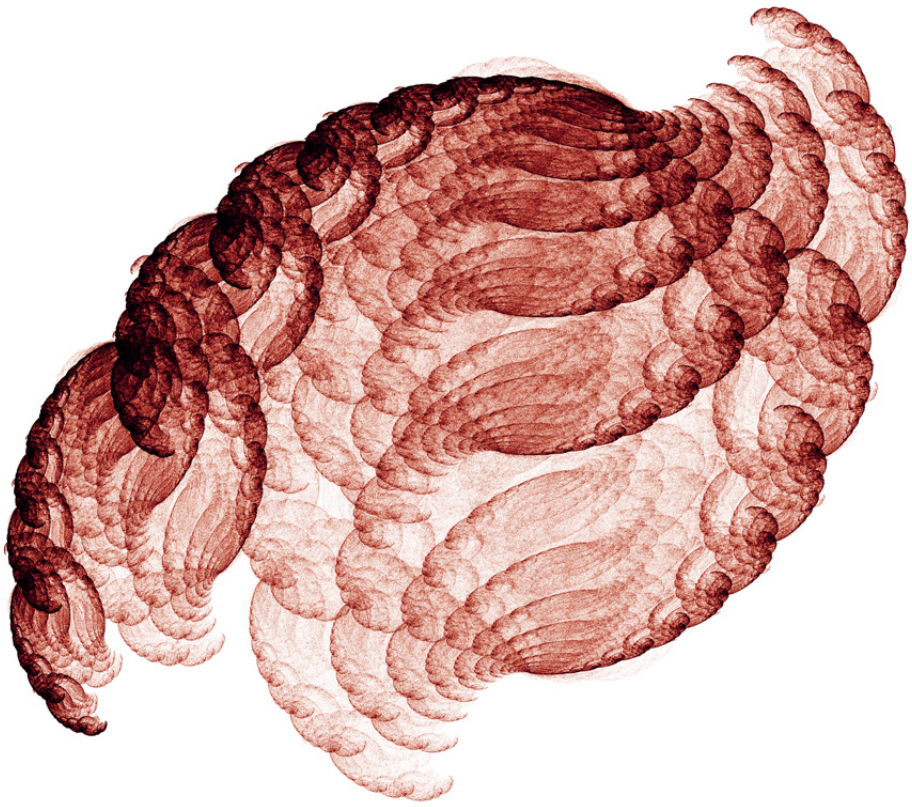
IFSLab

Version 1.0

A System For Interactively Designing
Iterated Function System Fractals



Stephan Kleinert

Heidelberg, 07 / 17 / 2005

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Chapter 1

About IFSLab

1.1 Introduction

IFSLab is a program which allows you to construct beautiful IFS fractals. Its main features are:

- Easy construction – simply draw a shape and transform it a few times. You don't have to know any of the math behind IFS Fractals (although it won't hurt if you do)
- Live preview – As you apply transformations, a live preview immediately shows you the results of your actions.
- Animation – IFSLab allows you to create stunning QuickTime movies of morphing IFS fractals.
- Fractal Assistent – New to IFS fractals? Don't want to read boring manuals which took weeks to write? No problem, just use the Fractal Assistent to get a basic idea of what this is all about.
- G4 and multiprocessor support – IFSLab is multithreaded and makes full use of the G4's AltiVec unit.

This manual is devided into three main sections. *Getting Started With IFSLab* is a step-by-step introduction to the basic features of IFSLab, *IFSLab*

reference explains every element of the program, while *FAQ* answers specific questions that might arise during the use of IFSLab.

1.2 What's an IFS fractal, anyway?

(from Wikipedia, the free encyclopedia)

Iterated functions systems are a kind of fractal that was conceived in its present form by John Hutchinson in 1981 and popularized by Michael Barnsley's book *Fractals Everywhere*.

IFS fractals as they are normally called can be of any number of dimensions, but are commonly computed and drawn in 2D. An IFS fractal is a solution to a recursive set equation. The fractal is made up of the union of several copies of itself, each copy being transformed by a function (hence "function system").

The canonical example is Sierpinski gasket. The functions are normally "contractive" which means they bring points closer together and makes shapes smaller. Hence the shape of an IFS fractal is made up of several possibly overlapping smaller copies of itself, each of which is also made up of copies of itself, ad infinitum. This is the source of its self-similar fractal nature.

Formally, $\mathrm{S} = \cup_i f_i(S)$ where $S \in \mathbb{R}^2$ and $f_i : \mathbb{R}^2 \to \mathbb{R}^2$.

The most common algorithm to compute IFS fractals is called the chaos game. It consists of picking a random point in the plane, then iteratively applying one of the functions chosen at random from the function system and drawing the point.

1.3 Acknowledgements

This program would not have been possible without the love and patience of Stephanie Schuldes, who had to endure me not being able to talk about anything else besides IFSLab, sitting in front of my Powerbook for ages...

Martin Giese helped a lot optimizing the program during my visit in

Sweden. Thanks, Martin – I've had a great time, not just because of the optimizations.

Last, but by no means least, special thanks to my beta testers: Víctor Carbajo, Jerry Jividen, Brent Etherwick, Stephanie Schuldes, Titus von der Malsburg and Annelen Brunner. Your comments, bug reports and feature suggestions where invaluable.

1.4 License

IFSLab is freeware – this means, you can copy and spread it freely as long as you don't charge any money for it.

BUT...: If you want to do me a little favor, go on and send me some pretty fractal files created with IFSLab (not TIFFs, just the .ifsl files). I'd be delighted to see anyone do something pretty with my program.

Bug reports, suggestions, etc. are welcome.

Write them to: ifslab@ubisonic.de

Happy rendering!

Stephan Kleinert, Heidelberg, July 2005

Chapter 2

Using IFSLab

2.1 Getting Started Quickly

After starting the program, IFSLab greets you with the Fractal Assistent. The assistent helps you getting started *really* quickly by providing you with a selection of pre-defined fractals and the possibility to create a random IFS fractal.

But since you're reading this manual I assume you want to know how to create your own IFS fractals. So for now, let's just skip the assistent by choosing "Empty" and clicking on the "Go" button.

2.1.1 Constructing The Base Shape

The two basic steps for constructing an IFS fractal are:

- construct a base shape
- apply a set of transformations to the base shape

After clicking "Go" in the assistent window, IFSLab shows three windows – two large ones at the top of the screen and a smaller one underneath them.

The left window is the *Construction Window* where you'll draw your shapes and transformations.

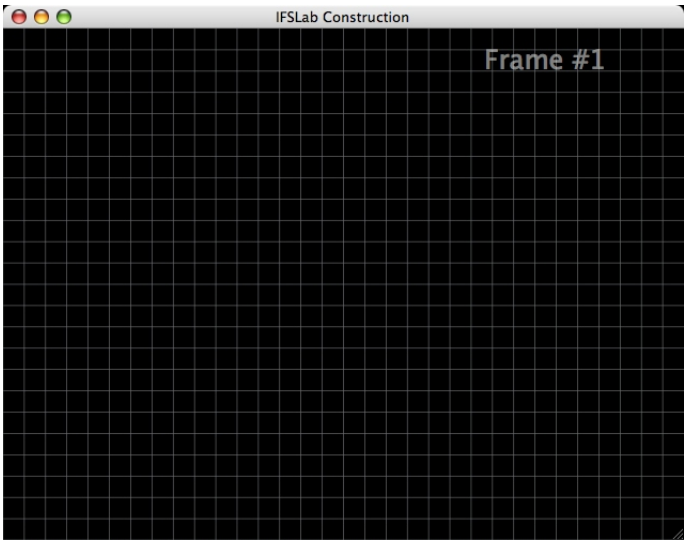

Figure 2.1: The Construction Window

The right one is the *Render Window* where the resulting fractal will be drawn.

The window underneath the Construction and the Render Windows is the *Control Panel*. This is where you'll adjust various aspects of your fractal. We'll come to that later.

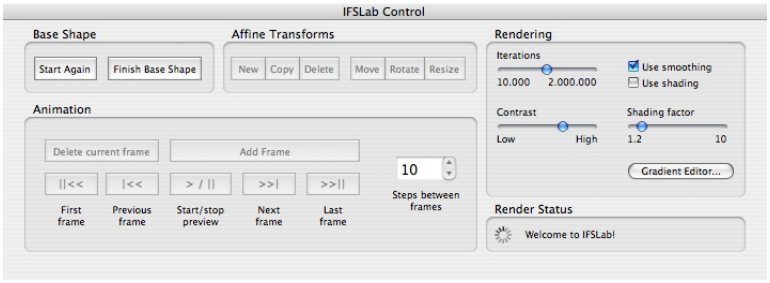

Figure 2.2: The Control Panel

Note that the Render Window won't display anything until you have created at least one affine transformation. Note also that IFSLab will render your image automatically when it has the time to do so – there is no need (and no means) to tell IFSLab to "render now".

Initially, the construction window in "base shape construction mode", which means, you may now draw your base shape which you will later

transform.

In ”base shape construction mode”, when you click a point inside the black area in the construction window, a line will be drawn. Every mouse click adds a new point in the line. A double click finishes the line.

Although you may draw any shape, let’s just begin by drawing a triangle[1].

2.1.2 Creating Affine Transformations

When you’re done drawing the triangle, click on ”Finish Base Shape” to enter *transformation mode*. In this mode, you apply transformations to copies of the base shape. To get a new copy, click on the ”New” Button in the ”Affine Transform” box.

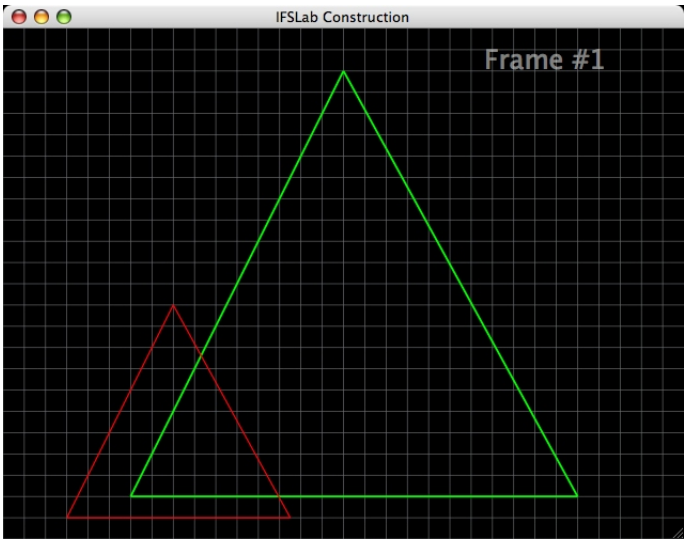

Figure 2.3: The first transformation of the Sierpinski Triangle

You will now see a smaller version of your triangle in red color. This is your current transformation. You may now move the shape around by clicking and dragging in the construction view.

[1]It’s important to notice that the base shape will have no effect whatsoever on the resulting IFS fractal. The fractal calculation is solely based on affine transformations, which could be applied to any shape, so in a sense the base shape is not important at all. It is a great help, however, if you want to put self similar shapes into IFS fractals.

Now, create two more transformations of your triangle, using the ”New” button again. Move the first one to the lower left corner of your base shape triangle. Move the second one to the lower right corner of the base shape, and the third one to the top corner.

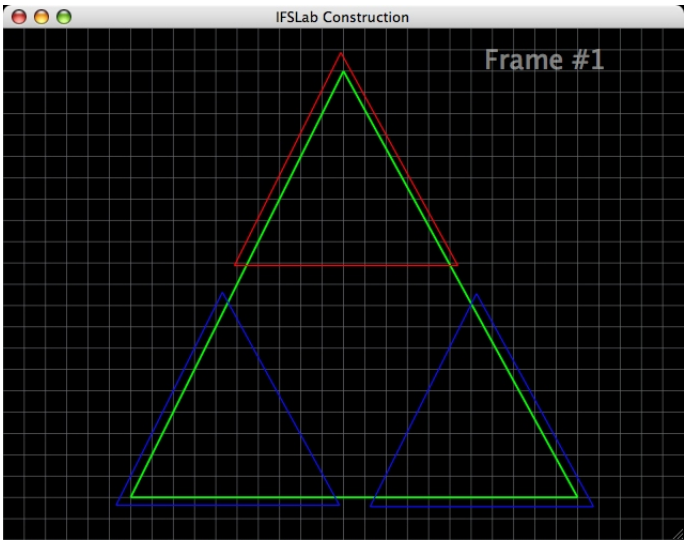

Figure 2.4: The three transforms for the Sierpinski Triangle.

In addition to moving the transformed shape, you can also:

- resize it by holding the SHIFT key while dragging
- rotate it by holding the CTRL key while dragging

(You can also use the ”move”, ”rotate” and ”resize” buttons to do so).

While setting up transformations, a preview of the finished fractal is drawn in realtime into the Render Window. You will however not notice any signifcant change until you’ve created at least two affine transformations.

When finished with your transformation, the ”New” button creates a new tranformation; the ”Copy” button creates a copy of the current transformation.

2.1.3 The Render Window

IFSLab automatically renders the fractal when you're not working on the transformations.

When changing the transformations, the Render Window displays a lower resolution preview of the resulting fractal.

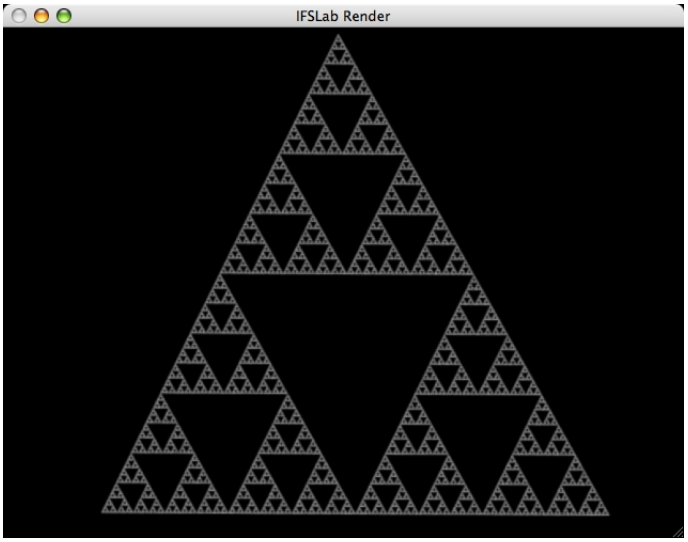

Figure 2.5: The resulting fractal in the Render Window.

2.1.4 Saving And Loading Your Fractals

You can save your fractal as soon as you have one affine transformation applied. If you have changed any of the rendering settings, these changes will also be saved.

To load an IFS fractal, simply double-click it in the Finder or choose "Load" from the "File" menu[2].

[2]A note for users of earlier versions of IFSLab: Version 1.0 introduces some changes to the internal representation of the IFS fractal. Because of these changes, save files from earlier versions of IFSLab need to be converted to a new format. IFSLab handles this automatically, you should however be aware that files saved with this version of IFSLab can not be read by earlier versions of the application.

Also, in versions 0.9.2 and earlier, there was a render setting named "brightness" which determined how many grayscale levels to draw. Since we're using gradients now (and the new gradient palette is much larger than the old 256 shades of gray), this setting has

2.2 Advanced Features

2.2.1 Rendering Parameters

You can fine tune the rendering process by changing the settings in the ”Rendering Parameters” box.

Whenever you change a parameter, the fractal will be re-rendered.

The parameters are:

Iterations

The more iterations, the more detail. Warning: A big number of iterations may slow down the rendering process considerably.

Contrast

When moving this slider to the right, bright points are rendered brighter and dark points are rendered darker.

Use Shading

Normally, for each rendered point one of your transformations is chosen at random. By enabling Shading, a probabilty is applied to each transformation, so that some transformations will be chosen more often than others. This can produce interesting visual effects.

Shading factor

Setting this to a higher value makes transformations less likely. Use with caution!

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gone away. When IFSLab encounters a save file from version 0.9.2 or prior, it adjusts the gradient according to the brightness setting by inserting an additional ”white” value into the gradient. If your fractal doesn’t look like what you expected, you might want to check the gradient.

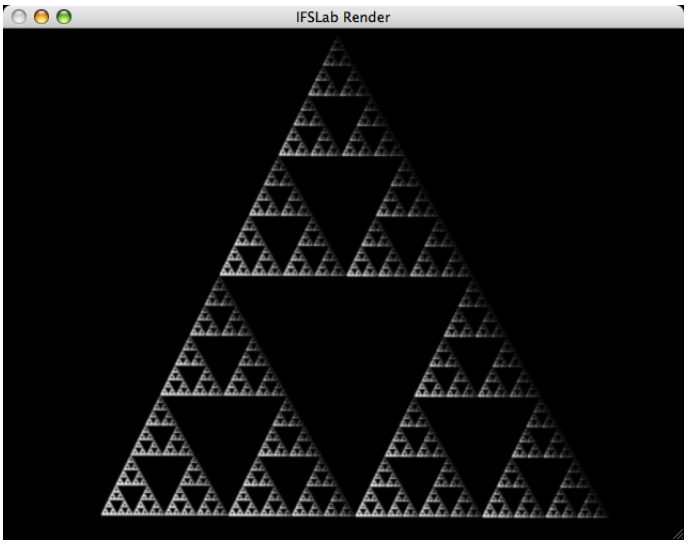

Figure 2.6: The Sierpinski Triangle rendered with Shading.

Use smoothing

With this option enabled, IFSLab smoothes the edges of the rendered fractal, making the image look softer.

2.2.2 Color

Basically, an IFS fractal is a black-and-white affair only, because in each iteration a point is plotted.

By default, IFSLab adds depth to the image by drawing more repeatedly plotted points brighter than less repeatedly plotted points. In other words, IFSLab uses a grayscale palette which goes from very dark grey (for the least frequent points) to white (for the most frequent points).

To bring color into your fractals, IFSLab features a gradient editor which allows you to map a gradient over the standard grayscale palette. You can bring up the gradient editor by clicking the ”Gradient Editor...” button in the Render Parameters box, or by choosing ”Gradient Edtior” from the Window menu.

To add color to your fractal, open up a color picker by pressing the ”Colors...” button and drag the desired color to the desired position in the

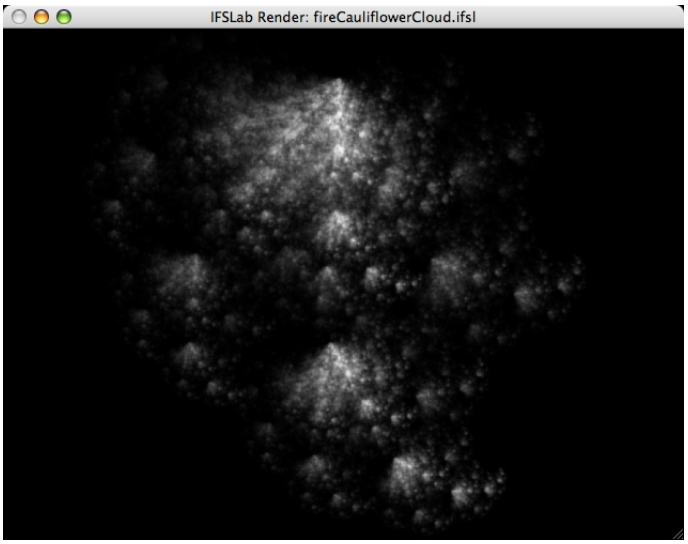

Figure 2.7: Cauliflower IFS fractal with standard gradient.

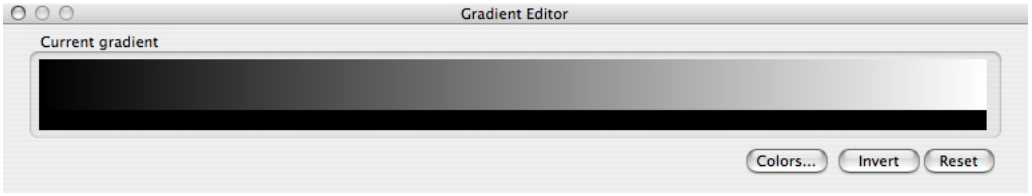

Figure 2.8: Gradient editor with standard palette

gradient editor.

The dragged colors show up as triangles in the gradient editor. You can move those to the left or right to adjust your gradient or drag them out of the editor to delete the corresponding colors.

As with editing the transformations, IFSLab re-colorizes the fractal as soon as you have made any changes to the gradient.

2.2.3 Fractal Inspector

To view detailed information about your IFS fractal, you may open the Fractal Inspector by choosing ”Fractal Inspector” from the ”Window” menu.

Hint: You can set the current transformation in the Construction Window by directly selecting a transformation in the inspector. This is espe-

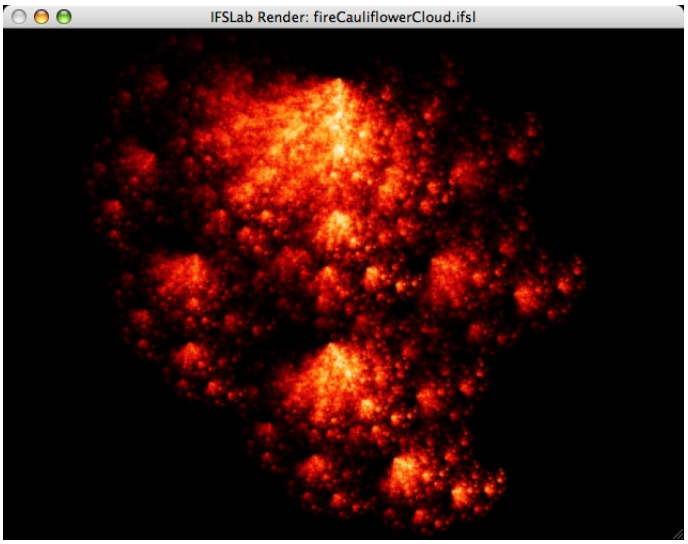

Figure 2.9: Cauliflower IFS fractal with color gradient.

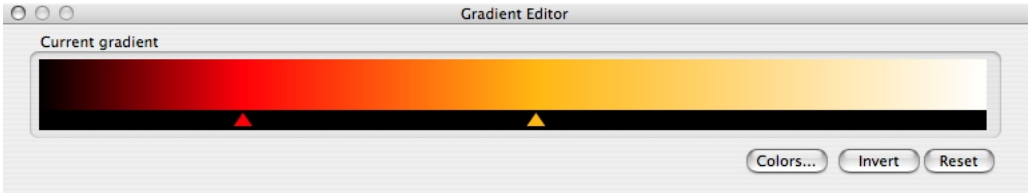

Figure 2.10: Gradient editor with color palette

cially useful if you're having trouble selecting it in the Construction Window because it's obstructed by another transformation.

2.2.4 Exporting Rendered Images

By choosing "Export Image As..." from the "File" menu, you can save the rendered image as a TIFF or JPEG file.

By default, rendered images have a resolution of 1024x768 pixels.

You can, however, enable "High Quality Mode" when exporting images, where you can adjust the resolution and the number of iterations freely.

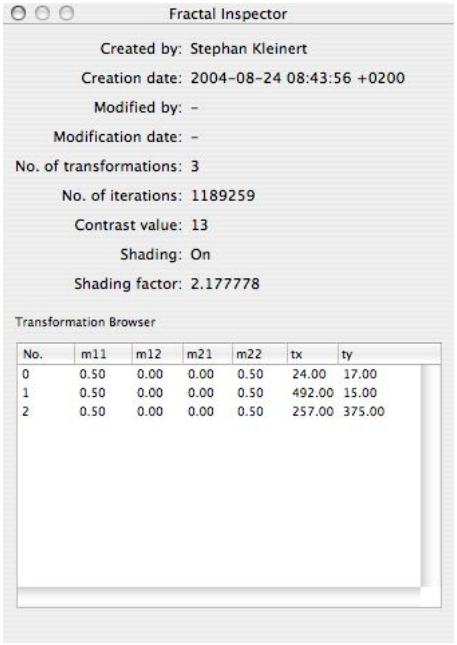

Figure 2.11: The Fractal Inspector

2.3 Animation

IFSLab allows you to create animations of IFS fractals morphing into other IFS fractals, from now on called ”Frames”. As each frame is made from a set of affine transformations, animation is accomplished by morphing one set of transformations into another. In order to do this, it is neccessary that each frame contains the same number of transformations[3].

Although this sounds fairly complicated, creating an animation with IFSLab is actually quite easy.

2.3.1 Creating A Simple Animation

Creating the first frame

We’ll start out with the Sierpinski Triangle again. Choose ”New IFS from Assistent...” from the ”File” menu, select ”Sierpinski Triangle” and click the

[3]There is, however, a way around this limitation – see ”Creating Animations Using IFSL Files”

”Go!” button.

The Sierpinski Triangle is the first frame in our animation.

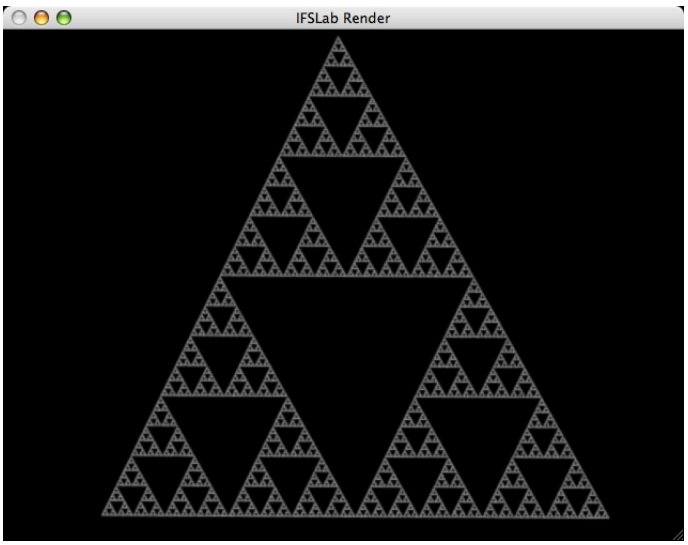

Figure 2.12: Our first frame.

Creating the second frame

Now let’s add a second frame by clicking ”Add New Frame” in the Control Panel.

You’ll notice that IFSLab now displays ”Frame #2” in the upper right border of the Construction Window. IFSLab has created a second frame by copying the first one.

Now, take one or two or all of the transformations and drag/resize/rotate them around a bit.

Previewing your animation

By clicking on the ”Play” button, you can preview your animation. The preview is in black and white and low resolution only.

After previewing, IFSLab jumps to the last frame in the animation.

Figure 2.13: The second frame.

Adjusting the number of steps between two frames

With the ”No. of steps between frames” control you can define how many frames between your fractals will be calculated; the more, the smoother your animation will look. Try setting the number to 150 and watch the preview again – you should now notice that the changes are more subtle.

Exporting the animation

When you’re pleased with the preview, you can export your animation. To do so, choose ”Export animation as Quicktime movie...” from the ”File” menu, which will bring up the Export Movie Dialog, where you can select the resolution of the finished animation. The higher the resolution, the longer it will take to render the movie. Select ”Medium” for this animation.

IFSLab now displays the standard QuickTime compression dialog (you might have seen this before in iMovie or other QuickTime based applications). Here, you can select a video codec and the number of frames per second.

As video codec, choose ”Apple Pixlet Video”, which gives you a very high quality in the finished movie and the ability to scrub backwards and

forwards in realtime (you may also choose ”MPEG-4”, which has a superb compression ratio while still retaining a high quality). You may, of course, choose any other codec, but MPEG4 and Pixlet Video turned out to be the most suitable ones for IFS animations.

After the export has finished, double-click your newly created movie in the Finder and watch it.

2.3.2 Appending Frames From IFSL Files

You can also use one or more already saved .ifsl files as animation frames. To do so, select ”Append frames...” from the ”File” menu.

Hint: When appending frames from an .ifsl file, the number of transformation in the existing frame(s) *does not have to be equal* to the number of transformations in the frame(s) you wish to append[4]

[4]Actually, IFSLab still needs each frame to contain the same number of transformations. However, when attempting to append a frame with fewer transformations than those in the already existing frames, IFSLab automatically adds copies of the new frame's transformations until their number is equal. Likewise, when appending a frame with more transformations, copies of transformations are added to all existing frames.

Chapter 3

Frequently Asked Questions

3.1 The rendered image is too dark

Try one or more of the following:

- Increase the number of iterations
- Increase the contrast
- Modify the gradient by dragging a bright color near the beginning of the gradient. This will help in most cases, although it may make the fractal look grainy.

3.2 Editing my transformations is very slow

The default settings of IFSLab assume a G4 equipped computer when rendering the preview. By deselecting ”Render High Quality Preview” in the ”Performance” tab of the ”Preferences” window, you can instruct IFSLab to render a lower quality preview which is much faster on G3 systems.

3.3 Now matter how I try, my fractals don't look good

- Start from a template or take a look at the examples coming with IFSLab. It takes a while getting used to the process of creating IFS fractals
- Start out with no more than two or three transformations. There are a lot of interesting things you can do with a limited number of transformations.

3.4 The program is always rendering! How can I stop this to continue working on my transformations?

You can't. In fact, you don't need to. As soon as you do anything in the program, the rendering stops immediately.

3.5 I can't select one or more transformations

Bring up the Fractal Inspector (Apple+I) and select your transformation from the transformation table. **Hint:** You don't need to have the mouse pointer over the transformation you want to move/resize/rotate. It is sufficient to have the mouse inside the construction window.

3.6 Why can't I 'draw' my transformations directly instead of having to modify transformations of the base shape?

As IFSLab is very flexible in terms of the base shape (just have a look at the "Infinite A" example), free-form drawing would lead to chaos when transforming a shape with more than four control points, as not everything you might draw would be a valid affine transformation. It was a design choice not to allow free-form drawing of transformations.

3.7 When I append an IFSL file, the base shape in the appended frame is the same as the base shape in my first frame... how can that be?

When appending a frame, IFSLab only uses the saved transformations and palette data – there is no way to have different base shapes in different frames. But, as the base shape has no effect on the rendered fractal, this is a purely cosmetical matter.

Chapter 4

IFSLab reference

4.1 The Menus

4.1.1 The File Menu

New Empty IFS

Creates a new empty IFS fractal, putting the program into Base Shape Construction Mode. All previously entered data (base shape, transformations and frames) will be deleted.

New IFS from Assistent...

Creates a new IFS fractal using the Assistent.

Open...

Loads a previously saved IFS fractal.

Save

Saves your IFS fractal.

Save As...

Lets you save your IFS fractal under another file name.

Export Image...

Exports the rendered image as TIFF or JPEG file.

By default, the rendered images are 1024x768 pixels in size. In the Save Dialog, you can also specify ”High Qualitiy Export”, which lets you choose a custom size for the rendered fractal.

4.1.2 The Construct Menu

Create random transformations

Creates a random IFS fractal. Although IFSLab tries its best to produce interesting looking fractals, you might want to repeat this a few times.

Align To Grid

Controls whether the base shape points should be aligned to the construction grid.

4.1.3 The Windows Menu

Gradient editor

Brings up the gradient editor.

Fractal Inspector

Brings up the Inspector window.

4.2 The Control Panel

4.2.1 Base Shape Controls

Start Again

Clicking this button lets you start again in Base Shape Construction Mode. All your previously created data will be lost.

Finish Base Shape

Finishes Base Shape Construction Mode.

4.2.2 Affine Transforms Controls

New

Creates a new affine transformation. The newly created transformation will have half the size of the base shape and will be positioned at the lower left corner of the base shape.

Copy

Creates a new affine transformation by making an exact copy of the currently selected transformation.

Delete

Deletes the currently selected transformation.

Move

Puts the editor into move mode. In this mode, dragging in the Construction Window will move the currently selected shape around.

Rotate

Puts the editor into rotate mode. In this mode, dragging in the Construction Window will rotate the currently selected shape.

Resize

Puts the editor into resize mode. In this mode, dragging in the Construction Window will resize the currently selected shape along the X- or Y- axis, depending on the dragging direction.

Although at the beginning it might be easier to use the ”Move/Rotate/Resize” buttons, you can also just remain in move mode and do rotating and resizing by pressing the Ctrl- and Shift Keys while dragging the mouse.

4.2.3 Rendering Controls

Iterations

The more iterations, the more detail. Warning: A big number of iterations may slow down the rendering process considerably.

Contrast

When moving this slider to the right, bright points are rendered brighter and dark points are rendered darker.

Use Shading

Normally, for each rendered point one of your transformations is chosen at random. By enabling Shading, a probabilty is applied to each transformation, so that some transformations will be chosen more often than others. This can produce interesting visual effects.

Shading factor

Setting this to a higher value makes transformations less likely. Use with caution!

Use smoothing

With this option enabled, IFSLab smoothes the edges of the rendered fractal, making the image look softer.

4.2.4 Animation Controls

Delete Current Frame

Deletes the current frame.

Add Frame

Adds a copy of the current frame after the last frame.

First Frame

Jumps to the first frame in an animation.

Previous Frame

Jumps to the previous frame.

Start/Stop Preview

Starts a low-quality preview of the animation.

Next Frame

Jumps to the next animation frame.

Last Frame

Jumps to the last animation frame.

Steps Between Frames

Controls how many steps between the frames will be calculated. Increase this number for smoother animations.

4.2.5 Render Status

This box shows you the status of the IFSLab renderer.

4.3 Preferences

You can bring up the ”Preferences” window by choosing ”Preferences...” from the ”IFSLab” menu.

The preferences window is divided into three areas, ”General”, ”Performance” and ”Construction Colors”.

4.3.1 General Preferences

Show assistent at startup

Controls whether to show the assistent at startup. If deselected, IFSLab simply creates a new empty IFS fractal after starting.

Show warning when converting old .ifsl files

By default, IFSLab warns you when you’re loading an old .ifsl file, because after you have saved again, the save file will not be compatible with old versions of IFSLab any more. If you don’t care and/or have a lot of old .ifsl files, you can deselect this option.

4.3.2 Performance Preferences

Draw point labels

Controls whether to label the edges of base shape and transformations.

High quality preview

Enables high quality preview, which has more detail and smoothing.

4.3.3 Construction Colors

Here you can customize the colors of the various elements in the Construction Window.

Chapter 5

Literature

Michael Barnsley: *Fractals everywhere*. Boston Academical Press, Inc., 1988

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Tamás Vicsek: *Fractal Growth Phenomena*. World Scientific Publishing, Singapore, 2nd Edition, 1992.

Chapter 6

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Version 1.1, March 2000

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