

## Deterministic Algorithm Overview

The Deterministic Algorithm fractal generator allows the user to create fractals by entering and removing rows in the table that represent each transformation and their respective values and probability. The user can also choose one of three preset fractals: Fern, Sierpinski Triangle, and Koch Curve. The user can choose which starting shape from which to derive fractals: Filled Rectangle, Framed Rectangle, Filled Circle, Framed Circle, and Point. The generation of the fractal can be stepped through in eight stages.

### Deterministic Algorithm Initial Screen

Annotations for the Deterministic Algorithm Initial Screen:

- START/RESET**: Click to draw fractal and/or reset to stage 0
- Copy to Clipboard**: Click to copy drawing area to clipboard
- Starting Shapes:** Filled Rectangle (Choose shape from which to generate fractal)
- Presets:** Fern (Select preset fractal)
- Drawing Area**: The main black area for fractal generation.
- Add New Row**: Click to add a new row in the transformation table
- Remove Selected Row**: Click to remove the selected row
- Navigation:**
  - Go back a stage
  - Current stage number: Stage: 0
  - Go forward a stage
  - << Step Back
  - Step Forward >>
- Transformation Table:**

a	b	c	d	e	f	P	Color
0.0	0.0	0.0	0.16	0.0	0.0	0.01	Green
0.85	0.04	-0.04	0.85	0.0	1.6	0.85	Blue
0.2	-0.26	0.23	0.22	0.0	1.6	0.07	Red
-0.15	0.28	0.26	0.24	0.0	0.44	0.07	Cyan
- Labels for Table:**
  - Transformation Values (points to columns a-f)
  - Probability Values (points to column P)
  - Transformation Colors (points to column Color)

### How Deterministic Algorithm Generates Fractals

This algorithm works like the Random Iteration algorithm, but instead of applying the transformations just to points, it can apply them to shapes as well.

This algorithm generates fractals from values specified in the transformation value table. Each row in the table corresponds to one of the affine transformations used to draw the fractal, and each affine transformation has the following form:

$$\begin{pmatrix} x' \\ y' \end{pmatrix} = \begin{pmatrix} a & b \\ c & d \end{pmatrix} \begin{pmatrix} x \\ y \end{pmatrix} + \begin{pmatrix} e \\ f \end{pmatrix}$$

This means that for each point  $(x, y)$  in the fractal at the current stage, the next stage will have a point  $(x', y')$  according to the preceding values. The green transformation in the image below indicates that the fractal is to be scaled by one half in both the x and y directions, and then it is translated half a unit in the x direction.

a	b	c	d	e	f	P	Color
0.5	0.0	0.0	0.5	0.5	0.0	0.33	Green
0.5	0.0	0.0	.5	0.0	0.5	0.33	Blue
0.5	0.0	0.0	0.5	0.5	0.0	0.34	Red

# Deterministic Algorithm Tutorial

## Starting the Application

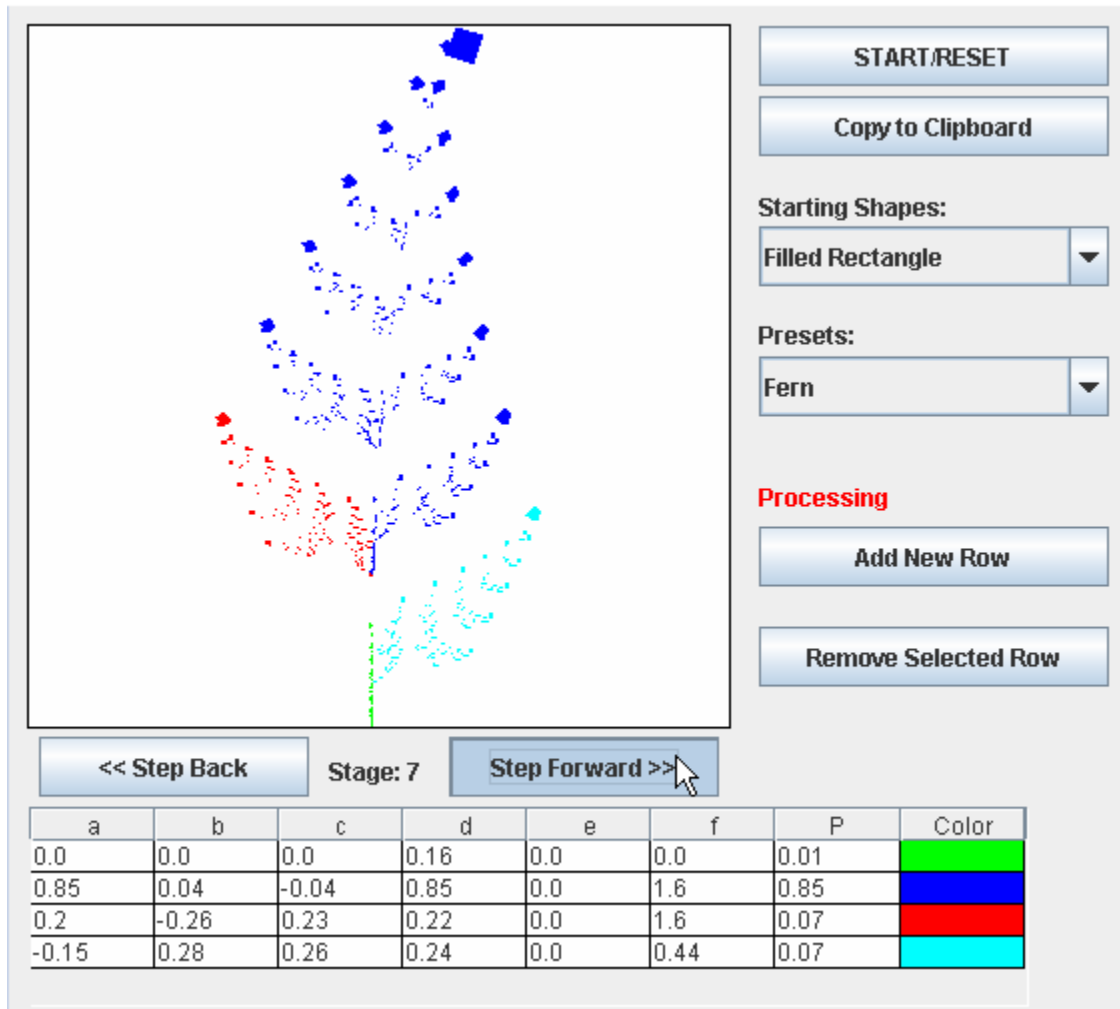
By default, the application begins in Stage 0 using a filled rectangle as the shape and using the “Fern” transformations.

The application interface consists of a large black canvas on the left. To the right of the canvas are several control elements: a "START/RESET" button, a "Copy to Clipboard" button, a "Starting Shapes:" dropdown menu set to "Filled Rectangle", a "Presets:" dropdown menu set to "Fern", an "Add New Row" button, and a "Remove Selected Row" button. Below the canvas are navigation buttons: "<< Step Back", "Stage: 0", and "Step Forward >>". At the bottom of the interface is a table with 8 columns: a, b, c, d, e, f, P, and Color. The table contains four rows of data, with the last row highlighted in cyan.

a	b	c	d	e	f	P	Color
0.0	0.0	0.0	0.16	0.0	0.0	0.01	Green
0.85	0.04	-0.04	0.85	0.0	1.6	0.85	Blue
0.2	-0.26	0.23	0.22	0.0	1.6	0.07	Red
-0.15	0.28	0.26	0.24	0.0	0.44	0.07	Cyan

## Stepping Forward Through Stages

Press the “Step Forward” button to apply the set of transformations to the fractal. The stage number corresponds to the number of times the transformations have been applied. The “Step Forward” button is disabled once Stage 8 is reached. This often takes some time to draw, so notice the “Processing” label indicates that the program is busy, as shown in the following image.



The screenshot shows a software interface for generating fractals. On the left is a canvas displaying a fractal composed of small colored rectangles. The fractal has a central vertical stem and several branching structures. The top part is blue, the middle part is red, and the bottom part is cyan. Below the canvas are two buttons: “<< Step Back” and “Step Forward >>”. The “Step Forward >>” button is currently active, with a mouse cursor over it. In the center, the text “Stage: 7” is displayed. To the right of the canvas is a control panel with several buttons: “START/RESET”, “Copy to Clipboard”, “Add New Row”, and “Remove Selected Row”. Below these buttons, the text “Processing” is displayed in red. The control panel also includes two dropdown menus: “Starting Shapes: Filled Rectangle” and “Presets: Fern”. At the bottom of the interface is a table with 8 columns: a, b, c, d, e, f, P, and Color. The table contains four rows of numerical values, with the last column showing color swatches corresponding to the values in the “Color” column.

a	b	c	d	e	f	P	Color
0.0	0.0	0.0	0.16	0.0	0.0	0.01	Green
0.85	0.04	-0.04	0.85	0.0	1.6	0.85	Blue
0.2	-0.26	0.23	0.22	0.0	1.6	0.07	Red
-0.15	0.28	0.26	0.24	0.0	0.44	0.07	Cyan

## Stepping Backwards Through Stages

Press the “Step Back” button to reduce the stage number and redraw the fractal. This button is disabled at Stage 0.

## Selecting a Different Starting Shape

Select a new shape from the combo box labeled “Starting Shapes” in order to change shapes. The fractal will immediately be redrawn from the same stage and using the values specified in the table. The following image shows the first stage with a Framed Circle selected as the starting shape.

a	b	c	d	e	f	P	Color
0.0	0.0	0.0	0.16	0.0	0.0	0.01	Green
0.85	0.04	-0.04	0.85	0.0	1.6	0.85	Blue
0.2	-0.26	0.23	0.22	0.0	1.6	0.07	Red
-0.15	0.28	0.26	0.24	0.0	0.44	0.07	Cyan

## Changing Between Presets

Directly beneath the “Copy to Clipboard” button there is the drop-down menu labeled “Presets”. This is how the fern originally appeared in the drawing area. There are three included fractals that can automatically be selected. To change the fractal, click the box once and then select one of the three fractals. The fractal will automatically be redrawn upon selection and the table below will be filled with appropriate values for that fractal.

## Adding New Rows

By clicking “Add New Row”, a new row will be added to the table under the last row. A color will immediately be associated with this new row and filled in the last cell. If enough rows are added, the table will have a scrollable bar on the right side. Note that every value in the new row is initially empty and the user must enter values.

a	b	c	d	e	f	P	Color	
0.0	0.0	0.0	0.16	0.0	0.0	0.01	Green	▲
0.85	0.04	-0.04	0.85	0.0	1.6	0.85	Blue	
0.2	-0.26	0.23	0.22	0.0	1.6	0.07	Red	≡
-0.15	0.28	0.26	0.24	0.0	0.44	0.07	Cyan	
							Magenta	▼

## Removing Rows

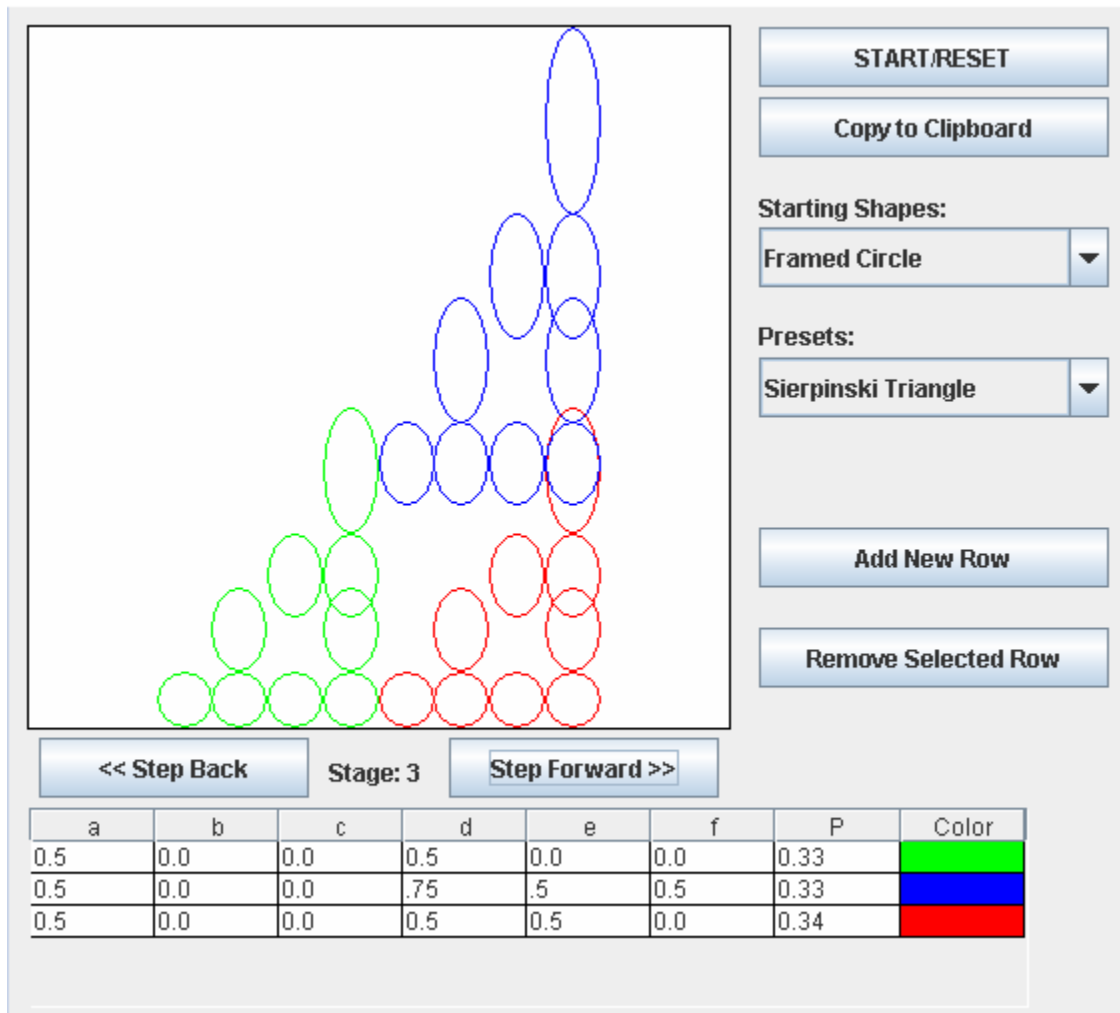
To remove a row, the user must first select a row in the table. Once selected, the row will be highlighted. Clicking the “Remove Selected Row” button will remove this row from the table. If no row is selected, then no row will be removed. The same follows for no rows being in the table.

a	b	c	d	e	f	P	Color	
0.0	0.0	0.0	0.16	0.0	0.0	0.01	Green	
0.85	0.04	-0.04	0.85	0.0	1.6	0.85	Blue	
0.2	-0.26	0.23	0.22	0.0	1.6	0.07	Red	

## Changing the Transformation Table Values

The user is able to select any entry in the transformation table and change the value. By clicking on a cell, the user may change the values within that cell. During this time the fractal will not change. When all the values have been set, to redraw the fractal, click the “START” button. If no changes are made and the “START” button is clicked, the fractal will simply be redrawn.

The following image shows the resulting fractal when the second row, fifth column value is changed to 100 from the original “fern”. Obviously one change can make drastic differences.



The screenshot shows a software interface for generating fractals. On the left is a canvas displaying a fractal composed of overlapping circles in green, blue, and red. The fractal has a triangular, fern-like structure. On the right is a control panel with several buttons and dropdown menus: "START/RESET", "Copy to Clipboard", "Starting Shapes:" (set to "Framed Circle"), "Presets:" (set to "Sierpinski Triangle"), "Add New Row", and "Remove Selected Row". Below the canvas are navigation buttons: "<< Step Back", "Stage: 3", and "Step Forward >>". At the bottom is a transformation table with 8 columns (a, b, c, d, e, f, P, Color) and 3 rows of numerical values.

a	b	c	d	e	f	P	Color
0.5	0.0	0.0	0.5	0.0	0.0	0.33	Green
0.5	0.0	0.0	.75	.5	0.5	0.33	Blue
0.5	0.0	0.0	0.5	0.5	0.0	0.34	Red

## Clicking the START/RESET Button

When satisfied with the transformation values, click the “START/RESET” button to save the transformation values and return to Stage 0.

## Creating a Fractal from New Transformations

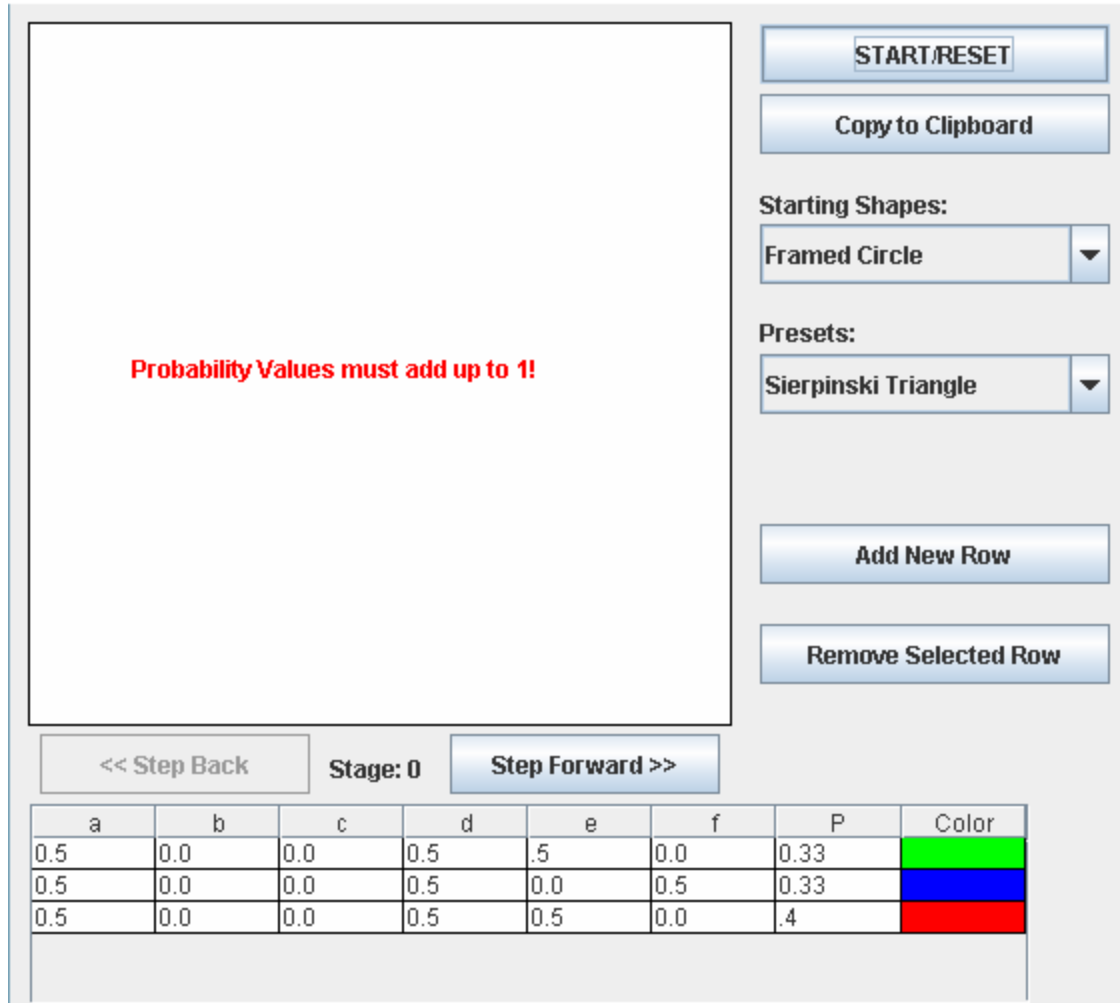
1. To remove all rows in order to make a fractal from scratch, click in a row and then click the “Remove Selected Row” button. Repeat until no rows remain.
2. Click the “Add New Row” button to add a blank row to the end of the table. Type in values for each cell in the row, and repeat until the desired number of rows has been entered.
3. When satisfied with the transformation values, click the “START/RESET” button to save the transformation values and return to Stage 0.
4. With the new values saved, press the “Step Forward” button as many times as desired to see the new fractal at various stages (up to stage 8).

a	b	c	d	e	f	P	Color
.333	0	0	.333	.5	.5	.333	Green
.333	0	0	.333	.5	0	.333	Blue
.333	0	0	.333	0	.5	.334	Red



## Receiving a Probability Error

If the user changes the probability column P values and they do not add up to 1 then a fractal will not be drawn, but in its place, a message will be displayed alerting the user of the error.



The screenshot shows a software interface for generating fractals. A large central canvas displays the error message "Probability Values must add up to !!" in red text. To the right of the canvas is a control panel with several buttons and dropdown menus: "START/RESET", "Copy to Clipboard", "Starting Shapes:" with a dropdown menu set to "Framed Circle", "Presets:" with a dropdown menu set to "Sierpinski Triangle", "Add New Row", and "Remove Selected Row". Below the canvas are navigation buttons: "<< Step Back", "Stage: 0", and "Step Forward >>". At the bottom of the interface is a data table with columns labeled 'a', 'b', 'c', 'd', 'e', 'f', 'P', and 'Color'. The table contains three rows of data, with the 'Color' column cells highlighted in green, blue, and red respectively.

a	b	c	d	e	f	P	Color
0.5	0.0	0.0	0.5	.5	0.0	0.33	Green
0.5	0.0	0.0	0.5	0.0	0.5	0.33	Blue
0.5	0.0	0.0	0.5	0.5	0.0	.4	Red

## Receiving a Null Values Error

Similarly, if the user modifies a table cell, but does not put a value into the cell the program will again not draw a fractal and prompt the user for the input.

## Copying the Fractal to the Clipboard

The next point of interest is the "Copy to Clipboard" button. This button's actions are only usable in the stand-alone JAR executable, and not the Web page. By clicking this button, a copy of the created fractal is automatically copied to the system clipboard. The image can then be pasted into a number of programs, such as Microsoft Word, Paint, or Adobe Photoshop. Note, simply clicking "Copy to Clipboard" will not save the image anywhere, it is up to the user to save the image.