

## 1 Overview

**1.1 Location** \$(AMDAPPSDKSAMPLESROOT)\samples\aparapi\examples

**1.2 How to Run** See the *Getting Started* guide for how to build samples. You first must compile the sample. Use the command line to change to the directory where the executable is located. The pre-compiled sample jar is at \$(AMDAPPSDKSAMPLESROOT)\samples\aparapi\examples\Mandel\

Under Windows, type the following command(s).

1. `mandel.bat`  
This runs the program.
2. `mandel.bat -h`  
This prints the help file.

Under Linux, type the following command(s).

1. `./mandel.sh`  
This runs the program.
2. `./mandel.sh -h`  
This prints the help file.

**1.3 Command Line Options** Table 1 lists, and briefly describes, the command line options.

**Table 1 Command Line Options**

Short Form	Long Form	Description
-h	--help	Shows all command options and their respective meaning.
-q	--quiet	Quiet mode. Suppresses all text output.
-e	--verify	Verify results against reference implementation.
-t	--timing	Print timing.
-v	--version	AMD APP SDK version string.
-x	--exec_plat	Execution platform [CPU   GPU   JAVAST   JAVAMT]

## 2 Introduction

Mandelbrot-set images are generated by

1. taking a complex number
2. checking if it tends to infinity when the formula is iterated on that number
3. using the number as X and Y coordinates in the picture
4. coloring the pixel depending on whether it tends to infinity or not.

A Mandelbrot set is a set of values of  $c$  in the complex plane for which the orbit of 0 under iteration of the complex quadratic polynomial  $z_{n+1} = z_n^2 + c$  remains bounded. That is, a complex number  $c$  is part of the Mandelbrot set if, when starting with  $z_0 = 0$  and applying the iteration repeatedly, the absolute value of  $z_n$  remains bounded however large  $n$  gets.

The definition of the Mandelbrot set along with its basic properties can be used to draw a picture. The region of the complex plane under consideration is subdivided into a certain number of pixels. To color a pixel, let  $c$  be the midpoint of that pixel; then, iterate the critical point 0 under  $P_c$ , and check at each step if the orbit point has a modulus larger than 2.

- If it does, then  $c$  does not belong to the Mandelbrot set, and color the pixel according to the number of iterations that was used to find out.
- If it does not, iterate up to a fixed number of steps, then decide that the parameter is “probably” in the Mandelbrot set, or at least very close to it, and color the pixel black.

## 3 Implementation Details

This example starts with a Mandelbrot image of a specific scale (default-scale), pauses for several seconds, then zooms in for 128 frames; finally, it zooms out to the image it started with. It supports four modes of execution: GPU, CPU (using Aparapi), Java single thread, and Java multi-thread. The sample does not override `Kernel.run()`; instead, it uses an OpenCL kernel in the `Mandel.cl` file by creating a `MandelBrot` interface that extends `OpenCL<MandelBrot>`. The location of the OpenCL kernel is specified by `@OpenCL.Resource( )`. `JavaMandelBrot.java` has Java single-thread implementation of the same kernel as in `Mandel.cl`, while `JavaMandelBrotMultiThread.java` has a multi-threaded implementation of the kernel.

In case the `--quiet` or `--verify` option is used, the zoom-in point is generated randomly; otherwise, it waits for users to click on the image, then zooms in at the clicked point.

## 4 Recommended Input Option Settings

For best performance, enter the following on the command line: `-x GPU -q -t`

## 5 Requirements

To build/run the Aparapi example requires the following environment:

- Set `JAVA_HOME` to the directory containing JRE/JDK, version 1.7 or above.
- Set `ANT_HOME` to the directory containing ANT, version 1.8 or above.

- Set `LIBAPARAPI` to the directory where `aparapi-2012-11-14.zip` (or [above](#)) is unzipped.
- Ensure that `PATH` is set so that `java` and `javac` executables are used from JDK version 1.7 or above, and that the `ant` executable is used from `ANT_HOME`.
- In Linux, set `LD_LIBRARY_PATH` to the directory where `aparapi-2012-11-14.zip` (or [above](#)) is unzipped.

## 6 References

1. [http://en.wikipedia.org/wiki/Mandelbrot\\_set](http://en.wikipedia.org/wiki/Mandelbrot_set)
2. <http://code.google.com/p/aparapi/>

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