High Performance Python Lab
Lecture 2

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ZHORES SUPERCOMPUTER
HIGH PERFORMANCE COMPUTING AND BIG DATA
SKOLTECH CDISE

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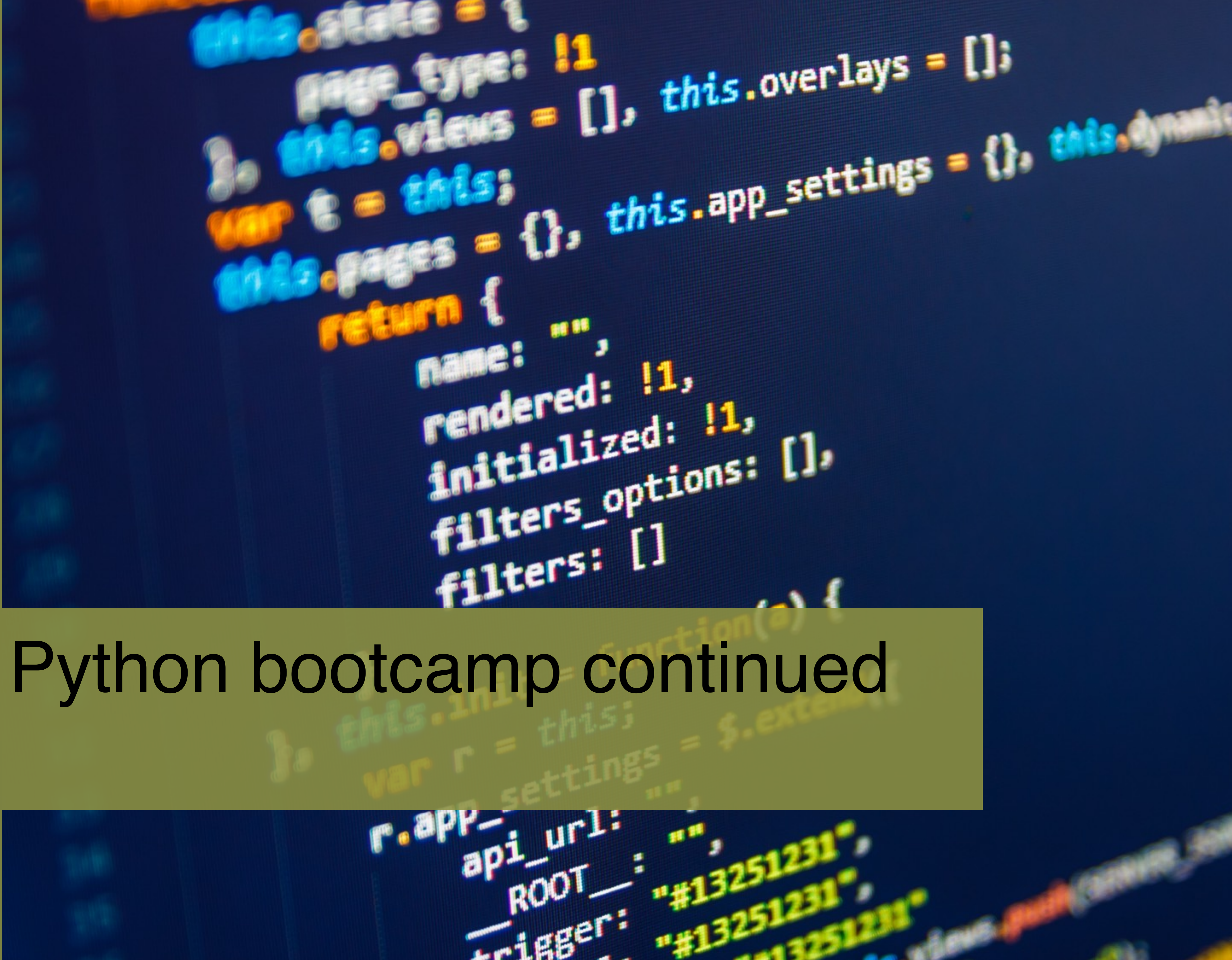
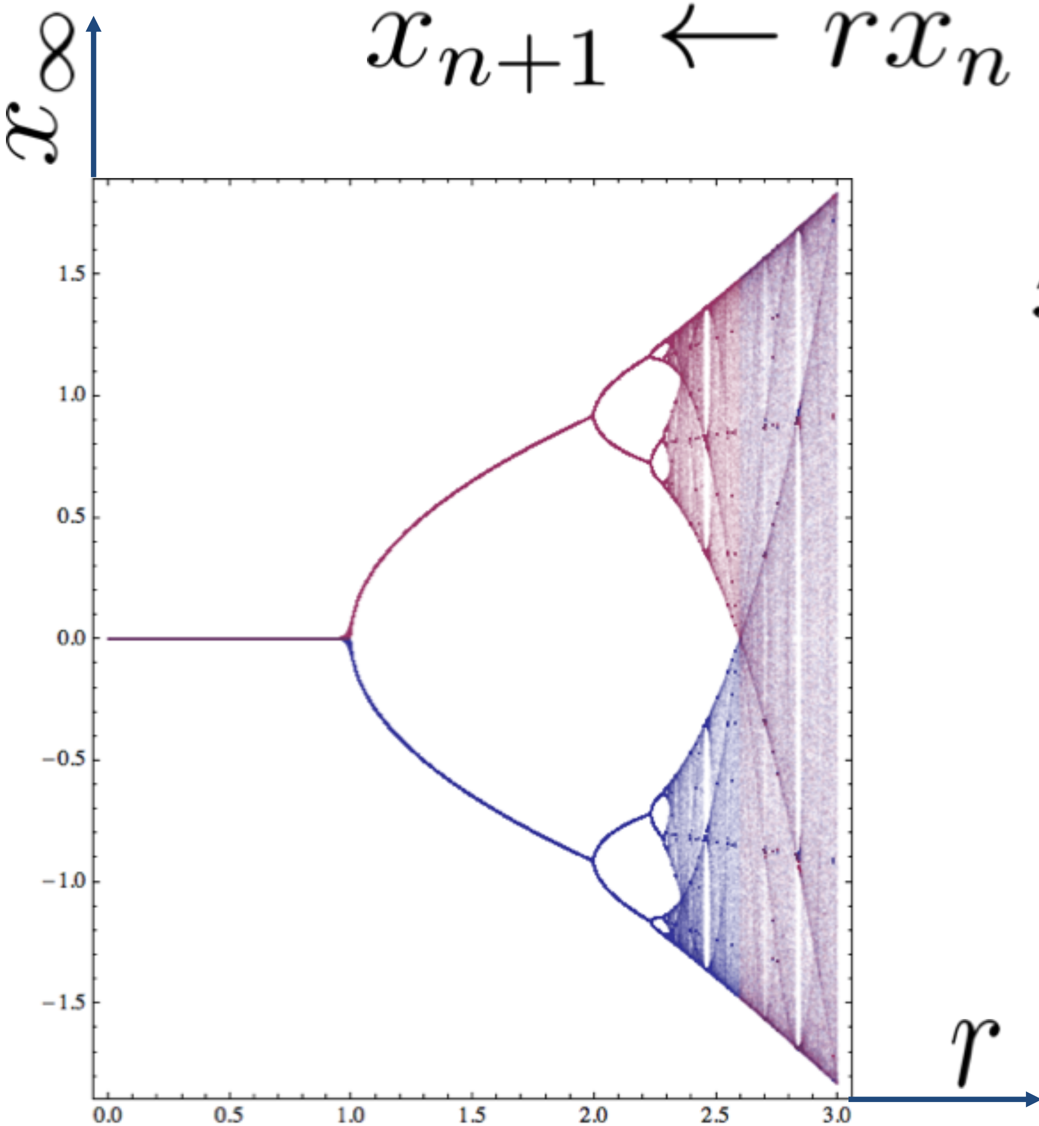
Term 2 / 2023



Python bootcamp continued

Task 1. Bifurcation map

$$x_{n+1} \leftarrow r x_n (1 - x_n)$$



$$x_0 \leftarrow \mathrm{rand}(0, 1)$$
$$r \leftarrow \mathrm{const}$$

Task 1. Bifurcation map

Step-by-step guide:

$$x_{n+1} \leftarrow r x_n (1 - x_n)$$
$$x_0 \leftarrow \mathrm{rand}(0, 1)$$
$$r \leftarrow \mathrm{const}$$

- implement the map, plot the evolution of x
- play around with values of r, see the change of evolution
- then create a linspace of r’s, for every r save last “m” values of x after first “n” values (can be m=200, x=200), play around with values
- Get the bifurcation map
- vizualize the evolution (play around)

if you are interested - describe real physical systems that exhibit bifurcation

Grading for task 1 (Bifurcations)

Subtask	Score
1.Implement the map, plot the evolution of x	1
2.Create a linspace of r’s, for every r save the last “m” values of x after the first “n” values (can be m=200, x=200), play around with values	1
3.Plot the bifurcation map	1
4.Parallel computation of bifurcation map	2
5.Plot speedup vs number of processes	2

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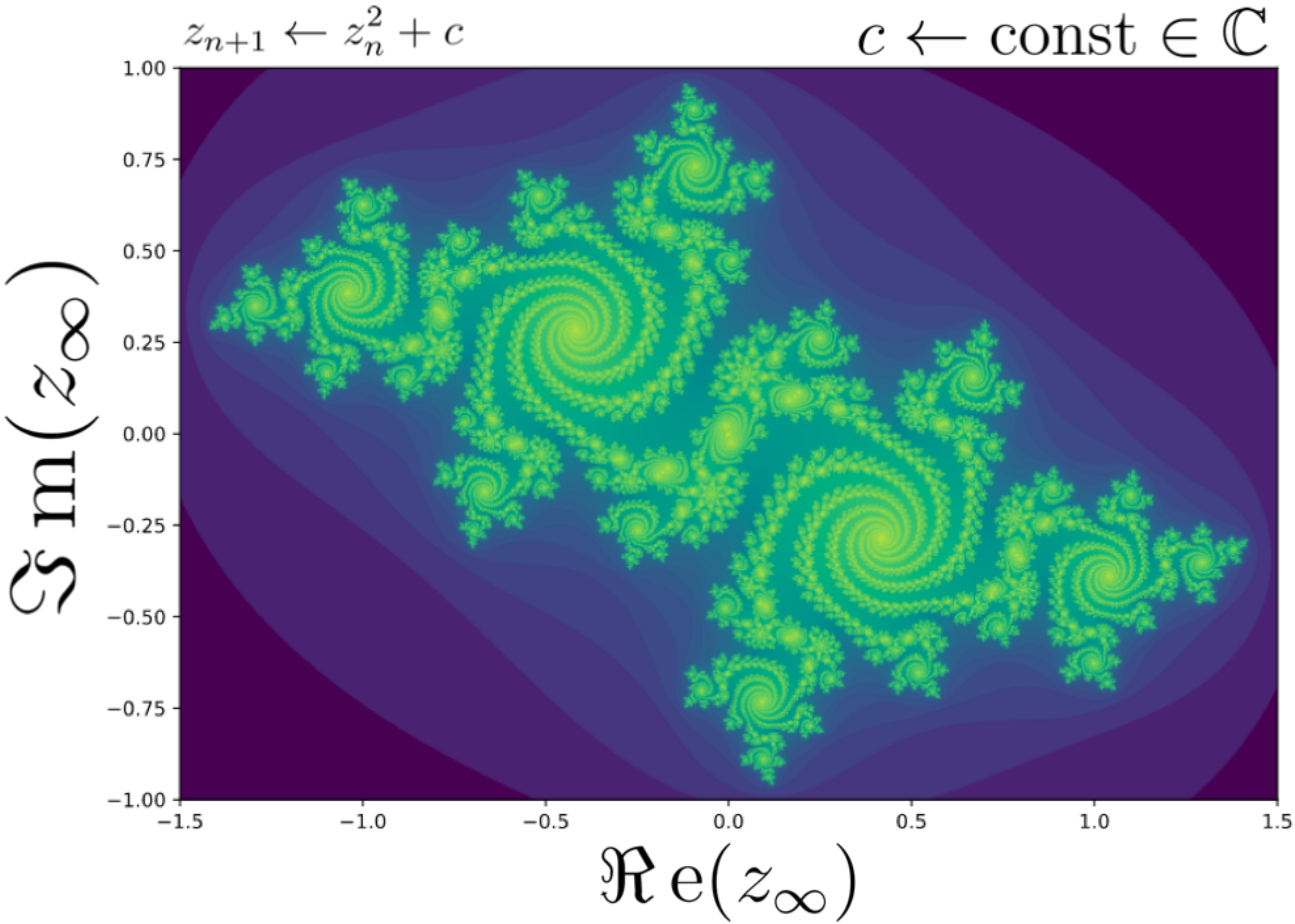
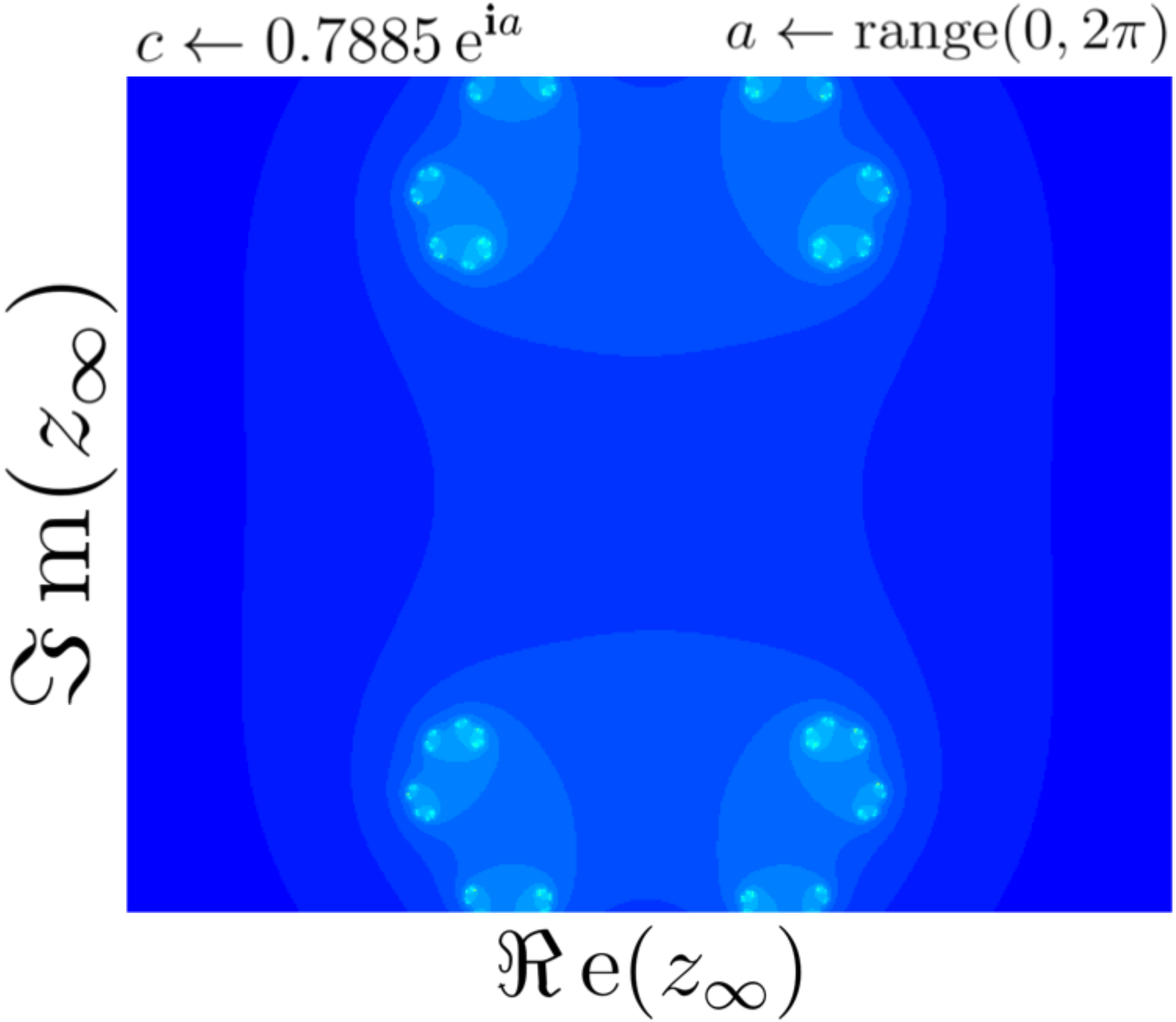
Task 2. Julia set



Task 2. Julia set – 2



Task 2. Julia set

Step-by-step guide:

$$z_{n+1} \leftarrow z_n^2 + c$$

- fix a value of C (can be 0)
- implement the map, plot the evolution of z (Re(z), Im(z))
- play around with values of z0, see the change of evolution
- for a given z0 if the sequence converges use black color, if it exponentially diverges use white color, if it starts jumping between "n" values use different colors
- plot the Julia set
- C=0 - Mandelbrot set

Mandelbrot set is z_n = 0, c - arbitrary

Grading for task 2 (Fractals)

Subtask	Score
1.Black and white colors of pixels are correct	1
2.Different colors for bifurcation points	1
3.Generate figure of Julia set (c = 1-r) where r is the golden ratio. Label the axes (Re(z0), Im(z0)), fontsize should be 20, figsize = (14,11)	2
4.Plot figures for c=exp(ia), a = range(0,2pi) & write down axes like in subtask 3, create animation of these figures slowly changing the a - value. hint: use, e. g., one of these examples: https://stackoverflow.com/questions/753190/programmatically-generate-video-or-animated-gif-in-python & title should include values of a & gif should have longitude 1 minute *(max score - 3)*	3

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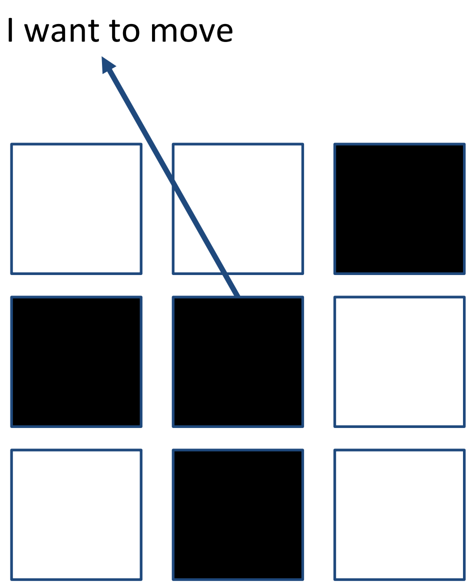
Task 3. Schelling's Model

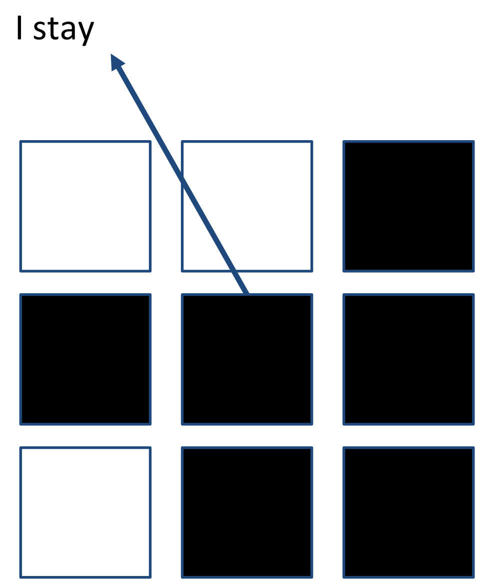
1) Suppose there are two types of agents: X and O. Two populations of the two agent types are initially placed into random locations of a neighborhood represented by a grid. After placing all the agents in the grid, each cell is either occupied by an agent or is empty.
2) Now we must determine if each agent is satisfied with its current location. A satisfied agent is one that is surrounded by at least t percent of agents that are like itself. This threshold t is one that will apply to all agents in the model.
3) When an agent is not satisfied, it can be moved to any vacant location in the grid. Any algorithm can be used to choose this new location. For example, a randomly selected cell may be chosen, or the agent could move to the nearest available location.
4) All dissatisfied agents must be moved in the same *round*. After the round is complete, a new round begins, and dissatisfied agents are once again moved to new locations in the grid.

Task 3. Schelling's Model

Segregation model (black and white households)

- map is large (i.e. 100x100 with periodic boundaries)
- each household on a map has 8 neighbours
- the agent decides to randomly move if less than R (you can change that) neighbours are of the same color





Task 3. Schelling’s Model

Segregation model (black and white households)

- map is large (i.e. 100x100 with periodic boundaries)
- each household on a map has 8 neighbours
- the agent decides to randomly move if less than R*8 (you can change that) neighbours are of the same color

Steps:
Randomize the map with half white/half black
define the value of R (0, ⅛, 2/8, ⅜, 4/8, ⅝,6/8,⅞, 1)
start the game
on each step for each cell find out if the cell wants to move - this cell is now on the market (considered free for moving in)
after you finished with the whole map - cells that want to move can move into free cells
repeat the whole procedure

Grading of task 3 (Schelling model)

Subtask	Score
1.Create 9 gifs of map evolution for 9 values of R	5
2.Plot number of households that want to move versus time for 9 values of R on one graph, label 9 curves, label the axes and title the graph	2

Task 4. Spectrogram

https://bit.ly/3kGqCEn

Grading for Task 4 (Spectrogram)

Subtask	Score
1.Add 4th wave packet (frequency = 4 and time_shift = 7 cycles). Demonstrate the effect on the plot of the FFT spectrum	1
2.Implement the spectrogram, show the effect of 1 on the spectrogram. Don’t forget to label the axes	2
3.Change the number of time steps in your signal to the power of 2 (i.e. 2**14) and then slightly change the number of timesteps. Measure the timing, can you explain the difference?	2
4.Parallel version of spectrogram implemented	2
5.Plot speedup vs the number of processors	2

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