**Homework 1. (return until March, 3rd 2018)**

All submitted code must be sufficiently commented.

1.) **Learn to submit to GitHub.**
You have write access to the folder "Homework1" on github. Find a git reference manual online and submit to the repository subfolder with your name in "Homework1". A quick start to git can be found here http://product.hubspot.com/blog/git-and-github-tutorial-for-beginners.

Or submit any file (e.g. the homework) to a folder with your name in "Homework1.

**Hint:** I put cheat sheets with various ways to fulfill the task into the github repository. These are instructions that were used by students last year and deemed to be useful.

**2.) Grow a DLA cluster from the bottom.**
Let walks emerge only from the top of the drawing window and let them stick walks stick to any pixel on the bottom. Use at least 2000 Walks for this task.
Submit your code and a pretty result image to the github classroom.

3.) **Turn DLA inside out.** Let walks emerge from the center of the drawing window and stick to the structure as soon it leaves the structure.
What is the difference between the branching structures we created in the class and your new structure?
Document with images, code and describe it in words.

4.) **Crossing walks:** Let two walks emerge from [50,50] and [75,75]. Print on the console output how often the crossed each other after 6000 steps.
**Graduate students only/Undergrads optional:** determine the average number of walk crossings.

**Hint 1:** Come up with a definition what you understand by two walks crossing each other. Include this definition into the comments you make in the code
**Hint 2:** The statistical average always comes with a variance. Please report both and report why your way of computing the average is a useful characteristic of this process.

5.) **Modifying DLA clusters with probabilities. (Grad Students/Undergrads optional):**
Modify your existent code such that the walkers stick to the structure with a given probability.
Note you can only stick to boundary pixels and it is helpful to implement a function that simply decides whether or not a particle sticks to the structure.
What changes if you change the probability? Document it with images for probabilities of 1.0, 0.5 and 0.2.

6.) **Fractal dimension of DLA clusters.**
Compute the distribution of fractal dimensions of the DLA.
How does it differ between the lecture code and the new structures computed in the exercise before? Explain quantitatively.

**Hint 1:** You need your cluster account to do so and run it ~1000 times and read the help below
**Hint 2:** Wikipedia states the correct fractal dimension for DLA clusters. However, this value is a theoretically derived value. Your computation does not necessarily compute this exact value. However, it can serve as an orientation.

**Help on fractal dimension:**

For a graphical representation, you can simply store the coordinates, (x, y), of the cluster (the occupied sites) at the end of the simulation. A standard graphics program will then draw the cluster. Discuss the following points: Why does this structure arise and not a more or less circular cluster? Where does the symmetry come from?

For the evaluation of the fractal dimension one has to calculate the size of the cluster, S, and the mean radius, R, (radius of gyration),

$$R = \sqrt{\frac{1}{S}\sum_{i=1}^{S} {r_i}^2}$$

where $r_i$ is the distance of the particle I to the center of the cluster. Calculating $S(R)$ during the growth of the cluster one can determine the fractal dimension $D_f$ assuming the relation

$$S \sim R^{D_f}$$

( Reminder to solve for exponents: http://mathonweb.com/help_ebook/html/expolog_4.htm )