Project examples

from past students

Simulating societal collapse

Question

“To what extent are inequalities and nature depletion linked to a possible civilization collapse?”

Model

Modified predator-prey (HANDY - “Human and nature dynamics”)

Data

Parameter values

Result

Increase in social disparity increases depletion of natural resources

A cartoon scenario

Question

How accurate are Randall Munroe’s comics about draining the Earth’s oceans and dumping the water onto Mars?

Algorithm

Discrete pathfinding

Data

Topological maps; rate of water removal/addition

Results

They are pretty accurate

https://what-if.xkcd.com/53/
https://what-if.xkcd.com/54/

Predicting soil properties

Question

How well is soil organic carbon content predicted by soil type?

Models

(soil carbon ~ soil type and density relations)

Data

Soil maps; reference soil carbon content

Result

Simple model misses certain features

Capturing spatial pollution gradients with low cost sensors

Question

Can low-cost sensors be calibrated to provide similar information as more expensive monitors?

Model

Linear model

Data

Monitor and sensor data, meteorological parameters

Results

Simple models do not achieve sufficient accuracy

Carbon capture and storage

Problem

Which absorbent is most effective for CO_2 capture at point of emission?

Model

Classic heat transfer

Data

Parameter values for model

Results

MOF-177 is the most effective absorbent

I&EC research
Industrial & Engineering Chemistry Research
pubs.acs.org/IECR Article

A New Equilibrium Shortcut Temperature Swing Adsorption Model for Fast Adsorbent Screening

Abdulmalik Ajenifuja,* Lisa Joss, and Megan Jobson

Cite This: *Ind. Eng. Chem. Res.* 2020, 59, 3485−3497 Read Online

$$N_{\mathrm{A,total}}^{k-1} - y_{\mathrm{A}}^{k} N_{\mathrm{out}}^{k} - N_{\mathrm{A,total}}^{k} = 0$$

$$N_{\mathrm{B,total}}^{k-1} - (1 - y_{\mathrm{A}}^{k}) N_{\mathrm{out}}^{k} - N_{\mathrm{B,total}}^{k} = 0$$

$$Q_{\mathrm{ext}}^{k} = mc_{P_{\mathrm{ads}}} \Delta T^{k} - \Delta H_{\mathrm{is,A}}^{k} \Delta N_{\mathrm{A,ads}}^{k} - \Delta H_{\mathrm{is,B}}^{k} \Delta N_{\mathrm{B,ads}}^{k}$$

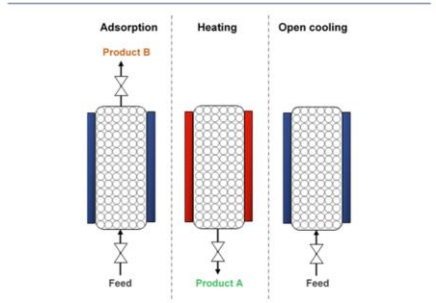

Figure 1. Schematic of the three-step TSA cycle with open cooling. Product A is the strongly adsorbed component of a binary mixture. Product B is the weakly adsorbed component.

Tips

Identify a domain of interest and formulate an interesting question.

Try to find instances of someone solving a related problem to get ideas for the approach – *you shouldn't have to start from scratch with respect to ideas*.

Identify the simplest model / data set to answer this question

- You should be able to (roughly) justify your simplifications
  - sometimes it is a matter of time constraints of the project
  - speculate on its impact on your results, and improving it can be mentioned in your outlook
- Are you capturing the important physics / mechanisms / features of your system?

State whether the answer is within the expected order of magnitude

- Does it make sense?
- Can you compare it to any reference value?

Note that you can change/redefine your project after the project proposal

If your problem ends up being too big/small, you can reduce/expand the scope.

Practical aspects

You can use a solver from an existing library

- numerically integrate differential equation(s)
- find values of unknown parameters of a model to match observations

Canonical use of multiple languages:

- Python/MATLAB as for I/O; glue language
- call C to do intensive computation

Contents

- Final report: you should be able to describe the model, algorithm, solution strategy without referring to implementation (how it's coded) in final report
- Code: repository is submitted separately and should describe the details of implementation

Interactive elements/interfaces should not be part of your proposal or final deliverable.