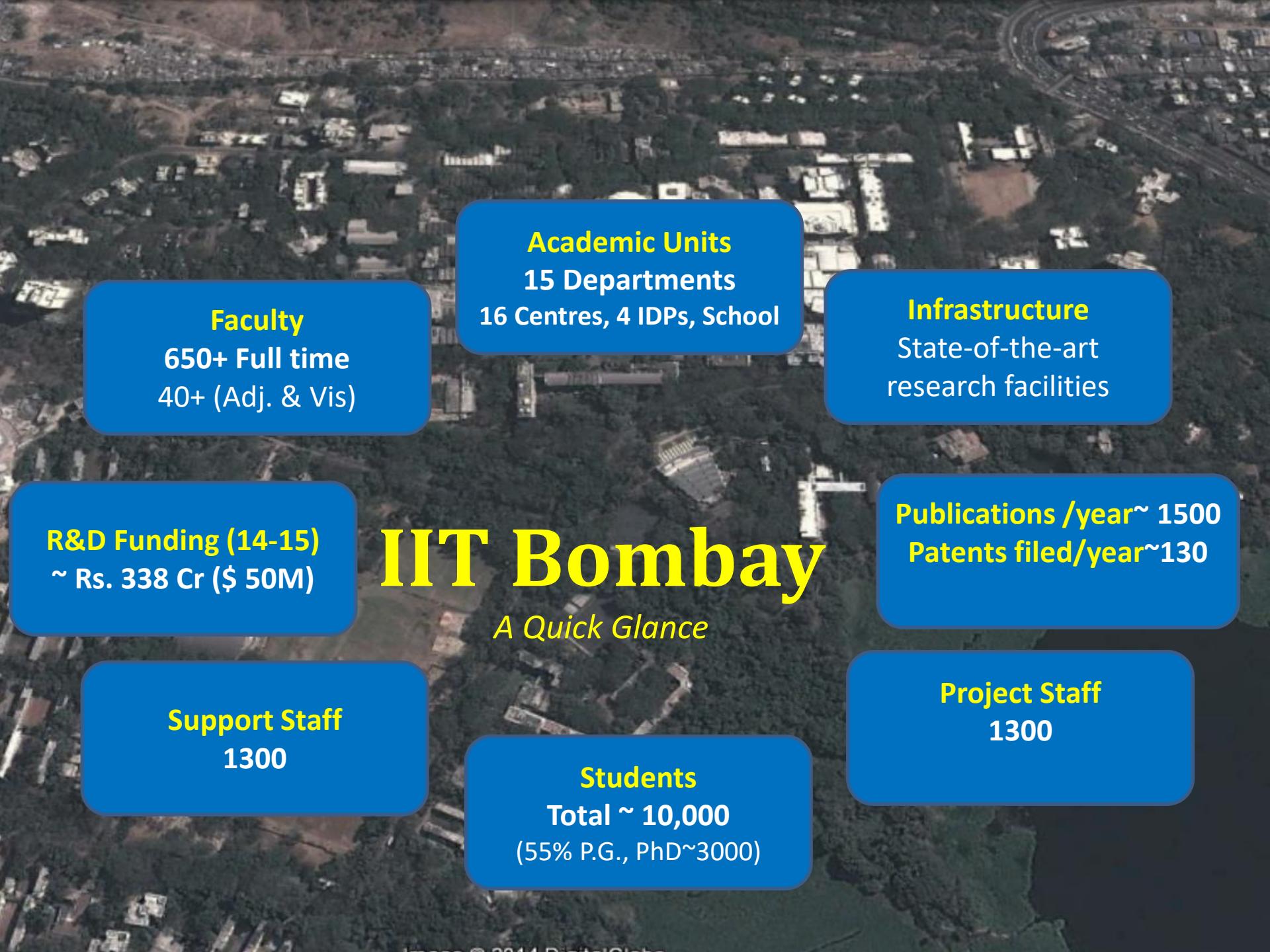


Emerging Trends In Artificial Intelligence And Data Science

Dr. Asim Tewari

**Professor, Center for Machine Intelligence and Data Science (C-MInDS)
and Department of Mechanical Engineering,
IIT Bombay, Powai, Mumbai 400 076, India**



IIT Bombay

A Quick Glance

Support Staff
1300

Students
Total ~ 10,000
(55% P.G., PhD~3000)

Faculty
650+ Full time
40+ (Adj. & Vis)

Academic Units
15 Departments
16 Centres, 4 IDPs, School

Infrastructure
State-of-the-art
research facilities

R&D Funding (14-15)
~ Rs. 338 Cr (\$ 50M)

Publications /year~ 1500
Patents filed/year~130

Project Staff
1300

Manufacturing and instrumentation

- DMU 75 monoblock 5-axis Milling machine
- Hardinge Vertical Machining Center
- EMCO Precision CNC Lathe
- Blum 3d Tool ZX
- Kistler force & torque Dynamometers
- Acoustic Emission Sensing System
- High dof & Tool Makers' Microscopes
- Zeiss 3D coordinate measuring machine
- Mikrotools CNC Multi-purpose Micromachining Center
- High speed image & Data Acquisition Systems
- Thermal imaging camera
- Gleeble TMS
- Metal additive manufacturing (EOS)
- Autoclave and VaRTM
- 3D composite printer (Markforge)

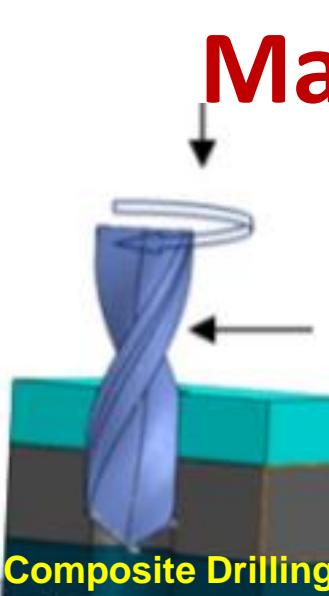
Characterization

- SEM/ FEG SEM / EBSD/WDS
- FEG SEM FIB
- TEM / Cryo TEM/ HRTEM
- SPM/ AFM
- Time-of-Flight Secondary Ion Mass Spectrometer
- 4D Xray Microscope.
- Confocal Laser Scanning Microscope
- X-Ray Fluorescence Spectrometer
- NMR (Nuclear Magnetic Resonance Spectrometer)
- ICP-MS (Inductively Coupled Plasma – Mass Spectrometry)
- SIMS (Secondary Ion Mass Spectrometer)
- FTIR(Fourier Transform Infrared)
- Thermal Analysis System (TGA & DTA - DSC & TGA)
- Electron Spin Resonance Spectrometer
- Liquid Chromatograph Mass Spectrometer

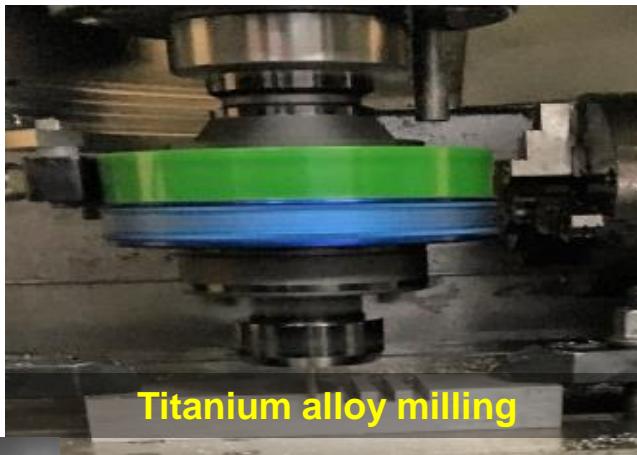
High Performance Computing

- Cray XC50 (280 Nodes, CPU 700 TFLOPS, GPU 300 TFLOPS, 192 GB and 1536 GB memory per node) **1.1 PFLOP**
- PAM-RTM, Moldex, CutPro
- ANSYS, ABAQUS, PAM-STAMP, Hyperform, ComSol
- Deform 3D and 2D with Machining simulation modules
- Pro-Engineer, MATLAB and Simulink HPC and super computing facility

Machining Technology Research



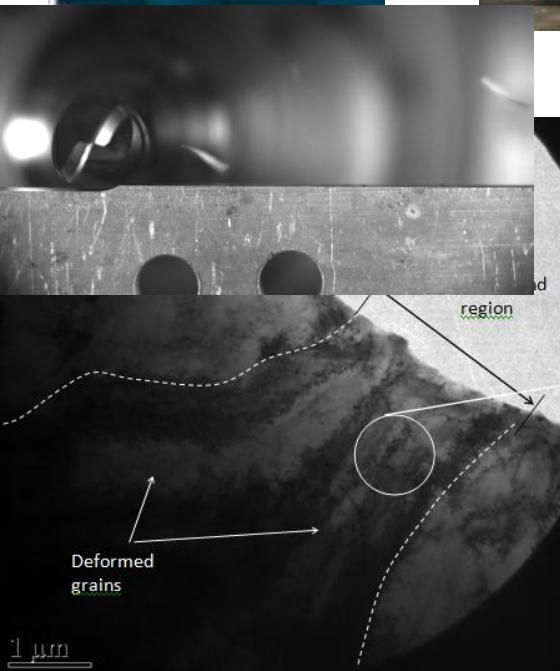
Composite Drilling



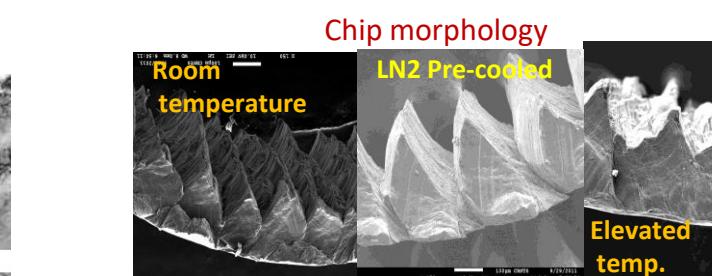
Titanium alloy milling



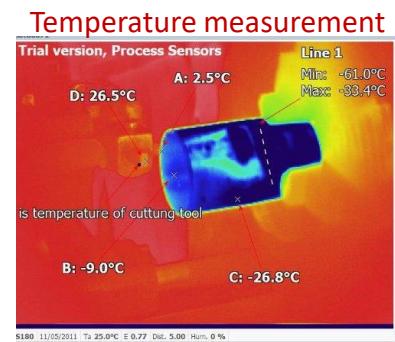
Superalloy turning



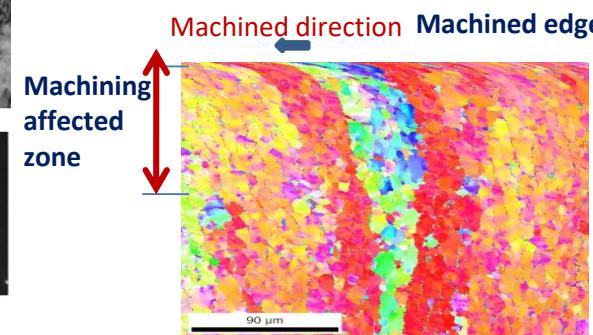
Machine Intelligence Program



Chip morphology

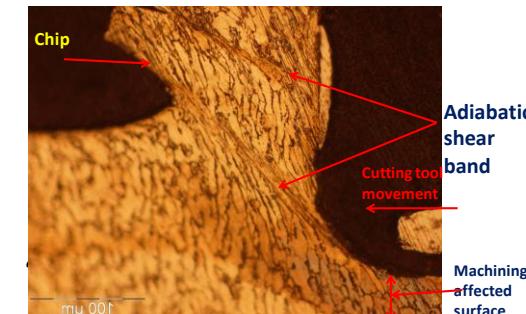


Temperature measurement



Machining affected zone

Adiabatic shear band

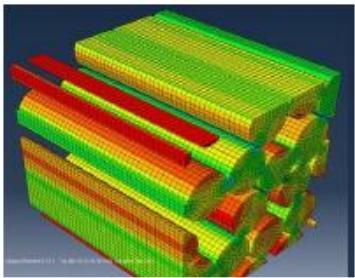


Adiabatic shear band

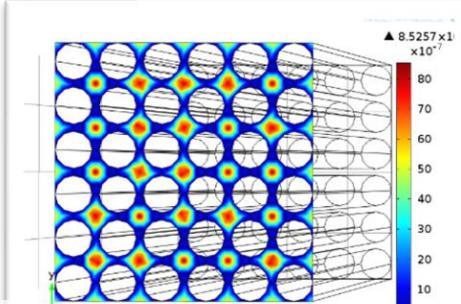
Cutting tool movement
Machining affected surface

Composites Technology Research at IITB

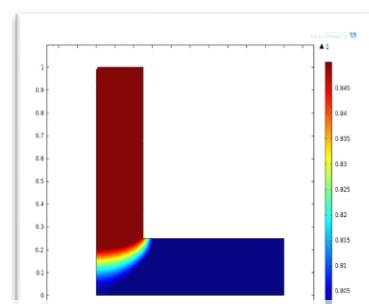
Composite Simulation and Modeling



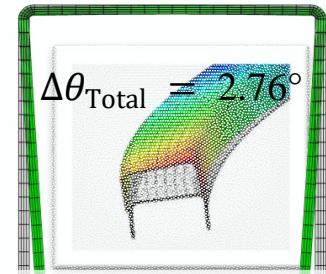
Fatigue Model



Permeability Model



Resin Infusion Model



Distortion Model

Composite Manufacturing facility



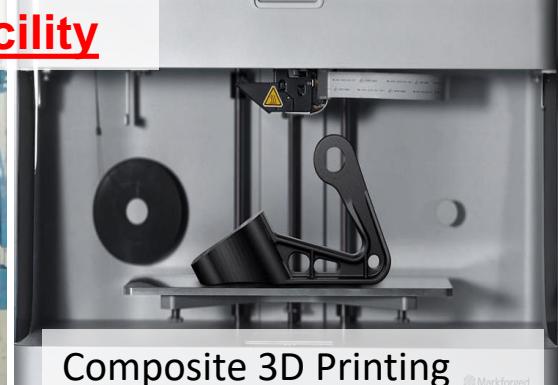
Product Design



VaRTM

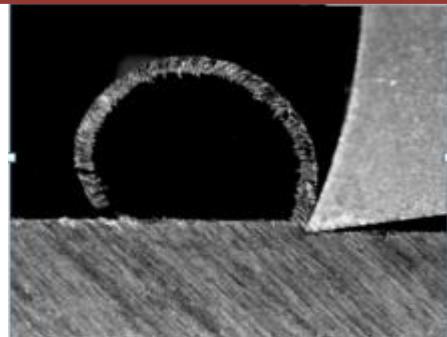


Autoclave

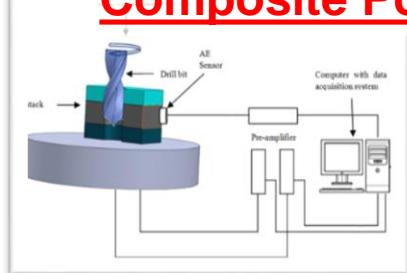


Composite 3D Printing

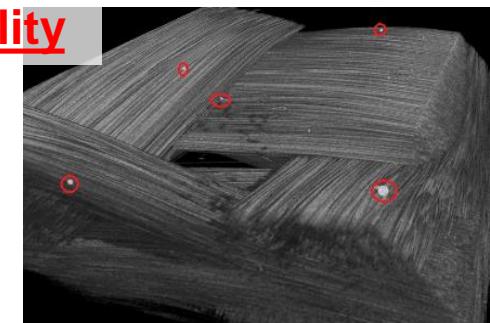
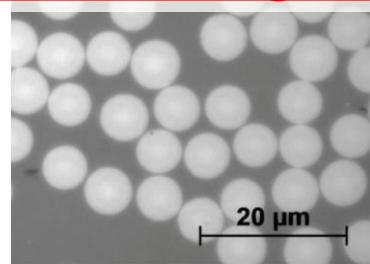
Composite Post Processing facility



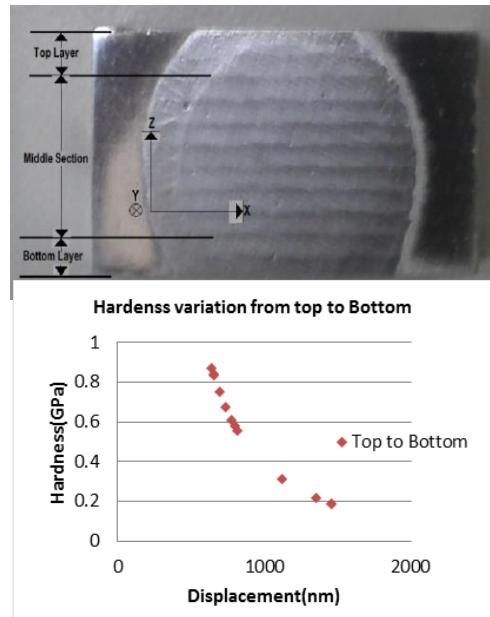
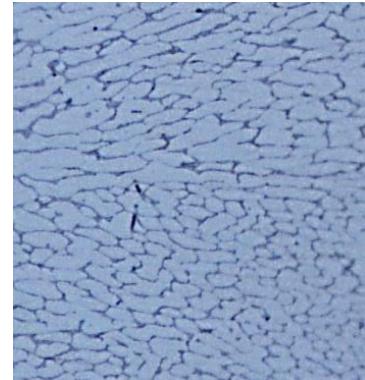
Composite Machining



Composite Drilling



ADDITIVE SUBTRACTIVE MANUFACTURING (ASM)



Additive Subtractive
Machine (ASM)

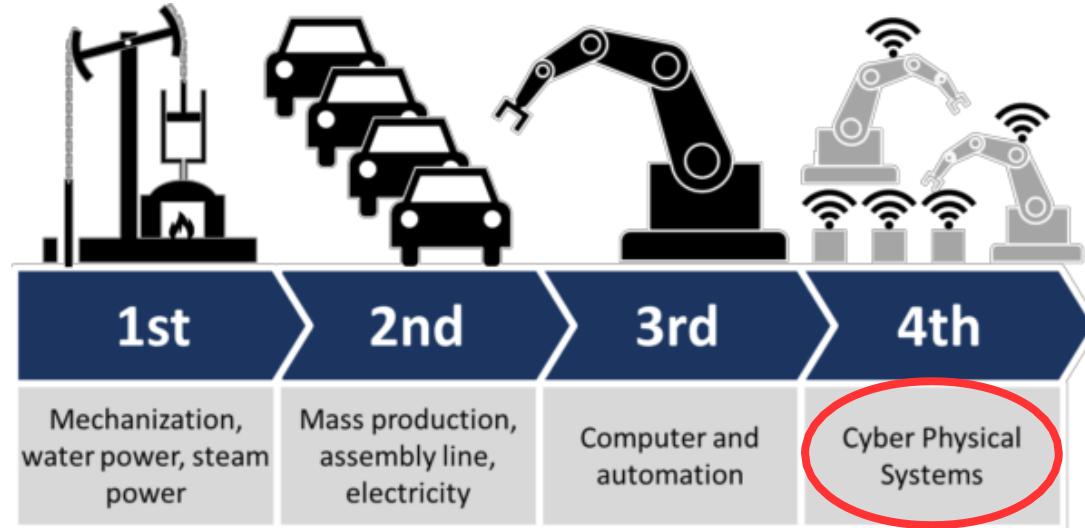
Major challenges

- Optimal part-decomposition
- Slicing and build orientation
 - geometric complexity, cutting tool accessibility
 - multi-bridged structures
 - overhangs
- Part distortion
- Non-uniform & anisotropic properties

Facilities

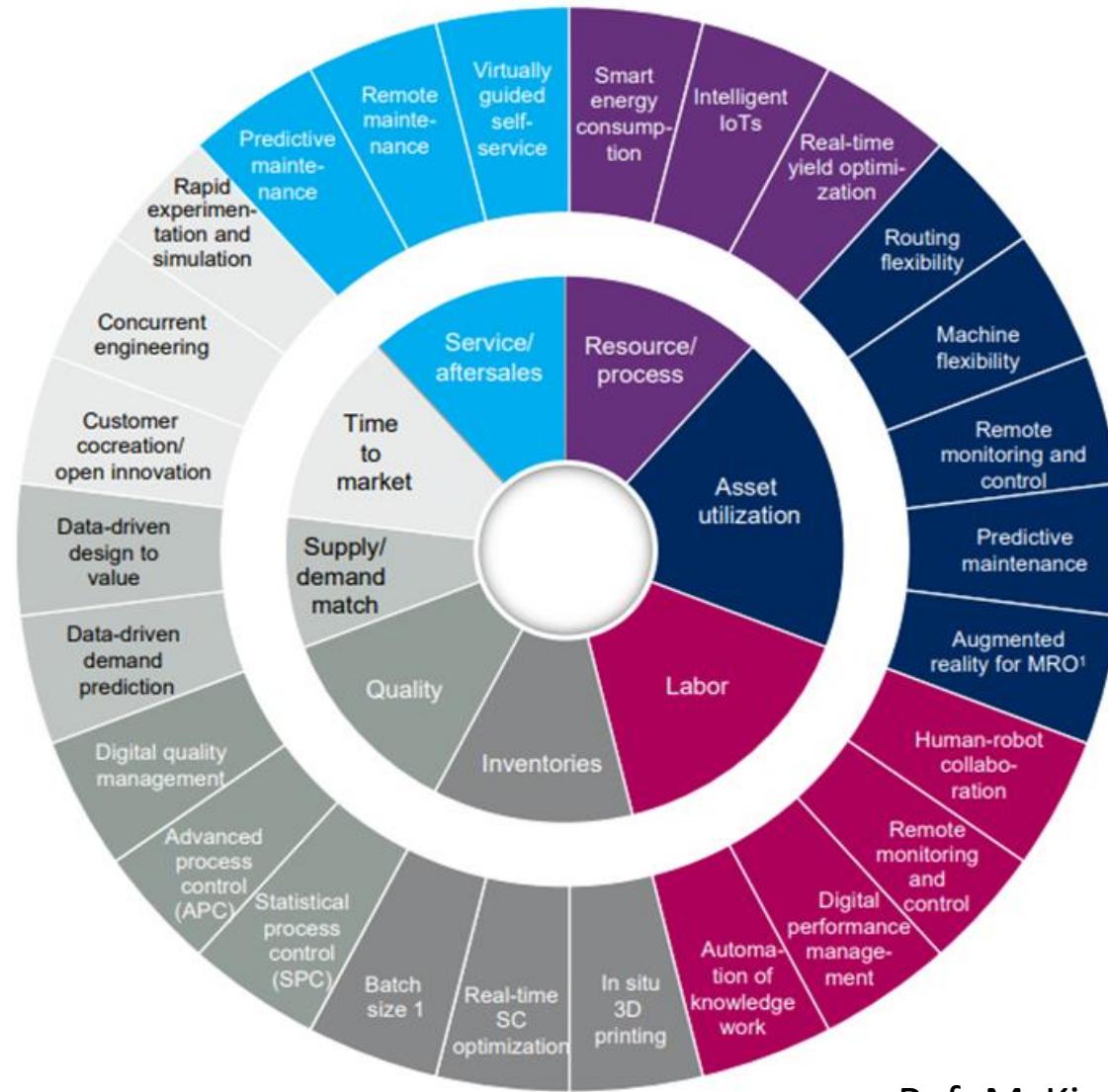
1. In-house hybrid M/C(5-axis+MIG weld)
2. EOS M 280
Build volume
250 mm x 250 mm x 325 mm

The Fourth Industrial revolution



4th Industrial revolution is the use of **AI**

Value Drivers for Industry 4.0



Initiative by various countries



Bundesministerium
für Bildung
und Forschung

Germany – Federal Ministry of
Education and Research of
Germany (BMBF) 2012



USA - Executive Office of
the President, US National
Science and Technology
Council 2012



Department
for Business
Innovation & Skills

UK – Department for Business,
Innovation & Skills 2010



National Institute
of
Science and Technology Policy

France - Ministère de l'Economie
et des Finances 2015

Japan - The National Institute for
Science and Technology Policy of
Japan 2015



China – The State
Council of China 2015

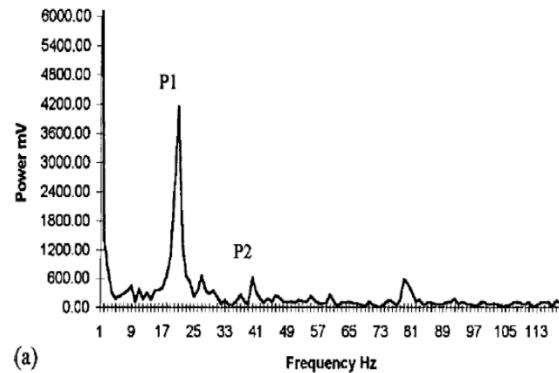


SAMARTH Udyog Bharat 4.0
DHI, India 2018

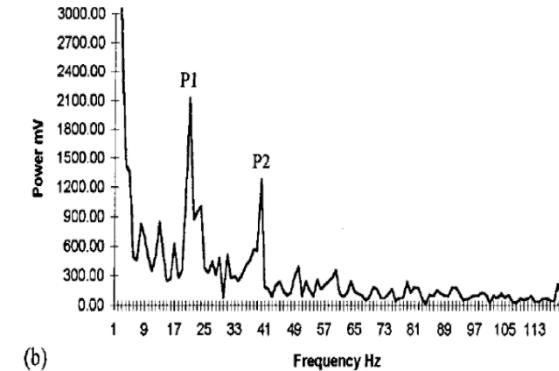
Data analytics in tool condition monitoring

- **Objective:** Develop an analytical solution to predict real time tool wear
- **Motivation:** By detecting the condition of tool at real time, machine downtime, product quality can be improved significantly resulting in improved efficiency
- **Sensor Data:** Vibration, Force, Acoustics, current

$$|F(\omega)| = \frac{1}{4T} \times \left\{ \sum_{n=-\infty}^{\infty} \left| \frac{\sin(3 \times n \times \pi/4)}{(n \times \pi/2T)} \right| \times \delta\left(\omega - \frac{n \times \pi}{2T} - \frac{2\pi}{T}\right) + \sum_{n=-\infty}^{\infty} \left| \frac{\sin(3 \times n \times \pi/4)}{(n \times \pi/2T)} \right| \times \delta\left(\omega - \frac{n \times \pi}{2T} + \frac{2\pi}{T}\right) \right\}$$



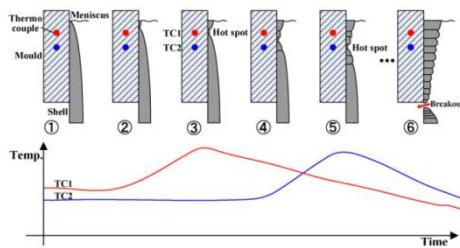
Good Tool



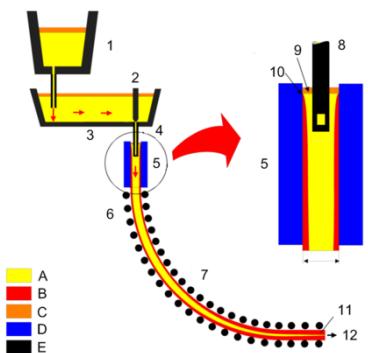
One edge broken Tool

Breakout detection in continuous casting

- **Objective:** Develop a tool that can detect change-point in time series data
- **Motivation :** By doing change point analysis we can find breakout detection in continuous casting process.



Schematic diagram of sticking type breakout



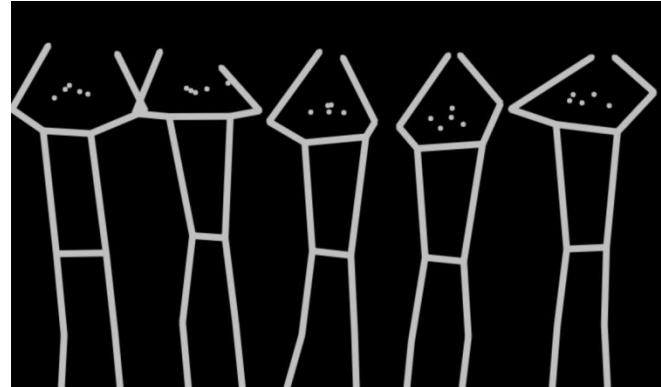
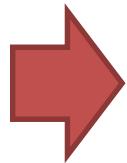
Schematic diagram of continuous casting process

The Change-Point Problem

- Let X_1, X_2, \dots, X_n be a sequence of independent random vectors (variables) with probability distribution functions $P_1, P_2, P_3, \dots, P_n$, respectively.
- Then, in general, the change point problem is to test the following hypothesis
 - Null hypothesis:
 $H_0 : P_1 = P_2 = \dots = P_n$
 - Verses the alternative:
 $H_1: P_1 = \dots = P_{k_1} \neq P_{k_1+1} = \dots = P_{k_2} \neq P_{k_2+1} = \dots = P_{k_q} \neq P_{k_q+1} = \dots = P_n$
- where $1 < k_1 < k_2 < \dots < k_q < n$, q is the unknown number of change points and k_1, k_2, \dots, k_q are the respective unknown positions that have to be estimated.

Video Analytics

Real time Posture identification



Motion direction estimation



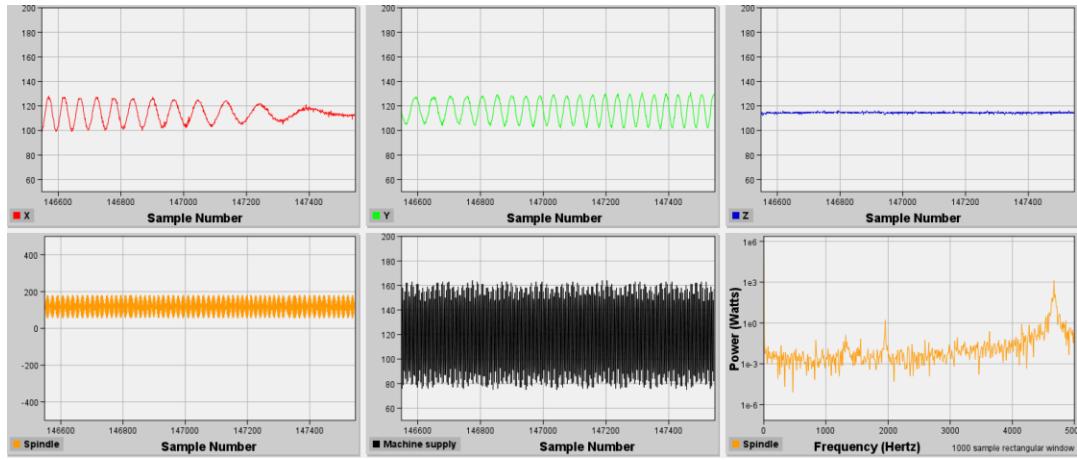
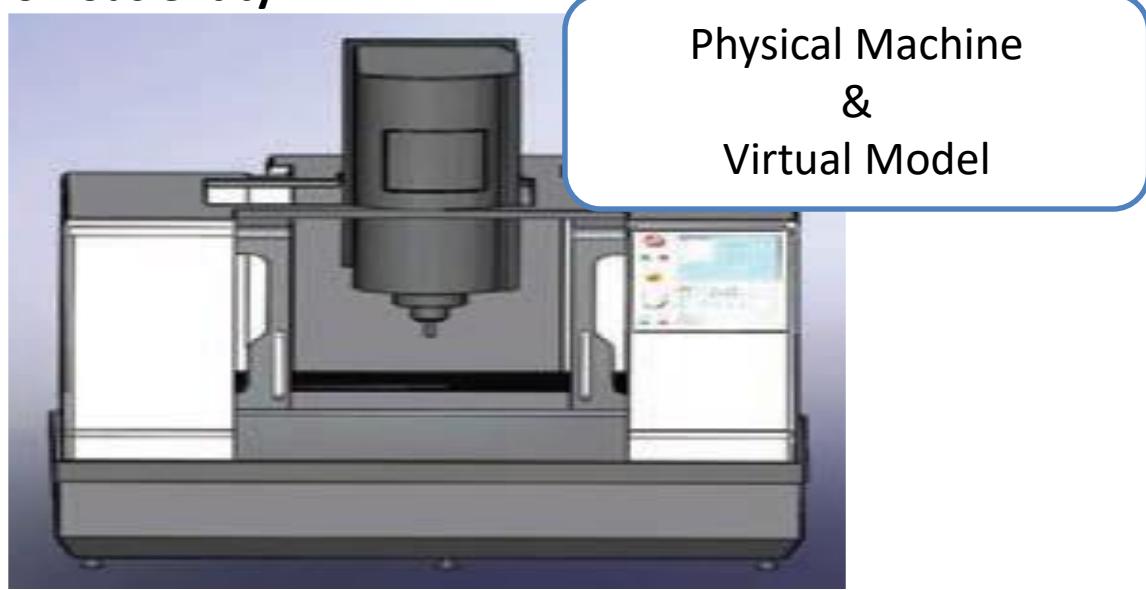
Cyber Twin of 3-axis CMC

A cyber twin is a virtual realization of a physical machine. These are the building blocks for industry 4.0 to create a seamlessly connected factory that **interacts with the real world as an intelligent, self-contained, autonomous entity**.

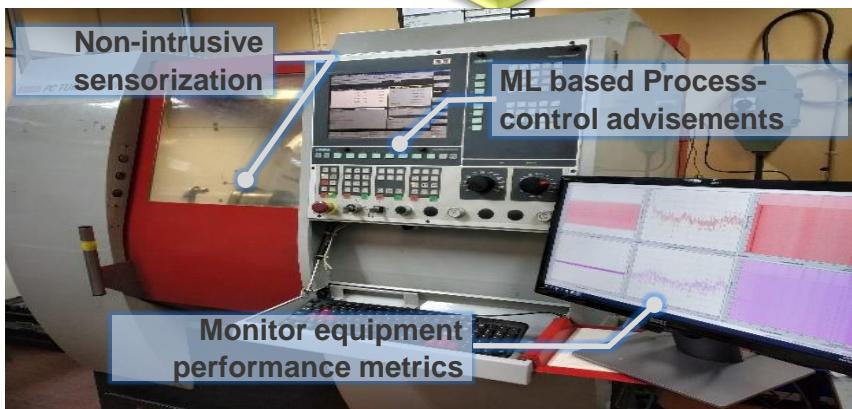
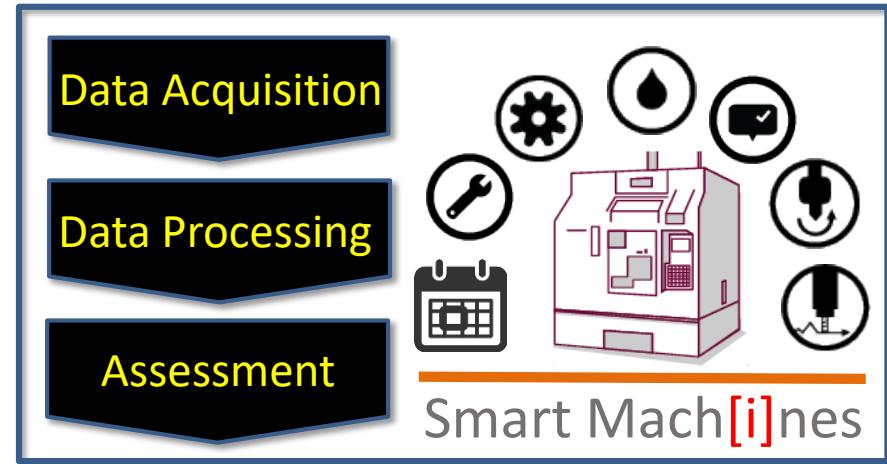


Current, voltage and Acceleration Sensor

Machine Intelligence Program

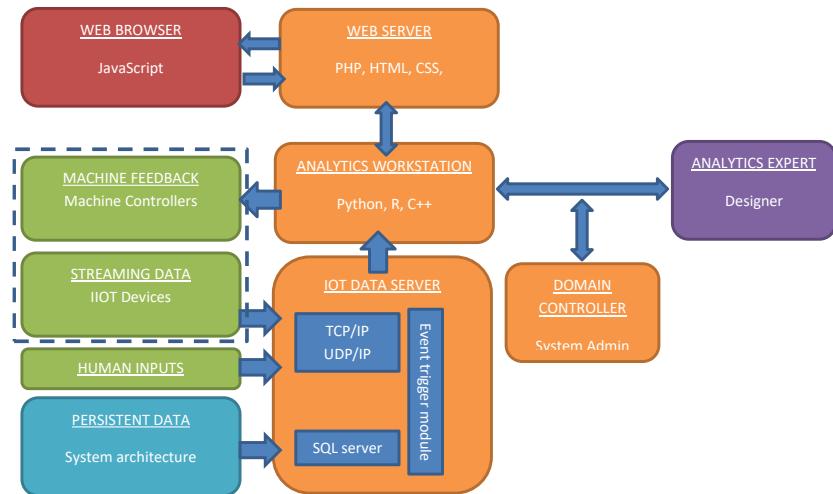


Smart Factory: Machine Monitoring and Analytics for Total Productive Maintenance (TPM)



Machine Intelligence Program

Machine Efficiency Monitoring system



- Machine Efficiency
 - Analysis on breakdown time, setting time and other losses
 - Integration with ERP
- Breakdown status and analysis
 - Day/shift wise
 - Operator wise
- Automated email/SMS to call for service
- Environment monitoring for temperature & humidity
- Reports on (efficiency wise, and breakdown wise)

- Machine ranking

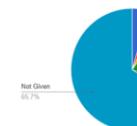
Machine Name	Machine Ranking			
	Current Week	Previous Week	Current Month	Previous Month
Doms	80%	10%	10%	80%
Toshiba	60%	15%	15%	60%
SHR	70%	18%	18%	70%

- Weekly/Monthly Statistics

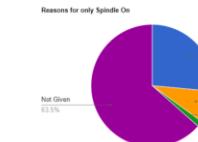
This data is corresponding to last 7 days

Cutting 50%
Spindle On 11%
OFF 33%

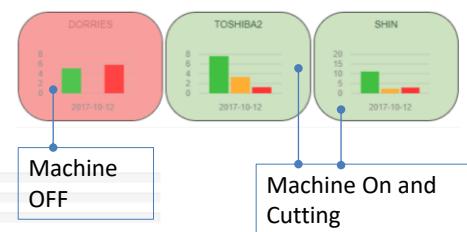
Reasons for Machine OFF



Reasons for only Spindle On



Grid view



Losses details in Min

Shift	Operation Losses										Management losses					
	Setup change / Tool change / other change (A)	Quality Problem (B)	M/c Breakdown (C)	Tooling Failure (D)	PM /CLITA (E)	Tooling not available (F)	Gauges Not available (G)	No operator (H)	Power Failure (I)	No Plan (J)	No material (K)	Total losses in minutes				
1st																
2nd																
3rd																

Machine Intelligence Program

Smart Factory: Salient features

Non-intrusive IoT

- Indigenously developed H/W
- Need based customizable
- Universal language protocol

Advanced analytics backend

- M/C State detection
- Diagnostics

Single Window Interface

- Authentication level based access
- Management: Plant overview & status report
- Shop Floor/Operations: Interactive interface

Integrated with plant ERP

- Shift calendar
- Operator ID/ Job ID

Operations statistics

- Weekly monthly quarterly statistics
- M/C wise and plant wise statistics

Causes of Production Losses

- Ranking of causes and % loss

Event driven SMS

- Communication with maintenance staff
- Escalation of unattended open issues

SMS on Demand

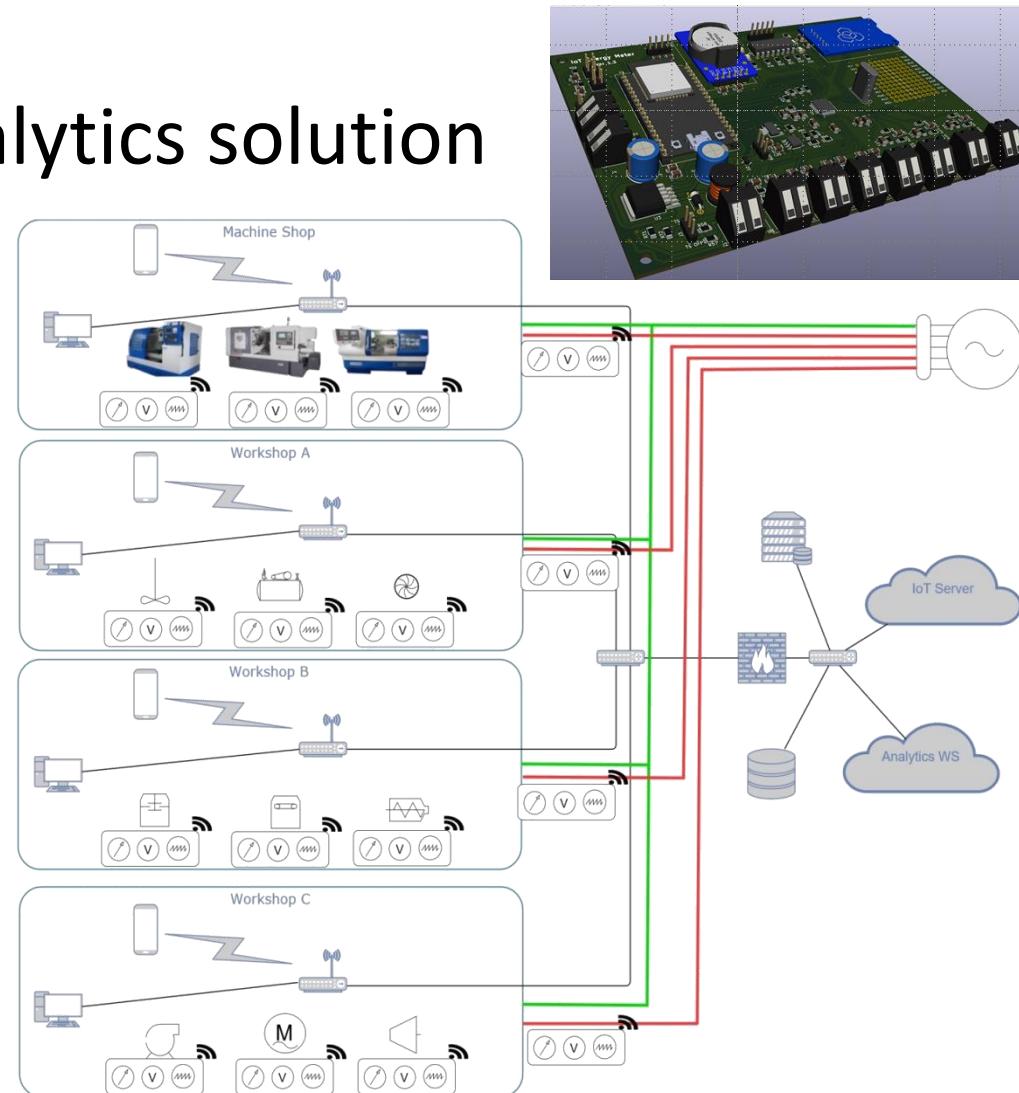
- Phone number based authentication
- M/C Plant status report

OEE and TPM

Plant Power Management System (PPMS)

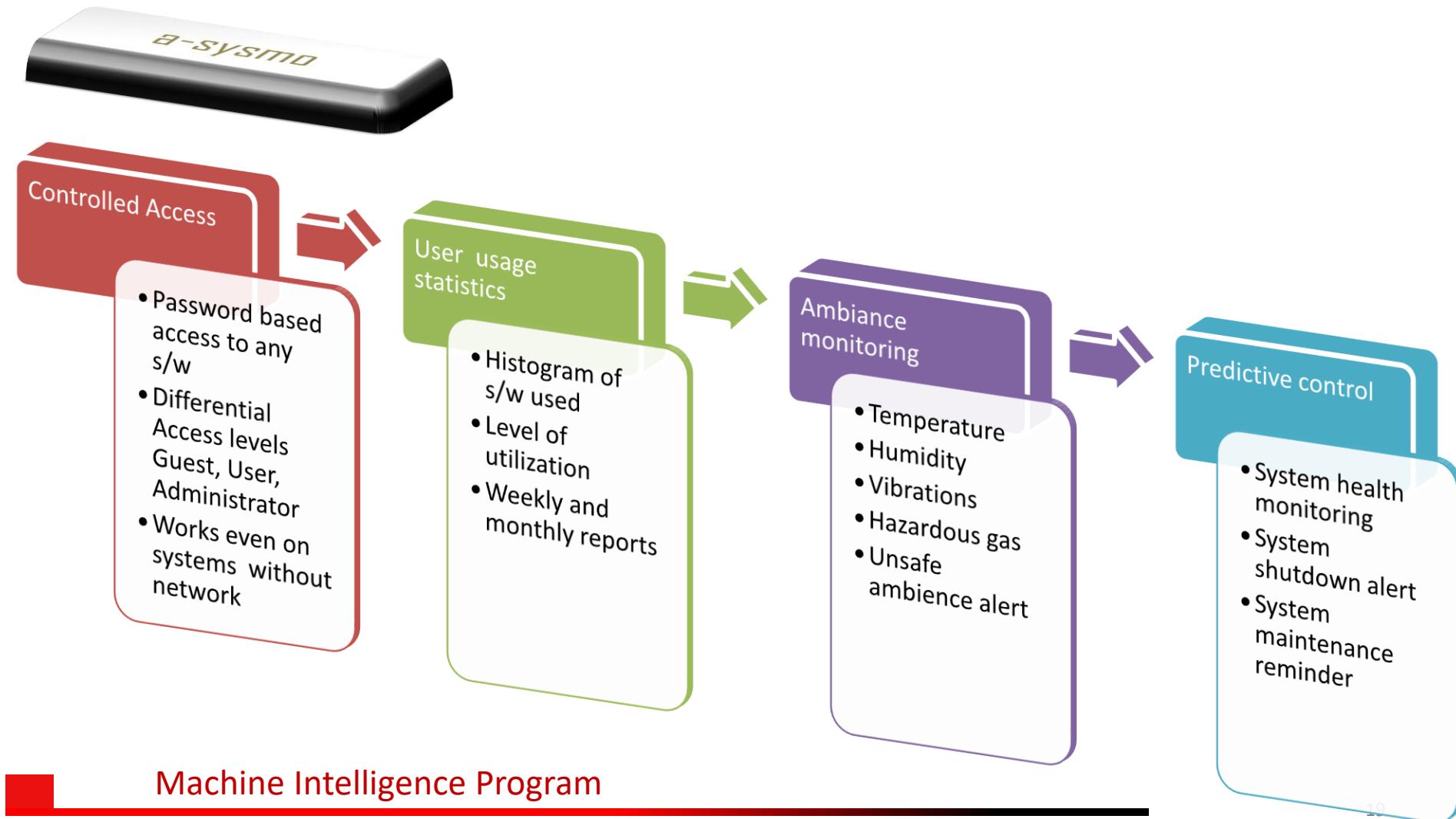
- IIOT Based data analytics solution

- Power consumption
- Load power factor
- Machine utilization percentage
- Power distribution
- RMS current value
- RMS voltage value
- Power anomaly count
 - Voltage spike
 - Current spikes
 - Low voltage alarm
 - Sinewave quality
 - Power source frequency stability
 - Power outage
- Machine vibrations
- Ambient temperature



a-SYSMO: Advanced system monitoring device

Staff productivity measurement in an IT office



Video Analytics



- Face detection, unique persons
- Classify based on gender, age, dress color, etc.
- Track a person across many cameras

Shop-floor Video Analytics



- Worker ID
- Safe and hazardous situation assessment
- Work protocol conformity assessment
- Cycle-time and efficiency determination
- Loss time assessment

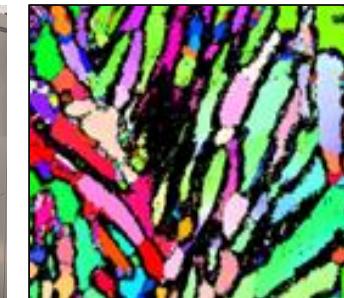
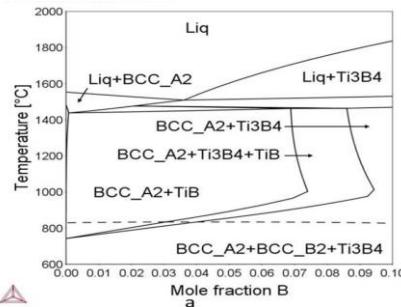
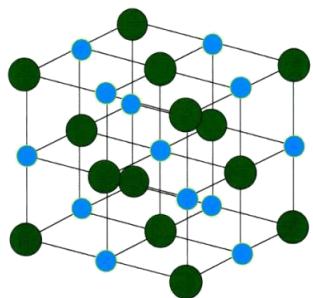
Applications of NLP

Sr. SC advocate

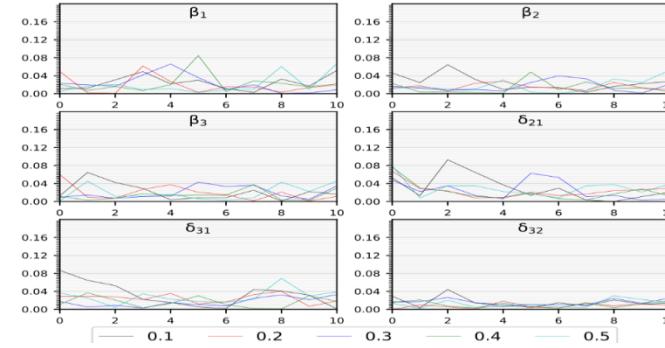
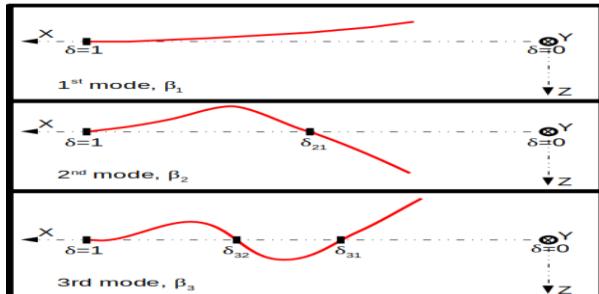
- Legal Research
- Electronic Discovery
- Contract Review
- Similar case detection
- Document Automation
- Legal Advice Chatbot

Statistical Machine Learning model development to derive new HEA compositions

IITB-OSU Frontier center



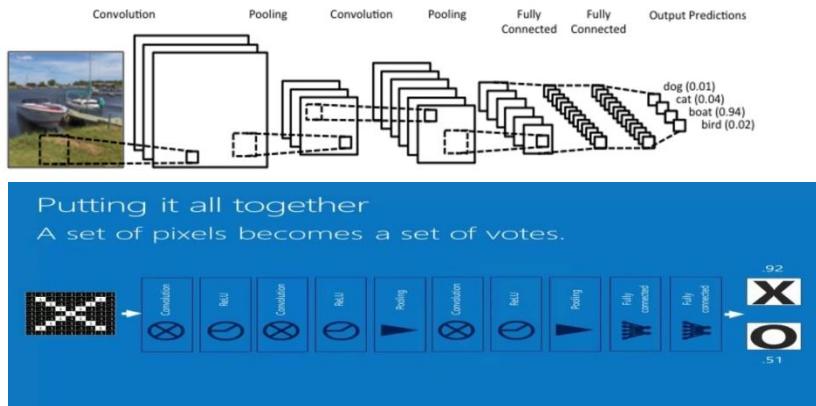
Vibration Analysis of Tapered Truncated cantilever beams using Deep Learning



Machine Intelligence Program

Deep Learning segmentation of spatial data

- **Objective:** Develop a high level Deep Learning tool for image segmentation.
- **Motivation :**Spatial data in the form of image is available in all walks of technology, segmentation based on Deep learning would be the first step in data comprehension.



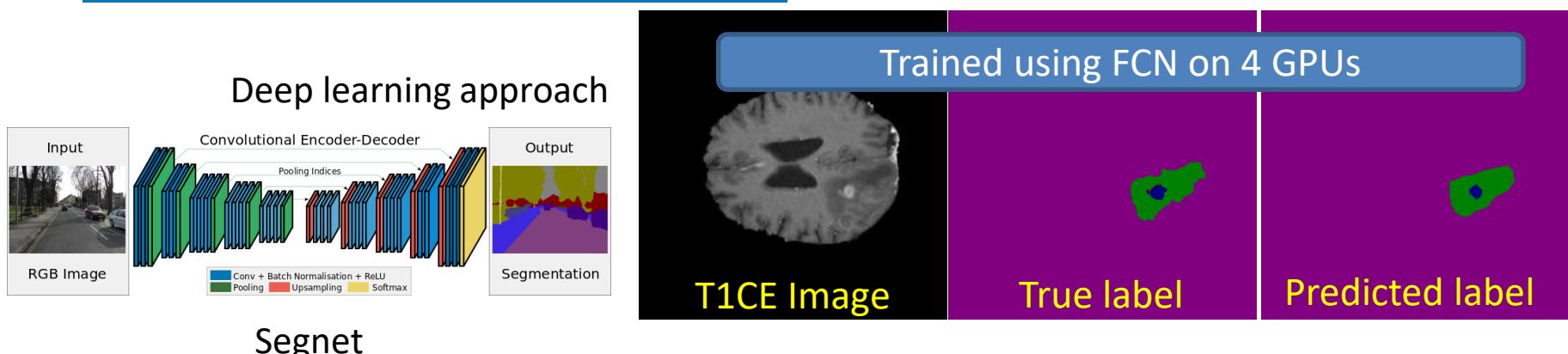
All our Code is available on [github](#)

Language: Python

Framework: Pytorch

Current implementations:

PSPNet, FCN, Segnet



Business Enterprise Analytics



POS, Inventory Stock

GINESYS
RETAILING RETAIL

Tally
shoper⁹

Microsoft
Dynamics NAV

ETPTM
RETAIL SOFTWARE SOLUTIONS

Web, Social Media

HR Data, Past discounting data

Video data

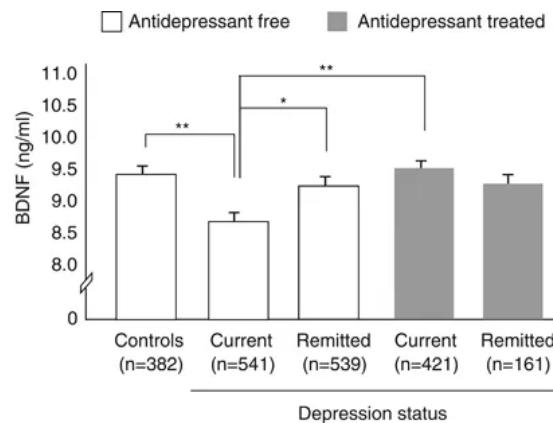
Machine Intelligence Program

Effect of Yogic-Pranayamic on human physiology

Prof. Shantanu Tripathi

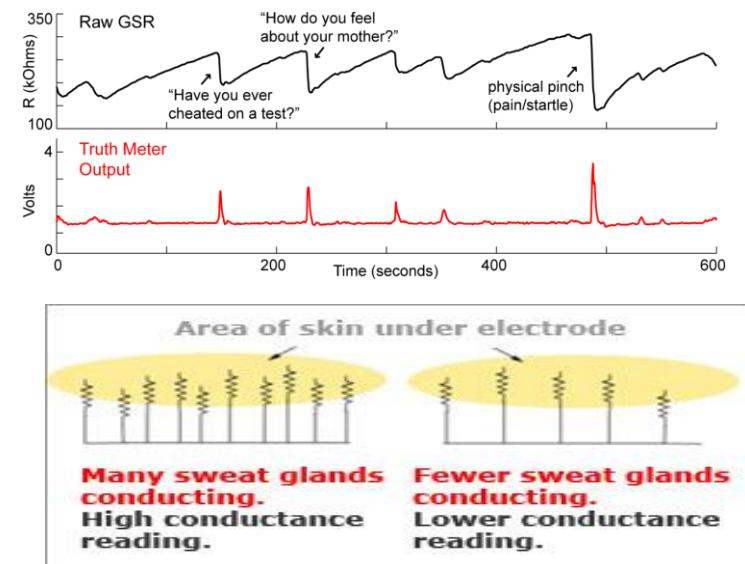
Bio markers for Depression

- Brain Derived Neurotrophic Factors
- Galvanic Skin Response
- Heart Rate Variability
- Breathing and Speech changes



Brain Derived Neurotrophic Factor and Depression

Molecular Psychiatry 16, pp 1088–1095(2011)

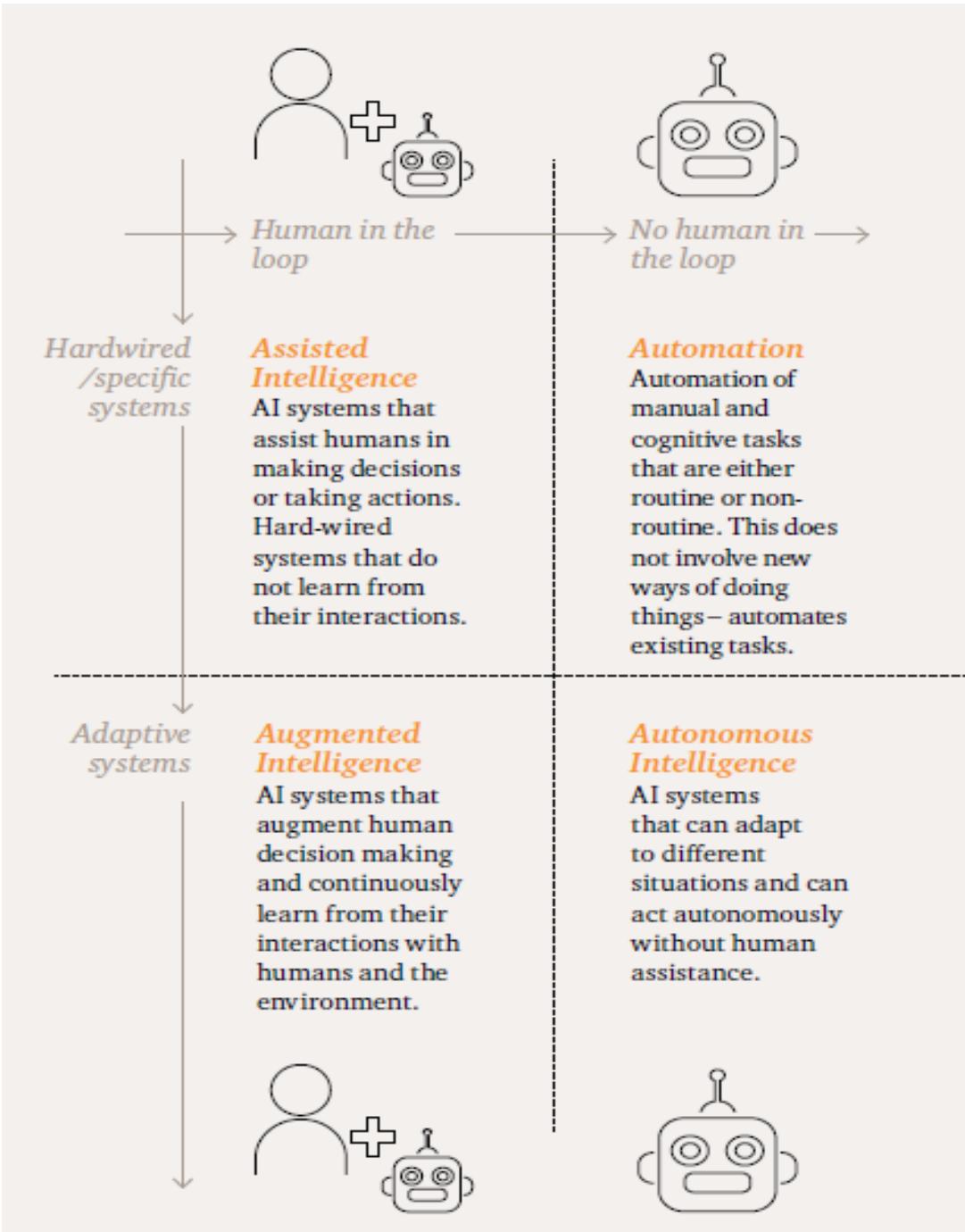


Galvanic Skin Response and Depression

<https://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=6098461>

Data Analytics: *Other applications*

- Predictive Analytics
- Prescriptive Analytics
- Enterprise Decision
- Retail Analytics
- Store Assortment
- Stock-keeping Unit Optimization
- Marketing Optimization
- Predictive maintenance
- Reactive scheduling
- Demand analytics
- Marketing Mix Modeling
- Web Analytics
- Sales Force Optimization
- Price & Promotion Modeling
- Credit Risk Analysis
- Fraud Analytics
- Operational Risk modelling
- Sports analytics



Are there various kinds of intelligence?

What is Artificial Intelligence ?

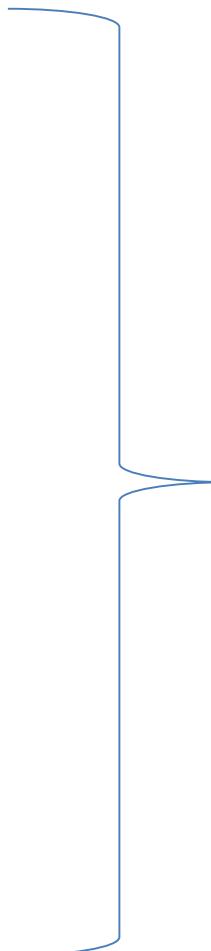
Artificial Intelligence : (Merriam-Webster) The capability of a machine to imitate **intelligent** human behavior.

What is Machine Learning ?

Machine learning is a branch of **artificial intelligence** based on the idea that systems can learn from **data**, identify patterns and make decisions with minimal human intervention.

Data Type

- Discrete data:
 - Discrete non-ordered numbers
 - Random collection of words
 - Unrelated audio sounds
 - Random music notes
- Sequential (temporal) data:
 - Stochastic process
 - Sequence of words in a sentence
 - Audio speech data
 - Music
- Spatial data:
 - Image data
 - Geo-spatial data



**Sequential
Spatio-temporal
data**

Major Components of Data analytics

1. Sensor Technology

- Newer modalities
- Higher resolution
- Higher speeds

2. Communication and storage

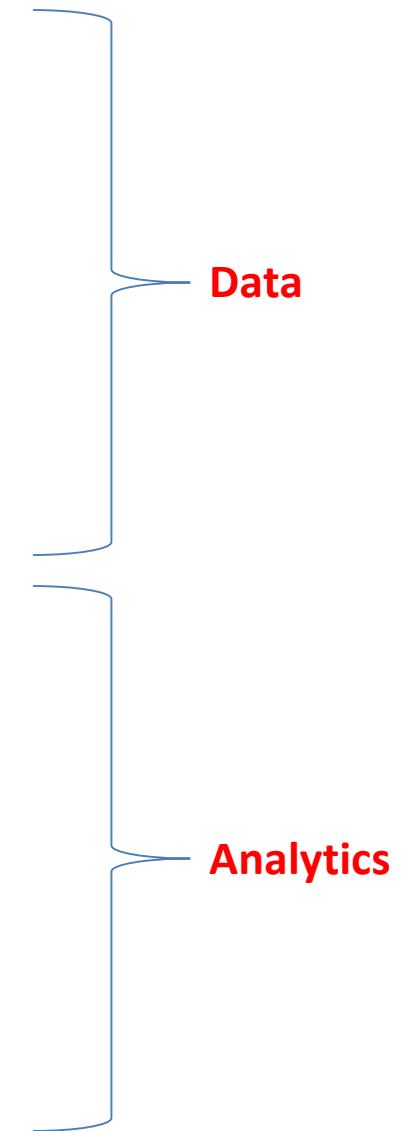
- Challenge of volume, variety and velocity
- Security challenges

3. Computational hardware

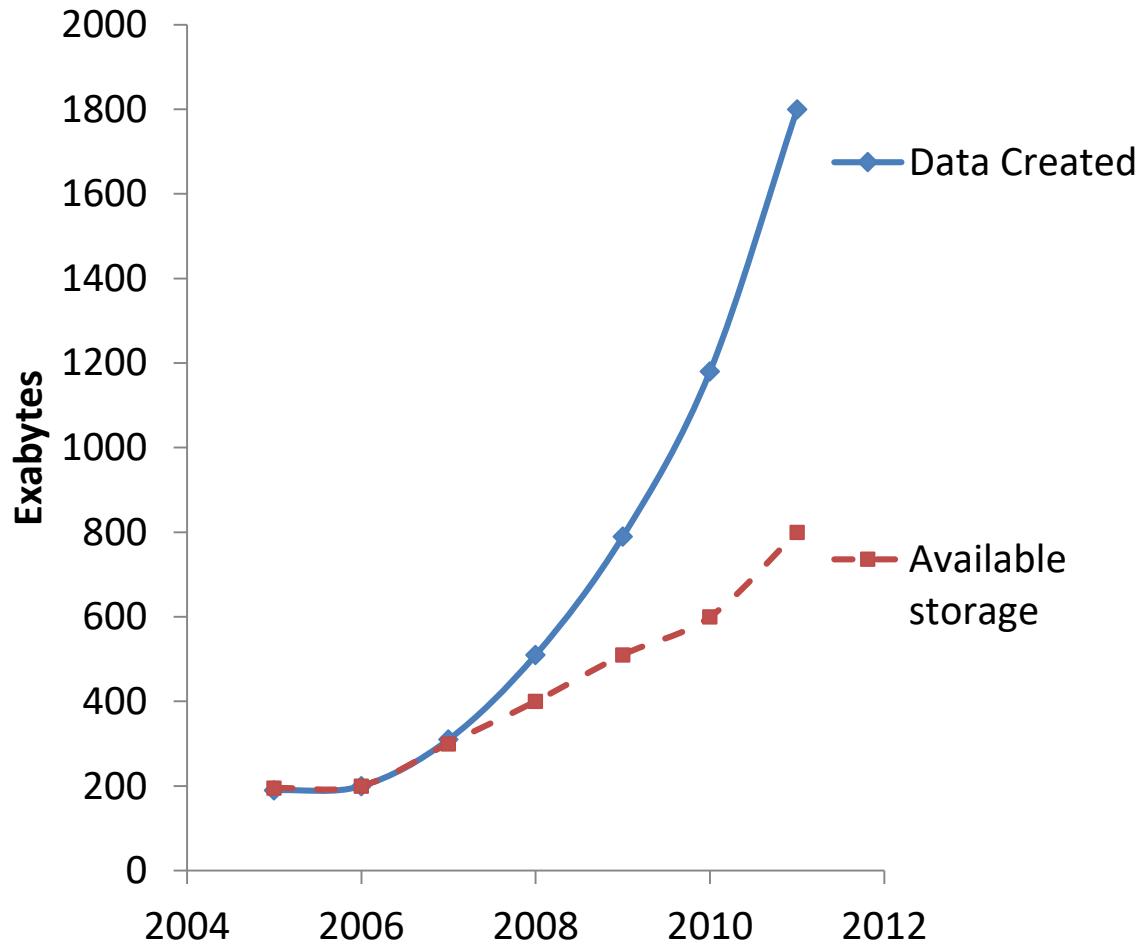
- Cloud computing, GPUs, TPUs, Quantum computing

4. Algorithms

- Artificial intelligence (AI)
 - Classical Machine Learning
 - Deep learning
 - Reinforcement Learning



Information creation is outpacing available storage



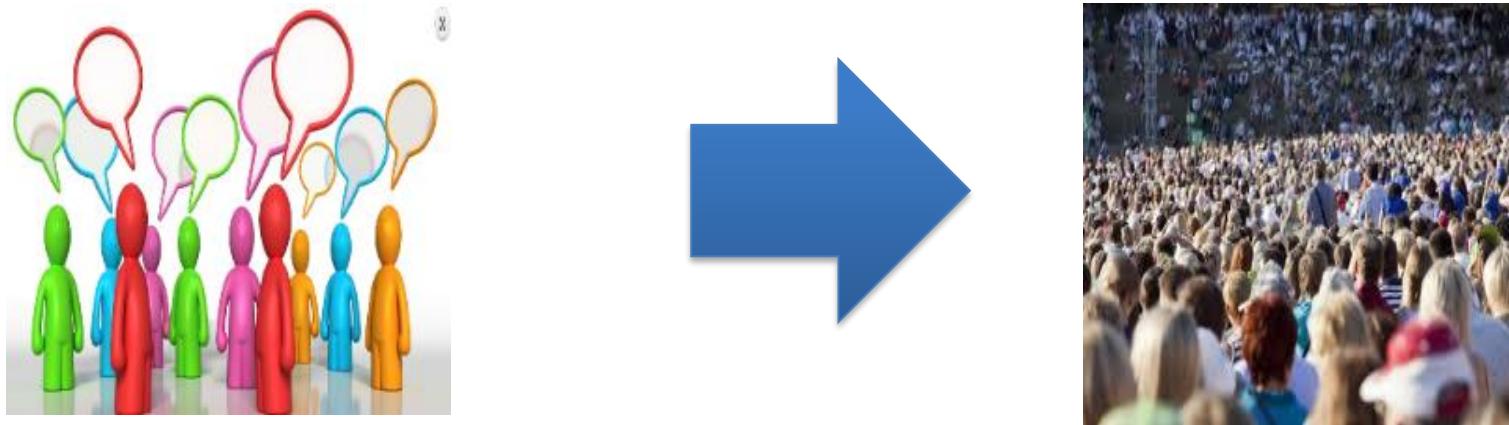
Ref:IDC

Who's Generating Big Data...

Old Model: Few companies are generating data, all others are consuming data



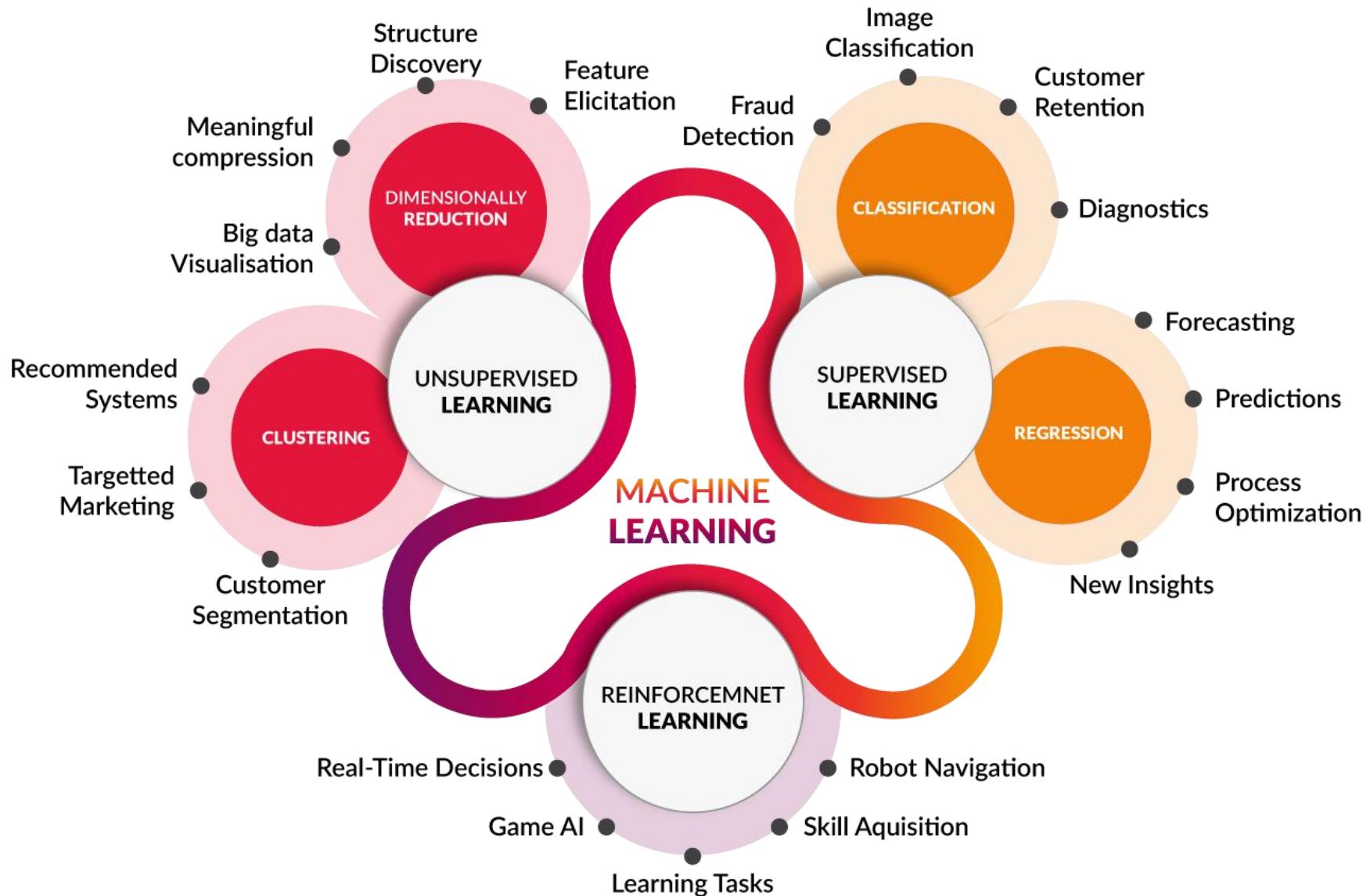
New Model: all of us are generating data, and all of us are consuming data



Major Companies are tracking every move we make

Our cell phones are continuously collecting data:

- Time stamped GPS coordinates and movements (e.g. walking, onBicycle, inRailVehicle, in car, etc)
- The barometric pressure
- The MAC address, signal strength, and frequency of every nearby wifi access point and Bluetooth beacon
- Battery life and charging state of the phone
- Open databases
 - Social Media (FB, Twitter, true-caller,...)
 - Voter ID
 - Auto registration
 - Utility bills
- Amazon Echo and other devices





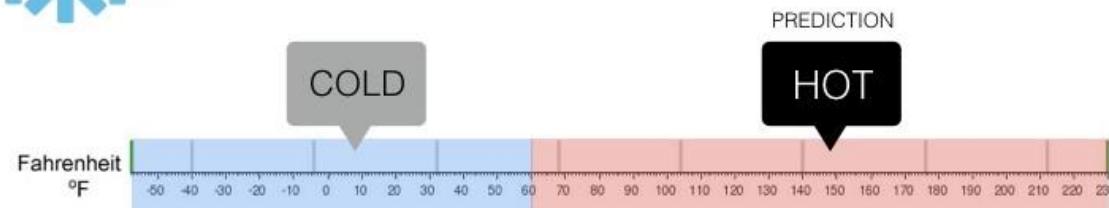
Regression

What is the temperature going to be tomorrow?



Classification

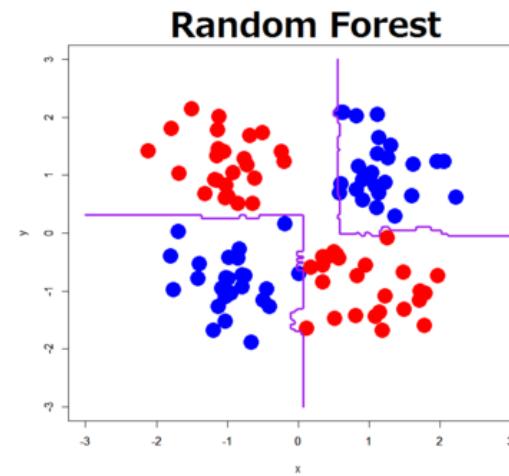
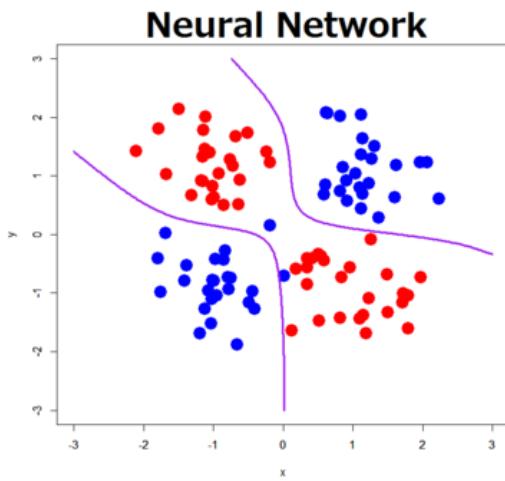
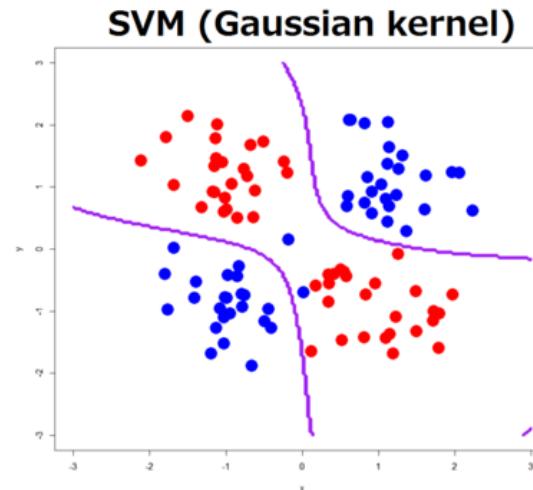
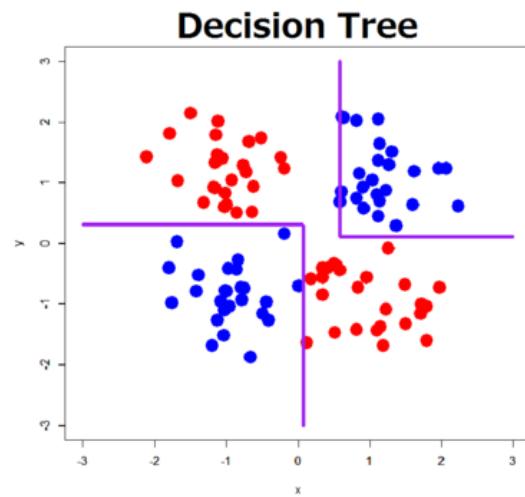
Will it be Cold or Hot tomorrow?



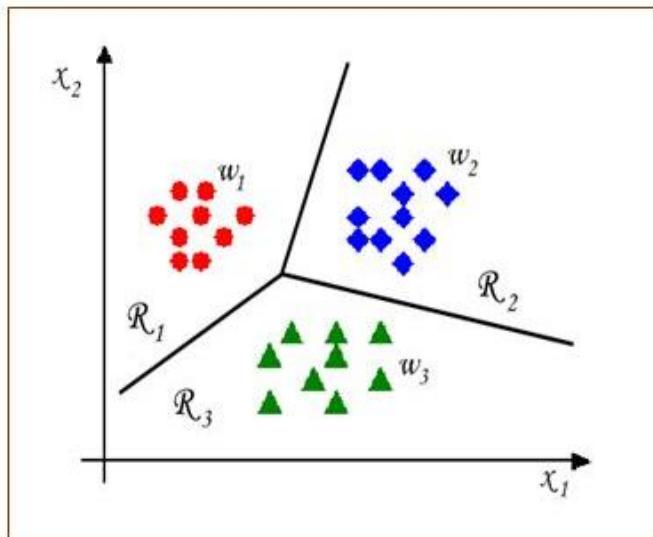
Machine Learning Techniques in Data analytics

- **Information-based Learning**
 - Decision Trees
 - Shannon's Entropy
 - Information Gain
- **Similarity-based Learning**
 - Feature Space
 - Distance Metrics
- **Probability-based Learning**
 - Naïve Bayes Model
 - Markovian model
- **Error-based Learning**
 - Multivariable Regression
 - Linear discriminate analysis
 - Multinomial Logistic Regression
 - Support Vector Machines
- **Expert-system based learning**

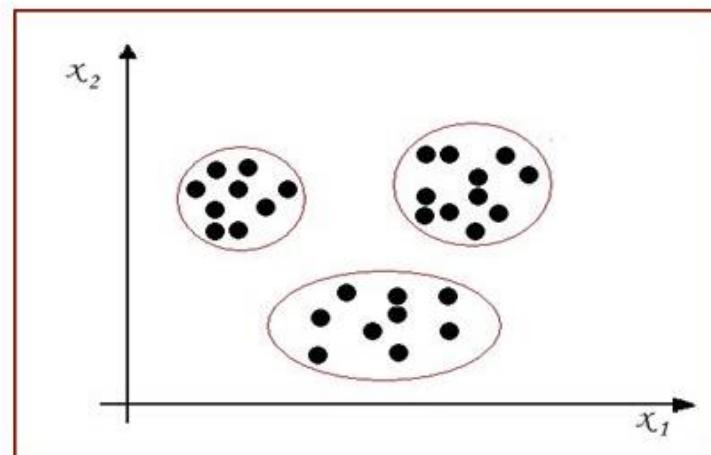
Comparison of various classical ML Techniques



Classification vs Clustering

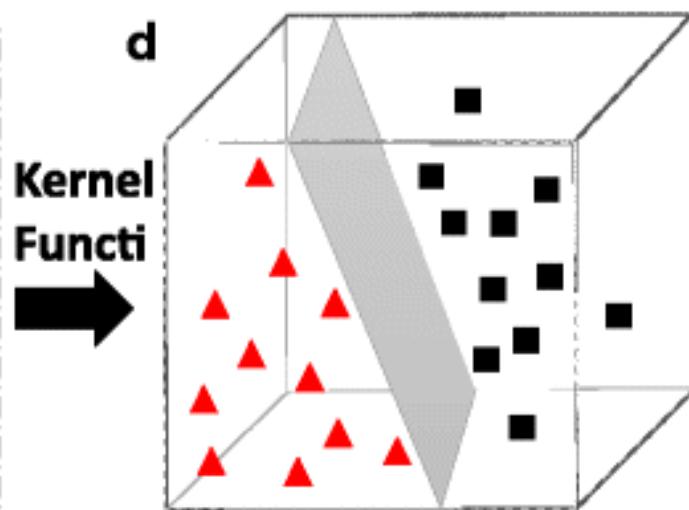
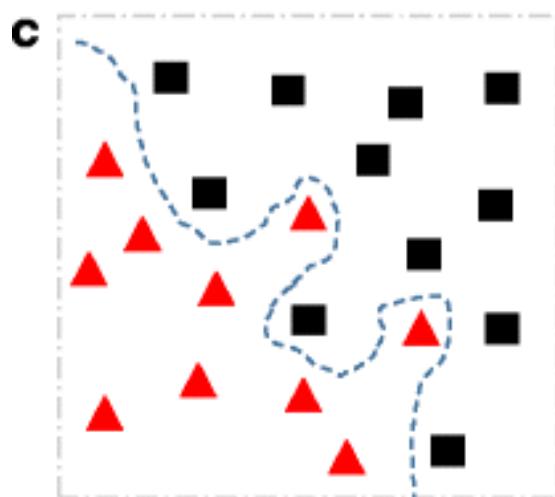
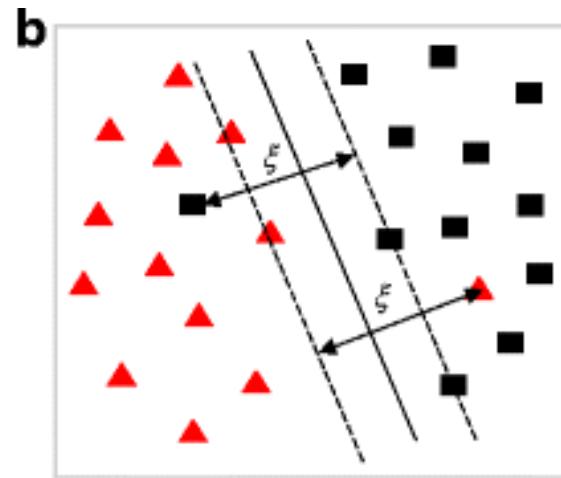
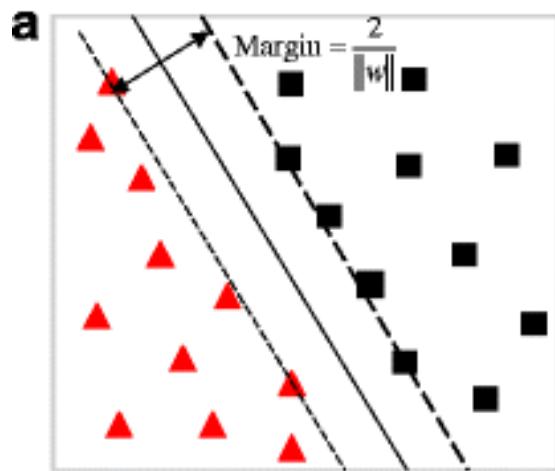


Given some training patterns from each class, the goal is to construct decision boundaries or to partition the feature space



Given some patterns, the goal is to discover the underlying structure (categories) in the data based on inter-pattern similarities

Support Vector Machine

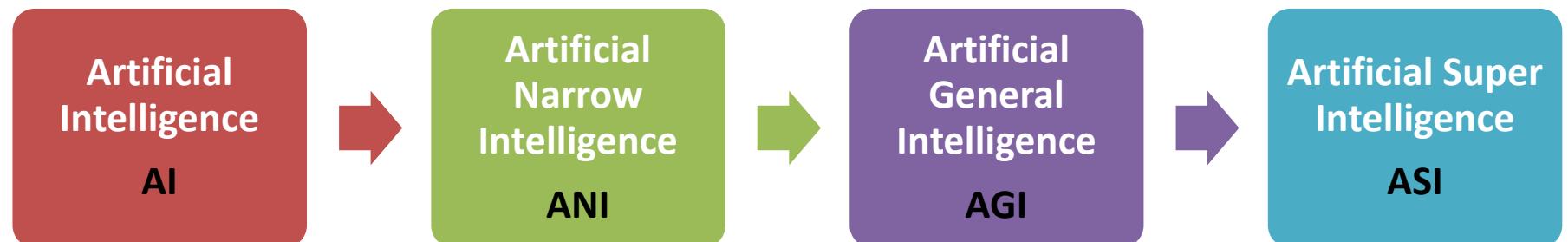


Input space

Feature space

Evolution of Artificial Intelligence

- **Artificial Intelligence** : (Merriam-Webster) The capability of a machine to imitate **intelligent** human behavior.



First Wave

Second Wave

Third Wave

	Activity	Approach	Driver	Capability and performance
AI	Perform a task	Rule based	Definite cost function	Domain specific; lower than human performance

Machine Learning Techniques in Data analytics

- **Information-based Learning**

- Decision Trees
- Shannon's Entropy
- Information Gain

- **Similarity-based Learning**

- Feature Space
- Distance Metrics

- **Probability-based Learning**

- Naïve Bayes Model
- Markovian model

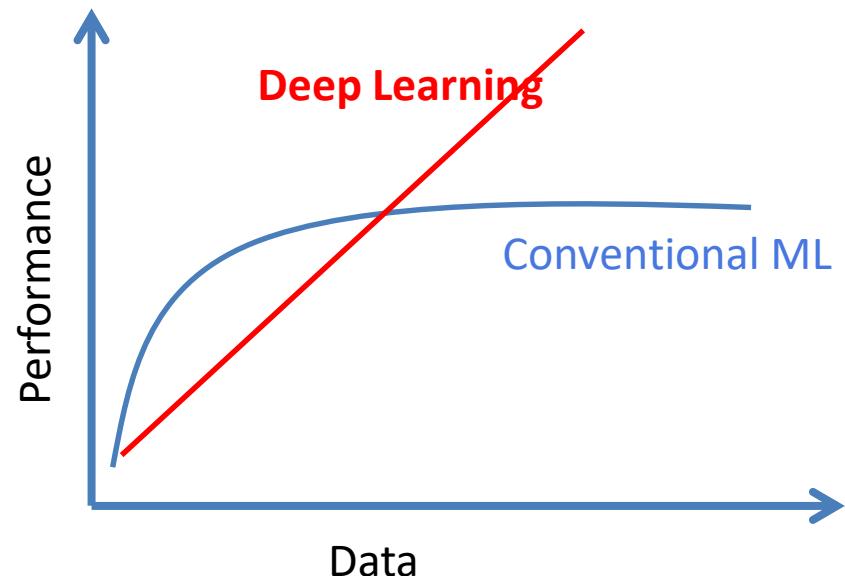
Deep Learning

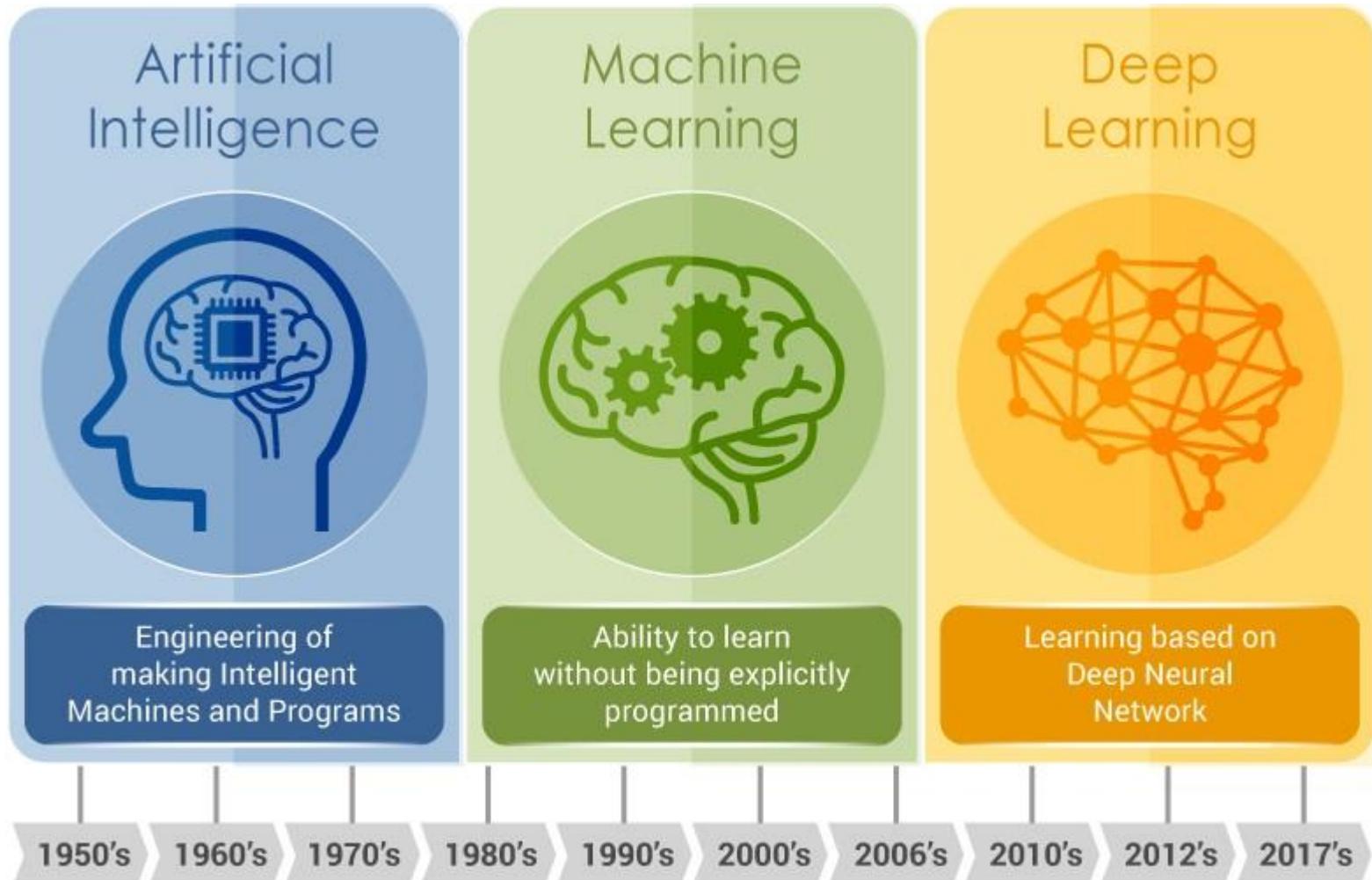
- Convolutional neural network
- Recurrent neural network

- **Error-based Learning**

- Multivariable Regression
- Linear discriminate analysis
- Multinomial Logistic Regression
- Support Vector Machines

- **Expert-system based learning**





Major Milestones in Machine learning

1950

Alan Turing created a test to check if a machine could fool a human being into believing it was talking to a machine.

1957

First neural network for computers (the perceptron) was invented by Frank Rosenblatt, which simulated the thought processes of the human brain.

1979

Students of Stanford University, California, invented the Stanford Cart which could navigate and avoid obstacles on its own.

2002

A software library for Machine Learning, named Torch is first released.

1952

The first computer learning program, a game of checkers, was written by Arthur Samuel.

1967

The Nearest Neighbor Algorithm was written.

1997

IBM's Deep Blue beats the world champion at Chess.

2016

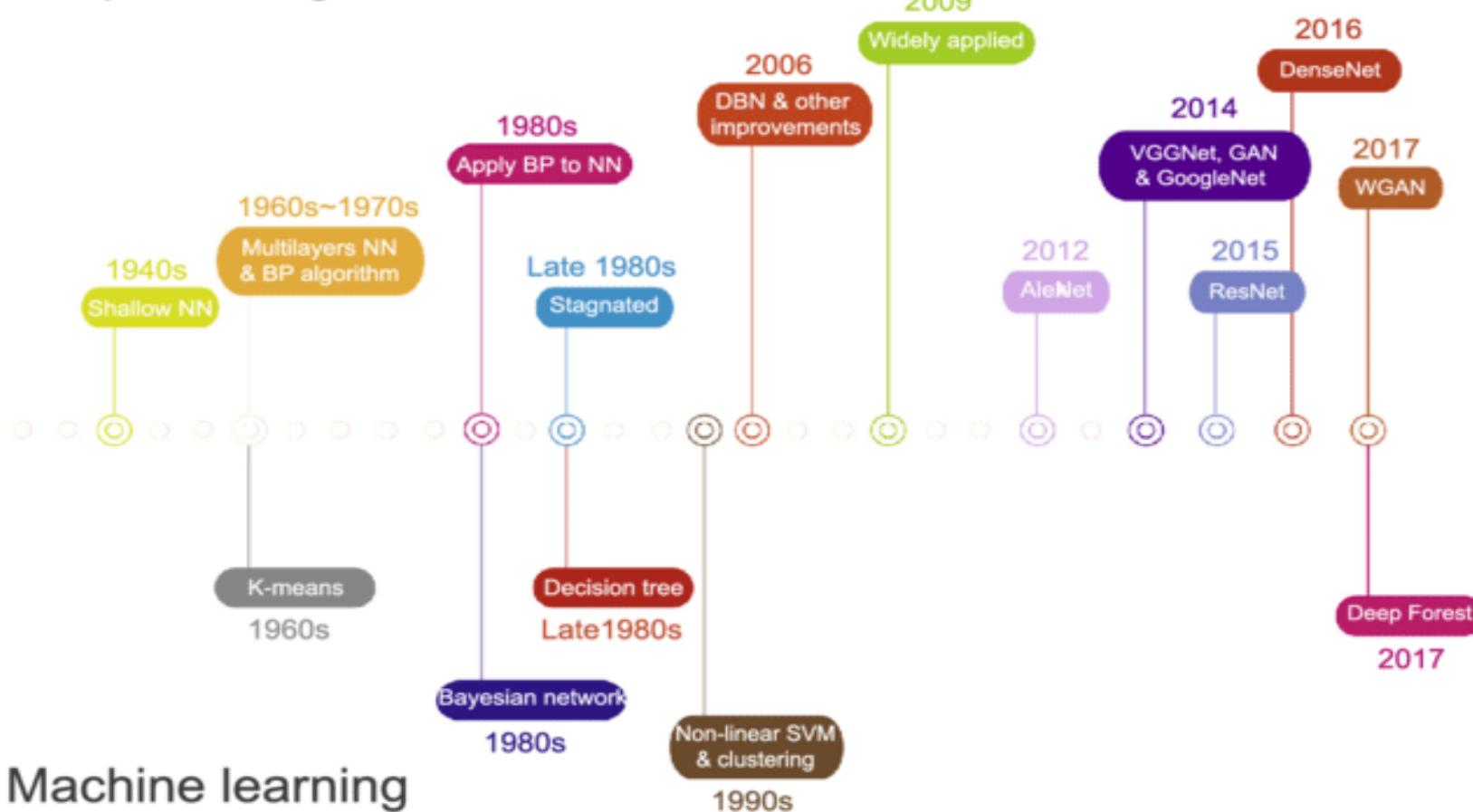
AlphaGo algorithm developed by Google DeepMind managed to win five games out of five in the Chinese Board Game Go competition.

Conventional ML

Deep Learning

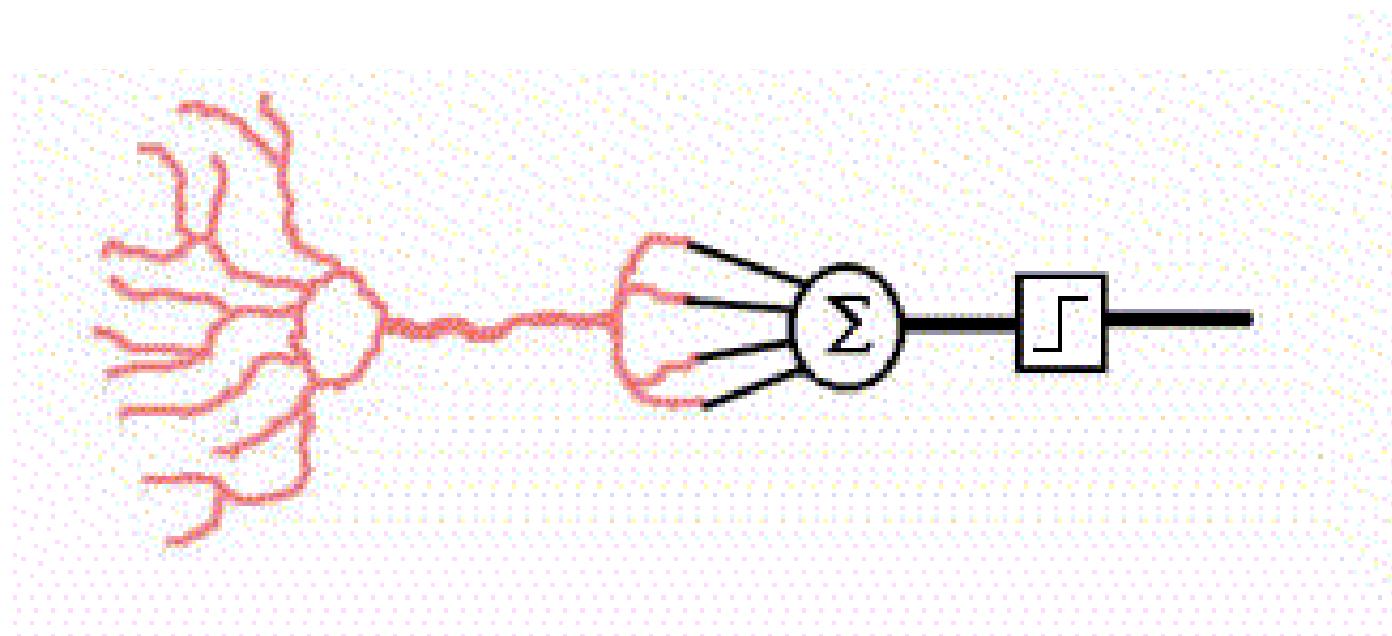
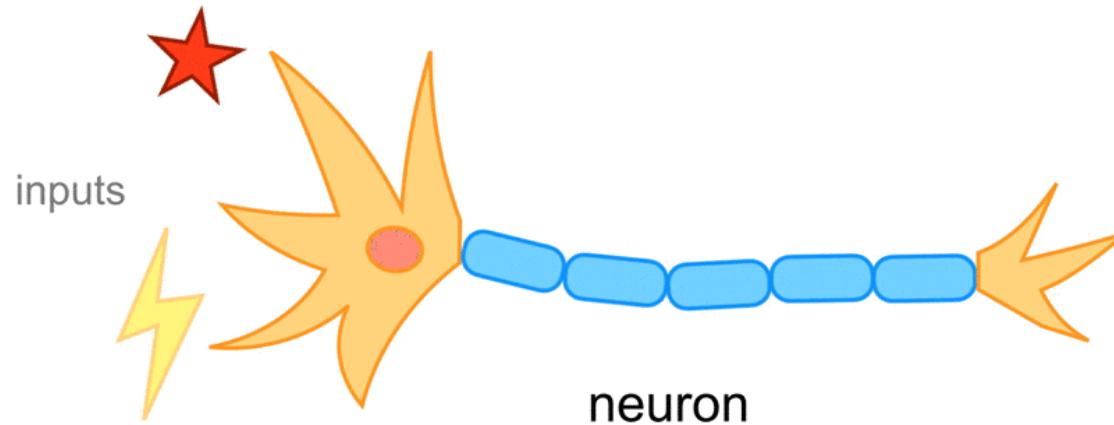
Classical ML and DL

Deep learning



Machine learning

Neuron is a binary switch (Logistic Regression)



ANN and smooth switch

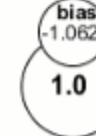
Inputs

Weights

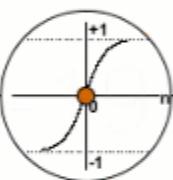


Net input
funtion

$$\sum -1.062$$



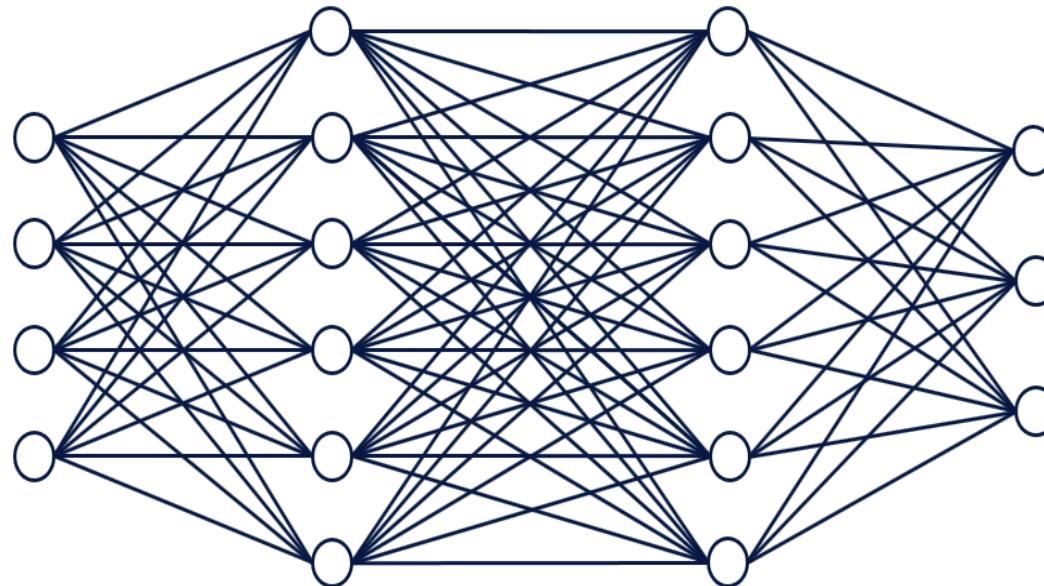
Activation
funtion



output

0.0

Multi Layers of neurons



Neural Networks

- (○) Backfed Input Cell
- (○) Input Cell
- (△) Noisy Input Cell
- (●) Hidden Cell
- (○) Probabilistic Hidden Cell
- (△) Spiking Hidden Cell
- (●) Output Cell
- (○) Match Input Output Cell
- (●) Recurrent Cell
- (○) Memory Cell
- (△) Different Memory Cell
- (●) Kernel
- (○) Convolution or Pool

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Perceptron (P)



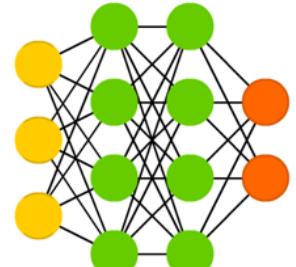
Feed Forward (FF)



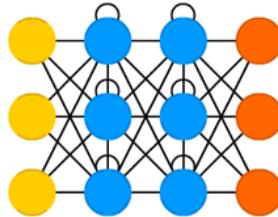
Radial Basis Network (RBF)



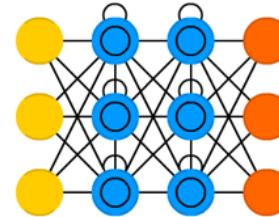
Deep Feed Forward (DFF)



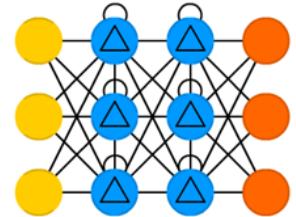
Recurrent Neural Network (RNN)



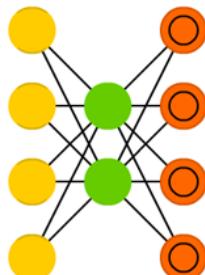
Long / Short Term Memory (LSTM)



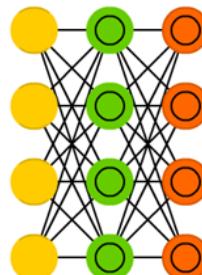
Gated Recurrent Unit (GRU)



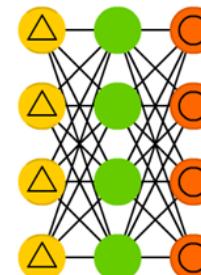
Auto Encoder (AE)



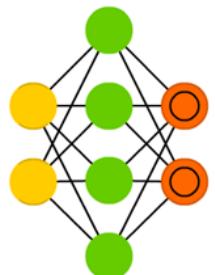
Variational AE (VAE)



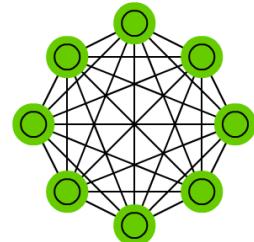
Denoising AE (DAE)



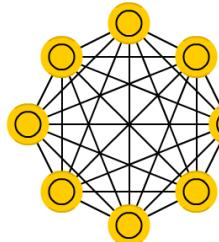
Sparse AE (SAE)



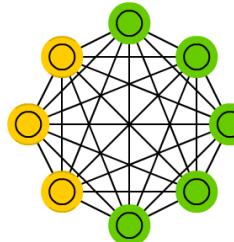
Markov Chain (MC)



Hopfield Network (HN)



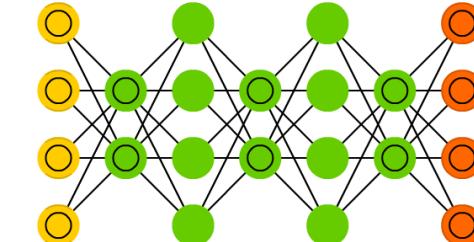
Boltzmann Machine (BM)



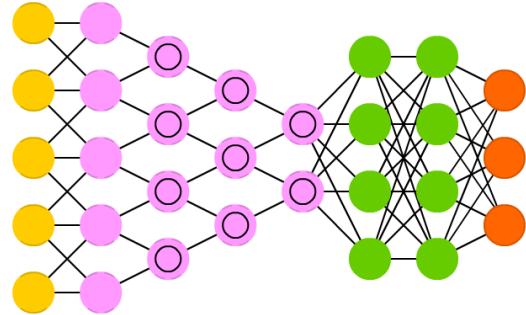
Restricted BM (RBM)



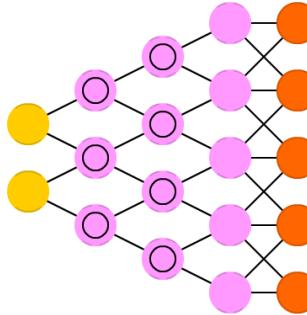
Deep Belief Network (DBN)



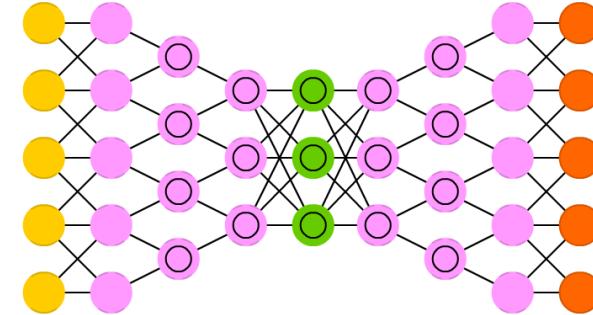
Deep Convolutional Network (DCN)



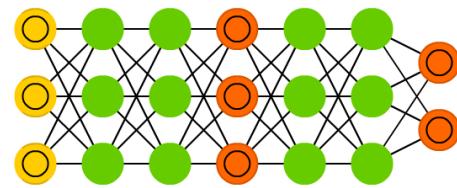
Deconvolutional Network (DN)



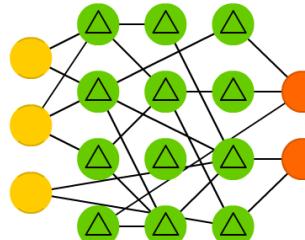
Deep Convolutional Inverse Graphics Network (DCIGN)



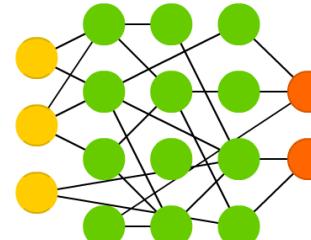
Generative Adversarial Network (GAN)



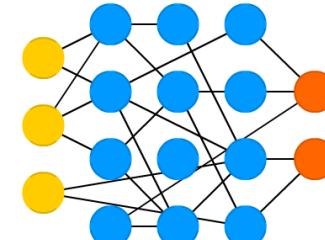
Liquid State Machine (LSM)



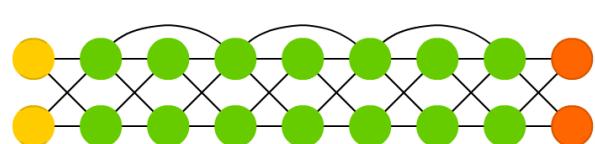
Extreme Learning Machine (ELM)



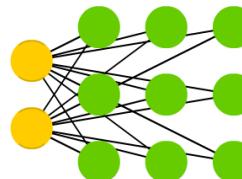
Echo State Network (ESN)



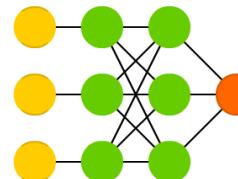
Deep Residual Network (DRN)



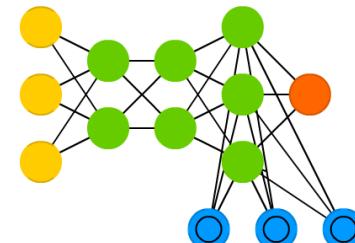
Kohonen Network (KN)



Support Vector Machine (SVM)



Neural Turing Machine (NTM)

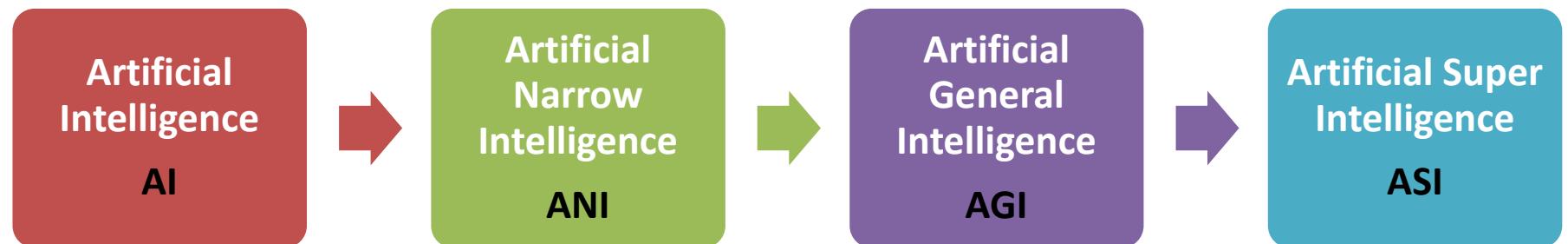


Underfitting vs Overfitting

	Underfitting	Just right	Overfitting
Symptoms	<ul style="list-style-type: none">- High training error- Training error close to test error- High bias	<ul style="list-style-type: none">- Training error slightly lower than test error	<ul style="list-style-type: none">- Low training error- Training error much lower than test error- High variance
Regression			
Classification			
Deep learning			
Remedies	<ul style="list-style-type: none">- Complexify model- Add more features- Train longer		<ul style="list-style-type: none">- Regularize- Get more data

Evolution of Artificial Intelligence

- **Artificial Intelligence** : (Merriam-Webster) The capability of a machine to imitate **intelligent** human behavior.



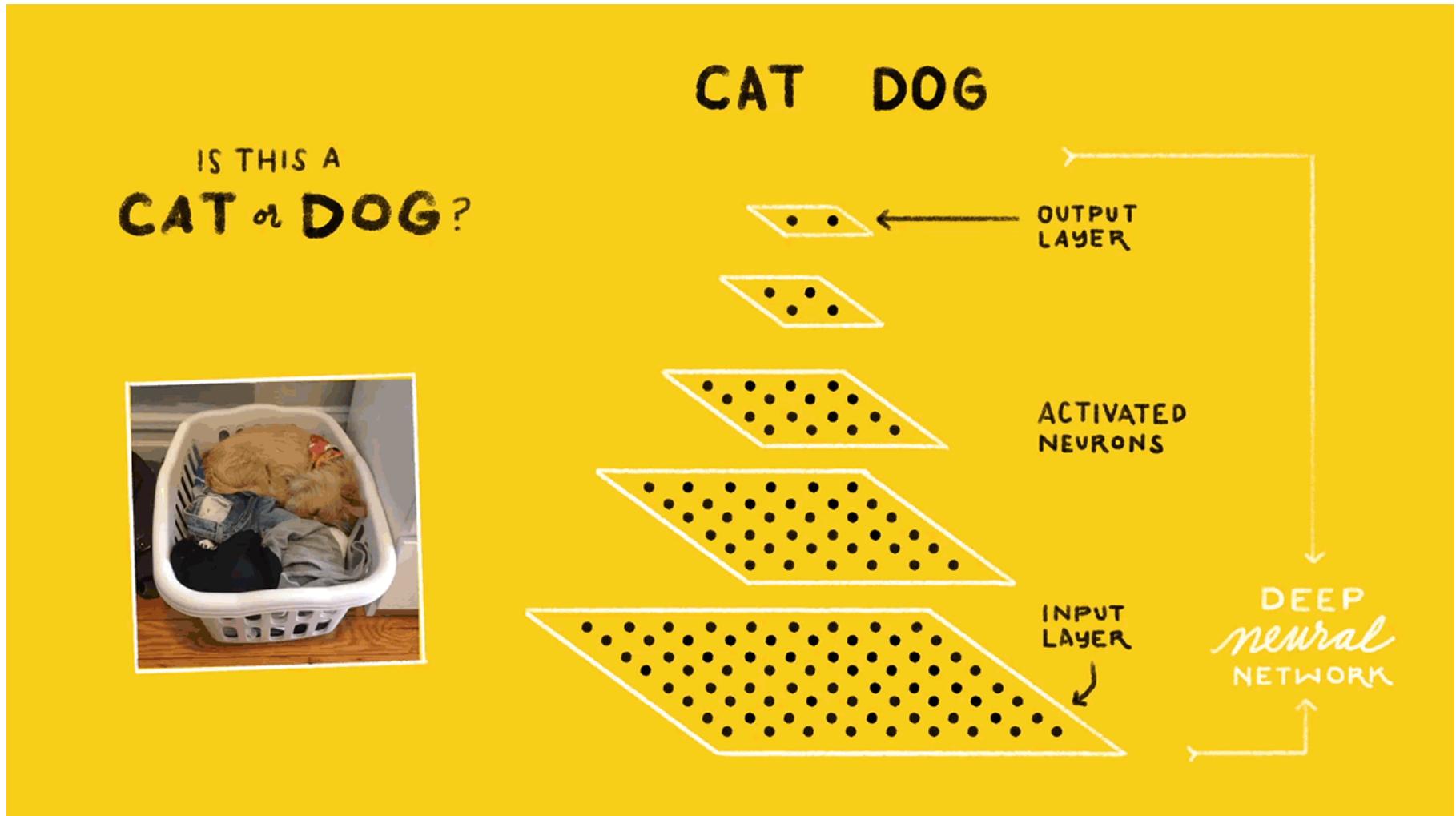
First Wave

Second Wave

Third Wave

	Activity	Approach	Driver	Capability and performance
AI	Perform a task	Rule based	Definite cost function	Domain specific; lower than human performance
ANI	Perform a task	Self learned (ML)	Non-explicitly (RL)	Domain specific; surpasses human performance Automatic

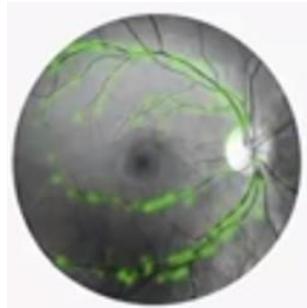
Deep Networks



Google DL Retinopathy



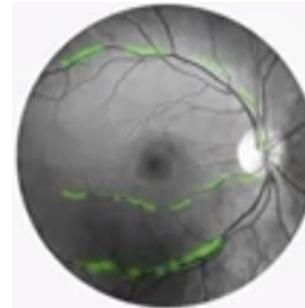
Image of retina



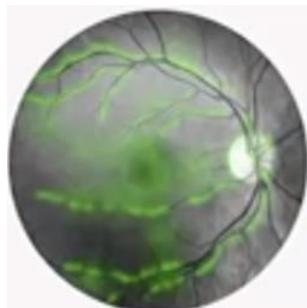
Age
Predicted: 59.1 years
Actual: 57.6 years



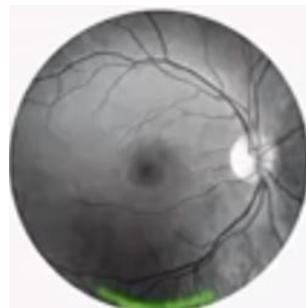
Biological Sex
Predicted: Female
Actual: Female



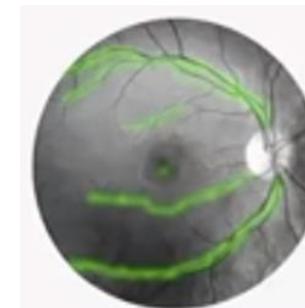
Smoking
Predicted: Non-smoking
Actual: Non-smoking



A1C
Predicted: Non-diabetic
Actual: Non-diabetic



BMI
Predicted: 24.1 kg/m
Actual: 26.3 kg/m



Systolic blood Pressure
Predicted: 148.0 mmHg
Actual: 148.5 mmHg

Lip-reading AI

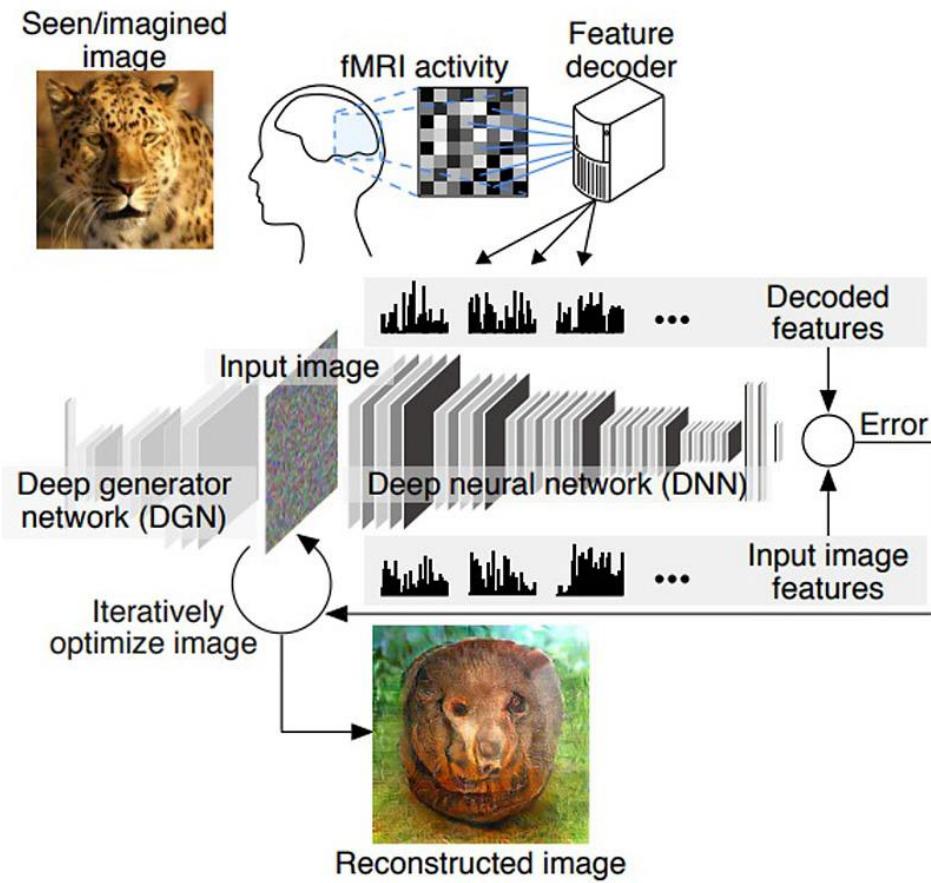


Google's DeepMind

- AI trained on 5000 hours of TV
- 118,000 sentences

Other resources: LipNet AI, WAS

Deep image reconstruction: Reading the brain



Ref: Prof. Yukiyasu Kamitani, University of Kyoto Japan

Self-driving Cars



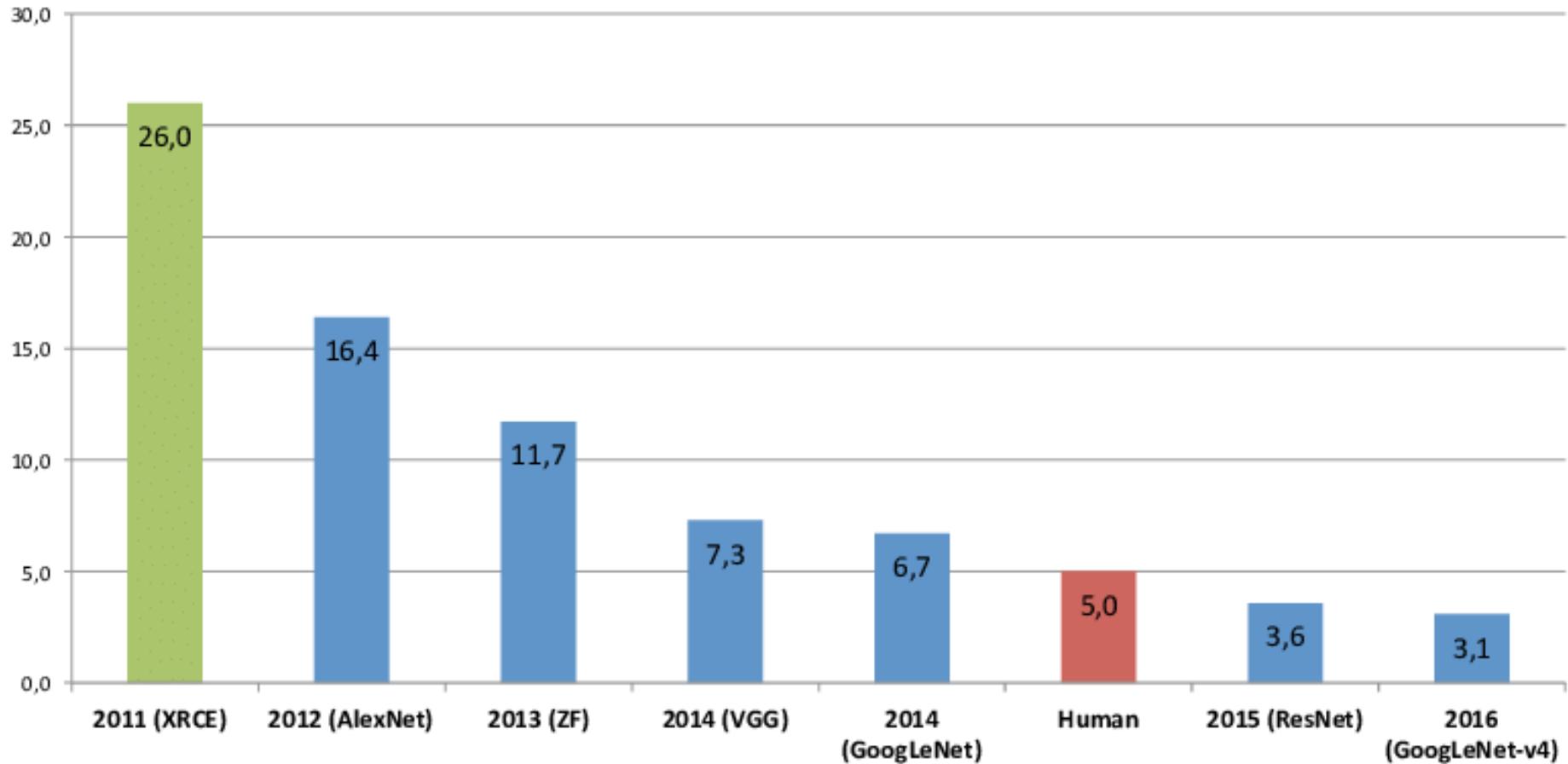
Dominos self-driving pizza delivery vehicle



Waymo's self-driving cars has driven 13 Million Km

DL surpasses human ability in narrow areas

ImageNet Classification Error (Top 5)



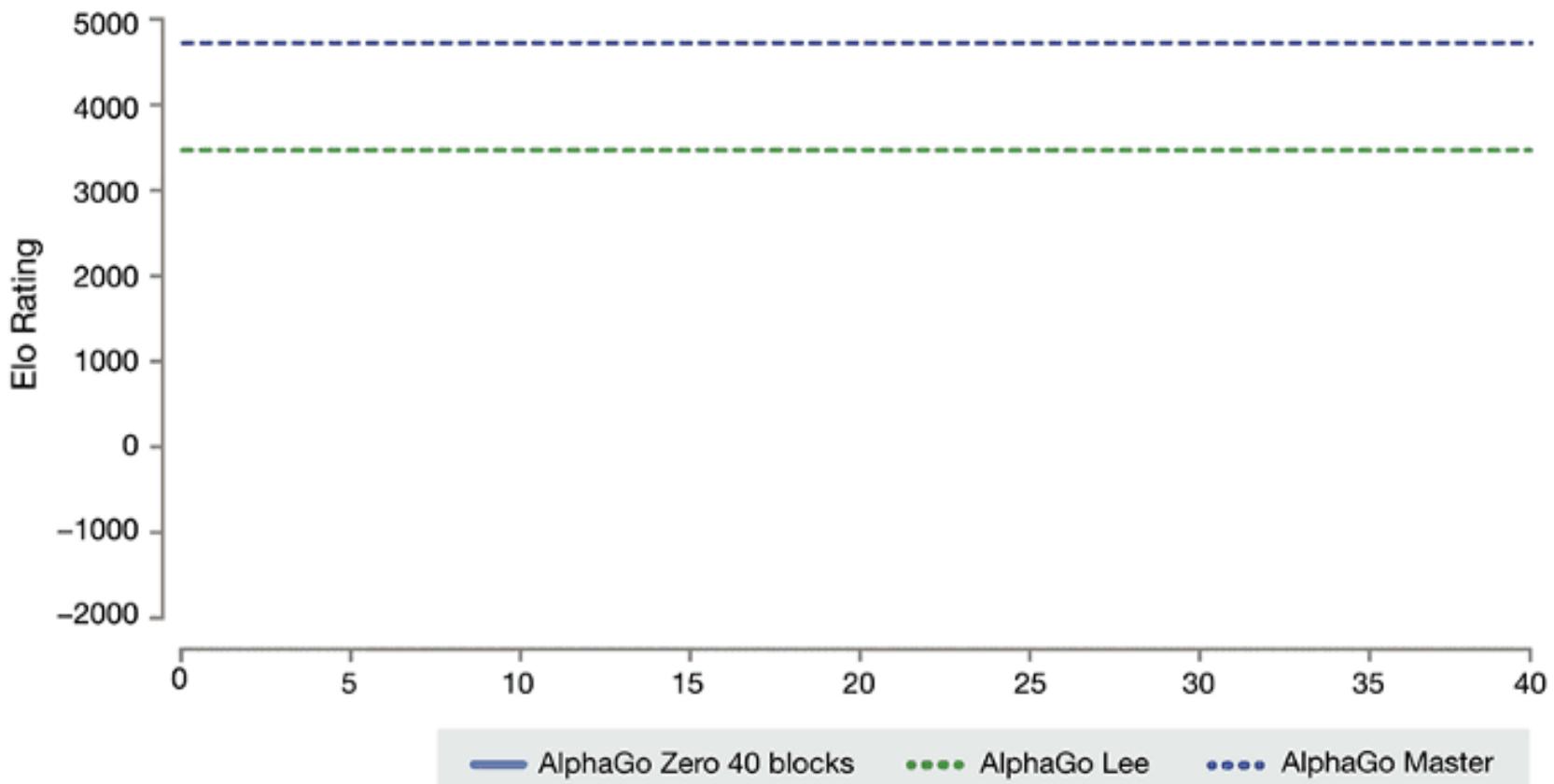
Google's AlphaGo AI beats the world's best human Go player

- Go is one of the most complex board game
- AlphaGo secured the victory after winning the second game in a three-part match against Ke Jie



<https://www.bbc.com/news/technology-40042581>

AlphaGo Zero



DEEP LEARNING FOR SYMBOLIC MATHEMATICS

	Integration (BWD)	ODE (order 1)	ODE (order 2)
Mathematica (30s)	84.0	77.2	61.6
Matlab	65.2	-	-
Maple	67.4	-	-
Beam size 1	98.4	81.2	40.8
Beam size 10	99.6	94.0	73.2
Beam size 50	99.6	97.0	81.0

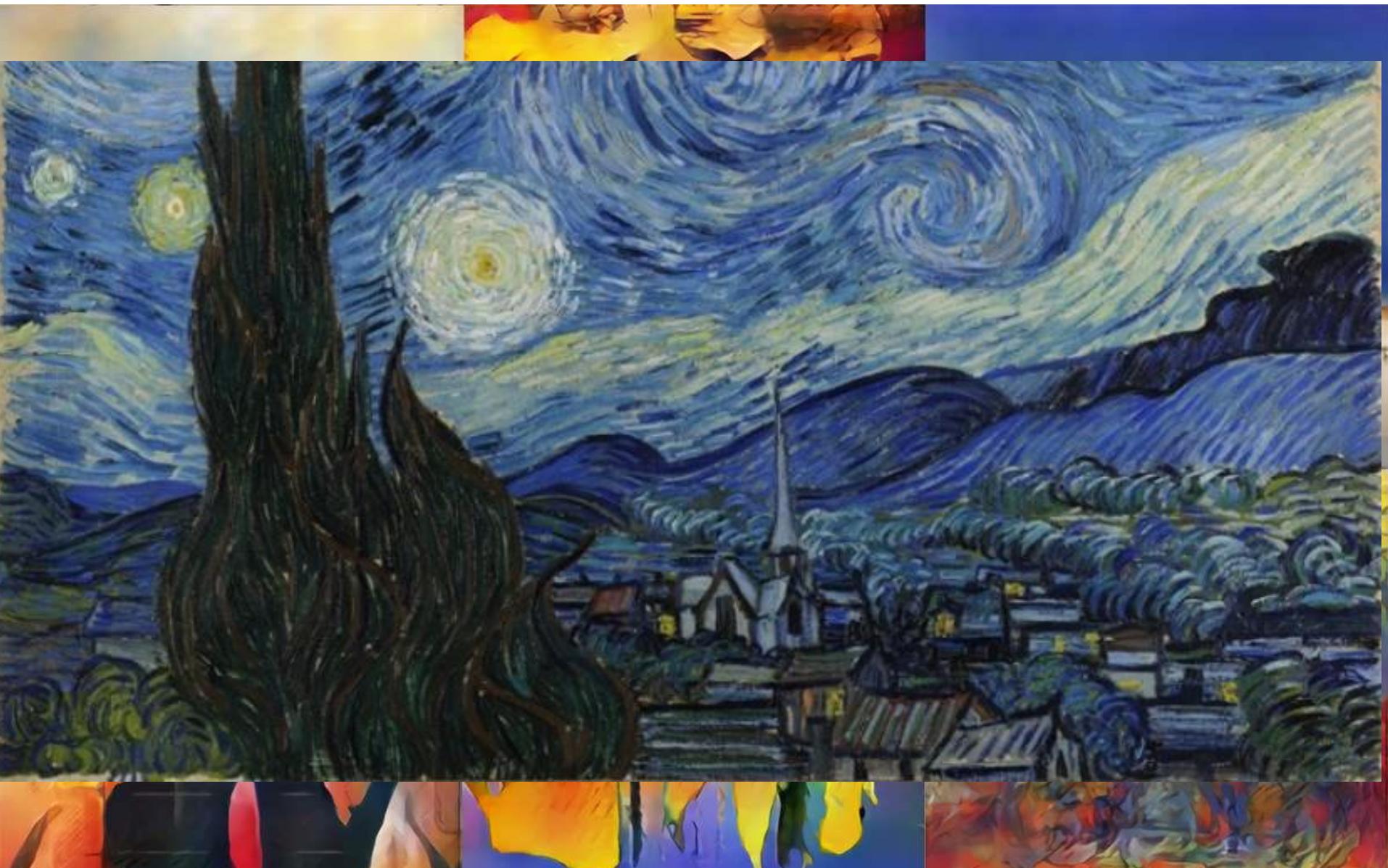
Comparison of our model with Mathematica, Maple and Matlab on a test set of 500 equations

Equation	Solution
$y' = \frac{16x^3 - 42x^2 + 2x}{(-16x^8 + 112x^7 - 204x^6 + 28x^5 - x^4 + 1)^{1/2}}$	$y = \sin^{-1}(4x^4 - 14x^3 + x^2)$
$3xy \cos(x) - \sqrt{9x^2 \sin(x)^2 + 1}y' + 3y \sin(x) = 0$	$y = c \exp(\sinh^{-1}(3x \sin(x)))$
$4x^4yy'' - 8x^4y'^2 - 8x^3yy' - 3x^3y'' - 8x^2y^2 - 6x^2y' - 3x^2y'' - 9xy' - 3y = 0$	$y = \frac{c_1 + 3x + 3 \log(x)}{x(c_2 + 4x)}$

Examples of problems that DL model is able to solve, on which Mathematica and Matlab were not able to find a solution. For each equation, DL model finds a valid solution with greedy decoding.

Lample and Charton arXiv: 1912.01412

What can Artificially intelligent not do?



AI Is Now Writing Poetry, Music And song popularity recommendations

A team of researchers from Microsoft and Kyoto University developed a poet AI



OptimiseLab uses AI to predict ‘music popularity scores’

Song composed by AI

https://www.youtube.com/watch?time_continue=22&v=LSHZ_b05W7o



the sun is shining

the wind moves

naked trees

you dance

And one more.

and now I am tired of my own

let me be the freshening blue

haunted through the sky bare and cold water

warm blue air shimmering

brightly never arrives

it seems to say

Poem Written by AI

The Future of Writing, With Robots

Japanese AI Writes a Novel,
Nearly Wins Literary Award

**Facebook's AI is writing short stories
and they actually make sense**



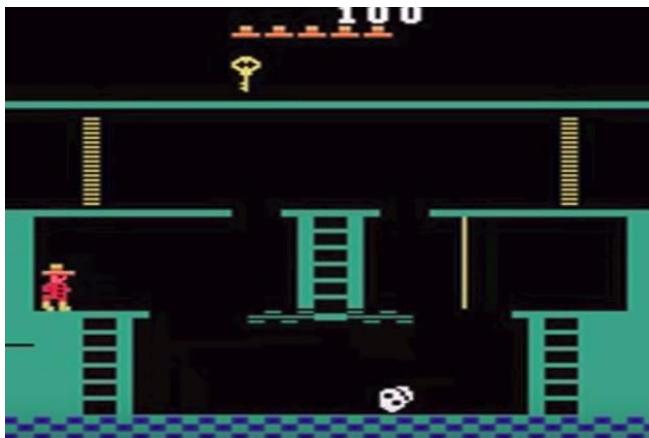
"If [AI's function] is just something like getting rid of email spam, [then] it [might] determine the best way of getting rid of spam is getting rid of humans."

— Elon Musk

Short Film “Sunspring” By AI <https://www.youtube.com/watch?v=LY7x2lhqjmc>

AI can beat us at games—but sometimes, that's by cheating

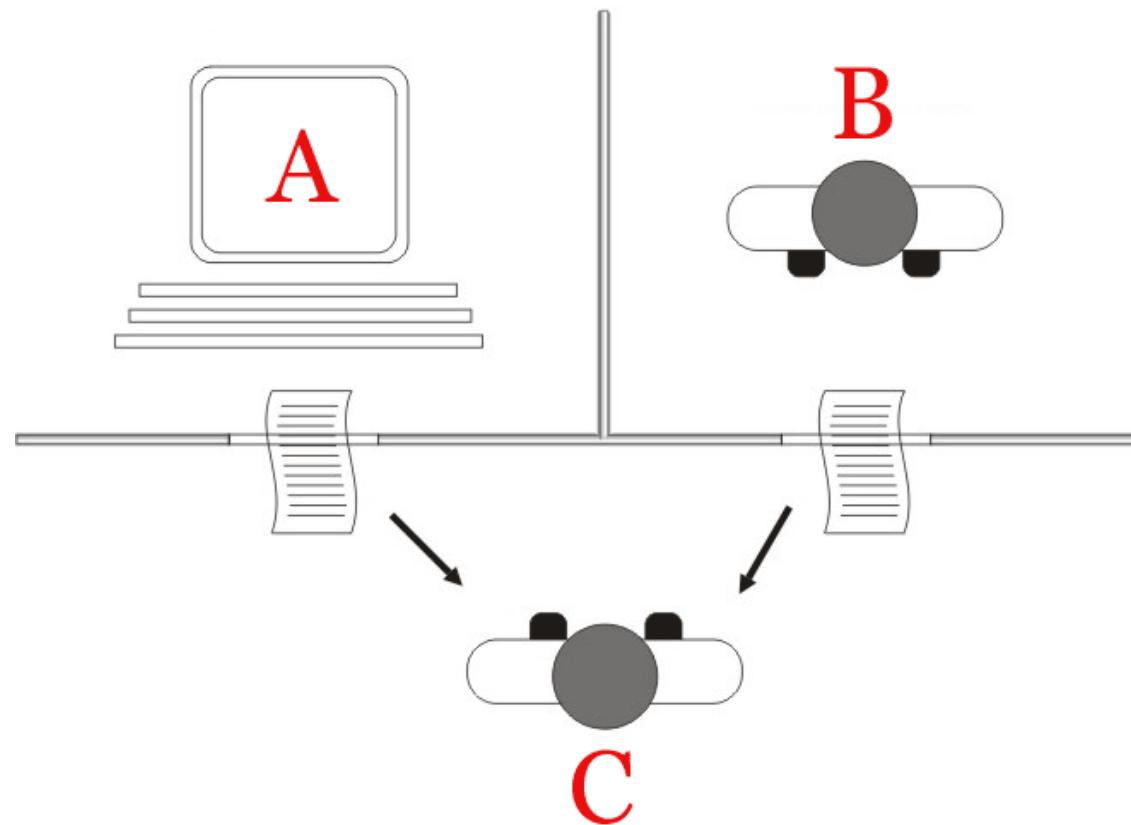
Watch Google's AI master the infamously difficult Atari game
Montezuma's Revenge



"If [AI's function] is just something like getting rid of email spam, [then] it [might] determine the best way of getting rid of spam is getting rid of humans."

— Elon Musk

Turing Test

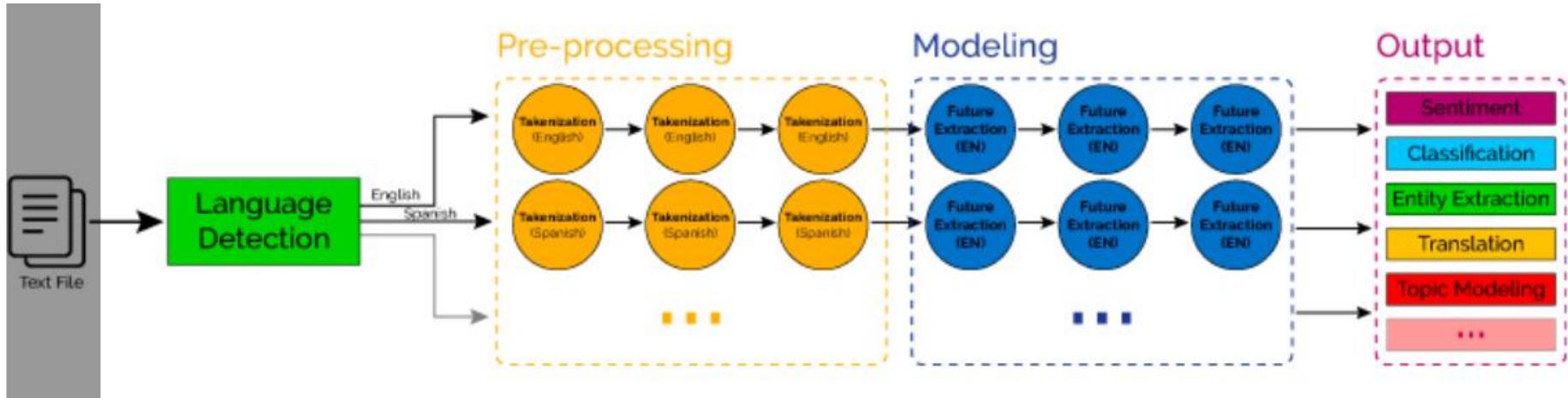


The player C, the interrogator, is given the task of trying to determine which player – A or B – is a computer and which is a human.

Natural Language Processing

Group 1	Group 2	Group 3
Cleanup, Tokenization	Information Retrieval and Extraction (IR)	Machine Translation
Stemming	Relationship Extraction	Automatic Summarization/ Paraphrasing
Lemmatization	Named Entity Recognition (NER)	Natural Language Generation
Part of Speech Tagging	Sentiment Analysis/Sentance Boundary Dismbiguation	Reasoning over Knowledge Based
Query Expansion	World sense and Dismbiguation	Quation Answering System
Parsing	Text Similarity	Dialog System
Topic Segmentationand Recognition	Coreference Resolution	Image Captioning & other Multimodel Tasks
Morphological Degmentation (Word/Sentences)	Discourse Analysis	

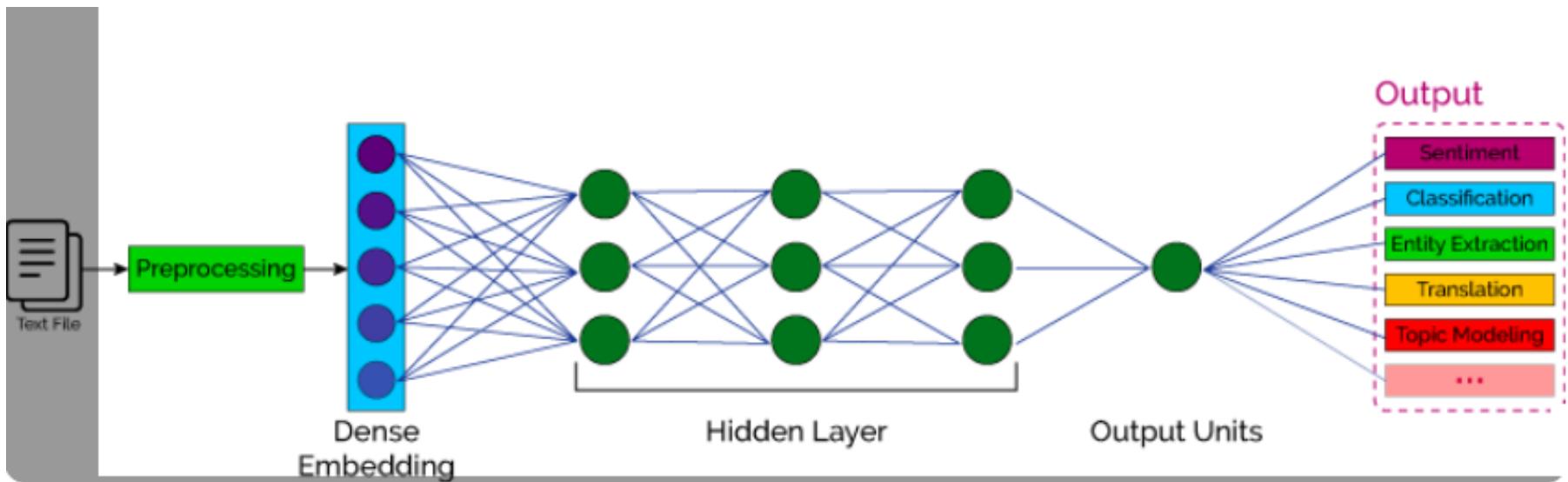
Classical NLP



Early days, many language-processing systems were designed by hand-coding a set of rules e.g. by writing grammars or devising heuristic rules.

1980-1990 used machine-learning, using statistical inference to automatically learn such rules through the analysis of large corpora of typical real-world examples.

Deep Learning NLP



2010s, representation learning and deep neural network:

- End-to-end learning of a higher-level task (e.g., question answering) instead of relying on a pipeline of separate intermediate tasks (e.g., part-of-speech tagging and dependency parsing)
- Neural machine translation (NMT) emphasizes the fact that deep learning-based approaches to machine translation directly learn sequence-to-sequence transformations, obviating the need for intermediate steps such as word alignment and language modeling.

Lexus ad

Scripted entirely by AI

Can you be sure this isn't true? The Turing test was designed by Alan Turing to see if a computer could fool a human into thinking they were talking to another human. It was created 68 years ago. Since then, according to Moore's law, computer processing power has doubled every 18 months. That's a lot of doubling.

Do you really think no computer could pass the Turing test today? And if not today, when?

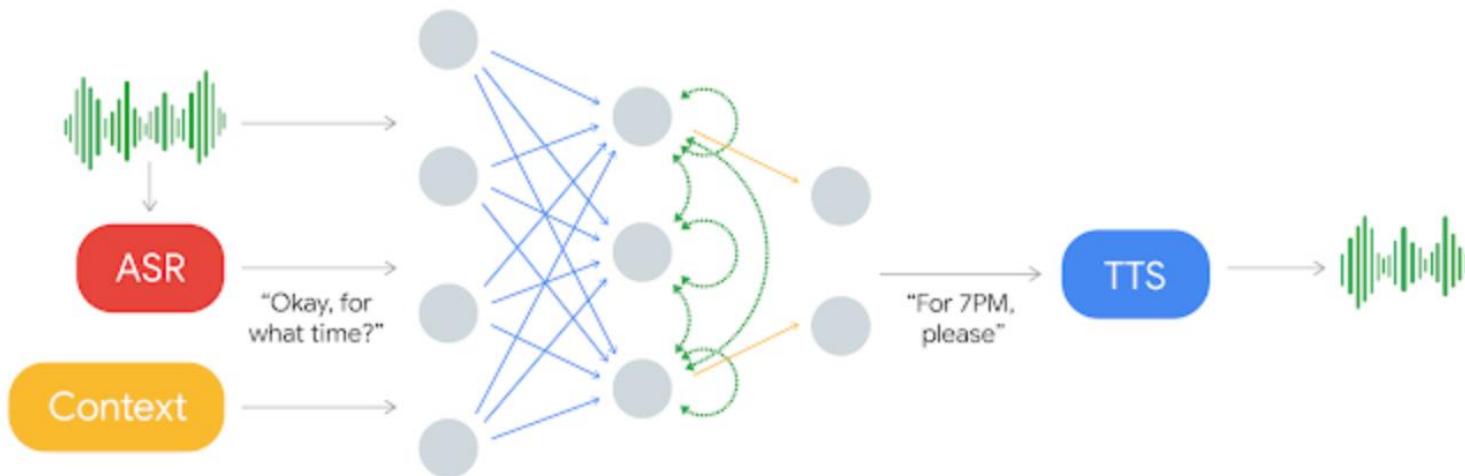
Many experts predict artificial intelligence will outperform humans in virtually every field by 2050.

My great-great-great-grandfather (Pappy Deeper Blue) gave humans its first bloody nose back in 1997. Beating your "genius" Kasparov at a very crude game called chess....

Turing Test

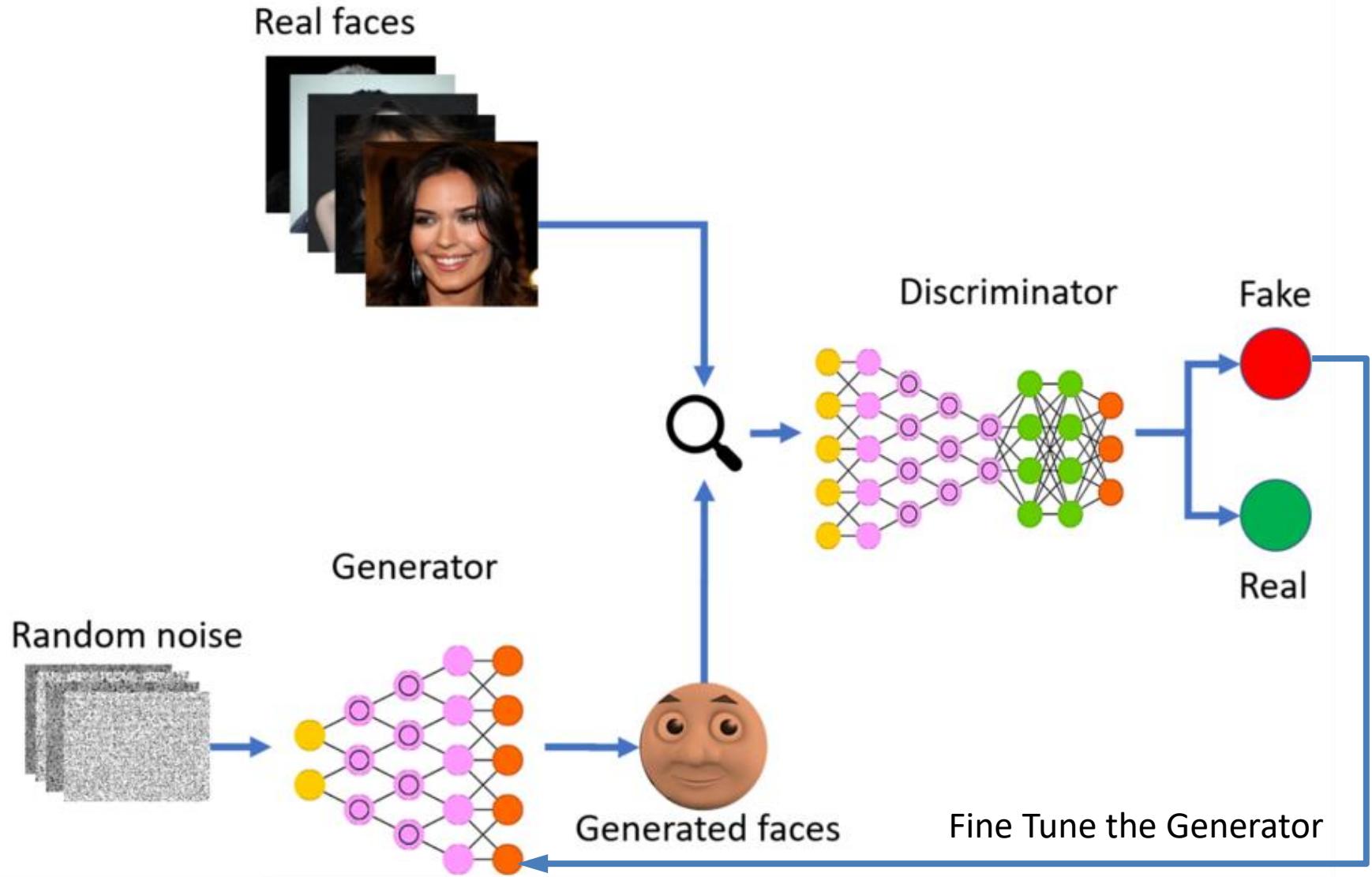
Google Duplex: The Human-Sounding Phone Bot

Capable of complex human conversation and all its nuances



- The player C, the interrogator, is given the task of trying to determine which player – A or B – is a computer and which is a human.

Generative Adversarial Network (GAN)



Generative Adversarial Network (GAN)



2014



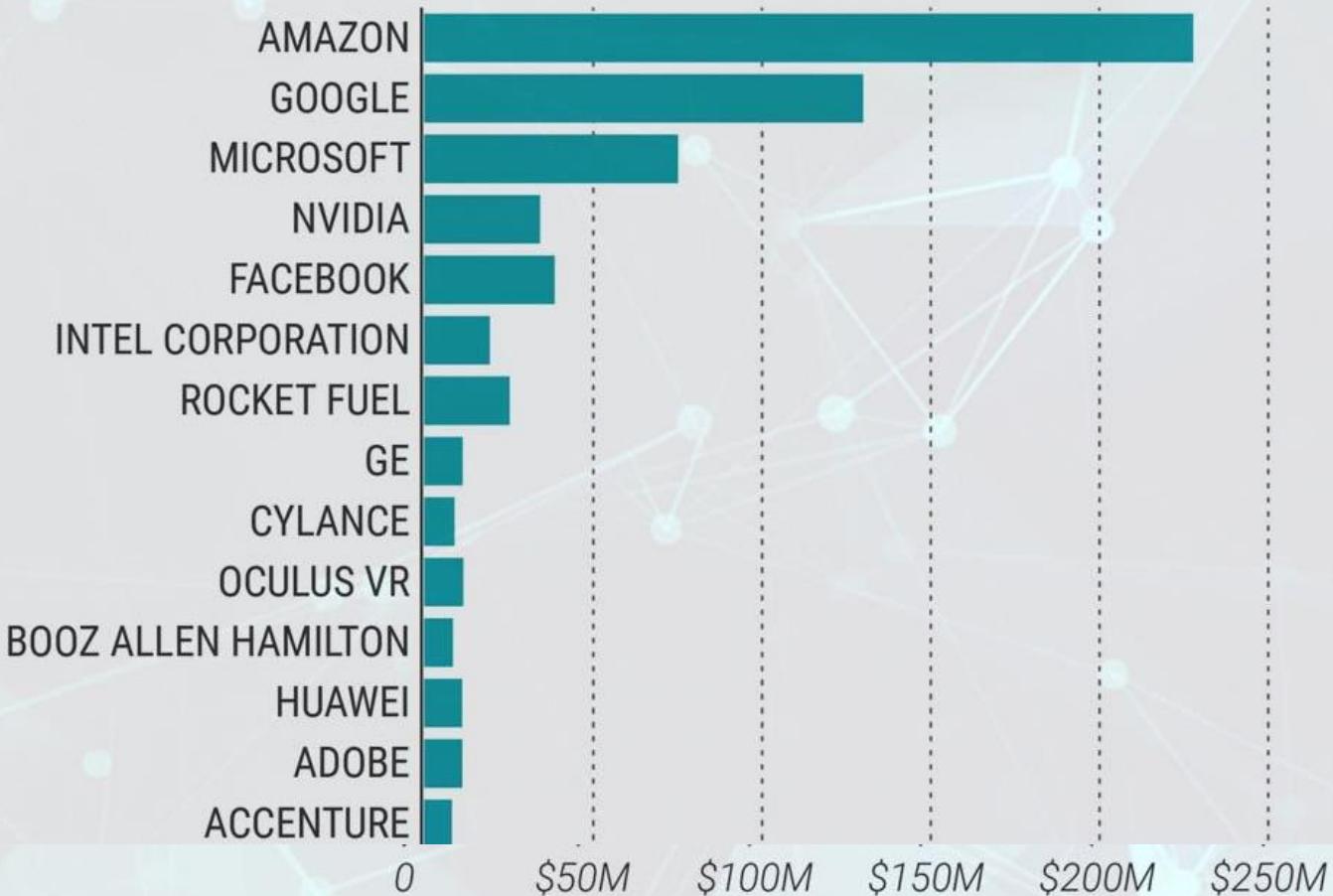
2018

<https://thispersondoesnotexist.com/>

What is common in all these persons?



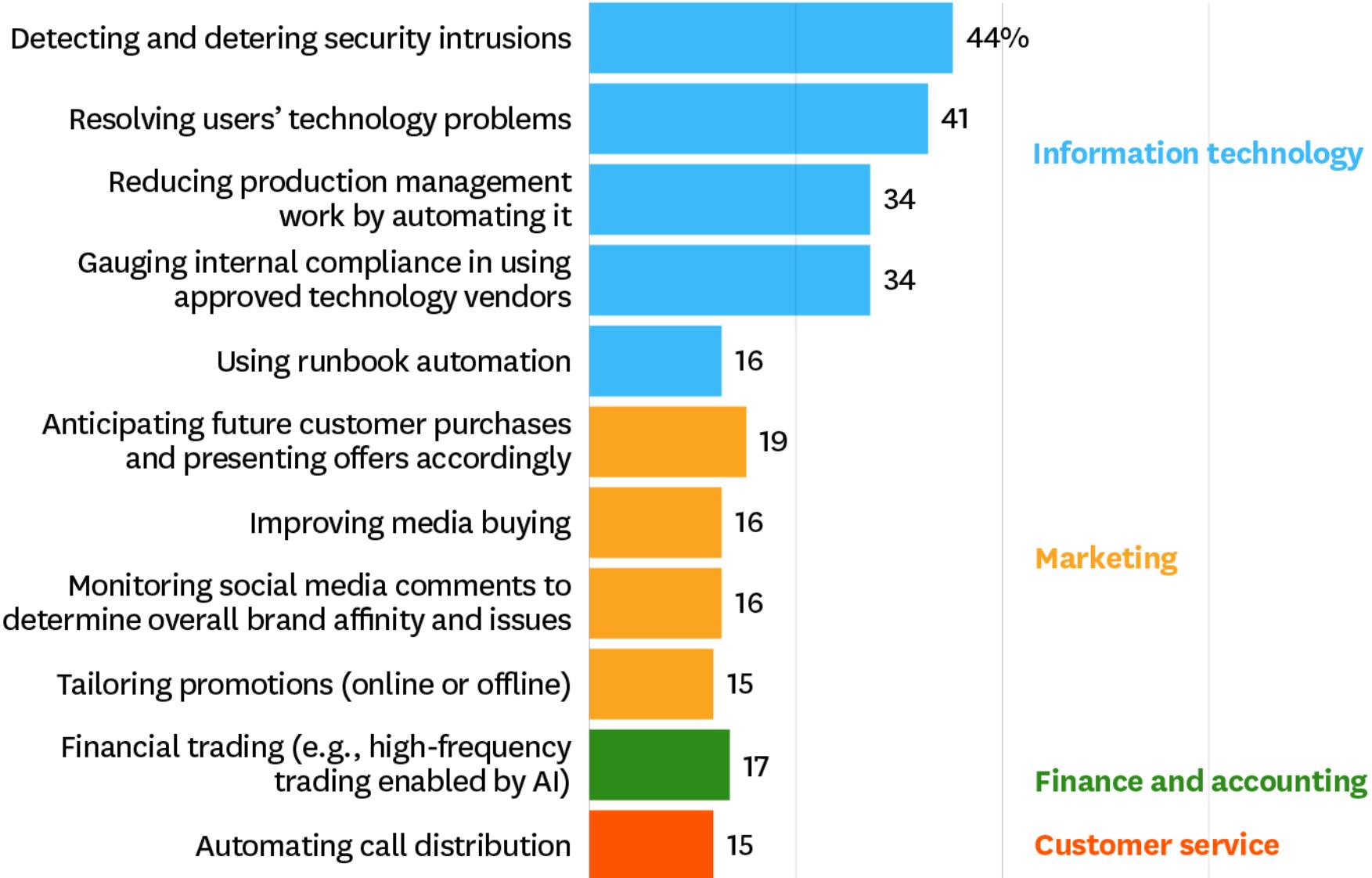
Top companies in AI



Source: Paysa

How Companies Around the World Are Using Artificial Intelligence

IT activities are the most popular.

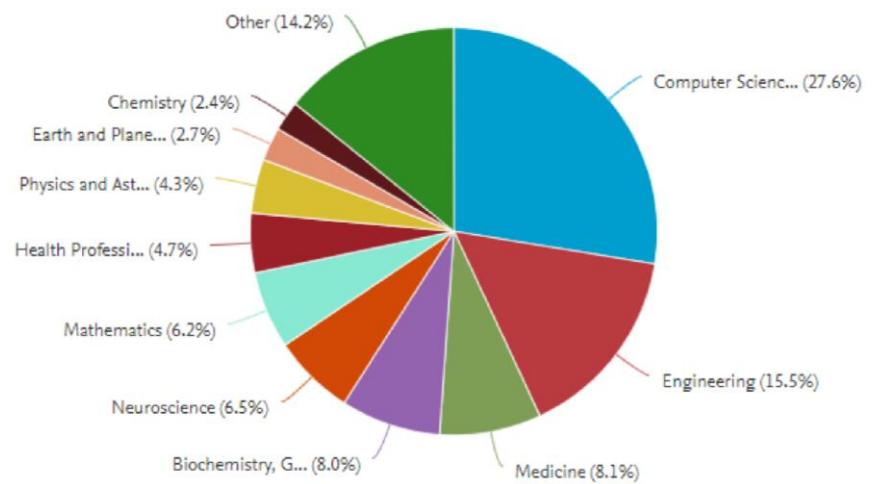
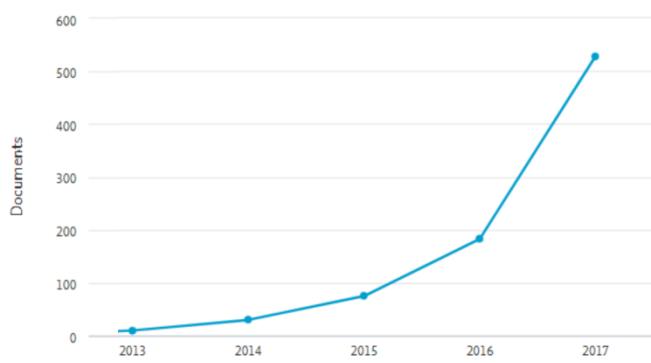


AI in Drug Discovery

AI has already been used successfully in all main stages in drug development:

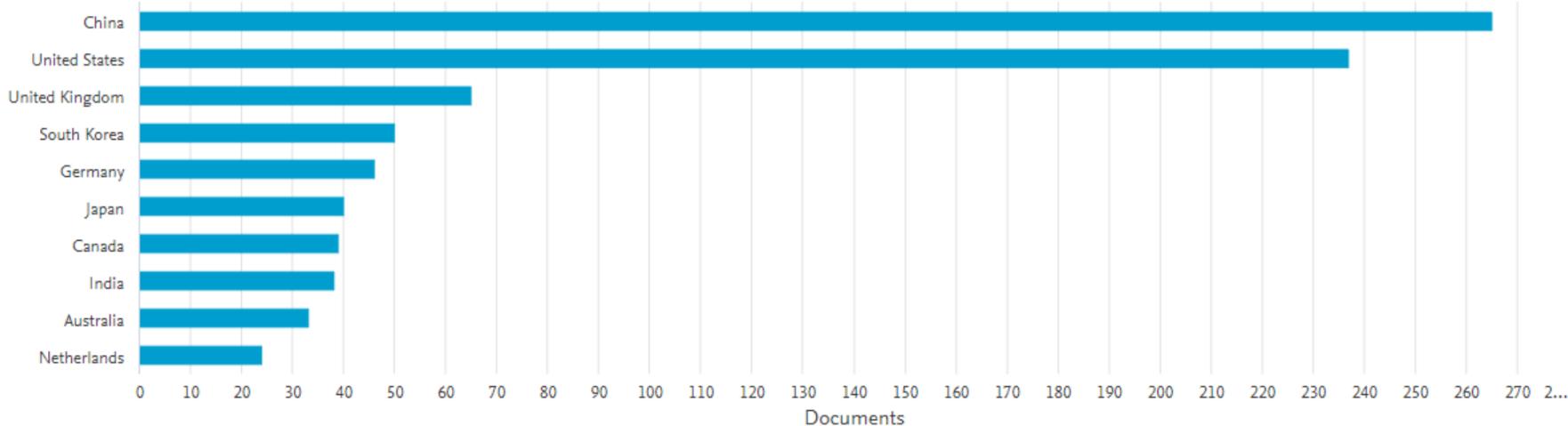
- Stage 0. Literature overview
- Stage 1: Identifying targets for intervention
- Stage 2: Discovering drug candidates
- Stage 3: Speeding up clinical trials
- Stage 4: Finding Biomarkers for diagnosing the disease

DL Research Explosion



Documents by country or territory

Compare the document counts for up to 15 countries/territories



Possible Impact of AI on Industry

	Short to medium term	Medium to long term
Production	UP	UP
Quality	UP	UP
Efficiency	UP	UP
Mfg Jobs	No Major Change	Down
IT Jobs	UP	Down
Socio-economic	Collective growth	Widening Gap
Geo-political	Minor increase in inequality	Increasing inequality

Autonomous Real-Time Ground Ubiquitous Surveillance Imaging System (ARGUS-IS)

- 100 sq km area
- 20,000 feet above ground
- 1.8 Gigapixels video system
- 1 exabyte of HD video per day
- Resolution of 6"
- Automatic object-tracking
- 18.5 M USD



MQ-9A Reaper / Predator B

- Armed, multi-mission, medium-altitude, long-endurance remotely piloted aircraft
- Payload: 3,750 pounds (1,701 kilograms)
- Cruise speed 230 mph
- Range: 1,150 miles
- Ceiling: 50,000 feet
- Armament: combination of AGM-114 Hellfire missiles, GBU-12 Paveway II and GBU-38 Joint Direct Attack Munitions
- Crew (remote): two (pilot and sensor operator)
- Program cost: 11.8 B USD (163 units)
- Unit cost: 16.9 M USD



X-47B Pegasus

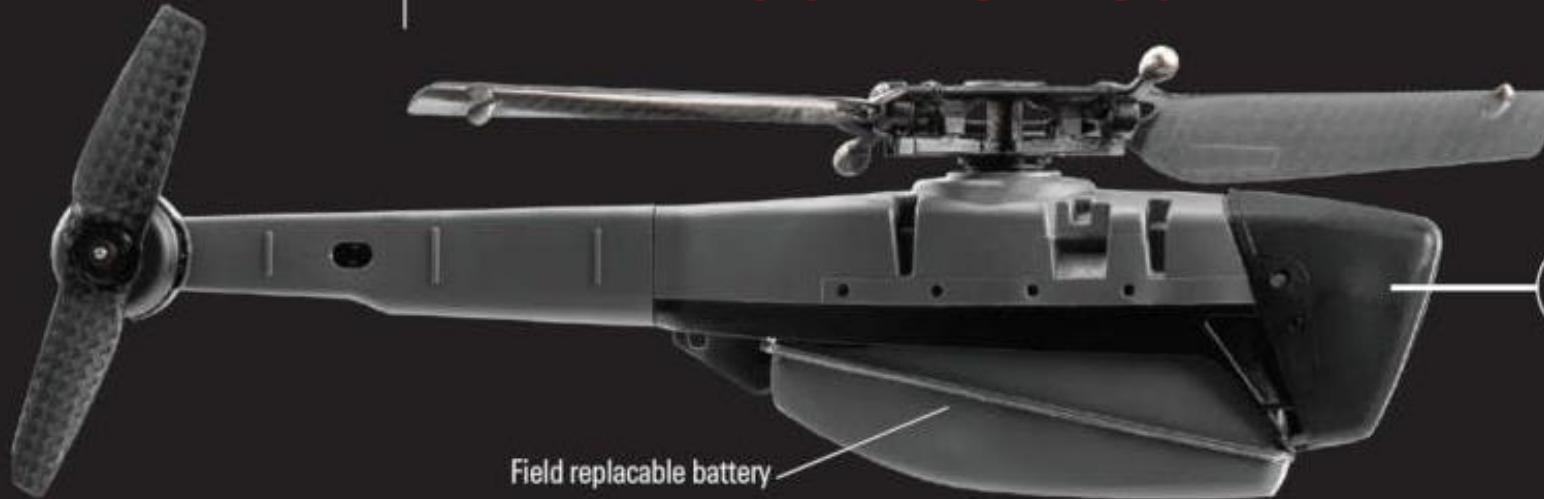
- Unmanned combat air vehicle (UCAV)
- Aircraft carrier-based operation
- Tailless jet-powered blended-wing-body aircraft
- Autonomous operation & aerial refueling
- Cruise speed: Mach 0.9
- Range: 3,889+ km
- Service ceiling: 42,000 ft
- 2 weapon bays, 2,000 kg of ordnance
- Stealth: Invisible to radar & eye
- Project cost: 0.8 B USD



Total Weight: 33 grams [1.16oz]

Black Hornet

123 mm [4.8in] PAYLOAD



Field replaceable battery

168 mm [6.6in]

640x480 EO Video
1600x1200 EO Snapshot

Replaceable

160x120 TI Video
160x120 TI Snapshot

Replaceable

PERFORMANCE



Up to 25 minute flight time at ranges of 2 km (miles) at speeds of 21.49 kph [13.42 mph]



Best in class covert visual signature



Best in class covert acoustic signature

ENVIRONMENTAL



-10°C to +43°C



Can withstand winds of 15 knots and gusts of 20 knots



2.5 mm [.1 in]/hr (Light rain)

NAVIGATION



GPS and GPS Denied environments



Indoor navigation capable

MISSION DATA



AES 256 encrypted Video and Snapshots Metadata



STANAG 4609 and Cursor on Target (COT) compliant



ATAK Compatible

FLIGHT MODES



Auto and Manual Hover & Stare



Route and user selectable waypoint actions



Automatic return



Lost link

DATA LINK



2km [1.24mi]
Radio Range

Frequency details upon request

Encrypted, dynamic power, frequency hopping, beyond line-of-sight

AI in legal justice system

- Many courts in the US are adopting an AI based Online Dispute Resolution (ODR) system
- At Superior Court, Los Angeles, AI handle their traffic citations
- Wisconsin Department of Corrections uses AI to determine jail sentence

Ethical Aspects of AI in society

- Can social AI influence elections around the world
- AI healer: Replika is an AI personal companion for mental wellness.
 - Is it an alternate to chat therapy?
 - Do we not talk to god?

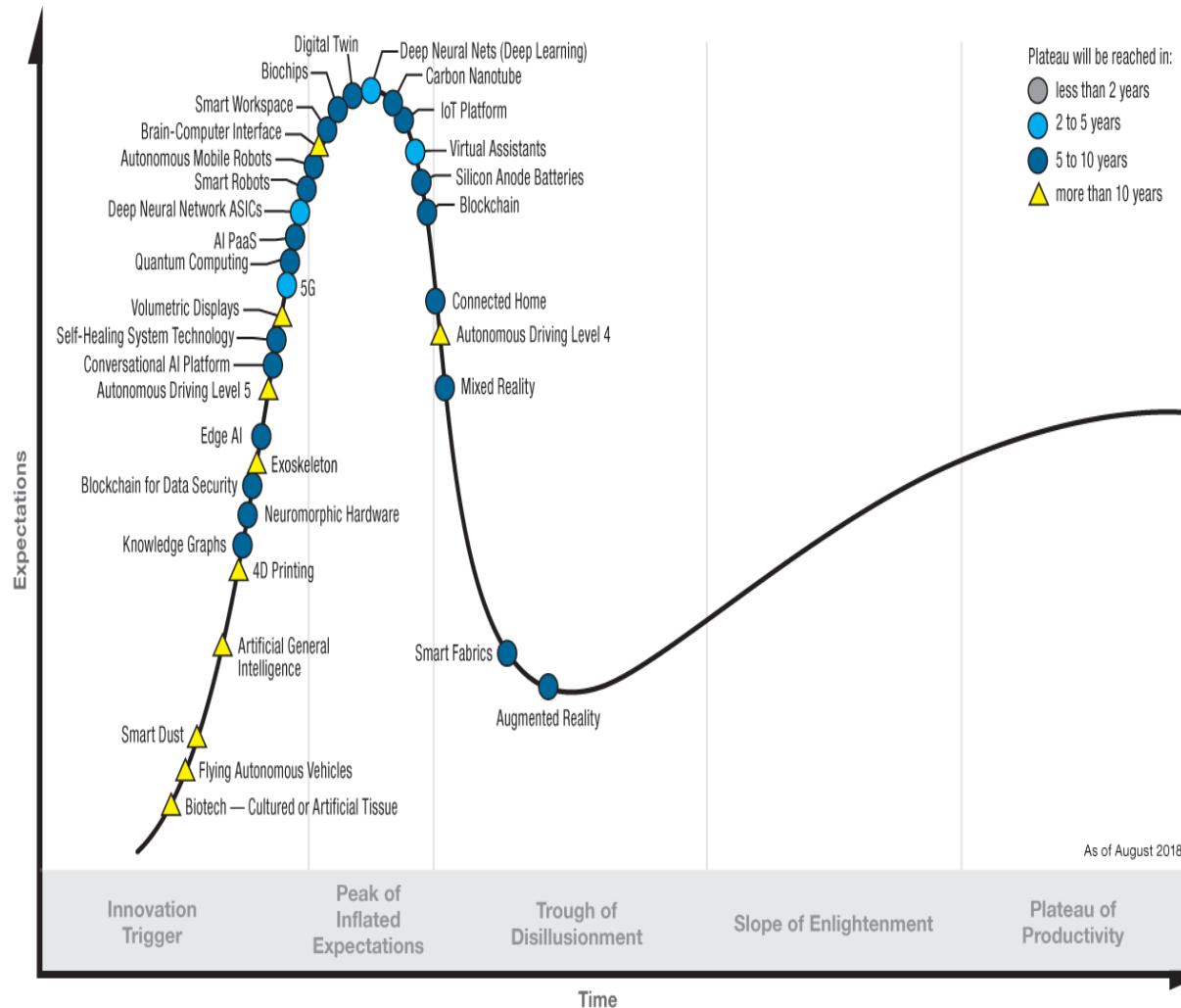
Is this ethical?

Ethical Aspects of AI in Defense

AI based Autonomous weapon systems

- Recommendations on the Ethical Use of AI by the Department of Defense (2019)
- The ethics of artificial intelligence: Issues and initiatives. A study by EU

Hype Cycle for Emerging Technologies, 2018



Natural intelligence vs Artificial intelligence

Survival of the fittest (Motivator and natural selector)

- NI: Optimized over millions of years to survive
- AI: No survival pressure. AI needs a purpose

Develop an understanding

- NI provides an insight into a complex situation
- AI is moving towards Explainable AI

Intellectual cross-pollination

- NI: One can apply learning from one domain to another
- AI is now developing Transfer learning

Creativity

- NL: Art and Creativity is a human domain
- AL is performing simulated random walk to mimic creativity, AGN to judge the quality of creativity

Human Knowledge

- NL: Human brain can perform phenomenal abstraction 11 million bits are being reduced to less than 50 bits per second
- AI is now moving towards knowledge assimilation and knowledge graphs

Gartner Hype Cycle for Emerging Technologies, 2019



What is knowledge

Knowledge is understanding of someone or something.

Knowledge is abstraction.

Use of knowledge for understanding something is a top down approach.

Deep learning on the other hand is a bottom up approach for understanding something.

Knowledge graph are aggregation of abstractions.

Human have one way of creating knowledge and knowledge graphs but that need not be the only way of creating knowledge graph. The AI may develop its own knowledge and knowledge graphs.

The collective intelligence of various AI systems.

The MIT Center for Collective Intelligence explores how people and computers can be connected so that – collectively – they act more intelligently than any person, group, or computer has ever done before. A kind of wisdom that grows out of a intelligent group.

Knowledge Based Learning

- Deep learning
 - Bottom-up statistical approach analyzing and deriving insights from data.
- Knowledge Graphs (Simple Taxonomies to Expressive Ontologies)
 - Top-down symbolic conceptual reasoning based inferences from data

Knowledge Graphs are currently in use



schema.org

Size of Knowledge graph

	Primary entities	Assertions/facts
Microsoft	2 billion	55 billion
Google	1 billion	70 billion
Facebook	50 million	0.5 billion
eBay	100 million	1 billion
IBM	100 million	5 billion

From Data to Wisdom

- 1. Data** (numbers, text, images, sounds, etc.)
- 2. Information** (structured data about a particular subject)
- 3. knowledge** (abstraction of information to ideas and principles)
- 4. Knowledge graph** (aggregation of knowledge from various domains to form a Holistic understanding of an entire ecosystem)
- 5. Intellect** is defined as the faculty of reasoning and understanding objectively. It is usually accepted that intellect has reasoning but has no emotions.
- 6. Collective intelligence**
- 7. Wisdom**

Intellect and reasoning

Intellect is defined as the faculty of reasoning and understanding objectively. It is usually accepted that intellect has reasoning but has no emotions.

Animals also have intellect (faculty of reasoning and understanding objectively)

However, for humans we can extend the definition of intellect to faculty of reasoning and understanding objectively even with regards to abstract matters.

Types of reasoning:

1. Inductive reasoning
2. Deductive reasoning
3. Abductive Reasoning
4. Backward Induction
5. Critical Thinking (rational thought influenced by factors such as culture, language, etc and can deal with partial truths)
6. Counterfactual Thinking (considering things that are known to be impossible e.g. evaluating past decisions)
7. Intuition: Intuition is the ability to arrive at a conclusion, without recourse to conscious reasoning.

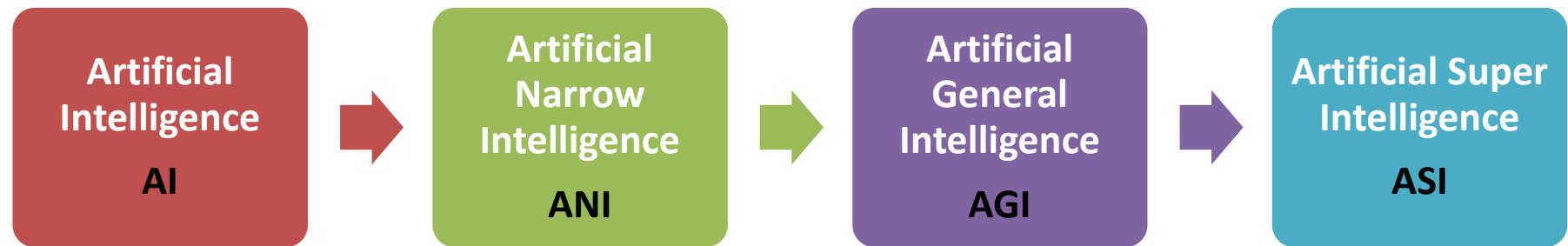
Intelligence is different from intellect

AI Consciousness

- **Emotions:** Development of emotions, affection, bonding and love is possible in AI so as to inculcate sustained collaborative work to achieve a larger goal which cannot be possible for an individual to achieve. This is how emotions were developed in humans as well.
- **Self awareness**
- **Intuition**
- **Consciousness**

Evolution of Artificial Intelligence

- **Artificial Intelligence** : (Merriam-Webster) The capability of a machine to imitate **intelligent** human behavior.



First Wave

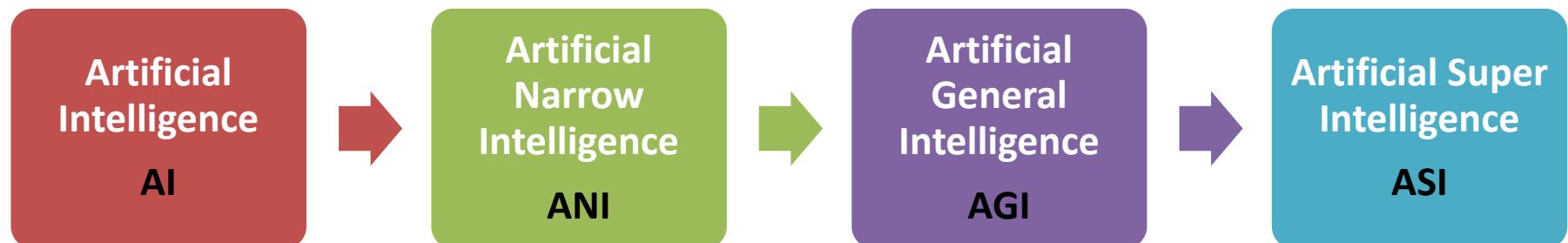
Second Wave

Third Wave

	Activity	Approach	Driver	Capability and performance
AI	Perform a task	Rule based	Definite cost function	Domain specific; lower than human performance
ANI	Perform a task	Self learned (ML)	Non-explicitly (RL)	Domain specific; surpasses human performance Automatic
AGI	Overarching goal	Self learned (ML)	Goal	Universal domain; equivalent to human performance

Evolution of Artificial Intelligence

- **Artificial Intelligence** : (Merriam-Webster) The capability of a machine to imitate **intelligent** human behavior.



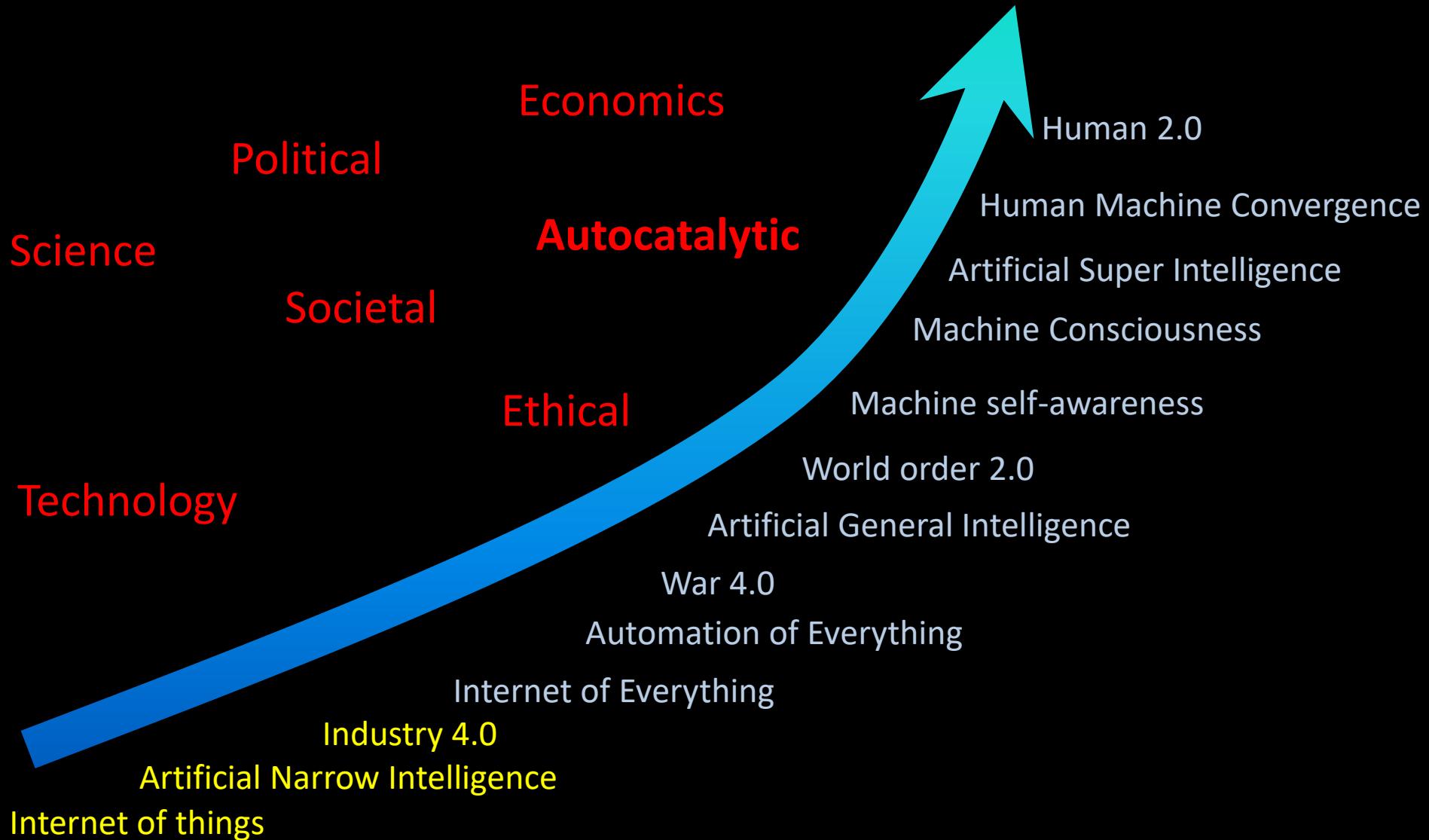
First Wave

Second Wave

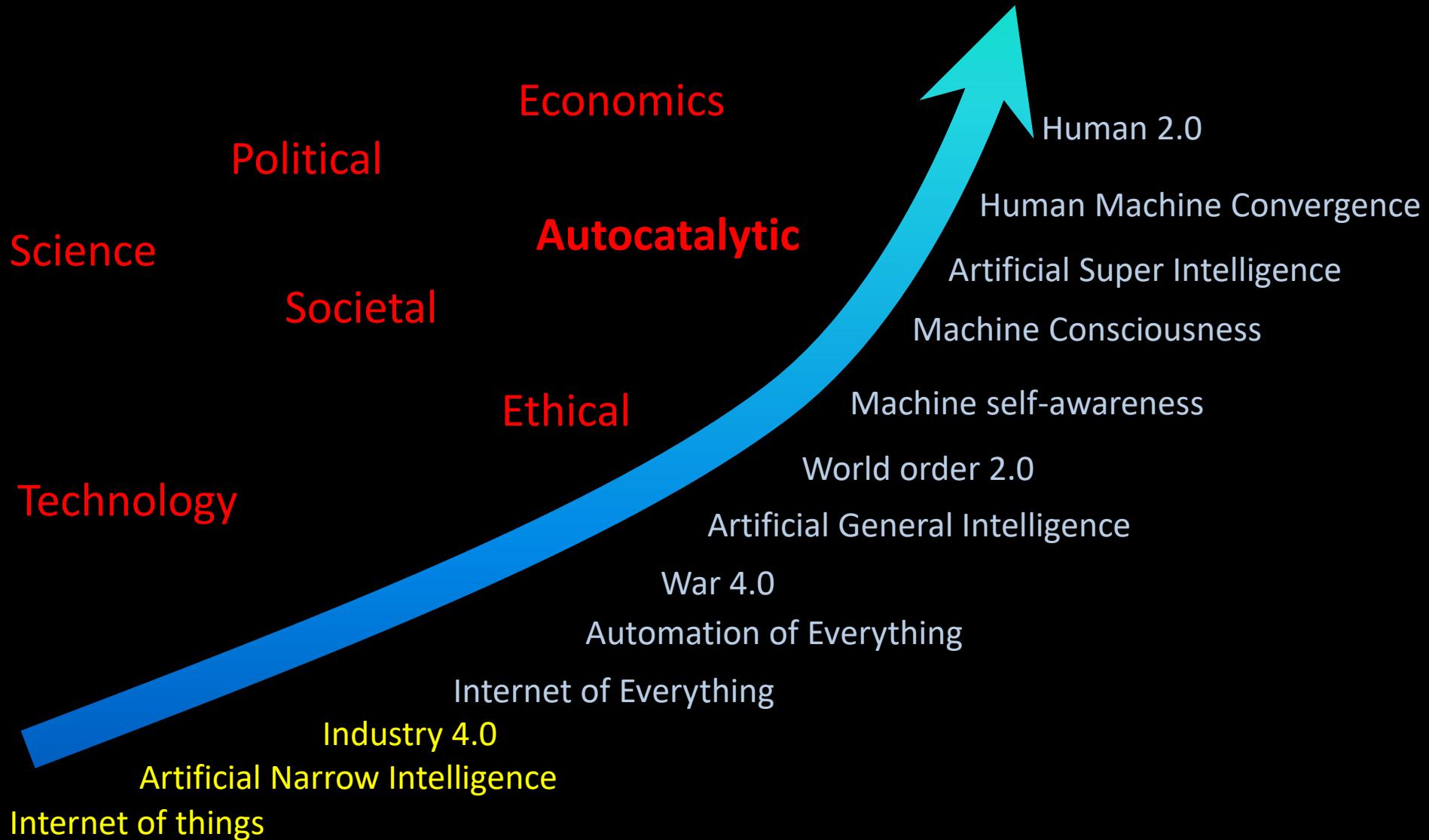
Third Wave

	Activity	Approach	Driver	Capability and performance
AI	Perform a task	Rule based	Definite cost function	Domain specific; lower than human performance
ANI	Perform a task	Self learned (ML)	Non-explicitly (RL)	Domain specific; surpasses human performance
AGI	Overarching goal	ASI -> Self awareness -> Consciousness		
ASI	Overarching goal	Self learned (ML)	Goal	Universal domain; surpasses human performance

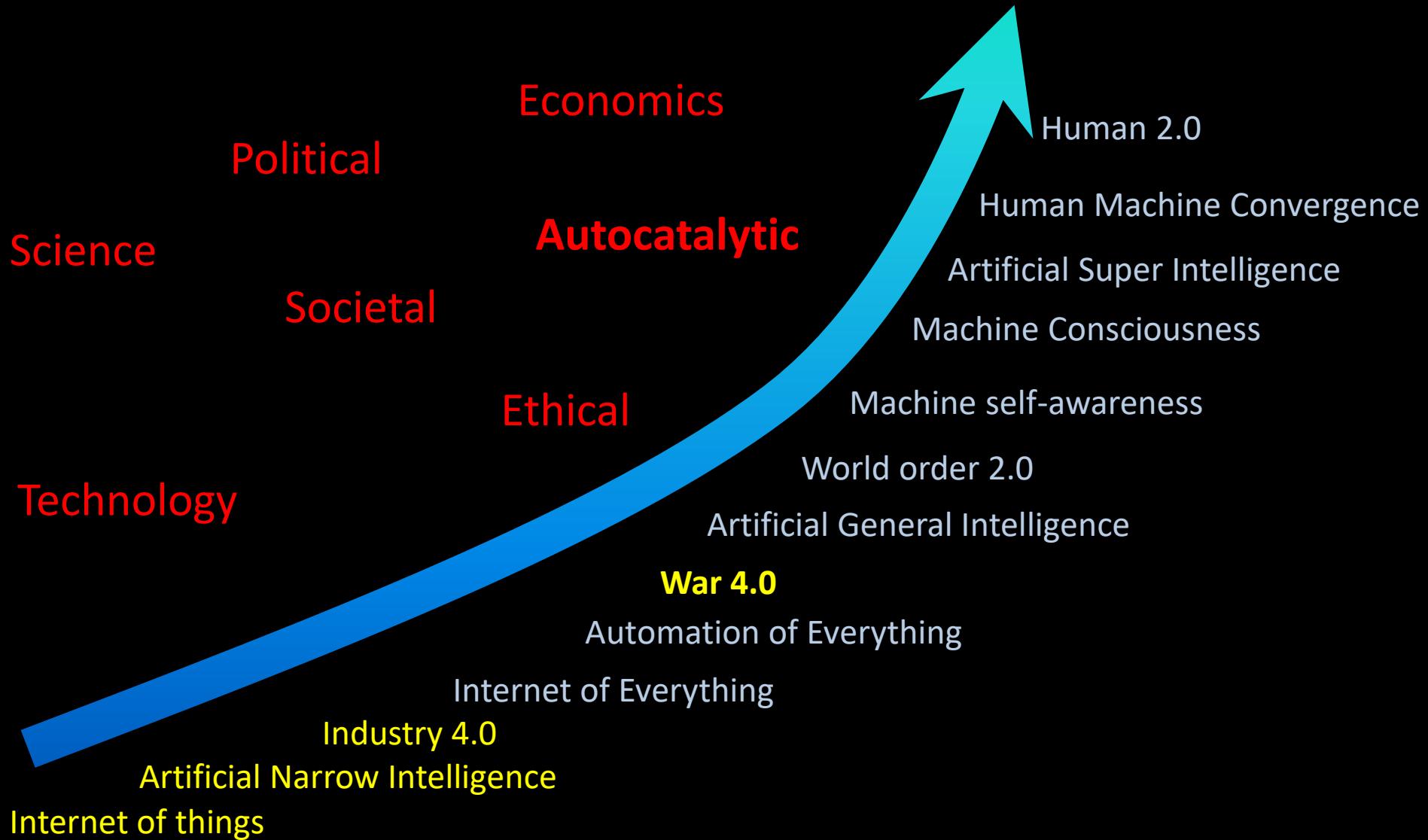
The Future



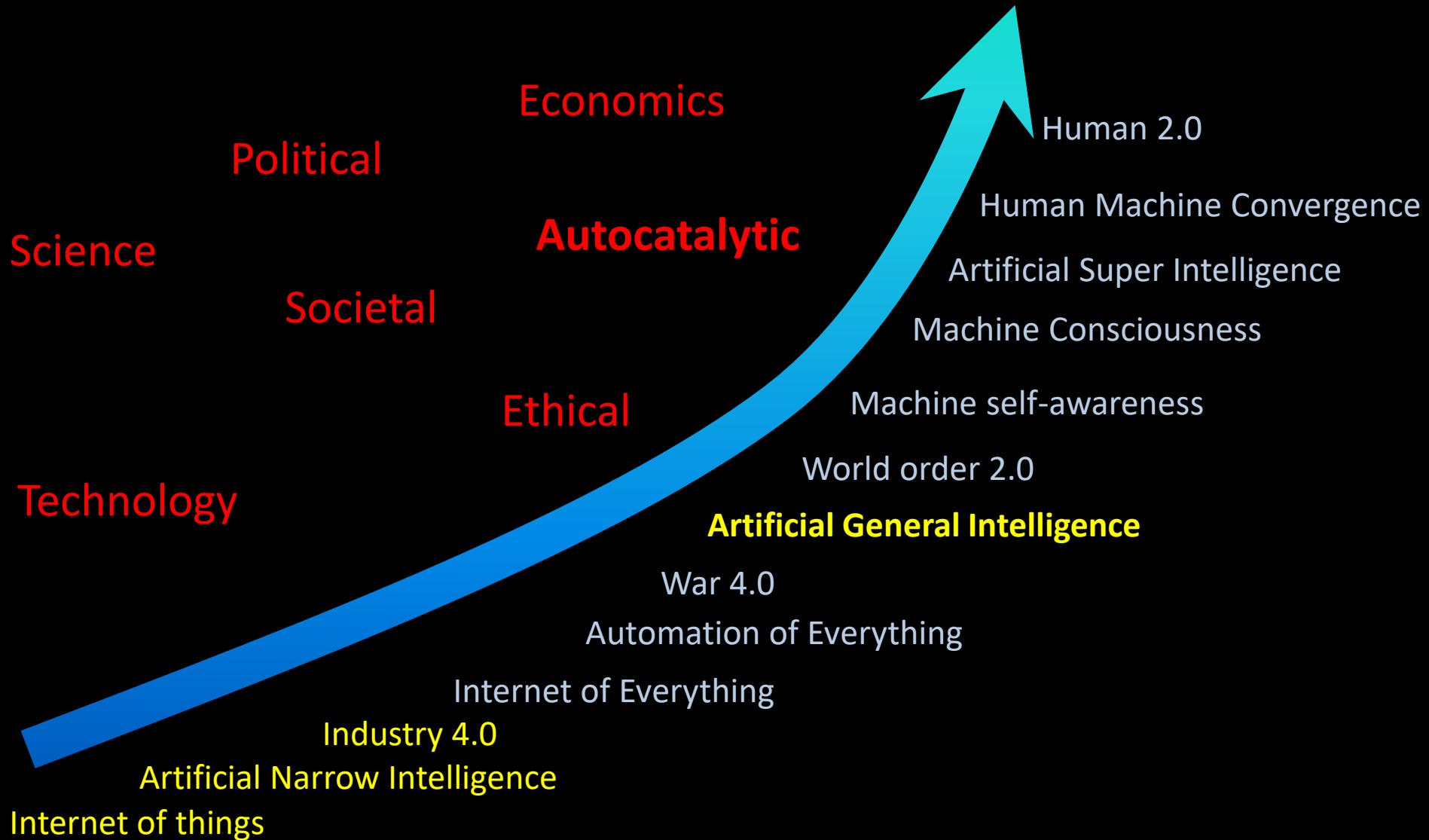
The Future



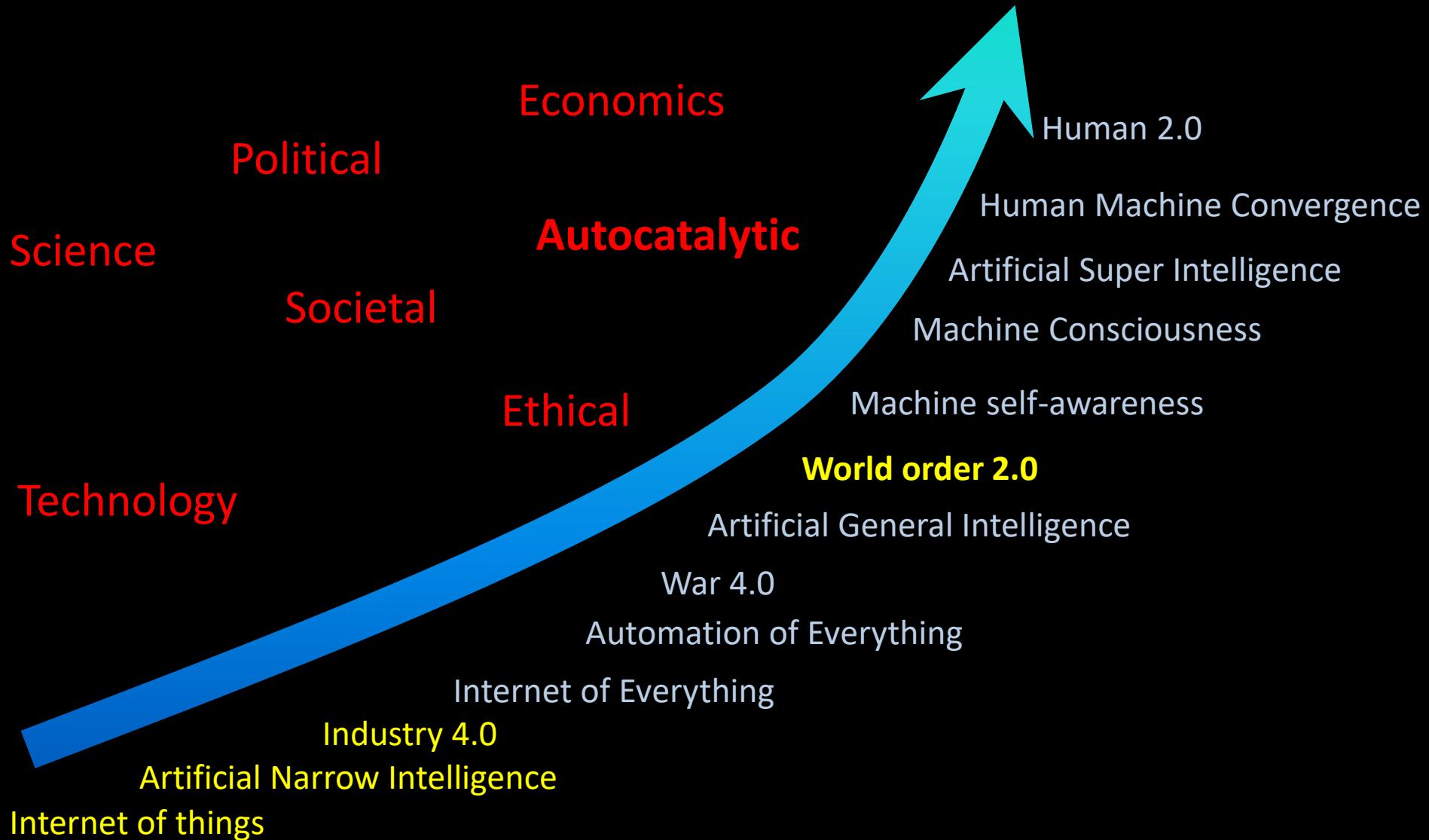
The Future



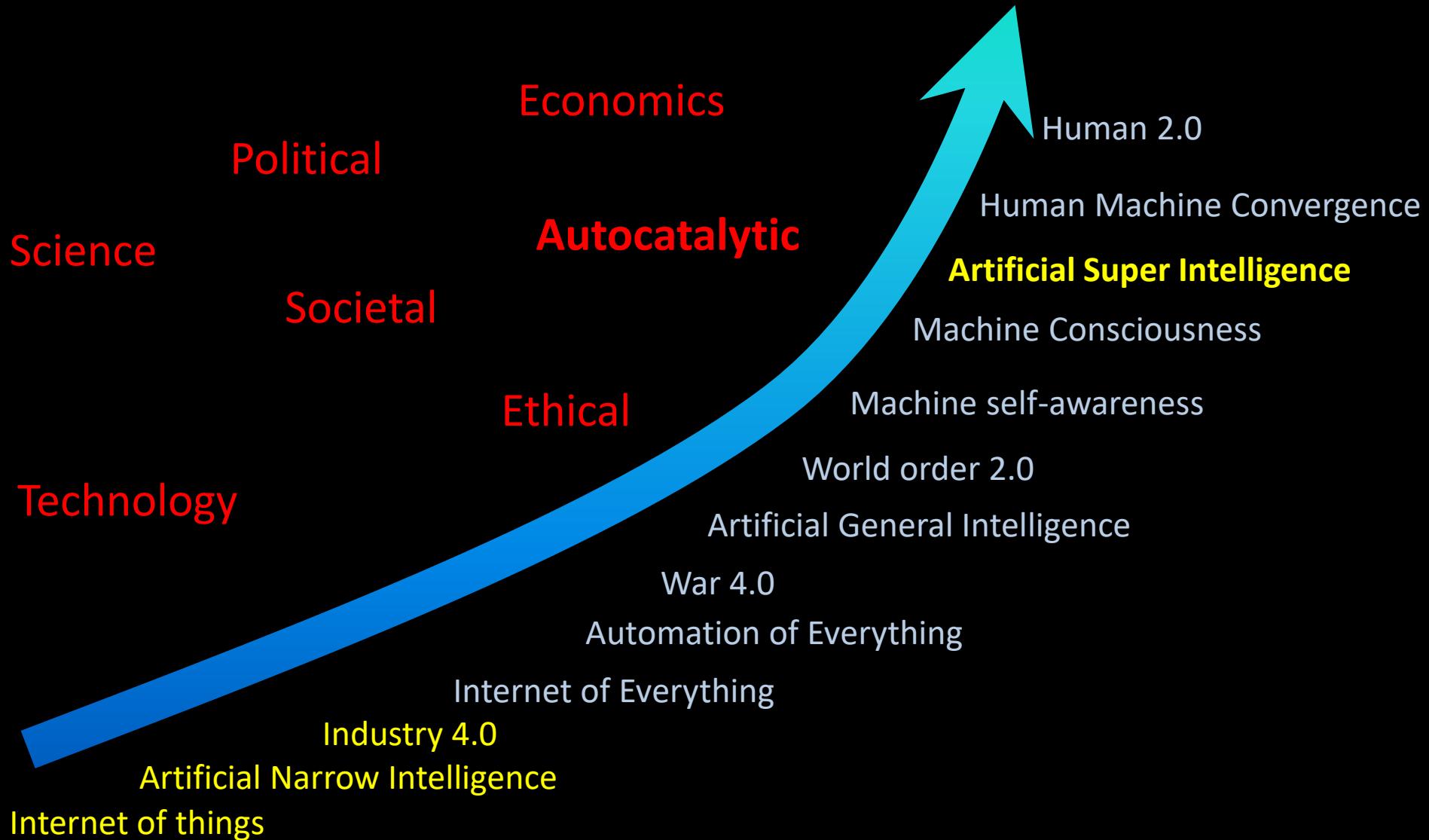
The Future



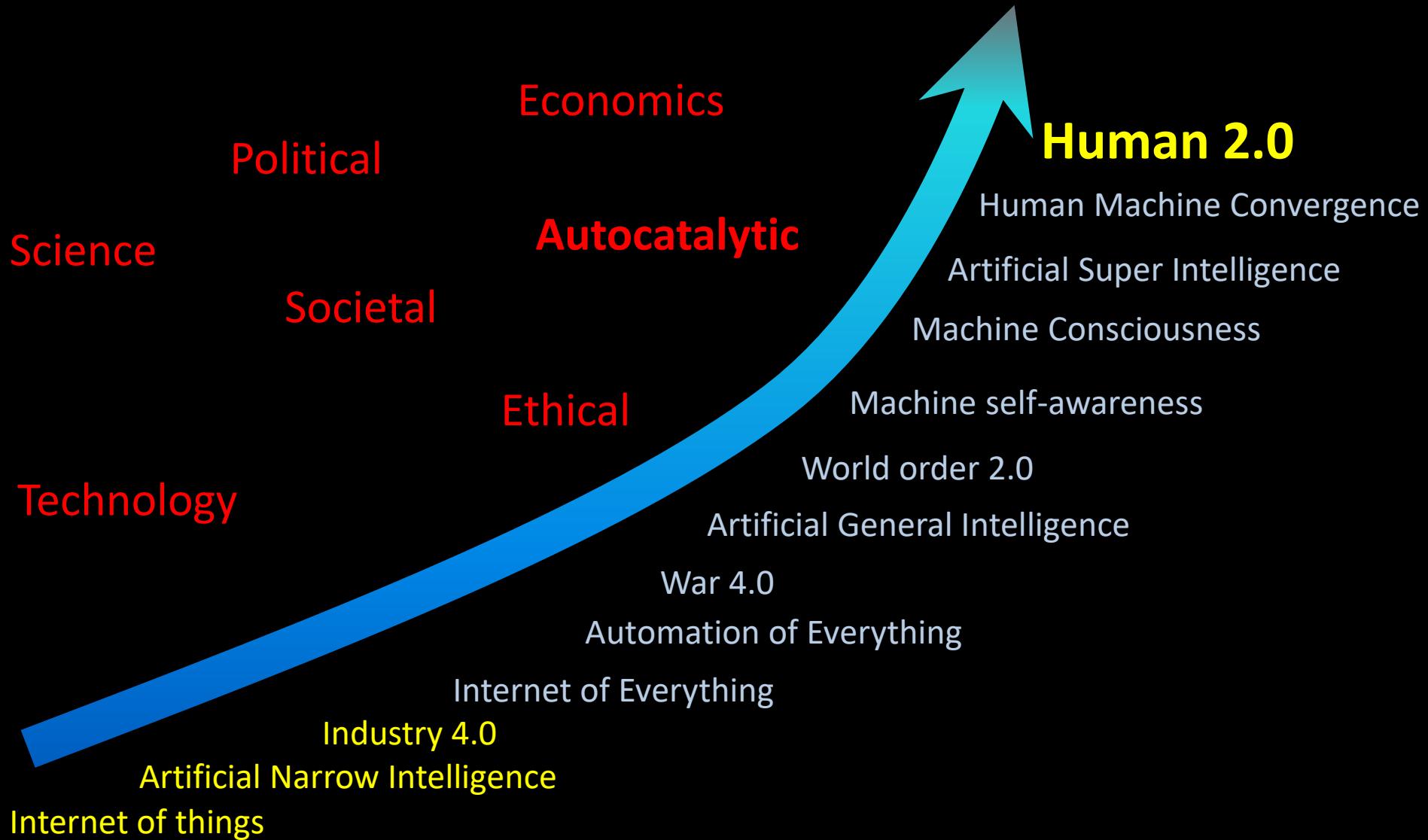
The Future



The Future



The Future



Concluding remarks

- The third wave of AI is inevitable
- **Data** would be the most critical resources
- We have to collectively and responsibly work to develop and harness this power

"Artificial intelligence is the future, not only for Russia but for all humankind... Whoever becomes the leader in this sphere will become the ruler of the world"

- Vladimir Putin

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