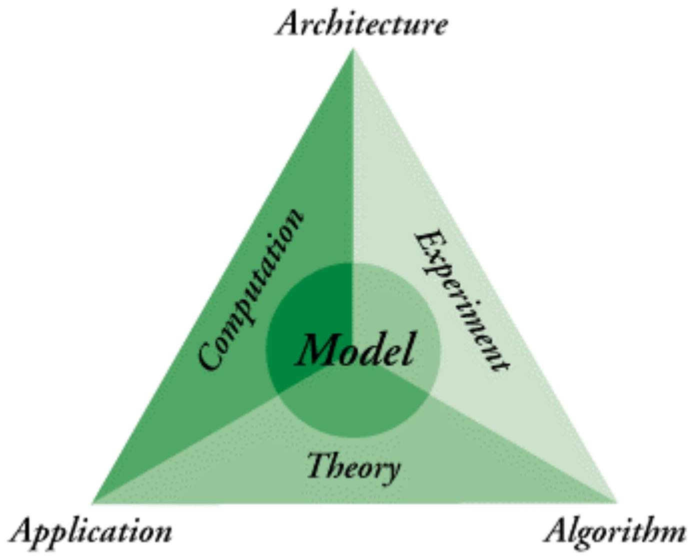
An Introduction to Modeling: What does it look like?



All models are wrong; some models are useful. – G. Block (English Statistician)

The purpose of computing is insight, not numbers. – R. Hamming (Computer Scientist)

If you can't trust the numbers, you won't get much insight. – R. Panoff (Physicst)

This exercise has three motivations:

a) To explore the mental space of exploration and inquiry (thought)

b) To build a simple model in Vensim

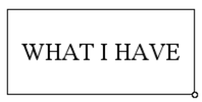
c) To realize how much of Nature could have similar, and simple, generating rules.

Even though it will look like a specific recipe for a specific model, the steps here are really generally applicable: Thinking, observing, conjecturing, observing, and back to thinking.

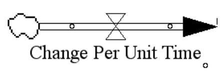
Not everything that we will do is written in this handout. That's because I have no idea what each of you will suggest along the way, and I suppose that it would be more fun to do what you think of, than for me to try to get you to do something I might think is fun.

SYSTEM DYNAMICS: Our starting point is the COLLECTIVE or a PROPERTY OF THE COLLECTIVE (also called the SYSTEM, the AGGREGATE). This approach takes a GLOBAL view of the world. We need to state the initial conditions of the SYSTEM and how it CHANGES. Our model can include as much information or conjecture as we want to build in.

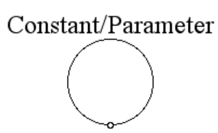
Almost every systems modeling environment includes four basic vocabulary words/symbols:



WHAT YOU HAVE: represented as a BOX or a CONTAINER (sometimes called a STOCK or RESEVOIR).



HOW SOMETHING CHANGES PER UNIT OF TIME: represented as a pipe flowing into or out of a box. This is sometimes called the FLOW or RATE.

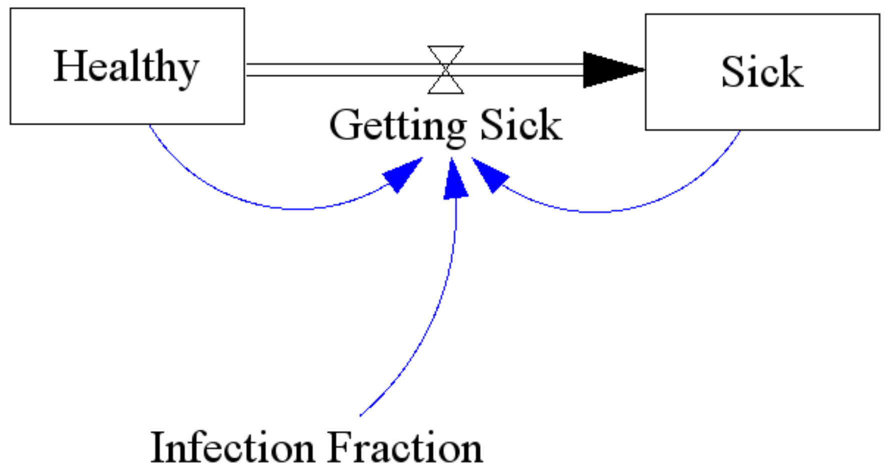


WHAT YOU KNOW: represented as a word or circle, this would be a variable, function, or constant input to the model. This could be some function or specific data affecting the model.

WHAT DEPENDS ON WHAT: represented as a directed wire or arrow from one part of the model to another, sometimes called an arrow or connector. Starting from the "dead" end towards the arrow, this arrow always could be read as, "I need to know this end in order to calculate what I am pointing to."

Applying this to a specific situation of modeling the spread of a disease, let's start with the simplest case, that is, that a healthy person "catches" a disease from contact with a sick person, and that once infected, this person doesn't get the infection again. For now we can even ignore the prospect that the sick people get better, as a first approximation.

If we consider that H healthy people can come in contact with S sick people, then H*S is the total number of possible contacts (within a factor of 2) and that some fraction of these contacts moves a person out of the healthy "bucket" into the sick "bucket," that is, if f is the infections per time per contact, then f*(H*S) is the number of people that get sick per unit time. There are many "bells and whistles" in Vensim and with most system modeling tools. But our goal is to make the model as appealing, transparent, robust, and applicable as possible, while refining it with successive approximations. Vensim can be used to build a simple graphical representation of this model using only the above 4 elements of a system dynamics modeling vocabulary. This "spread of infection" model can be pictured this way:



To define each item, double click on the object and answer the dialogue. Let's assume the following values:

INITIAL HEALTHY: 1000
INITIAL SICK: 1
Infection fraction: 0.001 (you can set *min* and *max* and *increment* to adjust a slider)
Getting Sick: Infection_fraction*HEALTHY*SICK

To run the model, push the "running man" icon.

To run the model and vary the model as you run, push the "run with the wind" icon.

You can examine various graphs and look at the output to see how the infection proceeds.

We will do this as an interactive exercise in the class to experiment with different teaching styles.

Extensions:

a) Allow sick persons to get better. Are they immune or can they get sick again? How would your models differ?

b) Introduce other factors to getting sick or getting better.

c) How would birth and death be taken into account?

d) What other physical processes can you imagine "spread" in a way that would be similar to how the flu spreads?

One aspect about using models in the classroom to think about: is BUILDING the model the learning objective, or is RUNNING the model your goal?

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