Mersivity 2023

Conference / Symposium
Mersivity.com
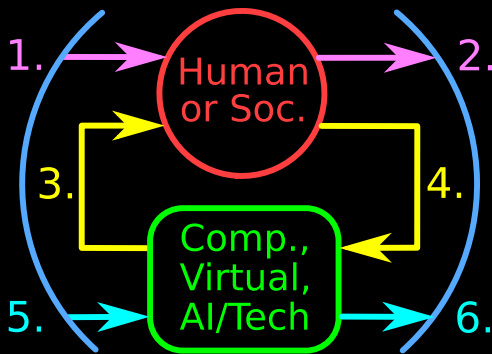
25th Annual Symposium, University of Toronto, MC102, December 14th

Sustainable Social Technology
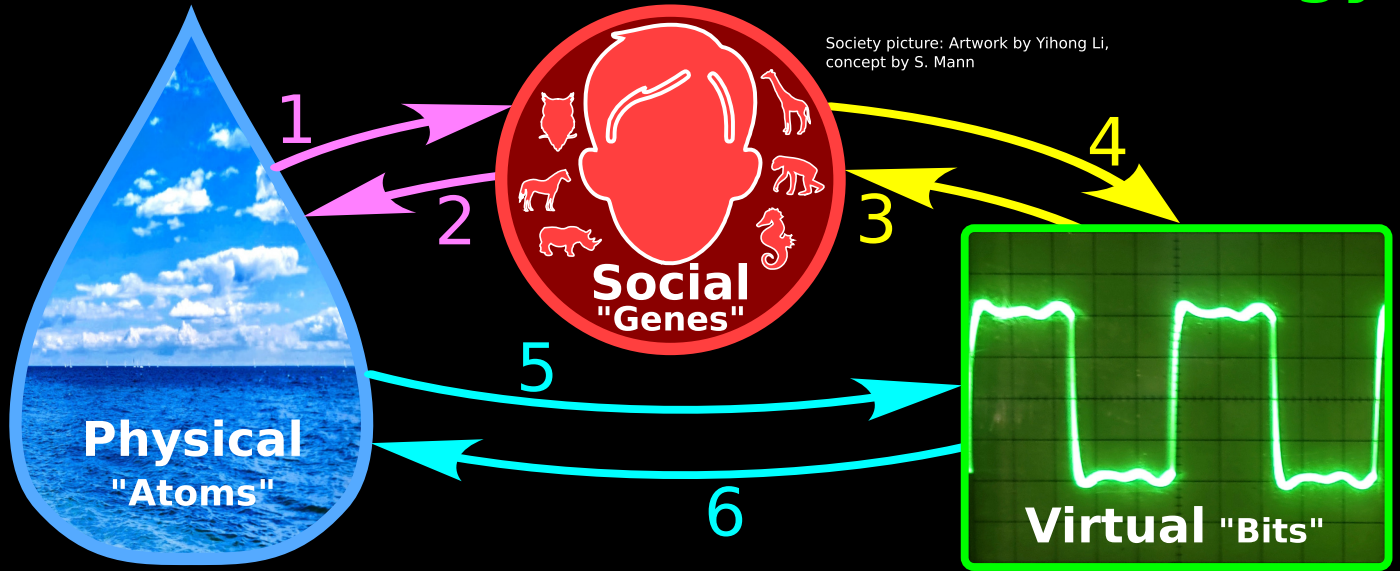
Society picture: Artwork by Yihong Li, concept by S. Mann

1

2

Social "Genes"

4

3

5

Physical "Atoms"

6

Virtual "Bits"

1.

Human or Soc.

2.

3.

4.

Comp., Virtual, AI/Tech

5.

6.

Proc. IEEE, 86(11), Nov. '98, p. 2126

Wearable AI or Smart Car.

1.

2.

3.

4.

5.

6.

Mersivity advances technology that is:

1. **Unmonopolizing** so we can sense our surroundings;
2. **Unrestrictive** so we can walk, hike, swim, socialize;
3. **Observable** so we can sense and understand it (alethia);.
4. **Controllable** so it serves us, not enslaves us;
5. **Attentive** to its environment... situational awareness;
6. **Communicative** to others around us... expressive.

Mersivity / WaterHCI 2023 Dec. 14 Symposium Schedule

(Superhumachines presenters from ECE1724)

Mersivity-2023 Schedule

- 12noon Introductory remarks, and Land + Water Acknowledgement, Meric Gertler, President of University of Toronto.

- 12:10pm, Tom Furness ("Grandfather of Virtual Reality"), Avi Bar-Zeev (co-inventor of Microsoft Hololens), and Steve Mann ("The Father of Wearable Technologies"), "Spatial Computing and Virtual Worlds for Sustainable Society"

- 1pm Mei Lin Fung, Founder, with Vint Cerf, People Centered Internet, Chair IEEE SSIT Sustainability Tech Cttee, "A. I. for Sustainable Society: Adaptive Intelligence for People and Planet"

- 1:30pm Jeff Archbold, Mete Isiksalan, and Steve Mann: "Freehicles: Vehicles and Veyances for freedom of mobility that reconfigure themselves for land, water, or air"
- 1:50pm Akarsh Aurora, Akash Anand, Massachusetts Institute of Technology CSAIL, "Autoregressively decoding EEG brain responses on a conditional language model prior"

- 2:10pm Perry Toone, "Freesource / Freecode for Mersivity"

- 2:30pm Reid Godshaw, "Chat GPT and DALL·E 3: How to Create Generative A.I. Imagery for Sustainable Activism"

- 2:55pm Anita Krajnc, "Plant Based Treaty's Safe and Just report provides framework for planet in peril"

(presented at 2023 United Nations Climate Change Conference)

- 3:20 to 4pm, mid-symposium food break
- 4pm-4:20 Ed Hore, Lawyer and Founder, Waterfront for All

- 4:30pm Mike Shoreman, "Technology, Humans, and Water" (a link)

- 5:00pm - 5:40pm Ajay Agrawal, "Prediction, Judgment, and Mersivity: Towards Intelligent Systems for All People and Our Planet"

- 5:40-6:10 Ryan Janzen, "Part 1: Advancing Transportation for Sustainable Society"

- 6:10pm Superhumachines team 1: "Heaven-Met" smart bike helmet

(rehearsal picture, Dec. 7th)

- 6:35pm Superhumachines team 2: "Sensing and machine learning lucid-dream states using Muse-S sleep band"

(rehearsal picture, Dec. 7th)

- 7pm Superhumachines Team 3: "EMG-controlled wheelchair with SWIM-based biofeedback"
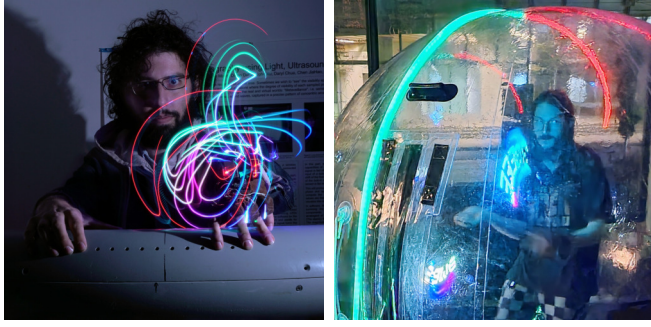
(rehearsal picture, Dec. 7th)

- 7:25pm Josh Matlow (confirmed) and Olivia Chow (to be confirmed), "Mersivity in the City..."

- 8pm Kyle Simmons and Kelson Rumak: Continuous interpersonal body and environment connection: Bridging distance using wearable humanistic intelligence.

See also our previous (now past) Summer Symposium (August Symposium) Schedule.

Sustainable Technology Society

Steve Mann, Tom Furness, Avi Bar-Zeev, Ajay Agrawal, Ryan Janzen, Mike Shoreman, Ed Hore, Akarsh Aurora, Akash Anand, Stefan Mozar, Chirag Desai, Jeff Archbold, Mete Isiksalan, John Giorshev, Stephanie Mann, Jackleen Atallah, Zhengyu Cai, Houfu Chen, Yiran Chen, Zijie Chen, Qiaosong Deng, Jiatong Han, Hongyuan Hua, Xinyu Huang, Yihong Li, Yuming Li, Yingshun Lu, Renze Luo, Zifan Meng, Gavin Mok, Xuwen Shuai, Qian Tang, Wayne Yuan Tian II, Hongliang Wang, Tracy Wang, Minghu Wei, Josh Wu, Xin Xia, Wenshuo Xu, Shuqi Yang, Songyu Yang, Zhiwen Yang, Zhuofan Yang, Hengjia Zhang, Bryan Zhu, Perry Toone*

Abstract

We propose a bold new initiative, **Technology for Society and Sustainability**, *at the intersection of: (1) Sustainability / environment / Earth / universe / nature (physical reality, i.e. "Atoms"); (2) Technology / computation / virtuality ("Bits" in the wider Claude Shannon sense that includes analog as well as digital information storage, communication, control systems, etc.); and (3) Society (humanity, the human race, and other races/species), including social constructs such as governance, law, privacy, security, trust, etc. ("Genes"). Specifically, we regard technology as a "container" that encloses us. Obvious examples include wearable technologies like clothes, wearable computers, vehicles, vessels, buildings, and cities. Such technologies define an inside and an outside. The outside is called the "environment" (our surroundings). Conversely we refer to the inside as the "invironment", and the technology therebetween as the "vironment". This gives rise to "vironmentalism", a new philosophy that examines the extent to which technology can isolate us from our environment, or help connect us to our environment. The aim of the latter is what we call the "Sustainable Technology Society".*
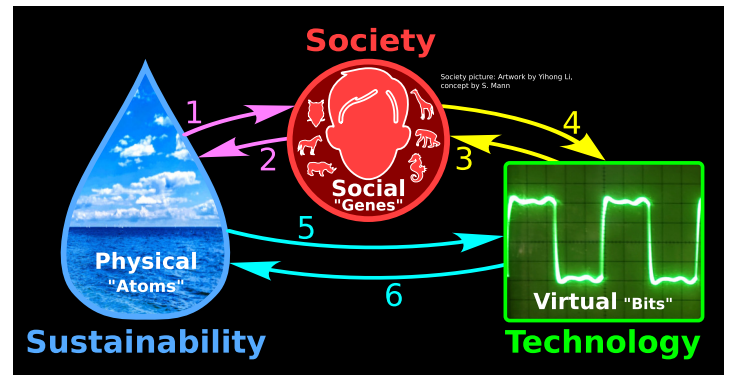
Figure 1. The interaction between us, our technologies, and our environment can be thought of in terms of six fundamental connections [1, 2].

1. Mersivity (Vironmentalism)

Our biggest technological challenges today are at the nexus of sustainability and society, e.g. access to fresh clean water, clean air, food supply, sanitation, privacy, security, trust, and the ability to understand and control technology.

Mersivity is technology that facilitates six important connections, shown in the illustration of Fig. 1, where the blue Mochoid-shape ("drop" shape) represents Sustainability/environment (earth, water, air, etc.), the green "box" represents Technology (computer, cyber, virtual, etc.), and the red circle represents Society/humanity/human/person/being.

A metaphorical "teardrop" or dripping-faucet water droplet shape is easily associated with sustainability. The shape used in Fig 1 was actually generated by

a string/cord/rope dangling onto a motorized turntable rotating at the approximate speed of a record player (Fig 2).

Consider the first two connections. These are the connections from the environment to each of us, and from each of us to the environment. As an example, consider our most basic input needs: food, clean water, and fresh air, and our most basic output needs, i.e. access to sanitation facilities, as illustrated in Fig 3.

Two of the most pressing technological challenges we face are a connection to (1) a supply of clean food, water, and air, to meet our input needs and (2) sanitation facilities to meet our output (e.g. waste) needs.

Thus technology should serve as a facilitator of the natural ecosystems in which we live, e.g. access to nature and the natural world, food, clean water, fresh air, exercise, etc., and also "nature's call".

But the connections between us and our environment and between our environment and us also extend into the virtual world. Today's technologies often make us (1) less aware of our surroundings, and (2) encumber us with bad user-interface designs.

To combat this problem, technology must be:

- Unmonopolizing of our attention, i.e. it must not block out the world around us. It should not make us turn our back on nature;

- Unrestrictive, i.e. it must not block us from the world around us. It must not prevent us from going for a hike or a swim.

Ideally technology should allow us to touch and be touched by nature, and our surroundings (including other people). In this way technology should facilitate this "two-way-street" to/from nature and more generally it should connect us to/from our surroundings which of course also includes other people.

The above diagrams are conceptual simplifications, because in reality, our surroundings are all around us, and we live and exist within (inside of) our surroundings, so it might look more like the situation depicted in Fig 4.

In order for technology to serve us and our environment, it must, in addition to the two properties outlined already, also be (3) Observable, and (4) Controllable. Our relationship with technology is a closed-loop feedback process, as shown in Fig 5.

For this to work properly, we must be able to observe, sense, and understand the technological universe around us. Today's technologies often sense us, watch us, or place us under surveillance, but the technologies are often not understandable or comprehensible. This can create a distopian surveillance society of runaway AI that is not accoutable to us. Therefore we must design technology as a closed-loop system where surveillance (oversight) is balanced by sousveillance (undersight) [3–11]. The word "sousveillance" is relatively new, having appeared in OED (Oxford English Dictionary) June 2021.

Well-designed technology functions as if it were a true extension of our own mind and body. Just like in the human body, where there are both efferent and afferent nerve connections [12], the human-technology interacation must also be a "two-way-street". Thus technology should not just be surveillance, but, rather, it should be a closed-loop feedback system.

This feedback loop of course occurs within the environment (our surroundings). For example, a human (red circle) and computer (green rectangle) both exist inside the blue drop, as shown in Fig 6.

There are two other very important connections. Technology can and does, and should be able to sense and affect its environment. This ability for technology to sense and affect our surroundings is captured in connections 5 and 6, as shown in Fig 7. Thus we see that there are six fundamental connections to be maintained, enhanced, and preserved.

We thus wish to advance technology for both people and planet, by preserving and enhancing the six connections to/from the technology, the people, and the planet.

Most of the problems we face today occur because of technologies that break or fail to create one of these six important connections.

The six fundamental properties of technology that we see as important for it to serve us and our environment are that it be:

1. **Unmonopolizing** so we can sense our surroundings;

2. **Unrestrictive** so we can walk, hike, swim, socialize;

3. **Observable** so we can sense and understand it (alethia = unconcealedness);

4. **Controllable** so it serves us, not enslaves us;

5. **Attentive** to its environment... situational awareness;

6. **Communicative** to others around us... expressive.
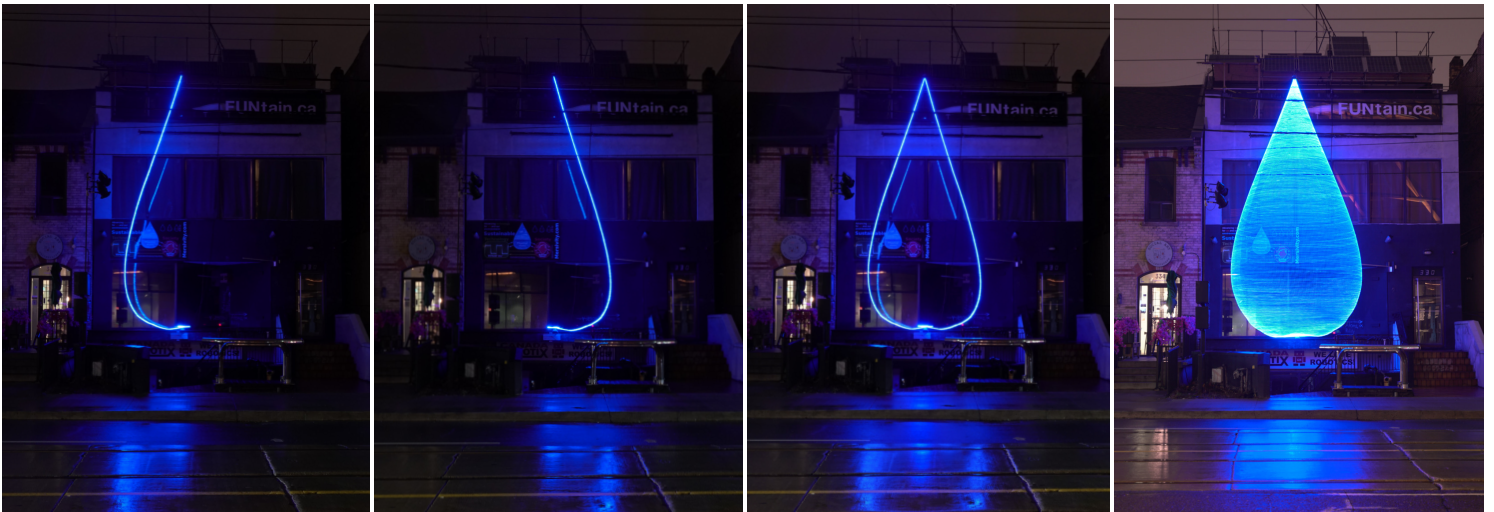
| Cord at leftmost extreme of the fundamental mode. | Cord at rightmost extreme of the fundamental mode. | Double exposure: **Mochord** shape. | Slow shutter: **Mochoid** shape. |

Figure 2. Mochord is a rotating (often motorized) stringed musical instrument (chordophone) invented by author S. Mann in the 1960s and 1970s. At larger scales it also functions well as a visual sculpture or art installation. Here a giant version of it is made from a string (of lights) dangling onto a motorized turntable. The interplay between gravity, centrifugal effects, and tension in the string creates various shapes, of which we use the fundamental mode to symbolize sustainability, the environment, and the physical world: Mochord as in the word "motor" (abbreviated to 2 letters as in other words like "motel" = motor hotel), and "chord", from the Ancient Greek word χορδό = chordó = cord = χορδόνι = kordóni, or χορδή = chordí = string. Mochoid as in "ellipsoid" or "catenoid". String is 10m long, 36 pixels/m, ρ=94.5g/m. Turntable is 25ft straight down from top.
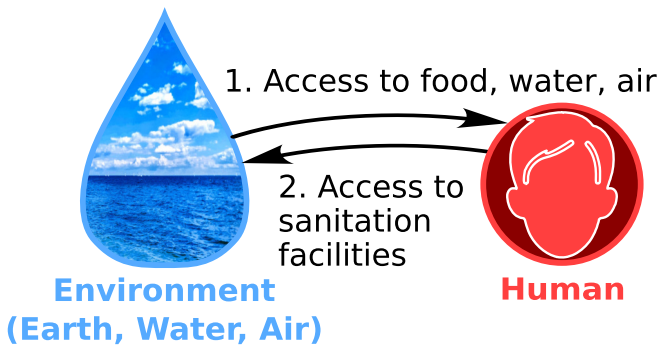

Figure 3. There is a closed-loop feedback system formed by us and our environment.

To really understand the 6th property, we need to realize that we're part of each others' environment. You're part of your friend's environment and your friend is part of your environment.

Technologies of Mersivity often exist as "wearables" or other devices like self-driving cars where the technology surrounds or encapsulates us, so we have the human (red circle) inside the green rectangle, as with Fig 4, where technology is a new layer between us and our environment, as shown in Fig 8. As an ASCII-art version of Fig 8, consider the following: ([O])™
which may assume the color-coding scheme as:
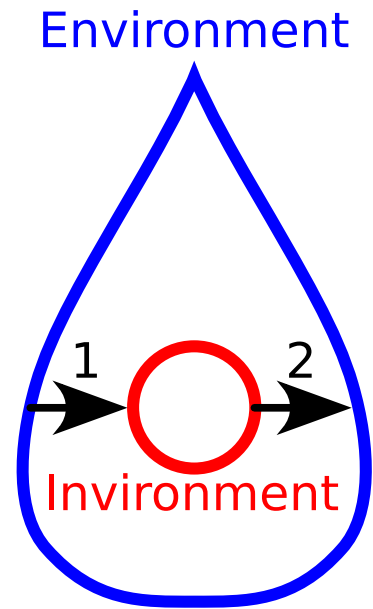
([O])

Figure 4. We live within our environment, so the situation of Fig 3 might be better understood as shown here where the Environment is our surroundings, and the "Invironment" is each of us. We each have or are our own Invironment.

(Note that as computers get smaller they can even be implanted inside of us so we could also have the green rectangle inside the red circle.)

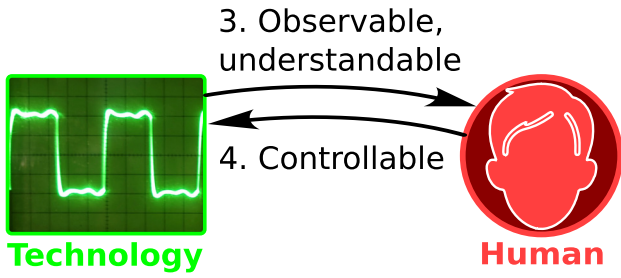Mersivity is our symbiosis with technology and our

Figure 5. Our interaction with our technologies works best when the technology is Observable (and understandable), as well as Controllable.
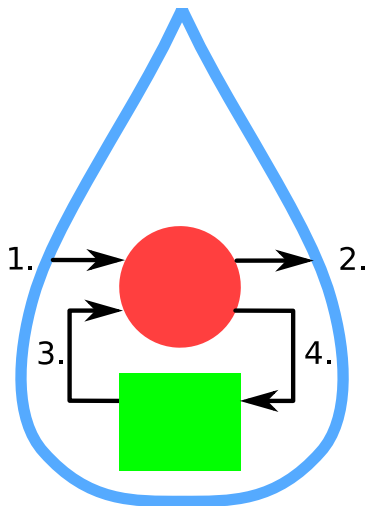

Figure 6. Our interaction with our technologies takes place inside of our environment. Ideally the technology will enhance, or at least not block or impede our ability to interact with our environment, i.e. to both sense and affect our environment.
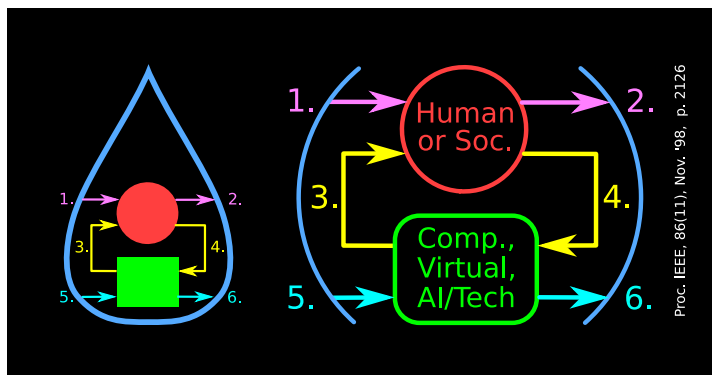

Figure 7. The six connections between us, our environment, and our technology.

surrounding environment. It embodies the above six connections. It helps us: 1. touch and 2. be touched by Earth, water, air (our environment), helping us to 3. sense and 4. control technology that is itself 5. in-touch
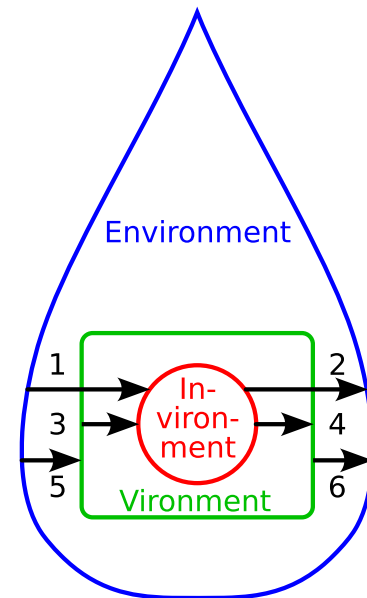

Figure 8. Concentricity of Mersivity: We're surrounded by technology[] which is itself surrounded by the environment(), i.e. in ASCII-art, denoted "([O])".

with, and 6. touches upon the environment.

Many technologies fail in making one or more of these six fundamental connections. The aim of the Sustainable Technology Society (Mersivity) is to ensure that technology evolves to sustain all six of these important connections.

2. 'Mersive technologies

Our technologies are becoming more and more ubiquitous, and more and more immersive. Technology like clothes, vessels, and vehicles encapsulates us and becomes part of us in our manner of thought as we internalize technology. In the marina, when there is a collision or allision, one captain will yell to the other "You hit me", not "Your boat hit my boat", just as among pedestrians we would not expect someone to say "Your shirt hit my shirt".

Technology that immerses us, but disconnects us from our surroundings, is harmful to both us and our surroundings (environment). This harm goes beyond pollution and other direct harm, but also harm in the sense that if we disconnect from nature, earth, water, etc., we turn our back on earth, water, etc..

Mersivity is technology that's reciprocally immersive and submersive for ethical inclusivity, creating a bridge between us ("invironment") and the world around us (environment).

Mersivity is immersive and submersive, e.g. it can immerse us (like fully immersive virtual reality) and it

can be immersed / submersed by us (one can dunk it in the water or go swimming or hiking with it and it won't suddenly stop working when it gets dunked in sea water).

If one can't go swimming or hike through a forest with a piece of technology, the technology could be out-of-tune with nature or distract us from nature. Technology that is not in-tune with nature encumbers us and imprisons us in a world that is divorced from nature. Wearing it or carrying it makes us hesitant to jump into the lake or venture into the wilderness with it, for fear it will be damaged (or lost or stolen if we leave it sitting on the shore or ground). And when we can't swim in the lake, we turn our back on the lake, and lose an important opportunity to be stewards of our supply of freshwater. Water is the "new oil", our most valuable resource. Thus we see Mersivity as a mandate for technology in service of both society and the environment (nature).

3. Inclusivity of other species

Mersivity is about inclusivity, such as the right of a person with a disability to modify the technology to accommodate their disability. This right often requires alethia (unconcealedness) so that the technology can be understood. This right also often requires control over the technology, i.e. the right to modify and run the modified aspects of the technology, as per the principles of the Free Software Foundation, and other similar efforts such as Right to Repair.

Moreover, we may apply this principles across various species not just humans. For example, birds are makers as they make nests from found objects in their environment. As members of the "maker community" they build their homes (bird's nests) which thus form vironments. In this way birds are vironmentalists. See Fig 9.

4. Mersivity as a Venn Diagram

Consider the following three overlapping spheres or circles, as illustrated in Fig 10 and 11:

α Nature, the environment, the universe, etc., as symbolized by planet Earth in Fig 10. The word "physics" is a Greek word meaning "natural things" or "nature". Indeed, the world's most prestigious scientific publication, *Nature magazine*, concentrates on physics. Thus Nature in Fig 10 also embodies physics and physical reality. It is also denoted "Atoms", which is also a Greek

Figure 9. Birds are "makers" and vironmentalists in the sense that they build their homes (nests) from found objects, such as to create a vironment that encloses or partially encloses them will still allowing them to connect to their environment. We can apply our conceptual framework to many different kinds of technologies among many species, not just humans. In this way Mersivity is inclusive.

word, and the word, in its Greek spelling, $\alpha\tau o\mu o\varsigma$, starts with the the first letter of the Greek alphabet, α;

β Technology, computation, virtuality, VR (Virtual Reality), etc., denoted by the (traditionally round) cathode-ray tube of a cathode-ray oscilloscope with its characteristic green glow (Fig 12). It is also denoted "Bits" which we use in the wider Claude Shannon sense that includes analog as well as digital information storage, communication, control systems, etc., which we shall abbreviate using the second letter of the Greek "alphabit" (alphabet), β;

γ Society, ranging from genome, to an entire human (or other species) body, to groups of humans (or other species), society, governance, security, trust, arts, philosophy, etc., represented in Fig10 as Leonardo da Vinci's 1487 drawing of the human body inside a circle. This circle is denoted in reddish hues which is the color of hemoglobin in human blood that runs through vessels throughout the human body, or the bodies of other species. We de-

Figure 10. The 3 spheres or circles of **Technology** for **Society** and the **Environment**. This is a departure from traditional HCI (Human-Computer Interaction) which only looks at the Human and Computer, e.g. the IEEE's tagline is "Advancing Technology for Humanity". We wish to consider a broader mission "Advancing Technology for Sustaiable Society", i.e. from "Humanity" to "Society" (inclusive of other races/species beyond the human race, as well as including "Sustainability" (i.e. the environment).
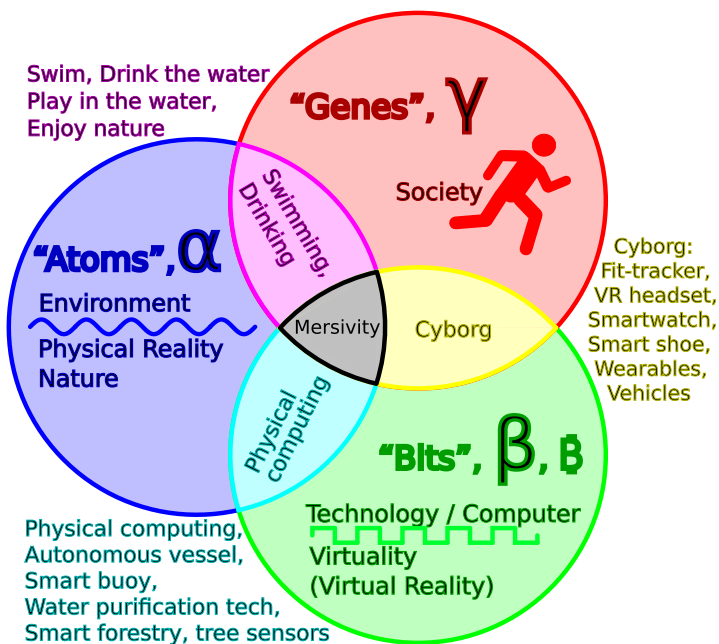
Figure 11. Venn diagram with the 3 circles of Fig 10.

note this circle as "Genes", analogous to "Atoms" and "Bits". The word "Genes" is also of Greek ori-

gin, and, in its ancient Greek spelling, $\gamma\epsilon\nu\epsilon\alpha$, begins with the third letter of the Greek alphabet, γ.

Thus we have, as labels, the first three letters of the Greek alphabet, α, β, and γ, for Atoms (Environment), Bits (Technology), and Genes (Society), respectively. This development follows closely that used in the field of WaterHCI (Water-Human-Computer Interaction), where "Water" is broadened to "Earth, Water, Air, ..." [13, 14].

4.1. Caveat: Humans are part of nature and so is tech.

Before proceeding further we must of course point out that technology and humans are made of atoms, i.e. are in some sense physical. Even software can't exist without hardware of some kind and therefore the three circles labeled α, β, and γ must be regarded as layers of abstraction. Once we can accept this layer of abstraction, we will find great utility in this model as it gives rise to a taxonomy, ontology, and classification system that brings order and structure to an otherwise complicated world of new technologies.
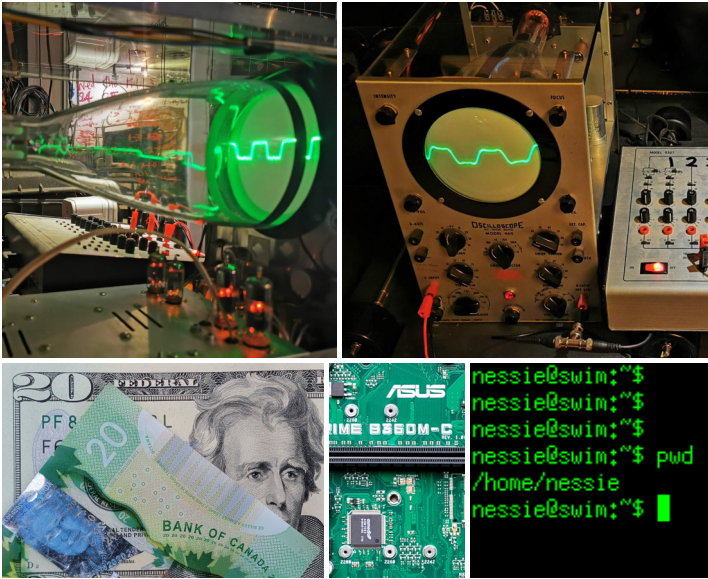
Figure 12. The green circle represents technology, inspired by the green glow of the CRT (cathode-ray tube) oscilloscope. Green is also the color of many other technologies like currency, circuit board, and video display terminals [13, 14].

If nothing else, this research paper will help us ask deeply fundamental questions such as "What is reality?" and "What is human?". For example much of our environment is human-built using our technologies, e.g. the classroom-environment, office environment, the home-environment, nature trails, and even some forests, lakes, and rivers are human-made, or at the very least, human-influenced.

Thus there is a lot of overlap or "grey area" between these three circles, and this overlap is intentionally the topic of much discussion, thought, research, and practice.

Moreover, in addition to the human race, there are other races, i.e. other species, and we must of course consider more broadly "society" as a collection of various beings.

4.2. Venn diagram of Technology for Society and the Environment

The three overlapping circles of Fig 11 form a Venn diagram, allowing us to easily refer to the seven different regions denoted in Fig 11.

$(\alpha - \gamma)$ Consider first the human-nature interaction, e.g. a human interacts with the surroundings (environment). Consider for example water, which can envelop the human (e.g. jumping into a lake or other body of water for a swim), or the human can envelop the water (e.g. drinking the water). This area of overlap is denoted by the magenta-colored region of overlap between the red

and blue circles. Examples include swimming, drinking, and otherwise immersing ourselves in our environment, and interacting with nature in various ways.

$(\alpha - \beta)$ Next consider the interaction between nature / physics / environment (α) and technology (β), which is the cyan-colored region of overlap between the blue and green circles. Examples include "physical computing" and the digitization and computerization of physical quantities. Another example includes water purification technologies, or smart forests with tree-sensing technologies.

$(\gamma - \beta)$ Finally, consider the interaction between a human and technology. Fields of research such as HCI (Human-Computer Interaction), HMI (Human-Machine Interaction), and HMC (Human-Machine Communication) [15]. Examples include the smartwatch, VR (Virtual Reality) headset, fitness tracker, smart shoes, and other "wearables" (wearable computers), as well as vehicles that the human can enter. Wearable technologies can envelop the human as fully immersive VR or as vehicles or even a spacesuit that fully encloses the human, as shown in Fig 13. Here we see technologies such as a vessel that contains and partially encloses a human user, or technologies like the air-tight waterball (a popular children's toy found at amusement parks), or the air-tight spacesuit that fully enclose the human. The latter two examples provide a very well-defined boundary between the environment (that which surrounds us) and us ourselves.

We also designed the Mersivity Ball which is an instrumented waterball having various sensors (position, orientation, etc.) together with a S.W.I.M. (Sequential Wave Imprinting Machine) as a 3D volumetric display for the sensors in the ball as well as other data like a brain-sensing headband (Muse-S). See Fig 14.

More generally, though, we may have a continuum between the environment, and the part of us we understand as ourselves, and the boundary may become fuzzy or imprecise. Additionally we may have layers, e.g. our clothes are vironments that may exist inside other vironments like vehicles which might exist inside other vironments like a ferry that carries cars across a body of water.

5. Three-Dimensional Mersivity Model

Here we consider Mersivity as a 3-D (3-dimensional) model where the physical world α, the virtual world β, and the social world γ each form one of the three axes, as previously proposed in [16, 17]. The Greek letters α,

Figure 13. Technologies that partially or completely encapsulate the human user.

Preparing Mersivity ball at the lab:

Testing Mersivity ball at Michael Hough Beach:

Figure 14. Mersivity Ball is a good example of a technology that helps us connect with nature in a precarious balance of human strength and muscle bandwith using Integral Kinesiology for mind+body training. A 3-dimensional volumetric display is visible to the rider as well as others in the area, resulting in a shared experience.

β, and γ are the first three letters of the Greek alphabet, and are appropriate labels for these three axes, denoting, somewhat metaphorically, "Atoms", "Bits", and "Genes" respectively.

In this way we may consider also the three planes, as follows:

- The $(\alpha - \beta)$ "Bits and Atoms" plane of physical computing;
- The $(\alpha - \gamma)$ plane defining our technology-free interaction with our natural world;
- The $(\gamma - \beta)$ plane of HCI (Human-Computer Interaction), "cyborg" technologies of human augmentation, human interaction with virtual reality, "metaverse" and related shared virtual realities.

Let us begin with the first of these three axes, the α axis.

5.1. Physical reality as an axis

Let us consider the physical reality in terms of physical scale, e.g. how big or small something is, as shown in Fig 15, as an axis (continuum) from zero scale at the left, to infinite scale at the right. This α-axis now has Atoms close to the origin (close to zero scale) at the left. The edge of the Universe is further out on the $s(\alpha)$ axis. A natural taxonomy results that separates wearables (wearable technologies, i.e. technologies of our Invironment = technologies that we consider to be part of us) from technologies that surround us (i.e. technologies of our Environment, i.e. technologies we usually don't consider to be part of us). The *Environment* is denoted as blue and the *Invironment* is denoted as fleshtones [16]. This boundary may be well-defined as in the waterball or spacesuit, or may have soft or fuzzy edges as with clothes and vessels where we can lean out over the edge of a boat, for example.

Figure 15. Physical reality on a sliding scale of distance (inside of or) from the body.

5.2. Cyborg = "Cybernetic Organism"

One example of overlap between a human and technology is that which forms a cybernetic organism (abbreviated "cyborg") as shown in the yellow-shaded area of Fig 11. The term "cyborg" was coined by Manfred Clynes [18] in 1960 as an interaction between human and technology that becomes so innately natural that it requires no conscious thought or effort to operate the technology. His favorite example is that of a person riding a bicycle [19]. Indeed the word "cybernetic" (κυ-βερνήτης) is of Greek origin and means rudder, helmsman, steersman, or governor (same word root as the word "government"). As a nautical term, it is most fitting to note that the earliest nexus of human and technology is the vessel or hominid raft. Thus the first cyborgs were our ancient ancestors, predating Homo sapiens, long before the invention of the wheel, or the invention of clothing. It has been argued therefore that cyborgs have existed for more than a million years [13].

6. Nature, Technology, Humanity axes

The axis of 15 represents one of the three circles of Fig 10 and 11, namely the Environment / physical reality / Atoms, α circle.

Consider now the Atoms, α circle together with the Bits, β circle, quantified as axes, as illustrated in Fig 16. Here, instead of physical scale, s(α), we have the amount or quantity, q(α). Along the q(α) we have "Less reality" to the left and "More reality" to the right. Along the q(β) axis we have "Less virtuality" near the
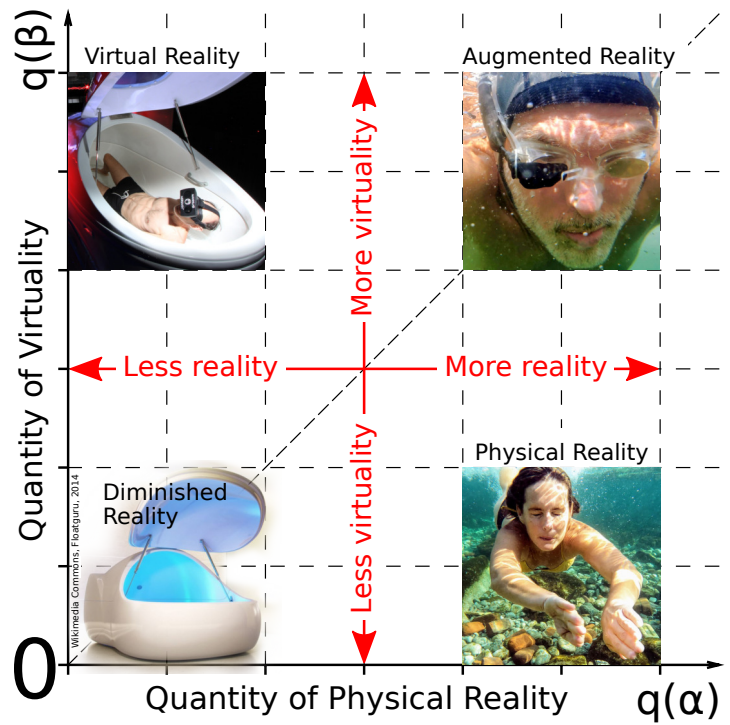
Figure 16. The axes $q(\alpha)$, and $q(\beta)$ form a taxonomy of four quadrants in the $q(\alpha) - q(\beta)$ plane.

bottom and "More virtuality" near the top. This creates a two-dimensional (planar) taxonomy of "the realities" in four quadrants.

In Fig 16 we have selected four examples that each illustrate a corresponding quadrant. A sensory isolation tank ("float tank") is used to represent the lower left "Diminished Reality" quadrant where the quantity of Reality and Virtuality are both zero or near zero. This quadrant defines the origin, $(0, 0)$ which is marked simply as 0 (zero).

Physical reality extends to the right, where the experience of icewater swimming is used to represent the lower-right quadrant, "PR" ("Physical Reality"), since this experience is fully immersive and very difficult to simulate using VR [16].

The idea of wearing a VR headset in a sensory isolation tank has also been explored, as a way to remove a great deal of input from physical reality and thus make the immersive VR experience more purely along the q(β) axis [20].

The term "Virtual Reality" (VR) was introduced in 1938 by Artaud [21] in the context of theatre as a technology to represent an analog of the real world, i.e. as an alternative synthetic reality we can think of as orthogonal to physical reality. Alternatively we can consider a VR (Virtual Reality) eyeglass that is totally immersive, such that it blocks out physical reality and allows
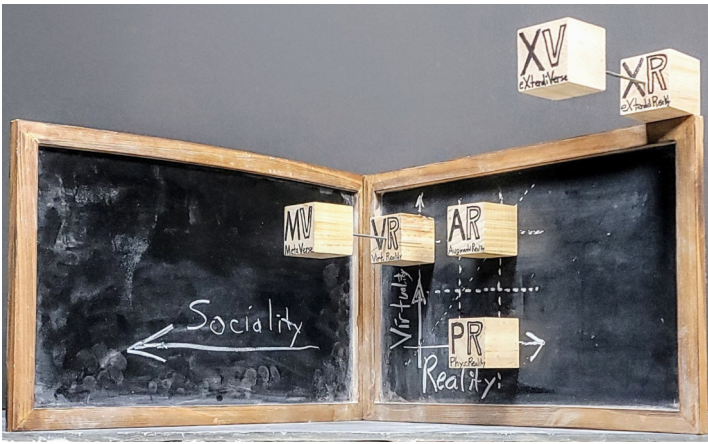
Figure 17. **The building blocks of the XV continuum.** The three axes of the continuum are: (1) Reality; (2) Virtuality; and (3) Sociality. The four blocks (PR, VR, AR, and XR) in the Reality-Virtuality plane are in the plane of the two axes drawn on the chalkboard. Compare with Fig. 16. The metaverse extends out of this plane, along the third (social) dimension, from VR, i.e. the metaverse is shared/social/collaborative VR. The eXtended metaVerse (eXtendiVerse, XV) extends out of the Reality-Virtuality plane from XR, i.e. XV is shared/social/collaborative XR [16].

us only to experience the VR technology. This situation, with the float tank, is depicted in the upper left quadrant of Fig 16.

Finally, let us consider a technology that allows us to be fully immersed in nature as well as in technology. A good example of technology that affords this possibility is the Vuzix SmartSwim which can overlay with virtual information technologies upon the real world, while icewater swimming, for example. Here we can monitor our vital signs, heart, respiration, etc., while swimming in icewater, as illustrated in the upper right quadrant of Fig 16.

This is referred to as AR (Augmented Reality), but more generally we wish to be able to interpolate between any of these realities and extrapolate beyond them, using what is known as XR (eXtended Reality) [22].

Let us now add the third axis, humanity, society, etc., to Fig 16. Imagine this third axis coming out of the page, and we have, extending from the upper left quadrant, the metaverse which is shared VR, which generalizes to the eXtended metaVerse (XV) which is shared XR. See Fig 17. Wheras XR interpolates as well as eXtrapolates (i.e. eXtends) across all the realities, XV interpolates as well as eXtrapolations + eXtends across all of the verses to include the metaverse, omniverse, multiverse, polyverse, or any other verses. Thus XV is to the metaverse

as XR is to virtual reality.

7. Mersivity

The intersection of all three spheres or circles, puts us into the 3-dimensional space of XV, which we call Mersivity (Fig 10 and 11), i.e. the degree to which a technology is sub-mersive or im-mersive (in the extreme case, a submserible immersive technology). Mersivity is at the intersection of nature, technology, and humanity.

8. Mindmap taxonomy / ontology

The three spheres, circles, or axes, Nature, Technology, and Humanity, form three top-level taxons for a range of activities of the IEEE, as shown in Fig 18. Of course there is more subtlety ommitted from Fig 18 for simplicity, e.g. XV really includes all three of the top-leval taxons to some degree.

9. The harm of software

A common problem with the the ethos of the modern era is the glorification of software and its layers of abstraction and encapsulation. In the past, technologies like pocket calculators would give consistent results, whereas software complexity has created a normalization of unreliability, where people become accustomed to technologies that are less than 100% reliable.

Additionally, another problem with software is its ability to conceal its functionality, e.g. the tendency of closed-source "secret code". This tendency frustrates those with special needs. There is an inherent need for persons with disabilities to be able to understand and modify products to best adapt to their particular needs, and software's tendency to deliberate obfuscation puts it on the wrong side of ethics.

A "ware" is an article or good of commerce, or an article of merchandise, as in "peddlers hawking their wares", or services or products of artistic or intellectual creativity that are salable (dictionary.com). Thus the very word "software" is suggestive of commercial activity. To the extent that software is expanding to enter all facets of our lives, there is a threat of the commodification of nearly all aspects of our lives.

Another problem is the ease with which a single business entity can capture an entire market and trap users within a certain ecosystem. This problem arises from software "platforms". Consider some examples: In the days of telephone calls, a person with one brand of telephone could call someone with another brand. Therefore we never heard people say something like "Bell me

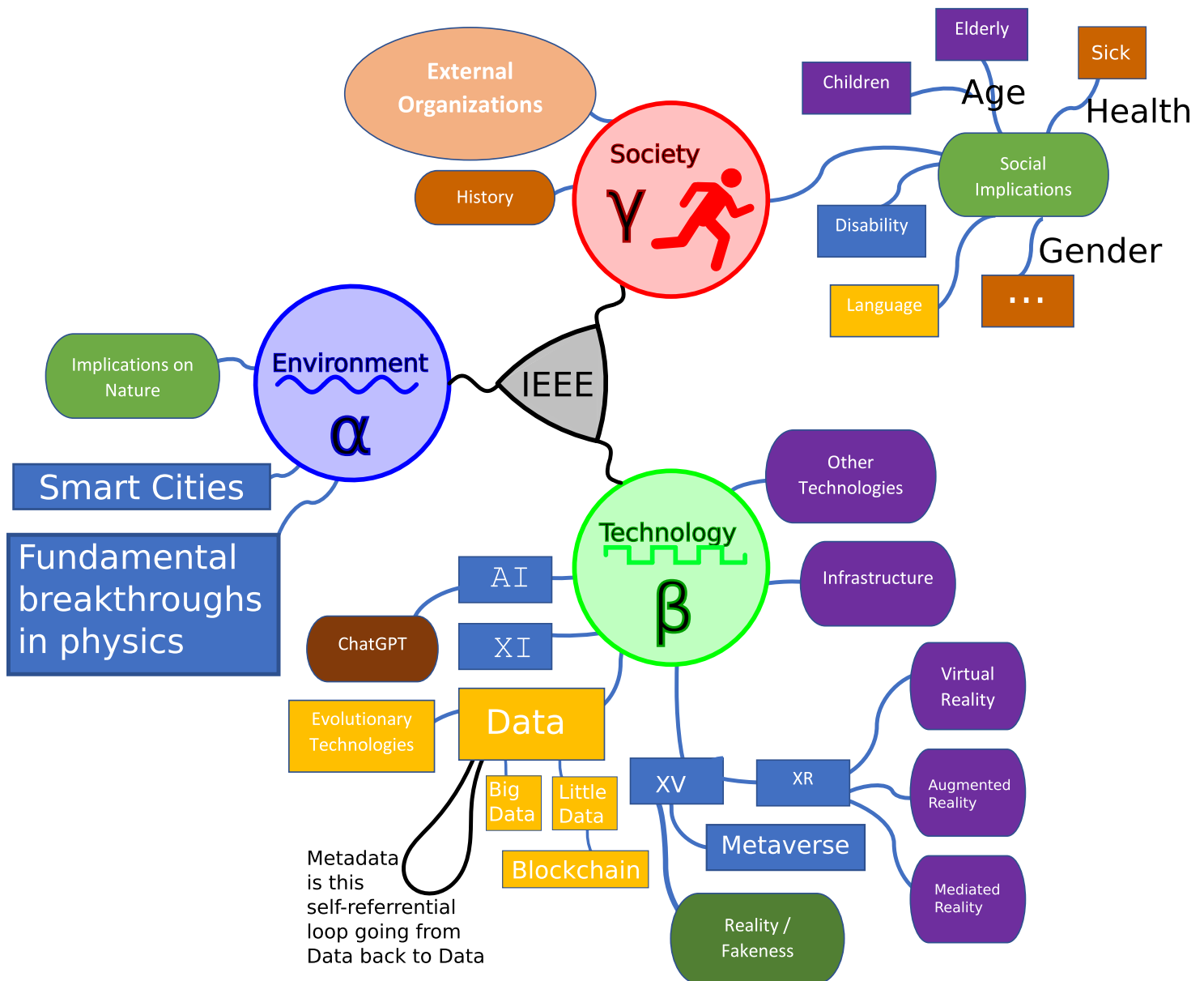# IEEE, Advancing Technology for Sustainable Society

Figure 18. Mindmap based on the three top-level taxons, Environment, Technology (e.g. AI=Artificial Intelligence, XI=eXtended Intelligence, etc.), and Society.

tomorrow" or you would not hear a radio talk show host say "She joins us by way of Nynex" or "He's with us by way of AT&T". But today we hear radio talk show hosts say "She joins us by way of Zoom", or "Skype me tomorrow." or "Let's meet on [Microsoft] Teams.". Presently, for example, if a call takes place on Microsoft Teams then it can't be joined by other brands or by a free open-source program like Jitsi which is standards-compliant.

There is a need for standards, and in particular, market-driving standards rather than market-driven standards.

Software (the green circle in Fig 10 and 11) should not exist alone, but must act in service of humanity and the environment. In particular, we might consider that a "ware" is an article or good of commerce, and that not all computer programs need be "software" in the sense that not all computer programs need be articles or goods of commerce. In particular, we might wish to consider computer programs or "code" that serves us and our environment, even if it does not serve the needs of commerce or the economy. Such code should, however, help to serve the six connections, especially (3) obervability and (4) controllability, e.g. that the end user can, if he

or she wishes to, understand it, and control it, e.g. modify it and be able to run the modified versions of it, as discussed previously.

Many of us have decided to adopt a wise Amish-like philosophy of rejecting certain technologies if they fail to serve our communities. We will often prefer simple command-line interfaces like CSH, BASH, etc., in a UNIX-like (particularly GNU Linux) environment, rather than a GUI (Graphical User-Interface) that is infused with undesirable properties.

Similarly, we sometimes need "deconomics" or economic "degrowth", i.e. "big" is not always better, and we often seek to slow down technological development, or to re-route technological development to serve a sustainable society rather than necessarily always quicken the pace of development at the possible expense of society and sustainability.

10. Technologies in service of humanity and the environment

Let us now consider examples of technologies which serve not just humanity but also the environment. Consider common problems encountered in nearly any large city, such as transportation. Presently a large number of automobiles contribute to pollution and environmental harm, many of them often carrying only 1 person and only a modest quantity of cargo. We seek a smaller form of mobility device designed to carry 1 person plus a small amount of cargo. Ideally such a device will provide mobility for those with disabilities, as well as provide some form of exercise and fitness. What we envision is a MVV (Minimum Viable Vehicle / (con)Veyance / Vironment) that can transform from helping a pedestrian, e.g. by way of a device that functions as a walker that can reconfigure itself as a scooter. In this way it can be pushed, or it can lead a person with a disability, e.g. back injury, or visual impairment, and it can self-drive and carry the person at times as well. In this way a person can walk part of the distance pushing or being pulled along by the device, and ride part of the distance, possibly contributing to some of the powering of the device, e.g. by way of pedals that can provide partial or full assistance.

Such a device is a form of reconfigurable micromobility that can operate indoors, outdoors, on sidewalks, bicycle paths, and roads. In this way it provides the most versatile form of transportation assistance, elimnating the need, for the most part, for large petrol-burning vehicles.

This is a project of S. Mann in collaboration with J. Archbold and others to create the "Freehicle" which is a vehicle of freedom for mobility. We envision the Freehicle™ as something that can enter establishments such as grocery stores, to assist with carrying groceries, as well as ride on sidewalks, bicycle paths (the Freehicle should be, at least in-part, human-powered), and roads. Moreover we might envision in the future the Freehicle as being amphibious so that it can cross water, and also we might envision it being able to fly, so that it can be used for land, water, and air.

11. Centre(s) for Nature, Technology, and Humanity

We envision a worldwide network of centres at the nexus of Nature, Technology, and Humanity, at the area of intersection shown in the central region of Fig 10 and 11 ("Mersivity", i.e. the degree to which a technology can be fully immersive and submersible). Mersivity means being environmentally-friendly as well as usable in any environment such as on land, in water, and in the air. Technologically, the most difficult criterion for most technology to be used in nature (e.g. in the rain, on a camping or canoe trip, in the water, etc.) is being waterproof, and thus an important part of Mersivity is that the technology be submersible in freshwater or saltwater.

We created an outdoor classroom and conference series at Ontario Place to research, test, and present many of the ideas that we are developing at the intersection of nature, technology, and humanity. Approximately 12 years ago, November 2011 we proposed Ontario Place as a university + science centre + research + teaching lab at the nexus of nature, technology, and the environment, and have been holding an annual conference series on this topic. We chose this location because of Ontario's role in freshwater stewardship, as Ontario is home to the world's largest (by surface area) freshwater lake, and to the Great Lakes which hold approximately 80% of North America's (approximately 21% of the world's) surface freshwater.

Fig 19 illustrates some examples of our approach to research and teaching at the nexus of nature, technology, and humanity. Our work, using primordial elements like water, crosses cultural, age, and generational boundaries, to make Ontario Place and other research centres places for fundamental scientific research for people of all ages. See Fig 20.

The idea of making a fun and playful research lab at Ontario Place – "Ontario Placemaking" has served to

Figure 19. Research, teaching, fun, and frolic, at the nexus of nature, technology, and humanity.

Figure 20. Stephanie, age 5, designs and builds a hydraulophone (underwater pipe organ) and gives a lecture presentation on the mathematical foundation of its design and operation. Additionally this work includes an analysis of flow as a function of hydraulic head, as it affects the sound output level of the instrument.

teach many important principles of nature, technology, and humanity, while having fun doing this important research, in collaboration with other locations at MIT and Stanford University and elsewhere. We hope to expand this effort worldwide, with the Hydraulikos / Mersivity research program.

Water-Human-Computer-Interaction/Interfaces (WaterHCI), a field that originated in Southern Ontario in the 1960s and 1970s, is gaining widespread acceptance and adoption, and we have highlighted the importance of WaterHCI to Ontario and to the world as a whole.

We envision Hydraulikos / Mersivity as a combination of a beach, wellness spa, research lab, and a university or school for researching and teaching and being taught by people of all ages and backgrounds, including Indigenous ancestral teachings on water. The Centres will create content that is also fun and playful, and expand around the philosophy of LBB (Learn-By-Being) to reach people of all ages, cultures, and backgrounds with nature / natural philsophy (physics) as a universal medium of human engagement.

We have established Ontario Place as a location for world-class research, teaching, scientific exploration, and fun and frolic and hope to expand this effort worldwide.

12. Summary and Conclusions

We propose Mersivity as a new discipline and global initiative at the intersection of nature, technology, and

society. The initiative looks at the intersection of "Atoms", "Bits", and "Genes", and offers a taxonomy and ontology for all forms of technology in service of society and sustainability (the environment), i.e. "Bits" in service of "Atoms" and "Genes", figuratively speaking.

In particular, there are six important connections that technology must facilitate in order to achieve the Sustainable Technology Society objectives. These six connections correspond to the six properties of Humanistic Intelligence. In summary, technology must be:

1. **Unmonopolizing** so we can sense our surroundings;

2. **Unrestrictive** so we can walk, hike, swim, socialize;

3. **Observable** so we can sense and understand it (alethia = unconcealedness);

4. **Controllable** so it serves us, not enslaves us;

5. **Attentive** to its environment... situational awareness;

6. **Communicative** to others around us... expressive.

More simply stated, if technology can 'merse us, we should be able to 'merse it!

References

[1] S. Mann. Humanistic intelligence/humanistic computing: 'wearcomp' as a new framework for intelligent signal processing. *Proceedings of the IEEE*, 86(11):2123–2151+cover, Nov 1998. 7

[2] Steve Mann. Wearable computing: Toward humanistic intelligence. *Intelligent Systems, IEEE*, 16:10–15, 2001. 7

[3] Steve Mann. Sousveillance, not just surveillance, in response to terrorism. *Metal and Flesh*, 6(1):1–8, 2002. 8

[4] C. Reynolds. Negative sousveillance. *First International Conference of the International Association for Computing and Philosophy (IACAP11)*, pages 306 – 309, July 4 - 6, 2011, Aarhus, Denmark. 8

[5] S. Mann, J. Nolan, and B. Wellman. Sousveillance... *Surveillance & Society*, 1(3):331–355, 2003. 8

[6] Jason Nolan, Steve Mann, and Barry Wellman. Sousveillance: Wearable and digital tools in surveilled environments. *Small Tech: The Culture of Digital Tools*, 22:179, 2008. 8

[7] John Danaher. Sousveillance and surveillance: What kind of future do we want? *h+ Magazine*, October 7, 2014. 8

[8] J. Thatcher. Sousveillant media. *Understanding spatial media*, page 56, 2017. 8

[9] V. Bakir. *Sousveillance, media and strategic political comm...* Continuum, 2010. 8

[10] Jan Fernback. Sousveillance: Communities of resistance to the surveillance environment. *Telematics and Informatics*, 30(1):11–21, 2013. 8

[11] K. Michael and MG Michael. Sousveillance and point of view technologies in law enforcement: An overview. 2012. 8

[12] Steve Mann, Cayden Pierce, Aman Bhargava, Christopher Tong, Khantil Desai, and Kyle O'Shaughnessy. Sensing of the self, society, and the environment. In *2020 IEEE SENSORS*, pages 1–4. IEEE, 2020. 8

[13] Steve Mann, Mark Mattson, Steve Hulford, Mark Fox, Kevin Mako, Ryan Janzen, Maya Burhanpurkar, Simone Browne, Craig Travers, Robert Thurmond, et al. Water-human-computer-interface (waterhci): Crossing the borders of computation clothes skin and surface. *Proceedings of the 23rd annual Water-Human-Computer Interface Deconference (Ontario Place TeachBeach, Toronto, Ontario, Canada). Ontario Place TeachBeach, Toronto, Ontario, Canada*, pages 6–35, 2021. 12, 13, 15

[14] Steve Mann, Mark Mattson, Steve Hulford, Seung min Park, Fadel Adib, Chris Houser, Stephen Diamond, Pierre Lafontaine, Florian Mueller, et al. WaterHCI: Exploring the intersection between water, humans, and technology. *Proceedings of the 24th annual Water-Human-Computer Interface Deconference, Ontario Place TeachBeach, Toronto, Ontario, Canada*, pages 5–22, 2022. 12, 13

[15] Andrea L. Guzman, Rhonda McEwen, and Steve Jones. *Handbook of Human–Machine Communication*. Cambridge University Press, 2023. ISBN-10 152977392X. 13

[16] Steve Mann, Yu Yuan, Tom Furness, Joseph Paradiso, and Thomas Coughlin. Beyond the metaverse: Xv (extended meta/uni/verse). *arXiv preprint arXiv:2212.07960*, 2022. 13, 14, 15, 16

[17] Steve Mann, Yu Yuan, Fabrizio Lamberti, Abdulmotaleb El Saddik, Ruck Thawonmas, and Filippo Gabriele Prattico. extended meta-uni-omni-verse (xv): Introduction, taxonomy, and state-of-the-art. *IEEE Consumer Electronics Magazine*, 2023. 13

[18] M. Clynes and N.S. Kline. Cyborgs and space. *Astronautics*, 14(9):26–27,and 74–75, Sept. 1960. 15

[19] Manfred Clynes. personal communication. 1996. 15

[20] Steve Mann, Max Lv Hao, and Jeremy Werner. Virtual reality games in sensory deprivation tanks. In *2018 IEEE Games, Entertainment, Media Conference (GEM)*, pages 1–9. IEEE, 2018. 15

[21] Antonin Artaud. The theater and its double, 1958. first published reference to "la realite virtuell" ("virtual reality"). 15

[22] S. Mann and C. Wyckoff. Extended reality. 1991. 16

Classification of Imagined Digits Brain Activity from EEG Brain Responses

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1 Introduction

In this study, we develop a robust classifier capable of distinguishing between numerical thought activity and a "rest" state, as recorded by EEG brain responses. Historically, the challenge in decoding types of imagined speech, such as numerical thought, lies in the inherently low signal-to-noise ratio of EEG signals. To address this, recent studies have turned to deep-learning techniques, notably Recurrent Neural Networks (RNNs) (1; 2) and Convolutional Neural Networks (CNNs) (3; 4), yielding accuracies surpassing random chance. However, these trained models often falter in maintaining high accuracy when applied across different subjects.

Our approach marks an advancement in this domain. We not only achieve state-of-the-art accuracy in classifying numerical versus non-numerical thought but also propose a deep learning schema that is adaptable to new subjects with minimal additional data. This schema is structured into three distinct phases: a) the preprocessing of existing EEG datasets, b) the pretraining of the classifier, c) the acquisition of personalized EEG data, and d) fine-tuning on a per-subject basis. Our method not only enhances classification accuracy but also provides insights for the development of cross-subject generalizable models in EEG-based speech decoding and brain-computer interface technology.

2 Methods

2.1 EEG Data

We employed the MindBigData Dataset (5) for training, which is comprised of EEG recordings obtained using the Muse 2 headset. This headset features four channels dedicated to EEG data capture, with each channel sampling at a rate of 220 Hz. The primary stimulus used was a visual presentation of integers, ranging from 0 to 9, each displayed for a duration of 2 seconds. Additionally,

the dataset includes a unique category, marked as '-1', which is used to denote the instances where no digit was displayed. Overall, the dataset encompasses a total of 163,932 samples collected from a single subject, of which 119,520 are digit samples and the remaining 44,412 are non-digit samples. The train, validation, and test splits were 80%, 10%, and 10%, respectively.

In addition to utilizing the MindBigData Dataset, we conducted our own data collection involving ten MIT undergraduate students, comprising an equal gender split of 5 females and 5 males, with an average age of 19.6 years and a standard deviation of 0.5 years. Each participant contributed 1000 samples, evenly divided between 500 digit displays and 500 non-digit (blank screen) instances. The data collection was performed using the same headset setup and stimulus parameters as those in the MindBigData Dataset. For each subject, 70% of their collected data was used for fine-tuning a pre-trained classifier, while the remaining 30% served as the test set. These splits included equal proportions of digit and non-digit samples.

2.2 Preprocessing

In our study, we filtered the EEG signals with a 0.1 Hz Butterworth high-pass filter, followed by a 60 Hz notch filter (6). These filters were employed to mitigate noise intrusions, particularly those from human movements like blinking and ambient electrical disturbances. Subsequently, the filtered signals underwent a Daubechies Wavelet Transform (7). Based on previous work using the Daubechies-4 Wavelet Transform (8), we used a 3-level split. At each level, the wave was decomposed based on its frequency bands into coefficients. At the first level, the frequency bands in the range from 110 Hz to 220 Hz were used for the detail coefficients, while the frequency bands in the range from 0.1 Hz - 110 Hz were used for the approximate coefficients. In the second level, the approximate coefficients of

the first level were further decomposed into detail coefficients (55 Hz - 110 Hz frequency range) and approximate coefficients (0.1 Hz - 55 Hz frequency range). In the third level, the approximate coefficients of the second level were again decomposed into detail coefficients (27.5 Hz - 55 Hz frequency range) and approximate coefficients (0.1 Hz - 27.5 Hz frequency range). These coefficients were then used to create a feature vector. We then removed relatively small components of the feature vector based on thresholding and used the modified vector to rebuild the EEG time series. This decomposition and reconstruction removes noise artifacts and enables the downstream model to capture meaningful information from the signal.

2.3 Neural Network

Our proposed model is designed to classify whether a person is actively thinking of a number. At the core of this deep learning model are multiple axis-wise convolutional layers, each sequenced with a dropout layer. This configuration is chosen to enhance the model's capability in feature extraction while simultaneously preventing overfitting. The convolutional layers are used to capture the spatial and temporal patterns inherent in EEG data (9). As the model progresses towards its final stages, we have incorporated three fully connected layers, followed by a softmax output layer. This layer transforms the aggregated neural representations into a probabilistic output to indicate whether or not the person is thinking of a number. Lastly, as our model has 920K parameters, we use a 20% dropout rate after each convolution to ensure that the network maintains a level of simplicity and generality in its learned representations (10).

2.4 Axis Convolutions

The implementation of axis-wise convolutions in our EEG analysis model is motivated by the requirement for feature extraction from the multi-dimensional nature of EEG data. By applying these convolutions along the time and channel axes, our model extracts features intrinsic to each dimension. The convolution along the time axis is designed to discern patterns and fluctuations over different time intervals. On the other hand, channel-wise convolution focuses on spatial patterns across different EEG channels, effectively mapping the topographical distribution of brain activity. This spatial analysis is key to understanding how different brain regions interact during cognitive processes.

By segregating and processing the EEG data along these two axes independently, our model is able to maintain a higher level of interpretability, allowing for clearer distinctions between different cognitive states. It also improves the model's robustness against noise and artifacts that may be present more prominently on one axis than the other.
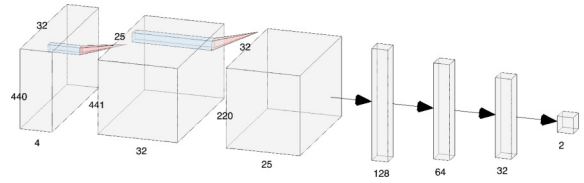
Figure 1: Depiction of convolutional layers and fully connected layers in the neural network architecture.

3 Results and Discussion

Our classification approach, as applied to the Mind-BigData Dataset, demonstrated a test accuracy of 99.65% in discerning whether a subject was engaged in numerical thought. This high accuracy indicates the model's effectiveness in identifying distinct patterns associated with numerical and non-numerical cognition within a single subject.

Furthermore, when fine-tuned to individual participants, the models exhibited an average test accuracy of 97.57% across the ten MIT undergraduate students (Fig. 2). This outcome not only highlights the model's capacity to adapt to individual variations in brain activity but also confirms its ability to perform the classification task across different subjects consistently.
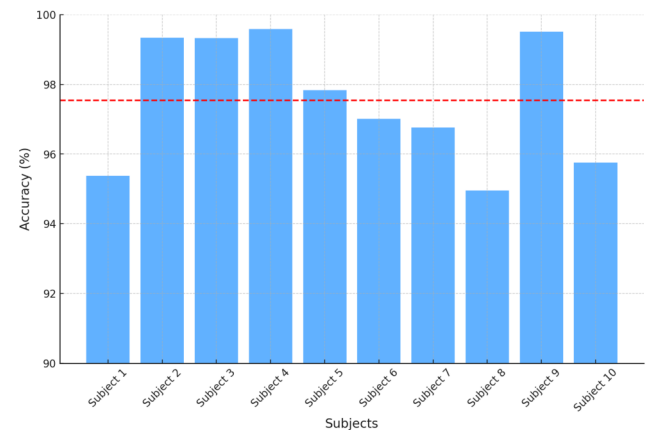
Figure 2: Classification accuracy of cognition type for ten subjects with per-subject fine-tuned CNN classifier

The observed high accuracy rates in both experiments suggest a robust capability in discerning

EEG response patterns linked to numerical cognition. The consistency in model performance across a diverse set of subjects, in terms of gender and age, also confirms a level of uniformity in how the brain processes different types of stimuli and information.

These results contribute to the broader conversation on the generalizability and individual specificity of brain activity patterns, particularly in the context of cognitive tasks involving specific stimuli and information types. Moreover, the findings emphasize the power of a pre-train-then-fine-tune schema for personalized applications in cognitive neuroscience, including the development of tailored neurofeedback systems or brain-computer interfaces.

References

[1] D.-H. Lee, S.-J. Kim, and K.-W. Lee, "Decoding high-level imagined speech using attention-based deep neural networks," *CoRR*, vol. abs/2112.06922, 2021. [Online]. Available: https://arxiv.org/abs/2112.06922

[2] D. Vorontsova, I. Menshikov, A. Zubov, K. Orlov, P. Rikunov, E. Zvereva, L. Flitman, A. Lanikin, A. Sokolova, S. Markov *et al.*, "Silent eeg-speech recognition using convolutional and recurrent neural network with 85% accuracy of 9 words classification," *Sensors*, vol. 21, p. 6744, 2021.

[3] B. v. d. Berg, S. v. Donkelaar, and M. Alimardani, "Inner speech classification using eeg signals: A deep learning approach," in *2021 IEEE 2nd International Conference on Human-Machine Systems (ICHMS)*, 2021, pp. 1–4.

[4] C. Cooney, R. Folli, and D. Coyle, "Optimizing layers improves cnn generalization and transfer learning for imagined speech decoding from eeg," in *2019 IEEE International Conference on Systems, Man and Cybernetics (SMC)*, 2019, pp. 1311–1316.

[5] D. Vivancos and F. Cuesta, "Mindbigdata 2022 a large dataset of brain signals," 2022.

[6] A. de Cheveigné and I. Nelken, "Filters: When, why, and how (not) to use them," *Neuron*, vol. 102, no. 2, pp. 280–293, 2019. [Online]. Available: https://www.sciencedirect.com/science/article/pii/S0896627319301746

[7] M. Mohamed and M. Deriche, "An approach for ecg feature extraction using daubechies 4 (db4) wavelet," *International Journal of Computer Applications*, vol. 96, no. 12, pp. 36–41, Jun. 2014, © 2014 International Journal of Computer Applications. Muhidin A Mohamed and Mohamed A Deriche. Article: An Approach for ECG Feature Extraction using Daubechies 4 (DB4) Wavelet. International Journal of Computer Applications 96(12):36-41, June 2014.

[8] N. C. Mahapatra and P. Bhuyan, "Eeg-based classification of imagined digits using a recurrent neural network," *Journal of Neural Engineering*, vol. 20, no. 2, p. 026040, Apr 2023.

[9] Z. J. Koles, J. C. Lind, and A. C. K. Soong, "Spatio-temporal decomposition of the eeg: a general approach to the isolation and localization of sources," *Electroencephalography and Clinical Neurophysiology*, vol. 95, no. 4, pp. 219–230, 1995. [Online]. Available: https://www.sciencedirect.com/science/article/pii/001346949500083B

[10] N. Srivastava, G. Hinton, A. Krizhevsky, I. Sutskever, and R. Salakhutdinov, "Dropout: A simple way to prevent neural networks from overfitting," *J. Mach. Learn. Res.*, vol. 15, no. 1, p. 1929–1958, jan 2014.

Mersivity 2023 Venue: Mechanical Engineering Building, MC102, 5 King's College ROAD

(Morgan Freeman's "Through The Wormhole" with Steve Mann, filmed at University of Toronto in MC102)

The Symposium takes place at University of Toronto downtown St. George Campus, 5 King's College Road (not King's College Circle!)
Toronto, ON, M5S 3G8,
Mechanical & Industrial Engineering building, as shown on the left side of the picture below, facing South (you can see the CN Tower in the background, which is to your South):
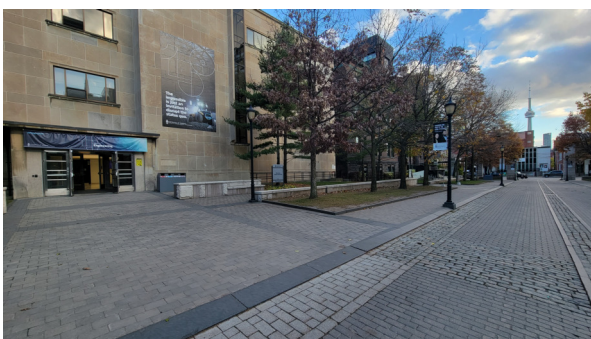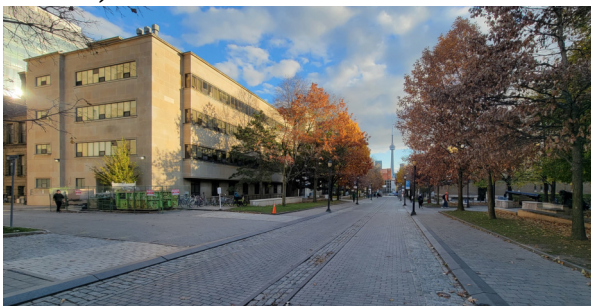
Enter through front door and go right to MC102 = Room 102 on the ground floor just inside the main entrance.

If you are coming from the South, you can see University College off in the distance, and the entrance is on your right:

Once you enter you will first see the large entrance hall / exhibit area:

Turn right and walk through the entrance hall / exhibit area, and enter the auditorium on the right hand side. There is seating for 354 people, facing the sliding chalkboards (counterweighted pulley system) and two large projection screens, one on each side of the chalkboard:
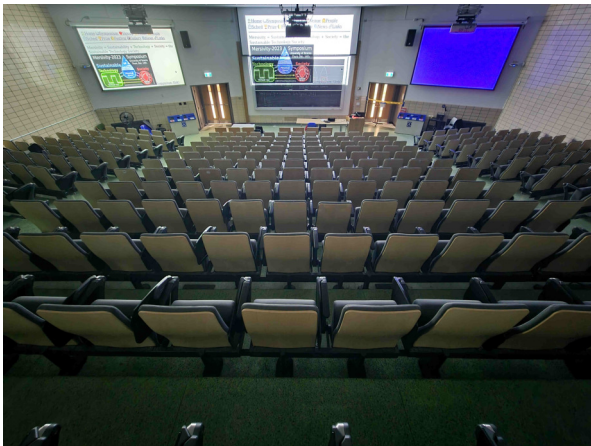
We have multiple projectors, multiple screens, and 3 nice large blackboards.

If you are presenting, please arrive early for setup and testing of the audiovisual

equipment. We have available a Sure SM58 mic, SC2 voice processor, and various other equipment (please let us know preferences) etc., as well as Hagoromo Fulltouch Chalk in all seven colours.

For your convenience we have booked the auditorium a week earlier, for rehearsals on Thursday December 7th from 12noon to 8pm if you wish to do (and perhaps record) a practice talk.

Upcoming [Festival: 2023 Dec. 21st](), Ontario Place, Lakeshore Boulevard
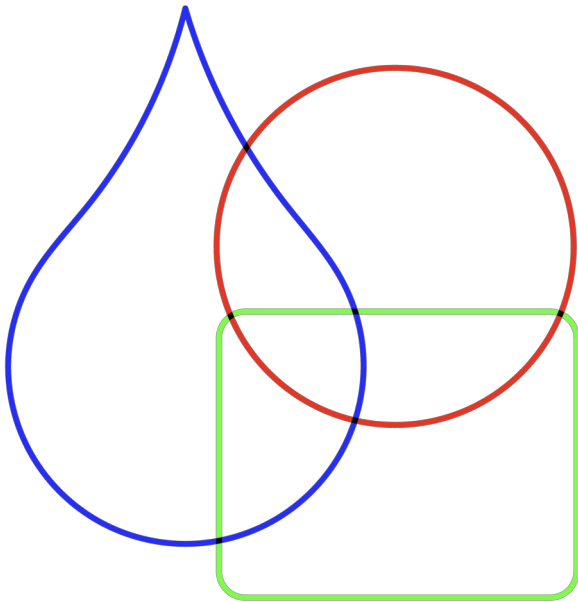
Check out our past Summer Symposium at a totally different venue, Michael Hough Beach:

Past: Tue. Aug. 15, 10am, Michael Hough Beach, Ontario Place, West Island

Summer Symposium (past), August 15th venue:

Location: Michael Hough Beach.
Here's a [link to map and GPS for the summer venue]().

"They are the largest collection of freshwater lakes in the world. They border eight U.S. states and the Canadian Providence of Ontario and at time have supplied water to one-third of Canadians and one-seventh of Americans. They're vaster than the entire New England region and define beachfront to many people who have never seen an ocean."

— **Susan Magsamen**

Canada

Disabled paddleboarder tackles five Great Lakes for charity

Liz Braun
Published May 24, 2022 • 2 minute read

Mike Shoreman is going to paddleboard across all five Great Lakes this summer, starting this weekend with Lake Erie.

People

SUBSCRIBE

Toronto Man Becomes First Person with Disabilities to Cross All 5 Great Lakes by Stand-Up Paddleboard

Mike Shoreman, who was diagnosed with Ramsay Hunt syndrome in 2018, completed the journey on Aug. 20 after months of training

Sign In

Mike Shoreman awarded 2022 Marg Starzynski Mental Health Leadership Award

Liz Braun

Published Dec 14, 2022 • 1 minute read

💬 Join the conversation

PESSE CANOE:

Dating back to 8040 BCE, the Pesse Canoe is considered the world's oldest known vessel. It was discovered in the Netherlands, showcasing the remarkable ingenuity of our ancestors.

Egyptian Reed Boats: Ancient Egyptians used reed boats known as "shashuf" for river transportation.

Records of earlier forms of Stand Up Paddleboarding have been found as early as 3,000 B.C. and its iterations span over various regions such as Peru, Levant, Italy, and China. Modern standup paddleboarding began in the 1940s in Waikiki.

Fisherman May Have Been Among
The First Paddleboarders

Paddleboarding came to prominence in the 2000s where it evolved into the sport that's recognized today. Its earliest roots trace it back to the 18th century when native Hawaiians paddled along the Pacific from island to island.

The modern applications of stand up paddle boarding, or SUP as some call it, emerged in the mid-20th century with the radical popularity of surf culture in the 1960s.

For thousands of years people have used vessels **to move goods and people across water.**

Today the paddle board is largely used for recreation and leisure promoting both physical and mental well being.

THANK YOU!

Three Key Points

First Key Point
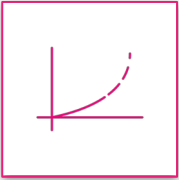
The Current Landscape

AI is just prediction but prediction, we've discovered, is foundational

Myth:

AI is a **magical** technology that can do almost anything

4

Essence:

AI is computational statistics that does **prediction**

A surprising range of tasks can be **framed** as prediction

Prediction:

Using information that you **do** have to generate information that you **don't** have

Rise in AI → Drop in the Cost of Prediction

Convert Problems Into

Predictions

Driving

Translation

Fraud Detection

HR

Particle Size Distribution

Email Replies

Inspection
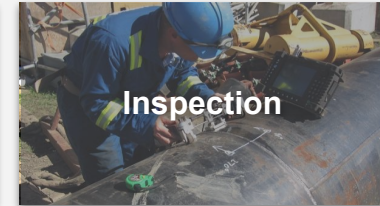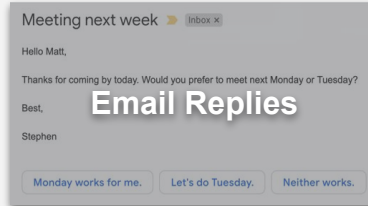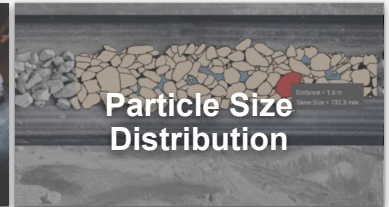
You

Mersivity advances technology that is:

1. Unmonopolizing so we can sense our surroundings.

2. Unrestrictive so we can walk, hike, swim, socialize.

3. Observable so we can sense and understand it (alethia).

4. Controllable so it serves us, not enslaves us.

5. Attentive to its environment...situational awareness.

6. Communicative to others around us...expressive.

What will be the greatest challenge with respect to achieving Mervisity?

ChatGPT

While each aspect of Mersivity presents its own challenges, one overarching and critical challenge is likely to be:

Interdisciplinary Collaboration and Ethical Frameworks:

- Achieving Mersivity requires collaboration across diverse fields such as technology, ethics, sociology, psychology, and more. Bridging the gap between these disciplines and fostering effective communication is challenging but essential.
- Developing a comprehensive ethical framework that guides the design, implementation, and use of Mersivity technology is crucial. Ethical considerations need to cover issues such as privacy, security, inclusivity, and the societal impact of these technologies.
- Ensuring that the technology respects individual rights, is unbiased, and aligns with societal values requires a collective effort from technologists, ethicists, policymakers, and the broader community.
- The challenge lies not only in technical innovation but also in creating a shared understanding of the ethical implications and societal impact of Mersivity. Balancing technological advancement with ethical responsibility is key to building public trust and ensuring the responsible development and deployment of these technologies.

Successfully addressing these interdisciplinary challenges will contribute to the responsible and human-centric advancement of Mersivity technologies.
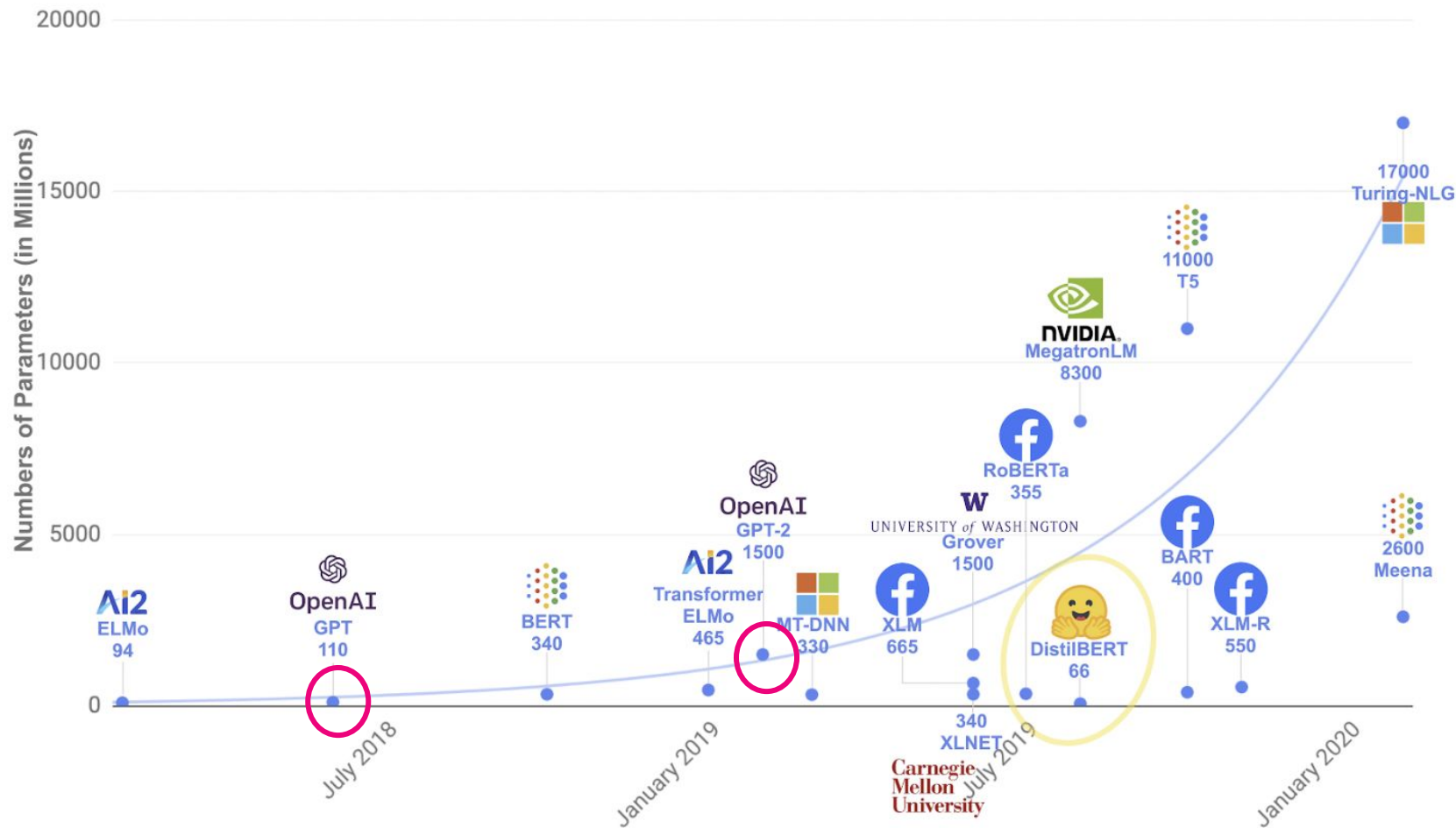
Numbers of Parameters (in Millions)

- Ai2 ELMo 94
- OpenAI GPT 110
- BERT 340
- Ai2 Transformer ELMo 465
- OpenAI GPT-2 1500
- MT-DNN 330
- XLM 665
- XLNET 340
- Grover 1500
- RoBERTa 355
- DistilBERT 66
- NVIDIA MegatronLM 8300
- BART 400
- XLM-R 550
- T5 11000
- Meena 2600
- Turing-NLG 17000

July 2018 · January 2019 · July 2019 · January 2020
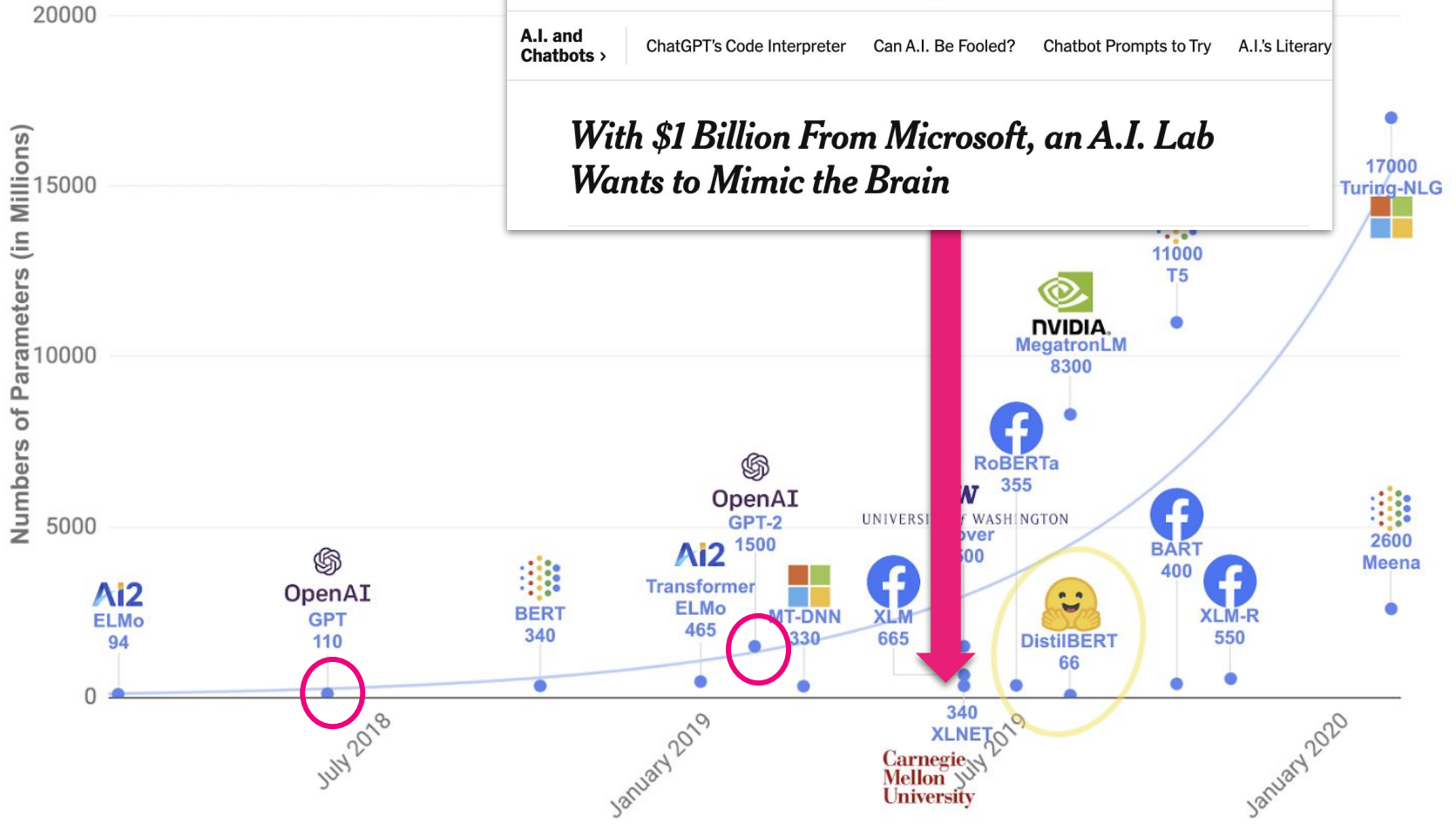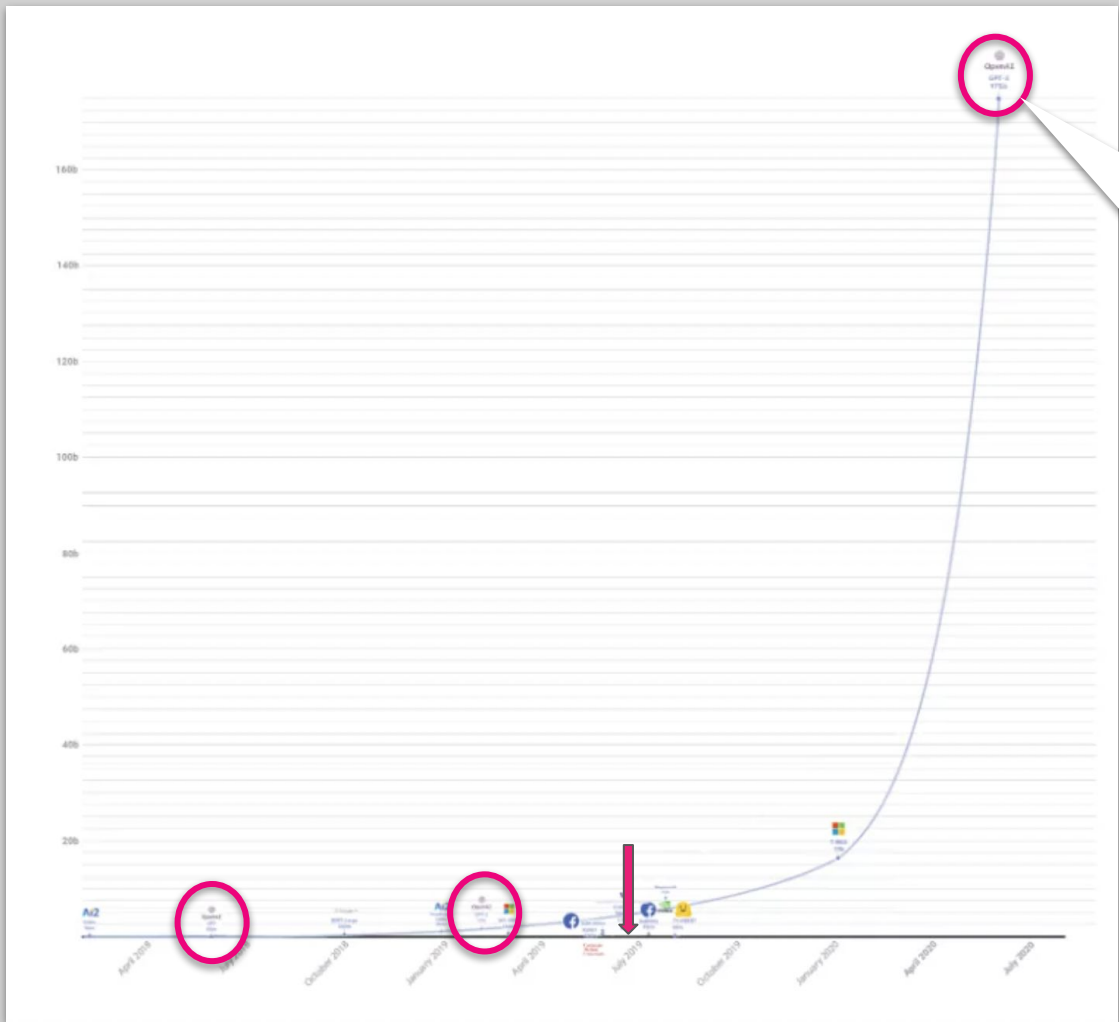
Generative AI: on the lips of the powerful

Number of mentions of 'generative AI' on corporate earnings calls
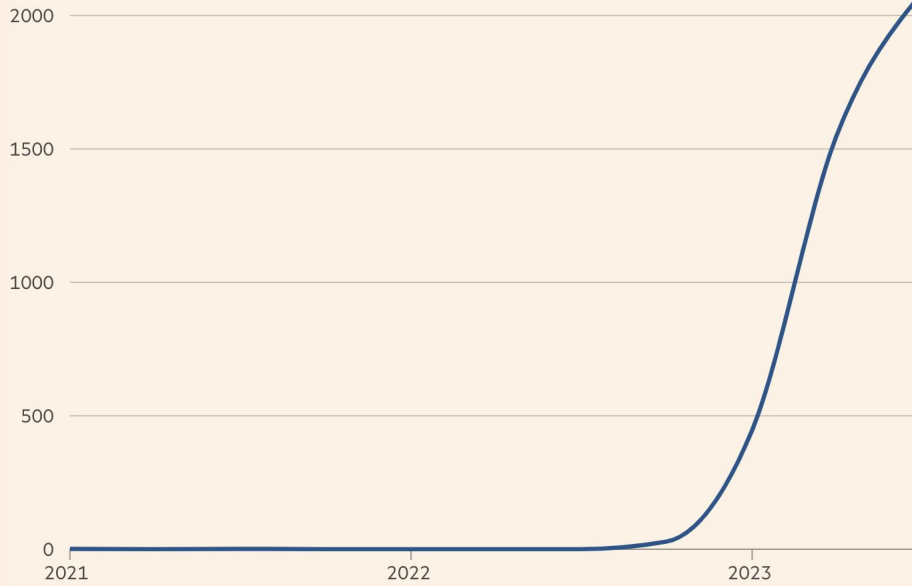
Source: CB Insights; earnings transcripts

Financial Times, November 24, 2023
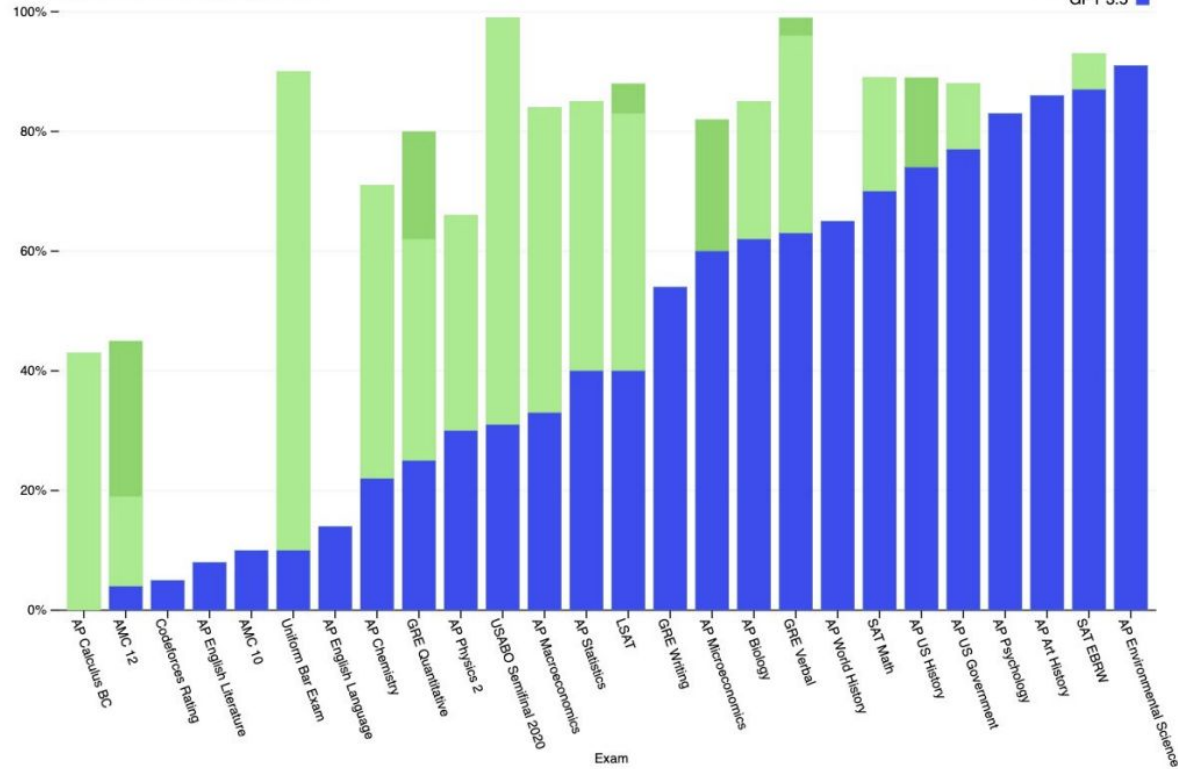
Figure 1: To get a sense of how quickly model capabilities are progressing – consider the jump in exam performance between GPT-3.5 and GPT-4 (OpenAI, 2023b).

TRI is developing a new method to teach robots overnight

Toyota Research Institute discusses the work it's doing to train robots using Large Behavioral Models

Brian Heater @bheater / 9:00 AM EDT • September 19, 2023

Comment

One of the key next steps is the creation of Large Behavior Models to help robots learn. "We're trying to scale," says Vice President of Robotics Research Russ Tedrake. "We've trained 60 skills already, 100 skills by the end of the year, thousands of skills by the end of next year. We don't really know the scaling laws yet. How many skills are we going to have to train where something completely new comes out the other end? We're studying that. We're in the regime now where we can start asking these pretty fundamental questions and start looking for the laws to know what kind of timeline we're on."

Have you ever really thought about how we do tasks?

We typically do tasks without thinking much about the details.

But many jobs have sub-components that are used over and over again, such as object manipulation, tool use, reading, writing, using a keyboard, and talking to people

All tasks can be **decomposed** into a small number of **extremely simple** underlying **primitive pieces**.

Grasp object

Place object on

Read text

Go to location

Open object

Align object

Close object

Turn object

Press button

Say phrase

Look at person

Remember item
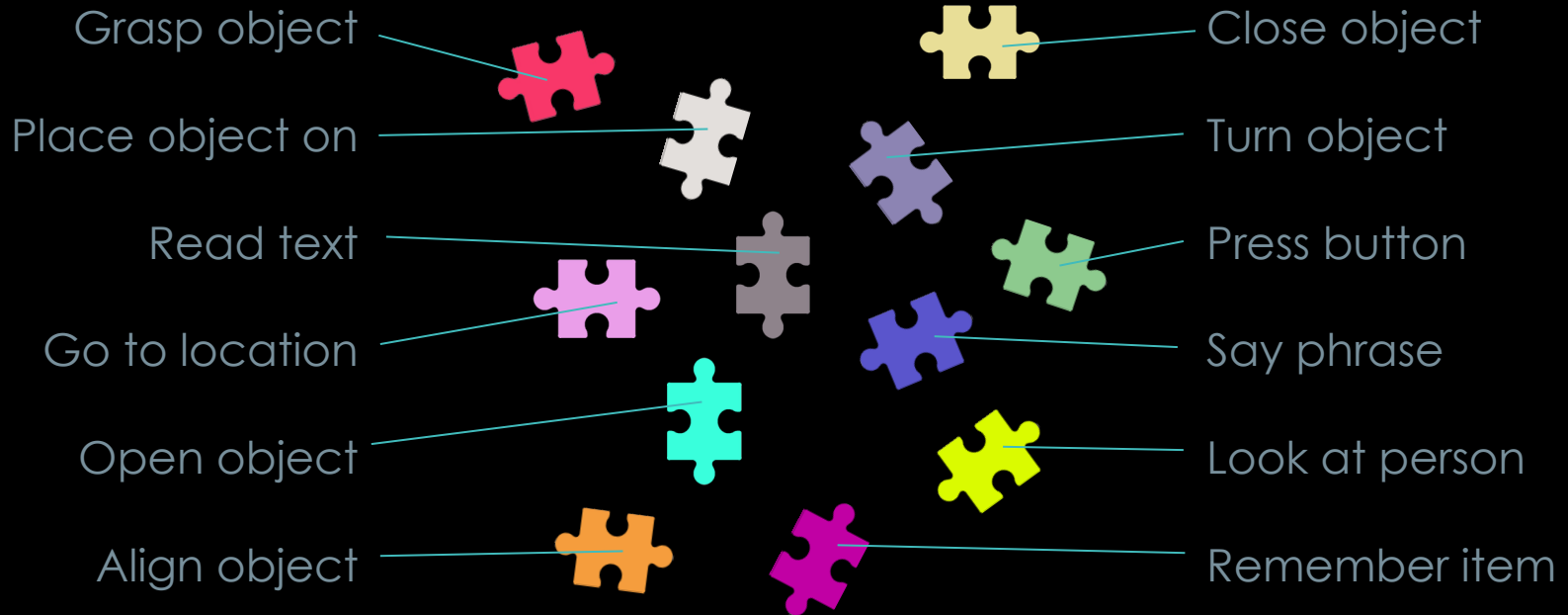
We call these primitive pieces the "Language of Labor"

We are discovering and automating this small set of primitive pieces, allowing them to run on a GPR.
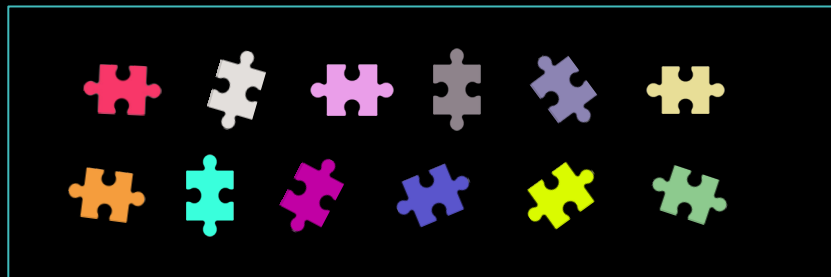
Re-combining them in different ways allows for the automation of thousands of tasks.
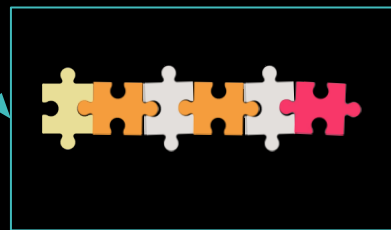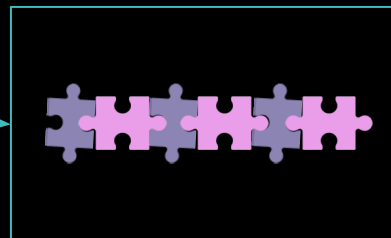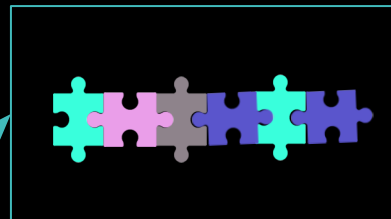
Sanctuary's 6th-gen general-purpose robot

phoenix™

GENERAL-PURPOSE ROBOT

human-like general intelligence

human-like full body mobility

max payload 55 lbs

max speed 3 mph

human-like hands

Height: 5 ft 7 in

Weight: 155 lbs

5th generation prototype (2021-2023)

The Optimus thing is extremely underrated, people just cannot comprehend the consequences ... the actual demand for something like Optimus … might be 20 billion units … a number that's vastly in excess of the number of cars.

My prediction is that Tesla's long term value, a majority of the long term value, will be Optimus. And that prediction, I'm very confident of.

Elon Musk
Tesla 2023 Shareholder Meeting

Vinod Khosla ✔ @vkhosla · Jun 29 · ✏️

The thing nobody talks about is that in 10 years we'll have a million bipedal robots and in 25 years we'll have a billion. You'll buy yours for $10k and it will be as important to your life as your smartphone is now

💬 419   🔁 738   ❤️ 3,541   ⬆️

TESLA LIVE

High Quality General Work For $5 / Hour by 2030?
A scalable workforce, with labor costs below average US wage by 2026?
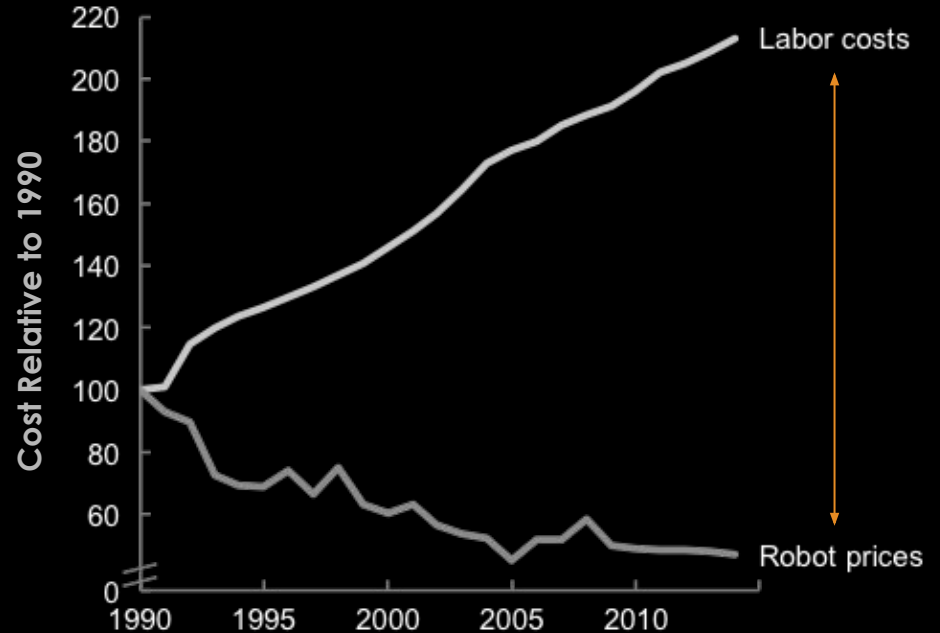
China Wants to Build Advanced Humanoid Robots by 2025

- Government urges development of core robotics technologies
- Shares of robotics firms surge on new guidance for industry

By Bloomberg News

China's harbored ambitions for years to take the lead in cutting-edge spheres from AI to quantum computing. Now it's set its sights on yet another realm with sci-fi qualities: lifelike robots.

Second Key Point
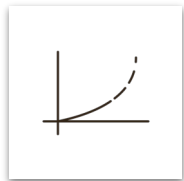
The Current Landscape

AI is just prediction but prediction, it turns out, is foundational

The Problem

We are racing forward to build AI systems that are increasingly powerful. Are these systems designed to benefit all people and our planet?

AI Causes Real Harm. Let's Focus on That over the End-of-Humanity Hype

Wrongful arrests, an expanding surveillance dragnet, defamation and deep-fake pornography are all actually existing dangers of so-called "artificial intelligence" tools currently on the market. That, and not the imagined potential to wipe out humanity, is the real threat from artificial intelligence.

Beneath the hype from many AI firms, their technology already enables routine discrimination in housing, criminal justice and health care, as well as the spread of hate speech and misinformation in non-English languages. Already, algorithmic management programs subject workers to run-of-the-mill wage theft, and these programs are becoming more prevalent.

THE NEW EYES OF SURVEILLANCE: ARTIFICIAL INTELLIGENCE AND HUMANIZING TECHNOLOGY

FORBES > INNOVATION

14 Ways AI Could Become A Detriment To Society

Expert Panel® Forbes Councils Member
Forbes Technology Council COUNCIL POST | Membership (Fee-Based)

About/Buy **MarketingWeek**
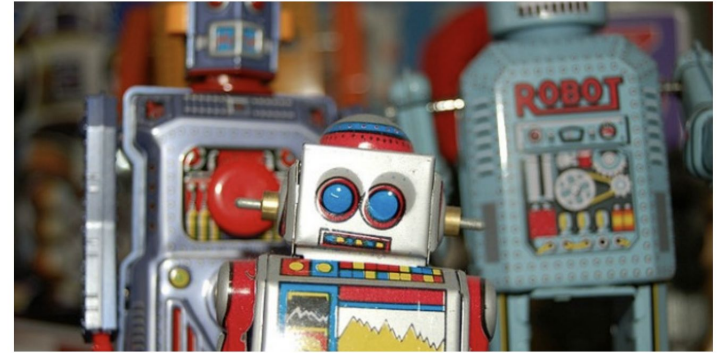
Marketing evaluation experts warn of dangers of AI

AI & Electricity: General Purpose Technologies

AI & Electricity: General Purpose Technologies

AI & Electricity: General Purpose Technologies

By **Catherine Jewell**, Publications Division, WIPO

Why AI Is the 'New Electricity'
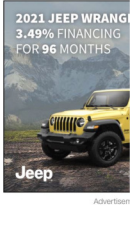
Google CEO: AI is 'more profound than electricity or fire'

AI & Electricity: General Purpose Technologies

Proportion Adopting Electricity (United States)

Chart showing proportion adopting electricity in the United States from 1880 to 1960. Y-axis ranges from 0% to 100% (0%, 25%, 50%, 75%, 100%). X-axis shows years 1880, 1900, 1920, 1940, 1960.

Legend:
- factory electrification--mechanical drive
- factory electrification--secondary motors
- household electrification---lighting
- household electrification--appliances

Proportion Adopting Electricity (United States)

Proportion Adopting Electricity (United States)
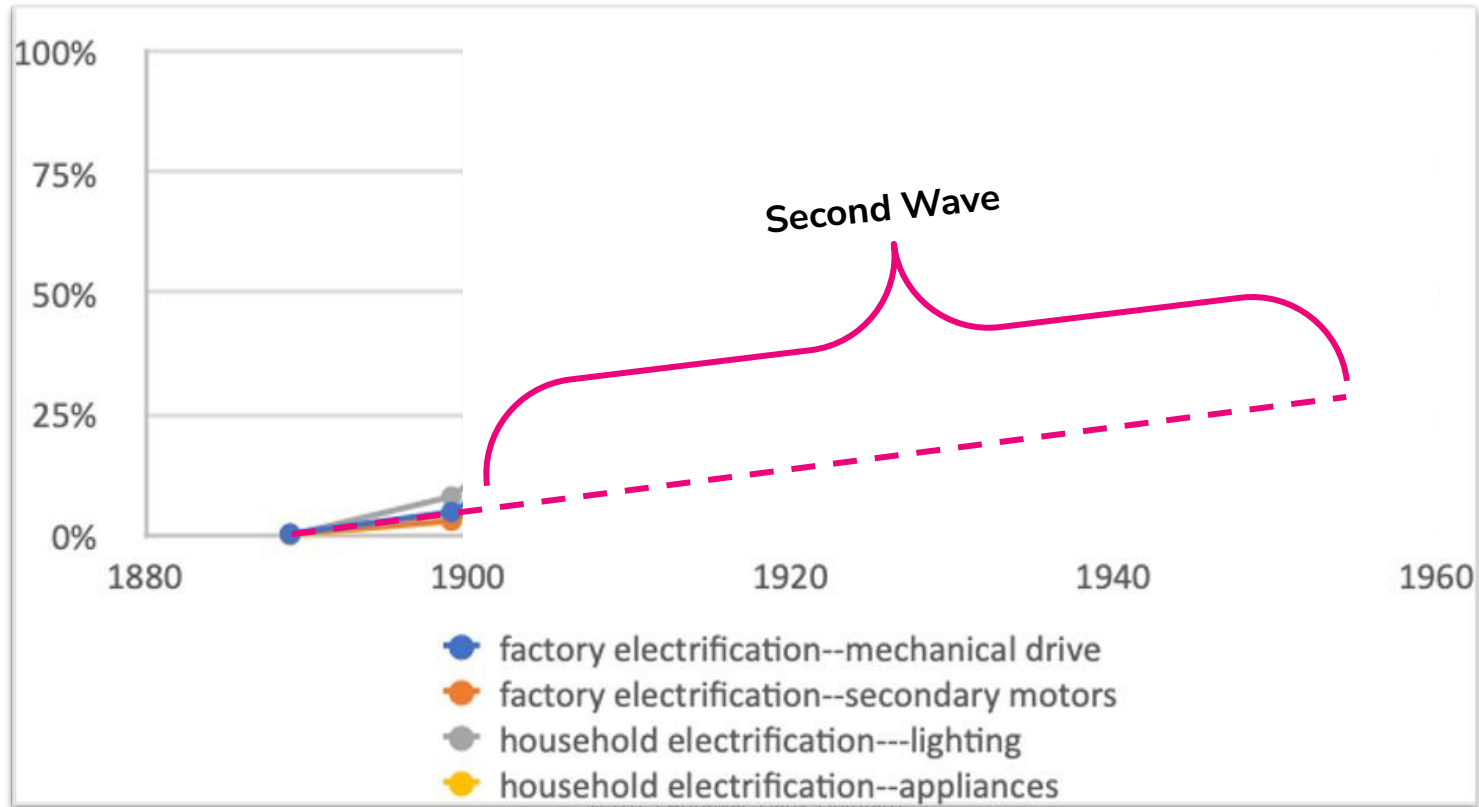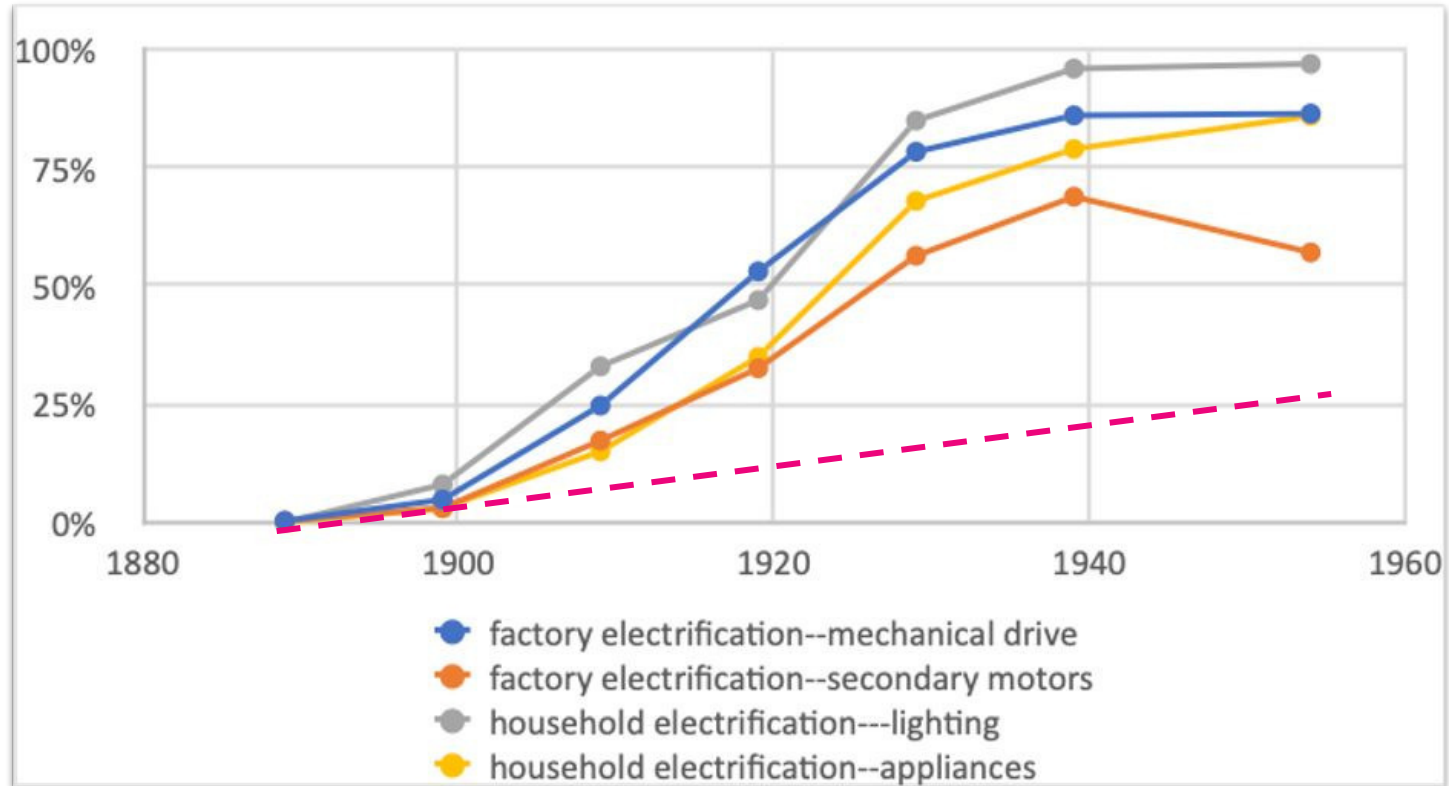
THE DIRECTOR

PROPOSED MEMORANDUM FOR THE HEADS OF EXECUTIVE DEPARTMENTS AND AGENCIES

FROM: Shalanda D. Young

SUBJECT: Advancing Governance, Innovation, and Risk Management for Agency Use of Artificial Intelligence

Artificial intelligence (AI) is one of the most powerful technologies of our time, and the President has been clear that we must seize the opportunities AI presents while managing its risks. Consistent with the Artificial Intelligence in Government Act of 2020,[1] the Advancing American AI Act,[2] and President Biden's Executive Order of October 30, 2023 (Safe, Secure, and Trustworthy Development and Use of Artificial Intelligence), this memorandum directs agencies to advance AI governance and innovation while managing risks from the use of AI, particularly those affecting the safety and rights of the public.

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1. OVERVIEW

While AI is improving operations and efficiency across the Federal Government, agencies must effectively manage its use. As such, this memorandum establishes new agency requirements and guidance for AI governance, innovation, and risk management, including through specific minimum risk management practices for uses of AI that impact the rights and safety of the public.

Strengthening AI Governance. Managing AI risk and promoting AI innovation requires effective AI governance. As required by President Biden's October 30, 2023 Executive Order (the "AI Executive Order"), each agency must designate a Chief AI Officer (CAIO) within 60 days of the date of the issuance of this memorandum. This memorandum describes the roles, responsibilities, seniority, position, and reporting structures for agency CAIOs. Because AI is deeply interconnected with other technical and policy areas including data, information
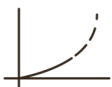
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Third Key Point

The Current Landscape

AI is just prediction but prediction, it turns out, is foundational
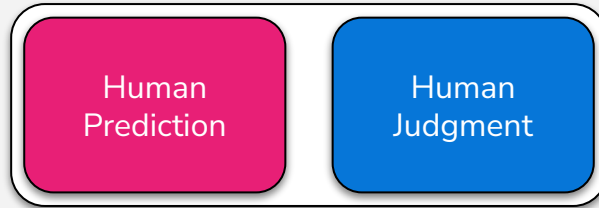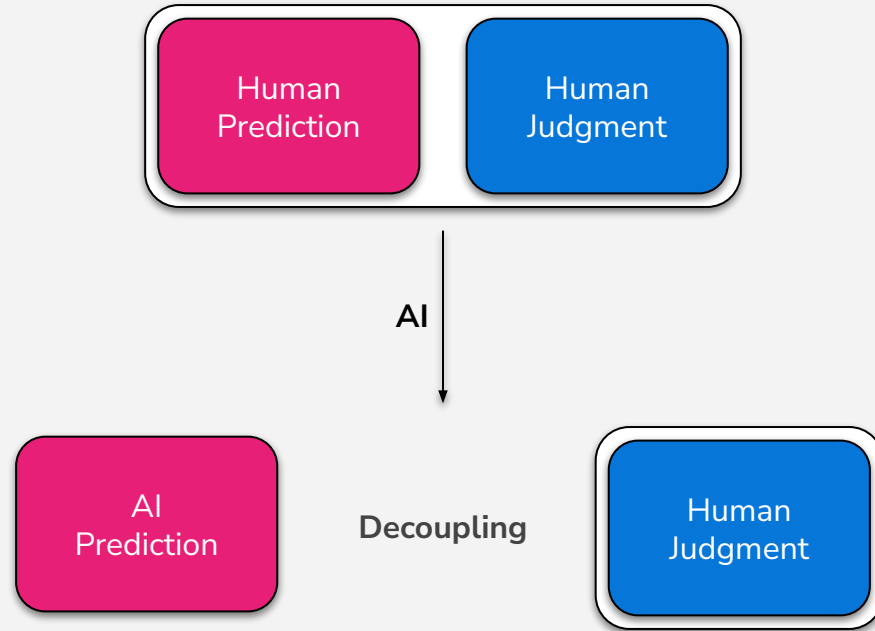
The Problem

The technology is advancing so quickly and is so misunderstood that companies struggle to develop a clear and compelling AI strategy

A Solution

Embed humanity into AI systems, even when there is no explicit human in the loop; bake this into decision-making
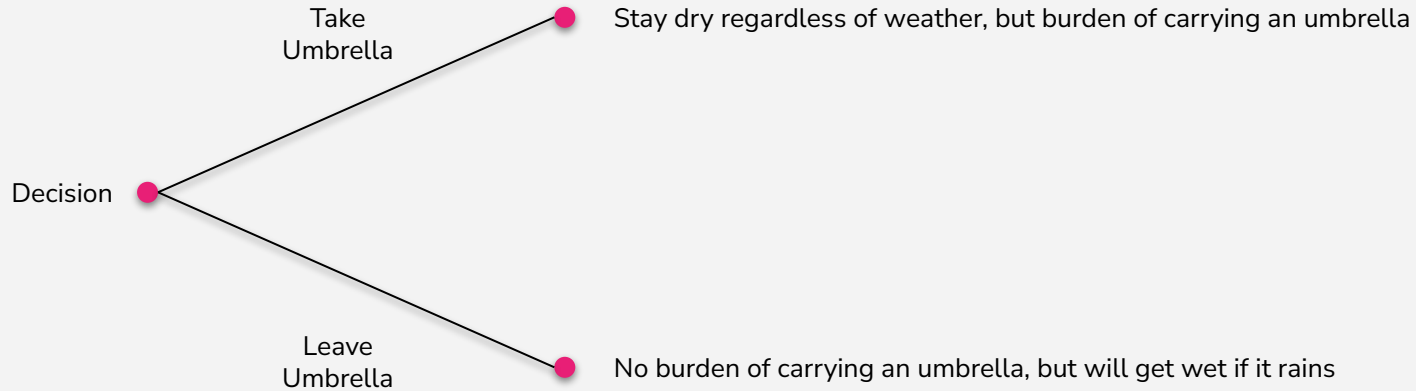
Decision Theory:

A branch of applied probability theory concerned with the theory of making decisions based on assigning probabilities to various factors and assigning numerical consequences to the outcome.
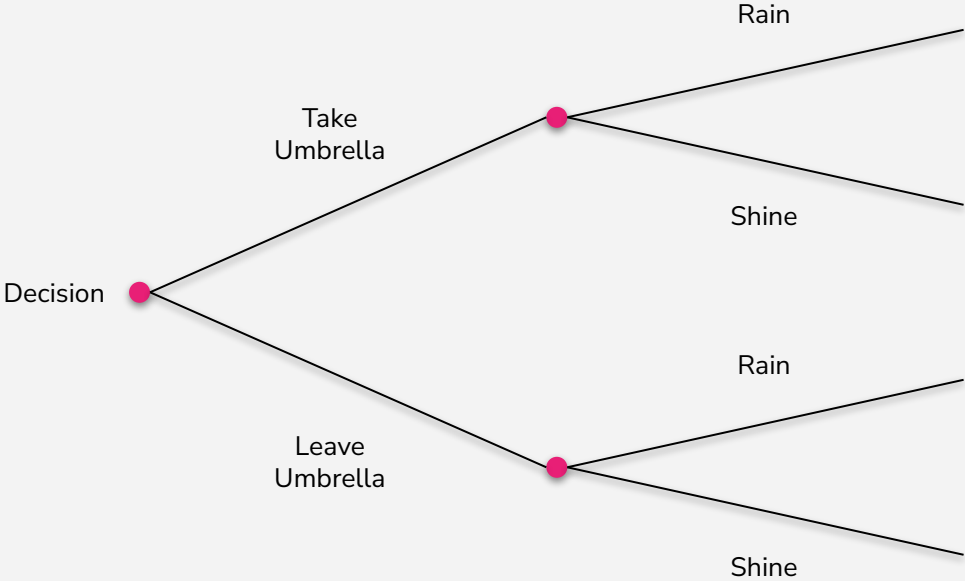
Decision

Decision Tree

Uncertainty

Decision Tree

Uncertainty   Outcome

Rain   Dry

Take
Umbrella

Shine   Dry

Decision

Rain   Wet

Leave
Umbrella

Shine   Dry

Decision Tree

Uncertainty (Prediction)   Outcome

Take Umbrella
- Rain (25%) → Dry
- Shine (75%) → Dry

Leave Umbrella
- Rain (25%) → Wet
- Shine (75%) → Dry
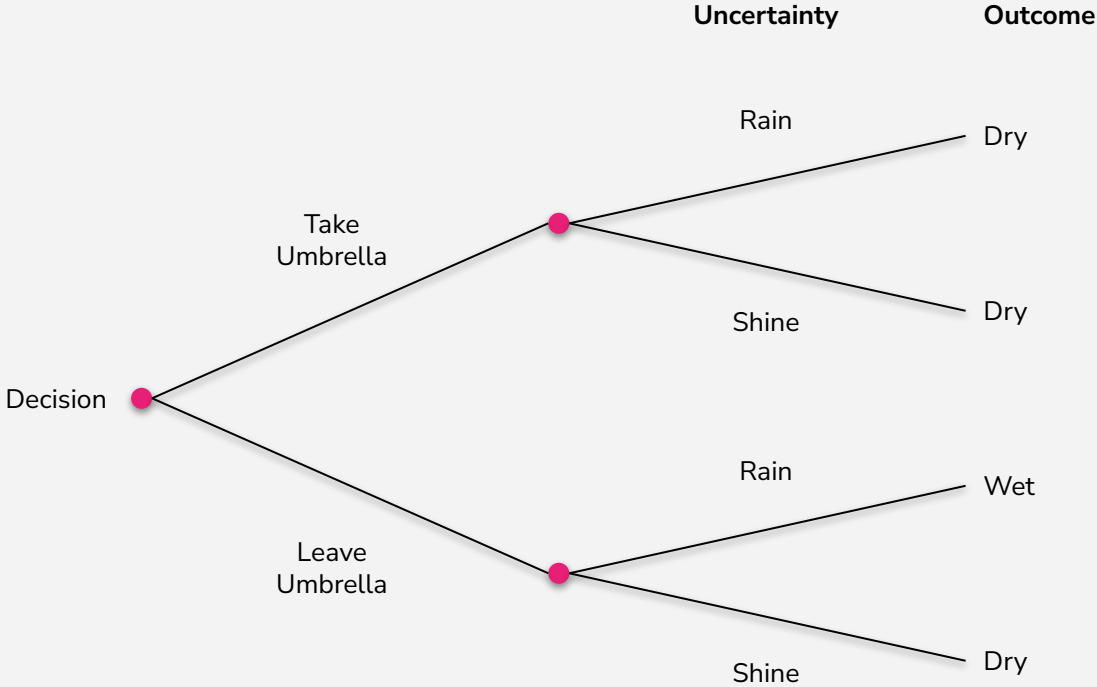
Decision
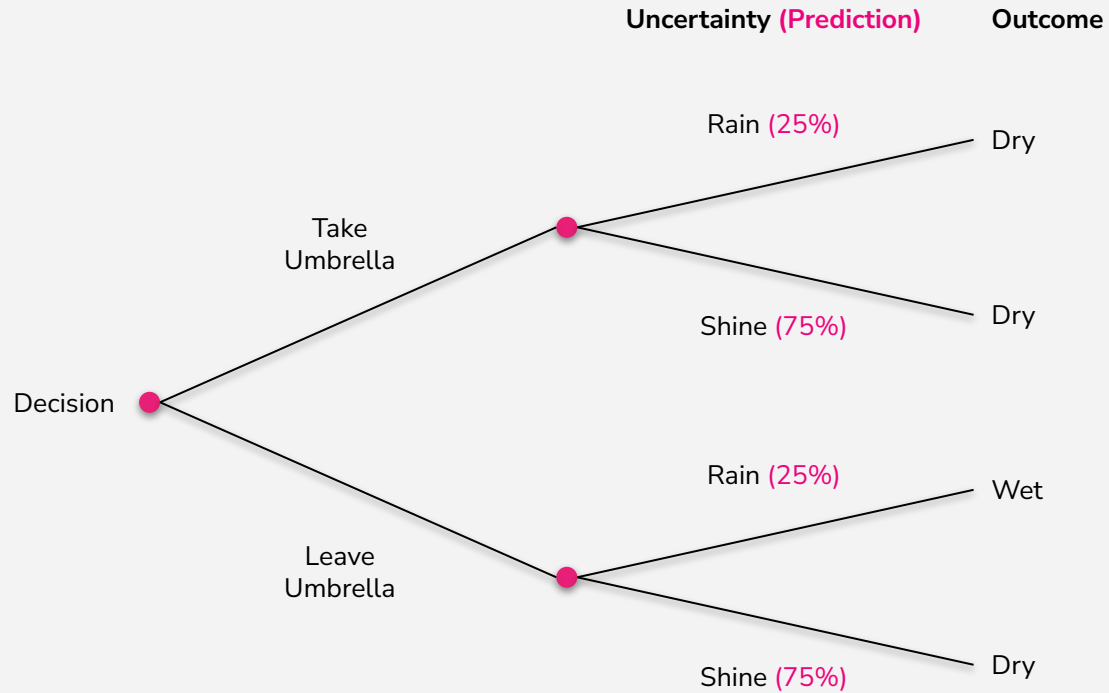
DeepMind AI accurately forecasts weather — on a desktop computer

The machine-learning model takes less than a minute to predict future weather worldwide more precisely than other approaches.

Decision Tree

Uncertainty (Prediction)   **Outcome (Judgment)**

Rain (25%) — Dry (100)

Take Umbrella

Shine (75%) — Dry (100)

Decision

Rain (25%) — Wet (-400)

Leave Umbrella

Shine (75%) — Dry (300)

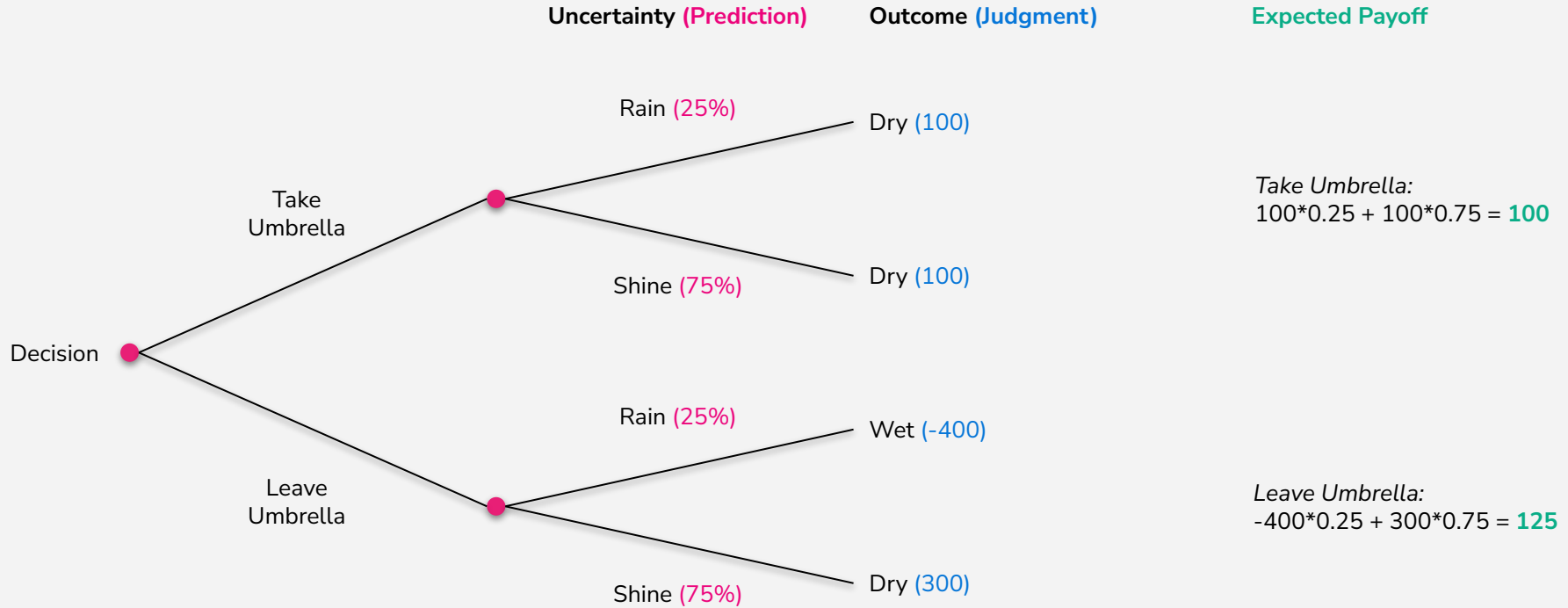# Decision Tree

Uncertainty (Prediction)   **Outcome (Judgment)**   **Expected Payoff**

Take Umbrella

Rain (25%) — Dry (100)

Shine (75%) — Dry (100)

Decision

Leave Umbrella

Rain (25%) — Wet (-400)

Shine (75%) — Dry (300)

Take Umbrella:
100*0.25 + 100*0.75 = **100**

Leave Umbrella:
-400*0.25 + 300*0.75 = **125**

Decision Tree

Uncertainty (Prediction)   **Outcome (Judgment)**   **Expected Payoff**

Rain (25%) — Dry (100)

Take Umbrella

Shine (75%) — Dry (100)

Decision

Rain (25%) — Wet (-400)

Leave Umbrella

Shine (75%) — Dry (300)

Take Umbrella:
100*0.25 + 100*0.75 = **100**

100 < 125, so Leave Umbrella

Leave Umbrella:
-400*0.25 + 300*0.75 = **125**

Decision Tree

Uncertainty (Prediction)

Outcome (Judgment)

Expected Payoff

Decision

Take Umbrella

Rain (25%) → Dry (100)

Shine (75%) → Dry (100)

Leave Umbrella

Rain (25%) → Wet (-400)

Shine (75%) → Dry (300)

Take Umbrella:
100*0.25 + 100*0.75 = **100**

*100 < 125, so **Leave Umbrella***

Leave Umbrella:
-400*0.25 + 300*0.75 = **125**

Puzzle

Where is the one place in every major city where middle income people are presented with luxury shopping, like Gucci and Prada, and ultra high net worth individuals are not?

Disruption

Every organization in every market is at risk of disruption because each has been optimized for a pre-prediction world

Disruption

Every organization is riddled with scaffolding designed to manage uncertainty

Most scaffolding is invisible

56

Winners

Organizations that are first to re-optimize for a post high fidelity prediction world will displace competitors

Why a first mover advantage?

Wait-and-See

Most organizations will take a wait-and-see approach. That's the common path. It will seem safer at first.
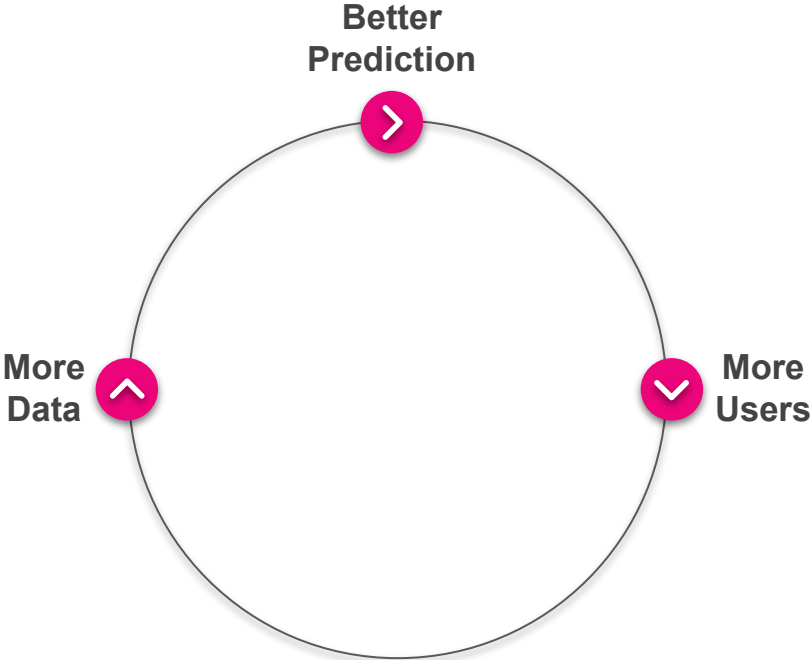
Lead

A few will travel the road less taken. They will lead. This will seem riskier at first, but early-movers collect data sooner, learn quicker, and improve faster.
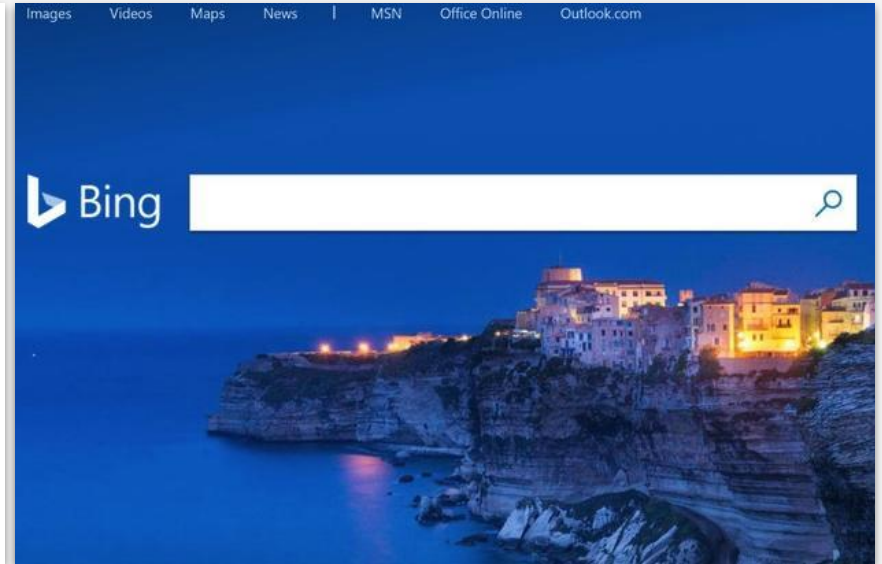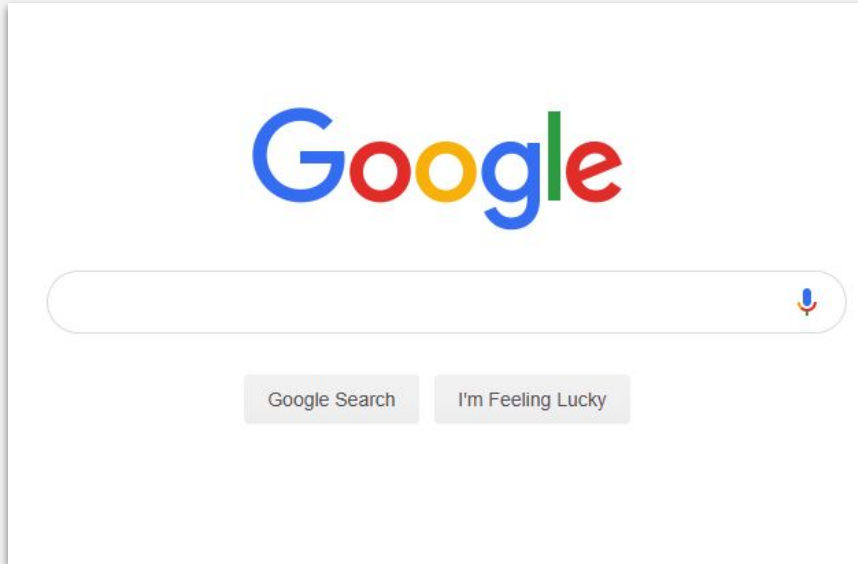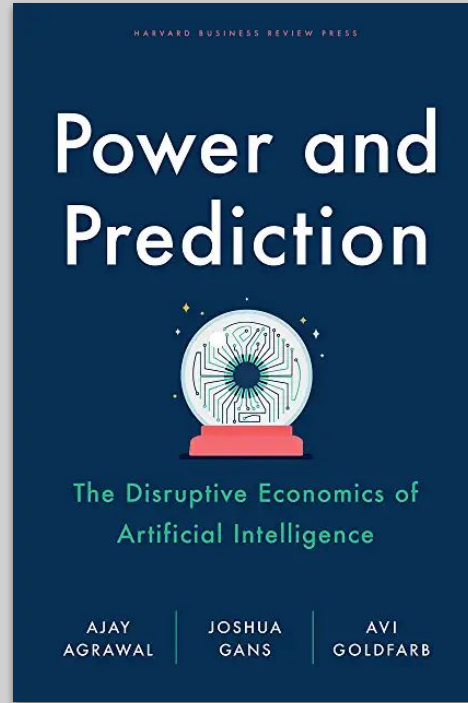
Learning by Feedback

Better Prediction

More Data

More Users

Feedback Loop

Learning to Drive via Feedback

Prediction Machines
HARVARD BUSINESS REVIEW PRESS
The Simple Economics of Artificial Intelligence
AJAY AGRAWAL | JOSHUA GANS | AVI GOLDFARB

Power and Prediction
HARVARD BUSINESS REVIEW PRESS
The Disruptive Economics of Artificial Intelligence
AJAY AGRAWAL | JOSHUA GANS | AVI GOLDFARB

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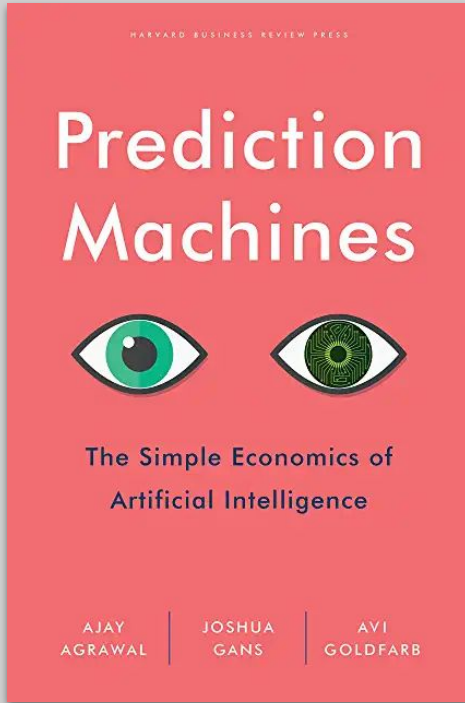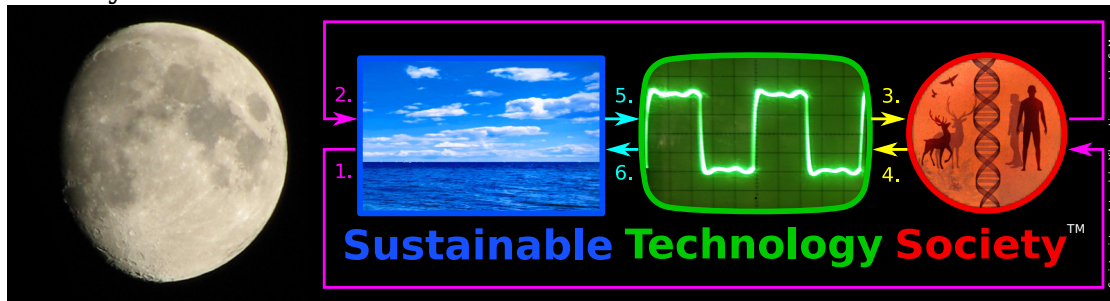
With appreciation to Steve Mann for organizing this symposium

ajay@agrawal.ca

Thank you

Mersivity = Sustainability + Technology + Society = a Sustainable Technology Society.

(moon picture, Wikimedia Commons, Kevin)

Following year's Dec. 14th Symposium, we will have our Solstice Festival on December 21st = Winter Solstice = the shortest day of the year. We'll light up the night on what might be considered the darkest day of the year.

The event will be led by Prof. Steve Mann who invented, designed, and built the world's first addressable strip of lights in his childhood more than 40 years ago, as strips of high-voltage (quick-responding) incandescent lights, gas discharge lamps, and colored LEDs that he would wave through the air to make text, images, graphics, and graphs (plots) appear, as if by magic, to the naked eye, or for photographic images (long-exposure "lightpainting" photography).

We invite flow-artists, photographers, "lightpainters" and anyone who cares about the Sustainable Technology Society to come to "The Wall" at Ontario Place and imprint some virtual "grafitti" upon the wall with lights. We will provide plenty of addressable light strips or you can send us your art and we'll "write" it upon the wall for you.

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The website was hand-coded by S. Mann, and hosted on Gitlab. The Symposium Proceedings were writtein and continue to be written in the LaTeX typesetting language, and the online conferences and discusses are done using Jitsi, a free open-source standards-based initiative. At IEEE we embrace free open-source code and standards, both of which help ensure accessibility.