
Command-Quit	quit without saving any windows. User must confirm.

X. Speed

There are two factors affecting the speed of a fractal program. The most important is the speed at which the calculations are performed. Of lesser importance is the overhead associated with converting the iteration counts to colors and plotting the fractal. I’ve tried hard to make Mandella as fast as possible. Rather then draw each pixel Mandella marks entire lines for later redrawing. This can have a dramatic effect on the faster fractals. For example the entire Mandelbrot set is drawn about 70% faster.

The fastest way to calculate fractals is to use fixed point numbers. These are often 32 bit numbers with, say, 16 bits for the integer part and 16 bits for the fractional part. However while it is fairly easy to implement the classic Mandelbrot fractal using fixed point it is a lot harder to write an entire fixed point math library for the other fractals. The transition to real numbers is also a troubling issue. Fixed point numbers have a rather limited precision. As you zoom deeper into the fractal eventually fixed point will fail and real numbers will have to be used. It turns out that some regions require reals much sooner then others. For these reasons Mandella uses 80-bit real numbers.

XI. The Windows

All the windows can be customized using the mouse and the modifier keys. To use a modifier key hold it down and click in a window. The standard modifiers are: the control key sets options for the window, the option key randomizes window colors, and the command key is used to choose window colors.

Fractal Windows

Fractal windows provide a view into a portion of the complex plane. When a fractal window is created the window size and number of pixels are set to default values. These defaults can be changed using the Preferences command in the File menu. The options dialog for a fractal window allows you to change the way solid guessing works and to turn period checking on and off.

Fractals Window

The Fractals window is used to hold presets for all the fractal types Mandella supports. These presets contain all the information needed to draw some of the better looking images I've found. The Fractals menu is organized like a browser. The first column is the fractal class: either Mandel, Julia, Other, or Orbital. The second column lists the fractals in the selected fractal class. The third column lists the presets in the selected fractal. To change a selection simply click on the new selection. To use a preset double-click on it. Shift-clicking on a preset allows the preset to be edited. The delete key will delete the selected preset.

Info Window

The Info window displays all sorts of information about the frontmost fractal window. The options dialog allows you to choose the options displayed. The possibilities include: the fractal name, the formula, the number of pixels, the coordinates, the cutoffs, any constants used, the current pass number, the elapsed time, the time it took to draw the fractal, the draw style, the number of colors used, the min and max counts, and the color map variables.

Mouse Window

The Mouse window displays information about points within the frontmost fractal window. The Mouse window will change as you move the mouse over different points. The options dialog allows you to control what is shown: the pixels coordinate, the point on the complex plane, the count value, and the color index.

Memory Window

The Memory window shows you how much memory is available. The options dialog allows you to choose from: the memory used by the front window, the memory used by the program, the amount of unused memory, and the amount of space left on the default disk drive.

Status Window

This window lets the user know the status of the front-most fractal window. It will tell the user if it is being drawn, which pass it's working on and if it's being automated. It's also used to display messages. For example if Show Point is selected the Status window will say, "Click on a point!".

Palette Window

The Palette window displays the palette for the frontmost fractal window. It also allows you to rotate the palette using the arrow buttons. The palette editor operates on a range of colors in the palette. This range is marked by little triangles in the Palette window. The markers can be dragged or a new range can be selected by selecting a range in the palette itself. The options dialog controls how Random Palette works (and is the same as the Random Options command in the Color menu).

Palette Editor Window

See the Editing Palettes section for a discussion of how to use the Editor. The options dialog controls how the HSV arrows work. The arrows can be set to change the HSV components or the RGB values. The increment value can be changed. And each component can be optionally wrapped around.

XII. The Menus

Apple

About Mandella
The about box includes some of the shortcuts and a list of credits. There is also a nice example of the 3D transform.

Other Programs
Lists some of my other programs.

DA's
The usual list of desk accessories.

File

New
Creates a new fractal window using the first preset of the selected fractal type in the Fractals window.

Duplicate
Duplicates the frontmost fractal window.

Open...
Reads a fractal from a file. Files saved with older versions may be read but the image and counts will be ignored.

Close
Closes the front window. Holding the the option key down will close every window saving any that are dirty. The command key closes all windows without saving. You will be asked if you’re sure you want to trash all the windows.

Next File
Opens the file after the last file opened.

Save
Saves the fractal using the same format it had on the disk. Option-Save will save every window.

Save As...
Saves the fractal in one of six formats:
1) Text: saves the information in the Info window as a text file. The creator can be specified in the Preferences dialog.
2) Info: saves everything required to redraw the fractal including the palette.
3) Image: saves the bit image and the Info vars.
4) Counts: saves the count values and the Info vars. If the fractal hasn’t finished drawing you can save using this format and Open it later to finish drawing.

5) PICT2: saves the bit image as a PICT.

6) TIFF: saves the bit image as a TIFF file. The format of the TIFF file uses the simplified format described in the revised TIFF standard so some older programs may not be able to read them.

Revert File...

Loads the fractal from the disk negating any changes you may have made. You'll be asked if you're sure you want to lose your changes.

Print

Prints the frontmost window.

Preferences...

Allows you to: 1) Set the default fractal and window sizes. 2) Set the defaults for solid guessing and period checking. 3) Turn image and counts file compression on and off. 4) Change the creator for the save as text option. 5) Control the number of digits used when displaying constants. 6)

Overnight...

Allows you to select a folder, specify a size, and choose save formats. Each file in the folder will be drawn at the specified size and then saved using the selected formats.

Quit

Exits the program. Holding the command key down will quit without saving any windows. (Cmd-Escape will do the same). You'll be asked if you're sure you want to lose everything.

Edit

This is the standard edit menu. This menu has been included for DA's, it will be enabled when a DA's window moves to the front.

Draw

Start Drawing

Turns drawing on. The frontmost fractal window will be drawn first. Then the next window, then the next.

Stop Drawing

Turns drawing off.

Draw Styles

This sub-menu is used to select from among Mandella various draw styles. The menu will change depending on if the front fractal window is an escape time fractal or an orbital fractal.

Draw Method

This sub-menu allows the user to change the way Mandella draws escape time fractals. The user can choose from Multiple Passes, One Pass, and Line by Line. The draw method can be changed at any time. Any points that have been already calculated will be remembered.

Automate

This sub-menu allows the user to automatically draw a sequence of images. See Section VIII for details.

Convolve

This sub-menu lists the kernels that have been defined. Selecting a kernel will convolve the front fractal window and display the result in a new window. New kernels can be added using the Add command. Old kernels can be edited or deleted using the Change command.

Transform

This sub-menu is used to select the transforms. Selecting a transform creates a new window with the transformed image.

Bump Counts

When this is selected the cutoffs will automatically be increased after Magnify or Extract is used.

Image Size...

Allows you to change the dimensions of the fractal. When you change the horizontal or vertical dimension the other will change according to which option is selected: 1) Same Ratio: the fractal dimensions will be updated to maintain the aspect ration of the fractal. In other words if the original fractal had an aspect ratio of 4:3 and you change the width to 400 the height will be changed to 300. 2) Same Area: the dimensions will change to maintain the same number of cells. 3) Free Form: allows you to set the dimensions to whatever you want. If Same Area or Free Form is used the portion of the complex plane used will change to prevent distortion of the image.

Color Map...

Allows the way counts are mapped to colors to be changed. A graph is drawn to make things easier to follow. There are two ways to change the color map: 1) Bezier: allows you to drag two little handles about to change the map. 2) Root Scaling: uses a real number to compute the color map.

Draw For

This is a sub-menu that controls how long Mandella spends drawing before handling other events (e.g. clicks of the mouse). The time is expressed in ticks (one tick = 1/60 of a second).

Window

Show/Hide/Select Mouse
Show/Hide/Select Memory
Show/Hide/Select Status
Show/Hide Fractals
Show/Hide/Select Palette
Show/Hide/Select Editor
Show/Hide/Select Info
Shows, hides, or selects the window.

Fractal windows

Each fractal window will be listed here. The frontmost fractal window will be checked. To bring a fractal window to the front select it in the menu. If a fractal in the back is

being drawn it will be marked with a diamond.

Stack Windows
Stacks the fractal windows neatly.

Tile Windows
Arranges the fractal windows so that they cover the desktop.

Next Window
Places the front fractal window in the back so that the next window becomes visible.

Photo Mode
Centers the front fractal window on the screen and hides everything in the background.

Save Positions
Saves the sizes and positions of the special windows so that when the program is restarted they will come up in the same place.

Fractal

Iterations...
This command allows you to adjust the Cutoff values. Larger numbers for the high Cutoff will give you a more accurate image but they will also take longer to draw.

Origin...
Use this to manually enter new coordinates. You can enter the corners or the center and width.

Constant...
Allows the user to change the constant used by a Julia fractal. The constant may be typed in or a random one chosen. Random constants will be restricted to a user defined box. Command-J will also randomize the constant.

Lambda...
Allows the user to change the Lambda constant, randomize it, or change the random bounding box. Command-L will also randomize lambda.

Perturb.../Orbit Seed
Perturb lets the user change the Perturb constant, randomize it, or change the random bounding box. Cmd-P randomizes Perturb. Perturb is used by Mandelbrot fractals. Normally z is inited to zero when calculating Mandelbrot fractals. Perturb can be used to set z to a different value.

If the front fractal window is an orbital fractal the menu item will change to a sub-menu named “Orbit Seed”. The user can choose to use a single point, a number of points along a line, or a grid of points.

Start Julia
This feature is enabled whenever an (unperturbed) Mandelbrot fractal is in front. It lets you pick a point to use for the constant in a new Julia fractal.

Show Point...

This works like the Mouse window: it shows information about a point. Unlike the Mouse window it actually calculates the count value for the point. Shift-click will do the same thing.

Show/Hide Grid
Overlays a grid on the front fractal. The lines at the origin will be drawn slightly larger.

Grid Spacing…
Allows the user to adjust the distance between grid lines. The distance is in terms of the complex plane displayed by the fractal window.

Add Preset…
Adds the front fractal window to the Fractals window as a preset. The user is prompted for a preset name.

Scroll

Extract Selection
Creates a new fractal window using the coordinates defined by the selection rectangle. If Bump Counts is selected the Cutoffs will also be increased.

Magnify Selection
Resizes the frontmost fractal window and changes the coordinates to match the selection rectangle. If Bump Counts is selected the Cutoffs will also be increased.

Constrain/Free Selection
Allows the user to constrain the selection rectangle to some aspect ration. For example you could use this to keep fractals produced using Extract or Magnify at a 4:3 aspect ratio.

Constrain By…
Lets the user set the aspect ratio used to constrain the selection rectangle.

Scroll Up
Scroll Down
Scroll Left
Scroll Right
Scrolls the screen by a fixed amount. The arrow keys will also scroll the image.

Scroll Size
Changes how much of the window to scroll by.

Zoom In
Blows up the center of the window a fixed amount.

Zoom Out
Shrinks the window a fixed amount.

Zoom By
Changes the zoom magnifications.

Center Point
Centers the fractal at whatever point you click on.

Palette

Palettes
If a palette is named Default it will be used when Mandella starts up. Otherwise a random palette will be used. Some of the more complicated palettes look better with a linear mapping.

Delete…
Allows you to delete a palette.

Add New…
Adds the current palette to the Palette menu.

Color

Random Palette
Creates a random palette.

Random Options…
Controls how random palettes are constructed. See the Tweaking Images section for details.

Animate Left
Shifts the colors in the palette left. Hit any key to stop.

Animate Right
Shifts the colors in the palette right. Hit any key to stop.

Animate Delay
This sub-menu controls the speed at which animation takes place.

Skip By…
This command allows you to skip one or more colors while animating. It’s useful whenever a palette is built with alternate colors.

Add Temp
Assigns the current palette to a number key (1-9). The first temp palette is assigned to the 1 key. The next is assigned to the 2 key. Typing cmd-1 will change the current palette to the first temp palette.

Clear Temp
Removes all of the temporary palettes.

Save Temp
Saves all of the temporary palettes in a file.

Load Temp
Loads the temporary palettes from a file.

Default Colors…
Allows you to change the default colors.

XIII. Known Bugs

The colors used in the text windows are not always restored correctly. The correct color can be restored by clicking on the window. Fractal windows are occasionally shown using the System palette. Again just click on the fractal window to restore the palette.

The Print command simply dumps the front window to the printer. It's equivalent to pressing command-shift-4. For color Macs this will usually not work. As far as I know the Apple printer drivers don't support screen dumps for color windows. Some third party printers do however.

PhotoShop 1.0.7 and apparently Color Studio read PICT files using the System palette. This is a problem with those programs, not Mandella. I believe PhotoShop 2.0 reads PICT files correctly.

XIV. Version History

Version 6.2

• Prefs dialog now includes a checkbox that allows the user to use the default TIFF resolution.

• Draw Selection checkbox in ZoomInto dialog is now disabled if save format does not include PICT or TIFF.

Version 6.1

• Modified the file names produced by the Automate options to better support Apple's Convert To Movie application.

• The ZoomPt automate option has been renamed ZoomInto.

• Made major changes to the way ZoomInto works.

Version 6.0

• Released Mandella as shareware instead of as a demo version with the save command disabled.

• Added the automate options: Randomize, Interpolate, Zoom Point, and Blow Up. See Section VIII for details.

• Two checkbox's have been added to the Open file dialog: the first allows the user to resume automating a saved file; the second allows the user to read in a FractInt par file.

• The 3D transform uses the (new) Status window to keep the user informed of its progress. Command period will now abort 3D.

• The Fractals item in the Window menu is now always enabled.

• All the windows are now redrawn when colors are changed from within the color editor reached using command-click.

• The Random button in the Palette Editor will now change interior colors if the option key is held down.

• The period checking checkbox in the fractal options dialog is now disabled if the fractal doesn't support period checking.

• Added Lambda, Manowar, Mark, and GenMark fractals.

• Removed MarkPwr fractal and modified Barnsley1 and Barnsley2 fractals.

• Convolve now leaves points within the set as is.

• Modified Overnight so that when it changes the image size it uses either the free form or same ratio method.

• Tweaked the Image Size command so that free form and same area work better.

• Start Julia is now disabled if the front fractal has been perturbed.

• Added a Constrain Selection command to the Scroll menu.

• The Preferences dialog now allows the user to specify the number of digits used for constants.
• Command-period now aborts Show Point, Evert, Start Julia, etc.
• Removed command key equivalents from Zoom In and Zoom Out.
• Clear Temp now asks for confirmation.
• Fixed some bugs:
a) Demo version no longer hangs when used with the UniFinder.
b) 3D transform now works correctly with stars set to zero.
c) Overnight now resizes fractals correctly.
d) Photo Mode is now turned off when the front window is closed or moved behind another window.
e) Fixed some problems that could have caused crashes in low memory situations.

Version 6.0d7

• Added two new draw methods: One Pass and Line by Line.
• Tweaked the old method (Multiple Pass) so that it is faster.
• Modified MandelClassic and JuliaClassic fractals so that they are faster on the deep zooms. Total speed increase from these two changes is around %15 to %30.
• User can select default draw method in Preferences dialog.
• The temporary palette Color menu items are now enabled and disabled properly.
• Added Save and Load Temp commands to the Color menu.
• All dialogs and alerts can be canceled using the escape key or command period.
• The Yes/No alerts now let the user type ‘y’ or ‘n’.
• The Fractals window now auto-scrolls when the up/down arrow keys are used. The user can also use the letter keys to select the first preset starting with that letter.
• Added a Status window.
• The Origin dialog has been widened so that it shows 19 digits. The Info window displays an additional two digits for the coordinates.

Version 6.0d6

• The biggest change from Mandella 5.6 is in the user interface. This would include things like: multiple fractal windows, arbitrary aspect ratios, scroll bars, menus are available while drawing, new special purpose windows (e.g. Mouse and Memory windows), and options dialog boxes.
• Added Orbital fractals.
• Added some new escape time fractals: Sqrt, Noel1, Noel2, NewtonExp, Halley1, Halley2, PiPwr, and EPwr. The Noel fractals are from Noel Giffin.
• Added new draw styles: Ratio, Stalks, and Periodic.
• Added new transforms: Blur, Full Color, and Color Sobel.
• Added convolution. An editor is built-in so users can create their own kernels.
• Added Show Grid command.
• Drawing in black and white using patterns is no longer supported.
• Image and Count files are compressed and decompressed much faster.
• The Palette Editor has some new options: a second alternate option, ability to use HSV or RGB for the arrows, and option-click on a Shade button will randomize the first or last color.
• In addition to Bezier curves, root scaling can be used to create color maps.
• The user can specify how long Mandella spends calculating count values. This allows the user to control how much time Mandella steals while in the background.
• A Perturb option has been added for Mandelbrot fractals.
• A Center Point option has been added.
• An Other item has been added to various sub-menus (e.g. Draw For, Scroll By, Animate Delay, etc.). The user can also use ResEdit to add or delete items from these

menus.

• Holding the space-bar down allows the user to scroll by dragging the mouse around. This is especially useful with Photo Mode.

• Solid guessing is now used for all but the floating point draw styles (instead of only for Level Sets).

The changes below should be of historical interest only so I've taken the liberty of removing bug fixes and minor changes. I've also added a few editorial comments in brackets.

Version 5.5

• The default window size is now 512x384 (instead of the full screen). [Versions prior to version 6 used a single large window for fractals.]

Version 5.4

• If you control click in the main window the window will move so that the point you click on is in the center of the screen. This can be useful with large images (e.g. finding the palette). [The fractal window had no scroll bars so I had to resort to this crude expedient to move the image around.]

Version 5.1

• Removed period checking from the Potts1 fractal.

Version 5.0

• Added the 3D transform.

• Added some new presets. The MandelClassic fractal includes five from MandelZot [20].

Version 4.1

• The color of the fractal can be changed using option or command click.

Version 4.0

• The new Draw styles include Level Set (the old method), Continuous Potential, Color Inside, Binary Decomposition, and the Distance Estimator.

• The new Transforms include Delta (similar to the old Trace Edges), Band, Sobel1, Sobel2, Sharpen, and Logarithmic. The Sobel and Sharpen transforms use an image processing technique called "convolution".

• Several changes have been made affecting drawing speed:

a) All math is now done using the FPU. This slows down the MandelClassic and JuliaClassic fractals down quite a bit. [The Classic fractals had been drawn using either fixed point or the FPU).

b) Period checking has been added to speed drawing of the fractal interiors.

c) The routines used for trig and power calculations have been sped up about 15%. Several other routines have been optimized for the 68882.

d) Solid guessing can now adjusted using the Options dialog. Guessing on the 1x1 pass is the old method. Guessing in the 2x1 pass is quite a bit faster but is slightly less accurate.

• Custom fractals are no longer supported. [These were fractals that were written by the user and added to Mandella using ResEdit. They worked rather like HyperCard's XTND resources.]

• The Origin dialog allows three "origin styles". They are: center/width, center/mag, and corners. This makes it easier to transfer fractals to and from Mandella. The center/mag option only makes sense if the first preset is of the entire fractal (like MandelClassic).

• Cutoffs are treated as unsigned integers so they can be as high as 64000. (And period checking will keep the program from bogging down within the fractal).

• The Brighter and Lighter buttons have been removed from the color palette editor. Instead there are six arrows allowing the hue, saturation, and value components to be changed independently.

• Added a whole slew of new presets using my new SE/30.

• Added Tetrate, Glass, and Spider, and Newton3 fractals to the Other menu. The Newton3 fractal is especially interesting.

• Drawing in the background now gives up more time to the foreground application. Although slow fractals can still cause the foreground app to be rather sluggish at times.

Version 3.0

• Drawing is now done using six passes. The first pass uses a 16x16 pen [version 6 starts with a 32x32 pen). The next uses an 8x8 pen. Drawing continues until the image is drawn with a 1x1 pen. To speed things up the count value for a cell is only calculated once. And on the last pass if the cells neighbors all have the same value the cell is assigned that count value. This new drawing style adds less then two minutes to the drawing time [the overhead for version 6 is much lower].

• Images are updated differently after zooming and scrolling. Mandella now uses the original image, a rectangle in the image, and a rectangle in the window. For a zoom Mandella would use a small rectangle in the image and a full sized rectangle in the window. Zoom Out would be the reverse. This new method has three advantages:

a) The original image is never lost: you can scroll around and around and always return to your original image. Or you can do a zoom in change your mind and do a zoom out and you'll be back to the original image.

b) Combined scrolling and zooming work better. For example you can scroll around in a zoomed image.

c) It provides a way to avoid saving a bit image from the window to the offscreen image. (I've never been able to get this to work properly with animating colors).

• Temporary palettes have been added.

• The space bar toggles photo mode on and off.

• An Options dialog has been added to control the compression formats, the last pass for automated drawing, enabling or disabling AutoDraw [i.e. Bump Counts], and when to shift the color palette.

Version 2.0

• Added a bunch of new fractals (most of which came from FracInt [24]).

• A color palette editor has been added.

• The palette can be changed by clicking inside of it.

• A Dimension command has been added. [This used the Box-Counting Theorem [see 4] to calculate the fractal dimension of whatever was within the selection rectangle.]

Version 1.0b2

• Custom fractals have been added.

• Draws into both the main window and the offscreen bitMap simultaneously. So screen savers will now work!

• The fractal and Vars windows can now be resized. The size boxes are not drawn because they include the lines for scroll bars.

• The counts can now be saved allowing you to finish the fractal later. When the counts are loaded the image will be redrawn.

• Redraw uses a new algorithm to boost performance. It has also been rewritten in assembly language. It now takes four seconds to redraw a 1x1 full size image!

• Trace Edges has also been rewritten. It takes five seconds on a Mac II and eleven seconds on a Mac+.

• The compression scheme has been reworked. Older versions used a few tricks to save memory that did not always work quite right. Images are now saved using RLE and counts are saved using Huffman encoding.
• The Presets menu has been added. There is a different preset for each fractal type.
• Palettes can be saved in the Palette menu. If a palette named "Default" is present it will be used when Mandella starts up. Otherwise a random palette is used.
• The patterns used with black and white machines can be edited.
• A Color Map is used to go from count values to the colors in the palette.
• Mandella works better with MultiFinder.

XV. References

[1] Algorithm, PO Box 29237, Westmount Postal Outlet, 785 Wonderland Road, London, Ontario, Canada N6K, 1M6. This is a small magazine edited by Dewdney of Computer Recreations fame. It covers the same sort of subjects as his column in Scientific American.

[2] Amygdala, PO Box 219 San Cristobal, NM 87564-0219. This is a newsletter about the Mandelbrot Set and other fractals.

[3] Art Matrix. This company sells videos, posters, t-shirts, and slides of the Mandelbrot and Julia sets. The phone number is: 1-800-PAX-DUTY or 1-607-277-0959. They'll mail you a free catalog on request.

[4] Barnsley, Michael. Fractals Everywhere Academic Press Inc. ISBN 0-12-079062-9. This is an excellent text book on fractals. This is probably the best book for learning about the math underpinning fractals. It is also a good source for new fractal types.

[5] Barnsley, Michael. A Better Way to Compress Images Byte. Jan 1988. A fascinating look at how Barnsley's company, Iterated Systems, is using fractals to compress images in excess of 10,000 times. Practical systems will require custom hardware to compress or decompress images.

[6] Bourke, Paul. FracHill This is an excellent fractal mountain type program. There are several ways to control the mountains, it works in color, and it exports in a variety of formats for ray-shading programs. Requires a Mac with color and an FPU.

[7] Dewdney, A.K. Computer Recreations Scientific American. August 1985. This is the article that started people writing fractal programs for microcomputers. Dewdney also presented a lot of other neat ideas in other columns. Unfortunately Dewdney no longer has a column in Sci Am.

[8] Dewdney, A.K. Computer Recreations Scientific American. November 1987. Follow up to above, describes the Julia Set.

[9] Henderson Associates. Hilbert A simple program that draws space filling curves.

[10] Goldberger, Rigney, and West. Chaos and Fractals in Human Physiology Scientific American. A fascinating article on how fractals and chaos apply to the body. They present data showing the healthy heart beats in a chaotic rhythm. Diseased hearts beat in a periodic or completely random fashion.

[11] Goldstein, Jerry. Animated Fractal Generator 2.0 A good color program for the Mac II. Best features: multiple fractals, nice built in palettes, some presets, can draw

very large images. Worst features: cluttered dialogs. Goldstein also has a 32-Bit QuickDraw version of the program available.

[12] Mandelbrot, Benoit. The Fractal Geometry of Nature New York: W.H. FreeMan and Company. ISBN 0-7167-1186-9. In this book Mandelbrot attempts to show that reality is fractal-like. He also has pictures of many different fractals.

[13] Media Magic POB 507 Nicasio, CA, 94946, 415-662-2426. I got one of their catalogs in the mail a while ago. They look like a good source for books and videos on chaos, fractals, cellular automata and the like. They also sell postcards, t-shirts, and a couple posters.

[14] MicroSpot. MacPalette uses dithering to allow you to print full color images on an ImageWriter II. They've got a free demo version available also. The address is:

MicroSpot
20421 Stevens Creek Blvd, Suite 240
Cupertino, CA, 95014
Phone: (408) 253-2064 or (800) 622-7568
Fax: (408) 253-2055

[15] Munafo, Robert. Super MandelZoom An excellent but limited black and white fractal program. Best features: great interface, very fast, palette editor. Worst features: lacks a save command, fixed window size.

[16] Nelson, Doug. FDesign An IFS fractal program for IBM compatibles. I haven't used this program but I have heard it is very nice. It allows the user to construct IFS fractals using a mouse and triangles. You can download FDesign from the COMART section of CompuServe.

[17] Peitgen, H.O. and Richter, P.H. The Beauty of Fractals New York: Springer-Verlag Inc. ISBN 0-387-15851-0. Lots of neat pictures. There is also an appendix giving the coordinates and constants for the color plates and many of the other pictures.

[18] Edited by Peitgen, Heinz-Otto and Saupe, Deitmar. The Science of Fractal Images New York: Springer-Verlag. This book was reviewed in the December 1988 Byte. It is based on a short course presented at SIGGRAPH '87. It contains many color and black and white photographs, high level math, and several psuedocoded algorithms.

[19] Eberhardt, Thomas and Parmet, Marc. The Beauty of Fractals Lab Springer-Verlag. ISBN 3-540-14205-3. This is a very nice program for color Macs. It does multiple windows, draws both the Mandelbrot and Julia sets, has a slick palette editor, and does an outstanding job drawing 3D fractals. Unfortunately thats about all it does.

[20] Pickover, Clifford. Computers, Pattern, Chaos and Beauty St. Martins Press. ISBN 0-312-04123-3. This is a really great book. Pickover presents a wide range of applications for computer graphics. He covers fourier series, image processing, fractals, chaos, spirals, and lots more. There are gorgeous pictures on nearly every page and Pickover includes algorithms for almost every topic he discusses.

[21] Platt, Dave. MandelZot 2.0 A fractal program with a lot of potential. Works on all Macs. Best features: multiple windows, powerful palette editor, distance estimator option. Worst features: no presets, runs badly on Mac+ and SE.

[22] Rietman, Edward. Exploring the Geometry of Nature Windcrest Books. ISBN0-

8306-9137-5. This is an excellent intermediate introduction to chaos, strange attractors, and fractals. It's aimed at readers with a background in calculus and he's included a bunch of Basic programs.

[23] Stevens, Roger. Fractal Programming in C M&T Publishing. ISBN 1-55851-038-9. This is a good book for a beginner who wants to write a fractal program. Half the book is on fractal curves like the Hilbert curve and the von Koch snow flake. The other half covers the Mandelbrot, Julia, Newton, and IFS fractals. Unfortunately Stevens has virtually nothing on advanced features.

[24] Strange Attractions. This is a new company started by a guy in England name Gregory Sams. He's using Mandella and a Mac IIfx to create posters, mugs, t-shirts, post cards etc. If you want a free catalog write him at:

Strange Attractions
204 Kensington Park Rd
London
W11 1NR

or FAX (081) 459-7354

[25] Tyler, Bert FracInt 11.0 A fractal program for IBM machines. Best features: over 40 fractals, 3D, distance estimator option, integer math for lmost all fractals, a built in formula editor that allows users to roll their own fractals. Tyler is the original author of FracInt. Later versions were developed by a group of programmers housed in the COMART forum on CompuServe. This program is continually being updated. I think they're up to version 16 now. They're currently working on improving the interface and adding a palette editor.

[26] Tyler, Bert WinFract 1.0 This is a port of FracInt to the Windows 3.0 environment. It has most of FracInt's features.

[27] Zimmer, Mark. MacFractal An older but well done fractal mountain program.

XVI. Address Info

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