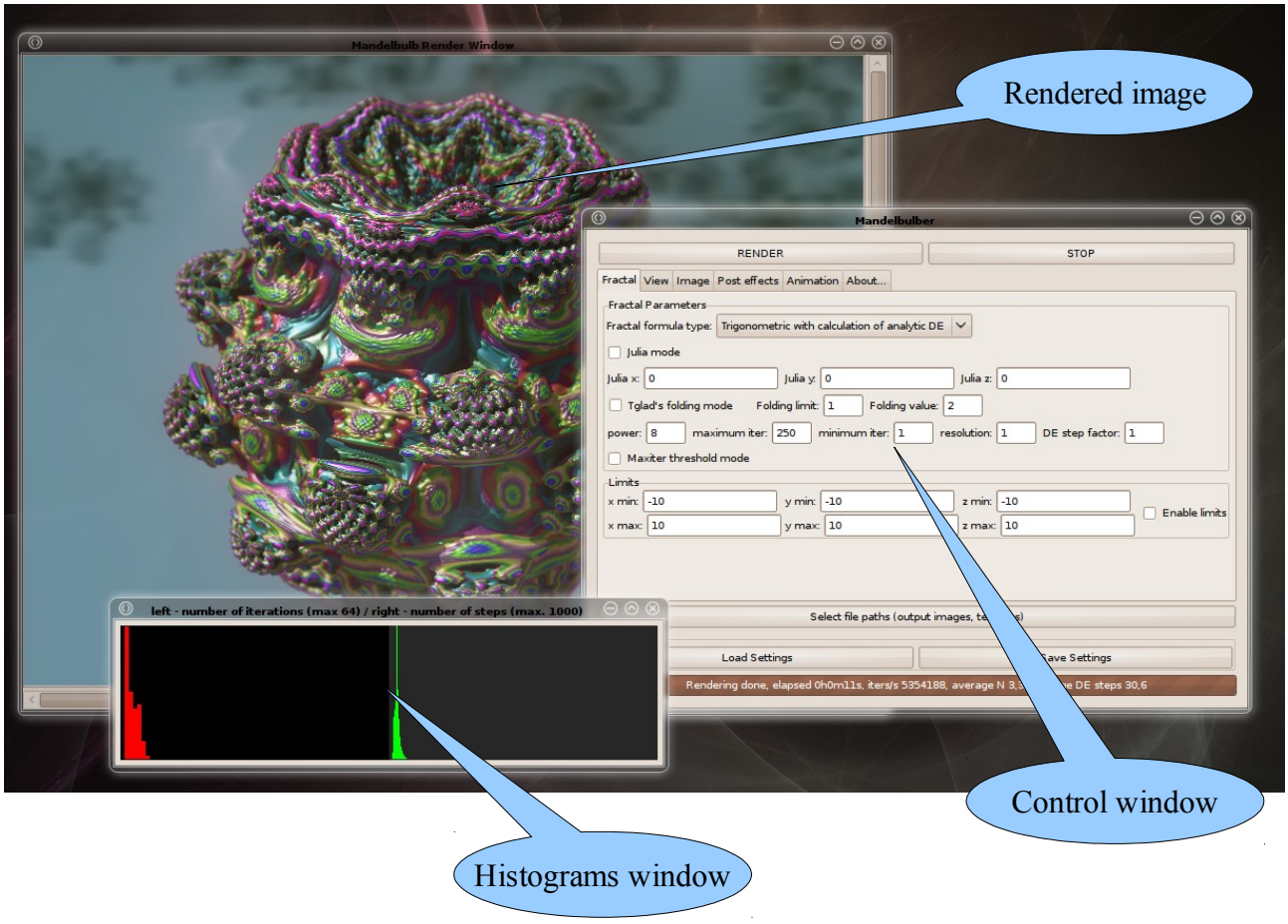
USER GUIDE

Mandelbulber

Program for rendering high quality 3D fractals

1 Main windows



2 Control window

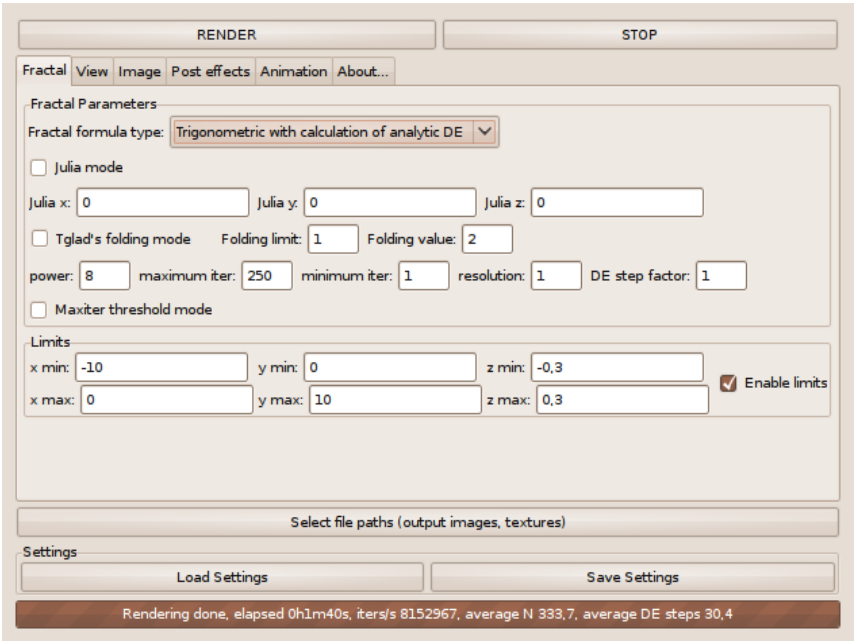
2.1 General buttons

- **Render** – Start image rendering. Image will be automatically saved in $HOME/*.mandelbulber/image* directory
- **Stop** – Stop rendering and save partially rendered image
- **Select file paths** – open window with setup for paths of additional files

  - **Destination image sequence** – path and file name prefix for saved images. To the name automatically will be added number of the image and extension "*.jpg*"
  - **Background** – path of the image which will be used as a image background
  - **Environment map** – path of the image which will be used as a fake reflection. Resolution of this image has to be 512x512
  - **Ambient occlusion colour map** – path of the image which will be used as a colour map for ambient occlusion effect. Resolution of this image has to be 512x512
  - **Animation path** – file in which will be stored recorded flight path
- **Load setting** – load all fractal parameters from file
- **Save settings** – save all fractal parameters to file

Settings files are text files which can be also edited using simple text editors. Important is to keep proper file syntax and names of parameters.
Default settings are stored in $HOME/*.mandelbulber/settings/defaut.fract* file.

2.2 Fractal tab

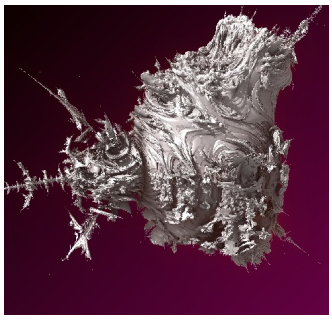


2.2.1 Fractal parameters

- **Fractal formula type** – Selection for fractal formula type.
  - **Trigonometric (Mandelbulb)**

$$r = \sqrt{x^2 + y^2 + z^2}$$
$$\alpha = atan2(y, x)$$
$$\beta = -atan2(z, \sqrt{x^2 + y^2})$$
$$x = r^p \cos(p\beta)\cos(p\alpha) + a$$
$$y = r^p \cos(p\beta)\sin(p\alpha) + b$$
$$z = r^p \sin(p\beta) + c$$

  - **Trigonometric with calculation of analytic DE –** is the same like the *Trigonometric formula* but distance estimation is calculated by analytic formulas. This formula is faster than *Trigonometric* but less accurate for low power fractals and Julia fractals
  - **Polynomic power 2**

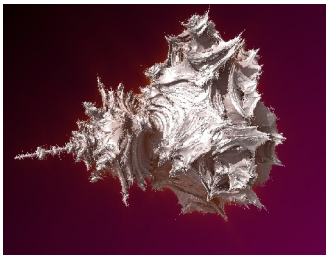


$$newx = (x^2 - y^2)\left(2 - \frac{z^2}{x^2 + y^2}\right)$$
$$newy = 2xy\left(2 - \frac{z^2}{x^2 + y^2}\right)$$
$$newz = -2z\sqrt{x^2 + y^2}$$
$$x = newx + a$$
$$y = newy + b$$
$$z = newz + c$$

  - **Polynomic power 2 – minus z**

$$newx = (x^2 - y^2)\left(2 - \frac{z^2}{x^2 + y^2}\right)$$
$$newy = 2xy\left(2 - \frac{z^2}{x^2 + y^2}\right)$$
$$newz = 2z\sqrt{x^2 + y^2}$$
$$x = newx + a$$
$$y = newy + b$$
$$z = newz + c$$

  - **Hypercomplex**



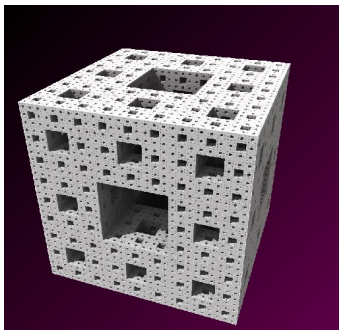
$$newx = x^2 - y^2 - z^2 - w^2$$
$$newy = 2(xy - wz)$$
$$newz = 2(xz - yw)$$
$$neww = 2(xw - yz)$$
$$x = newx + a$$
$$y = newy + b$$
$$z = newz + c$$
$$w = neww$$

- **Quaternion**

$$newx = x^2 - y^2 - z^2 - w^2$$
$$newy = 2xy$$
$$newz = 2xz$$
$$neww = 2xw$$
$$x = newx + a$$
$$y = newy + b$$
$$z = newz + c$$
$$w = neww$$

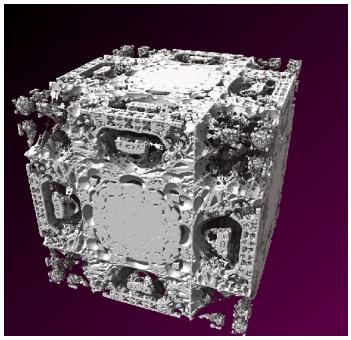
- **Menger sponge**

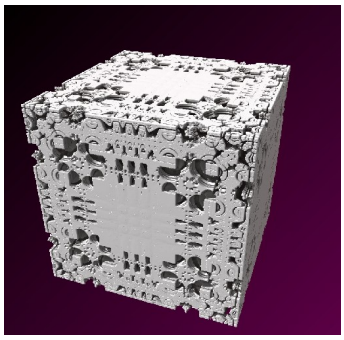
  details:
  http://en.wikipedia.org/wiki/Menger_sponge



- **Tglad's formula (Mandelbox)**

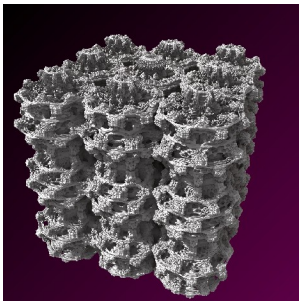
  details:
  http://www.fractalforums.com/3d-fractal-generation/amazing-fractal/





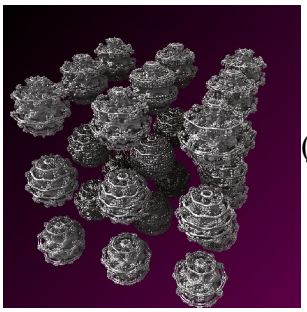
Scale parameter for Tglad's formula can be put in Power edit field (power = scale)

- **Julia mode** – enable rendering of 3D Julia fractals
- **Julia x, Julia y, Julia z** – Julia constant
- **Tglad's folding mode** – add Tglad's folding function to fractal formula
  example of Mandelbulb with folding function:



(*folding limit* = 1, *folding value* = 2)

- **Folding limit, Folding value** – parameters for folding function



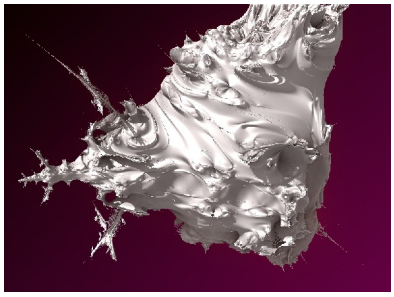
(*folding limit* = 2, *folding value* = 4)

- **Power –** power value of fractal formula:

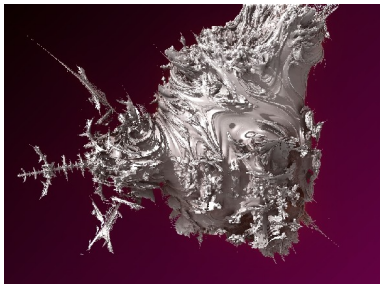
  $z_{n+1} = z_n^p + c$ p – power

- **Maximum iter** – maximum number of iterations of fractal formula. Higher value gives higher amount of details.

Max iter. = 10

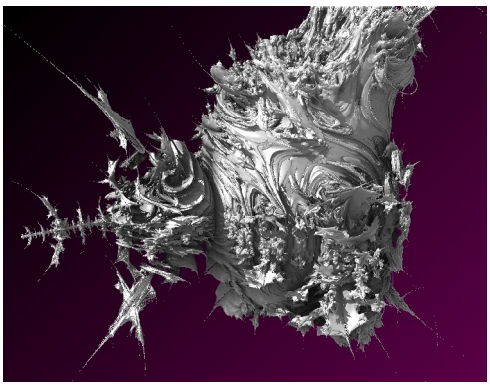


max iter. = 15

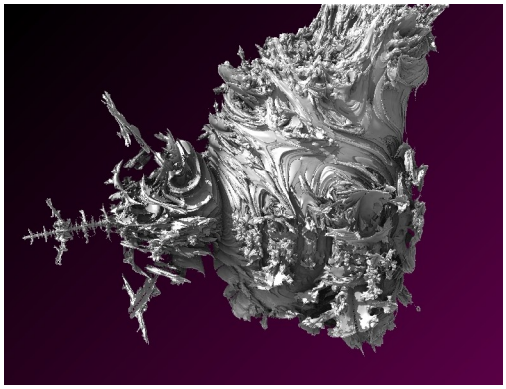


- **Minimum iter** – minimum number of iterations which allow to stop ray marching. It is useful to reduce details in areas with high estimated distance and low number of iterations.

Min iter. = 1.0

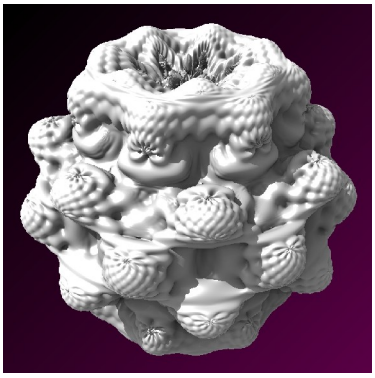


Min iter. = 10.0

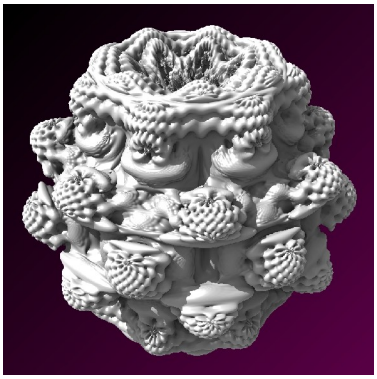


- **Resolution** – factor for dynamic threshold based on estimated distance. Higher value gives sharper details. Resolution = 1.0 is an equivalent to minimum details size = 1 screen pixel

Resolution = 0.2



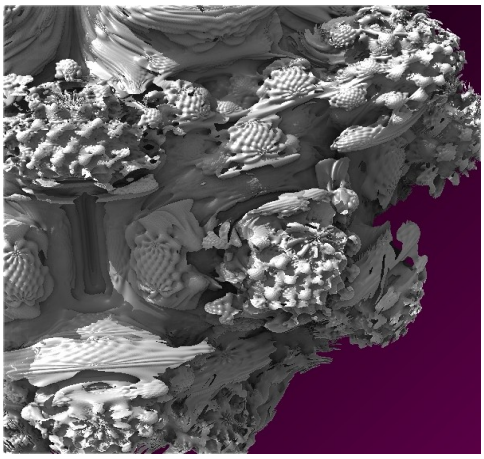
Resolution = 0.4



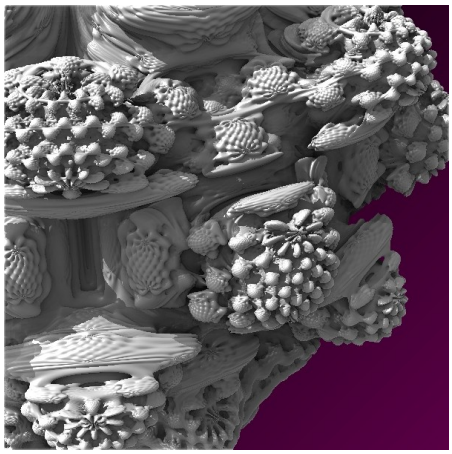
Resolution = 1.0

- **DE step factor** – quality of ray marching. Lower value gives better quality (avoiding of overstepping) but slower rendering. For most fractals optimal value is between 0.5 and 1.0

  to high *DE step factor* (visible errors)

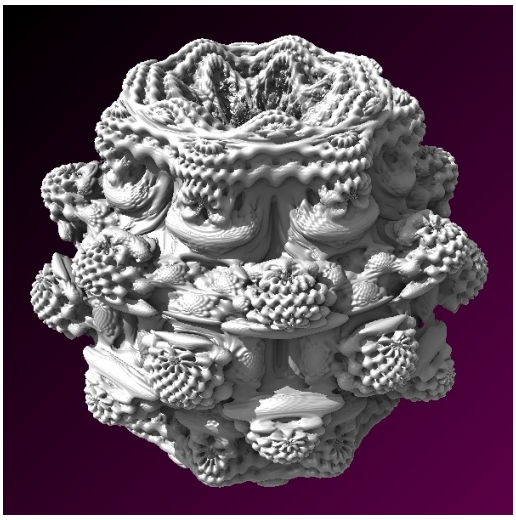


  proper *DE step factor*



- **Maxiter threshold mode** – ray marching stops when achieve required maximum number of iterations. Shape of fractal is different than in distance estimation threshold mode

  DE threshold mode

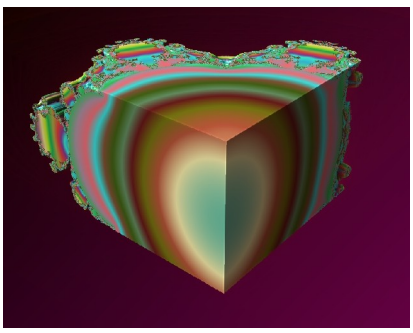


  Maxiter threshold mode

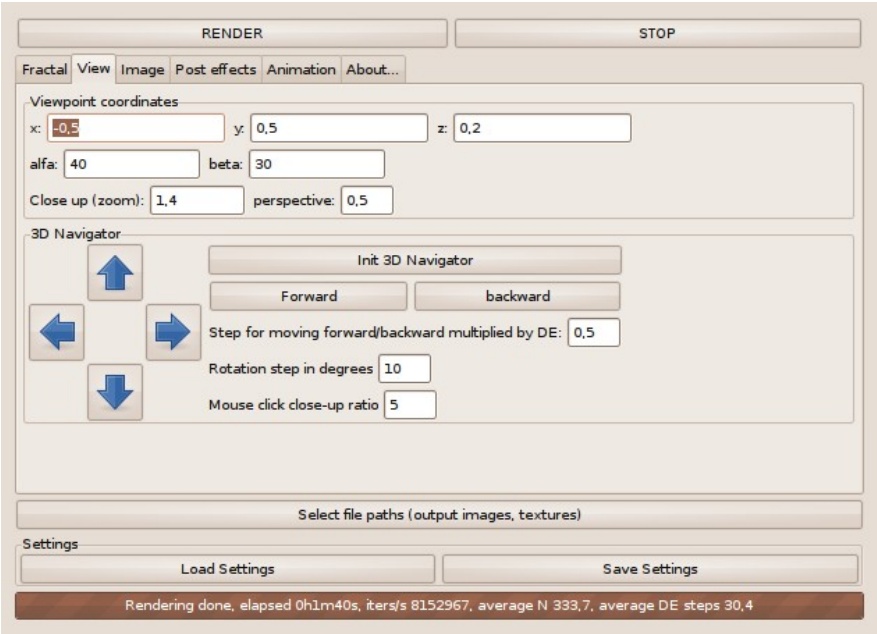
2.2.2 Limits

- **Enable limits** – fractal will be cut according to entered slicing planes
- **x_min**, **y_min**, **z_min**, **x_max**, **y_max**, **z_max** – coordinates of cross-section planes

  Example: *x_min*=-10, *x_max* = 0, *y_min* = 0, *y_max* = 10, *z_min* = -0.3, *z_max* = 0.3



2.3 View tab



2.3.1 Viewpoint coordinates

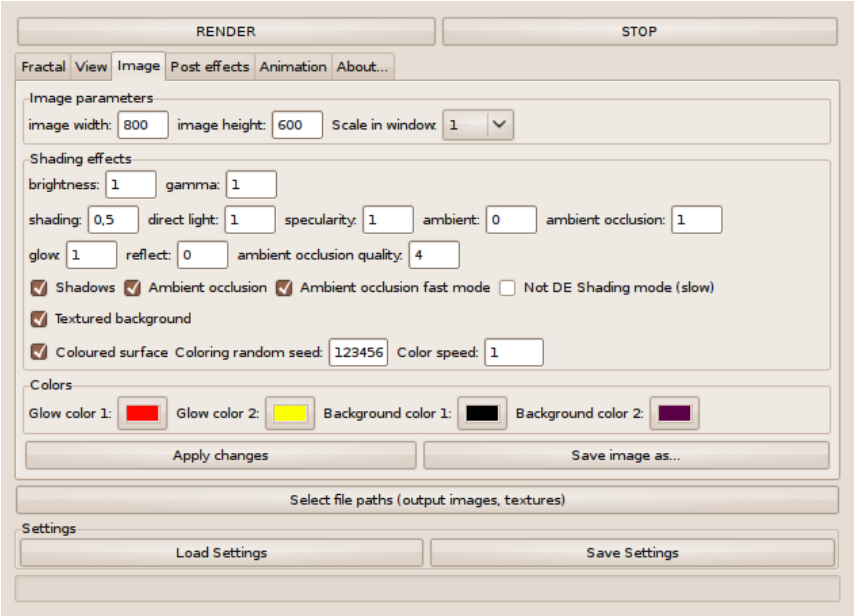
- **x, y, z –** the point where camera is looking
- **alfa** – camera rotation around vertical axis
- **beta** – camera rotation around horizontal axis
- **Close-up (zoom)** – the size of the object located on viewpoint which will fit on screen. Lower value takes camera closer to viewpoint (higher zoom). For example, Mandelbulb has diameter 2.2, viewpoint is located in centre of fractal (0,0,0) and if whole of the Mandelbulb has to be visible on screen, the best Close-up will be around 2.5.
- **Perspective** – deepness of the perspective effect. If perspective = 0, then will be axonometric projection.

2.3.2 3D Navigator

- **Init 3D Navigator** – move camera far from the object and set-up default camera angle, zoom and position
- **Forward** – move camera forward
- **Backward** – move camera backward
- **Step for moving forward/backward multiplied by DE** – camera will move on distance entered in this field multiplied by actual distance to the fractal surface.
- **Rotation step** – camera rotation step in degrees.
- **Arrows** – camera rotation
- **Mouse click close-up ratio** – after zooming by mouse clicking on image the *Close-up (zoom)* parameter will be divided by this value

If you indicate by mouse some interesting detail on image and press left mouse button, the program will calculate new camera position and move the camera closer.

2.4 Image tab



2.4.1 Image parameters

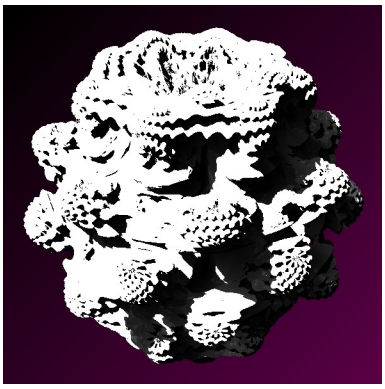
- **Image width, Image height –** size of final image
- **Scale in window** – scale of viewed image

2.4.2 Shading effects

2.4.2.1 Edit fields

- **Brightness*** – brightness of the fractal
- **Gamma*** – image gamma
- **Shading*** – intensity of the shading effect based on angle of incidence of the light

- **Direct light*** – intensity of the direct light which casting shadows

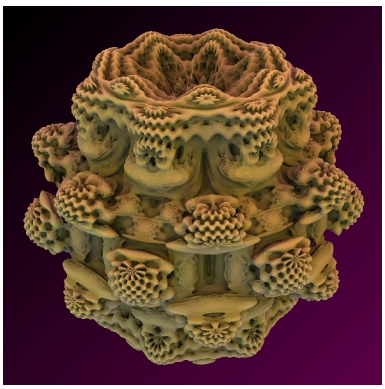


- **Specularity*** – intensity of the specular reflection which is the mirror-like reflection of the light from a surface

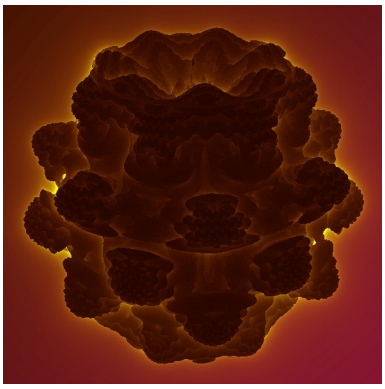
- **Ambient*** – intensity of the ambient light

without ambient light: with ambient light:

- **Ambient occlusion*** – intensity of the ambient occlusion effect (simulation of light going from all directions)



- **Glow*** - intensity of the glow effect



- **Reflect*** - intensity of the reflection effect. This effect based on environment mapping technique (reflections are taken from reflection map texture).
- **Ambient occlusion quality –** quality of ambient occlusion effect. This parameter determines how many rays of light will be calculated for each point.

quality	1	2	5	10	15
Number of rays	8	64	165	645	5702

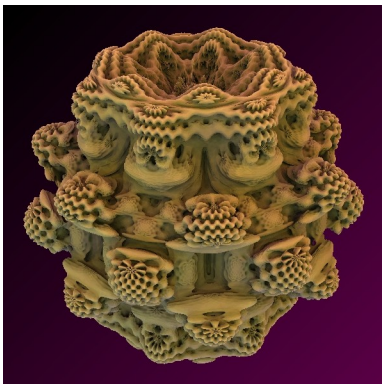
quality = 1 quality = 2 quality = 3

All parameters marked by * can be changed during or after rendering and updated on image by *Apply changes* button

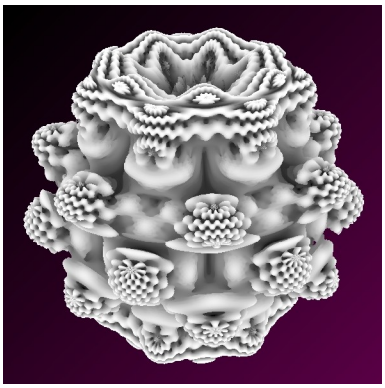
2.4.2.2 Check-boxes

- **Shadows** – enable shadows
- **Ambient occlusion** – enable ambient occlusion effect
- **Ambient occlusion fast mode** – enable rendering of fake ambient occlusion based on calculation of point orbit traps. It is very fast to render but works properly only with Mandelbulbs (trigonometric formulas) and high power value (higher than 4)

Normal ambient occlusion

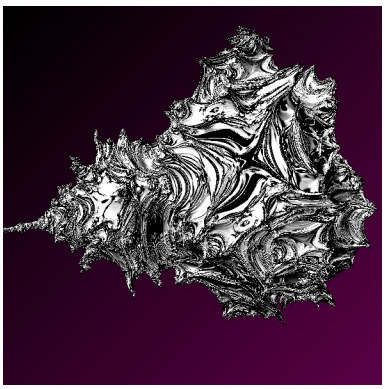


Fast mode (fake)



- **Not DE shading mode** – normally shading is rendered based on calculation of normal vectors from estimated distance value. For some kinds of formulas (hypercomplex, low power mandelbulbs) it is not accurate. When *Not DE shading mode* is enabled, then normal vectors are calculated as average gradient of binary potential function. It is very slow method but always works.
  Example for hypercomplex fractal:

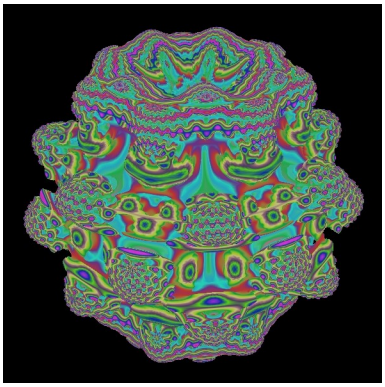
  normal shading mode

  not DE shading mode

- **Textured background –** background will be rendered as a textured 3D sphere
- **Coloured surface* –** enable colouring algorithm for the fractal surface

- **Random seed*** – random seed for colour palette
- **Coloring speed* –** frequency of colour variations

2.4.3 Colors

- **Glow color 1*** – color of glow effect in low intensity areas
- **Glow color 2*** – color of glow effect in high intensity areas
- **Background colour 1** – color of background in left top corner of image
- **Background colour 2** – color of background in right bottom corner of image

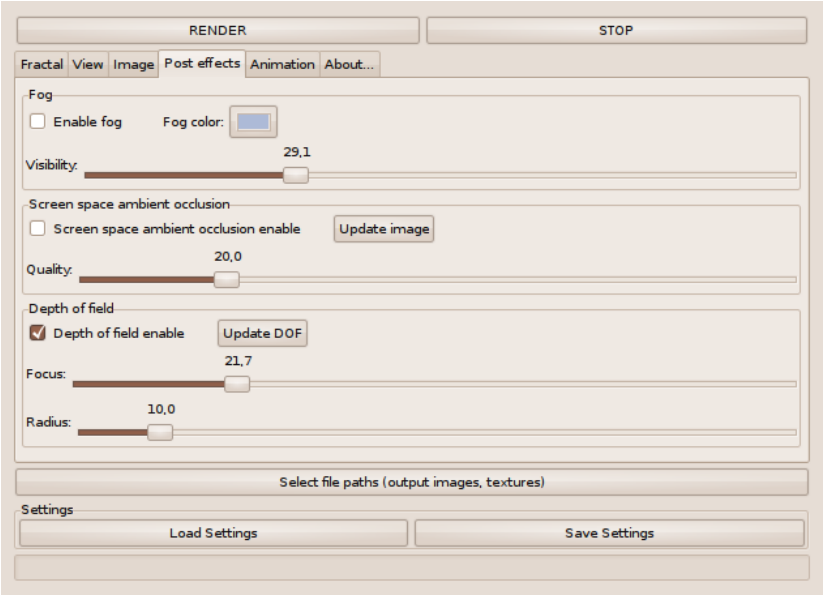
2.4.4 General

- **Apply changes** – update image after changing shading parameters.
- **Save image as...** - save image in selected place.

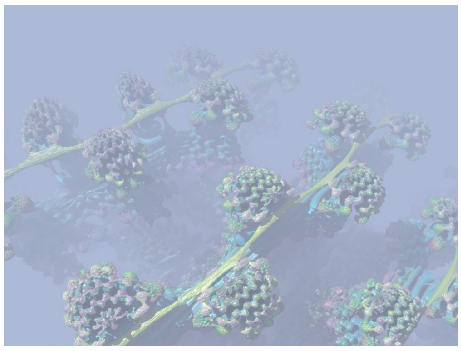
All parameters marked by * can be changed during or after rendering and updated on image by *Apply changes* button

2.5 Post effects

These effects are based on z-Buffer and can be rendered/updated after rendering image



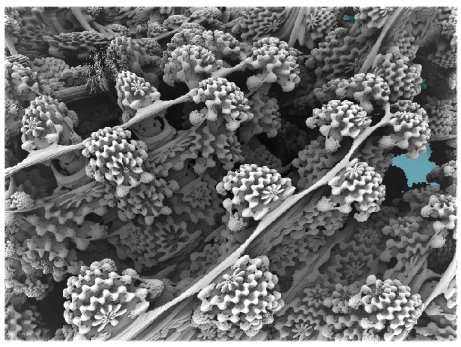
2.5.1 Fog



- **Enable** – enable fog effect
- **Fog color** – selection of color of fog
- **Visibility** – visibility distance (algorithmic scale)

2.5.2 Screen space ambient occlusion

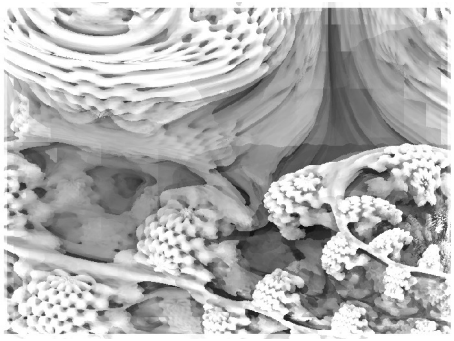
This is equivalent of standard ambient occlusion effects. This effect is based only on depth information recorded in screen z-Buffer. Rendering of this effect is much more faster than ambient occlusion based on many rays but sometimes gives worse result and and ambient light is monochromatic.



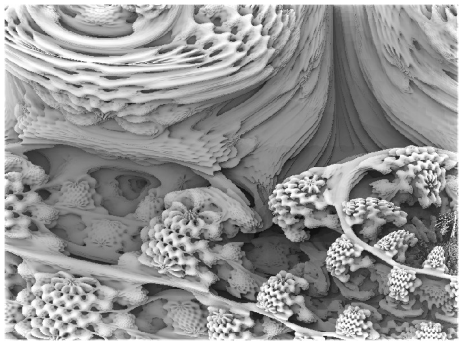
- **Enable –** enable screen space ambient occlusion effect
- **Quality** – number and resolution of fake rays. Optimum quality value is:

$$quality = \sqrt{\frac{1}{2} ImageWidth}$$

quality = 6 (*image width* = 800)



quality = 20 (*image width* = 800)



This effect has preview during rendering with half quality

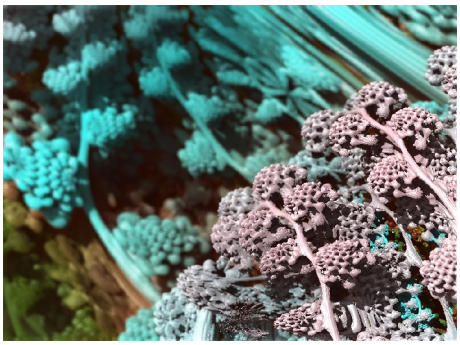
- **Update image** – update SSAO effect during and after fractal rendering

2.5.3 Depth of field

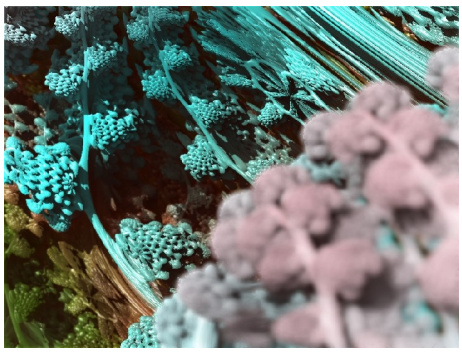
This effect simulates focus blur. Rendering of DOF is based only on depth information recorded in screen z-Buffer and can be done after fractal rendering.

- **Enable** – enable depth of field effect
- **Focus** – focal length

Low *focus* value (foreground is sharp)

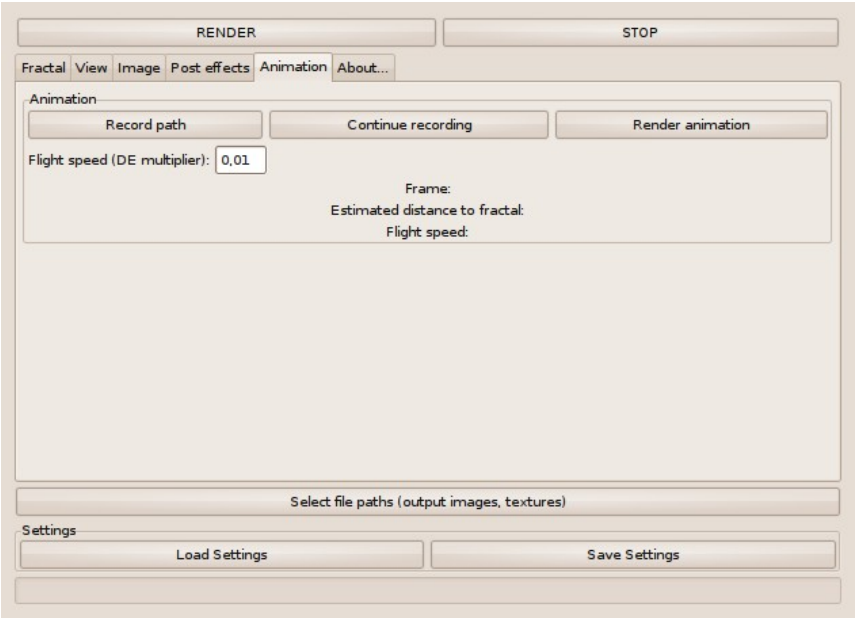


High *focus* value (background is sharp)



- **Radius** – blur radius – intensity of depth of field effect
- **Update DOF** – update deep of field effect on image

2.6 Animation Tab



- **Record path** – record flight path to file indicated in *Select file paths function / Animation path*
- **Continue recording** – continue recording of flight path from last point saved in path file
- **Render animation** – render animation using file with recorded flight path
- **Flight speed** – speed of flight during recording. Resultant flight speed is a *Flight speed* multiplied by actual distance to fractal surface. It means that the flight speed is automatically reduced when camera is getting closer to the fractal. *Flight speed* can be adjusted during recording by clicking left/right mouse button inside *Render window.*

Procedure for preparing and rendering animation

1. Prepare starting viewpoint. You can click "Init 3D Navigator", then the camera will move to the default starting position. You can also put your own camera coordinates and angle, set "perspective" to around 1.2 and "Close up (zoom)" to very low value (e.g. 1e-6). You can also decide how fast flight will be. It is adjustable by the "Flight speed (DE multiplier). Camera speed is proportional to estimated distance to the fractal surface.
2. Set up very low image resolution (e.g. 160x120) and "Scale in window" to higher value (e.g. 4). Because Mandelbulber program offers high quality of images instead of calculation speed it will be faster to record flight track in low resolution.
3. Click "Record path" and navigate camera by mouse movement inside render window. Your flight track is recorded in "paths/path.txt: file (default) and low-res stills are recorded in "images/imageXXXX.jpg" files
4. When the flight path is ready, set-up requested resolution of animation (e.g. 1280x720) and other quality parameters
5. Set up image stills destination path by *Select file paths* / *destination image sequence*. This folder should be empty.
6. Save actual setting by "Save settings". It will be helpful when you will want to continue rendering animation after stop.

7. Click "Render animation". Animation is now rendering according to camera coordinates saved in path.txt file.
8. If you want to continue rendering animation which you started before (e.g. after some power failure), please load proper settings file and just click on "Render animation". Program will scan which frames are already rendered and render all missed frames.

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