

# Mandelbrot quest

*IHEP, Beijing,  
13-15 November 2013*



## The Mandelbrot set definition

<http://en.wikipedia.org/Mandelbrot>

The vicinities of the Mandelbrot set area provide an astonishingly rich fractal images

The algorithm consists in assigning a color to each point in the complex plane as a function of a speed of divergence of the Mandelbrot sequence

You certainly have seen some of them but even more are even not discovered yet

In the tutorial we will explore those images while exercising the use of DIRAC tools and grid resources

Complex plane



In the quest we will be using the *mandelbrot* application

<http://dirac.ihep.ac.cn/demo/mandelbrot>

The *mandelbrot* application is a simple python script to construct fractal images:

Builds a fractal image around a chosen C point

One can vary the size of the image, its precision ( zoom level ), color scheme

The output is an image file in BMP format

Can be easily visualized in a Web browser

The *mandelbrot* application is available also from a grid DIRAC-USER Storage Element:

<LFN:/vo.france-asia.org/user/a/atsareg/mandelbrot>

## Usage:

```
mandelbrot [options] [<output_file>]
```

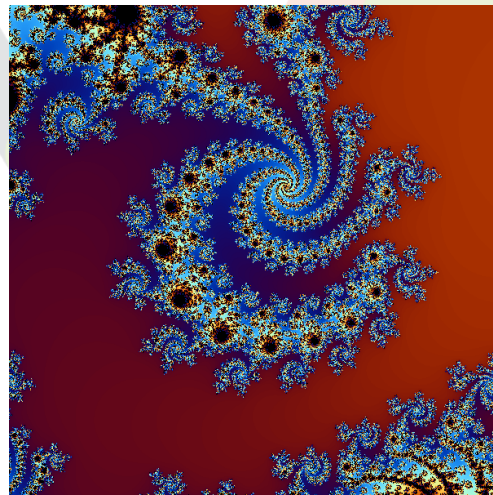
## Options:

```
-X, --cx - the real part of the C parameter in the center of the image,  
           default = -0.5  
-Y, --cy - the imaginary part of the C parameter in the center of the image,  
           default = 0.0  
-P, --precision - the step size of the C parameter increment per pixel  
                  of the image, default = 0.01  
-M, --max_iterations - the maximum number of the mandelbrot algorithm  
                      iterations, default = 100  
-W, --width - image width in pixels, default = 300  
-H, --height - image height in pixels, default = 300  
-B, --bw - force black and white image, default is a color image  
-F, --color_factor - color palette parameter defining how quickly the  
                    colors are changing, the value should be in the range 0.<x<1.0,  
                    default = 0.02  
-S, --color_phase - a magic color palette parameter, default = 1.0  
-D, --color_delta - yet another magic color palette parameter, default = 1.0  
-h, --help - print this usage info
```

Goal: find a new interesting and beautiful area in the Mandelbrot set vicinity and let everybody admire it !

Of course, by doing the whole work with the *mandelbrot* grid jobs

```
mandelbrot -W 600 -H 600 -X -0.46490 -Y -.56480 -P .000002 -M 500
```



## ▶ Task steps

1. Find an interesting seed  $C$  point
2. Build a series of images with an increasing zoom level centered around the seed  $C$  point from step 1.
3. Build a movie using the images from step 2. as frames



# Mandelbrot quest task: step 1

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Run several mandelbrot jobs with varying  $C$  and precision

Use the Job Launchpad Web interface

Submit a number of mandelbrot jobs with varying contents of the Arguments JDL parameter

Hint: put the *mandelbrot* application into the Input Sandbox

Store the output file in the Output Sandbox

Get the output file from the Web portal Job Monitor and inspect it in the browser

Choose the most appealing  $C$  point

## Remark

Running mandelbrot locally on your computer is allowed but this is cheating !

# Mandelbrot quest task: step 2

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Run a series of 300-500 mandelbrot jobs with a fixed C parameter and increasing precision (zoom level )

Use Parametric Jobs with the Job Launchpad

Store output files in a grid Storage Element

▶ DIRAC-USER



Collect the output image files from Step 2. and build a « Mandelbrot journey » movie

Use DIRAC API to write a script to launch a grid job creating the movie

Use *convert* Unix program as an Executable to do the work. For example:

```
convert *.bmp movie.gif
```

▶ Use image files from Step 2. as Input Data

▶ Store the resulting animated gif image as Output Data

Alternatively, use DIRAC API to write a script to collect the image files on your local computer to create the movie

Download and store image files in one directory

Invoke the *convert* program locally to create the movie

Upload the resulting animated gif file to a grid Storage Element

- ▶ The resulting images and movies will be demonstrated to the tutorial audience and the authors of the best movies will be declared

*Winners of the DIRAC Mandelbrot Quest !*