Exercises in computer-oriented physics

1 Logistic equation

Shows many of the basic principles of chaos using the simplest means.

General: 1-dim. Illustrationf:R→Rdefines iteration

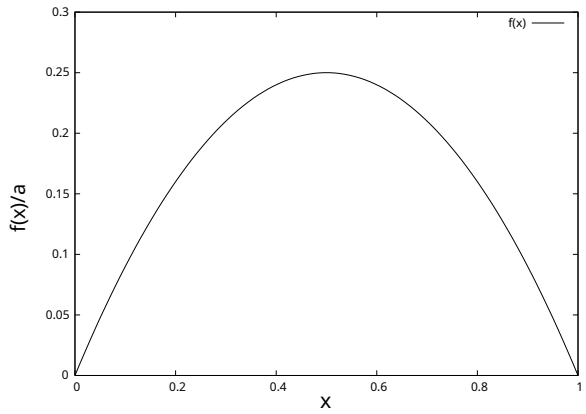
$$x_{n+1}=f(x_n)\ (n=0, 1, \ldots) \tag{1}$$

Here: logistic illustration

$$f(x) = a*x(1-x) \tag{2}$$

For example, describes population growth.
Has maximum at$x_m=0.5$ with$f(x_m) = a/4$.

→ Restrictiona∈ [0, 4]
→ f([0, 1])⊂ [0, 1]



1. Design and implement a C program on Linux that solves the logistic equation for given value ofaiterated, starting withx=0.5.There should be a loop for this num_steps=400times and each time the loop counterstepand the current value ofx (and a \n)be output in one line.

2. Compile with the C compiler (e.g. with the options -o logistic -g)and make sure the program works. (For example, you could Debuggergdbwithlogisticcall as an argument. In the debugger you can use break <line>set a breakpoint with the programrunstart and from when the breakpoint is reachedstepfollow step by step.)

3. Let the program run fora=2.9and redirect the output in the shell to a file, e.g

. /logistic > logistic_a29.dat

Consider the output (“time series”) withgnuplot,by starting the program from the shell (or otherwise) and writing in the command input:

plot "logistic_a29.dat"

What are you observing?

Minimum goal

4. Repeat the simulations and plotting fora=3.1, a=3.5, a=3.6anda=3.83. What do you observe for the time series?

5. Expand/change your program as follows:

   - Iterate in your programa=2.8untila=4.0in 120 intermediate steps (delta_a=0.01) and let each run through the entire iteration as above.
   - The output should be given value ofaonly after num_equilibration = 100Equilibration steps (“settlement time”) begin.
   - There should now be in every line of every outputaandxare issued, so they are sent to everyoneaWorth manyxValues output.

   Pipe all output (for all values ofa)back into a (single) file

   . /logistic > logistic_dots.dat

   and provide the output file againgnuplotWhat are you observing?

6.additional task

Varyain the range 3.4 and 3.6 with 200 intermediate steps. What are you observing?