1. **Koch Curve**   present ☐

   For the construction of the Koch curve, the line segment is divided into three equal parts, a fourth one is added and used to form a triangular extrusion. Use a similar construction but add two segments to form a square extrusion. What is the dimension of the resulting fractal?

   In continuation, divide the line into four equal parts and add sufficient pieces to construct two square extrusions, one above, the other one below. Again calculate the fractal's dimension.

2. **Sierpinski Carpet**   present ☐

   For the Sierpinski carpet of order n (left frame of Fig. 5.19), calculate the size-distribution of the holes.

3. **Utopia – Getting Operational**   present ☐

   The aim of this exercise is to get operational with the numerical modelling framework Utopia, which will be used in most of the remaining exercises to investigate models of complex systems.

   Utopia is a comprehensive approach to modelling: it aims to provide all tools necessary for implementing a model, configuring and running it, and subsequently investigating it. In the exercises, the focus will be on the latter two points[1].

   Follow these steps to get operational with Utopia **[caveat: as of Dec 15, 2020, installing on MacOS Big Sur (version 11.0.1) is possible, but a bit finicky.]**:

   1. Install Docker on your machine using the guide at `docs.docker.com/get-docker/`[2].
   2. Following the instructions on `hub.docker.com/r/ccees/utopia`, pull the Utopia Docker image, `ccees/utopia:latest`, and run the container.
   3. Open the Utopia Documentation[3] and go through the Utopia Tutorial to familiarize yourself with the following aspects of the framework:
      i. Running already implemented models. (In the tutorial: `SandPile` and `ForestFire`)
      ii. Configuring those model using YAML configuration files (a human-readable data-serialization language commonly used for configurations)

   For this exercise, focus on the "Getting Started" and "Running a Simulation" sections of the tutorial.

   - Configure and perform simulation runs for one or multiple models of your choosing. Use interesting parameters.
   - Check the generated plots for your chosen model and describe what you see. What was the effect of your particular choice of parameters?

   Refer to the Utopia documentation for information about available models and their parameters.

   Remarks regarding hand-in:

   - Please bundle all information needed to recreate the plots (command line interface command, configuration files, the plots themselves) into a single PDF.
   - Do **not** submit simulation data or videos via Moodle. If you want to include videos, please upload them to heiBox or a similar service.
   - Optionally, to keep all commands in one place, you can work interactively with the Docker container[4] using a Jupyter Notebook[5].

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[1]For those proficient in C++ and interested in having a look at the backend, there always is the possibility to dive deeper. In case you are interested, have a look at the development repository, `ts-gitlab.iup.uni-heidelberg.de/utopia/utopia`.

[2]Unfortunately, this requires a signup. If you are uneasy with using your own e-mail address: `temp-mail.org`.

[3]Version corresponding to the latest docker image: `hermes.iup.uni-heidelberg.de/utopia_doc/latest/html/`

[4]See `hermes.iup.uni-heidelberg.de/utopia_doc/latest/html/frontend/interactive.html#with-the-docker-container`

[5]Magic Commands like `%%writefile` and `%sx` might also be useful, see `ipython.readthedocs.io`