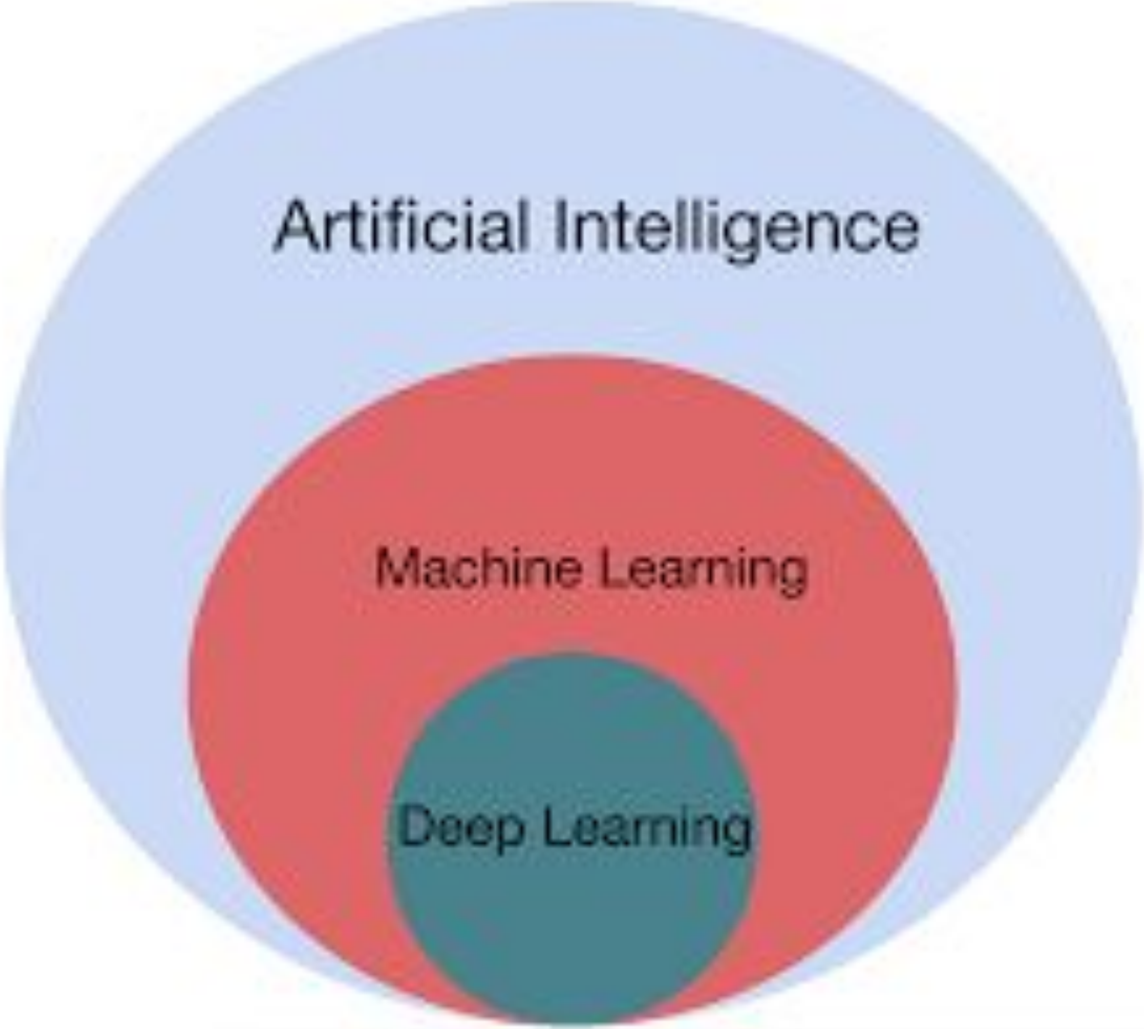
AI and Future of Computing for Humanity

Introduction to Artificial Intelligence

A.I. is a branch of Computer Science dealing with the Simulation of intelligent behaviour in Computers and Machines.

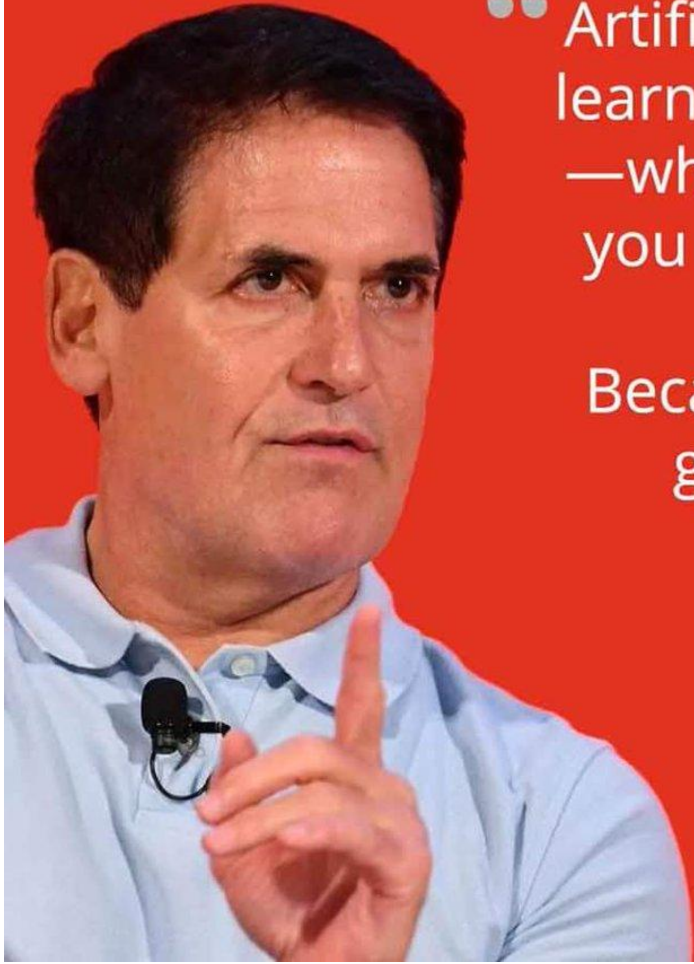

Artificial Intelligence
Machine Learning
Deep Learning

‘AI IS THE NEW ELECTRICITY’

"Just as electricity transformed almost everything 100 years ago, today I actually have a hard time thinking of an industry that I don't think AI will transform in the next several years."

Andrew Ng

Former chief scientist at Baidu, Co-founder at Coursera



“Artificial Intelligence, deep learning, machine learning —whatever you’re doing if you don’t understand it— learn [the basics] it. Because otherwise you’re going to be a dinosaur within 3 years.

~Mark Cuban

Carnegie Mellon University
Machine Learning

Introduction to Machine Learning

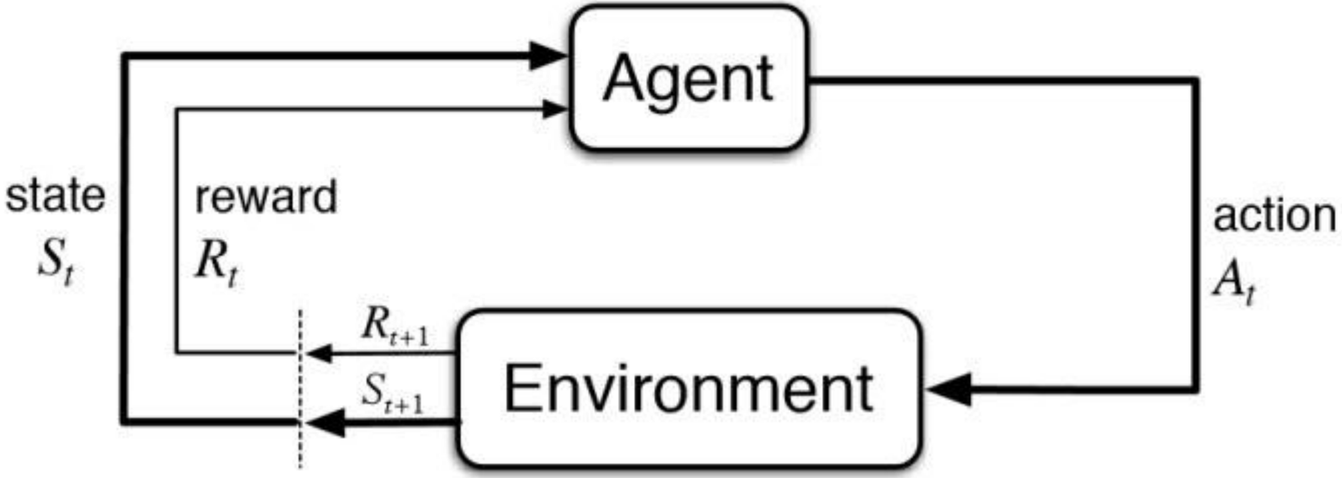
SUPERVISED LEARNING

- Linear Regression
- Gaussian Naive Bayes
- Decision Trees
- Support Vector Machine (SVM)
- Random Forest

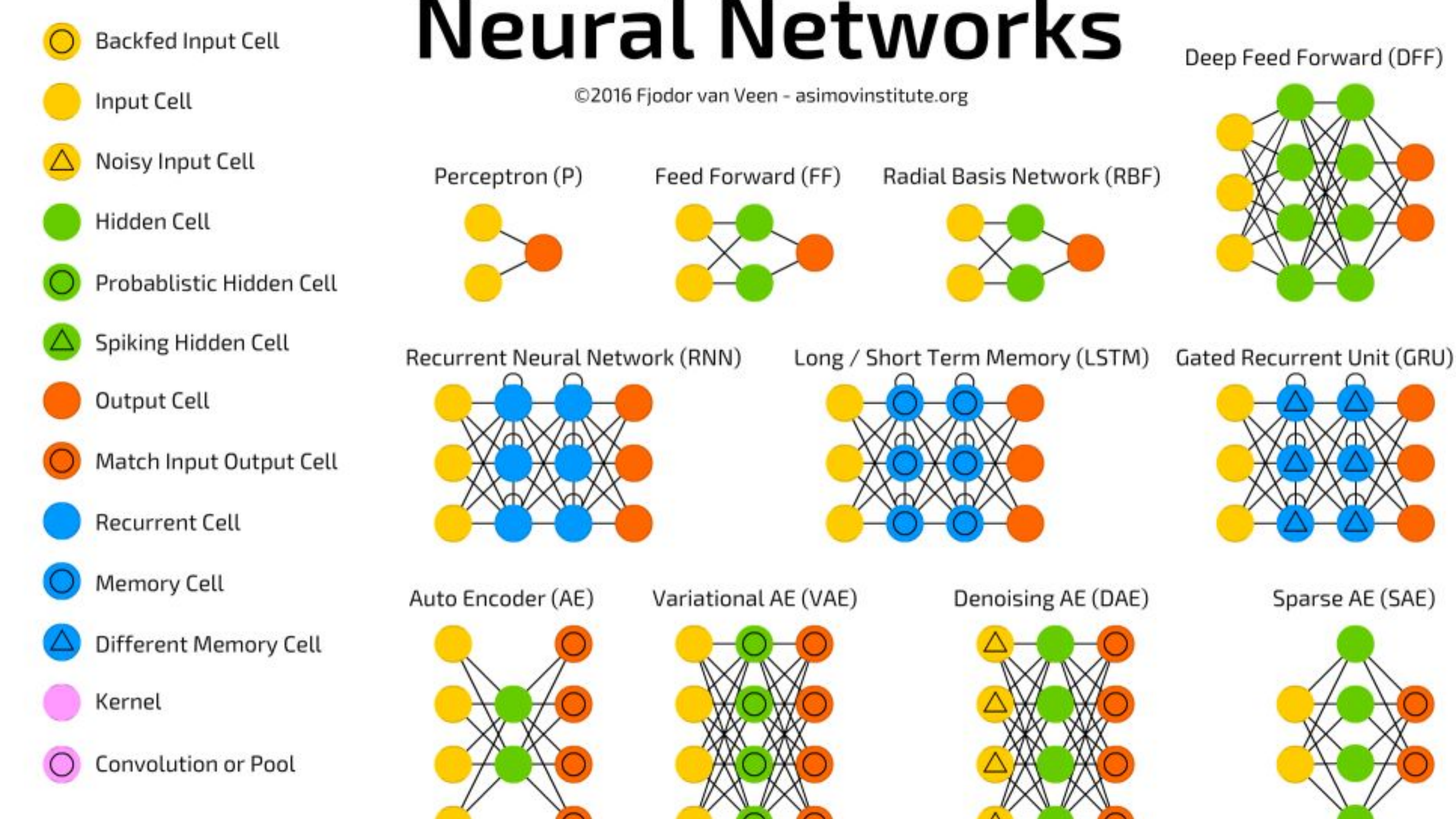
UNSUPERVISED LEARNING

- Hierarchical clustering
- K-means clustering
- K-NN (k nearest neighbors)
- Principal Component Analysis

REINFORCEMENT LEARNING


Agent
state
S_t
reward
R_t
action
A_t
R_{t+1}
S_{t+1}
Environment

INTRO TO DEEP LEARNING AND NEURAL NETWORKS


Neural Networks
©2016 Fjodor van Veen - asimovinstitute.org
Backfed Input Cell
Input Cell
Noisy Input Cell
Hidden Cell
Probablistic Hidden Cell
Spiking Hidden Cell
Output Cell
Match Input Output Cell
Recurrent Cell
Memory Cell
Different Memory Cell
Kernel
Convolution or Pool
Deep Feed Forward (DFF)
Perceptron (P)
Feed Forward (FF)
Radial Basis Network (RBF)
Recurrent Neural Network (RNN)
Long / Short Term Memory (LSTM)
Gated Recurrent Unit (GRU)
Auto Encoder (AE)
Variational AE (VAE)
Denoising AE (DAE)
Sparse AE (SAE)

HEROES OF DEEP LEARNING REVOLUTION

deeplearning.ai presents

Heroes of Deep Learning

Geoffrey Hinton

Professor at the University of Toronto
& Researcher at Google Brain

deeplearning.ai presents

Heroes of Deep Learning

Yoshua Bengio

Professor at Université de Montréal, Head of MILA, and co-founder of Element AI

deeplearning.ai presents

Heroes of Deep Learning

Yann LeCun

Chief AI Scientist at Facebook

deeplearning.ai presents

Heroes of Deep Learning

Andrej Karpathy

Director of AI at Tesla

the RACE to AUTONOMY

WAYMO VS

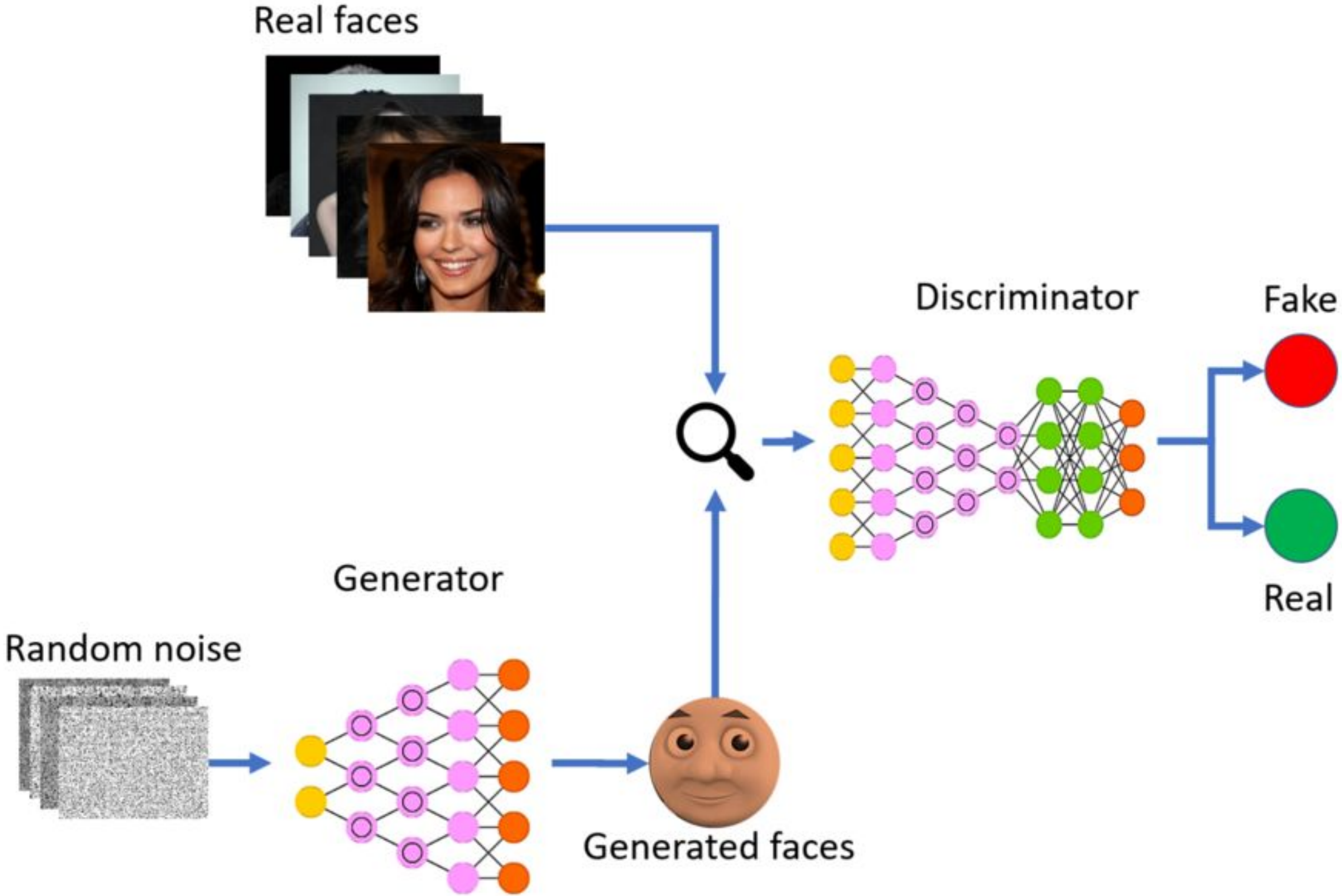
deeplearning.ai presents

Heroes of Deep Learning

Ian Goodfellow

Research Scientist at Google Brain

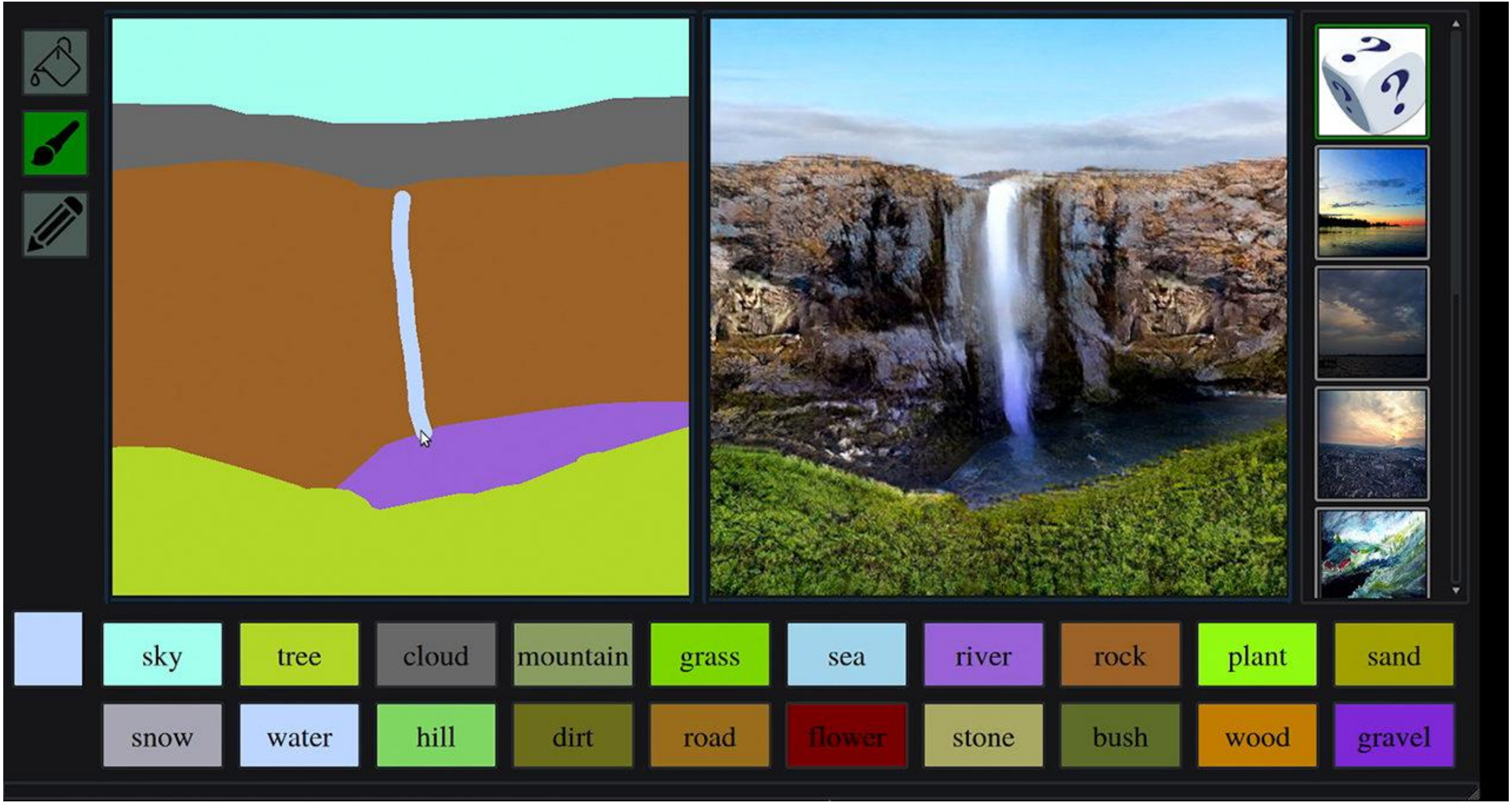
ADVENT OF GANS (GENERATIVE ADVERSARIAL NETWORKS)



Real faces
Discriminator
Fake
Real
Generator
Random noise
Generated faces

NVIDIA®

AI

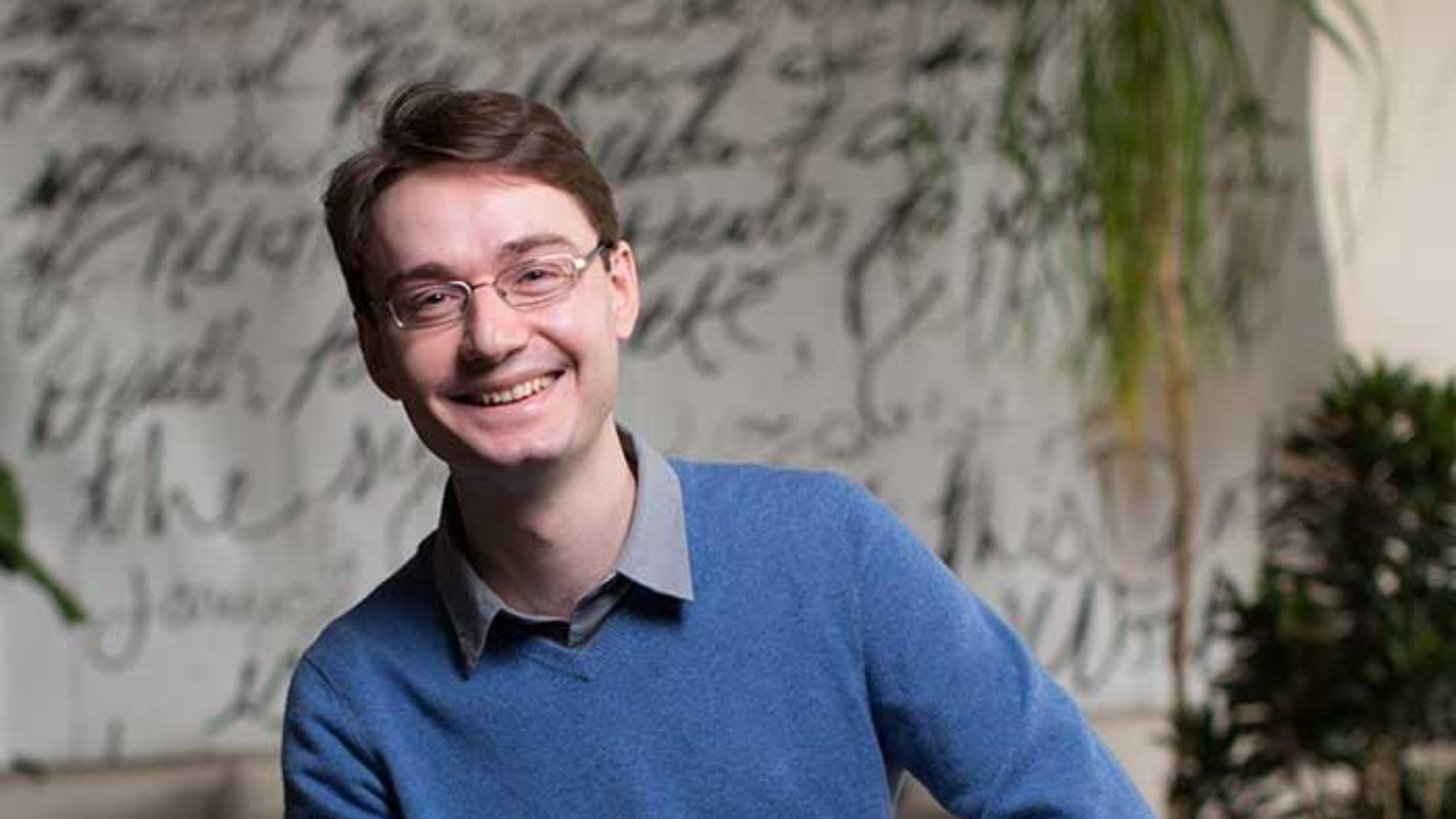

sky
tree
cloud
mountain
grass
sea
river
rock
plant
sand
snow
water
hill
dirt
road
flower
stone
bush
wood
gravel

DEEP LEARNING FRAMEWORKS AND WHICH ONE TO CHOOSE

TensorFlow

theano

PYTORCH



Keras

RECENT ADVANCEMENTS IN MACHINE LEARNING AND DEEP LEARNING

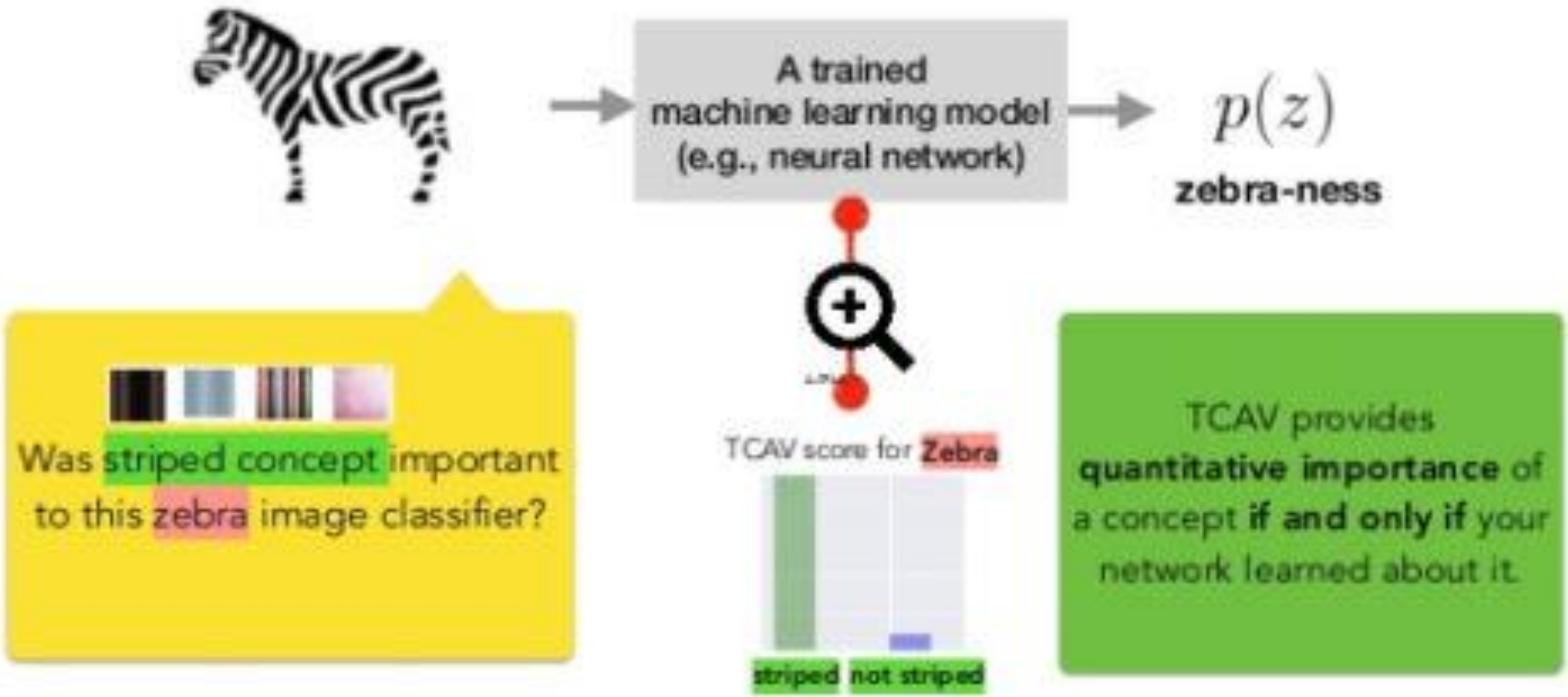
Google AI

Google

BERT

Federated Learning

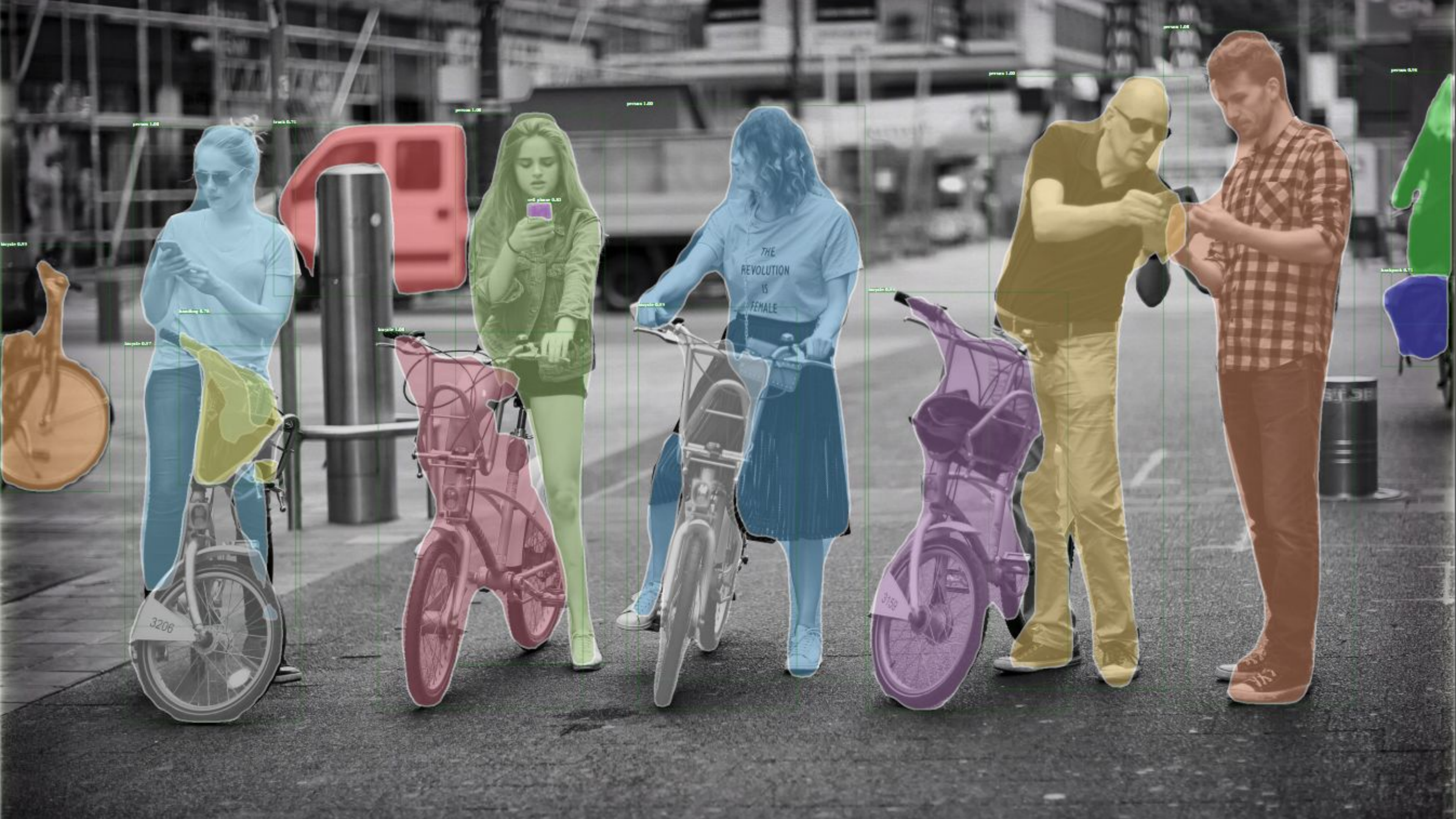
Testing with Concept Activation Vectors



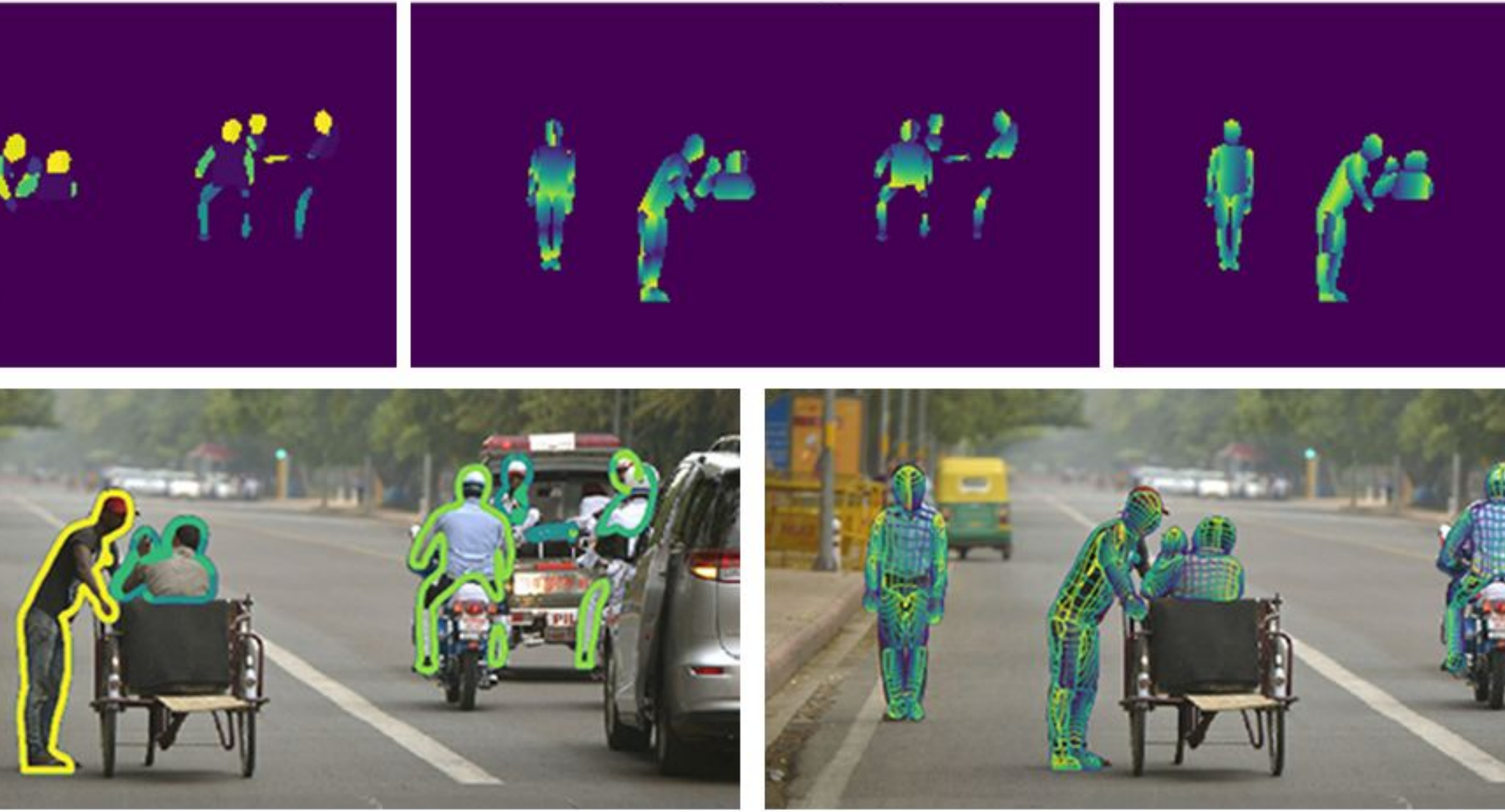
DeepMind Health

Facebook AI Research

DETECTRON AND DETECTRON2

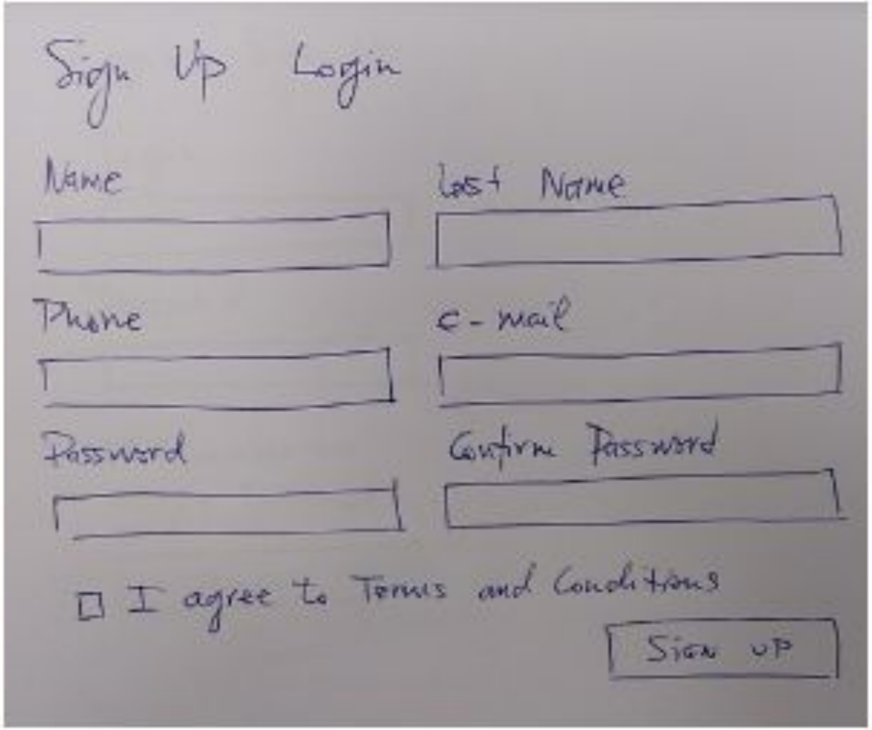

THE
REVOLUTION
IS
FEMALE
3206
3159

DENSE POSE AND HUMAN POSE ESTIMATION

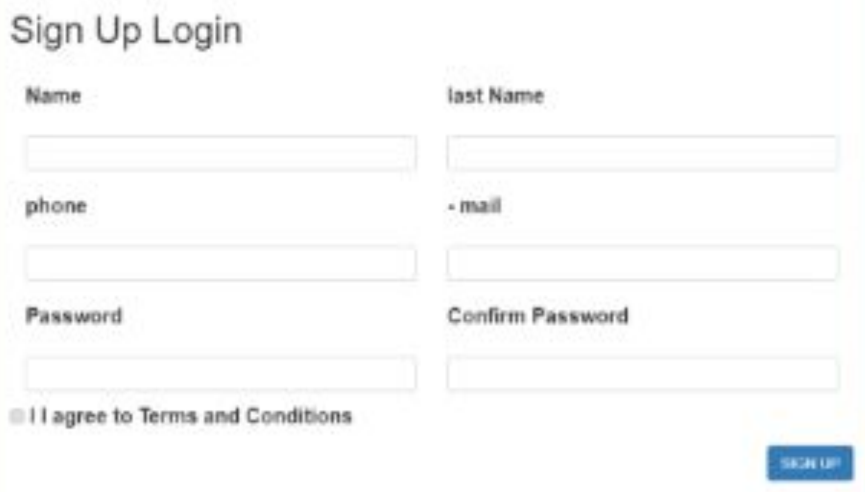


Microsoft Research AI

YOUR SKETCH

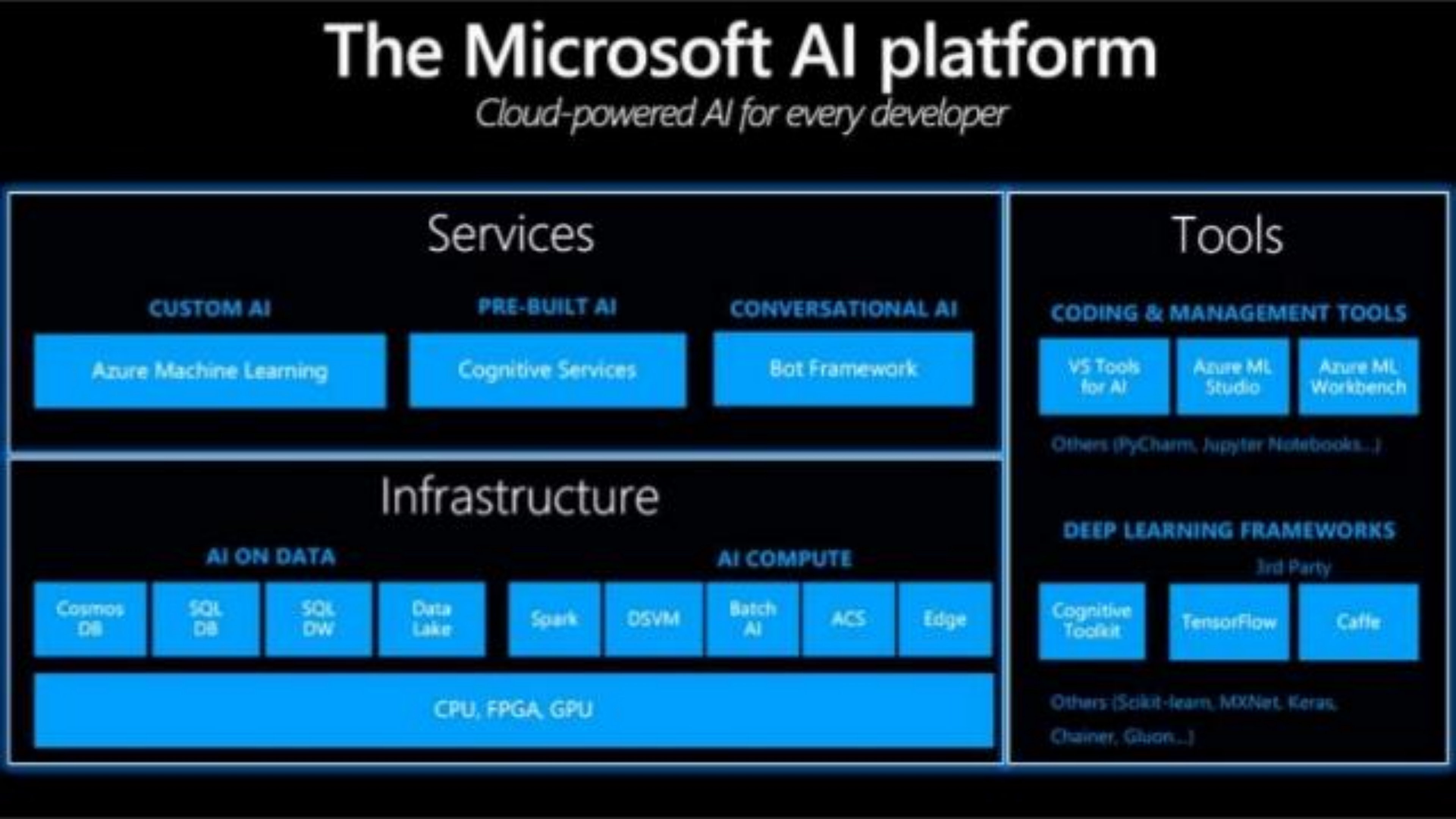


YOUR HTML



Microsoft

AI for Good

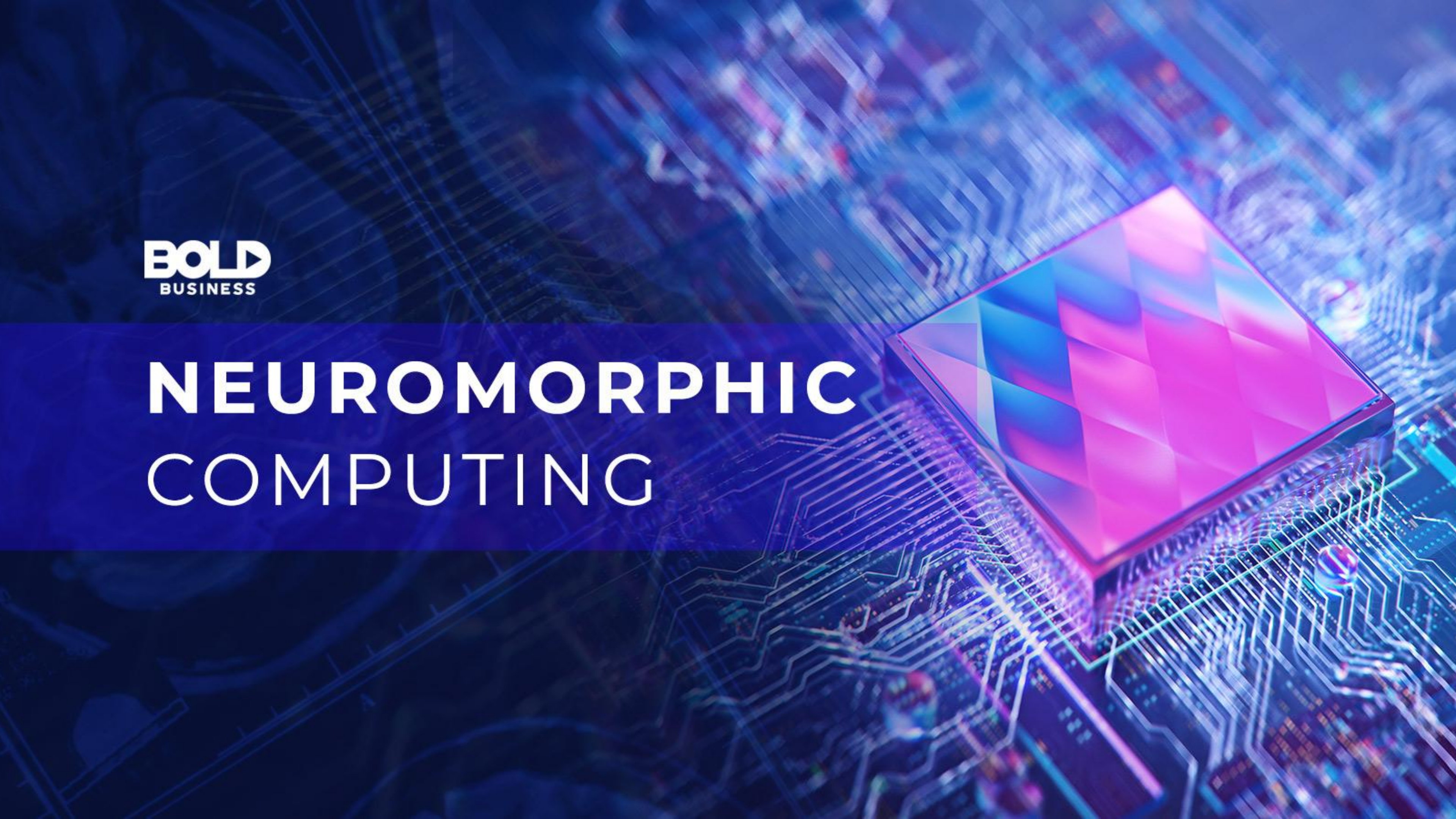

The Microsoft AI platform
Cloud-powered AI for every developer
Services
CUSTOM AI
Azure Machine Learning
PRE-BUILT AI
Cognitive Services
CONVERSATIONAL AI
Bot Framework
Infrastructure
AI ON DATA
Cosmos DB
SQL DB
SQL DW
Data Lake
AI COMPUTE
Spark
DSVM
Batch AI
ACS
Edge
CPU, FPGA, GPU
Tools
CODING & MANAGEMENT TOOLS
VS Tools for AI
Azure ML Studio
Azure ML Workbench
Others (PyCharm, Jupyter Notebooks...)
DEEP LEARNING FRAMEWORKS
3rd Party
Cognitive Toolkit
TensorFlow
Caffe
Others (Scikit-learn, MXNet, Keras, Chainer, Gluon...)

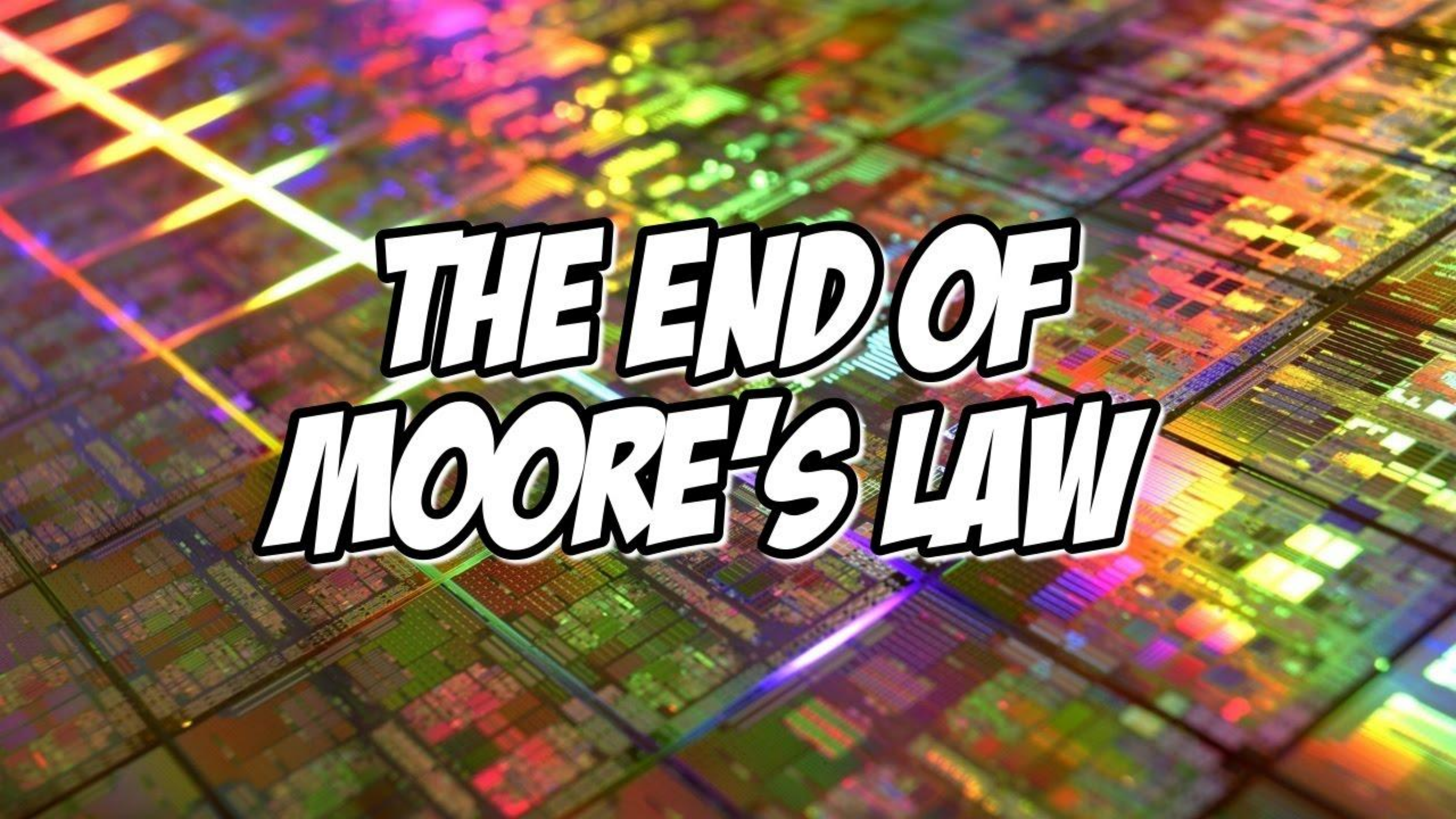
OpenAI

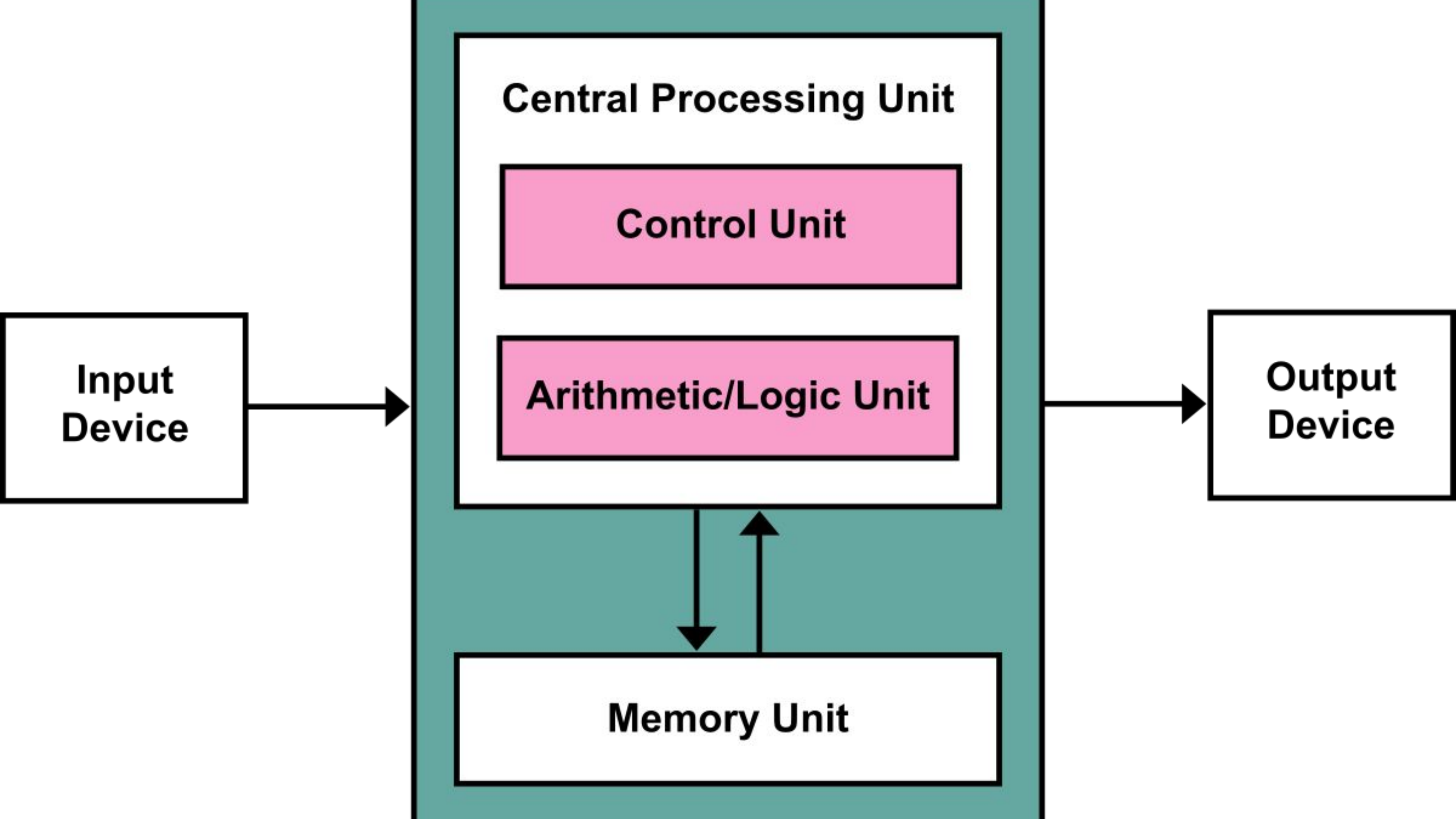
Microsoft

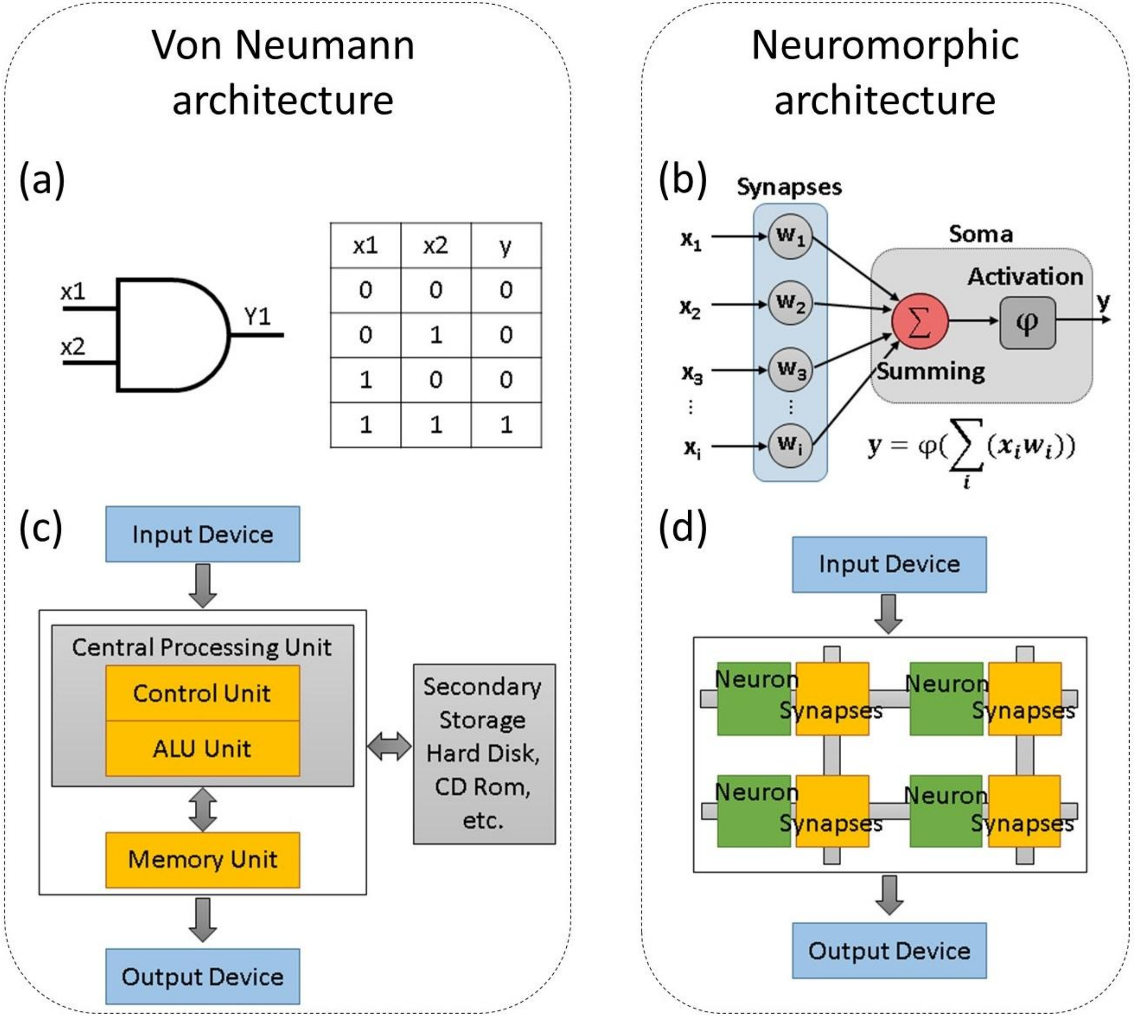
ML.NET

FUTURE OF COMPUTING FOR HUMANITY AND BEYOND

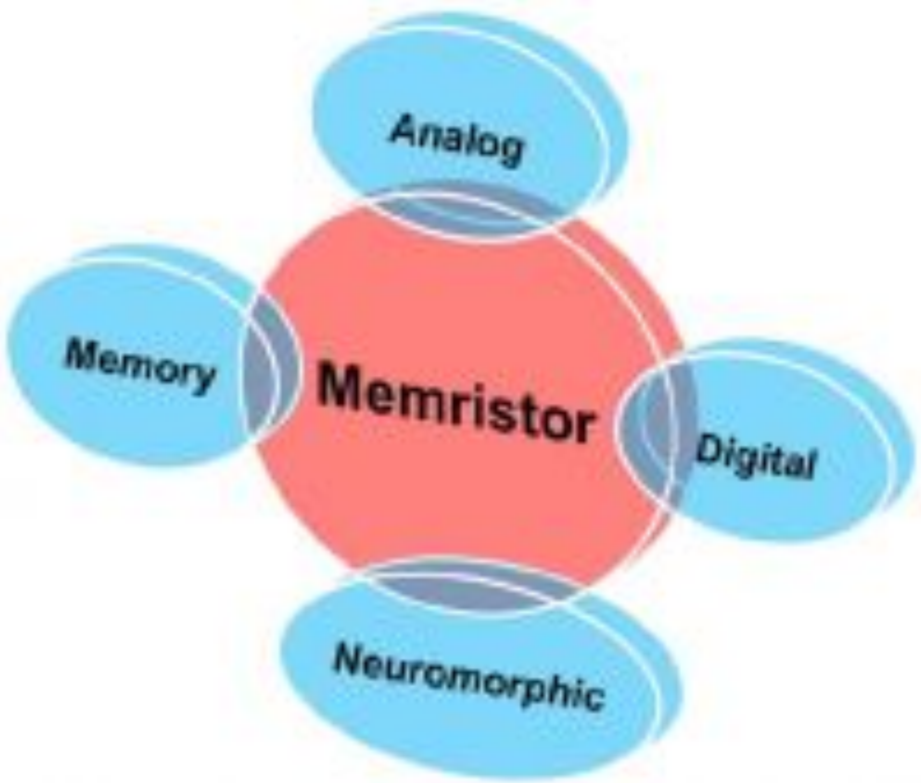

BOLD
BUSINESS
NEUROMORPHIC
COMPUTING


THE END OF
MOORE'S LAW


Central Processing Unit
Control Unit
Arithmetic/Logic Unit
Input Device
Output Device
Memory Unit


Von Neumann architecture
Neuromorphic architecture
(a)
x1
x2
Y1
x1 x2 y
0 0 0
0 1 0
1 0 0
1 1 1
(b)
Synapses
Soma
Activation
Summing
x_1 x_2 x_3 x_i
w_1 w_2 w_3 w_i
φ
y
$y = \varphi(\sum_i (x_i w_i))$
(c)
Input Device
Central Processing Unit
Control Unit
ALU Unit
Memory Unit
Secondary Storage Hard Disk, CD Rom, etc.
Output Device
(d)
Input Device
Neuron
Synapses
Output Device

INTRODUCING MEMRISTORS


Analog
Memory
Memristor
Digital
Neuromorphic

WHAT TO USE AS A MEMRISTOR

- GRAPHENE NANOSTRUCTURES
- OPTO ELECTRONICS

PREDICTION TIME

WE WILL USE SINGLE CELL ORGANISMS AND LIVING MEMRISTORS

Amplifying Genetic Logic Gates

Jerome Bonnet, Peter Yin,* Monica E. Ortiz, Pakpoom Subsoontorn, Drew Endy†

Organisms must process information encoded via developmental and environmental signals to survive and reproduce. Researchers have also engineered synthetic genetic logic to realize simpler, independent control of biological processes. We developed a three-terminal device architecture, termed the transcriptor, that uses bacteriophage serine integrases to control the flow of RNA polymerase along DNA. Integrase-mediated inversion or deletion of DNA encoding transcription terminators or a promoter modulates transcription rates. We realized permanent amplifying AND, NAND, OR, XOR, NOR, and XNOR gates actuated across common control signal ranges and sequential logic supporting autonomous cell-cell communication of DNA encoding distinct logic-gate states. The single-layer digital logic architecture developed here enables engineering of amplifying logic gates to control transcription rates within and across diverse organisms.

Researchers have used genetically encoded logic, data storage, and cell-cell communication to study and reprogram living systems, explore biomolecular computing, and improve cellular therapeutics (*1–9*). Most approaches to engineering cell-based logic champion two-terminal device architectures upon which gate-gate layering, similar to conventional electronics, is used to realize all logic functions (*10*, *11*). Despite recent advances (*11*, *12*), such designs are difficult to scale because of problems associated with reusing regulatory molecules within the self-mixing environments of individual cells. As representative examples, a single-cell two-input "exclusive or" (XOR) gate, a function whose output is high only if the inputs are different, required controlled expression of four gate-specific regulatory molecules from four plasmids (*12*); an amplifying "exclusive nor" (XNOR) gate, high output only if inputs are equal, has not been demonstrated within single cells (*10*).

Department of Bioengineering, Y2E2-269B, 473 Via Ortega, Stanford, CA 94305–4201, USA.

*Present address: Department of Biology, University of Pennsylvania, Philadelphia, PA 19104, USA.

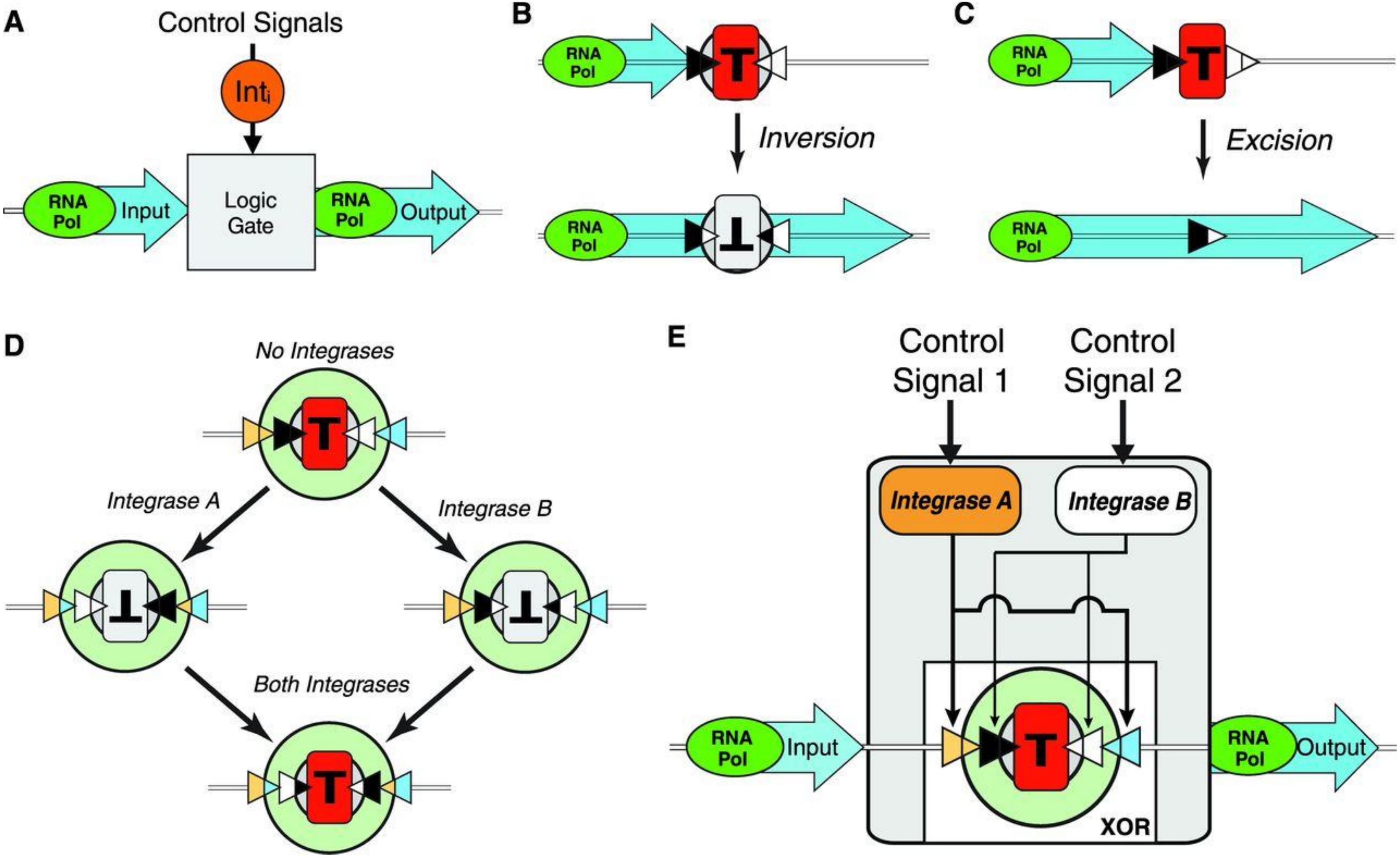
†Corresponding author. E-mail: endy@stanford.edu

We instead sought a device architecture in which the same regulatory molecules could be simply reused to implement all logic gates within a single logic layer (*13*). We also sought to decouple the signals controlling gate switching from gate inputs and outputs. Realizing both goals would enable straightforward engineering of distinct gates with constant switching thresholds and support signal gain and amplification if desired. Lastly, we wanted all gate signals to be encoded via a common signal carrier supporting connectivity within natural systems and across a diverse family of engineered genetic devices (*14*).

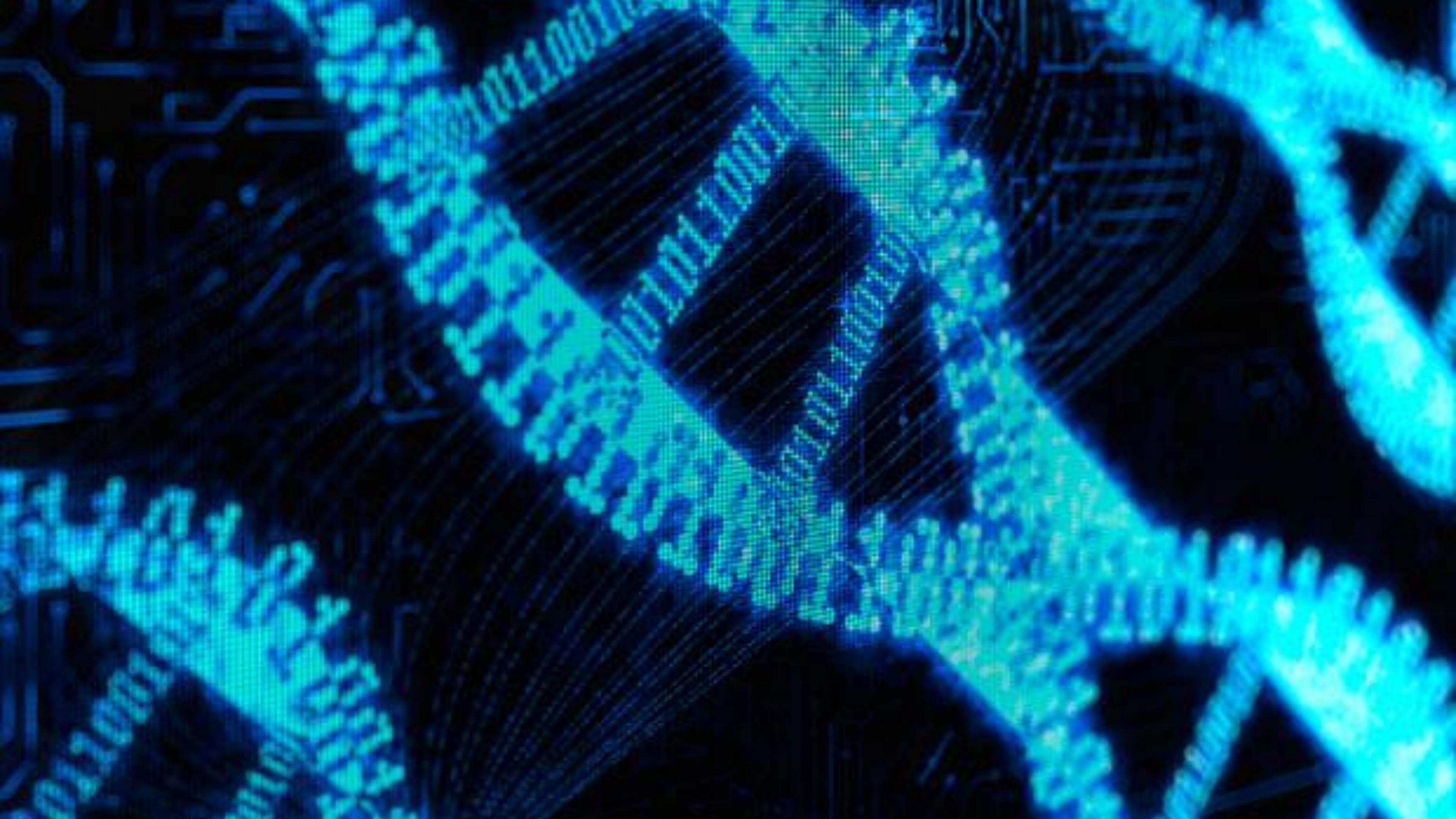
We combined earlier concepts (*14–17*) to invent a transistor-like three terminal device (*18*) termed the transcriptor. Independent control signals govern transcriptor logic elements that regulate transcriptional "current," defined by the flow of RNA polymerase along DNA (Fig. 1A). Gate input and output signals are transcription rates at positions on DNA marking logic element boundaries. Logic elements use asymmetric transcription terminators as reversible check valves that disrupt RNA polymerase flow in only one of two possible orientations (Fig. 1B). Recombinases catalyze unidirectional inversion of DNA within opposing recognition sites (Fig. 1B) or dele of DNA between aligned sites (Fig. 1C), viding independent control over the orienta or presence of one or more terminators. St differently, we developed a device architec similar to a transistor but leveraged unique p erties of genetic regulation to implement all g without requiring that multiple instances of pler gates be connected in series (i.e., wit layering) (*18*, *19*).

For example, a transcriptor XOR logic ment requires bracketing one asymmetric t scription terminator with two pairs of oppo recombination sites recognized by indepen integrases (Fig. 1D). If neither integrase is pressed, then the terminator blocks transcrip (Fig. 1D, top). Expression of either integrase a inverts the DNA encoding the terminator allows transcription to flow through the t scriptor (Fig. 1D, middle). Expression of l integrases inverts and then restores the orig orientation of the terminator, again blocking t scription (Fig. 1D, bottom). A complete X gate requires placing an XOR logic elen within a three-terminal device in which integ expression is controlled by two independent trol signals (Fig. 1E).

We designed additional transcriptor logic ments encoding Boolean OR, NOR, XNOR, AND functions for use within a common architecture (Fig. 2 and fig. S1). Straightforv changes only to logic element DNA were ficient to design functionally distinct gates pected to be responsive to identical control sig Designing a transcriptor-only "not and" (NA element, low output only if both control sig are high, proved more challenging. We ins used a hybrid architecture that combines flip of a terminator along with a constitutive moter. Although noncanonical, the NAND still responds to the same control signals w exhibiting varied output levels (below).

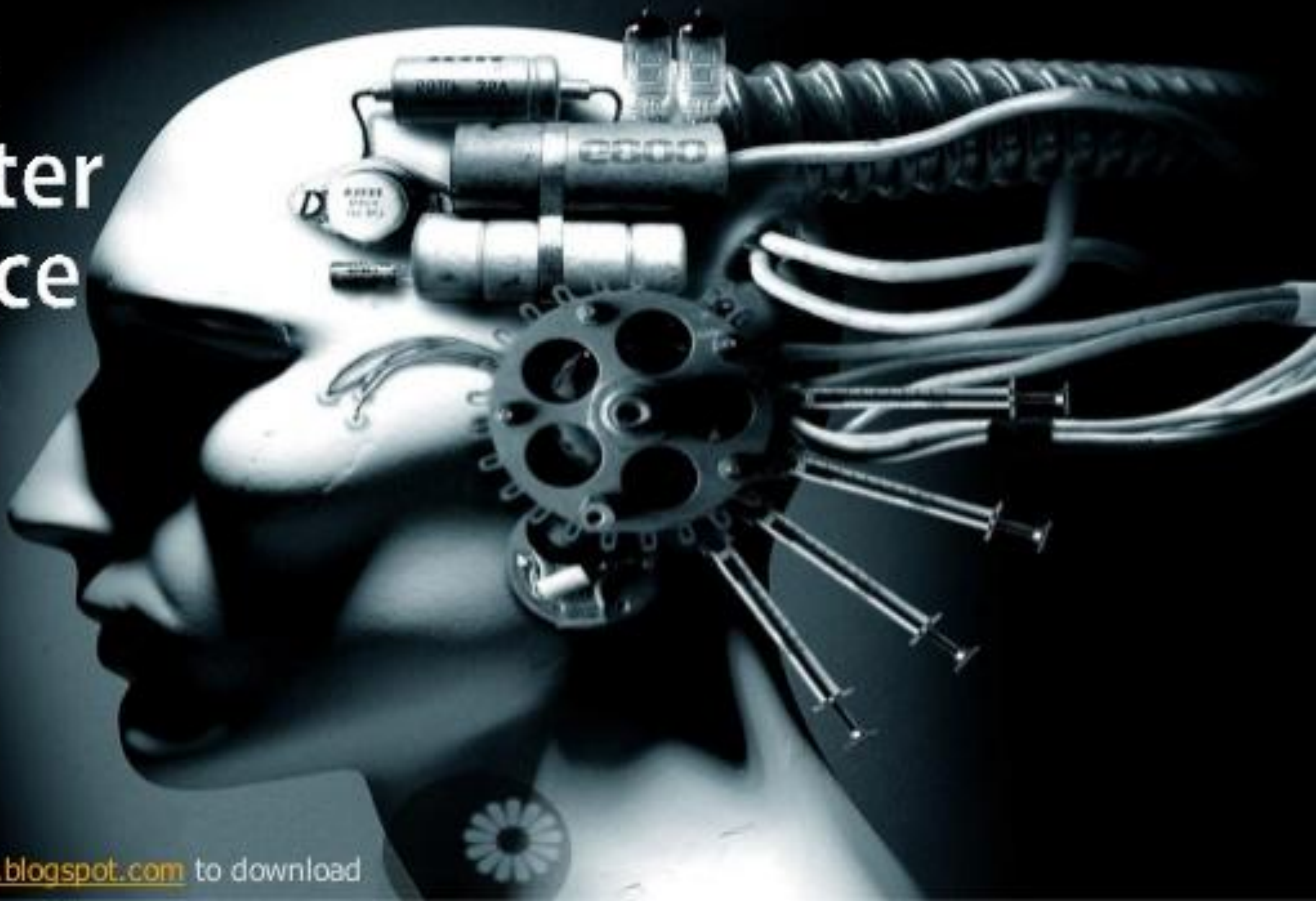


A
Control Signals
Intᵢ
RNA Pol
Input
Logic Gate
RNA Pol
Output
B
RNA Pol
T
Inversion
RNA Pol
T
C
RNA Pol
T
Excision
RNA Pol
D
No Integrases
T
Integrase A
Integrase B
T
T
Both Integrases
T
E
Control Signal 1
Control Signal 2
Integrase A
Integrase B
RNA Pol
Input
T
RNA Pol
Output
XOR



SINGLE GRAM OF DNA CAN STORE 215 PETABYTES OF DATA

Brain Computer Interface (BCI)



NEURALINK

kernel


QUANTUM COMPUTING

Quantum Mechanical Computers

By Richard P. Feynman

Introduction

This work is a part of an effort to analyze the physical limitations of computers due to the laws of physics. For example, Bennett[1] has made a careful study of the free energy dissipation that must accompany computation. He found it to be virtually zero. He suggested to me the question of the limitations due to quantum mechanics and the uncertainty principle. I have found that, aside from the obvious limitation to size if the working parts are to be made of atoms, there is no fundamental limit from these sources either.

We are here considering ideal machines; the effects of small imperfections will be considered later. This study is one of principle; our aim is to exhibit some Hamiltonian for a system which could serve as a computer. We are not concerned with whether we have the most efficient system, nor how we could best implement it.

Since the laws of quantum physics are reversible in time, we shall have to consider computing engines which obey such reversible laws. This problem already occurred to Bennett[1], and to Fredkin and Toffoli[2], and a great deal of thought has been given to it. Since it may not be familiar to you here, I shall such. We see we really have two more logical primitives, FAN OUT when two wires are connected to one, and EXCHANGE, when wires are crossed. In the usual computer the NOT and NAND primitives are implemented by transistors, possibly as in Fig. 2.

What is the minimum free energy that must be expended to operate an ideal computer made of such primitives? Since, for example, when the AND operates the output line, c' is being determined to be one of two values no matter what it was before the entropy change is $ln(2)$ units. This represents a heat generation of $kT\,ln(2)$ at temperature T. For many years it was thought that this represented an absolute minimum to the quantity of heat per primitive step that had to be dissipated in making a calculation.

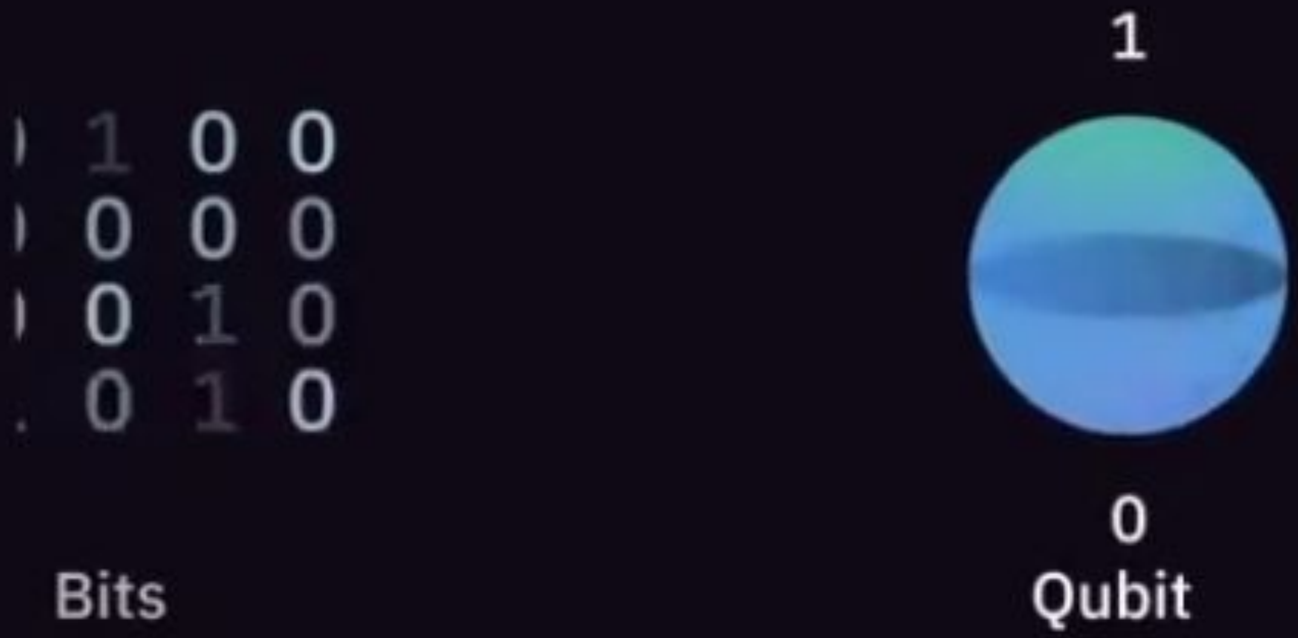
The question is academic at this time. In actual machines we are quite concerned with the heat dissipation question, but the transistor system used actually dissipates about $10^{10}kT$! As Bennett[3] has pointed out, this arises because to change a wire's voltage we dump it to ground through a resistance; and to build it up again we feed charge, again through a resistance, to the wire. It could be greatly reduced if energy

could be stored in an inductance, or other reactive element.

However, it is apparently very difficult to make inductive elements on silicon wafers with present techniques. Even Nature, in her DNA copying machine, dissipates about 100 kT per bit copied. Being, at present, so very far from this $kT\,ln(2)$ figure, it seems ridiculous to argue that even this is too high and the minimum is really essentially zero. But, we are going to be even more ridiculous later and consider bits written on one atom instead of the present 10^{11} atoms. Such nonsense is very entertaining to professors like me. I hope you will find it interesting and entertaining also.

What Bennett pointed out was that this former limit was wrong because it is not necessary to use irreversible primitives. Calculations can be done with reversible machines containing only reversible primitives. If this is done the minimum free energy required is independent of the complexity or number of logical steps in the calculation. If anything, it is kT per bit of the output answer.

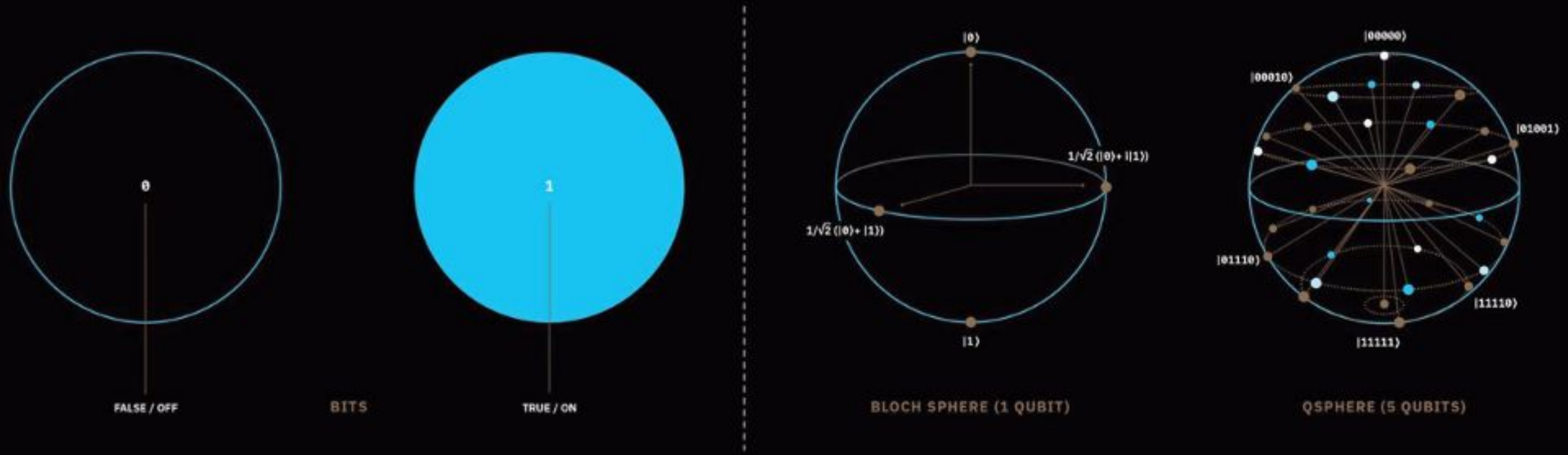
But even this, which might be considered the free energy needed to clear the computer for further use, might also be considered as part of what you are going to do with the answer—the informa-


1 0 0
0 0 0
0 1 0
0 1 0
Bits
1
0
Qubit

Why is quantum different?

1. Superposition

N qubits
2^N paths



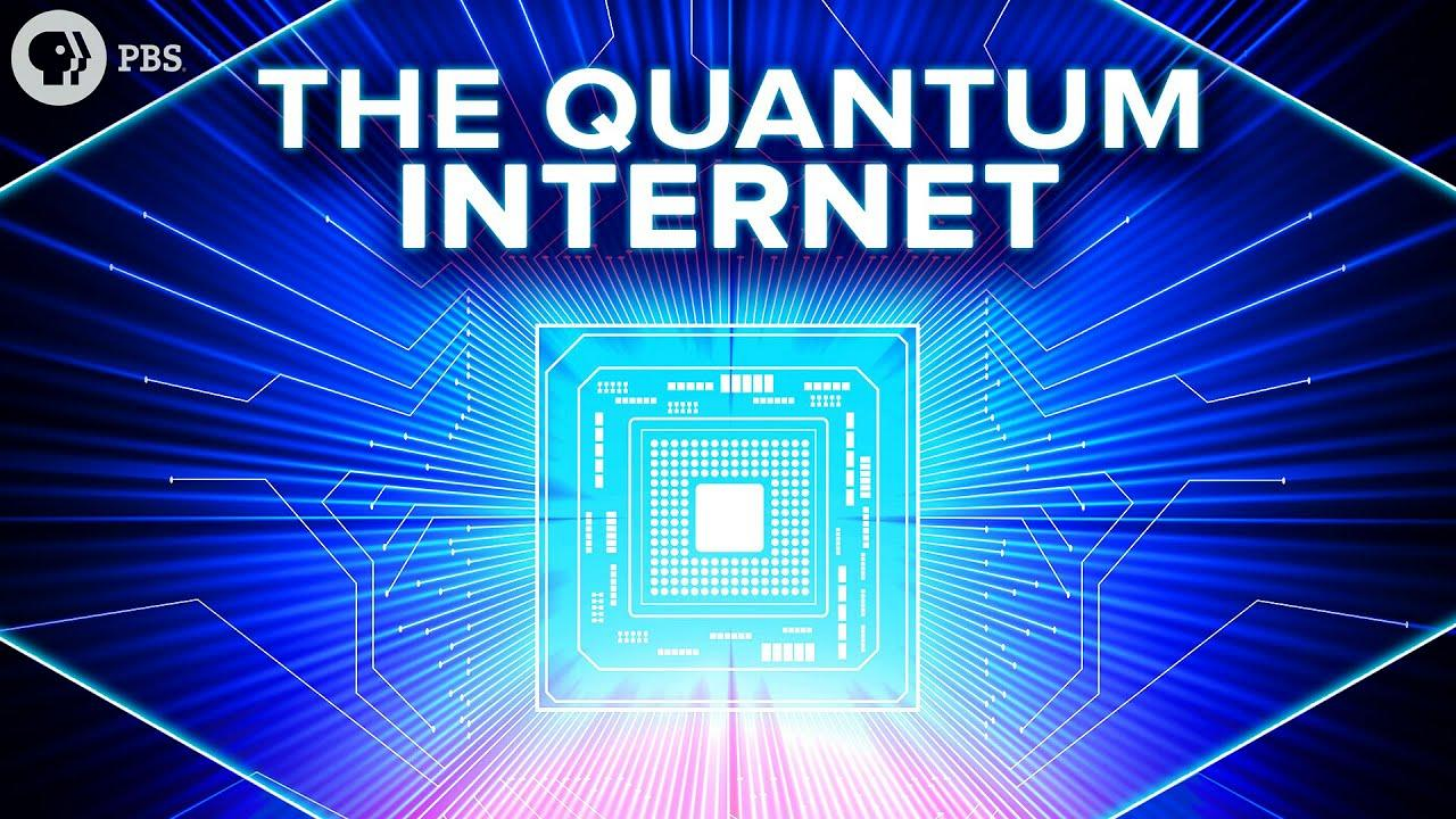
Classical states

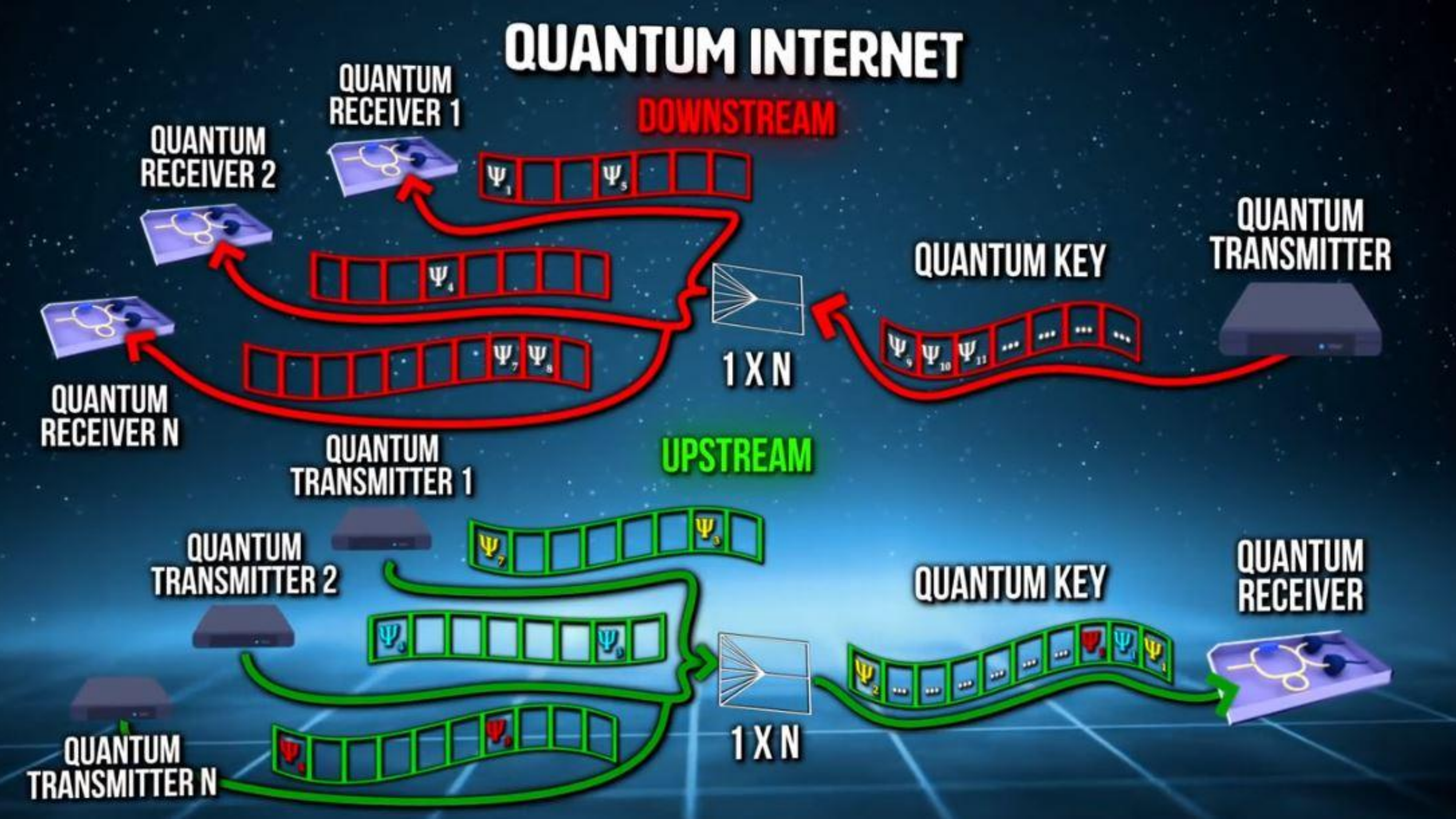
Quantum states


QUANTUM
ENTANGLEMENT
A MYSTERY OF CONNECTIONS

IT COULD BE THE CASE THAT ALL LIVING THINGS ARE CONNECTED THROUGH QUANTUM ENTANGLEMENT. SO,CONSCIOUSNESS NOT MATTER IS FUNDAMENTAL TO NATURE OF REALITY.

WE STILL NOT KNOW YET.


PBS
THE QUANTUM
INTERNET

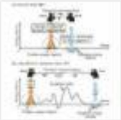

QUANTUM INTERNET
QUANTUM RECEIVER 1
DOWNSTREAM
QUANTUM RECEIVER 2
QUANTUM TRANSMITTER
QUANTUM KEY
1 X N
QUANTUM RECEIVER N
QUANTUM TRANSMITTER 1
UPSTREAM
QUANTUM TRANSMITTER 2
QUANTUM KEY
QUANTUM RECEIVER
1 X N
QUANTUM TRANSMITTER N

Quantum energy teleportation without a limit of distance

Masahiro Hotta, Jiro Matsumoto, and Go Yusa
Phys. Rev. A **89**, 012311 – Published 13 January 2014

ABSTRACT

Quantum energy teleportation (QET) is, from the operational viewpoint of distant protocol users, energy transportation via local operations and classical communication. QET has various links to fundamental research fields including black-hole physics, the quantum theory of Maxwell's demon, and quantum entanglement in condensed-matter physics. However, the energy that has been extracted using a previous QET protocol is limited by the distance between two protocol users; the upper bound of the energy being inversely proportional to the distance. In this paper, we prove that introducing squeezed vacuum states with local vacuum regions between the two protocol users overcomes this limitation, allowing energy teleportation over practical distances.



Received 16 May 2013 Revised 8 August 2013

DOI: https://doi.org/10.1103/PhysRevA.89.012311


D:Wave
2000Q
D:Wave
D:Wave
2000Q


Q
IBM Q

Azure Quantum

Announcing

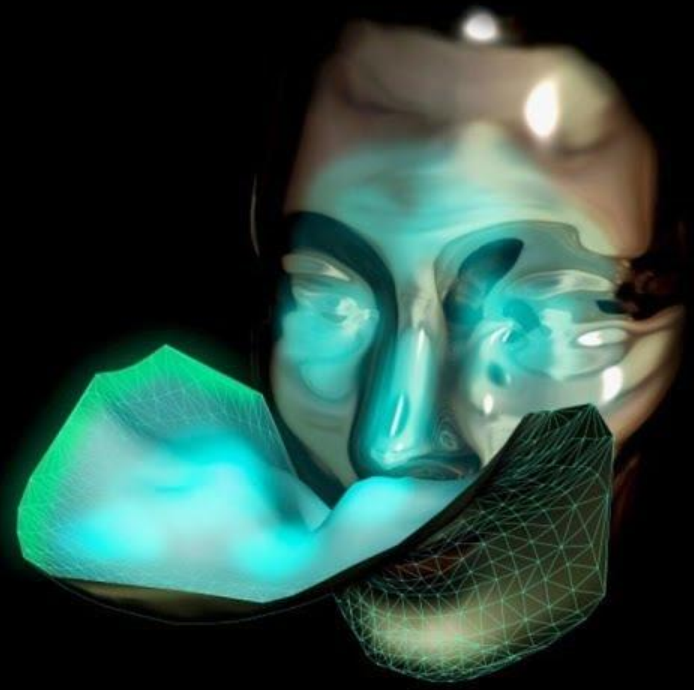
Microsoft


Google
Bristlecone

GOOGLE SYCAMORE

UPCOMING ADVANCEMENTS OF THE NEXT DECADE


Quantum
Machine Learning
The Next Big Thing



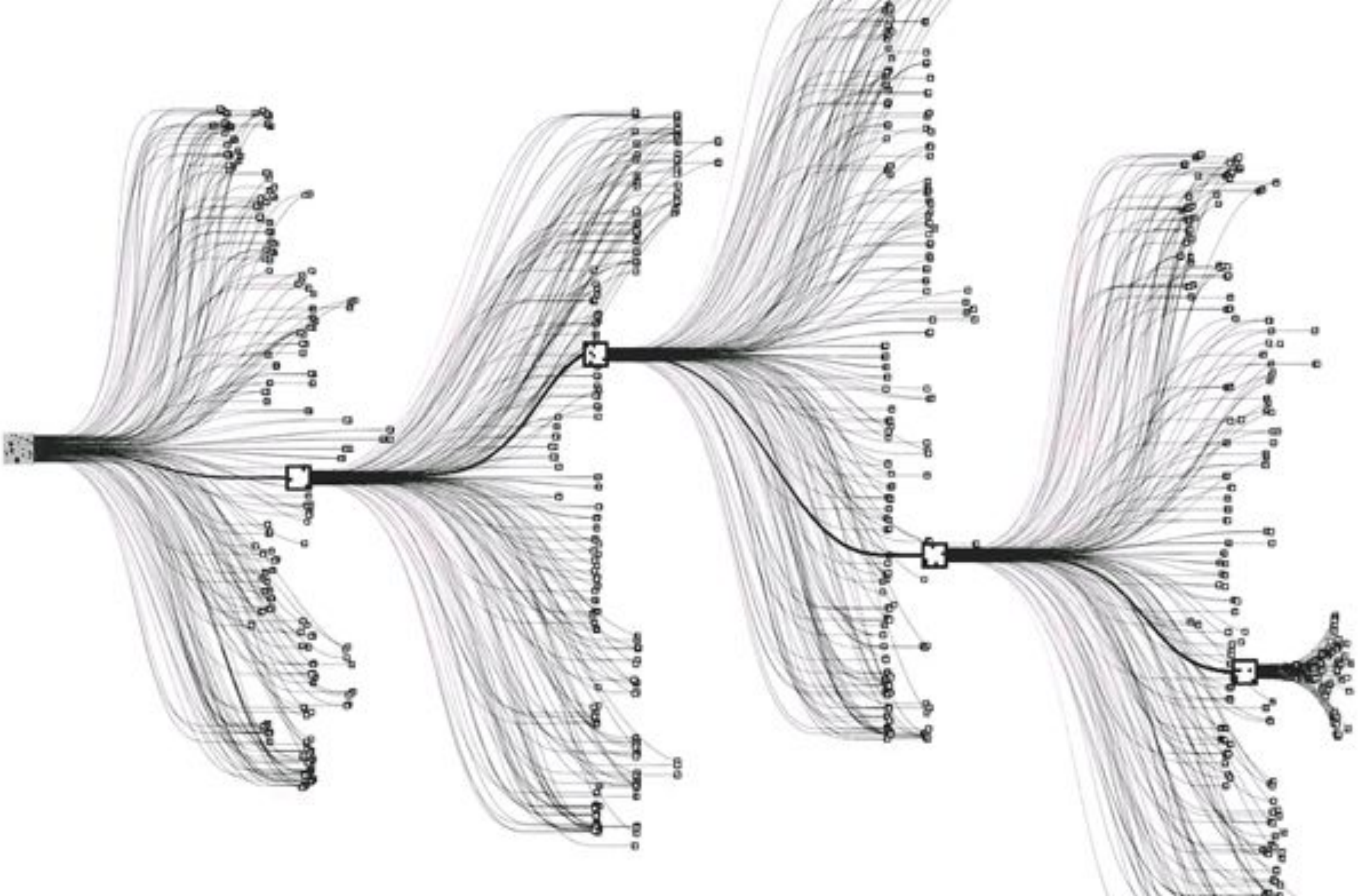
Geometric deep learning

Michael Bronstein


AGI

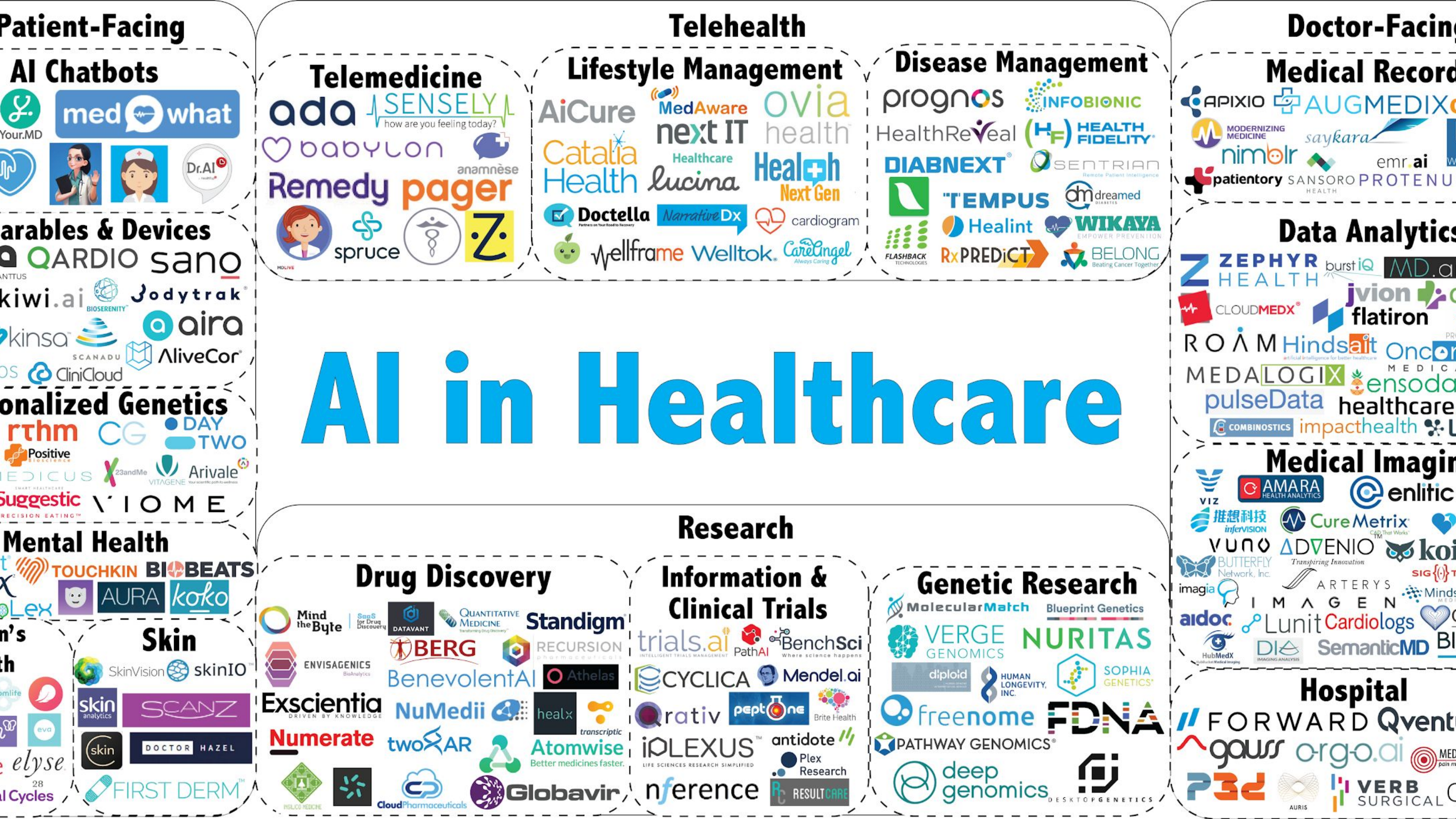
DeepMind


Google DeepMind
AlphaGo



Move 37


AI 101
MONTE CARLO
TREE SEARCH
Tommy Thompson
AI & Games



AI in Healthcare
Patient-Facing
AI Chatbots
Your.MD
med what
Dr.AI
arables & Devices
QARDIO
sano
kiwi.ai
BIOSERENITY
bodytrak
kinsa
aira
SCANADU
AliveCor
CliniCloud
onalized Genetics
rthm
CG
DAY TWO
Positive Bioscience
23andMe
VITAGENE
Arivale
Suggestic
VIOME
Mental Health
TOUCHKIN
BIOBEATS
AURA
koko
Skin
SkinVision
skinIO
skin analytics
SCANZ
DOCTOR HAZEL
FIRST DERM
eva
elyse
Telehealth
Telemedicine
ada
SENSELY
how are you feeling today?
babylon
anamnèse
Remedy
pager
spruce
MDLIVE
Lifestyle Management
AiCure
MedAware
next IT
ovia health
Catalia Health
Healthcare
lucina
Healthy
Next Gen
Doctella
NarrativeDx
cardiogram
wellframe
Welltok
CareAngel
Disease Management
prognos
INFOBIONIC
HealthReveal
HEALTH FIDELITY
DIABNEXT
SENTRIAN
TEMPUS
dreamed
Healint
WIKAYA
FLASHBACK TECHNOLOGIES
RxPREDiCT
BELONG
Beating Cancer Together
Doctor-Facing
Medical Record
APIXIO
AUGMEDIX
MODERNIZING MEDICINE
saykara
nimblr
emr.ai
patientory
SANSORO HEALTH
PROTENUS
Data Analytics
ZEPHYR HEALTH
burstIQ
MD.ai
jvion
CLOUDMEDX
flatiron
ROAM
Hindsait
Oncora
MEDALOGIX
ensodata
pulseData
healthcare
COMBINOSTICS
impacthealth
Medical Imaging
VIZ
AMARA HEALTH ANALYTICS
enlitic
推想科技 infervision
CureMetrix
VUNO
ADVENIO
BUTTERFLY Network, Inc.
ARTERYS
imagia
IMAGEN
aidoc
Lunit
Cardiologs
HubMedX
DIA IMAGING ANALYSIS
SemanticMD
Hospital
FORWARD
Qventus
gauss
orgo.ai
P3d
AURIS
VERB SURGICAL
Research
Drug Discovery
Mind the Byte
SaaS for Drug Discovery
DATAVANT
QUANTITATIVE MEDICINE
Standigm
BERG
RECURSION pharmaceuticals
ENVISAGENICS
Athelas
BenevolentAI
Exscientia
NuMedii
healx
transcriptic
Numerate
twoXAR
Atomwise
Better medicines faster.
INSILICO MEDICINE
CloudPharmaceuticals
Globavir
Information & Clinical Trials
trials.ai
PathAI
BenchSci
CYCLICA
Mendel.ai
Qrativ
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Molecular Programming


OUR VIOLENT UNIVERSE

DARK ENERGY AND DARK MATTER

Allie Hohmann

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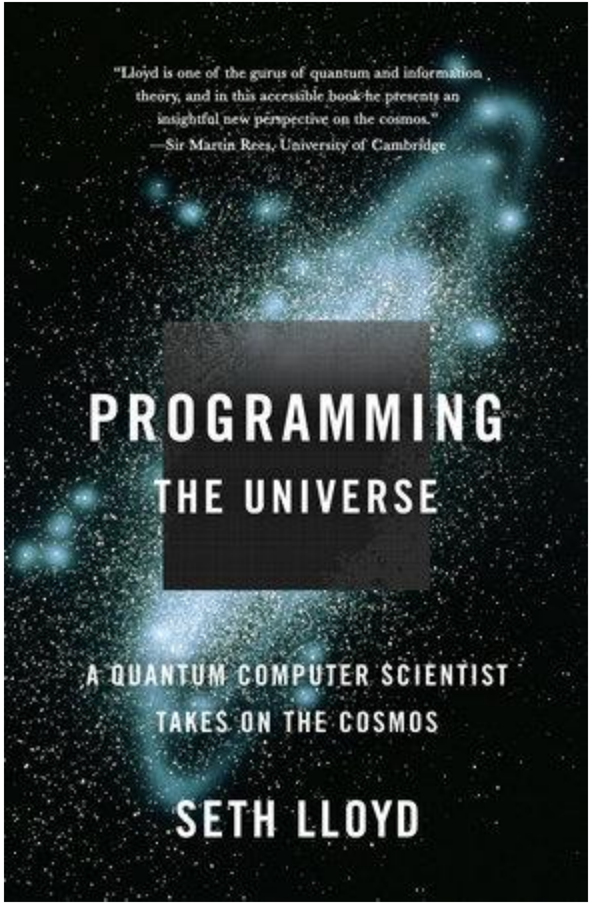
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