TRUST, EVOLUTION, AND COMPUTATIONAL THINKING

This slide and materials are available at
https://github.com/RickWeber/NYSEA2023

PART I: RELEVANCE FOR *YOU AND ME*

WHAT DO YOU REMEMBER FROM YOUR UNDERGRAD EXPERIENCE?

- facts
- skills
- beliefs
- modes of thinking

WHAT ARE WE REALLY PROVIDING OUR STUDENTS?

- A mix of skills, beliefs, and ways of thinking are the lasting contribution of our schooling.
    - They can look up the facts as they need them.
- Hopefully we're helping them learn to think more clearly about complex systems.

Economics is a method rather than a doctrine, an apparatus of the mind, a technique of thinking which helps its possessor to draw correct conclusions.

The master-economist must possess a rare combination of gifts .... He must be mathematician, historian, statesman, philosopher... [computer scientist, statistician, etc.]

WAYS OF THINKING

- The Economic way of thinking is incredibly powerful.
- There are lots of ways of thinking, and they're often complementary. (Mathematical thinking, statistical thinking, design thinking, etc.)
- Pluralism is good. And **we can replicate it our own heads.**

COMPUTATIONAL THINKING

(Many) computer scientists are basically economists asking questions about how to manage a scarcity of:

- data availability and quality
- storage size
- storage reliability
- computational capacity
- network capacity

EVOLUTIONARY THINKING

- Markets are evolutionary processes
  - but students often have a limited handle on the concept of evolution beyond the over-simplified "survival of the fittest".
- Computational models often lend themselves to the use of the Genetic Algorithm.
  - Simulator’s prerogative: stop/start/inspect the model
  - See the evolutionary process unfold in real time

COVERING NEOCLASSICAL BLINDSPOTS

- A common trope among scholars of Emergence[1] is how ants are individually stupid but collectively brilliant.
- Neoclassical economics runs into the opposite problem: individually brilliant individuals who get trapped in Prisoners' Dilemmas

1. Not all of them know it, but they're implicitly thinking computationally already

ECON STUDENTS NEED COMPUTER SCIENCE

EVEN IF WE HAVE TO DITCH THE COMPUTER

- Computational thinking is more about thinking than computing
- Students should learn computer skills, but the bigger value is how it lets you see the underlying logic of a situation
- All of the coding skills I've learned and forgot are still useful because they've expanded my thinking tool kit.

HOW CAN WE GET SOME OF THAT IN PRINCIPLES?

- One place to start is playing around with computational versions of a model we already know and love.
- Bonus: the descriptive stories we tell about (e.g.) shortages are really computational stories.
    - People get signals about the state of the world, adjust their behavior, and change the state of the world through their actions.
    - (I'm guessing Clair Smith will tell us this story in session D1.)

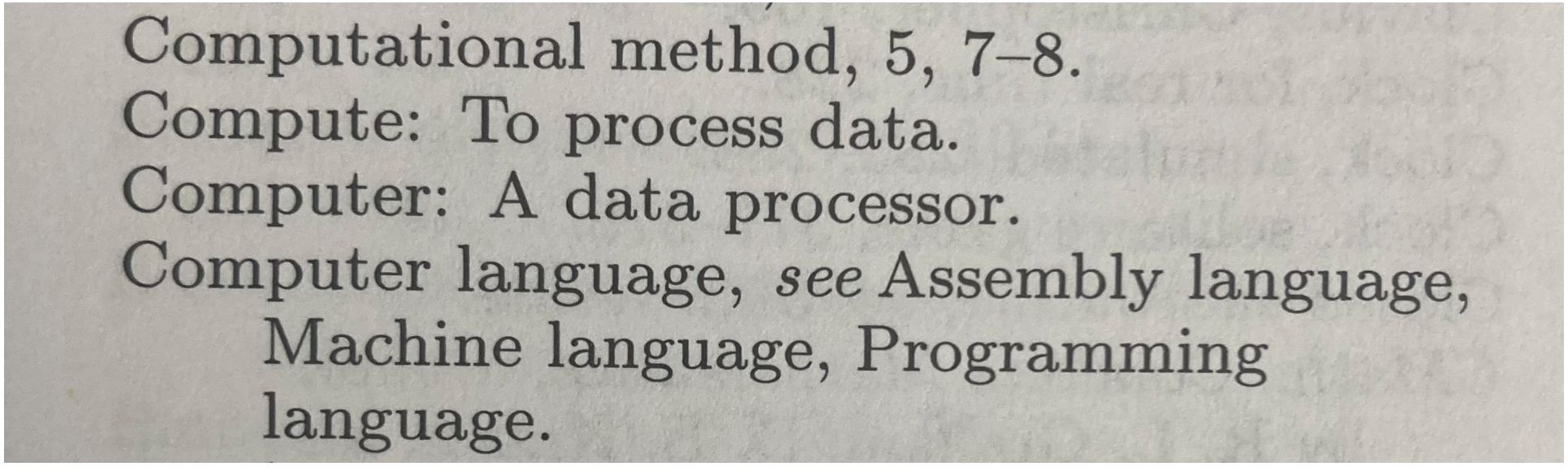
OKAY, SO WHAT ARE WE DOING?

- 2.5-minute crash course in computational thinking.
- See a small sample of economic issues that Computer Science sheds light on.
- Then we'll look at a computational model of trust.

PART II: CRASH COURSE IN COMPUTATION

WHAT IS COMPUTATION?

From *The Art of Computer Programming*'s index:



Computational method, 5, 7–8.
Compute: To process data.
Computer: A data processor.
Computer language, *see* Assembly language, Machine language, Programming language.

COMPUTATION IS JUST DATA-IN-DATA-OUT

There are abstract models of computation like *Turing Machines* and *Lambda Calculus*.

For our purposes:

1. Many possible computations might take longer than the lifespan of the universe to finish computing.

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- process it according to some rules, and
- ultimately[1] generate output (e.g. some change within the computer or the world it occupies).

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COMPUTATIONAL EQUIVALENCE

Even incredibly simple systems like Cellular Automata can be used for sophisticated calculations like computing prime numbers.

Any system that is "Turing complete"[1] is Turing equivalent to any other Turing complete system: given enough time, any Turing complete system is capable of simulating any other.

1. which turns out to be a surprisingly low bar.

COMPUTATIONAL IRREDUCEABILITY

One of the early findings of Computer Science is that we can't count on finding a shortcut for any but the simplest programs. **We just have to run through "the program"** to see what happens.

CAVEAT

When we create a computational model, we're inventing a little world and hoping it corresponds to the real world, just like when we're using equation-based models. As always, buyer beware!

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- Even so, we can get started and hold constant the ineffable while we continue learning how the human mind works.
- "any system whatsover--can be viewed as performing a computation that determines what its future behavior will be." (Wolfram)

COMPUTATIONAL BIOLOGY

Earth *was a giant supercomputer designed to find the Ultimate Question of Life, the Universe and Everything. Designed by Deep Thought and built by the Magratheans, it was commonly mistaken for a planet, especially by the ape descendants who lived on it. It was situated far out in the uncharted backwaters of the unfashionable end of the Western Spiral Arm of the Galaxy).*

The Hitchhiker's Guide to the Galaxy

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- It's like Borges' cartographers but worse! (but it might be a smaller problem than those of Borges' library)
- **Moral of the story:** no matter how much we learn, there's always room for mystery.

PART III: PARALLELS IN ECON

EXAMPLES

- The Socialist Calculation Debate
  - Markets are "computationally irreducible"
  - You have no way to compute equilibrium faster or more effectively than the market itself (a distributed parallel computer that calculates the relative scarcity of exchangeable goods).
  - Econ's parallel to Turing's Halting Problem and Godel's Undecidability Proof.

EXAMPLES

- Markets as a discovery procedure (entrepreneurship as “search” in a many-dimensional space)
- Bounded rationality (e.g. modeling heuristics-based behavior rather than optimization)
    - (Seeing a simple case of machine learning with a simple agent is a valuable inoculant for AI snake oil sales pitches)

EXAMPLES

- Strategic interactions (e.g. Industrial Organization)
- Finance with heterogeneous agents (answering question: why do people keep doing technical investing instead of fundamental analysis?)
- Evolution of cooperation (i.e. computational political economy)

PART IV: EVOLUTION OF COOPERATION

PRISONERS' DILEMMA

- The Prisoners' Dilemma (PD) is as concise a formulation of civilization as I could hope for:
  - variable-sum game that requires two people to choose between cooperation and conflict.

ONE-SHOT SOLUTION

DEFECT, DEFECT

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- But life isn't one-shot, it's iterated!

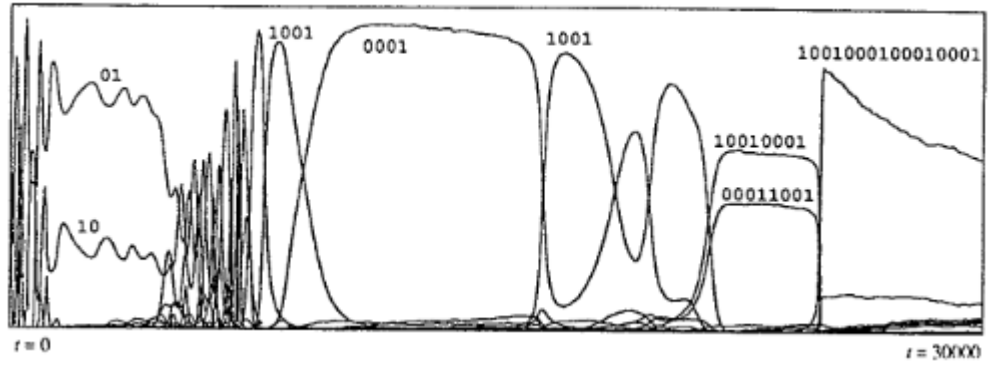
ITERATED SOLUTION

- It depends... but it's probably tit-for-tat.

LET'S SEE IT IN ACTION

- We'll see a NetLogo implementation that you're free to mess with at home.
- Nicky Case has a great (simpler) version in the form of an interactive webpage at ncase.me/trust

EVOLUTIONARY DYNAMICS IN A PRISONERS' DILEMMA



Lindgren, 1992 (p. 303)

PART IV: WHERE NOW?

WHAT HAVE WE SEEN?

- Computation is a relatively abstract property--we don't need sophisticated computers to do sophisticated computation.
- Social systems (e.g. markets) are computational systems in their own right.

WHAT HAVE WE SEEN?

- Computational modeling can help build understanding about processes that affect economic life.
- This understanding is critical for students to understand the world they’re graduating into.

EXPLORE/EXPLOIT

When knowledge is scarce, start by exploring. Once you've got the lay of the land, exploit that knowledge to whatever your ends are.

RECOMMENDED READING

- Evolution of Trust interactive web app
- *The Selfish Gene*
- *Algorithms to Live By*
- *Complex Adaptive Systems*

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- *The Hitchhiker's Guide to the Galaxy*
    - It's a beach read, but try reading it after some of the others.

DIVING DEEPER

- A New Kind of Science by Stephen Wolfram
- Leigh Tesfatsion's webpage
- Complexity Explorer from the Santa Fe Institute

THIS PRESENTATION INCLUDING LINKS AND MODEL

- https://github.com/RickWeber/NYSEA2023

THANK YOU

QUESTIONS/COMMENTS:

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