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How Computing May Change Our World

Mark D. Hill
Univ. of Wisconsin-Madison Computer Sciences
Computing Community Consortium (CCC)

10:00 AM CT September 17, 2020 @ PLATO
(Participatory Learning And Teaching Organization)

How Computing May Change Our World

While computing has already changed how we communicate, work, and play, more big impacts are afoot. Prof. Hill will define and discuss impacts of three important examples on the horizon:

(a) why artificial intelligence will free humans from more repetitive tasks,

(b) how quantum computing will eventually enhance discovery, and

(c) how computing and very human issues like fairness will increasingly interact.

This talk assumes no background in computer science and is based on visioning work Prof. Hill collaborated on when he led the Computing Community Consortium (CCC) (https://cra.org/ccc/about/). He will seek to finish early to enable time for questions and discussion on computing's directions and would value any questions submitted in advance.

Mark D. Hill (http://www.cs.wisc.edu/~markhill) is Gene M. Amdahl and John P. Morgridge Professor Emeritus in Computer Sciences at the University of Wisconsin-Madison. His work targets computers with complex memory systems, multiple processing cores, and systems which do not yet exist so they have to be simulated. Over three decades, he has collaborated with over 160 co-authors, has over 40 patents, and has held several visiting positions in the computer industry, most recently as a 2018 Google Intern. He serves as Chair Emeritus of a national computing think tank--the Computing Community Consortium--and he was Wisconsin Computer Sciences Department Chair 2014-2017. Mark won the highest award in computer hardware--Eckert-Mauchly—in 2019. Mark is a fellow of his two major professional societies (ACM and IEEE), and has a PhD from the University of California, Berkeley.

Outline

Background & Computing Community Consortium

→ Computing has & will change our world

Artificial Intelligence (AI) / Machine Learning

Quantum Computing

Computing & Society

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Artificial Intelligence (AI) / Machine Learning

→ Freeing humans from r ut…

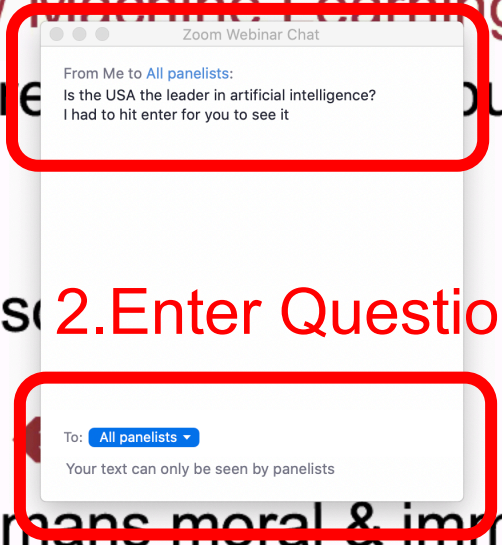
Quantum Computing

→ Enhancing discovery (s

Computing & Society

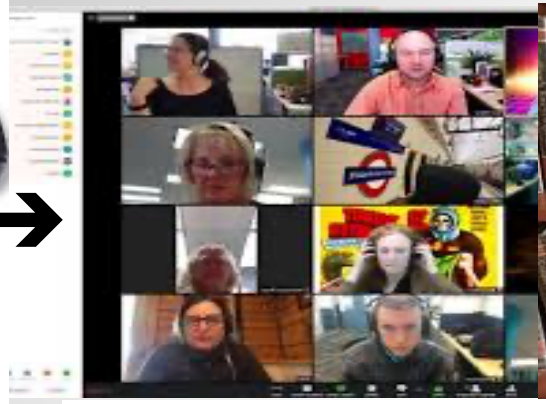
→ Computing amoral; humans moral & immoral

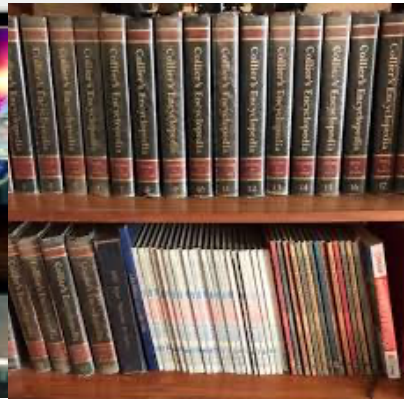
3. Question Appears



1. Press Chat

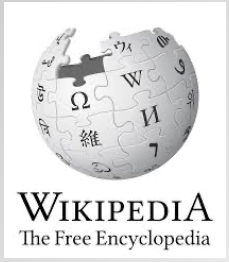
Computing has changed our world





Why is computing so effective? Universal Hardware

Computing: One Tool for Many Problems



Software (Algorithm)

Instructions to divide
any number A by
any other number B
to get quotient C

← Load Software on Hardware

← Data In: A=1200, B=50

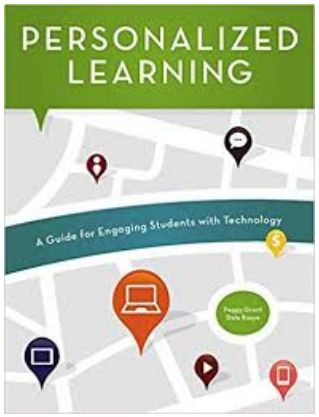
→ Data Out: C=24

One hardware for many tasks selected by software!

Computing to change our world more

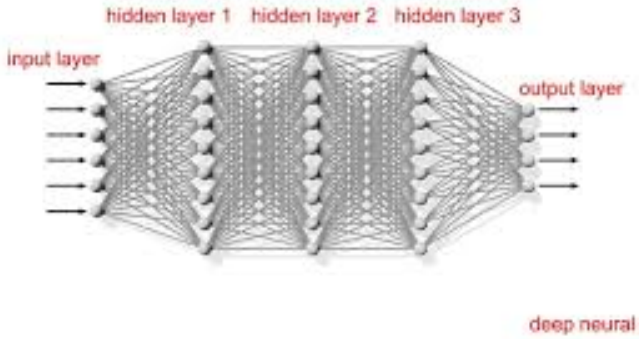
Virtual Reality

Augmented Reality



Personalized Learning

Self-Driving Vehicles



Via Deep Neural Networks

In the News: New York Times, 9/17/2020

THE NEW YORK TIMES **BUSINESS** THURSDAY, SEPTEMBER 17, 2020

TECHNOLOGY | MEDIA | INTERNATIONAL

Facebook Nails the Headset, Not the Games

The Oculus Quest 2 virtual-reality system has the hardware you'll want, and the content you won't.

Brian X. Chen
TECH FIX

A group of five boxers and I recently threw punches to upbeat music while an instructor egged us on. By the end of the 20-minute workout, I'd broken a sweat and my smartwatch showed my heart rate thumping at 140 beats a minute.

Normally, this would be the result of a workout at my local gym. But in a

1960's Mouse

...omputers as well as wireless goggles ...at relied on smartphones to run ...mes.

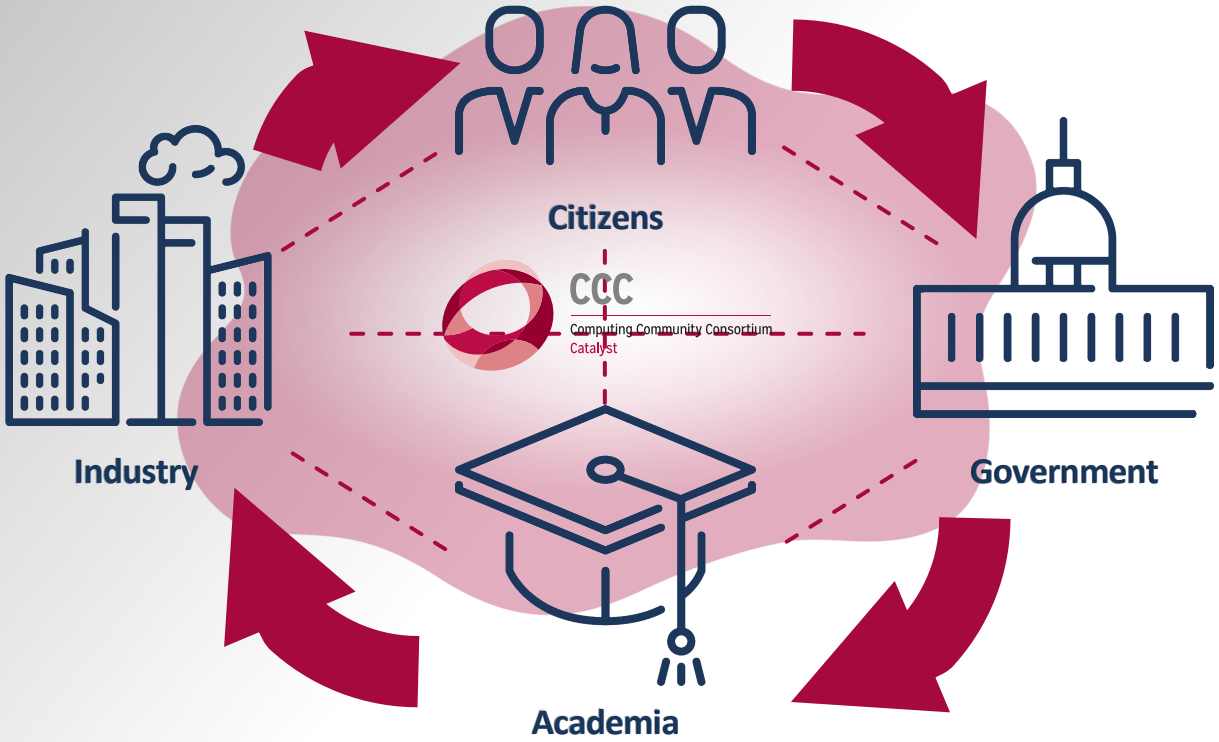
Now the Quest 2, the company said,

Metal Gear Solid, the ... this one imitates. (In ... I got to move around ... I picked out other ... my interests. Poker ... interesting approa... Just like in a casin... at a card table an... to pick up your c... the players arou... tions using thei... made me nosta... vice, but sittin... for cards to be... headset and ... and made m...

I also dow... wich Tale, ... list of mos... name, the ... sandwich ... game (c...

V.R. ... wor... Tec...

Computing Community Consortium: Catalyzing I.T.'s Virtuous Cycle



Pre-competitive white papers & workshops catalyzing I.T. research for the nation's benefit

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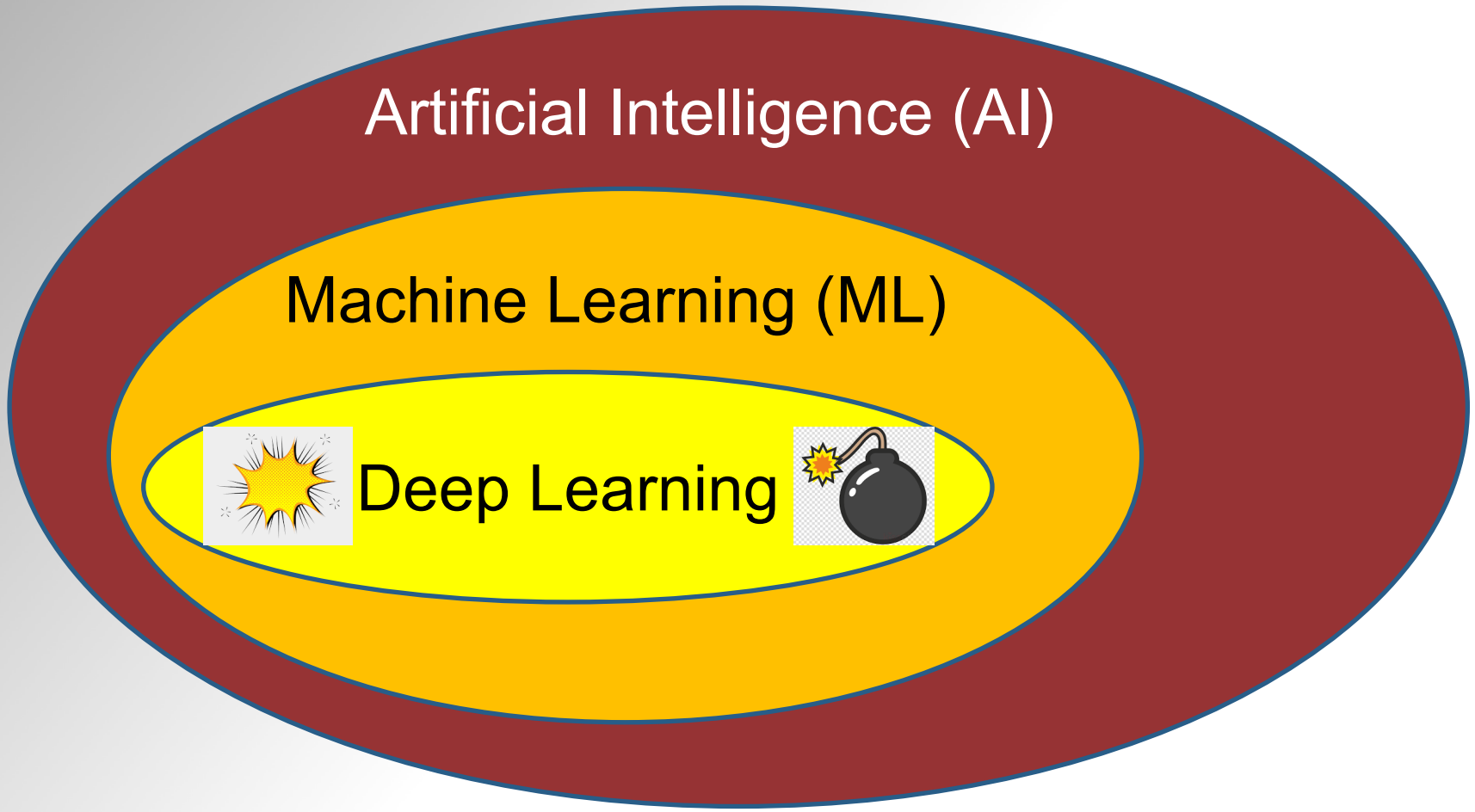
Artificial Intelligence (AI) / Machine Learning ← ← ←

→ Freeing humans from repetitive tasks, but…

Quantum Computing

Computing & Society

Artificial Intelligence (AI) & Machine Learning (ML)

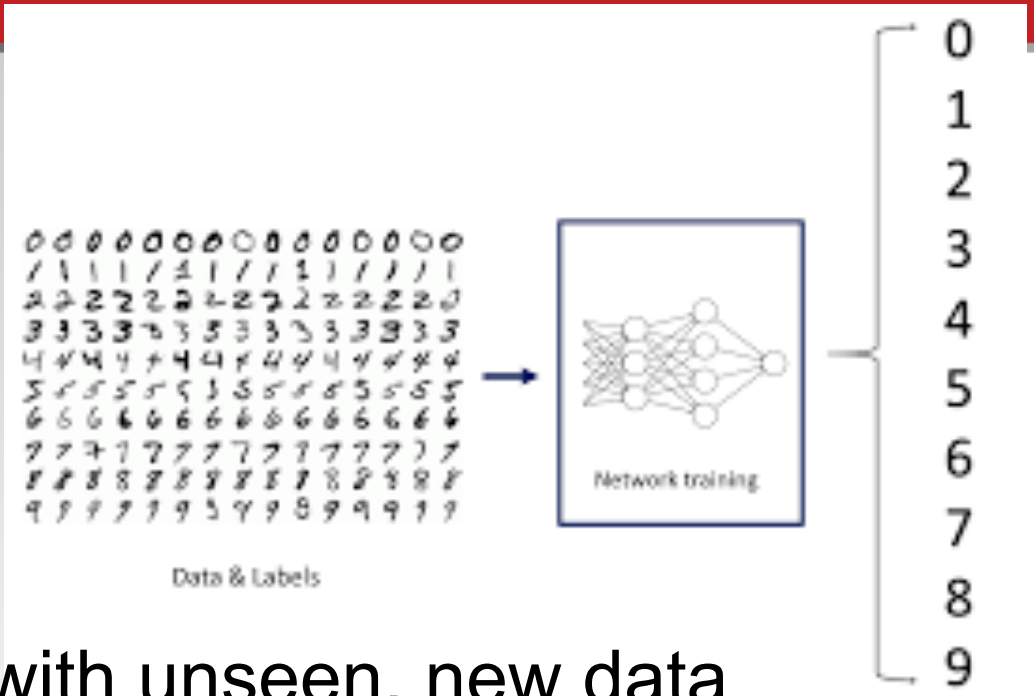


Popular press synonyms, but technically different

Deep Learning (Deep Neural Networks)

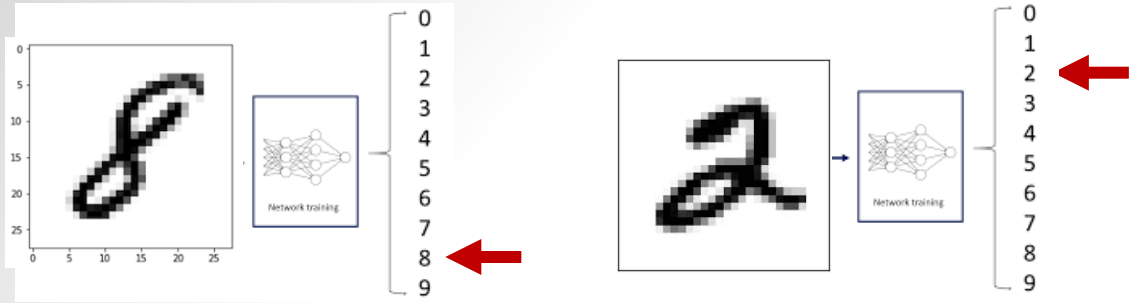
1. Training in advance

Input: example data with answers



Train network to learn correct answer as output

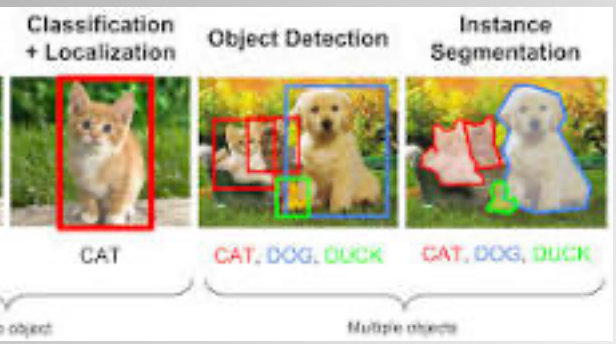
2. Inference with unseen, new data

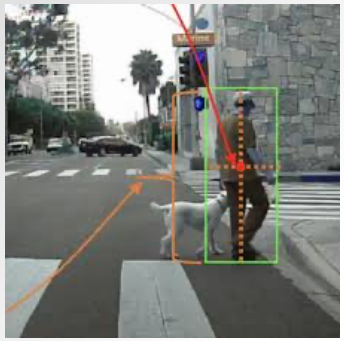


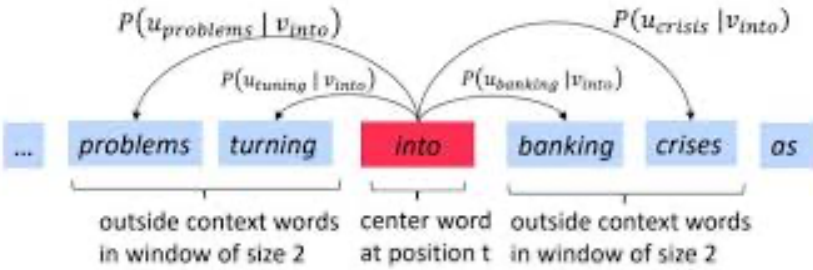
See Supervised Learning & MNIST
http://yann.lecun.com/exdb/mnist/
Compare with linear regression

AI's Deep Learning: The Good & Bad

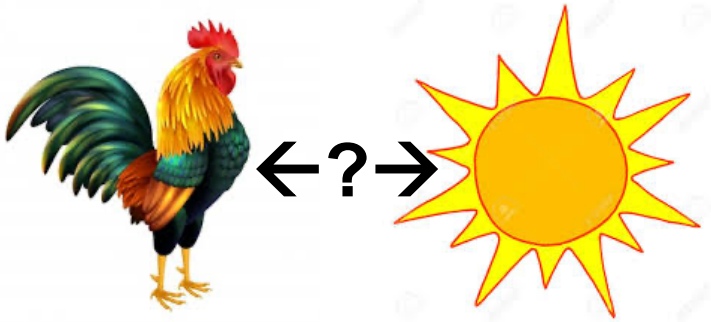
Good: Learn complex functions we can't program







Bad: Fragile, can't explain (well), counter factual



IT, AI, & the Future of Work & Society

IT & AI moving humans toward the unique/creative

CCC/AAAI AI Research Roadmap

Amazing success with learning from patterns

How to also use human-like symbolic reasoning?

https://cra.org/ccc/visioning/visioning-activities/2018-activities/artificial-intelligence-roadmap/

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Computing & Society

Today's (Classical) Computing

Computers store everything as (binary) numbers

1 Bit: ONE of  or  (a.k.a. 0 or 1)

2 Bits: ONE of four possible values: 00, 01, 10, or 11




8 bits = ONE of 256 possible values (called a "byte")

N bits = ONE of 2^N possible values

Quantum Computing Setup

What if a 2-bit number could be ALL Combinations:

with some probability

Example: 10% Tails-Tails, 35% Tails-Heads,
25% Heads-Tails, & 30% Heads-Heads

That would be ……. bizarre & counter intuitive

Quantum mechanics is bizarre & counter intuitive

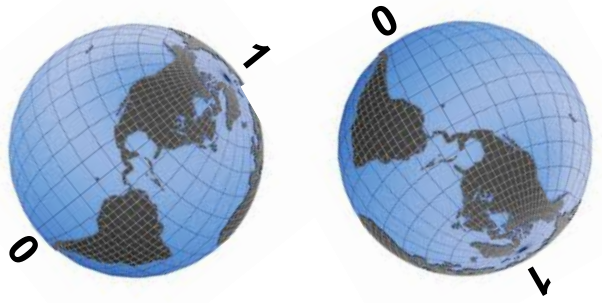
Quantum Computing: Qubits

Until looked at or “measured”

One quantum bit or qubit can be in ALL values “from” 0 to 1

Like at all latitudes & longitudes at once (with some probability)

Two qubits can be at ALL combinations latitudes & longitudes for both (with some probability)



See coherent & entangled qubits, Dirac notation & Bloch sphere

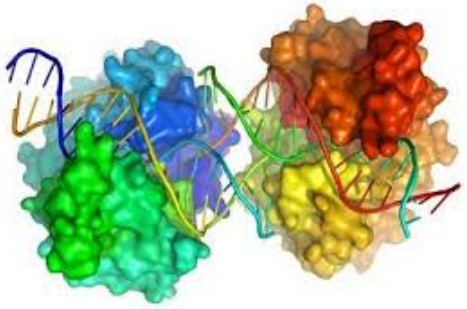
Quantum Computing: The Good

Great for hard search when easy to check answer

E-commerce depends on factoring being hard

- Example: Given 15, can you find 3*5? Yes, but:
- 1071508607186267320948425049060001810561404811705533607443750388370351051124936122493198378815695858127594672
  9175531468251871452856923140435984577574698574803934567774824230985421074605062371141877954182153046474983581
  941267398767559165543946077062914571196477686542167660429831652624386837205668069375

To be great for hard searches for chemicals/materials



Quantum Computing: The Bad

Useful solutions are likely 10-20 years away

Cold: < −459.68°F
= 0.01°K

Small: # qubits
2006: 12
2019: 53

Not reliable: correcting errors expensive (7x,49x,...)

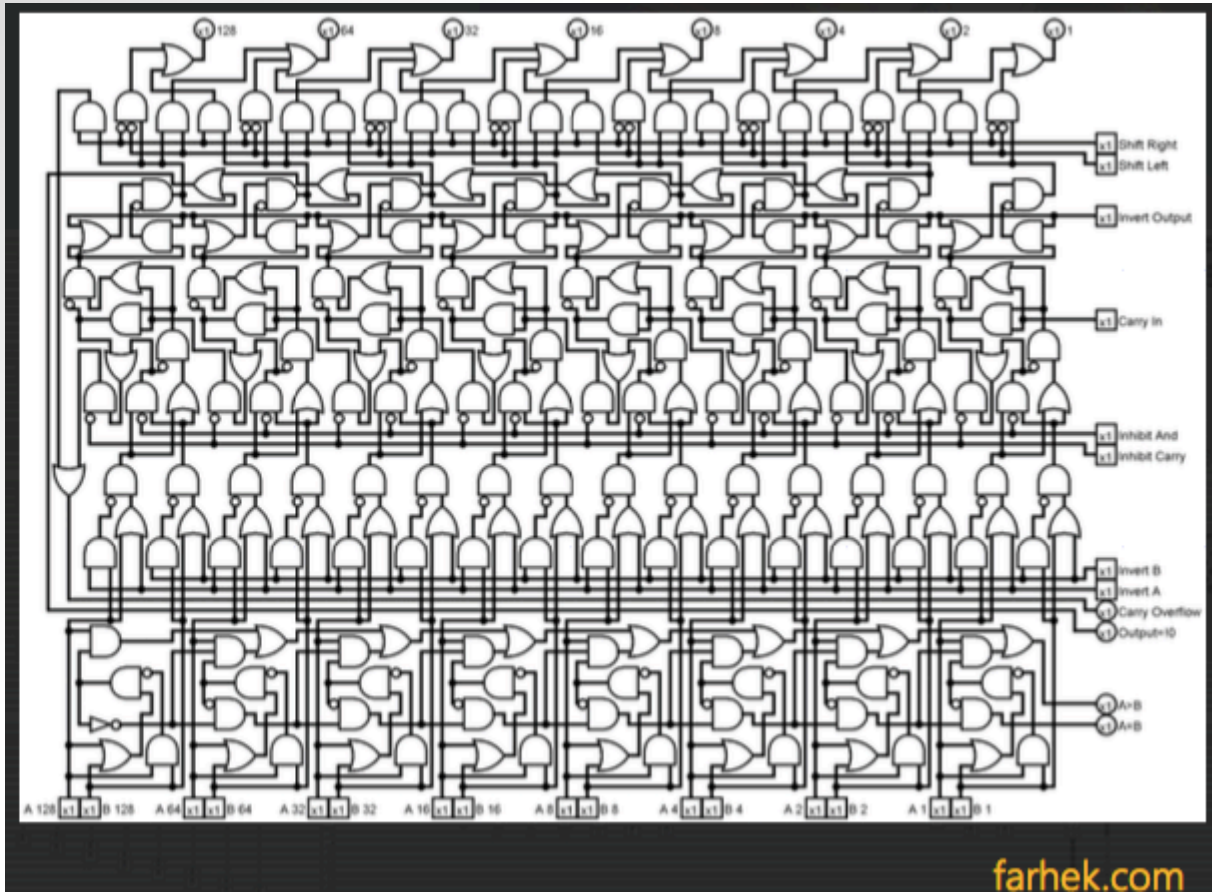
Programming/debugging: next slide

Making Quantum Computer Programming More Accessible

Programming quantum comp. somewhat like specifying 1940s hardware

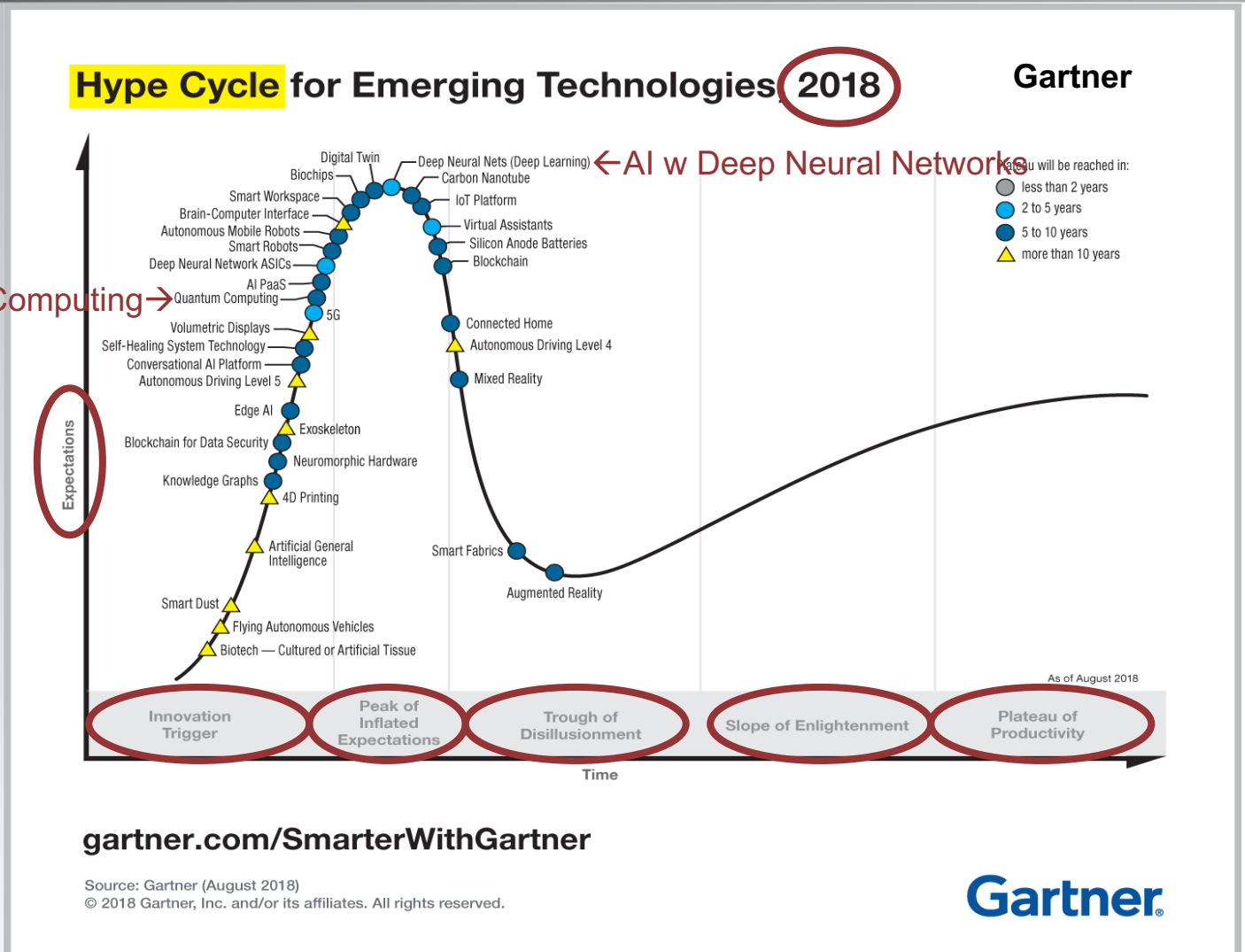
Want more accessible:

A + B (8 bits)



See https://cra.org/ccc/events/quantum-computing/

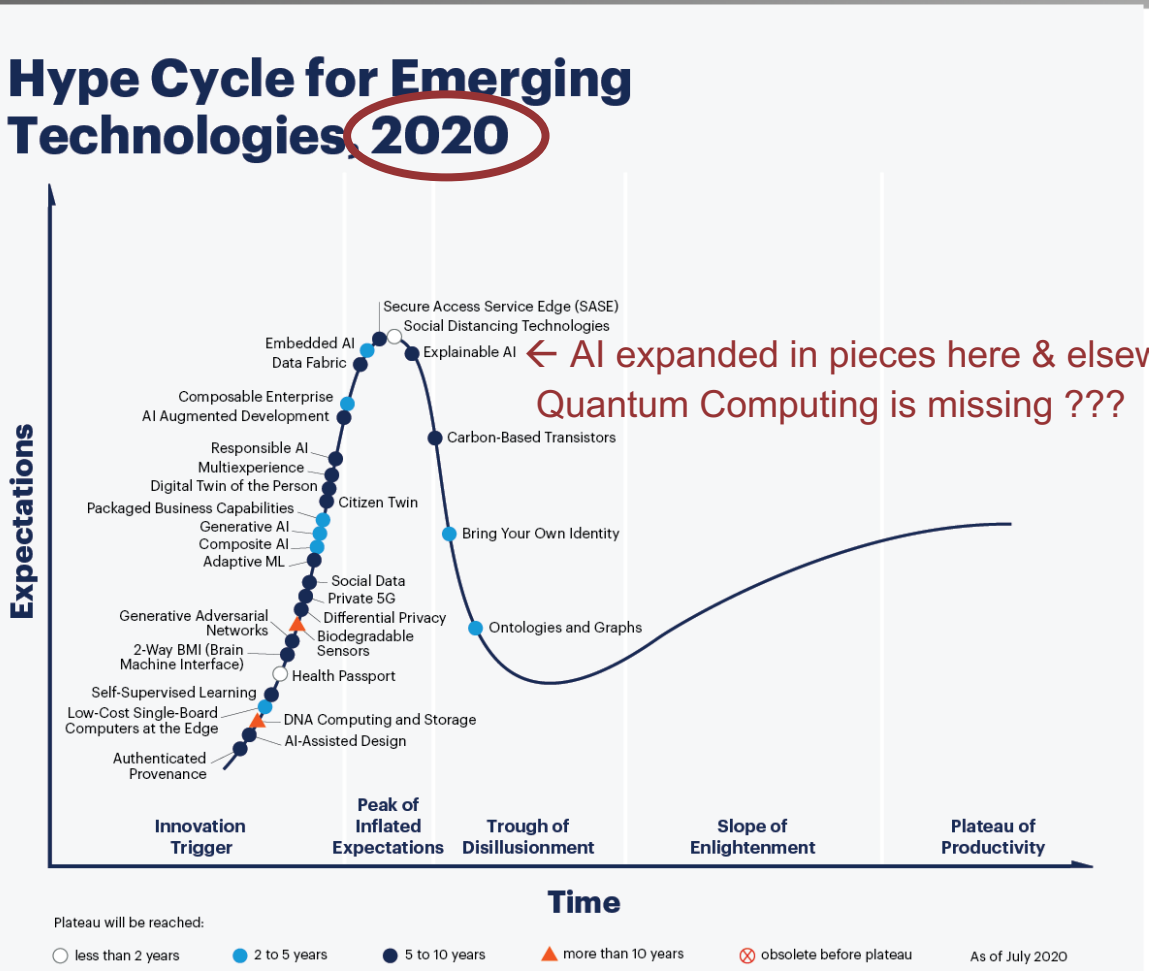
Gartner Hype Cycle 2018



←AI w Deep Neural Networks

Quantum Computing→

Gartner Hype Cycle 2020



← AI expanded in pieces here & elsewhere

Quantum Computing is missing ???

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Computing & Society ← ← ←

→ Computing amoral; humans moral & immoral

Computing & Society: Questions

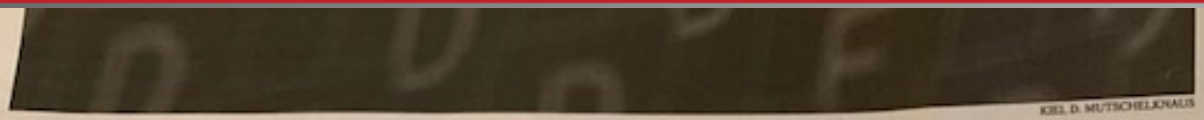
Use computing for:

- Better solar panels
- More efficient supply chains
- Remote communication

Use computing for:

- Facial recognition of terrorists or citizens?
- Recommending movie or surgery?
- Predicting human behavior?
  Example: after parole, return to prison or not?

In the News: New York Times, 9/9/2020



KIEL D. MUTSCHELKNAUS

When Algorithms Do the Grading

Meredith Broussard

ISABEL CASTAÑEDA'S first words were in Spanish. She spends every summer with relatives in Mexico. She speaks Spanish with her family at home. When her school, Westminster High in Colorado, closed for the pandemic in March, her Spanish literature class had just finished analyzing an entire novel in translation, Albert Camus's "The Plague." She got a 5 out of 5 on her Advanced Placement Spanish exam last year, following two straight years of A+ grades in Spanish class.

And yet, she failed her International Baccalaureate Spanish exam this year.

When she got her final results, Ms. Castañeda was shocked. "Everybody believed that I was going to score very high," she told me. "Then, the scores came back and I didn't even score a passing grade. I scored well *below* passing."

How did this happen? An algorithm assigned a grade to Ms. Castañeda and 160,000 other students. The International Baccalaureate — a global program that awards a prestigious diploma to students in addition to the one they receive from their high schools — canceled its usual in-person final exams because of the pandemic. Instead, it used an algorithm to "predict" students' grades, based on an array of student information, including teacher-estimated grades and past performance by students in each school.

Ms. Castañeda was not alone — tens of thousands of International Baccalaureate students protested their computer-assigned grades online and in person. High-achieving, low-income students were hit particularly hard: Many took the exams expecting to earn college credit with their scores and save thousands of dollars on tuition.

Nor was the International Baccalaureate the only organization to use a computer program to assign students grades amid the pandemic. Britain's in-person A-level exams, which help determine which universities students go to, were also canceled and replaced with grades by algorithm. Only after an uproar did the government change course, though many students were left in limbo without university admission.

The lesson from these debacles is clear: Algorithms should not be used to assign student grades. And we should think much more critically about algorithmic decision-making overall, especially in education. The pandemic makes it tempting to imagine that social institutions like school can be replaced by technological solutions. They can't.

The bureaucrats who decided to use a computer to assign grades are guilty of a bias I call technochauvinism: the idea that technological solutions are superior. It's usually accompanied by equally bogus notions like "Computers make neutral decisions"and "Computers are objective because their decisions are based on math."

Computers are excellent at doing math, but education is not math — it's a social system. And algorithmic systems repeatedly fail at making social decisions. Algorithms can't monitor or detect hate speech, they can't replace social workers in public assistance programs, they can't predict crime, they can't determine which job applicants are more suited than others, they can't do effective facial recognition, and they can't grade essays or replace teachers.

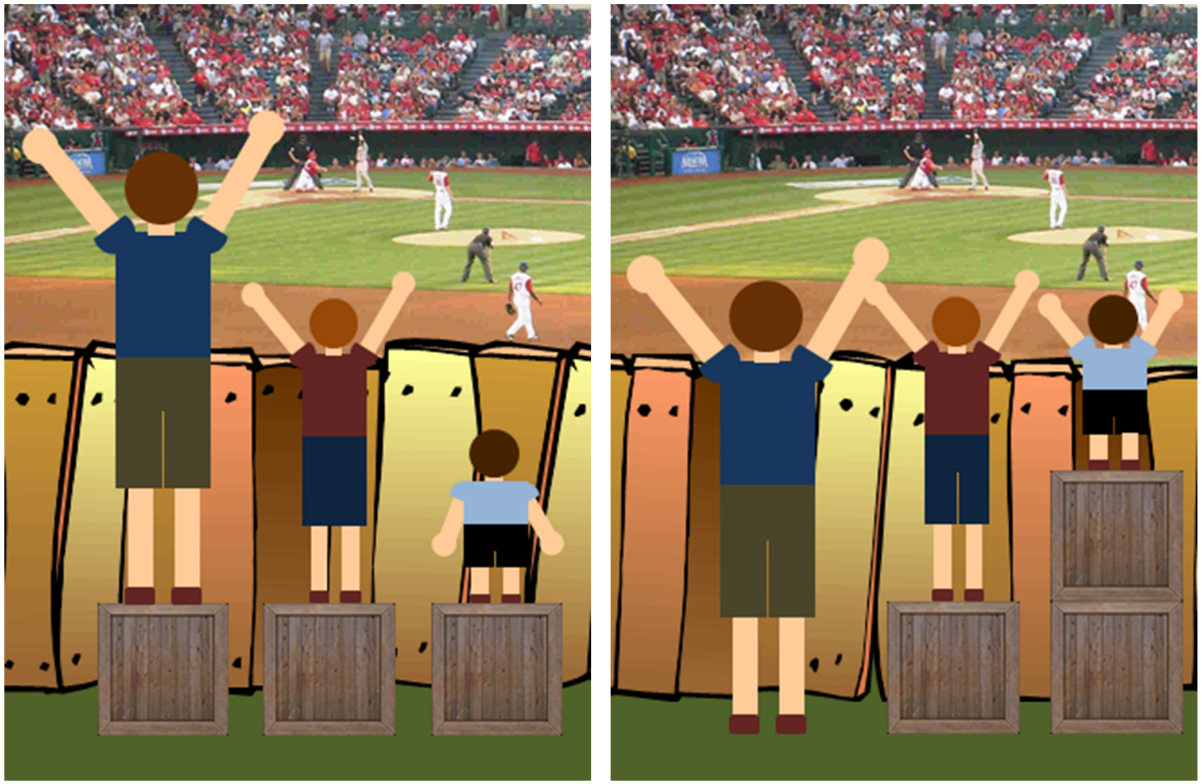
In the case of the International Baccalaureate program, grades could have been assigned based on the sample materials that students had already submitted by the time schools shut down. Instead, the organization decided to use an algorithm, which probably seemed like it would be cheaper and easier.

The process worked like this: Data sci-

Computing for Societal Issues Hard: Fairness as Example

Which is FAIR?

In education, employment, accessibly?



A start: https://cra.org/ccc/events/economics-and-fairness/

Computing & Society: Fairness

Automatic credit scoring, etc., half century old

What's new?

Scale: Err a million times rather than several

Ubiquity: Credit score used beyond original purpose

Accountability: Who explains or takes appeals?

More questions than answers:

- How to consider factors a person can/cannot control?
- What to do when training data has unfair bias?
- How to best make computing a tool for human deciders?

Computing & Society: Forward

Computing professionals should

- Incorporate ethics & other viewpoints
  - Learn themselves & work with other disciplines
- Build in computing mechanisms to implement policies
  - E.g., implementing EU's policy "right to be forgotten"
- Be a resource for citizens & government

Society must remember that computers are amoral:
lacking a moral sense; unconcerned with the rightness or wrongness

We humans should aspire to be moral, not immoral, with computing as a tool; Shall we?

Some Quotes

All computers do is fetch and shuffle numbers, but they do it fast enough that the results appear to be magic. –Steve Jobs, Apple Founder

I think, therefore I am. –Descartes

God does not play dice. –Einstein re quantum physics

Any sufficiently advanced technology is indistinguishable from magic. –Arthur C. Clarke

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Q & A time

1. Press Chat ↓ 2. Enter Question

Some Questions

1. What are issues in protecting the national power grid against cyberattacks?
2. What are emerging opportunities for “hackers?”
3. Is the USA the leader in Artificial Intelligence?
4. Will quantum computing replace my computer?
5. Does computing make misinformation, disinformation, or propaganda worse?