

Lyapunovia

COLLABORATORS

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Chapter 1

Lyapunovia

1.1 Index

Welcome to

LYAPUNOVIA V1.5

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Contents:

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Contacting the author, The serious part

Notes

"Why do I have to keep reading
these technical manuals?"

-Roger Waters

1.2 Introduction to Lyapunovia

Introduction to Lyapunovia

=====

-Tired of zooming endlessly around the Mandelbrot set?

-Irritated by little graphic thingys daftly named "Sea of solitude", "Dragons mouth", "Mountain of magic", or even worse?

-Bored by a 1000 dull fractal programs all the same, except for small twists concerning the "cache modes" of the "68030"?

Well, this is no cure. This is Lyapunovia V1.5.

-- -----

But what then, is Lyapunovia?

-To be brief, Lyapunovia makes pictures.

-To be more elaborate, Lyapunovia IS a fractal program, and it does allow you to zoom.... But it is NOT a Mandelbrot program. (Everybody should be screaming with relief at this point.) The great thing here is the variations of the images; from cute candy-like patterns to ragged and torn metal. Lyapunovia pictures contain depth and strange interacting, ever-changing shapes with NO names.

-Lyapunovia is

Shareware

.

And what is Lyapunovia V1.5?

When I originally released Lyapunovia, I used the traditional "stingy programmer" shareware concept: I released a good enough program to the public, but kept all the fancy functions such as AGA and FPU support to myself and the registered users. This worked out just fine.

But after a while, a feeling of silliness came to me: Why spend hours, days and weeks in social isolation for the benefit of so few people?

I thought for a long time and decided to release the full program this time. This makes me feel good anyway, and I hope that you, the user, will appreciate it.

From the original V1.0, a lot of things has happened; the user interface has improved, many functions have been speeded up, support for various chips and 24-bit output has been added. Most of the changes were suggested by various users.

I've tried to make a program that takes advantage of AGA graphics and the 68040 internal FPU on a 4000, but still runs on an old '500.

(The mathematically disinterested should skip the following explanatory part and go directly to "

Installation

" and "

```
Getting started
".)
```

The mathematical way

Where Mandelbrot graphics (the ones you've seen a 100 times before) are renditions of the "Mandelbrot Set", Lyapunovia renders "Lyapunov Space" (unsurprisingly named after the russian mathematician Aleksandr M. Lyapunov). If the Mandelbrot set is the "most complex object in mathematics", Lyapunov Space must be the juiciest, spiciest and most outrageous object ever found within numbers.

The specific formulas used to produce these breathtaking pictures were thought up by Mario Markus of the Max Planck institute for Nutrition. And it all reached my mind by means of the "Mathematical Recreations" column in the September, 1991 issue of "Scientific American".

If you've ever spent some time with the Mandelbrot set, zooming, changing colors, etc... You'll be well off to understanding how Lyapunovia works. Picture a square with coordinates, going horizontally from 2.0 to 4.0, vertically from 2.0 to 4.0:

```

          (X1)      (X2)
          2.0      4.0
          -----
(Y1) 2.0 |          |
      |   | The      |
      |   | Picture  |
(Y2) 4.0 |          |
          -----
```

That's what you see when running the program. Lyapunovia enables you to zoom in, to watch in closer detail whatever part of the screen appeals to you. This is like the Mandelbrot set.

What makes Lyapunov Space perhaps so much more fascinating, is the ability to switch between an endless amount of different domains, each possessing an individual "personality" of sorts. And things are very strange, jagged and torn. Very appealing to any decently deranged imagination.

Like the Mandelbrot set, Lyapunov Space is a map of chaos, meaning: Lyapunovia calculates the "Lyapunov exponent" of each pixel; an indication of whether the formula is order or chaos at the given X and Y-positions. Chaos is mapped as black, order is mapped with the highest colors for the orderliest function. The basic formula is equivalent to the one used for making "Feigenbaum trees"; $x=rx(1-x)$. The Lyapunov exponent is calculated like this:

```
;A SMALL PROGRAM FOR DETERMINING A LYAPUNOV EXPONENT
```

```
X=0.5      ;JUST AN INITIAL VALUE
TOTAL=0
ITERATIONS=50
R=3.5      ;OR SOMETHING ELSE BETWEEN 2 AND 4.
```

```

FOR I=1 TO ITERATIONS
  X=RX(1-X)
  TOTAL=TOTAL+LOG (ABS (R-2RX)) /LOG (2)
NEXT I

```

```
TOTAL=TOTAL/ITERATIONS
```

The TOTAL variable now holds the Lyapunov Exponent for the formula $X=RX(1-X)$.

Now you should be asking yourself: How does one plot a two-dimensional picture when the formula only has one parameter? Right: What we do is, for each iteration, to replace R with either the X coordinate or the Y coordinate of the pixel we're going to plot. The sequence parameter determines how X & Y should alternate: An "AB" sequence does X, then Y, X, then Y and so on... "AAB" does X,X,Y,X,X,Y... and so on and so forth.

Naturally, there are various ways to rewrite the formula to speed up calculations as I've done, but this should give you an idea of what is going on.

Reading on Lyapunov Space:

 Scientific American, September 1991. A.K. Dewdney: "Leaping into Lyapunov Space".

Generally on fractals & chaos:

 Brian H. Kaye: A Random Walk Through Fractal Dimension. VCH, 1989.
 H.O. Peitgen, P.H. Richter: The Beauty of Fractals. Springer, 1986.

1.3 installation

Installing Lyapunovia

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Lyapunovia uses Nico Francois' ReqTools library for file-requesters, information boxes, palette requesters and the like, therefore:

Before running, REQTOOLS.LIBRARY (version 2.0 or above) must be present in your LIBS: directory. In the "Install" drawer of this distribution, you'll find instructions as how do this.

Also make sure to have the mathtrans.library in the LIBS: directory as well. (It comes with the computer, so don't worry.)

And be sure to use the version that suits your
 chips
 the best!

Program versions

 Three different program versions are included in this distribution:

"Lyapunovia V1.5 68000" - for unaccelerated A500/A1000/A2000.
 "Lyapunovia V1.5 68020+" - for accelerated Amigas, A1200,3000,4000.
 "Lyapunovia V1.5 FPU" - for Amigas with a floating point unit.
 All three versions will run under 1.3-3.0, and will automatically adjust to your computer.

Libraries, screens and memory allocation

Whenever the program is unable to open a library or a screen, or unable to allocate some required memory, it will instantly exit and clean everything up. An alert (the flashing thing) will then inform you of the error. If using WB3.0+ on a non-AGA machine, trying to load a 256-color picture will result in a "unable to open screen"-error. Using 1.2-2.1, the picture just won't be loaded, instead calculations are started based on the coordinates.

1.4 Getting started

Getting started
 =====

To quickly get a feel of what Lyapunovia does, do the following:
 Install Lyapunovia. Double-click on the icon. The title-screen will appear, press "OK" to continue.

(In the following, letters within {} indicate that the function can be activated by press "right amiga" and that key.)

The program will start making a very simple Lyapunovia picture. Note that I generally programmed Lyapunovia to automatically begin calculating every time a parameter has been changed. You can always stop the program via the menus or by pressing right amiga+ "." (the latter being much faster).

Do the following:

Stop the program. {.) Try choosing a new screenmode:
 -On 1.2/1.3, select # of colors etc.. from the menus.
 -On 2.0-3.0, press {M} to get a screenmode requester.

Let the picture finish.

That was easy enough, but you've probably noticed that the picture isn't very interesting. So lets try loading a coordinate file: A coordinate file is simply a little file describing a certain "place" in Lyapunov Space. When you load a coordinate file, Lyapunovia automatically starts calculating it in the current screenmode, with the current palette. Load a coordinate file, say "Cross" or "ABBBBA 24 - 3". {D} (You'll find the files in the "Coordinates" drawer of this distribution.)

While the picture is being calculated, you can experiment with different palettes; with menus or by pressing right-amiga and 1,2,3, or 4. -Or try bringing up the palette requester. {P}

Once the picture's done, try loading some palette files. In the "Palettes" drawer, you'll find a lot of different palettes:

- On a 256-color AGA screen, try "256 - Shiny" or "256 R&G".
- On a 32-color screen, try "32 - lift up my nights".

Try selecting a cycle speed of 1 {Z}, then try the "cycle" function. {Y}

If you like the picture, try saving it, using "Save IFF". {S} From then on, you can print it, edit it or whatever you want to do. At some later time, you can also load the picture again, change the colors or zoom in somewhere that looks interesting - this is the next point:

Zooming is very simple: You can select the area you want to see in further detail either from corner to corner {R} or from center to corner {N}. Try it; a requester will appear, asking if you're sure. If you were, the screen is cleared and the image you've selected starts being drawn.

To more fully appreciate what Lyapunovia has to offer, this is how to make some of my favorite pictures:

Coordinate file	Palette (AGA / non-AGA)
Flash; Curve II	256 Cycle - II / 32 Cycle - III
5A5B 50, ibd 11	256 - Shiny / #1
5A5B 50, 'In-between, detail'	#4 / #4
5A5B 50, 'In-between'	#4 / #4
5A5B 50, ibd something	256 - R&G / 32 - Light up my nights
6A6B 30, Agurk	#4 / #4
ABABA 50, Radiant	256 - R&G / 32 Cycle, Bilal II
ABABA 50, Spider	256 - Lift my days / 32 - Lift my Days
5A5B 50, ibd 5	256 - Shiny / #4
5A5B 50, The Big Parable	256 - Yellowie Eyes / 32 - Greenscale
AB 100, 'Indian Eyes'	#4 / #4
6A6B 30, 'CrissCross'	256 Cycle - III / 32 Cycle - III
5A5B 50, 'Loneliest Object'	#4 / #4
Flash; 6AAB, 'Cross'	256 Cycle - Seventies / 32 Cycle - II

(#1 means standard palette 1; right amiga + 1.)

If you like a picture, you can always save it {S}, and then reload it at some later time for deeper zooming.

If you want to produce a 24-bit file, just load the coordinate file, stop {.), press {F}. Select dimensions, select a palette file, then an output file name.

To make sure that the color transitions are absolutely smooth, you may want to expand a palette file first {X}: Select the palette to expand, select the # of colors to expand to (just say 4096), then the file name of the new palette. To avoid confusion, it can be a good idea to name the palettes the way I've done: Thus expand "256 - Shiny" to "4096 - Shiny".

A general rule is that you should zoom on the border between black and color. That's where the "action" usually is.

1.5 Program functions

Program functions

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(NOTE: letters within {} indicate that the function can be activated by press "right amiga" and that key.)

(In order to gain speed, Lyapunovia will only check for menus, pressed keys etc. every now and then. This is unnoticeable on pictures with a low "iteration" value; with large values (larger than, say, 500 on an unaccelerated Amiga), there will be a noticeable delay from selecting a menu till the program reacts. Don't worry, your Amiga will remember what you did!)

Menu 1: PROGRAM

This concerns basic program and file options.

- Stop: Stops drawing the picture. {.}
- Go: Though changing almost any parameter automatically restarts calculations, you sometimes need a separate function to do this. This is it. {G}
- Save IFF: Saves the current picture as a standard IFF file. {S}
- Load IFF: Loads a picture saved from Lyapunovia, including coordinates etc... This enables you to continue exploring where you left off... {L}
- Save Prefs: Saves the current screen settings as "S:Lyapunovia.prefs". This file is automatically loaded when the program is started.
- Load Prefs: Loads the preference settings.
- About: A bit of information about Lyapunovia. {A}
- Priority: Sets the task priority of Lyapunovia. Generally speaking, "1" gives Lyapunovia priority over most other programs, "0" splits the CPU time, and "-1" makes the program run quietly in the background.
- Quit: Quits Lyapunovia. {Q}

Menu 2: SCREEN

This concerns screen resolution and colors.

Palette:

Edit:	Edit palette. {P}
Palette 1-4:	Four different standard palettes. {1,2,3,4}
Cycle:	Performs a standard color cycle on the current picture. I realise that this is probably the oldest and least original effect on the Amiga, but boy! it does look great. Anyway, press mouse button or any key to stop. {Y}
Cycle speed:	Some people asked for a faster cycle, some asked for a slower. This function allows you to select the delay (in screen frames) between each step of a cycle. {Z}
Save:	Saves the current palette in a standard format. {V}
Load:	Loads a new palette. Note that it is possible to load a palette from any standard IFF file. Loading a palette with a different number of colors than the the current will delete the current image. A prompt appears, asking you to confirm. {O}
Rotate:	When you perform a cycle, sometimes you'll notice some unexpectedly good-looking color-combination that you want to keep. This function moves through a standard cycle step by step, allowing you to save the good-looking colors when they appear.
Title bar:	Toggles the title bar. {T}
Screenmode:	Users with WB2.0+ can change screen resolution and # of colors using a single menu. This replaces the below-mentioned menus. Lyapunovia supports ALL resolutions supported by the system software. If you seem to be able to a select a mode that causes strange flickering or the like, please note that this is due to a faulty preference setting, not a faulty program! As standard, the program assumes the screen size specified as "Text overscan" in the preferences. To produce pictures bigger than the screen, enter the desired dimensions in the "width" and "height" gadgets. If the screen requires more chipram than available, you'll be returned to the previous resolution. On an oversize picture, the screen will automatically scroll when you move your pointer around. {M}
Hires:	Turns high resolution on/off. (640 pixels per line, rather than 320.) * Under WB1.3 only!
Interlace:	Turns interlace mode on/off. (PAL: 512 lines rather than 256. NTSC: 400 lines rather than 200.) * Under WB1.3 only!
2-32 Colors:	Selects the number of colours on screen. (2, 4, 8, 16 or

32.) See "
Chipram
" note. * Under WB1.3 only!

Menu 3: IMAGE

For moving around in Lyapunov Space.

Coordinates: Alters the specifications of the current image.
See "
In-depth explanations
" for elaboration.

Zoom in:

Center/corner: To zoom with the mouse. Point at the center of the
"place" you want to view, hold left mouse button and move
mouse to the corner of the square. Release button.
Lyapunovia will ask you if you're sure. {N}

Corner/corner: Same as above, except that you select from corner to
corner. {R}

Zoom out:

All the way: Returns you to the initial coordinates.

2 times: Zooms out two times.

4 times: Zooms out four times.

Save: This saves the current image setting; the settings
specified under the "Coordinates menu": What sequence
you're using, and where you're zooming, etc.. {E}

Load: This loads such a file. You can also load them from a
Lyapunovia IFF file. {D}

Precision

:

Half: Half precision is a special "preview" mode to quickly see
what a picture will look like. Faster, especially on a
68000 system. This mode has to be selected manually. Not
very useful, really.

Single: Single precision is the default precision. Precise enough
for most purposes. Switching back to this mode has to be
done manually.

Double: Double precision is for extra deep zooming. Lyapunovia
will automatically switch to this mode when it is
required.

24-bit output:

This is what a lot of people have been asking for for a long time. It's fairly simple; to produce a picture you just enter the dimensions (in pixels), select a palette and an output file name, and away you go. The picture is always drawn based on the current coordinates. Maximum dimensions are 65000 x 65000 pixels. Note: The picture on the screen doesn't have to be fully drawn before you do the 24-bit output; the normal display should be seen as a navigator to help you produce the best 24-bit pictures possible, 24-bit output is independent of current screen resolution etc.. But NOT from precision

.
{F}

24-bit palette expansion:

Since a lot of people don't have AGA, and since even with AGA it can be hard to manipulate colormaps with over 256 colors, this is a small tool to help you: What it does is that it takes a previously existing palette file and then "expands it", smoothing any jumpy color-differences along the way, allowing you to get smooth color transitions in your 24-bit output. (Incidentally: This can also be used to turn old 16/32 color palettes into 256-color palettes for use on AGA machines.) {X}

1.6 Tips & Tricks

Tips & Tricks

=====

Cycle

For optimum results, use a palette where color 1 is nearly equivalent to the last color. That way, cycling is less "jumpy". The "32 color cycle I" palette is a good example thereof, so is "256 - shiny".

Where do i zoom?

Well, in the end you should let your own tastes decide:

Do you like the soft & smooth quality of "Candy" with palette #1? -Then focus on pictures with a low "iteration" value; don't zoom to deep, but experiment with "color-divide" and palettes instead.

If you prefer the spaced-out metallic of "AAB 100, Indian eyes" with palette #4, then stick to fairly high iteration values and always zoom on the edges between black and color, in places that seem layered.

For the rather moving, "loneliest mathematical object in the universe"-feeling of "5a5b 50, zoom1", zoom on the little islands of color in the blackness.

Note that all images change appearance radically when changing palette. Try the "X-ray" palettes!

Sometimes, but seldomly, you may experience the feeling that the pictures you get tend towards the repetitive.

The official advice is this: Zoom where you don't usually zoom! That usually does the job. After having played with Lyapunov Space for nearly a year, I still get a lot of surprises. The possibilities are endless.....

1.7 In-depth explanations

In-depth explanation of a few points:

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Coordinates, the short explanation:

If you're not that interested in mathematics, you only need to know one thing: The "coordinates" menu decides what your picture should look like:

"Sequence" make the picture different.

"Color-divide" changes the brightness of the picture.

"Iterations": The bigger the number, the stranger the picture, the slower the program.

"Plot repeat": Repeats the palette.

Coordinates, the in-depth explanation:

Sequence

Selects the general formula you want to look at. Not as complicated as it sounds: Lyapunovia works by - at each point on the screen - running through a basic formula as many times as you specify in the field "Iterations".

In this field, only the letters "A" or "B" are legal. "A" runs through the formula using the X coordinate of the current point, "B" uses the Y coordinate. To give an example: A sequence of "ABABB" and 7 iterations will repeat the formula like this:

A,B,A,B,B,A,B	-The "sequence", repeated.
X Y X Y Y X Y	-Its' X or Y partner.
1 2 3 4 5 6 7	-The current iteration.

That is to say that sequences are wrap-around.

Color-divide

Determines the general brightness of the picture. When using default palette #1, a high color-divide makes the picture light, a low one will make the picture dark. I can't tell you what color-divide should be set to at all times - rather you should experiment from picture to picture, adjusting this number along with the palette. Nevertheless, a good rule is

to stay between 1500 and 5000.

Iterations

This determines how many times the basic formula should be repeated - for each iteration, the program moves to the next step of the "sequence". Thus, if you specify fewer iterations than the sequence is long, only part of the sequence will be executed.

The more

iterations

, the more weird the picture... And the longer time to do calculations.

Plot repeat

With a value of 1, the palette is distributed evenly by mathematical means. Higher "plot repeat" values will distribute the palette _several_ consecutive times. If you then alter the palette so color 1 and the last color are close, and then cycle, you'll have a great effect of moving bars. Check out the "Curve x4 II" with different cycle-palettes to see what I mean. Do try it with a cycle speed of 1!

Only 1-4 are valid plot repeat values.

Errors

When pressing "OK" in coordinates, the program will inform you of any faulty values..... Respond accordingly. If you're lost, just press "UNDO" or "CANCEL".

1.8 Contacting the author

Contacting the author

=====

Contacting me

First of all, you're always welcome to contacting me with any suggestion, bug report (aargh!) or comment that springs into your mind.

If you've found somewhere nice in Lyapunov Space; a great palette or a great picture or some great coordinates, please mail them to me. You will then be mentioned in the next doc. file!

The serious part

And now the serious part: Since the last release of the program, I decided not to keep a special registered version of the program to myself and a few registered users, but rather to share it with as many people as possible.

In return for that, I'd like you to share something with me:

The suggested shareware fee for this program is 50 DKR, 15 DM, US\$ 10, or the equivalent in any other currency. If you think I deserve it, this can be communicated in several ways:

- * By mail: Wrap the bills in some dark paper and write me letter and give me a few comments, tell me a bit about your Amiga and what you're doing with it.
- * By EuroCheque, addressed to "Jesper Juul". Remember to write the card number at the back of the cheque.
- * In most countries, you can pay at the post office via my Giro account: Girobank Denmark, 1-205-3207.
- * But no national cheques, not even Bank-signed ones.

If you don't feel like sending money, you can mail me something else:

- * Records, tapes and CDs! (Keywords: Pixies, Stravinsky, Jethro Tull, Living Colour.)
 - * Good books! (Keywords: Paul Auster, Jonathan Culler, Douglas Adams, Jorge Luis Borges.)
 - * Or some (preferably good) software you've written.
 - * Or if you make something like t-shirts or posters or videos or demos or anything from the program, I'd like a copy.
 - * Or whatever you think.
- * No matter what you do, be sure to mail me some comments and/or suggestions!

Anyway, this is my address:

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Guldsmedgade 34, 1.
DK-8000 Aarhus C.
Denmark

E-mail: norjj@stud.hum.aau.dk

1.9 notes

Notes:
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The future

There are (still) a lot of things I might want to add to this program.

- Speed.
 - Movie mode, letting you save animation-files.
 - A color dithering mode.
 - Extended rendering choices.
 - More mathematical formulas to choose from.
 - Whatever you can think of..... AREXX interface and SCSI support?
-

An animation mode is the next project, after that I'll probably try looking at some other formulas.

Lighter notes:

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"It's too bad they don't do this covernote thing anymore, 'cause it's not a bad thing to say something, even if it doesn't amount to much."

-Ian Anderson

The hard road to excess

Lyapunovia was written in 100% pure assembler. It was written late at night, early in the morning, while cooking Spaghetti Bolognese, while brushing my teeth, while I was supposed to be doing something else, while half asleep, while everybody else was watching TV, while I had too many drinks the night before, while I didn't really want to, while under almost divine inspiration, while reading, while making phonecalls, while watching the tiny little bit of blue sky I can see from my room if I push my head flat against the window and look directly up, while singing loudly, while thinking 'bout the night before, while drying my hair, while eating breakfast, while snapping my fingers, and while I was in small gaps between everything else that my life contains. And now it's here. Makes you wonder....

Slogans

The official slogan of this manual is, as you know, this:

"Why do I have to keep reading these technical manuals?"

-Roger Waters.

The official slogan of this program was suggested by Iivo Vehvilainen:

"Way off in some indistinguishable distance was a stunning peak that overarched the sky, climbed and climbed and spread out in flowing aigrettes, agglomerates and archimandrites."

-Douglas Adams: Mostly Harmless.

The official slogan of my entire life is this:

"Though they may have won all the battles, we had all the good songs."

-Tom Lehrer.

The slogans, by the way, are self-contained and have no slogans.

Laws

The official law governing the production of this program is Hofstadters law:

"Things always take longer time to finish than you expect, even if you take Hofstadters law into account."

-Douglas R. Hofstadter.

Copyrights

Lyapunovia is © 1992-93 Jesper Juul.

ReqTools is © Nico Francois.

The rest of the copyrights belong to whoever owns them.

Thanks go to:

Nico Francois for ReqTools.

Jan van den Baard for GadgetEd.

Stefan Borberg for LhA.

Olaf "Olsen" Barthel for Term.

Fred Fish for his library.

Mads Christiansen, Mads Rydahl and Jens Christian Hansen for different things.

(The former Mads especially for showing me the article that got me started, the latter Mads for designing disklabels.)

Kaare Heinsen, Phill Coxon, Jesper Skov, and Jes Sørensen for beta-testing.

(Special thanks to Jesper for "answering questions".)

Lotte, Kim, Annette, Anne, Henrik, Lilo, Line, Marianne, Hanne, Lars, Rasmus, and Trine for endurance.

And finally, the great mathematical minds behind it all:

A. K. Dewdney, Mario Markus, Benno Hess, and Aleksandr M. Lyapunov.

1.10 Concerning Amigas with chipram only.

On Amigas without Fastmem, selecting 16 colors in hires mode (256 colors, a 1280 pixel screen on AGA machines) will significantly slow down program execution. But also notice that this is only true when the Lyapunovia screen is being displayed. Therefore, bring Workbench to front while Lyapunovia is calculating; the screen will automatically be re-displayed when the picture has finished.

1.11 Iff-files

When saving an IFF file, Lyapunovia will include the coordinate parameters, thus enabling you to load the picture some other time and continue zooming. However: If you process the picture (in a drawing program, for example), that information will be lost, so keep a copy of the original file. (For the technically interested: The information is saved as a TEXT chunk, which is probably the best solution.)

1.12 precision

The "iteration" parameter is a source of frequent misunderstanding for experienced Mandelbrot users. Lyapunovia is very different in that an increased number of iterations has nothing to do with increased precision; rather a low iteration count leads to smooth curvy pictures, a high count leads to ragged and chaotic pictures. Precision is constant.

1.13 chips

You should of course use the program version that suits your system best. The 68020+ version will be faster than the normal version, the FPU version will generally be faster than the 68020+ version. However: On some systems, single precision calculations will actually be faster with the 68020+ than with the FPU version. And also: Single precision FPU calculations are a bit less precise.

The program attempts to automatically adjust the level of precision according to the zoom depth. With FPUs, the program may not be that good at guessing the needed precision. With an FPU, my best advice is to select "double precision" at all times.