Progression of Rivers - PCS Proposal

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Project plan

Project title:	Progression of Rivers
Team members:	Melvin Seitner
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Group name:	Mediocre Mice Jugglers

Scientific question (max. 350 words)

Rivers are hugely complex, and evolve over many thousands of years influenced by a great amount of factors, such as surface elevation, yearly weather cycles, plate tectonics, climate and even human influences. Most rivers stretch across thousands of kilometers, moving incredibly large amounts of sediment across continents and by doing so, changing the shape of the land as well as their own course. As our goal, we wish to study the following phenomena that may occur within rivers:

- Meandering of rivers.
- The splitting of rivers into multiple branches (bifurcation).
- The formation of deltas.

To this end, we've set up the following research questions:

1. What causes the meandering of rivers?
2. What is the effect of the speed of a river on phenomena such as meandering, bifurcation and the formation of river deltas?

While potamology, the scientific study of rivers, takes the large number of factors listed above (and more) into account, two of the most important factors in the progression of rivers are the processes of corrosion and sedimentation[1]. Our hypotheses to the above questions rely mostly on these processes:

[1]R. Charlton, *Fundamentals Of Fluvial Geomorphology*, 2007

1. **Hypothesis:** The meandering of rivers is caused by a difference in speed between the inner and outer sides of the bends in the river, with the flow being faster in the outer side. Since corrosion occurs at a faster rate at higher speeds, while sedimentation occurs more at slower speeds, the outside bend is slowly deteriorated, while the bank on the inside of the bend is slowly expanded due to sedimentation. This process slowly expands the size of the bends in a river.

2. **Hypothesis:** Since rivers at higher speeds have a higher rate of corrosion of the river bed, their paths are less obstructed by terrain, and they are less likely to result in meandering or bifurcation. Meanwhile, rivers at much slower speeds —when the surface elevation is more even— will often create obstacles for themselves through sedimentation. Because of this, sufficiently slow rivers tend to split often, leading to the creation of river delta's.

Numerical method (max 100 words)

We'll use the Lattice Boltzmann Method (LBM)[2] to simulate the flow of rivers, and expand this method to allow for the simulation of corrosion and sedimentation. The Lattice Boltzmann Method allows for efficient flow simulation on a fixed grid, where obstacles are usually added as static objects. In this project one of our goals would be to make it possible for these grid points to break off, flow with the water, and then rejoin the grid if they move slowly enough. Additionally, LBM is famous for making parallelization easily implementable and efficient, which is one of the reasons for our technical considerations below.

We'll validate our model by first looking at just Lattice Boltzmann, by carefully analysing the simulated fluid flow in a couple simple tubes. Then we'll look if our implementation of corrosion and sedimentation is correct by placing a couple of corrosable grid points in the tubes, and seeing if they corrode as expected when we vary the corrosion rate and water flow.

Provisioned tools (max 100 words):

The tools that will be used to implement the Lattice Boltzmann Method will be C++ in combination with OpenGL, using SDL[3] to create the OpenGL context. Our goal is to port the Lattice Boltzmann code given on the PCS course page on Canvas to a OpenGL shader, which we can then run efficiently on the GPU. OpenGL will also be used to directly visualize and render the results. We'll use Git for version control, with Github as hosting service. Finally we'll use Python with Matplotlib to graph the results of our measurements.

[2] Y.B. Bao & J. Meskas, *Lattice Boltzmann Method for Fluid Simulations*

[3] https://www.libsdl.org/

Plan for division of work (max 100 words):

- **Maxim**:
  Implementing LBM in parallel using OpenGL shaders, with help from Melvin. Finding and designing experiments, as well as validation scenarios.

- **Melvin**:
  Understanding LBM, implementing corrosion and sedimentation into LBM.

- **Jurriaan**:
  The SDL/OpenGL implementation in C++, and visualization of the rivers. Visualising the results of the experiments.

Timeline (max 100 words):

1. Week 1:

   - Finishing the project proposal.
   - Creating a proof of concept application in Python.
   - Creating the C++/OpenGL backbone implementation.
   - Starting to work on the Lattice Boltzmann implementation using OpenGL.
   - Reading about the Lattice Boltzmann method.

2. Week 2:

   - Finishing the Lattice Boltzmann model, with some basic visualisation.
   - Setting up some simple experiments using the implementation, which ideally show that the implementation works properly.
   - Expanding the model for corrosion and sedimentation.
   - Evaluating some of the results we get using the new implementation.
   - Improving the visualization.

3. Week 3:

   - Finishing up the implementation if needed.
   - Run experiments.
   - Graph/visualize the experiment data.
   - Draw conclusions and answer our research question.
   - Start working on the short report.
   - Start working on creating and designing the poster.

4. Week 4:

- Write the short report.
- Finalize and print the poster
- Work on the poster presentation.
- Finish writing the short report.

Alongside this schedule we'll also do the required course assignments, such as the project proposal peer review and code reproducibility peer review.