CE 5362 Surface Water Modeling

1D/2D Hydrodynamic Models

Algorithms and Software

- What is an algorithm
  - Why is it important?
- Programming and Tools
- Installing R, RStudio
- Installing HEC-RAS; EFDC; iRIC; SWMM

What is an algorithm?

- An algorithm is a recipe.
  - An algorithm is a computational method or an ensemble of rules determining the order and form of numerical operations to be applied to a set of data $\boldsymbol{a}(a_1, a_2, \ldots)$ in order to nd a new set of values $\boldsymbol{x}(x_1, x_2, \ldots)$ forming the solution of a problem.
  - An algorithmic procedure can be represented as

$$\boldsymbol{x} = f(\boldsymbol{a})$$

- From a practical perspective the main concern is that the algorithm is well posed:
  1. A solution exists for a given $\boldsymbol{a}$.
  2. The computation must lead to a single solution for $\boldsymbol{x}$ given $\boldsymbol{a}$.
  3. The results for x must be connected to the input a through the Lipschitz relation.

$$|\delta\boldsymbol{a}| < \eta \text{ then } |\delta\boldsymbol{x}| < M|\delta\boldsymbol{a}|$$

where M is a bounded natural number, $M = M(\boldsymbol{a}, \eta)$.

What is an algorithm?

- Thus an algorithm is a recipe to take input data and produce output responses through some relationships.
- If a well posed problem then each result is related to the inputs,
  - The same inputs (in an algorithm) should produce the same results (deterministic).
- By the recipe analogy, if you follow the same recipe each time with the same raw materials then the cake should taste the same when it is baked.

What is an algorithm?

- An that algorithm operates on data is procedure-oriented;
- An algorithm that performs a task (generate response) based on states established by the data is object oriented
  - Both points of view are valid and equivalent.
- Most computational hydraulics models are built (by a quirk of history) in a procedure oriented perspective.

Programming and Tools

- A practicing modeler needs a toolkit -- these tools range from the actual computation engine (EPA-SWMM, HEC-RAS, FESWMS, HSPF, WSPRO, TR-20, etc.) to analysis tools for result interpretation (R, Excel) to actual programming tools (FORTRAN,PERL, etc.) to construct their own special purpose models or to test results from general purpose professional models.
- Modeling is comprised of computation , interpretation, and presentation

Why programming?

- There are there fundamental reasons to mention programming:
- Teaching someone else a subject or procedure forces the teacher to have a reasonable understanding of the subject or procedure.
  - Teaching a computer (by virtue of programming) forces a very deep understanding of the underlying algorithm.
- You will encounter situations that general purpose programs are not designed to address; if you have a moderate ability to build your own tools when you need to, then you can.
  - In all likelihood, you will “trick" the professional program, but you cannot invent tricks unless you know a little bit about programming.
- Programming a computer requires an algorithmic thought process -- this process is valuable in many other areas of engineering, hence the act of programming is good discipline for other problems you will encounter.

Software we will need

- R and RStudio
- HEC-HMS, SWMM
- EFDC, iRIC