

## Homework 9

*Due: Thursday 2 November*

In this homework you will investigate another fractal structure arising from a nonlinear map involving complex numbers. This is a famous fractal the *Mandelbrot* fractal named after one of the fathers of the field of fractals Benoit Mandelbrot. One simple takes the Julia set dynamics

$$z_{n+1} = z_n * z_n + a$$

and iterates from a fixed initial point  $z = 0$  and asks now whether the magnitude of  $|z|$  diverges *as a function of  $a$* . Again the set of diverging from non-diverging  $a$ 's is a fractal when plotted in the complex  $a$ -plane.

1. Modify your Julia set code to plot the Mandelbrot fractal.
2. Experiment with color coding the points. Points where  $|z|$  diverges fastest can be colored differently from points where  $|z|$  diverges more slowly. This is how some of the commercial plots of the Mandelbrot fractal are done. This can be simply done by noting the number of iterations needed for  $|z|$  to first exceed 2.0. Notice that as in the lab one only performs a finite number of iterations say 20 to determine whether the point lies in the convergent regime – so small errors will occur at fine resolution - one will say a point is convergent when in reality it is just diverging very slowly. This is just something to be aware of – in principle one needs to increase the number of iterations close to the boundary of the convergent region.