Observation and Interaction
(and Determinism and Free Will)

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Language and Automata Theory and Applications (LATA), St. Petersburg, Russia, March 26, 2019
Feedback

Harold Black
Feedback

Norbert Wiener
In Contrast: Turing Machines Lack Interaction

Machine designed by Mike Davey to resemble as closely as possible Turing’s 1936 description. [Photo by Gabrielf, CC BY-SA 3.0, via Wikimedia Commons]
In This Talk...

I will leverage the results of four Turing-Award winners:

Robin Milner
Judea Pearl
Shafi Goldwasser
Silvio Micali
First Person vs. Third Person
Subjective vs. Objective

Interaction is about first-person involvement, “I” not “them” or “those.”

Eliminating first-person involvement has long been a goal in science. The mantra:
“Objective is better than subjective.”
“Let the data speak for itself.”

Karl Popper
How to Explain Zero-Knowledge Protocols to Your Children

QUISQUATER Jean-Jacques(1), Myriam, Muriel, Michaël
GUILLOU Louis(2), Marie Annick, Gaïd, Anna, Gwenolé, Soazig
in collaboration with Tom BERSON(3) for the English version

(1) Philips Research Laboratory, Avenue Van Becelaere, 2, B-1170 Brussels, Belgium.
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(3) Anagram Laboratories, P.O. Box 791, Palo Alto CA 94301, USA.

The Strange Cave of Ali Baba

Know, oh my children, that very long ago, in the Eastern city of Baghdad, there lived an old man named Ali Baba. Every day Ali Baba would go to the bazaar to buy or sell things. This is a story which is partly about Ali Baba, and partly also about a cave, a
The Challenge

How can one person prove to another that they know a secret, while revealing nothing about the secret, and without giving that other person the ability to prove to anyone else that they know the secret?

We want absolutely minimal information transfer!
Ali Baba’s Cave

Shah Fi

Mick Ali

Requires password: Abra-Cadabra

Abra-Cadabra

Does she know?
Knowledge becomes available to any third-person observer.
Zero Knowledge Proof
Zero Knowledge Proof

A or B?
Zero Knowledge Proof

Repeat
Essential Features

- Residual uncertainty
- Randomness
  - First person
  - Free will
First Person, Free Will, and Randomness

Knowledge becomes available to any third-person observer.

[CC BY SA 2.0, ICMA Photos]
‘The Berkeley philosopher John Searle has dubbed the free will problem “a scandal in philosophy” on which we have made little progress since antiquity.’

[Doyle, 2012]

Sam Harris: Free will does not and cannot exist in any material system.
Modeling the Cave With Automata

Shah Fi

Mick Ali

Shah Fi (Without Password)

Shah Fi (With Password)
Language Equivalence

The essential difference between these is whether alternatives resolve early or late.

No passive observer can tell the difference.
Bisimulation is interactive.

Constructing a bisimulation relation gives certainty, but it requires knowledge of the internal structure of the state machines.
Simulation relations, in contrast, have one-way information flow.

**Mick Ali**
- outside → inside
- B → endB

**Shah Fi (Guessing the Password)**
- outside → guessed correctly
- A → insideA
- B → insideB
- A → endA
- B → endB
Resolution of Alternatives: Determinism

As a property of the physical world:
• Everything that happens is inevitable, preordained by some earlier state of the universe, and then following from the laws of physics.

As a property of a model:
• A model is deterministic if given an initial state of the model, and given all the inputs that are provided to the model, the model defines exactly one possible behavior.
Both definitions are about resolution of alternatives.

Questions:
• *How* are alternatives resolved?
• *Why* do alternatives resolve the way they do?
• *When* do alternative resolve?
A Tiny Universe

Consider a tiny universe that comes into existence with a finite number of beings, and for each being, one of two things happens later:

*tick* or *tock*.
In a deterministic tiny universe, the choice between *tick* and *tock* is resolved at the time of the “little bang.”

Edward

nothingness

being1

tick

end1

bang

being2

tock

end2
In a nondeterministic tiny universe, the choice between *tick* and *tock* is resolved later.

**Pablo**

- Nothingness → Being
- Bang

Tick → End 1

Tock → End 2
Modeling in a Tiny Universe

Pablo simulates Edward, but not vice versa.
A tiny universe where actions may be predetermined or not.

Eduardo simulates Pablo and vice versa, but they are not bisimilar.
Determinism and Free Will

Mick requires late resolution of alternatives (after Shah has resolved hers).

Mick requires free will to achieve zero-knowledge proof.
Is the physical world deterministic?
Naïve assumption: Newtonian mechanics is deterministic.

Metastable system that obeys all of Newton’s laws but is nondeterministic.

[Norton, 2007]

Pierre-Simon Laplace
Incompleteness of Determinism

Any set of deterministic models rich enough to encompass Newton’s laws plus discrete events is incomplete.

Causality or Causation

Every effect is produced, as a consequence of some law of nature, by a cause.

“All philosophers, of every school, imagine that causation is one of the fundamental axioms or postulates of science, yet, oddly enough, in advanced sciences such as gravitational astronomy, the word ‘cause’ never occurs ... The law of causality, I believe, like much that passes muster among philosophers, is a relic of a bygone age, surviving, like the monarchy, only because it is erroneously supposed to do no harm.” (Russell, 1913)
Causal Reasoning

You cannot reason about causality by objective observation alone.

Judea Pearl

Lee, Berkeley

[Pearl and Mackenzie, 2018]
Interaction enables reasoning about causality.

Intervention is analogous to Mick calling out A or B. But the purpose is to broadcast the result!
Mutual Simulation is Not Enough

Randomized Controlled Trial

Flawed Trial

Simulates

Simulates
Interaction vs. Observation

• Machines that look identical to an observer are not identical if you can interact with them.
• Interaction can do things that are not possible without interaction (zero knowledge proofs).
• Reasoning about causality requires interaction and subjective judgment.

First person is fundamentally different from third person!
Lessons from Physics
The Quantum Observer Problem

• Pure observation is impossible, at least under the Copenhagen interpretation.
• But the Copenhagen interpretation ignores the backwards direction, the effect on the observer.
“The mind simply does not exist as something decoupled from the body and the environment in which it resides.”

[Thelen, E., 2000: Grounded in the world]

AI will arise from cyber-physical systems and cyber-human systems, not pure cyber ones.

Esther Thelen (1941—2004)
Developmental psychologist,
Indiana University, pioneer of embodied cognition.
Conclusions

Interaction is more powerful than observation.

Subjectivity rules!

Спасибо

MIT Press, 2017

Living Digital Beings
Edward Ashford Lee

MIT Press, 2020
References