

Technology Trends Driving Digital Innovation

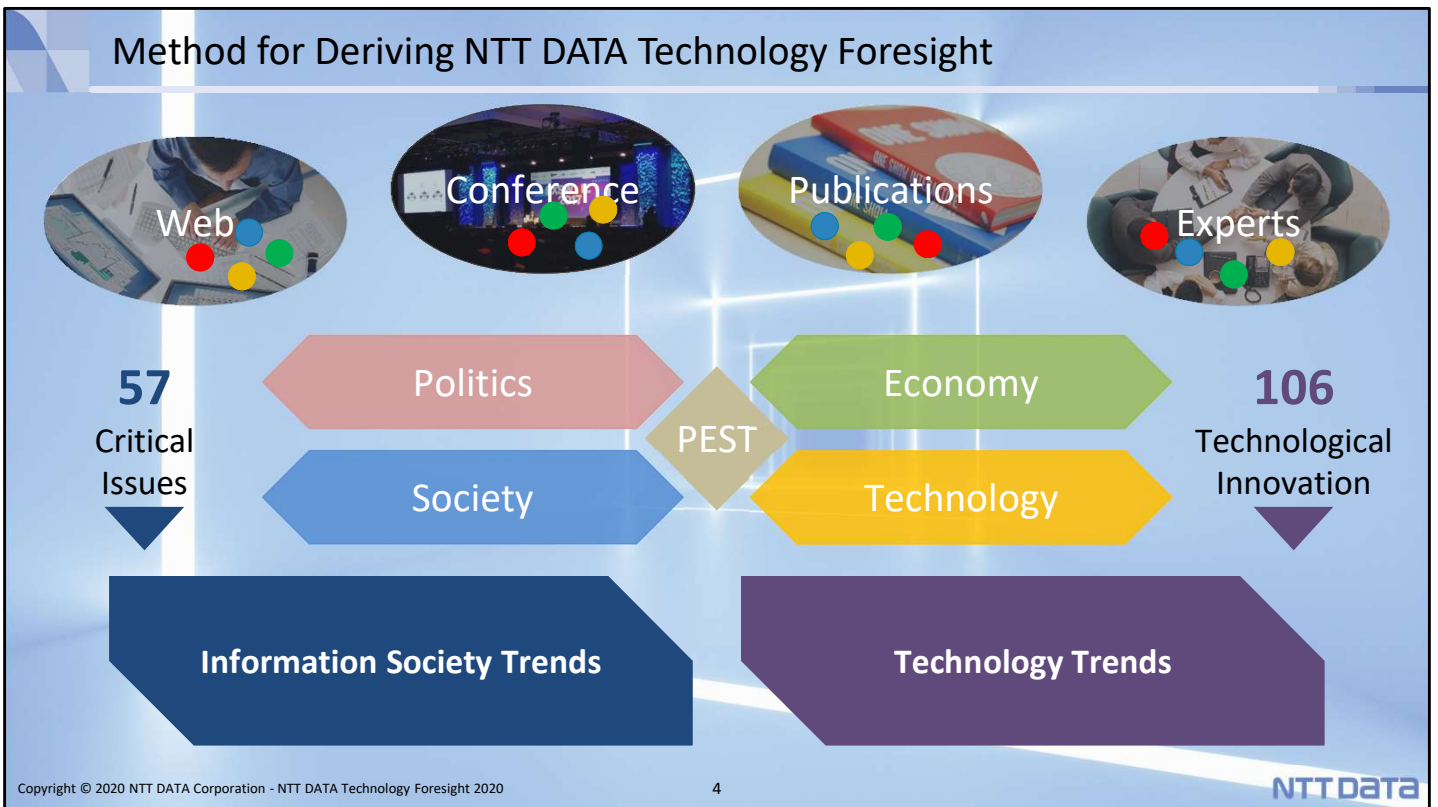
NTT DATA Technology Foresight 2020

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- NTT DATA Technology Foresight is an annual research project. Here we predict changes that are happening or we anticipate will be brought on by specific technologies we believe will have a significant impact on our society and business over the next 3 to 10 years. Launched in 2012, this research published in 2020 is our 9th report.

Method for Deriving NTT DATA Technology Foresight



- As in the past, we have been doing research for this over the last year. Our research is reported within 2 kinds of trends and is derived from 57 critical issues and 106 technological innovations.
- Information society trends indicate the direction of technological application in future society and business.
- Technology trends indicate the direction of innovative, attention-worthy technologies that will lead to changes in society and business.

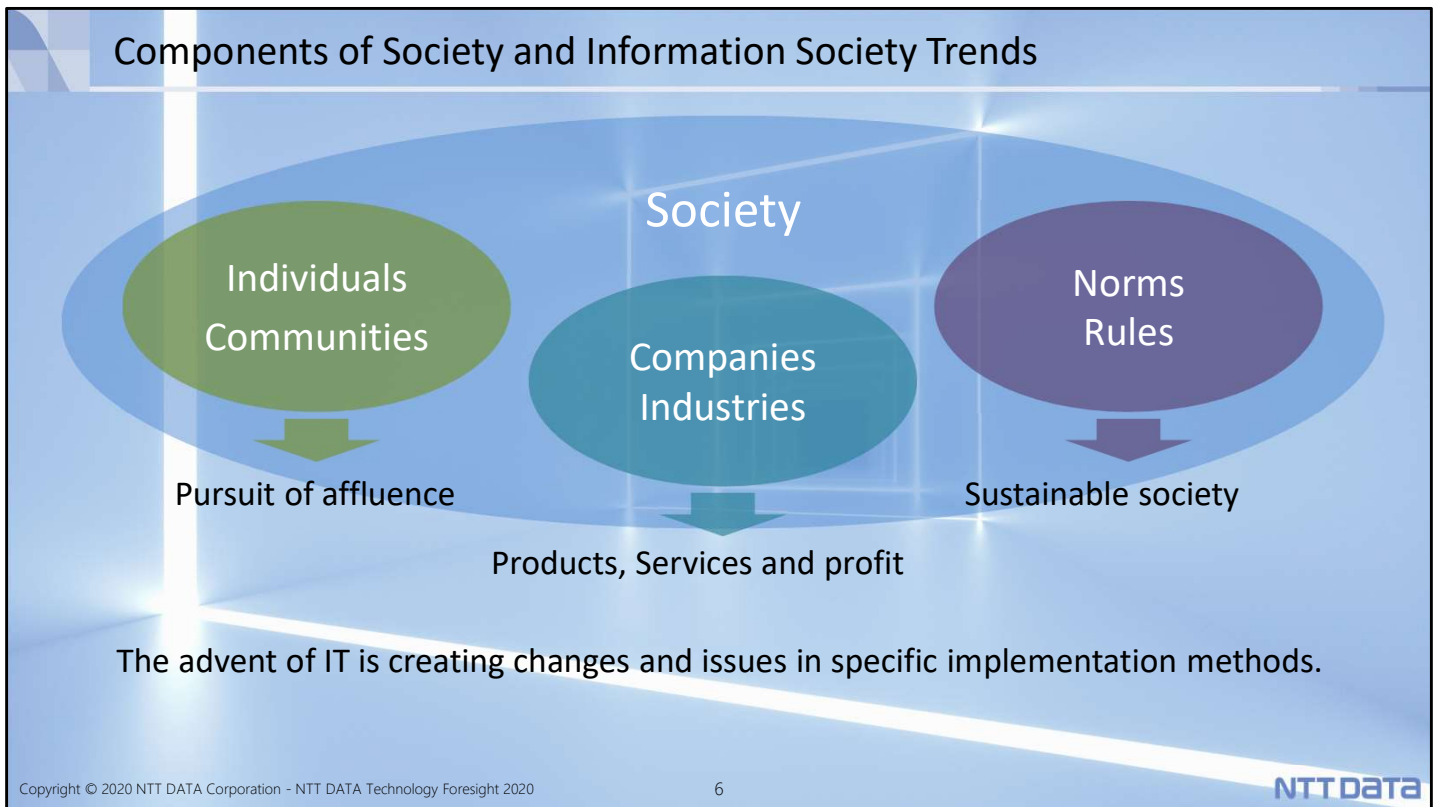
The image is a cover for a report titled "Information Society Trends". It features a blue background with a grid of white lines and bright light sources at the intersections, creating a futuristic, digital atmosphere. The title "Information Society Trends" is written in large, white, sans-serif font across a dark blue horizontal band in the center. In the bottom left corner, there is a small copyright notice, and in the bottom right corner, the "NTT DATA" logo is visible.

Information Society Trends

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- Information Society Trends describes NTT DATA Technology Foresight's outlook on the world, as well as the hopes for the future provided by technology.



- Information Society Trends analyzes the direction of technology use for activities common in each of society's components.
- A society is made up of individuals living in it, who in turn populate communities like families and regions.
- Individuals work for companies, which together form various kinds of industries. These activities of individuals and companies make up our society.
- These activities are conducted under certain rules and norms.
- This graphic displays the three basic components that make up our society.
- Each of these three components pursues its own set of common activities. Individuals pursue wealth, while companies create customers for profit. Rules and norms encourage sustainability in society. In other words, rules and norms exist to prevent disruption of society.
- These common activities have been continuing, but recent advancements in technology have caused changes and problems in concrete implementation methods.
- How does technology impact common activities in light of these changes and problems? Information Society Trends identifies the trends together with the changes and challenges.

57 Important Issues that Influence the World



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- To identify information society trends, we examine current critical problems in social, political, and economic aspects of society, and analyze how technology is used to solve them.
- This is the list of 57 critical problems identified for the 2020 Information Society Trends that will change the world.
- Some of the 57 may be described as challenges, while others can be thought of as issues. In our 2020 edition, we focused on challenges and identifying what role technology plays in these challenges.

NTT DATA Technology Foresight 2020: Information Society Trends



Thorough optimization and individualization

IST01

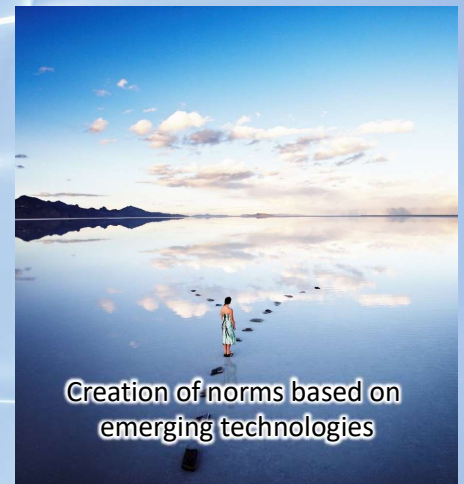
Individual-Centered Design



Expansion of active fields, development of uncharted territories

IST02

Expand Beyond Borders



Creation of norms based on emerging technologies

IST03

Forge New Norms

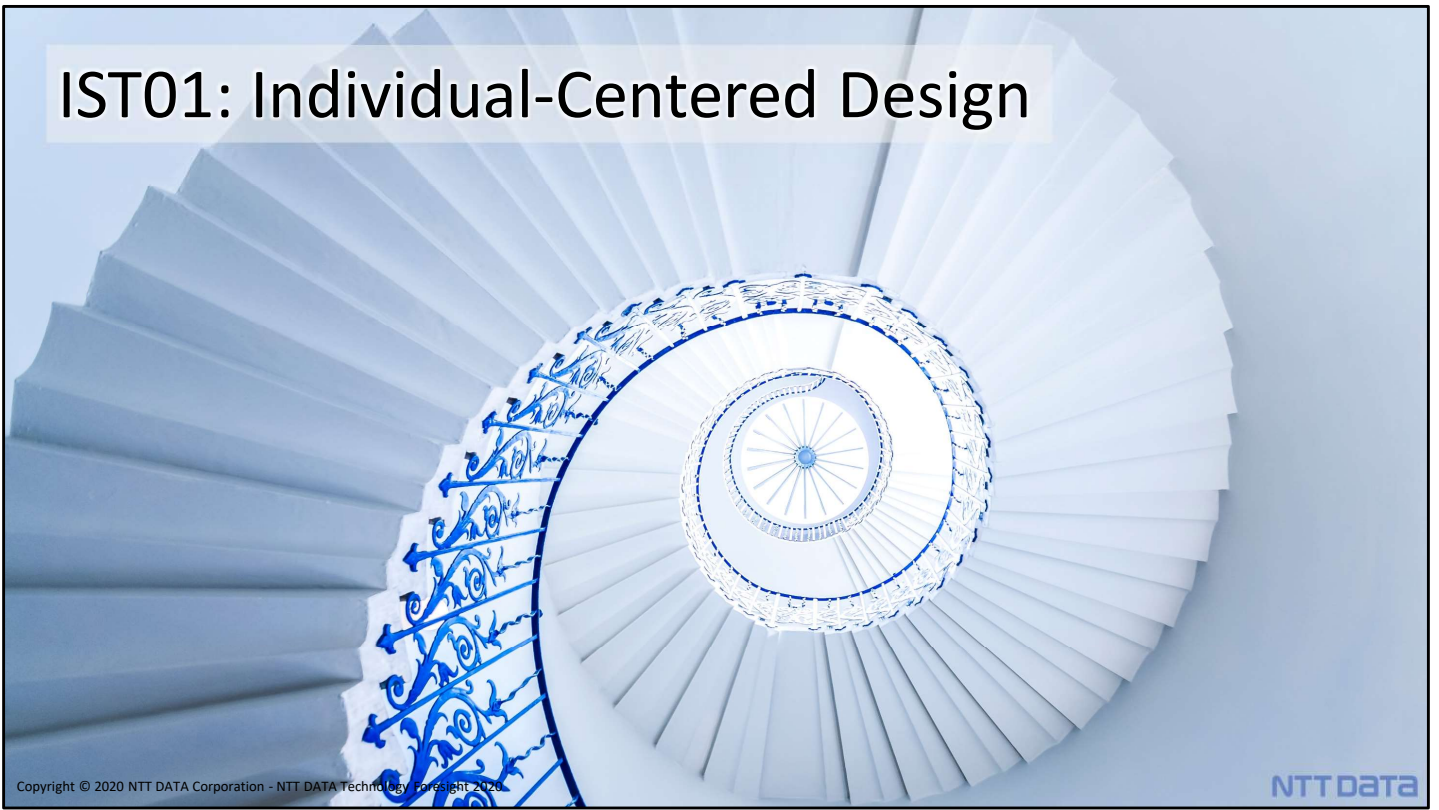
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- NDTF 2020 has identified three themes for information society trends: Individual-Centered Design, Expansion Beyond Borders, and the Forge New Norms.
- In the area of Individual-Centered Design, in a society where technological advancements continue to increase the power of the individual, governments and corporations are starting to adopt individual-centered activities. The keyword in this context is personalization. For future corporate growth, it will be essential to personalize and provide services that align with individual needs.
- The theme of Expand Beyond Borders captures the current efforts on digital transformation in many different industries. The evolution of technology has enabled us to expand the scope of our businesses and activities, transcending the country and industry as well as physical and digital boundaries. The environment and society and business itself has also been changing. As the starting point of digital transformation, the use of digital data has enabled us to use data that never existed before, such as ground observation data from satellites and the knowledge acquired from the accumulation and analysis of biological information. Such data will increase the scope of digitalization, affording us new views of the world, including global perspectives and the pursuit of the origin of life. These views of the world will in turn help our efforts to improve the world we live in, such as the resolution of global issues we discuss in SDGs.
- The theme of Forge New Norms captures the current phenomenal elements such as the unprecedented speed at which emerging technology is permeating society, creating a gap with the speed at which norms and rules to protect society are established. To achieve a sustainable society, it will be essential to establish norms and rules that help technology adapt to society, instead of focusing on technological innovation alone.

IST01: Individual-Centered Design



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- The first theme of Information Society Trends is Individual-Centered Design.

Current State of Growing Internet Use



Almost half (49%) of the world's population uses social media, continuing to increase at an annual rate of 9.2%.

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Source: We are social ("DIGITAL 2020")

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- The current number of people with access to the internet is 4.5 billion, which is equivalent to 53% of the population of the entire world.
- The internet enables the provision of products and services to users worldwide and the global disbursement of huge amounts of knowledge accumulated throughout the world.
- Social network services have also proliferated around the world to amass 3.8 billion users, which translates into 49% or about half of the world's total population.

[Source]

<https://wearesocial.com/digital-2020>

Influence of Individuals Makes Individual-Centered Design Inevitable

Individual-Centered Activities



Understanding of Detailed Individualities



As preferences and activity change from “mass” to “personal,” the individualistic viewpoint becomes key to creating new business opportunities.

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- The emergence of social network services has increased the power of the individual.
- In our current society, it is now easy for individuals to deliver messages of their own perspectives to others creating material political and social impacts.
- Society and companies can no longer ignore this individual power and must shift their focus to individual-centered activities.
- Additionally, advancements in technology are accelerating this trend.
- Breakthroughs in sensing technology and AI have made it possible to identify detailed aspects of the individual.
- As a result, it is now possible to identify profound individual intentions, changes at shorter time intervals, and associated events and phenomena including one’s surroundings.
- As intentions and behaviors shift focus from mass to individual, it becomes necessary to identify things in greater detail and to pursue individual attributes.

AI Plays a Key Role in Individual-Centered Design

Personalization

Examine things
from an individualistic
viewpoint

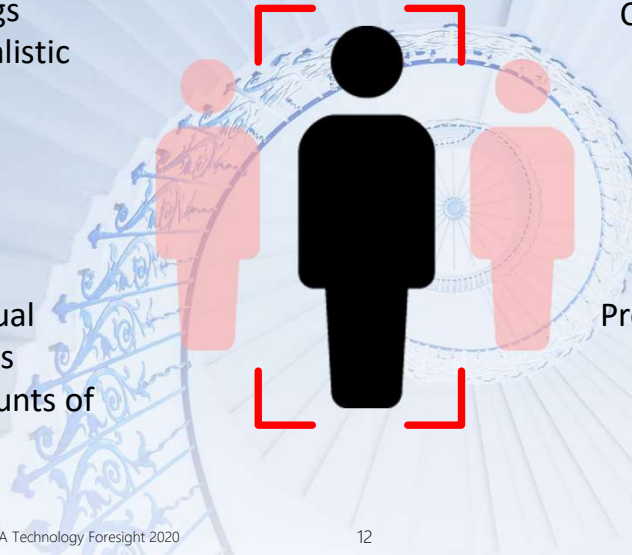


Extract individual
characteristics
from massive amounts of
information

Complete individualization
and optimization



Provide personalized services
to each individual



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- In the pursuit of individual-centered design the key is personalization. And the use of AI is critical to its realization.
- AI enables us to extract user attributes such as hobbies, thoughts, and behavior patterns out of huge amounts of information, and to provide the personalized services that best suit those individual attributes.
- This means re-identification of things from an individual perspective in a detailed and thorough way. Shifting focus from external to internal results using more detailed processes and deeper-level tasks creates novel ideas and challenges. The result -- another dimension of innovation.

Use of AI Takes Personalization of Advertisements to the Next Phase



Improve accuracy in target-user extraction and reduce missed service opportunities

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Source: Tencent Campaigns by Tencent Holdings. Ltd.

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- These AI-based personalized services have permeated our lives without our knowledge.
- A good example is newsfeed. It delivers news on politics, business, industry trends and hobbies that interest a particular individual. Many now learn about the world based on this news. Personalization is also employed in the film and music industries as a recommended service.
- Also a typical example of personalization, advertisements have entered a new phase with the use of AI.
- For example, Tencent, one of the largest online video platforms has partnered with Mirriad to incorporate its in-video technology to deliver integrated brand content in videos to promote a specific sponsor's products based on the user profile.
- The benefits of personalization are the improvement of accuracy in target-user extraction and the reduction of missed service opportunities.
- In an age of enhanced individual influence, close pursuit of user needs is a critical element that directly leads to business success. Many industries are realizing more than ever that the business model to achieve success is personalization.

[Source]

<https://www.mirriad.com/mirriad-partners-with-tencent-one-of-the-worlds-largest-video-platforms/>
<https://finders.me/articles.php?id=1378>

Development of a Device to Control Hand Trembling in Parkinson's Patients



<https://www.youtube.com/watch?v=R6rAlFYDffQ>

The age of the individual will see a growing focus on the use of technology for capturing the characteristics of the individual to solve individual challenges.

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- Ultimate personalization maximizes individual power.
- Let's say a female graphic designer developed Parkinson's Disease and due to trembling could no longer draw lines or even write.
- A device was developed in the form of a wristband that sensed her trembling hands and learned the pattern of her trembling, delivering a timed tremor in the opposite direction.
- When worn, this device offset her trembling, enabling her to write names and draw straight lines once again.
- Identifying individual attributes, characteristics and challenges, and using technology to solve those challenges, will lead to the maximization of individual ability as well as to new life and business opportunities.

[Source]

<https://www.youtube.com/watch?v=R6rAlFYDffQ>

<https://news.microsoft.com/en-gb/features/how-a-watch-helped-emma-write-again/>

IST01: Individual-Centered Design

Increase in the power of individuals

Increase in business opportunities by personalization

Maximization of individual ability

In an age of increasing power of individual, capturing things from individualistic viewpoints to pursue complete personalization will create new services and experiences, building long-term relationships with customers.

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- In an age of enhanced individual influence, it will be important to identify individuals in greater detail and understand them from perspectives at a far deeper level, to determine what types of challenges should be solved.
- And this mode of thinking will likely create new business opportunities as well as form the basis of building long-term trust with customers.

IST02: Expand Beyond Borders

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- The second theme of Information Society Trends is Expand Beyond Borders.

Changes in the Engine of Economic Growth

Population Explosion
(Increased Workforce)

Development of Fossil Fuel
(Power Innovation)

Mechanization
(Improved Productivity)



New Engine of Growth ⇒ Technology

Exponential Advancement of
the IT Infrastructure

Software Versatility and
Expandability

Continued Advancement Afforded
by Open Systems

It will be critical to understand how to incorporate advancing technologies in business to enjoy the benefits of advancement.

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- How does the world as we see it today compare to the past?
- Social growth, which equals economic growth, has been led by different types of growth engines.
- These engines include increases in labor, innovation of power afforded by fossil fuel development and advancements in productivity afforded by increased mechanization.
- However, social and political factors such as the falling birthrate, an aging population, environmental devastation and dilapidated facilities are now undermining these traditional growth engines.
- Meanwhile, technology triggered economic growth from the late 20th to the early 21st century, becoming an essential tool for future economic prosperity.
- But why technology? Technology has robust evolutionary force and growth leverage.
- Networking, arithmetic devices and other technologies often referred to as IT infrastructure continue to evolve at an exponential speed. This evolution has made it possible for business and services to grow rapidly.
- The presence of software is also noteworthy. Software has made it possible to implement complex functions, which become services and in turn create new business.
- The permeation and expansion of the internet has also made it possible to gather global forces to propel technology, which has enabled the application of new, high-quality technologies to business at an unprecedented speed.
- Thus, the incorporation of technology's evolutionary and growth abilities to business will be the essential driver of future economic development and success.

Technological Significantly Change Society to Expand the World Directly

Under robust IT support, corporate strategies will build innumerable global supply chains at will beyond political boundaries.

Bringing order out of chaos and utilizing regional characteristics and knowledge will enable the re-definition of existing businesses.

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- Evolving technology is also changing society and expanding the world in which we see it.
- Business had already transcended national borders to provide services in many countries and regions.
- This was followed by the permeation of smartphones and social networking services, implementation of IoT and the emergence of platforms that connect individuals with other individuals as well as individuals with companies. This process encourages the creation of new services and collaboration beyond industrial boundaries.
- In addition, the wave of digitalization has played an important role in the expansion of the world itself.
- From customer experience to business model development afforded only by digital services, the digitalization process can update the value of traditional markets and existing society by creating businesses in line with these new advantages, deep-mining conventional markets and acquiring new ones.

Expanding Internet Access Allows for Further Marketing Opportunities



Artificial satellites will expand regions' and populations' accessible to the Internet. This holds the promise of discovering new customers and further expanding markets and production centers.

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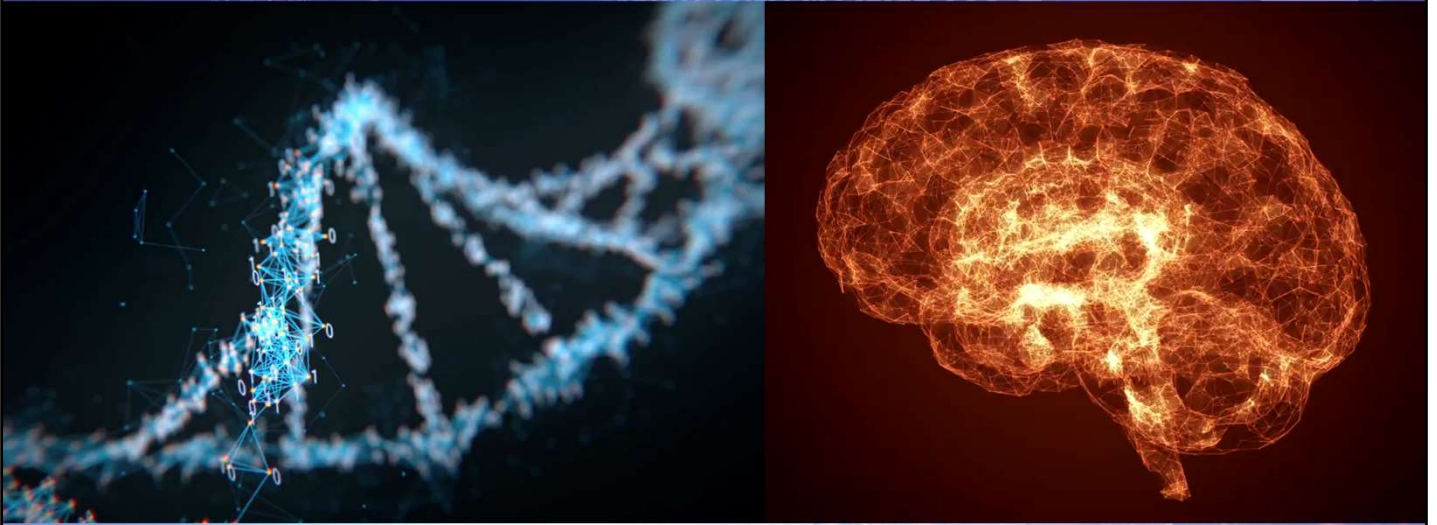
- Technology is also giving rise to the expansion of the world in a physical sense.
- One of the business fields that attracted most attention in 2019 was the space-usage business.
- Projects are underway to place micro-miniaturized artificial satellites in multiple space orbits to operate them as a set of constellations.
- What this leads to is internet connection services on a global scale.
- These services may well be commercialized as early as the end of 2020, dramatically increasing the number of users and regions having access to the internet.



Digital data of new types with new perspectives
will shape business opportunities.

- These satellites we are discussing cost less and have another important advantage.
- The environment required to use terrestrial data observed from space, called space IoT data, is being set up for any user at low costs.
- Thus, completely different perspectives and new types of digital data are about to emerge in fields not yet exploited by humans, such as space, deep sea, subterranean locations and other frontiers.
- This will likely give rise to markets and business opportunities not even dreamed of today.

Challenging Life-Related Issues



Advancement of the elucidation of genes, proteins and the brain, linked with the mechanisms of thinking, behavior and disease, will give humans the potential to transcend the limits of their physical and psychological activities.

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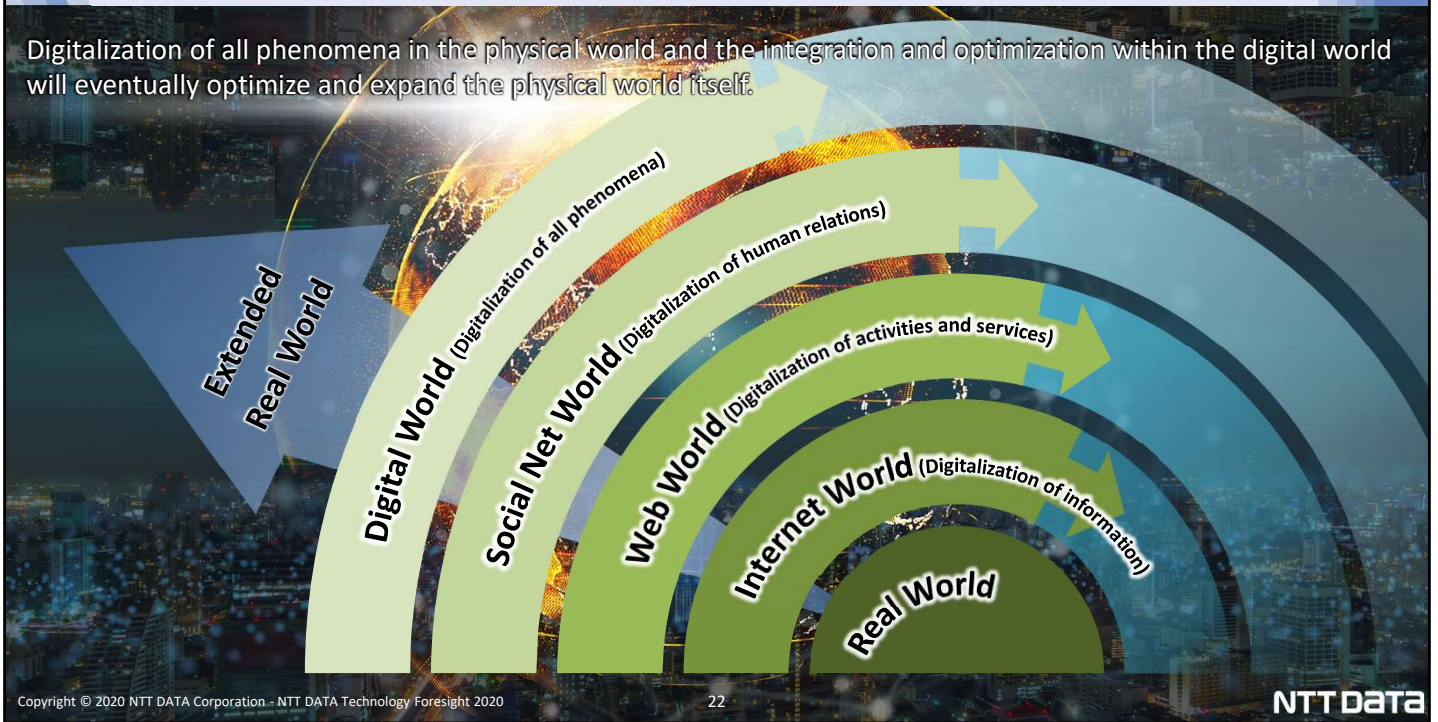
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- There is another new effort that encourages the expansion of the world: a challenge to life-related issues.
- The elucidation of genes, proteins, the brain, nerves and other structural components of the human body is underway.
- The elucidation of the human brain system may enable us to acquire deeper and longer-term memory.
- The elucidation of human genes may shift medical care from symptomatic to causal therapy.
- In other words, we are about to enter a future where all kinds of possibilities will become reality, like transcending the physical activity limit of humans.

Beyond the Digital World

Digitalization of all phenomena in the physical world and the integration and optimization within the digital world will eventually optimize and expand the physical world itself.



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- New digital data that used to be unreachable is about to be unveiled.
- Sensing will be performed on all things in the physical world to digitalize them, giving rise to a digital world.
- If capturing the physical world, people and nature for replication and simulation is possible, we will be able to forecast and make decisions at levels of success unimaginable in the past.
- This new environment currently has many names, including digital twins, a mirror world and an extended real world. We are getting closer to this kind of environment.

IST02: Expand Beyond Borders

Expansion of the scope of activity brought on by technological advancement

Exploration of uncharted territories

A world where physical and digital realms converge

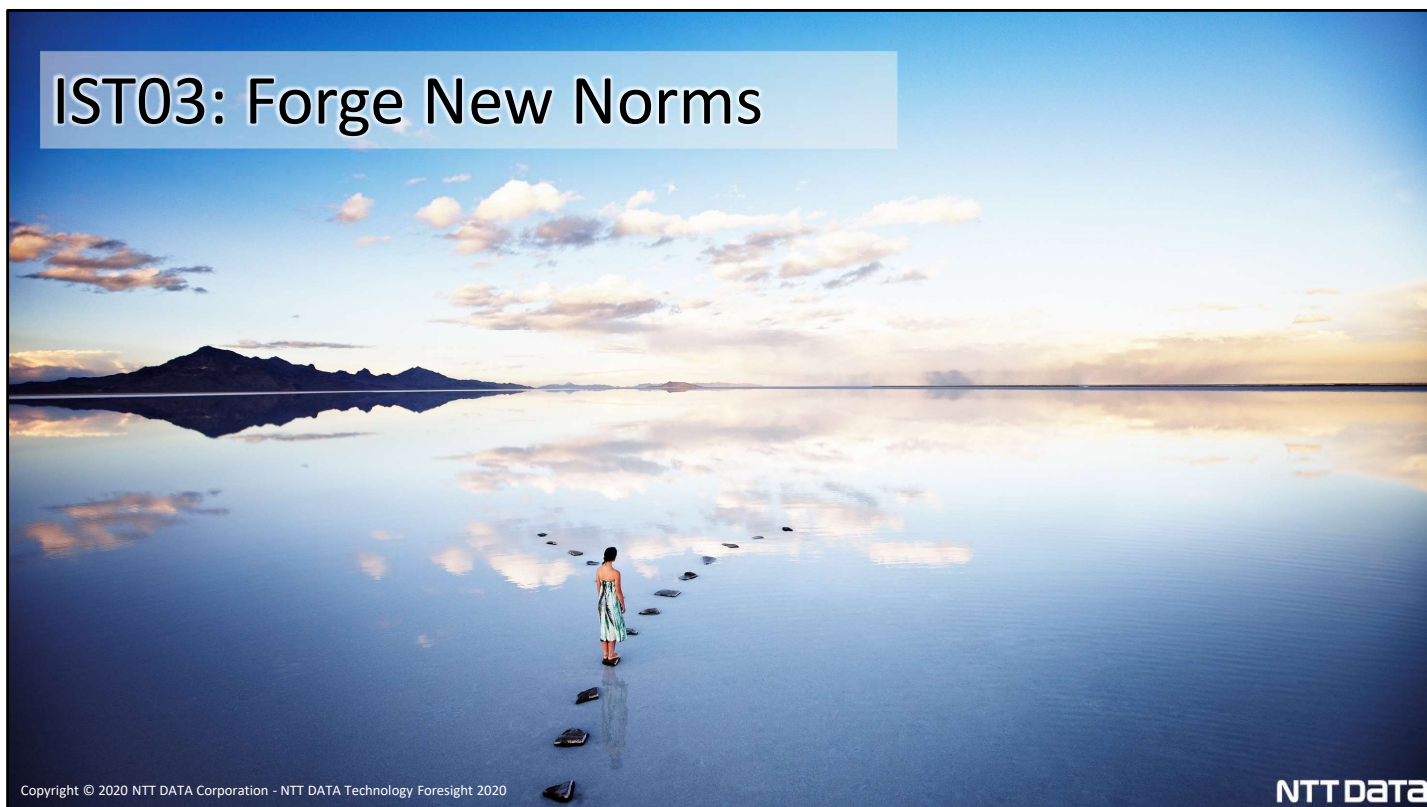
In a world that continues to expand, the driving force of growth will be the realization of one's own position in a broad perspective and the efforts to find one's strategic roadmap.

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- As we have seen, advancements in technology are about to expand the world in which we live in countless ways.
- As the world expands, it will likely become "the" driving force of future economic growth by enabling the understanding of overall processes and the development of strategies from a broad, global perspective driving social and business growth.

IST03: Forge New Norms



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- The third theme of Information Society Trends is Forge New Norms.

Technology Will Start a New Era

Fulfill Healthy, Comfortable, and
Convenient Life

Build a Satisfying Society

Challenge Global Issues

These cause new issues
in addition to benefits.

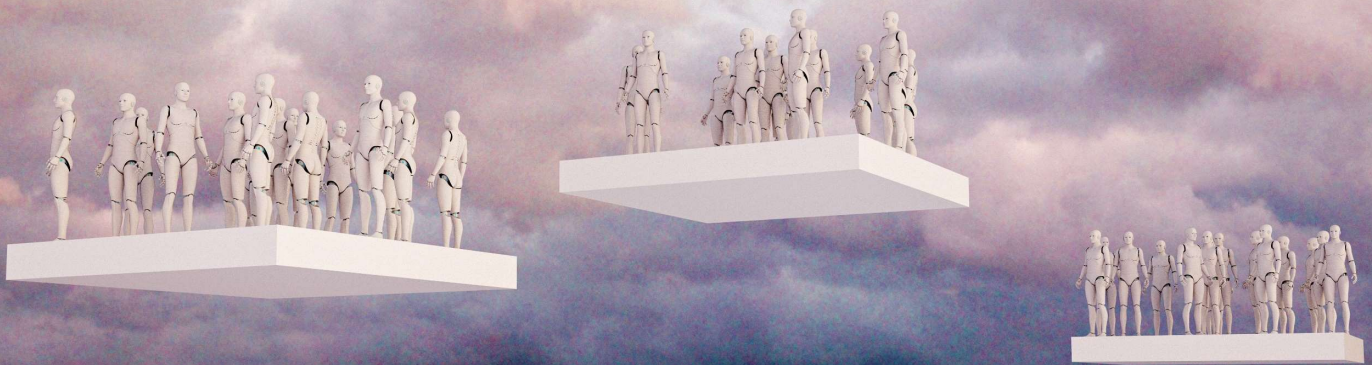
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- The evolutonal ability of technology will enable us to pursue individual-centered activities and to expand the world. These activities will grow the economy to allow a more sustainable society.
- The benefits of technology range broadly from the expansion of markets, to provision of individual-optimized services, enhancement of health and solutions to global problems.
- Benefits, however, are not the only thing technology delivers.
- Amid such rapid change, new problems are arising that existing norms cannot address.

A New Disparity Called the Digital Divide



Disparity in digital literacy directly leads to daily/social detriments and danger to individuals.
Efforts to increase digital literacy will be a top-priority challenge.

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- For example, until the benefits of technology are delivered to everyone, or as long as people exist who cannot enjoy the benefits, a gap might result between technology haves and have-nots.
- And the over-universalization of technology will create a situation where a disparity in digital literacy directly leads to all kinds of day-to-day, social disadvantages and risks, making it even more difficult to eliminate the disparity.
- It is a fact that some people cannot take advantage of the rapid changes that accompany digitalization.
- As the definition of society itself changes to one that presupposes technology, the acquisition and enhancement of digital literacy will likely become a critical and high-priority issue.

AI Exposes New Challenges

Bias

Ethics

Fake

Privacy

AI is like a mirror that reflects society.

AI is exposing issues that have been neglected in traditional society.

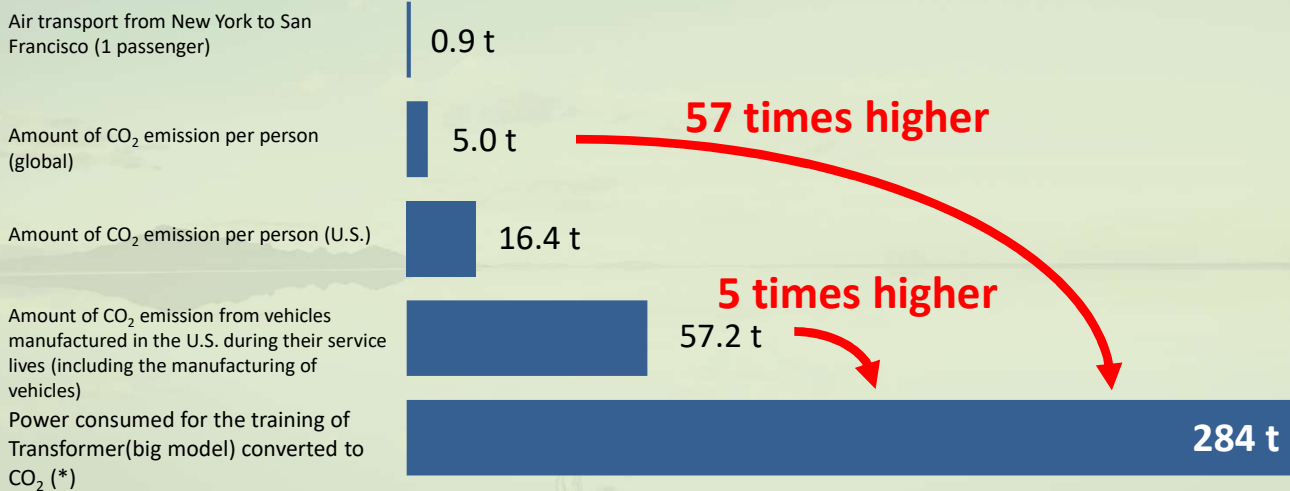
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- Even AI, the technology currently attracting the most attention, has negative aspects.
- AI is like a mirror that reflects society. The advent of AI is exposing issues that have been neglected within traditional society.
- An example of this is the AI-bias issue. Biases that exist in AI's learning data may be directly reflected in its performance, resulting in undue disparities. By contrast, providing unbiased learning data to AI might expose the disparities that exist in the actual society.
- Another negative aspect is that it is now possible for anyone to create a fake voice or video that behaves as if the individual himself or herself were actually speaking and moving. Some cases have gone as far as to trap a certain individual, manipulate public opinion, and use AI to advance a specific agenda.
- As we have seen, while AI confers tremendous benefits, it also exposes new problems that require attention and speedy resolution.

The Correlation of the Permeation of AI With the Global Environment



* A big transformer model was trained by one GPU for up to one day and the power consumed was measured. Then, using the number of training hours described in the original article about the model, the total energy consumed during the entire training process was calculated. The figures obtained from this calculation were converted to the CO₂ amount based on the mix of thermal, hydraulic, nuclear, and renewable energies.

As large-model studies on AI and its commercialization gather momentum, the CO₂ emission also increases.

The development of low-power semiconductors and the high-efficiency operation of data centers are required.

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Source: <https://arxiv.org/abs/1906.02243>

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- Advancements in AI may have a considerable impact on the global environment.
- A research team at the University of Massachusetts Amherst found that it would generate a carbon dioxide conversion amount of more than 284 tons to train a large-scale AI model.
- This amount is equivalent to approximately 57 times the annual global-average of carbon dioxide generated by ordinary human life, which is 5.0 tons.
- If studies and commercialization become widespread using large-scale AI models, the global amount of carbon dioxide generation will skyrocket. As a consequence, the development of low-power semiconductors and the high-efficiency operation of data centers are needed.

[Source]

<https://arxiv.org/abs/1906.02243>

<https://www.technologyreview.jp/s/146072/training-a-single-ai-model-can-emit-as-much-carbon-as-five-cars-in-their-lifetimes/>

Exploration of New Norms and Rules Has Begun



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- To address these situations, different entities have already begun seeking new norms and rules that will deal with the changes brought about by technology.
- With AI, full-scale global efforts are underway, including the EU Ethics Guidelines for Trustworthy AI as well as policies and guidelines issued by companies themselves.
- The Sustainable Development Goals established by the United Nations in 2015, while recognizing the significance of technology in solving real-life problems, also called attention to the environmental burdens caused by technology itself. Such information is helping to develop a shared sense of awareness that we must continue to address these challenges.

[Source]

EU Ethics Guidelines

<https://ec.europa.eu/futurium/en/ai-alliance-consultation>

https://ec.europa.eu/newsroom/dae/document.cfm?doc_id=60419

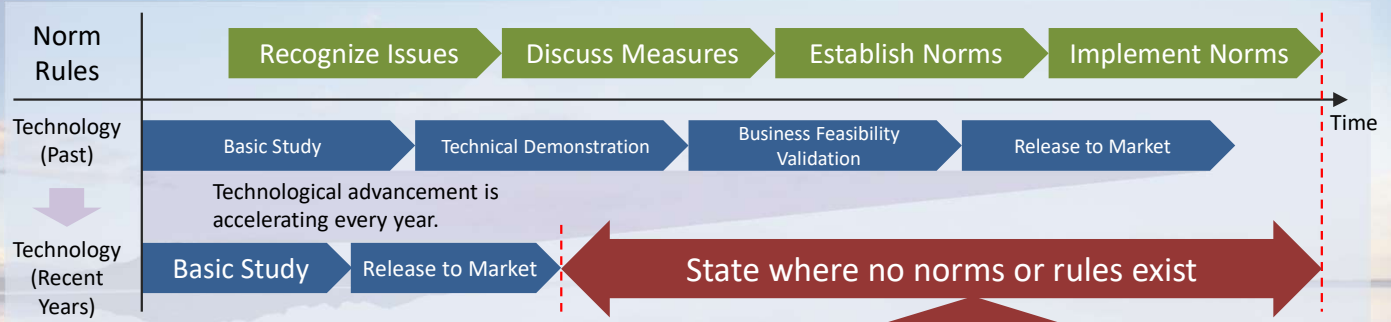
California Consumer Privacy Act

https://leginfo.ca.gov/faces/codes_displayText.xhtml?lawCode=CIV&division=3.&title=1.81.5.&part=4.&chapter=&article

SDGs

<https://www.un.org/sustainabledevelopment/>

The Time Lag Between Norms and Technological Innovations



- Protection of privacy and personal information
- Scope of application of genetic editing technology
- Appropriation of technological innovations for weapons
- Trusted model of cryptocurrencies
- Trusted model of data distribution
- Quality assurance of AI
- Interpretation of the antitrust law regarding platformers
- Ownership of AI models and learning data
- Character judgment based on social trust scores
- Geopolitical control of the export of emerging technologies
- Preferential treatment for the securement of highly competent human resources

These are a few of the various emerging challenges.

- A time gap exists between the establishment of new norms and the advancement of technology.
- The time-to-market of a technology since its invention used to be generally in step with the time to recognize problems and establish related rules and norms.
- In recent years, however, the speed of technological advancement has been accelerating, causing a gap between the time-to-market and the time to establish rules.
- How should we handle problems that arise during the period before norms and rules are established?
- For example, unconventional discussions become necessary on such topics as the scope of application of genetic editing technology and the trustworthiness of distributed data, e.g., the ownership of sensing data.

To build a sustainable society, it is necessary for the technology makers and users to cooperate in an effort to build norms and rules.

In addition to the pursuit of technology, the exploration of norms will be synonymous with the exploration of the fundamental value of humans.

- To address these problems and build a sustainable society, it will be necessary for technology providers and users to coordinate. That is for everyone to sincerely face each of these problems, while making an effort to build norms and rules together.
- In the future, when we are even more dependent on technology, the quest for norms will go hand in hand with the development of business and society and the pursuit for sustainability of humankind itself.

IST03: Forge New Norms

Negative Aspects of Technology

Forging New Norms in Line with Technological Advancement

Pursuit of Sustainability

The pursuit of technological innovation and the exploration of new norms and rules suitable for the consequent rapid changes in society and business will become a requirement for building a sustainable society.

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- In today's society where technology is advancing on a daily basis to increase our dependency on digital data, technology does benefit us. Meanwhile, the slightest mistake might fragment the world and expose unprecedented problems, collaterally giving rise to new ethical problems.
- In addition to the quest for technology, a quest for new norms and rules is needed today that respond to the rapid changes in social and business environments brought on by technology. These norms and rules will be the requirement for building a sustainable society.



Technology Trends

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106 Technological Innovation

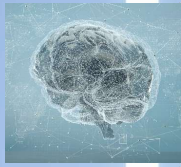
Active Learning
 Adversarial Example
 Deep Reinforcement Learning
 Model Compression
 Distributed Deep Learning
 Embodied AI
 Explainable AI
 GAN
 Graph Analysis
 Imitation Learning
 Machine Learning as a Service
 Meta Learning
 Multi-task Learning
 Natural Language Processing
 Neural Architecture Search
 Neural Network Exchange
 Real-Time Machine Learning
 Self-Supervised Learning
 Semi-Supervised Learning
 Transfer Learning
 Bioprinting
 Cellular Agriculture
 DNA Sequencing
 Gene Drive
 Genome Editing
 Genomics Analysis
 Liquid Biopsy

Microbiome Technology
 Alternative Data
 Media Forensics
 Satellite Remote Sensing
 AI diagnostics
 AI drug discovery
 Artificial Synapse
 Biometric Sensor
 Digital Therapeutics
 Neurofeedback
 Neuromodulation
 Non-Invasive Cyborg Technology
 Prosthetic Technology
 Smart Medical Device
 Container-orchestration
 Digital Twin
 Domain Specific Arch
 Edge Computing
 Serverless Architecture
 AI Chip
 Coherent Ising Machine
 Edge AI
 High-Speed Wireless
 Communication
 Low Power Wide Area
 Processor Architecture
 Quantum annealing

Digital Annealer
 Radio over fiber
 Satellite constellation
 Storage Class Memory
 Supercomputer
 Time-Sensitive Network
 Universal gate quantum computers
 Visible Light Communicate
 Wireless Power Transfer
 Additive Manufacturing
 Biomimetics
 Carbon dioxide Capture
 Collaborative robot
 Aerogel
 All-solid-state Battery
 Carbon Nanotube
 Hydrogen fuel
 Mechanochromic Material
 Self-Healing Material
 Advanced Driver Assistance
 Connected Car
 Drone
 Electric Car / Fuel Cell Vehicle
 Mobile Robotics
 Next-Generation Transportation
 Reusable Rocket

Self-Driving Car
 AI Based Threat Detection
 AI vulnerability
 Anonymity Technology
 Biometric Authentication
 CPU security vulnerability
 Cryptography Technology
 IoT Security
 3D Reconstruction
 3D Sensing
 Computational Photography
 Holographic Display
 Super Resolution
 Volumetric Video
 xR Cloud
 xReality
 xRHMD
 Behavior Analysis Technology
 Behavior Prediction
 BMI / BCI
 Emotion Recognition
 End-to-End translation
 Face Tracking
 Gesture Recognition
 Sense Reproduction
 Speech Recognition
 Voice Assistant

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TT01
Intellectual Advancement of AI



TT05
Security for the Digital Era



TT02
Coexistence with AI



TT06
Computer Power Evolution



TT03
Data-Driven Transformation



TT07
Synergy in Human-Machine Systems



TT04
AI for Healthcare & Life Sciences



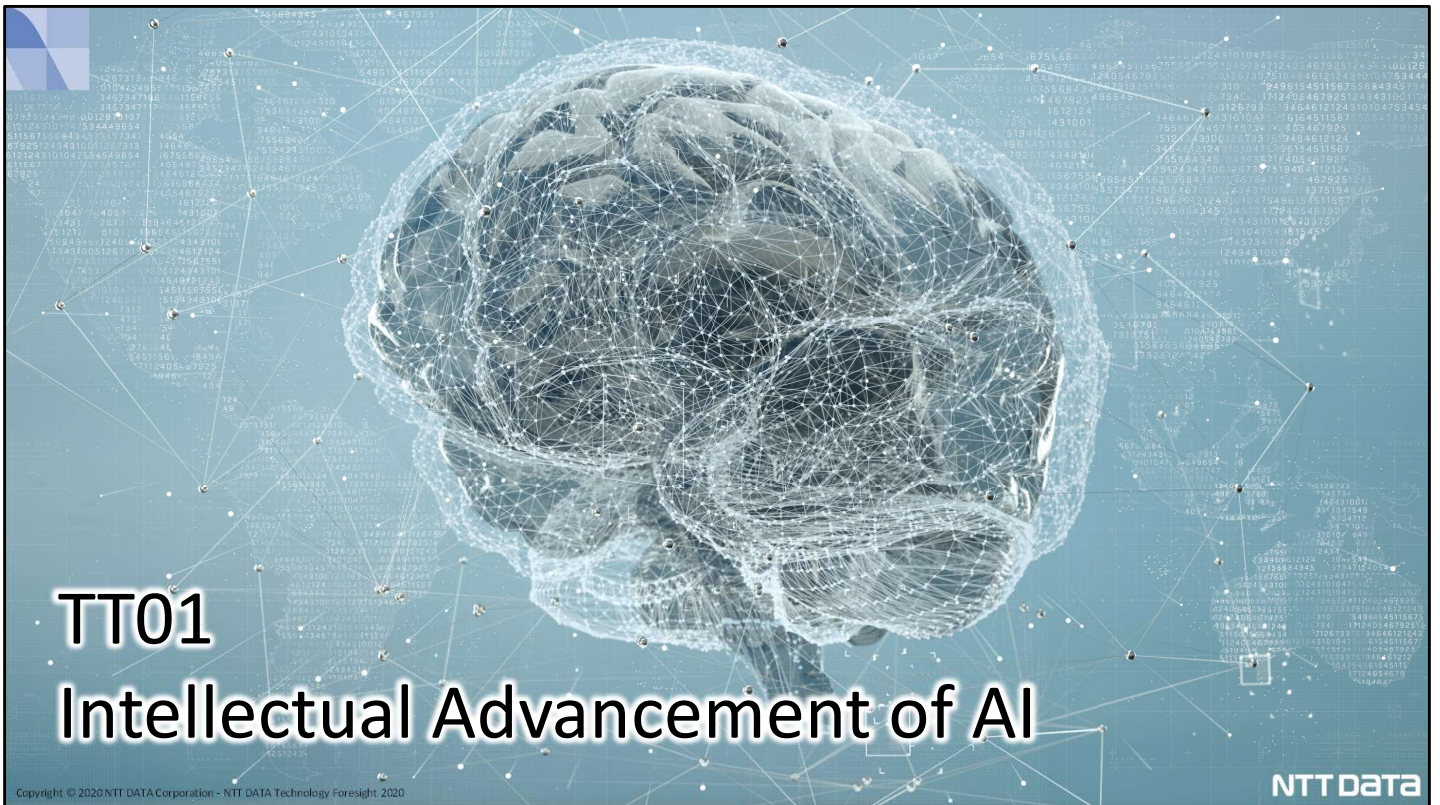
TT08
Hardware Evolution for Service Operations

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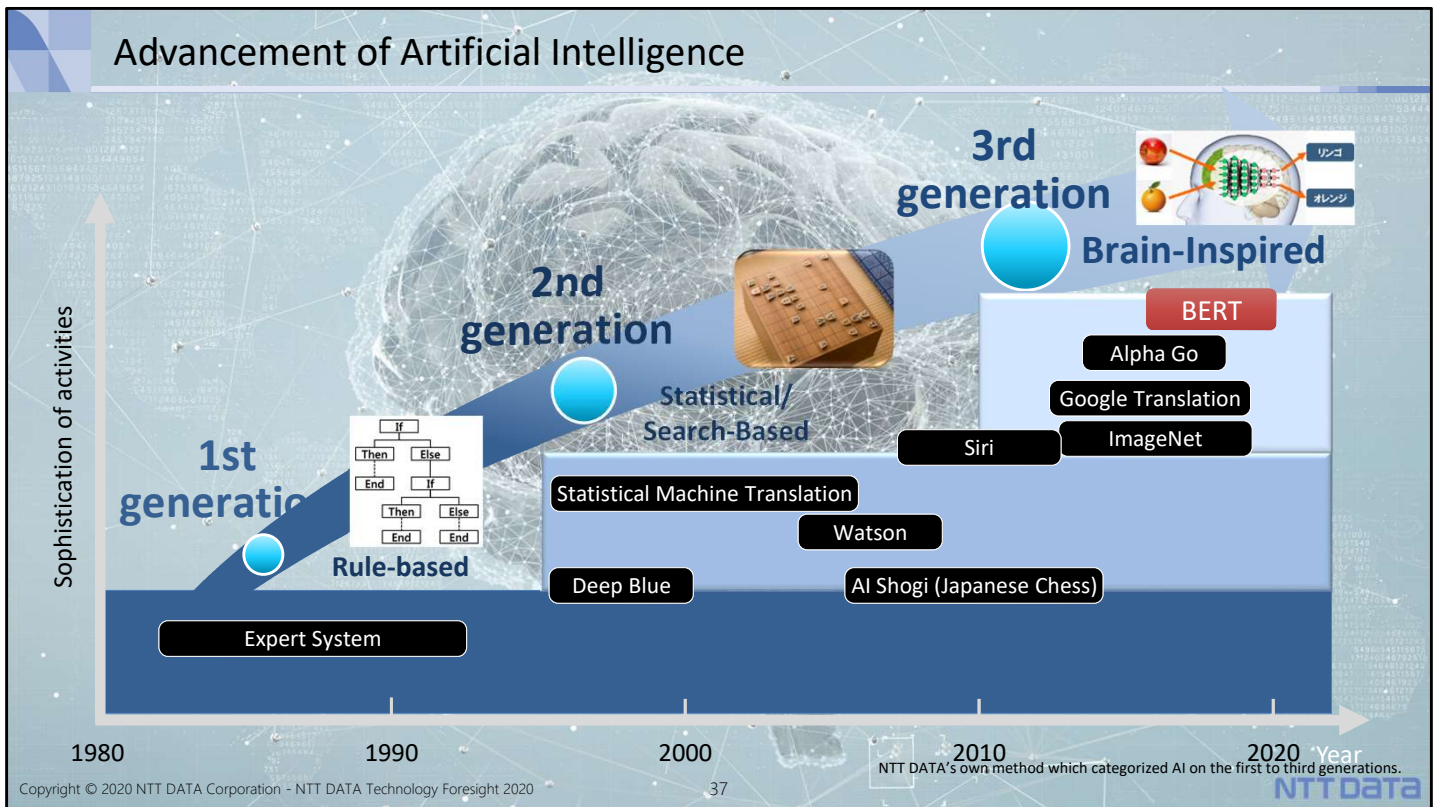
- The following are eight technology trends identified in the NTT DATA Technology Foresight 2020 report. I would like to state that every trend that we will discuss today involves somewhat of an advancement of AI.



TT01 Intellectual Advancement of AI

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- The first trend.
- First and foremost, it's still important to discuss AI. This one is specifically about the intellectual advancement of AI.



- What do we mean by AI? In terms of a technology definition, technologies from the second generation and third generation is what we mean by AI. This includes statistical-based methods with machine learning, and brain-inspired methods with deep learning and other related technologies. As you can see in the chart, many technologies have been realized throughout the history of AI, and this year's big difference is in language, originating from BERT a couple of years ago.

XLNet (improved version of BERT) answering correctly to more than 90% of questions.

185 Points > 170 qualify score

Exceeds the first-round qualification score for admission to the University of Tokyo.

up from
83 Points
(Average: 43 Points)

<Sample questions from the university admissions test>

Q:For the following questions (Questions 1~3), please remove a segment within this paragraph that would improve the overall structure of the paragraph. From the following underlined segments ①~④, please choose the most appropriate segment to remove.

When flying across the United States, you may see giant arrows made of concrete on the ground. Although nowadays these arrows are basically places of curiosity, in the past, pilots absolutely needed them when flying from one side of the country to the other. ①The arrows were seen as being so successful that some people even suggested floating arrows on the Atlantic Ocean. ②Pilots used the arrows as guides on the flights between New York and San Francisco. ③Every 16 kilometers, pilots would pass a 21-meter-long arrow that was painted bright yellow. ④A rotating light in the middle and one light at each end made the arrow visible at night. Since the 1940s, other navigation methods have been introduced and the arrows are generally not used today. Pilots flying through mountainous areas in Montana, however, do still rely on some of them.

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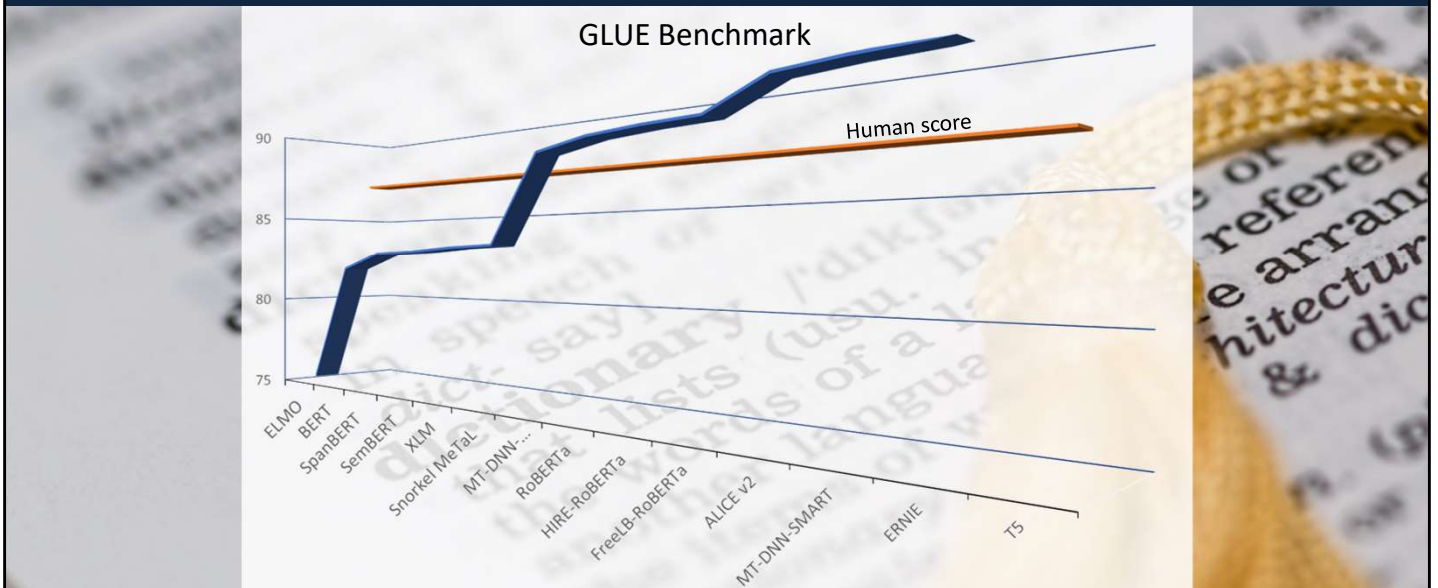
- The first case is from NTT. In this case, AI has shown the human level language understanding in a university entrance exam.
- AI took the test and scored 185 points, which is above 90% of the score. This score is also above 170, which is the qualifying score for the university students of Tokyo University. In fact, the average score of all high school students who took the same test was 123 points.
- NTT used the technology called XLNet, which is an improved version of BERT, in this university exam.

[Source]

<https://www.ntt.co.jp/news2019/1911/191118a.html>

Remarkable Improvements in Natural Language Processing Started From BERT

Scored greater than human in language proficiency test (GLUE Benchmark)



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- So what's the advancement? It is the remarkable improvements in natural language processing that has occurred over these several years.
- This stems from BERT and other technology around transformers.
- As you can see in the graph, the human score, drawn horizontally, has been surpassed by AI. In fact, many other benchmarks in NLP show AI outperforming human scores.
- From now on, this advancement will be applied to many applications.

[Source]

<https://gluebenchmark.com/leaderboard/>

Expected Use Cases

Question & Answer



Understand human questions and create natural sentences to answer

Search in natural sentence



Understand context (e.g., "Ramen without miso")

Extract knowledge



Accurate extraction of sentence meaning

- There are many examples of expected use cases for natural language processing. Here are a few:
- One case may be with a question and answer format. As you can easily imagine, many of the chatbots can become smarter in question and answering.
- In search in natural sentences, a fun example might be typing "ramen without miso" in Google search, where it uses "without" correctly to list ramen but excluding miso type. In a business context, imagine a call center situation where someone is speaking, and the AI is capturing that sentence to create an answer. The search would use the captured sentence correctly to understand its context. Perhaps, frequently asked questions and answers would be searched for the efficient answer by understanding a caller's questions in its right context. This is near-future usage that will provide efficiency to the call center.
- In the last case, AI can also extract knowledge from sentences. This is like catching a sentiment or topics as in the past but being more precise. Because AI can now extract some "meaning" from flat text, in a business case we may extract information from business documents. In legal documents, it might be legal risks in a particular agreement for an entity. In business documents, it might be conditions of certain businesses or similarities between business models.

Significant Features of BERT

Important attributes to ensure high accuracy and easy utilization

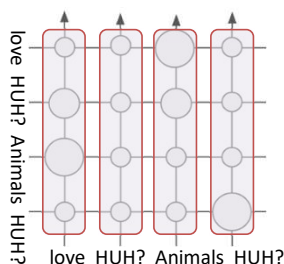
Self-supervised learning

Learning from large online text data such as Wikipedia, etc.

800 Million Words from Book Corpuses
+
2.5 Billion Words from the English Wikipedia
(with BERT)

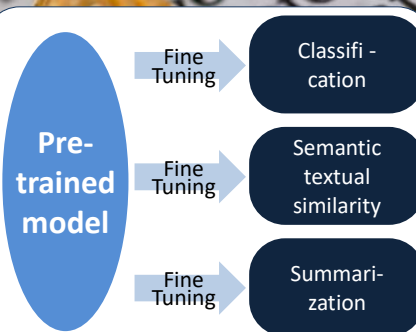
Innovative algorithm

Relationships between distant words



General purpose model

Variety of tasks realized by pre-training + specific tasks

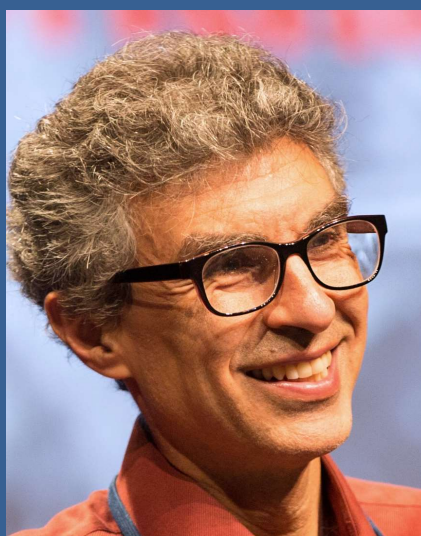


- So what's the significant feature of these technologies originating from BERT? We think it is these three points.
- The first is that it is self-supervised. The models in this type of NLP use a lot of text. In BERT's case, it is 800 million words from book corpuses and more additions from Wikipedia. This was the training data that trained the model.
- As you may remember, accuracy of current AI depends on the amount of data that can be accumulated for its training. Learning was not done by supervised learning where you need to label everything manually for training as input and output.
- In fact, BERT and others use a clever way to turn plain text into training data, as inputs being labeled as "masked text" to outputs being the original text. This result in preparing training data is called "self-supervised" learning. By turning vast amount of plain texts automatically into training data, NLP has achieved its accuracy.
- The second important part is its innovative algorithm.
- Transformer architecture is being used in BERT and by the followers for modeling the language. So in this case, the relationship between distant words in forward direction and backward direction, both ways, was modelled. As a result, it was proven to be very effective for the use in natural language.
- The third point that makes the technology very useful is the structure of this technology.
- It is divided into two parts. First is its pre-trained model, which provides the understanding of the basics for the languages. Second is its application part, where specialized tasks can be added by fine tuning the pre-trained model. As a result, many special tasks around the natural language, such as classification, understanding semantic textual similarities, and summarizing text can be done providing general purpose to the model.
- With these key features, BERT and its descendants proved to be easy to apply in many different languages and many domain-specific texts and tasks.

The Future of AI by ACM Turing Award 2018 Winners



Yann André LeCun



Yoshua Bengio



Geoffrey Hinton

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- Going back, there were many big advancements in images, voices and sounds, etc. Now we are seeing big advances in languages with AI. (Note: There might be other areas with significant advancement in the future like languages this year, may be something like graphs which would show relations and meanings.)
- This year, many researchers including these big three are stating what will come next for AI or where it should head to.
- One of the things that they're describing as important is self-supervised learning. It is very interesting at the moment and also being used to make a lot of advancements, such as one in language processing. In language processing, AI uses original text and masks it to make a question, using the original text as the answer to create the pair. The pair can easily be generated automatically enhancing the training data for AI.
- In other discussions, issues in just feeding a lot of data to AI for its accuracy is stated. In many of the current research and development efforts, technology is headed in the direction of learning by feeding more and more data for simple learning of inputs & outputs, which still proves to be achieving improvements.
- But if we think of a human's way of learning, we apply what we already know to what we don't know, adapting to the situation. So, a hierarchical way to learn, adapting to other domains is another direction of technology sought, providing a much more efficient way for AI to learn and adapt.
- These, of course, would be studied in parallel, using all the advancements made by computation intensive for current AI improvements. There is still more news for AI.

[Source]

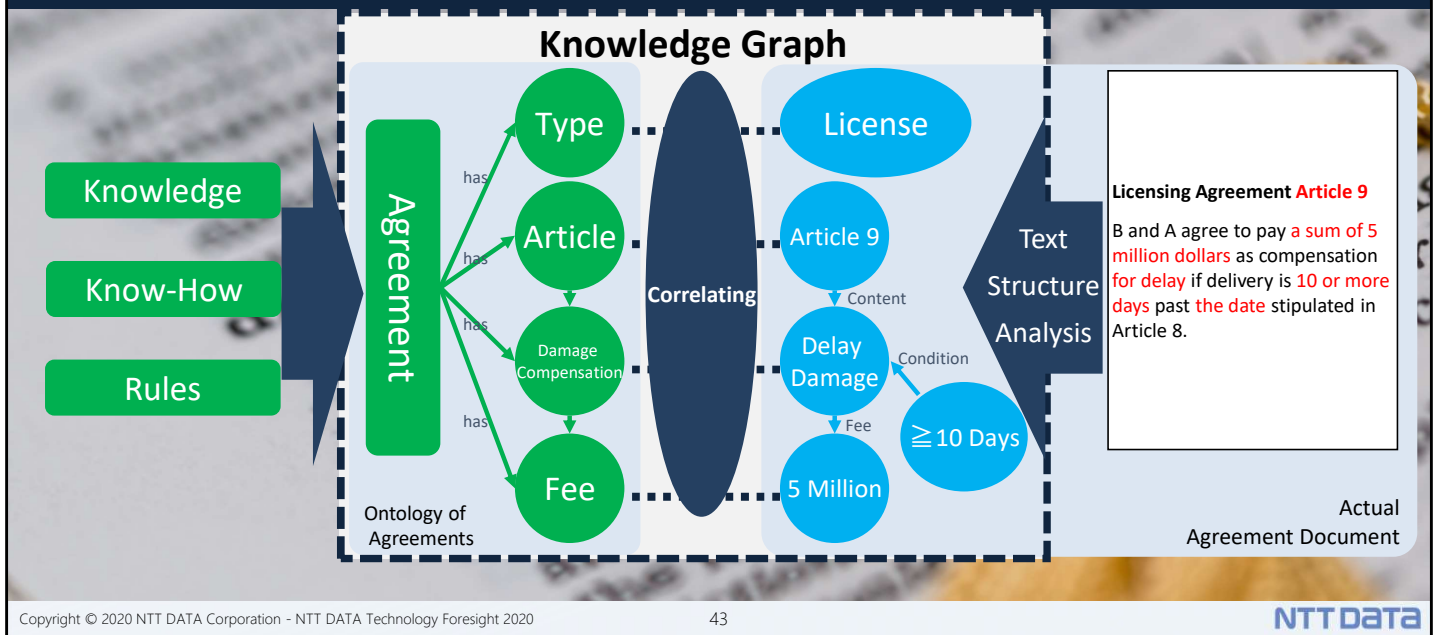
<https://amturing.acm.org/2018-turing-award.cfm>

[Picture Info]

[https://en.wikipedia.org/wiki/Yann_LeCun#/media/File:Yann_LeCun_-_2018_\(cropped\).jpg](https://en.wikipedia.org/wiki/Yann_LeCun#/media/File:Yann_LeCun_-_2018_(cropped).jpg)

https://en.wikipedia.org/wiki/Yoshua_Bengio#/media/File:Yoshua_Bengio_-_2017.jpg

Defining the knowledge, know-how and rules (ontology)



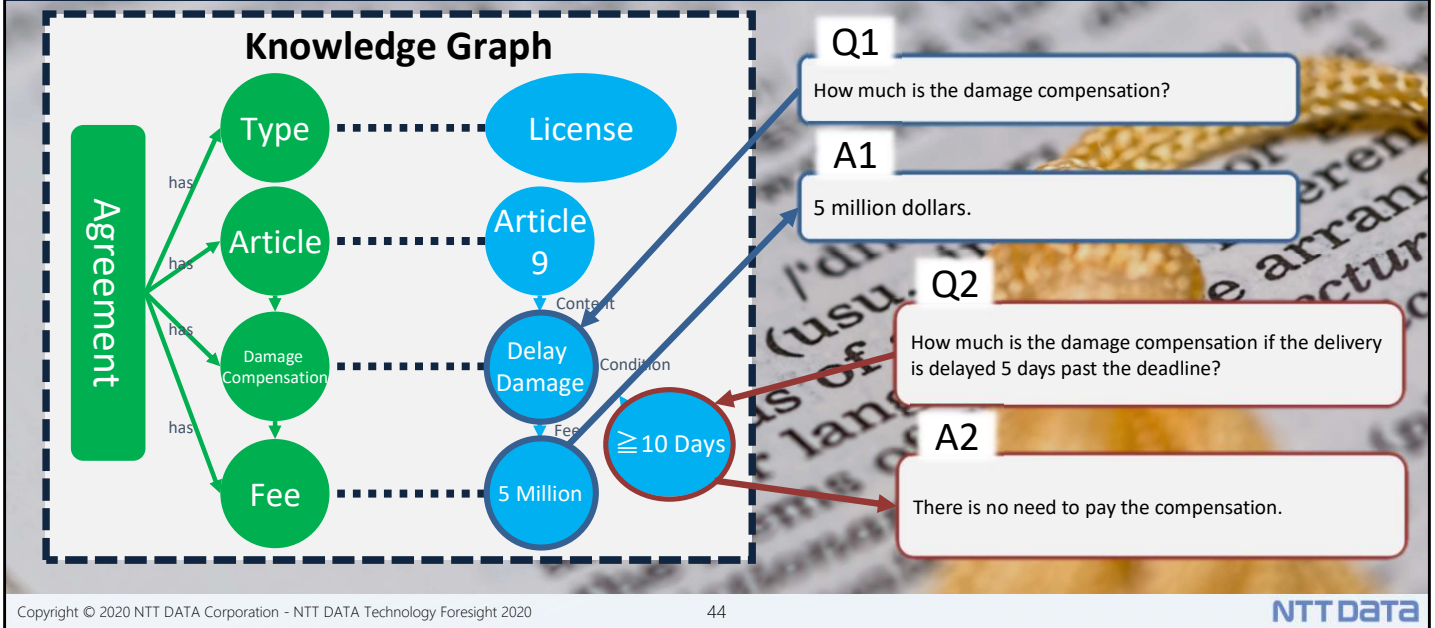
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- In discussing the advancement of AI, in NTT DATA, we're combining some of the technology that we can use at the moment, namely ontology, with NLP advancements.
- Here, we organized our ontology into a knowledge graph. In this case, we have been creating an ontology for the legal domain to understand legal documents & agreements.
- In the left section in green, it represent a part of ontology where agreement is made by articles with some other things like damages, compensations, and fees. By feeding that ontology with the actual legal documents, such as license agreements, which is in the right in blue, we can automatically analyze the agreement into "Article 9" which says "delay and damage" will be "5 million yen" but with conditions of "10 days or more" where it changes the amount of fees.
- In the past, ontologies could only be made by hand. So it was very difficult to have comprehensive knowledge. Today, because of the advancement of natural language processing, we can use AI to support ontology development to acquire this type of knowledge.

Meaning-based decision can be made using knowledge graphs



- Using ontology, as structured knowledge of a certain domain, in combination with natural language processing and understanding, we can answer some questions like “how much is the damage compensation?” where it will return “5 million yen.” However, if the question includes some condition such as “delayed 5 days,” it could provide a different answer.
- This type of understanding in legal documents is very attractive to many industries with high value contracts like trades, utilities, constructing buildings, real estate & financial assets, etc. Of course, there are many contracts in financial institutions, banks, and insurance companies as well.
- So at NTT DATA, we are talking to these types of businesses to apply this technology and executing some proof of concepts to further develop technology solutions.



- The second trend is about AI again. Because AI is becoming more and more prevalent in actual use, in this trend, we're discussing how we coexist with AI.

Available Tools for Custom AI Models

Automation quality is comparable to top level experts

Kaggle Days SF competition

Top level competition
for data analytics experts

Compete on defects prediction
with real data in 8.5 hours

AutoML tables performed

Model selection

Hyper-parameter tuning

Evaluation

Result: Second place

#	Δpub	Team Name	Team Memb...	Score
1	▲29	Erkut & Mark		0.61691
2	▲1	Google AutoML		0.61598
3	▼2	Sweet Deal		0.61576
4	▲10	Arno Candel @ H2O.ai		0.61549
5	▼1	ALDAPOP		0.61504
6	▲11	9hr Overfitness		0.61437
7	▼5	Shlandryn		0.61413
8	▲1	Erin (H2O AutoML 100 ...		0.61312
9	▼3	[ods.ai] Adel, Jiashun ...		0.61298
10	▲17	Sairam, Mehul & Naray...		0.61237

Source: <https://www.kaggle.com/>

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- Many advancements are becoming real and useful. These include not just the API's and other available tools that could be used to develop AI into applications, but also custom AI where you need to develop some sort of customized models.
- In this example, Google is providing AutoML to build the machine learning model automatically, to some extent. In this situation, they used the tool to create a model to compete against a high-end data scientist in the Kaggle competition. The result – they won second place in the contest. The lesson learned is that AutoML is now easier to use and even comparable to a human high-end expert data scientist.

[Source]

<https://ai.googleblog.com/2019/05/an-end-to-end-automl-solution-for.html>

<https://www.kaggle.com/c/kaggledays-sf-hackathon/overview>

<https://www.kaggle.com/c/kaggledays-sf-hackathon/leaderboard>

AI Diagnosis Developed by Doctors (Non-AI Expert)

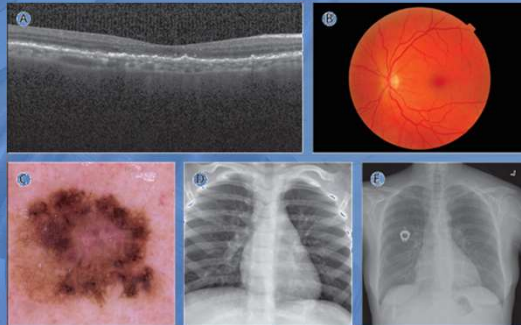
What do we need to consider when using an AI system?

Doctor who is NOT AI expert creates
AI disease classification

Developed only
with browser

Leverage open data

Self-tuned



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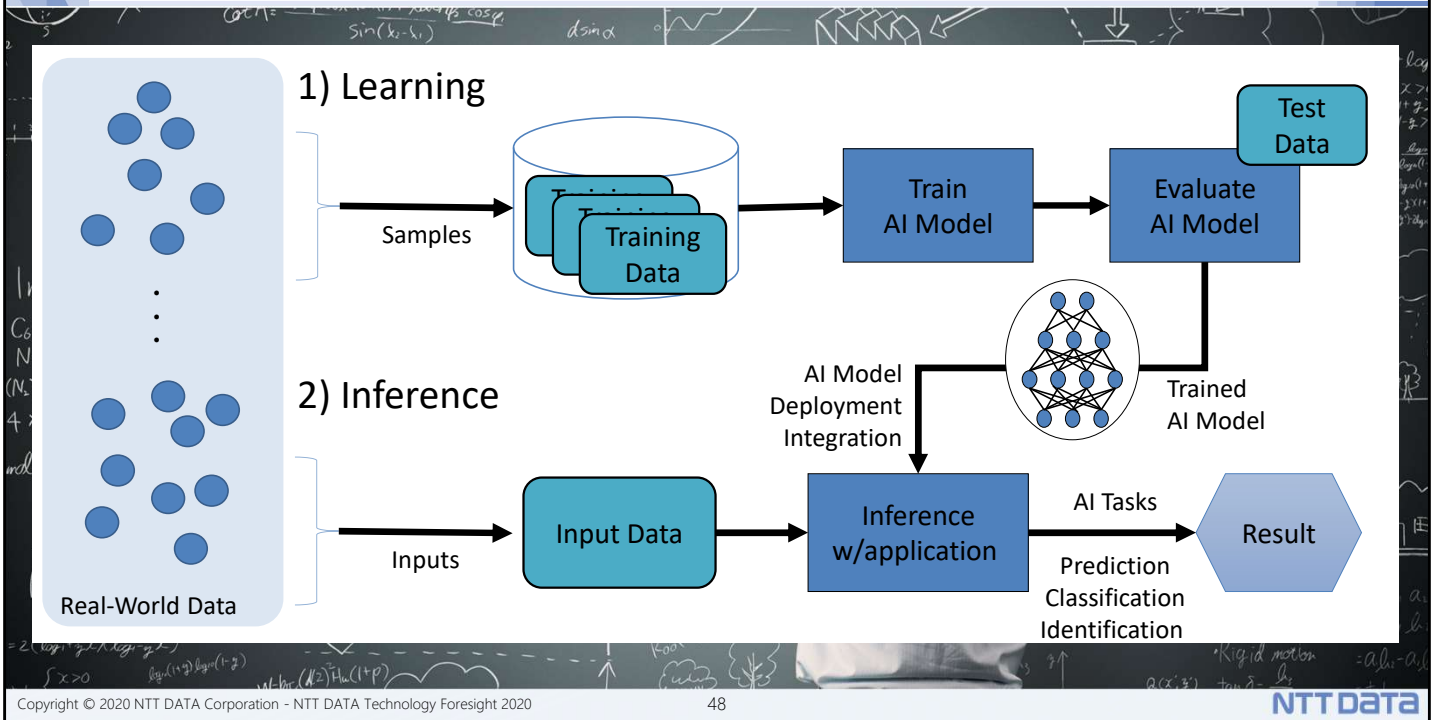
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- In this case with Lancet Digital Health, a medical doctor who is not expert in AI created an AI disease classification or an image diagnosis program from open data from medical institutions. They self-tuned the model by only using a browser with the APIs, specifically Google Cloud AutoML Image, another type of AutoML.
- If you think about it, this type of development process raises many potential issues and questions. How accurate are the actual models? Who is responsible for AI quality? Can we use and trust the diagnosis? How should we use them? And many other questions such as these.

[Source]

[https://www.thelancet.com/journals/landig/article/PIIS2589-7500\(19\)30108-6/fulltext](https://www.thelancet.com/journals/landig/article/PIIS2589-7500(19)30108-6/fulltext)

AI in Development & Operations



- Many of the issues stem from the differences in developing AI systems and legacy IT systems.
- In AI systems, there are basically two large development phases. First is the learning phase where AI is being trained from training data based on samples from real data. The trained AI model is then evaluated by test data, also based on samples from real-world data. The evaluated model is then deployed, where once again the input data is originating from real-world data.
- Second is the inference phase, where AI will provide inference from inputs. In this phase, the model made from past limited samples is integrated/deployed in the application system to provide results such as prediction, classification and identification. Because the model is proven to handle the data only by evaluation with samples, in some cases real-world data will change or come from data outside of the samples originally used, making unrelated or nonsensical inferences.

AI-Specific Challenges in Need of Solutions

Fairness

AI needs to be fair in its use

Transparency

AI result needs to be convincing and understandable to users

Security

AI needs to be secure from all inputs and from being extracted

Continuity

AI needs to adapt to data drift

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- Some of the challenges that are prevalent in the development and usage of AI applications include:
 - Fairness: AI needs to be fair in its use.
 - Transparency: you need to actually be able to see and understand what it has done.
 - Security: AI needs to remain secure even when inputs change or includes data not out of samples.
 - Continuity: when something changes AI needs to adapt to the new situation.

Impact of Learning-Data Bias on AI



Accuracy by race or gender in
AI face-recognition

False recognition rates:

-Light-skinned male 0.3%

-Dark-skinned female 34.7%

**Need to adjust model
for actual use**

- This is a slide from a previous Technology Foresight presentation, but it is still relevant. Because of AI learning from training data, AI can be biased if the model and/or actual use is not adjusted to the data. In this case, think about face recognition at Customs. If the data is only about light-skinned males, dark-skinned people or females might be falsely singled out due to biased results.

[Source]

<http://proceedings.mlr.press/v81/buolamwini18a/buolamwini18a.pdf>

The numbers used in this slides are from Table 4 in the pdf.

Transparency of AI

How to counteract the black box problem of AI

Use transparent model	Use decision tree
Human in the loop	Human expert is responsible for making decision
Keep transparency with application	Explainable AI

- A second major challenge with AI is transparency, because some AI is simply blackbox.
- For instance, some of the AI that we have talked about is actually a neural network's optimized result to inputs and outputs and nothing else. So basically, we don't really know why the system comes out with a particular answer. There are several ways to address this challenge:
 - You can just use other models not using a neural network that show a clear path leading to a decision such as a decision tree.
 - You can include some expert human in the loop, who is ultimately responsible for making decisions, not the AI.
 - Finally, you can use explainable AI in combination with actual AI

Enabling XAI (Explainable AI)

Research to explain rationale for AI's recognition and other inferences continues

Grad - CAM

Highlight the pixels which contributed most to the result

TCAV

Propose human-friendly concepts to show influence to result

L2X

Extract the words that influenced most to resulting emotions

Truth	Model	Key words
positive	positive	Ray Liotta and Tom Hulse shine in this sterling example of brotherly love and commitment. Hulse plays Dominick, (nicely) a mentally handicapped young man who is putting his 12 minutes younger, twin brother, Liotta, who plays Eugene, through medical school. It is set in Baltimore and deals with the issues of sibling rivalry, the unbreakable bond of twins, child abuse and good always winning out over evil. It is captivating , and filled with laughter and tears . If you have not yet seen this film, please rent it. I promise, you'll be amazed at how such a simple film could go unnoted.
negative	negative	Sorry to go against the flow but I thought this film was unrealistic , boring and way too long. I got tired of watching Gene Rowlands long arduous battle with herself and the crisis she was experiencing. Maybe the film has some cinematic value or represented an important step for the director but for pure entertainment value, I wish I would have skipped it.
negative	positive	This movie is a chilling reminder of Bollywood being just a parasite of Hollywood. Bollywood also tends to feed on just blockbusters for furthering its industry. Vidya Vadod Chopra made this movie with the reasoning that a cocktail mix of deers and on the waterfront will bring home an oscar . It turned out to be a rookie mistake! Even the idea of the title is inspired from the Elia Kazan classic . In the original, Brando is shown as raising doves as a symbol of peace. Bollywood must move out of Hollywood's shadow if it needs to be taken seriously.
positive	negative	When a small town is threatened by a child killer, a lady police officer goes after him by pretending to be his friend. As she becomes more and more emotionally involved with the murderer her psyche begins to take a beating causing her to lose focus on the job of catching the criminal . Not a film of high voltage excitement, but solid police work and a good depiction of the faulty mind of a psychotic killer .

Truth	Predicted	Key sentence
positive	positive	There are few really hilarious films about science fiction but this one will knock your socks off. The lead Mattian Jack Nicholson take-off is side-splitting. The plot has a very clever twist that has been seen to be enjoyed. This is a movie with heart and excellent acting by all. Make some popcorn and have a great evening.
negative	negative	You get 5 writers together, have each write a different story with a different genre, and then you try to make one movie out of it. Its action, its adventure, its sci-fi, its western, its a mess. Sorry , but this movie absolutely sinks . 4.5 is giving it an awfully high rating. That said, its movies like this that make me think I could write movies, and I can barely write.
negative	positive	This movie is not the same as the 1954 version with Judy Garland and James mason, and that is a shame because the 1954 version is, in my opinion, much better. I am not denying Barbra Streisand's talent at all. She is a good actress and brilliant singer . I am not acquainted with Kris Kristofferson's other work and therefore I can't pass judgment on it. However, this movie leaves much to be desired. It is paced slowly, it has gratuitous nudity and foul language, and can be very difficult to sit through. However, I am not a big fan of rock music, so its only natural that I would like the judy garland version better. See the 1976 film with Barbra and Kris, and judge for yourself.
positive	negative	The first time you see the second renaissance it may look boring. Look at it at least twice and definitely watch part 2. it will change your view of the matrix. Are the human people the ones who started the war? Is it a bad thing?

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- What the current explainable AI does is essentially show how much influence part of the input or intermediate results had to the actual result.
- For example, with image recognition, it can highlight the important part of an image. In the textual results, it will highlight specific text, or some percentage numbers or similar metric attached to a word.
- In the example on the left, when AI sees the image and decides that something is a cat or dog, it shows where it sees the animal in colored pixels.
- In the middle example, when AI examines the image of a zebra, it shows that it is a zebra because the image is 53% stripes, 41% horse, and 29% Savannah in combination.
- In the example on the right, in text, some of the highlighted words have a higher influence on the analyzed results.

[Source]

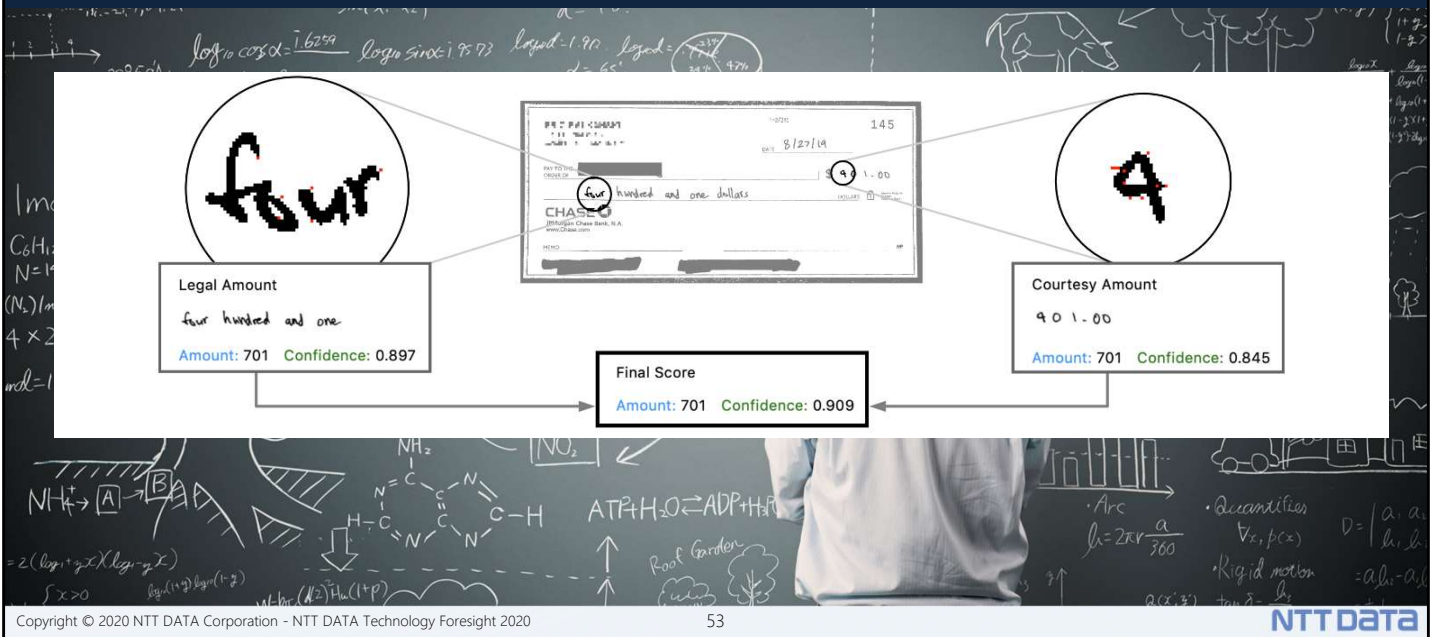
<https://arxiv.org/pdf/1610.02391.pdf>

https://beenkim.github.io/slides/TCAV_ICML_pdf.pdf

<http://proceedings.mlr.press/v80/chen18j/chen18j.pdf>

Security for AI System

Countermeasures are essential for AI vulnerability, e.g., adversarial attack



- The third major issue when using AI is security. AI needs to handle many things, even something that's outside of what was initially thought of as inputs.
- In previous versions of NDTF, we have often discussed the major challenge of adversarial attacks.
- In this area, we are currently working with a startup specializing in AI quality, including a type of security called Robust Intelligence. They provided us with an interesting example.
- In the US, a check is often used as a means of currency exchange. It is handwritten using characters and digits. Then, a recipient will take this paper where it will be checked by looking at two places and then compared for a match.
- In this case, there's a written "four" on the left-hand side and also a numerical "4" on the right-hand side. If you're human, you can read it correctly. However, as you can see in the blue part where it says "Amount," a computer decided that to be seven. So it was seen as 701 where it should have been 401.
- This can happen with both letters and digits with AI because of the additional red points added to the text and letters.
- We must understand these types of unexpected inputs and react correctly with countermeasures to correct for these vulnerabilities.

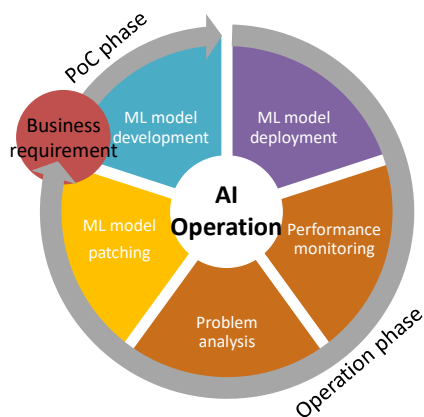
[Source]

Robust Intelligence : <https://robustintelligence.com/>

*Picture is provided by Robust Intelligence directly and not shared openly.

MLOps Is Required for AI System

Need to monitor and improve during the operation



Examples of Consistency

Error detection – MHIAL



Changing the settings of the work-line, alters the trend of sensor data and makes the machine learning model obsolete.

Credit assessment



When financial trends and lifestyles change, important parameters also will be altered resulting in obsolete models.

As the environment changes, data trends shift and the machine-learning model learned becomes obsolete.

Examples of Completeness

Self-driving car



Under conditions of rain, snow, heavy fog, etc., lack of learning data in system performance compared to fine weather is reduced.

Hostile sample attack



To impart minute noise to an input image. Generates images that cannot be identified by humans. **An attack method that alters the results of AI recognition.**

In addition to the problem of false positives due to naturally occurring noise, intentional noise can also disrupt AI decisions

- Recognizing unexpected inputs is not just for security, because some inputs from real world data which is not the human-made attacks are unexpected. As a result, AI needs to be monitored and improved during its operations.
- For instance, we have been providing a machine learning system for a factory with a continuously changing work line. In addition, there will also be some physical deterioration of machines. So trend sensor data fluctuates, which means input to the running AI model changes. We need to monitor the change to know when the current model is obsolete. The same is true in financial sectors due to shifting financial trends and economic situations.
- Now imagine a self-driving car, which needs to recognize many conditions such as rain, heavy fog, snow, etc., in order to drive you safely. That lack of learning data in even the rarest case might result in some disastrous system performance. Rare conditions and adversarial inputs are issues that must be efficiently addressed in operations to ensure the needed quality of AI systems.

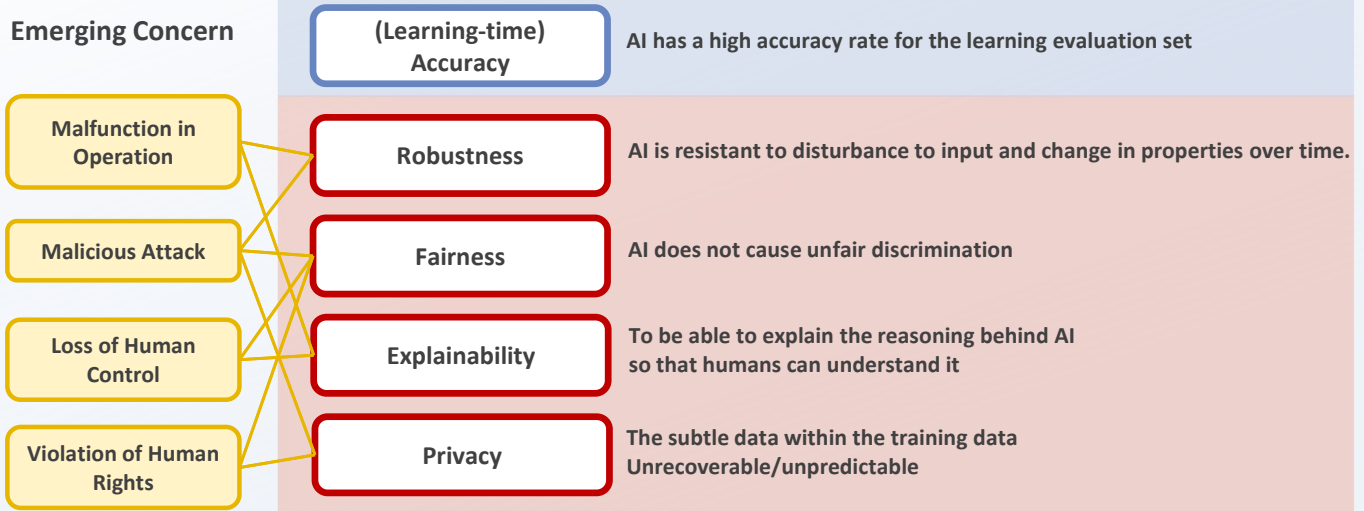
[Source]

Quote: <https://raw.githubusercontent.com/microsoft/MLOps/master/media/ml-lifecycle.png>

Quality Characteristics Required for AI in Operation

As expectations for AI increase, required quality becomes more specific and diverse

Source: QA4AI AI Quality Assurance Guidelines, Ethics guidelines for trustworthy AI (EU)



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- The quality characteristics required of AI in operation is changing as it becomes more socially accepted and used.
- However, in many cases, only the “accuracy” during or after the training is discussed. But many emerging concerns are also significant in operations. Some important operational qualities in AI are robustness, fairness, expandability and privacy in the use of data.

[Source]

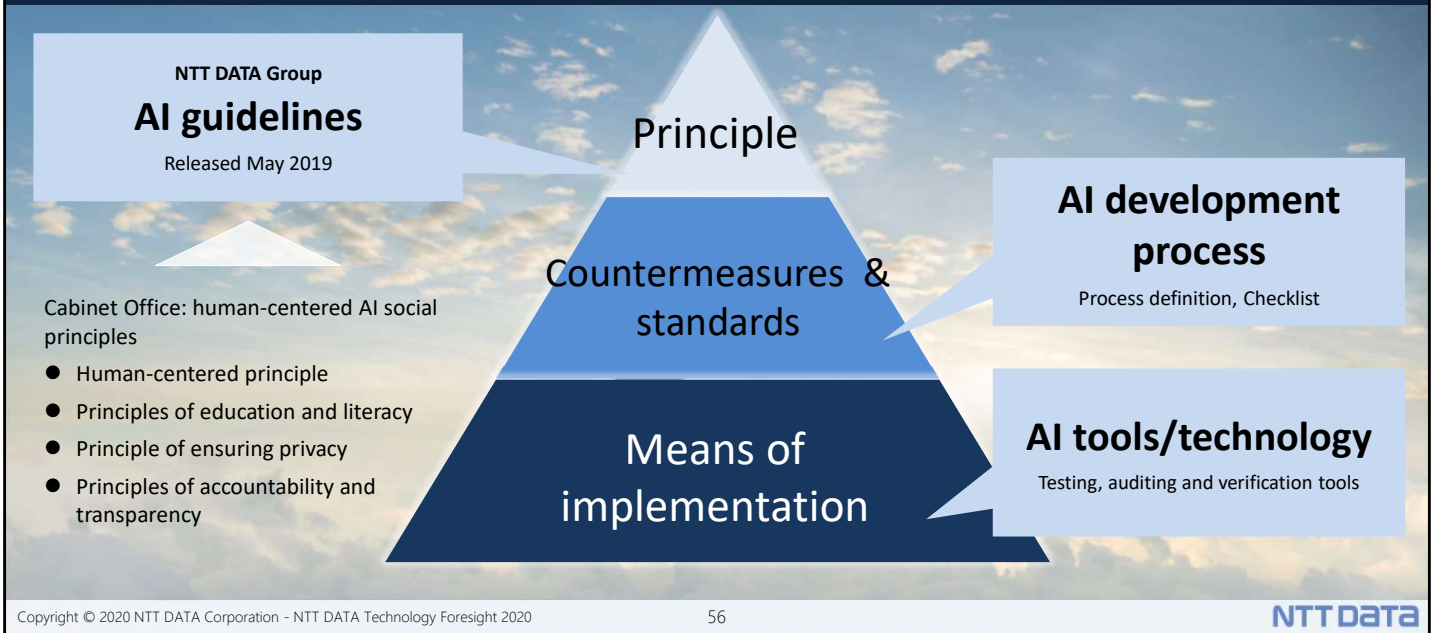
QA4AI AI Quality Assurance Guidelines,

<http://www.qa4ai.jp/>

Ethics guidelines for trustworthy AI (EU)

<https://ec.europa.eu/digital-single-market/en/news/ethics-guidelines-trustworthy-ai>

Define and embody not only "principle" but also actions



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- I would like to conclude the discussion of this trend by telling you what NTT DATA is doing with AI operations in society.
- One important step is that we developed a governance structure with initiatives from principle to AI tools. For principles, we published our AI guideline in May 2019. During the first quarter of this year we worked on AI development process guidelines, which we will begin to use in Japan. Finally, we're evaluating and developing AI tools for tests, audits and to verify and monitor the quality of AI models, which is critical with real-world data that is constantly changing.
- All these initiatives are of great importance because of the trend to coexist with AI.

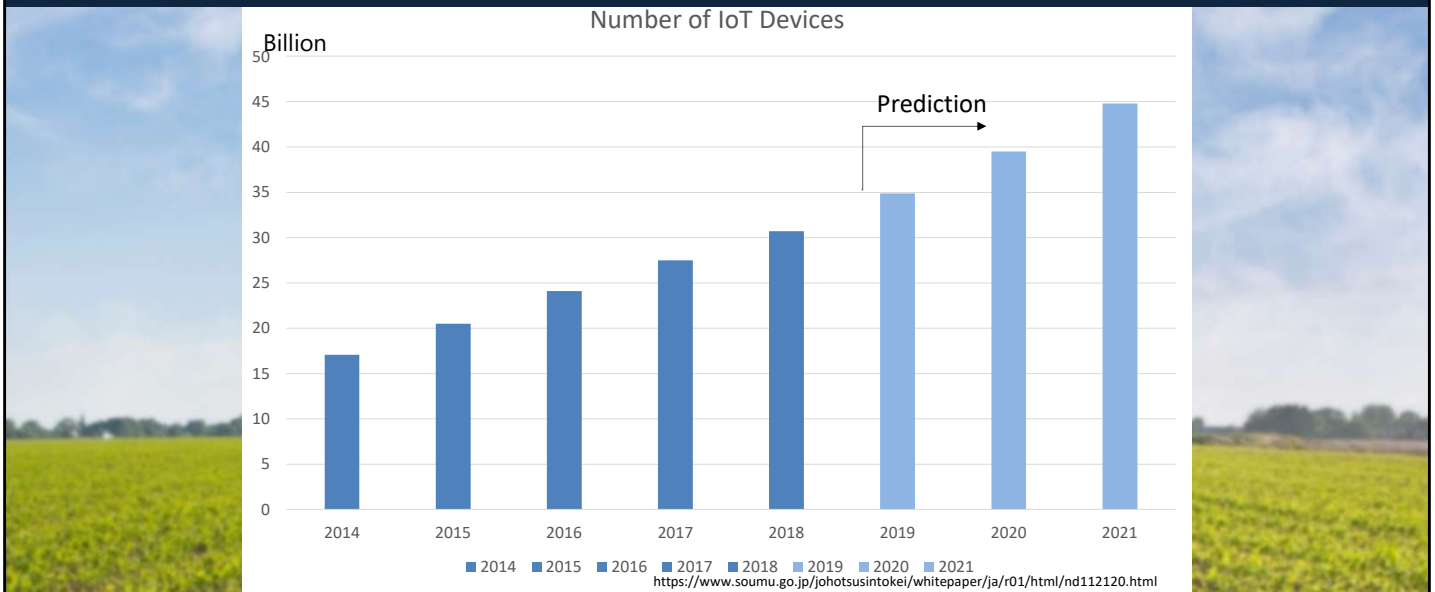


TT03 Data-Driven Transformation

- The third trend is about data. We separated data from AI because it is the transformation medium for our clients' businesses.

More Data Will Be Available Through Multiple Channels

The number of IoT devices is still increasing



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- As you all are aware, we have a lot of data and the amount is increasing and becoming more available. This graph shows only one aspect, the number of IoT devices producing data that could be used in many of our client cases.

[Source]

<https://www.soumu.go.jp/johotsusintokei/whitepaper/ja/r01/html/nd112120.html>

Improvement in Sensors That Can Detect The Physical World

Accuracy and intelligence make it easier to capture data in the real world

Intelligent edge
detects and analyzes important information



Camera sensors
capture objects with meaning



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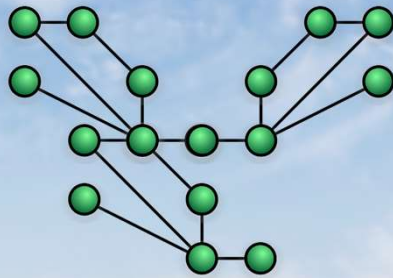
- Sensors are providing vital information from the edges, and the improvement in sensors is of great importance in understanding the physical world.
- The first major development is the intelligent edge. More accurate and smart edges provide detailed and specific information to the analytics in the central cloud server. Images can contribute information such as on the deterioration of cutters or the status of batteries on a bus.
- The second significant advancement in AI is the capabilities of camera sensors capturing meaningful information about objects, movements, materials, distances, meanings, etc. from drones, smartphones and other sources such as satellites. The alternatives for capturing data with camera sensors continues to increase as AI advances.

[Source]

Intelligent Edge example

- 1) Sandvik coromant : <https://azure.microsoft.com/ja-jp/blog/azure-iot-suite-helps-sandvik-coromant-stay-on-cutting-edge-within-digital-manufacturing/>
- 2) Vantage power : https://aws.amazon.com/partners/success/vantage-power-luxoft/?nc1=h_ls

Real-time connectivity between edge sensors



Low-power mesh network

Testing in field multiple edges form mesh network to create low-cost Wide Area Networks



Stand alone 5G by 2023

Granular control of 5G becomes concrete. Multiple terminals, real-time connection and high-speed communication realized.

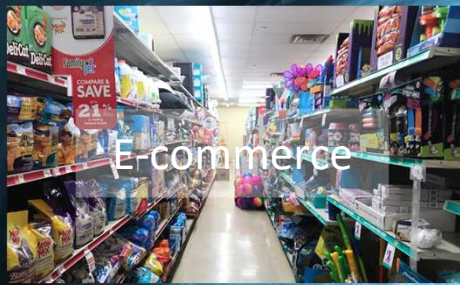
- Another important advancement that will impact future trends in AI are 5G and mesh networks, which will enable real-time connectivity to all sensors, cameras and central servers. Wide-area connectivity to these IoT devices and smart edges are expected to play an important role in AI soon.

[Photo Info]

https://en.wikipedia.org/wiki/Mesh_networking#/media/File:NetworkTopology-Mesh.svg

Why Digital Businesses Succeeded?

Digitalized business transformed itself by gaining access to direct consumer data



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- Also, think about what and how digital transformation has been occurring in other businesses such as e-commerce, books, video, media and advertising. All of which provide personalization or design-for-one services. Understand that this transformation too has been enabled by information coming from the edges, which in this case means smartphones and PCs.

Smartphones Provided Access to Direct User Actions

Number of sensors collect individual data in real time



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- What's so significant about the smartphone? It enables services or businesses to capture the results or activities at the edge close to real-time. It also accumulates masses of individual data for analysis. This is very powerful compared to the past where organizations only had samples, estimates or historical data to predict the future.
- If you combine the idea that we are more capable of capturing information at the edges with digital transformation, we can see how businesses can now alter strategies and markets more rapidly.

Transformational Power of Edge Information

Demand forecast by analyzing operation rate of construction = actual need of construction!



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- One example of using sensor data is at company Komatsu, where they use sensors within their construction machines. These are similar to what GE calls “digital twins.” At the edge, these types of sensors provide lots of information to support smart maintenance and services.
- You can see that capturing real-time data at every edge is very different from past analytics. What is actually most significant at Komatsu is that they use the operation rate of machines to predict future sales within a particular area.
- In the past, predicting sales from past data or local economics was problematic in construction, because trade drives economic growth. With an ongoing prosperous local economy, it may already be too late to sell these machines. However, in the digital twin case, using real-time data for actual movements and operations of these machines, the company can more accurately predict where they can sell more machines.
- Since many digital businesses did A/B tests of actual clients and new services, that kind of real data was the driver of the digital transformation for those businesses such as media, e-commerce and others. Understanding such edge data and how to leverage it to get results will continue to rapidly transform digital businesses.

[Source]

<https://shokokaikan.or.jp/jouhoukoukai/pdf/sangyo30.pdf>



TT04 AI for Healthcare and Life Science

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- The fourth trend about Healthcare and Life Sciences also focuses on AI transformation.

AI for Healthcare & Life Science

Data-driven healthcare and life science accelerates solutions for life-related issues

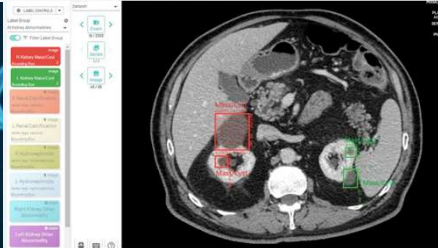
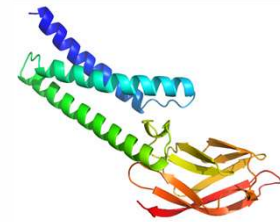
Accumulation of biodata
increases AI-assisted applications



AI-based medical image analysis
that robustly supports physicians



Possibilities with AI handling massive data-
like protein structure and brain waves



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- In healthcare and the life sciences domain, it's all about the accumulation of meaningful data, and AI applications are playing a big role. Much of it is being captured through advanced wearables.
- In addition, active research and development focused around images and data, such as AI-based medical image analysis supporting physicians and other workers, are progressing rapidly.
- Importantly, the possibility of leveraging AI in many complex cases is becoming a reality.

[Picture Info]

The image in the bottom center is by NTT Data (EVIT image diagnosis support). Others are royalty-free images from Pixabay.

Accumulation of Biodata Using Wearable Devices

Detailed physical condition by accumulating and analyzing data



Accumulate huge amounts of data on players

Running distance

Maximum speed

Impact shock

⋮

Combine with past data to quantify the level of fatigue



A professional soccer team recorded 25% fewer injuries compared to the prior season.

'Sehrou Guirassy dehnt sich vor dem Training' by Marco Verch available at https://foto.wuestenigel.com/?utm_source=41192699590&utm_campaign=FlickrDescription&utm_medium=link Available in full resolution on Flickr. under a Creative Commons Attribution 2.0. Full terms at <http://creativecommons.org/licenses/by/2.0>

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- First let's discuss capturing data.
- Wearables and other devices are advancing in sophistication and gaining approvals and certifications. Consequently, they are more accurate and useful.
- If you remember the Rugby World Cup, some teams captured athlete bio/activity information, including running distances, speed, impacts, heart rates and other data to determine conditioning of their athletes in order to increase the effectiveness of practices and lessen injuries.

Continuous Effort to Gathering Genomic Information

Technology improvement reduces cost and time for genome analysis

Cost and time
of the human genome
analysis

13 years
\$ 2.7 billion
(2003)

A few days
Less than \$1,000
(2019)

Accumulation of genome
information is more affordable

US: All of US Research Program



Images: Courtesy of National Institutes of Health (NIH)
<https://allofus.nih.gov/sites/default/files/aou-collage.jpg>

Aims to accumulate the data on the genomes and other
health information of millions of people.

300,000 people had participated by December 2019.

Britain: Genomics England



'The official logo for Genomics England' by Lsadnh available at
https://commons.wikimedia.org/wiki/File:Genomics-England-logo_colour.jpg?uselang=ja under a
Creative Commons Attribution 4.0. Full terms at <http://creativecommons.org/licenses/by/4.0>

Aims to use genome analysis to contribute to the treatment
of cancer and rare diseases.

75,000 people had participated by December 2018.

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- Initiatives involving genomic information, which began several years ago, is also becoming more and more important due to the accumulation of information.
- In the US, genomic information from 2016/17 includes about 300,000 people within the databases, and such information is becoming more easily extracted and prepared.

[Source]

All of Us

https://www.amed.go.jp/aboutus/collaboration/ga4gh_dp001.html

Genomics England

https://www.amed.go.jp/aboutus/collaboration/ga4gh_dp013.html

Risk Prediction Realized by DNA Information

Enables earlier prediction of risks of personal health

Polygenic risk score (PRS)

Combines dozens or even one million mutations within scored index

Evaluates an individual's genetic predisposition for certain diseases and complex genetic attributes

For example, heart disease, diabetes and obesity, risk can be calculated

- With such information, potential risks and mutations can be more accurately calculated.

Encourage preventive healthcare through genome analysis to reduce medical costs



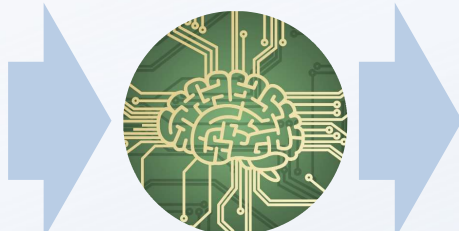
Medical check



Genome



Activity



**Big Data
Analysis**

Genetic Testing

Calculate disease risks.
Advise on lifestyle habits likely to cause diseases.



Support for Awareness Reform

Use apps to manage daily exercise and diet.
Incentivize users.



Health Management Business Consulting

Cooperate with medical institutions throughout the nation. Provide services for health management business.



A trial is starting in FY2020 for NTT Group employees.

- Why is this so important? It's because combined information provides a more accurate picture. Such data can include your genetics, current and past medical conditions and activity data, which can all be integrated to better understand your health.
- At NTT, we recently established the NTT Life Sciences company to analyze such information and to use it to diagnosis and prevent diseases. Moreover, it can help keep our employees and others healthy. NTT has about 200,000 employees in Japan with very detailed and accurate historical health data accumulated over many years. We are using this data together with newly captured genomic information to produce new sets of data that may prove highly useful.

[Source]

NTT Life science : <https://www.ntt-lifescience.co.jp/>

3D Image Diagnosis as Accurate as Physician



*The image is a typical CT scan image. It is different from the one used in the research.

45,856 anonymized patients
Use of chest CT screening cases

From hundreds of CT images
Construct 3D shapes to identify lung cancer



A single CT scan:
False-positive results decreased by 11% and
false-negative results decreased by 5%,
respectively

- The most direct application of AI technology, is of course, image diagnosis. Not just 2D images but CT scan images; 3D-type analytics are also being developed. This one is Google providing more accurate diagnosis for lung cancers with CT scans.

[Source]

Google Shows Off The Power Of 3D Image Recognition "lung cancer diagnosis AI"

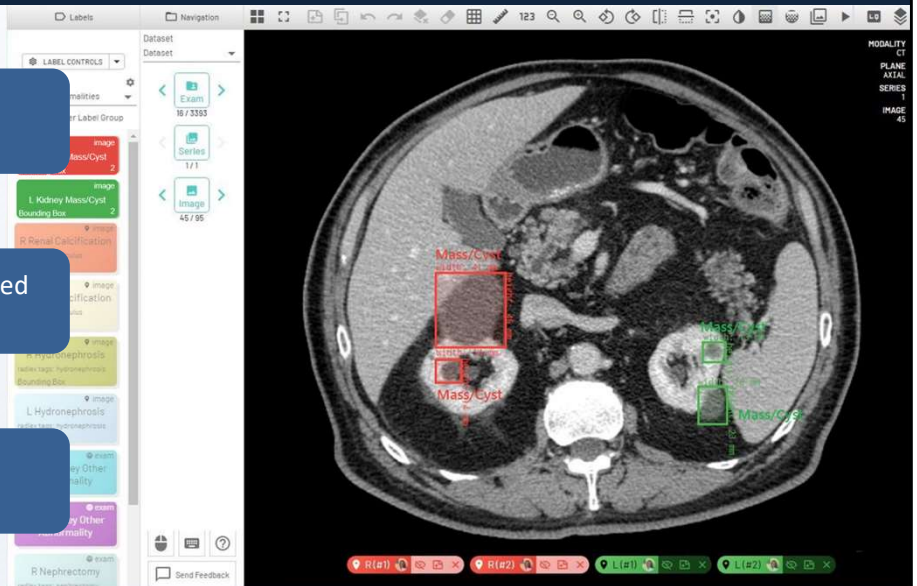
<https://tech.nikkeibp.co.jp/atcl/nxt/column/18/00692/052300004/>

AI to augment physicians by identifying target organs then its diseases

Detects abnormalities in organs

Over 80% accuracy for abnormality detected on a kidney

Will cover variances based on regional differences (e.g., climate and lifestyle) to further improve efficiency



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- NTT DATA also uses CT and MRI data to support doctors, but with a very different approach. What we're trying to do is provide image recognition that points out any anomalies first. In other words, which part of the CT scan is abnormal? Then, which organs? And then we want to label the abnormality or show a particular condition with the information to radiologists to confirm. The goal is to give doctors precise information to better understand which part of the patient is problematic based on a series of images, and then more effectively diagnose symptoms and decide on a treatment plan.
- We already have multiple sources of data tested from different regions and institutions of the world.

[Source]

NTT DATA Collaborates with Miyazaki University,

An AI imaging support solution is used to automatically diagnose enormous medical images such as CT images and detect abnormalities.

Contributes to reducing the burden on radiologists.

<https://www.nttdata.com/jp/ja/case/2020/021400/>

Estimating Protein's 3D Structure

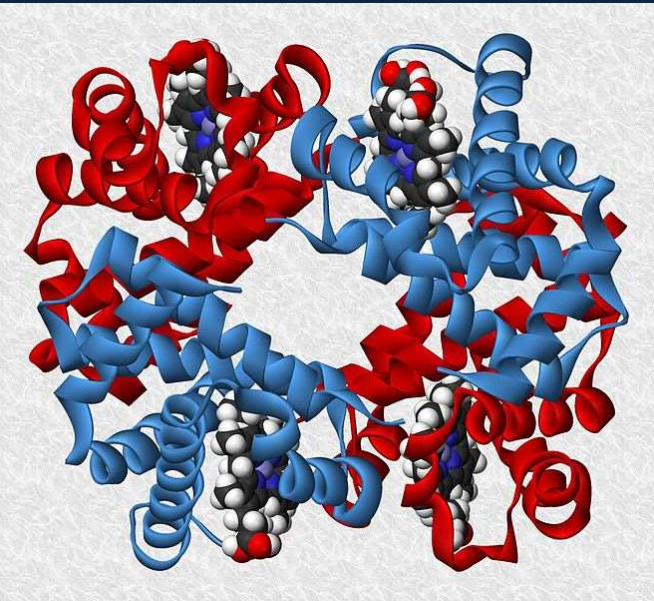
Elucidation of proteins contributes to therapeutic methods and drug discovery

AlphaFold

Protein's three-dimensional structures require months to years to analyze

Deep learning estimates the length and angles of chemical bonds in amino acids

Top accuracy in 25 of 43 protein's competition



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- This case shows a potential future use of AI by Google DeepMind.
- It is very difficult to estimate the structure of a protein. Using AI, they now can view the protein's three-dimensional structures. This would previously take months to years of time to analyze. These algorithms estimate the length and angles of proteins accurately.
- What's significant about protein is that much of the status or how your body works is done by proteins. So understanding proteins in structure is vital to developing therapies and medicine. This is one of the most important advancements that we foresee using AI. Drug discovery combinations is not only vital to the future of medicine, but to help solve the current Covid-19 pandemic.

[Source]

AlphaFold: Leveraging AI for Scientific Discovery

<https://deepmind.com/blog/article/AlphaFold-Using-AI-for-scientific-discovery>

COVID-19

<https://deepmind.com/research/open-source/computational-predictions-of-protein-structures-associated-with-COVID-19>

[Picture Info]

<https://commons.wikimedia.org/wiki/File:Haemoglobin-3D-ribbons.png>



TT05 Security for the Digital Era

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- Another important trend, of course, is security.

New Risks in the Era of Data Utilization

When data is not available ... business continuity is at risk

Mishandle data

Lose Trust

Users won't provide data

Service no longer used

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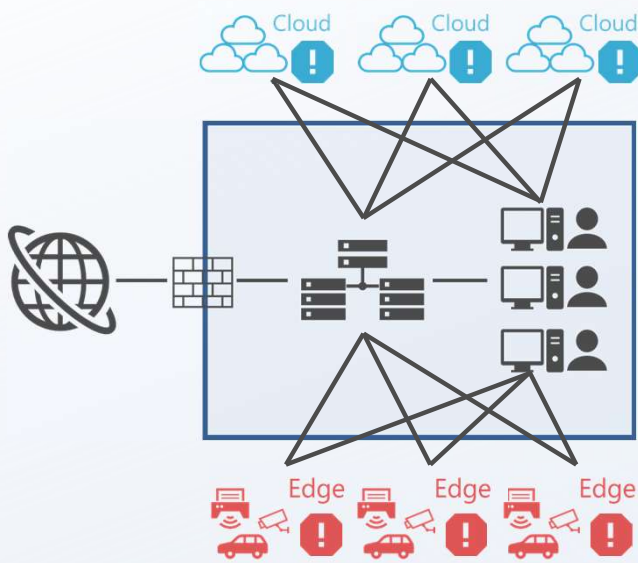
74

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- In terms of security, data is becoming more and more important. If you mishandle data, you lose trust; users won't provide data and your service will no longer be used. This is happening to many businesses providing services today.

New Technologies Create Vulnerabilities

The traditional idea of "prevent all" is becoming untenable



Financial Company in US
Over 100 million credit card numbers leaked



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- If you think about it, the traditional security concept to "prevent all" is becoming obsolete.
- In this example at Financial company in the US there was a leak of 100 million credit card numbers. What we think is significant is that the leak happened during a period of cloud environment updates. Because these were misconfigured in some cases, that misconfiguration was utilized by hackers to capture credit card numbers.
- In the past, before access to the internet we had a firewall, and with systems closed behind your own firewall, "prevent all" might have been a realistic goal. But now, organizations use a lot of edge devices, smartphones and connectivity to clouds with servers deploying services. In many cases, the ability to contain everything on your own is now virtually impossible.

Reconsider How to Protect Systems

Minimize damage with technologies



Defense

Protection beyond the firewall is essential



Monitoring

Proactively search for everything and track all actions not just suspicious signals

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- So thinking about things differently to protect your systems is becoming necessary. To secure your system perfectly remains an important goal, but at the same time, you must add an objective to minimize damage.
- One thing organizations should think about is good defense. Defense is not just about protecting something behind the wall. It's also about protecting things within the wall as well. The critical aspect of defense is monitoring. What a typical company or organization does currently is monitor some things, and then sees issues when someone is alerted or some signal is triggered. What companies must now do is to look at everything and track all actions to understand proactively what is being done. And then organizations need to act quickly in order to minimize damage.

Encrypting Everything

Minimize damage by encrypting entire system, including Edge



Adiantum

New encryption standard for mobile devices

Combining existing encryption technologies to reduce weight

Low-spec edge also can be encrypted

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Source: <https://developers-jp.googleblog.com/2019/03/adiantum.html>

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- In terms of outside the walls, organizations must now focus on the edges. In the past, it was very difficult to encrypt IoT devices because of their low specifications. You couldn't do encryption because of its impact on performance. Thankfully, now there is a lighter kind of encryption as well as some higher end smart devices at the edge. So we will be able to encrypt the entire system including edge.

[Source]

Adiantum

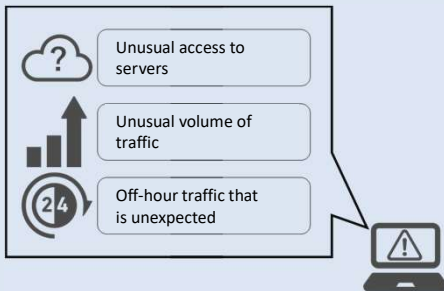
<https://developers-jp.googleblog.com/2019/03/adiantum.html>

Enabling Early Detection and Response

Security measures to quickly respond and minimize damage

UEBA

User and Entity Behavior Analytics



Detects abnormal behavior from user and device behavior

EDR

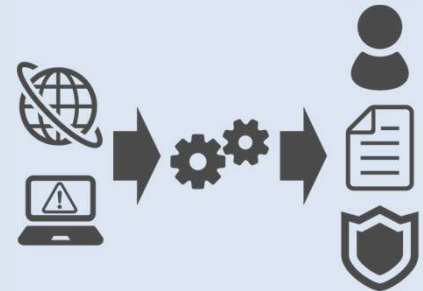
Endpoint Detection and Response



Deals with a terminal where an attack has been confirmed

SOAR

Security Orchestration Automation and Response



Automate and streamline incident analysis and response

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- This slide shows the process for an effective response and for minimizing damage. As previously stated, several factors must be considered including analyzing all user and entity behaviors. Detect everything including endpoints! Then have prepared responses using security orchestration automation. In security faster is always better.

[Source]

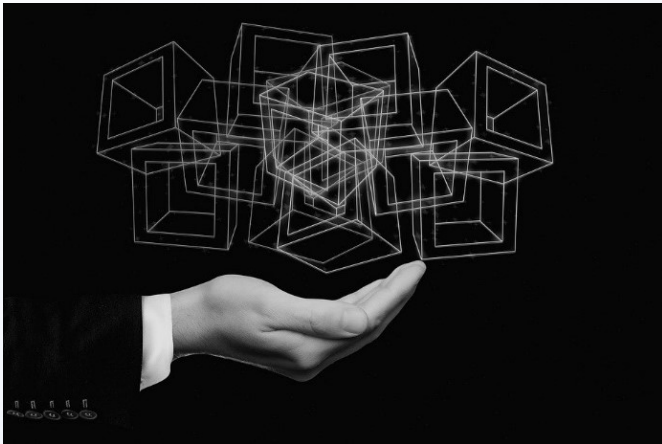
<https://blogs.mcafee.jp/user-entity-behavior-analytics>

<https://www.infosec.co.jp/column/287.html>

<https://www.nttdata.com/jp/ja/data-insight/2019/0902/>

Use of Data: Respecting Users

Is the user's intention reflected in the handling of data?



Control of data by users



Use of data without specifying users

- With the use of more and more personal data, the user continues to become critically important. As a result, it's vital to control that data by user, and also, whenever possible to anonymize it so that the data cannot be associated with a specific user or ID.

User Control of Data

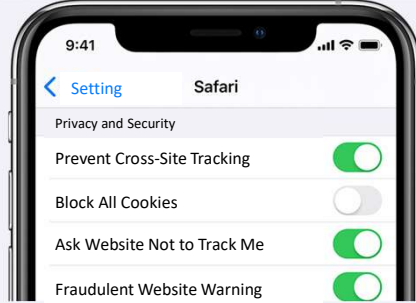
Respect the user's willingness to provide data

Location information



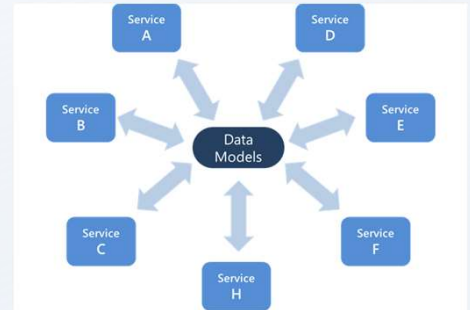
Allows choice to deny tracking

Cookies



Enables cookie restrictions

Migration



Allows data migration between services

- Some of the most common ways to share data with user consent are listed here. I assume all of you are familiar with these.

[Source]

<https://support.apple.com/ja-jp/guide/iphone/iph3dd5f9be/ios>

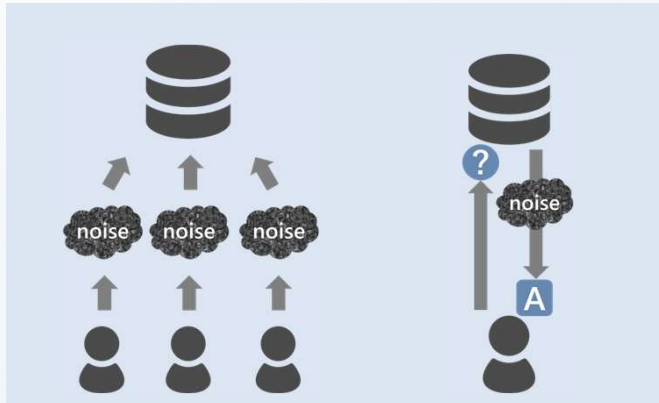
<https://support.apple.com/ja-jp/HT201265>

<https://about.fb.com/news/2019/12/data-portability-photo-transfer-tool/>

Use of Data Without Specifying Users

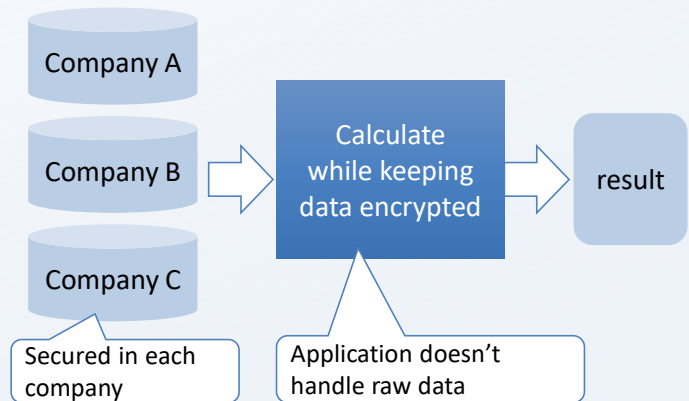
Sensitive data can be used while ensuring safety

Differential Privacy



Add noise to make private information unidentifiable

Secure Computation System



Calculation to handle encrypted data as is

Source: https://published-prd.lanyonevents.com/published/rsau20/sessionsFiles/17935/2020_USA20_ACB-T10_01_protect-privacy-in-a-data-driven-world-privacy-preserving-machine-learning.pdf
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- But in addition to those, there are some newer technologies that need to be considered for this purpose.
- The first one is differential privacy. This has been discussed a lot in past trends, but Google released an open-source version last year. What it does is add some noise to the original data to make a person unidentifiable from the results.
- The second one, provided by NTT, is secure computations. We are now trying out this method together with machine learning. In some instances, you don't want the data to be decrypted at all, but there is benefit to calculate the accumulated data. Secure computation is a way for encrypted data to be calculated "as-is" in order to use it to build a model.

[Source]

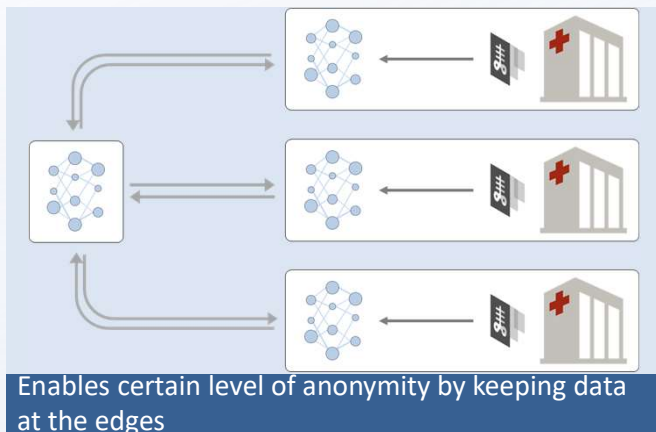
Open sourced differential privacy library by Google

<https://developers.googleblog.com/2019/09/enabling-developers-and-organizations.html>

Secure Computation System

https://www.ntt.co.jp/sc/project_e/data-security/NTT-secure-computation.pdf

Distributed Learning



Google

Federated Learning

MIT

Split Learning

- Other technologies that are very significant for AI are machine learning techniques and distributed learning.
- When you think about personal and private data, you don't want to accumulate that raw data on central servers and then do the learning. But that's how deep learning or machine learning usually works. How distributed learning functions is to learn in each distributed part, and then gather the information at the end so that the assembled data as a whole can be used for the learning.
- Distributed learning is not just about anonymizing the data at the edges. It's also trying to provide a more efficient way to gather learning. As a result, there are several different types. One example is Google's Federated Learning. It is geared toward smartphones where a great deal of personal information resides. The AI is trained in each device and then assembled. Each task is simple and one device can also be discarded easily since many are used to create the federation.
- The second one is MIT's split learning. Split learning is often used for larger projects such as an organization's databases. It accomplishes learning partially on a distributed basis and then collects intermediate features and parameters, which are then sent to the central server for training.

[Source]

<https://blogs.nvidia.co.jp/2020/01/08/what-is-federated-learning/>

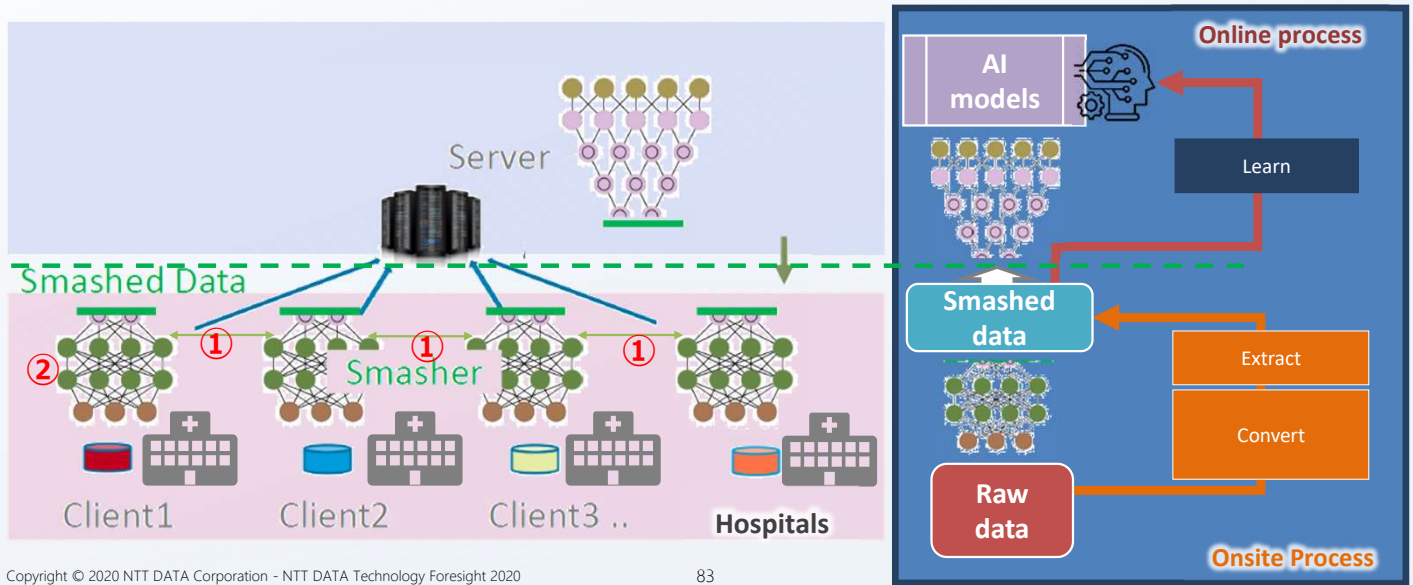
Federated Learning

<https://ai.googleblog.com/2017/04/federated-learning-collaborative.html>

Split Learning

<https://www.media.mit.edu/projects/distributed-learning-and-collaborative-learning-1/overview/>

Aggregated model covering multiple hospitals without direct access to raw patient data



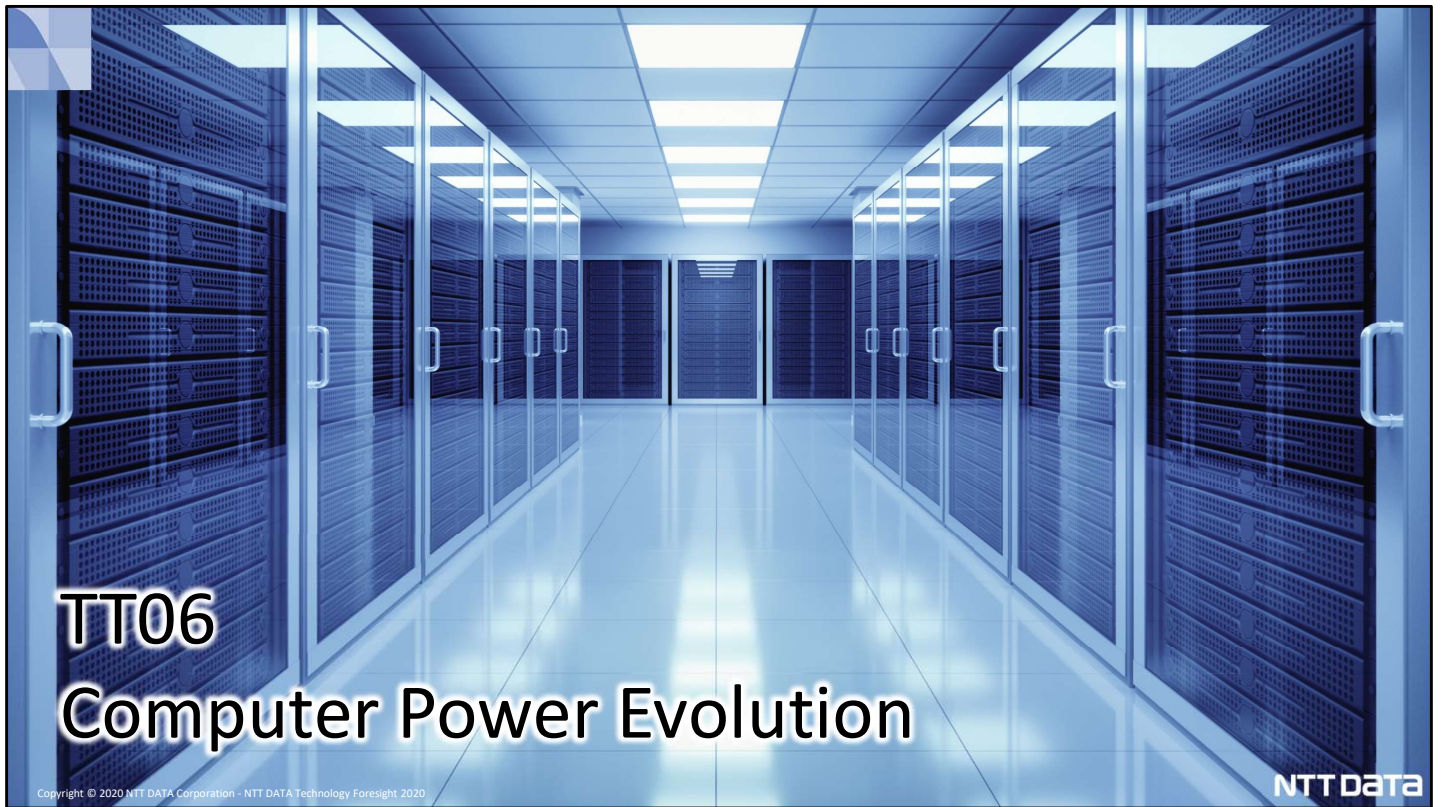
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- At NTT DATA, we are using split learning in hospitals. Imagine image diagnosis, where we want to use different types of information (ethnicities, etc.) from varied areas and hospitals within one all-inclusive AI model. However, because of privacy issues and the sensitivity of the data, this information usually resides within each individual hospital. What we do in this case is to partially learn from the individual hospital data at the end of the edge side, and then put the features and parameters into smashed data, which is then sent to the central server. We then use the collected smashed data at the end to learn and make a holistic AI model applicable to all hospitals.
- This is the distributed learning that we're developing based on the concept first created at MIT.

[Source]

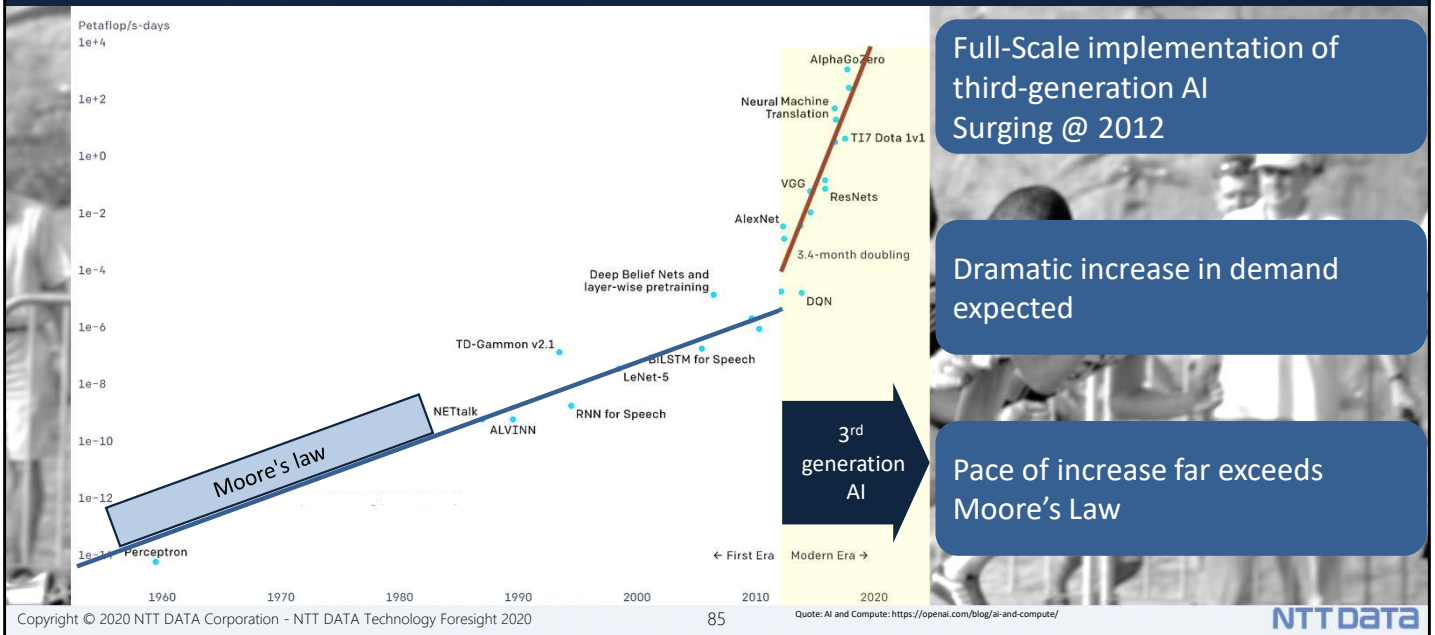
*Please contact NTT DATA R&DHQ for further information



- The next six trends are about the evolution of computer power, which is a foundational requirement for computer learning and other advanced movements. Hardware is essential for advanced calculations and this is all about what's happening in hardware today.

3rd Generation AI Requires Stronger Computational Power

From 2012 demand doubled in 3.5 months, reaching x300,000 by 2018



- This is a very interesting graph. The left-hand side of the graph, which uses a blue line, represents Moore's Law. As you can see it increases until about 2012 or so.
- But after that date, when most big data analytics and deep learning took place, the amount of required calculation is growing materially greater than the past exponential steps.

[Source]

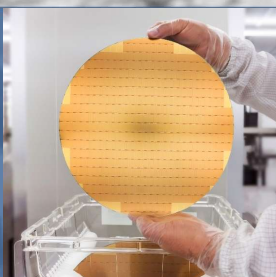
AI and Compute: <https://openai.com/blog/ai-and-compute/>

AI continues to evolve over the next six years, and over 300,000 times more can be learned - GIGAZINE: <https://gigazine.net/news/20180517-ai-and-compute/>

Measures to Expand Computational Power

Efforts continues to match the demand for computational power

Semiconductor
miniaturization
technology

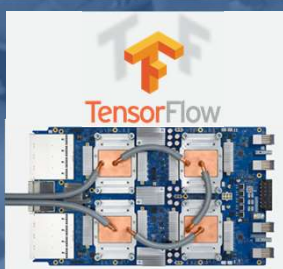


Build more circuits on silicon



Faster computation with processor
and higher capacity with memory

Specific-purpose
technology



Make hardware and software for specific
applications



Calculate faster and more efficiently
for specific purpose only

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- So, at the moment, computation demand is increasing greater than Moore's law, and that is currently being accommodated by minimization of semiconductors or by special-purpose technology, especially in the area of tensor flow processors, which are an open source, machine learning platform.

[Source]

By Zinskauf - Own work, CC BY-SA 4.0, <https://commons.wikimedia.org/w/index.php?curid=77299254>

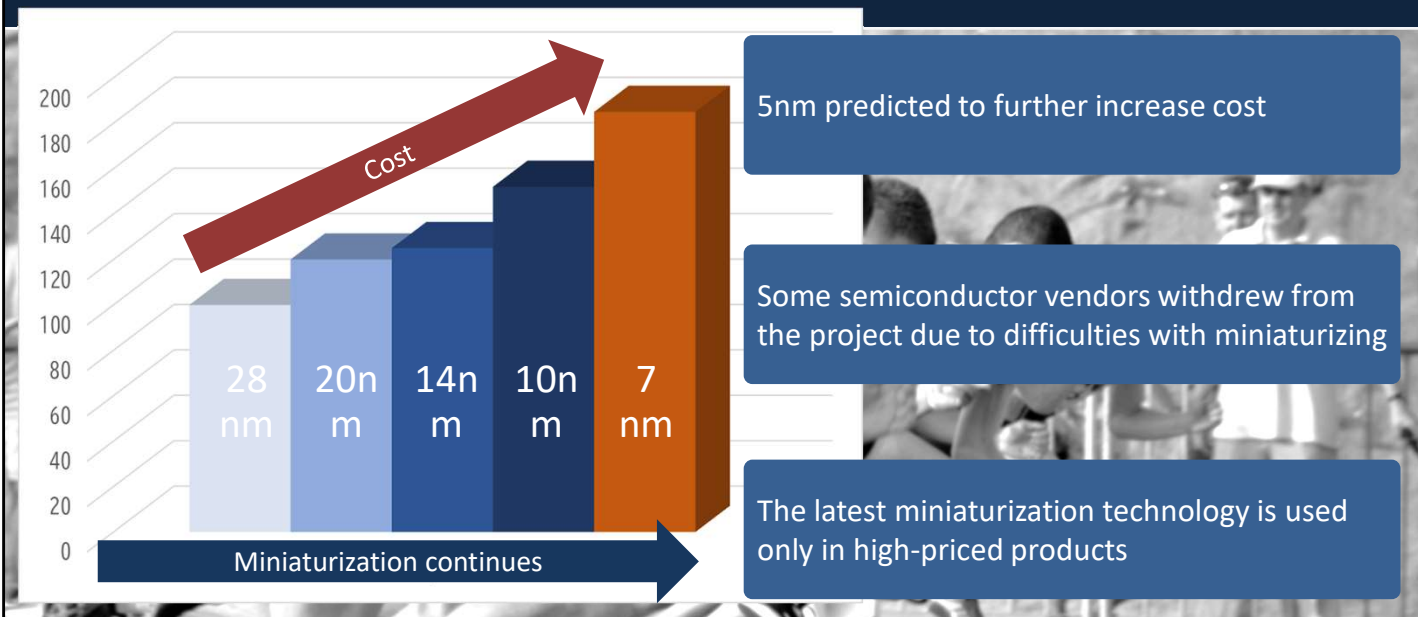
By TensorFlow - vectors combined, edited - Begoon –

<https://github.com/tensorflow/tensorflow><https://github.com/valohai/ml-logos/blob/master/tensorflow-text.svg>

<https://github.com/valohai/ml-logos/blob/master/tensorflow-tf.svg>, Apache License 2.0,

Limitations of Semiconductor Miniaturization Technology

Microfabrication will continue ... but costs are on the rise



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87 Quote: [[Goto Hiroshige's Weekly Overseas News] 7nm process characteristics responsible for AMD architecture changes - PC Watch] <https://pc.watch.impress.co.jp/docs/column/kaigai/1199176.html>

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- In terms of miniaturization of semiconductors, they are becoming smaller and smaller but are now reaching the limit of what realistically can be done. So now they're using multilayers and condensing them in order to execute more calculations. However, this process is very costly. As a consequence, some companies have decided not to go forward with their development. At the very least, current miniaturization is targeting only high-priced, premium products.

[Source]

<https://pc.watch.impress.co.jp/docs/column/kaigai/1199176.html>

Proprietary AI environment using specific AI software and AI chips

1024 GPUs CPU 5760 core

Original interconnect focusing on high-speed deep learning

Preparing a new model with chip specialized in matrix arithmetic optimization

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- The other area of major innovation is in the building of specific hardware and architectures. In many cases, faced with a lot of large calculations using AI, businesses are building a specific AI architecture with specialized chips and GPU cores. In this example, Preferred Networks is using a 5760 core and 1024 GPU machines to handle their calculations with AI.

[Source]

<https://syncedreview.com/2019/03/22/preferred-networks-builds-state-of-the-art-supercomputer-mn-2-powered-with-nvidia-gpus/>

<https://medium.com/syncedreview/preferred-networks-builds-state-of-the-art-supercomputer-mn-2-powered-with-nvidia-gpus-dcc9aed19d67>

<https://pc.watch.impress.co.jp/docs/column/kyokai/1207201.html>

High-Efficiency IT Inspired By Human Brain

Go Champion's Brain = 20 Watts

AlphaGo = > 250,000 Watts

Spiking Neural Network Architecture

Supercomputer that simulates brain by mimicking nerve cells (spike). Simulates 80,000 neurons

Pohoki Beach Loihi

DL specialized chip for edge that mimics neurons x10,000 more efficient than conventional

Power-saving DL specialized chip with nonvolatile memory

Power savings by nonvolatile memory aiming for human brain's power consumption

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- With these advancements one of the biggest issues is power itself, electricity. A Go champion brain used just 20 watts but AlphaGo takes 250 kilowatts to do the very same calculation. So how the human brain works is actually inspiring a very promising pathway for future efficiency in calculations. This is the area of neural network architecture, brain movements and stimulus, etc. It is a hot area of research that looks very promising and important for the future.

[Source]

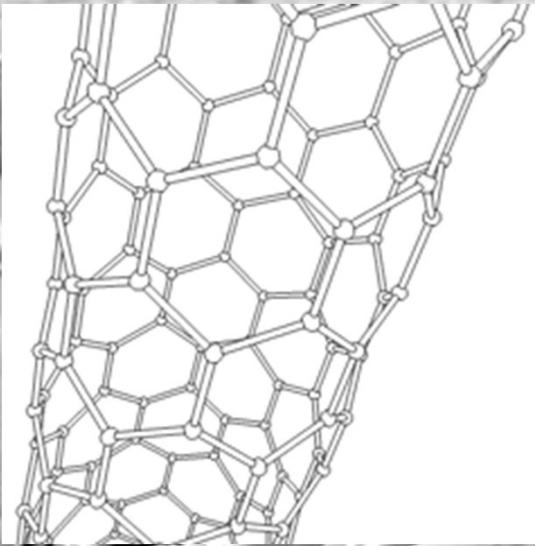
<https://www.manchester.ac.uk/discover/news/human-brain-supercomputer-with-1million-processors-switched-on-for-first-time/>

<https://newsroom.intel.com/news/intels-pohoiki-beach-64-chip-neuromorphic-system-delivers-breakthrough-results-research-tests/>

https://www.nedo.go.jp/news/press/AA5_100977.html

Next Semiconductor Device CNFET Provides Power Savings

Exploring low-power and high-speed semiconductor materials using carbon nanotubes



10x energy efficiency and speed compared to silicon

Processor is completed at the research level

Application expected for sensor element and processor of images

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- The other way to increase energy efficiency is to use different materials, like carbon nanotubes, which are also a conductor. There is major research being done for this solution that is currently ongoing.

[Source]

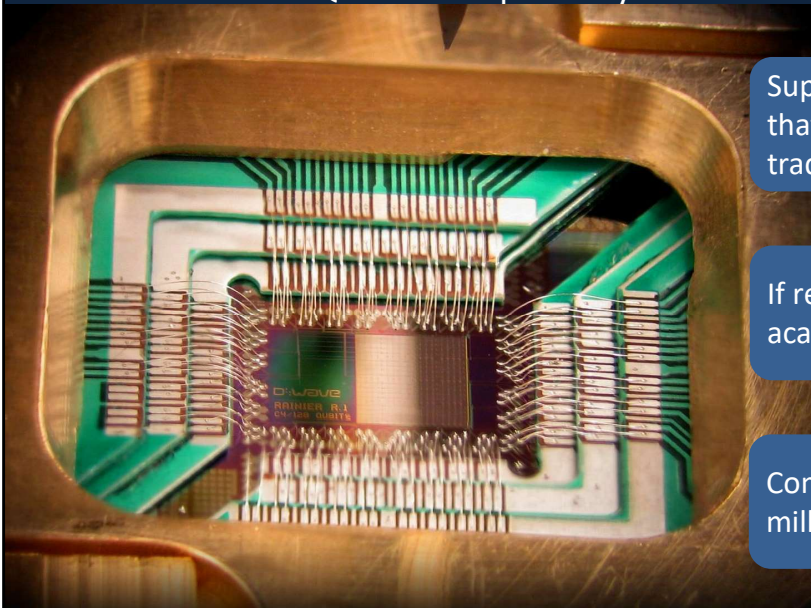
<http://news.mit.edu/2019/carbon-nanotubes-microprocessor-0828>

[Picture Info]

By Original hochgeladen von Schwarzam am 30. Aug 2004; Selbst gemacht mit C4D/Cartoonrenderer, GNU FDL - German Wikipedia, original upload 29. Dez 2004 by APPER, CC BY-SA 3.0, <https://commons.wikimedia.org/w/index.php?curid=350208>

Competition To Develop Quantum Gate Computers

“Quantum supremacy achieved” claims research group



Supremacy is proof that there are problems that can be solved much more quickly than traditional computers

If real, this would be a major milestone for academia

Computation power aiming for 100,000 or 1 million bits

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- A very different paradigm in computation continues to be quantum computing. As we discussed last year, significant research in this area is continuing. However, for business, available annealing machines and pseudo-quantum simulators are the more mature machines to test.
- In addition, there's some quantum gate computers, which are generic computers that use quantum physics that can be programmed to perform different operations.

[Source]

By D-Wave Systems, Inc. - D-Wave Systems, Inc., CC BY 3.0,
<https://commons.wikimedia.org/w/index.php?curid=10722194>



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Synergy in Human-Machine Systems

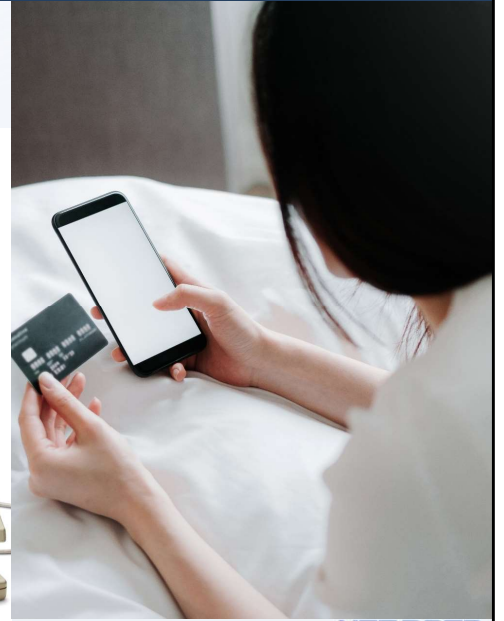
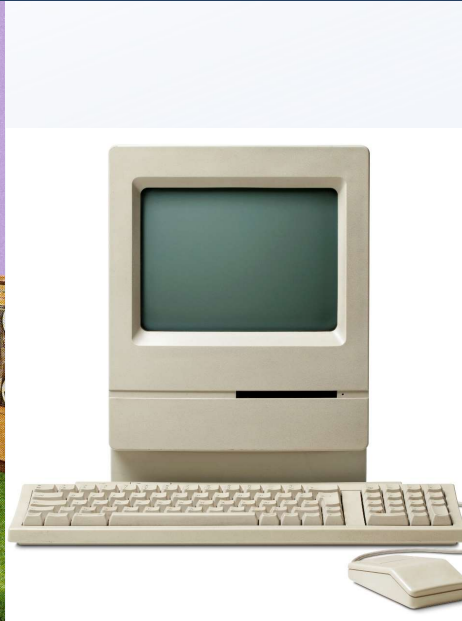
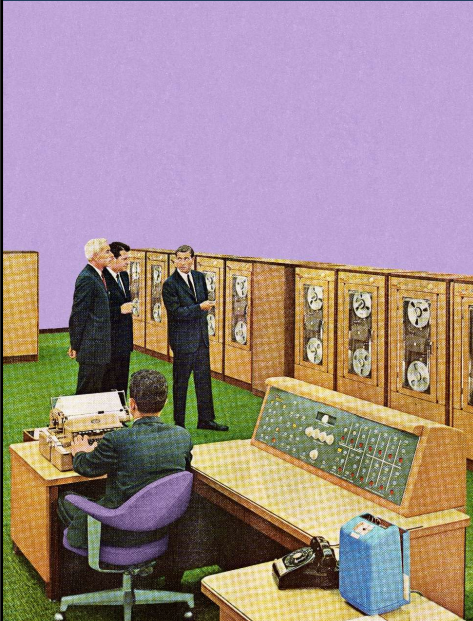
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- Other areas of interest that we found focuses on interfaces and interactions.

History of Human-Machine Interaction

Interaction has been improving toward ease of use



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- Human and machine interactions have been evolving for decades.

Using Same Interface for Multiple Tasks

Search/translate with image captured by camera



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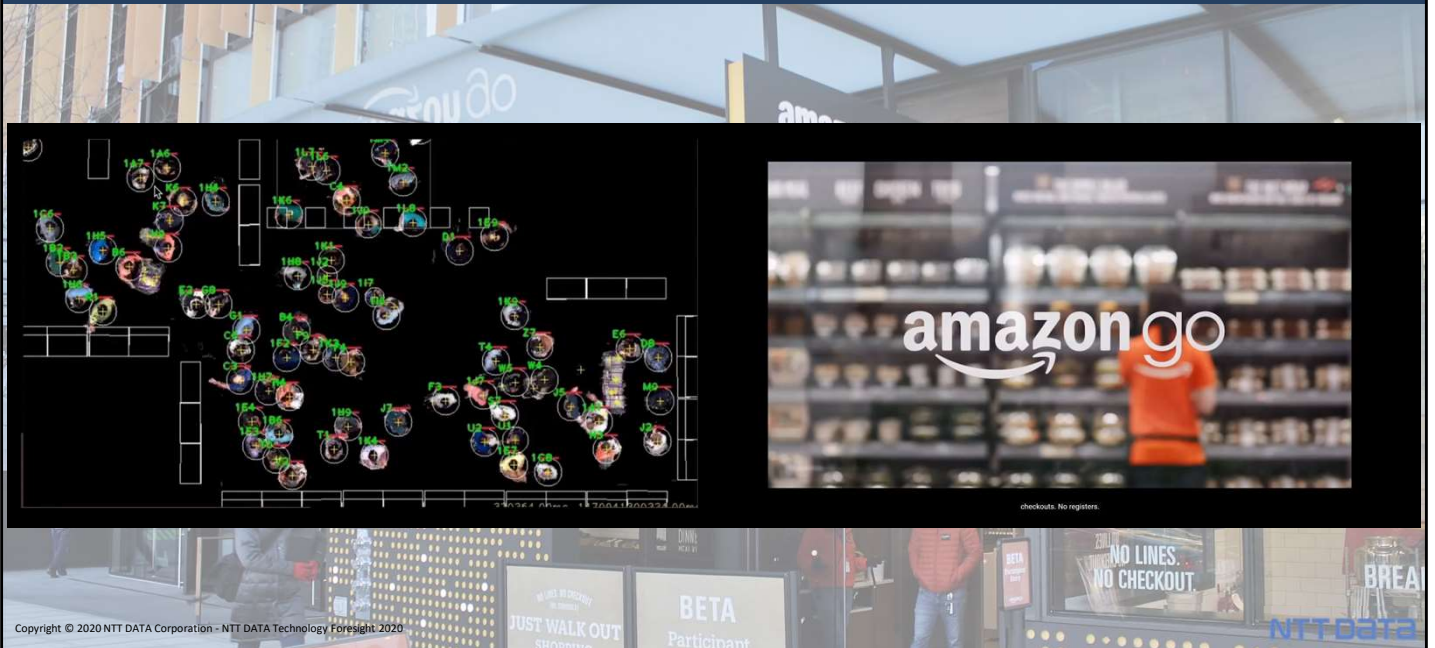
- Now because of the AI, computers are easier to access than ever. People and computers are actually having more productive interactions as well. In this case, Google Lens is providing different services through the same interaction by taking an image through a camera. On the left, it sees the text inside the camera image, so it translates it. In the middle, it see the building and shows the result of the search of the buildings bringing up relevant information. On the right-hand side, it sees a product so it compares that to a shopping list. So from just the picture, a computer is selecting the most appropriate collection of services.

[Source]

<https://lens.google.com/intl/ja/>

Understand Variety of User Behaviors

Recognize each person's behavior without awareness by individual users



- Interaction between humans and computers can also take place even if a user is unaware of it. When the computer gathers information from images, it can do some things much easier than a human.
- For example, in Amazon Go, the camera can see a person “shopping.” But what “shopping” means here is different for each individual person. One person may grab the product and leave, while another will place it in a bag or a pocket. The computer sees any of those actions as shopping so it then issues payment.
- So without the awareness of users, it can support what you are doing in real time.

[Source]

<https://justwalkout.com/>

<https://www.businessinsider.jp/post-192580>

<https://www.youtube.com/watch?v=Lu4szyPjIGY>

<https://www.youtube.com/watch?v=NrmMk1Myrxc>

Synergy By Supporting Human w/Machine Ability

Provide best action from analysis of learned data



Human drives flexibly

AI takes action to avoid accident

Movie (Pop out & Slalom) :
<https://global.toyota.jp/newsroom/corporate/26072372.html>

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- What's so significant about these advancements?
- If you think about driving, at the moment a true self-driving car is not yet a reality. A human is in charge of driving by providing the flexibility to understand real situations, such as road changes or people crossing in front of the vehicle in real time. But in some cases, appropriate actions can be taken by computers. In this video, AI avoids an accident when suddenly something appears so quickly that a person could not react in time. Just like ABS systems, AI controlled the car to avoid a crash.
- So as you can see in this case, in addition to human ability, everyone can be safer using the augmented, capabilities of computers and AI.

[Source]

<https://ascii.jp/elem/000/001/928/1928972/>

<https://global.toyota.jp/newsroom/corporate/26072372.html>

Synergy by Supporting Human w/Machines Ability

AI to provide knowledge of expert surgeon for every operation



Human operate as usual



Provide wide range advice and in-depth knowledge

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- If you can think about such synergy with doctors it becomes even more significant. For example, super doctor information is captured and then displayed within a surgery machine. Human doctors can then operate as usual supported as if the procedure was also being done by the super doctor or surgeon.



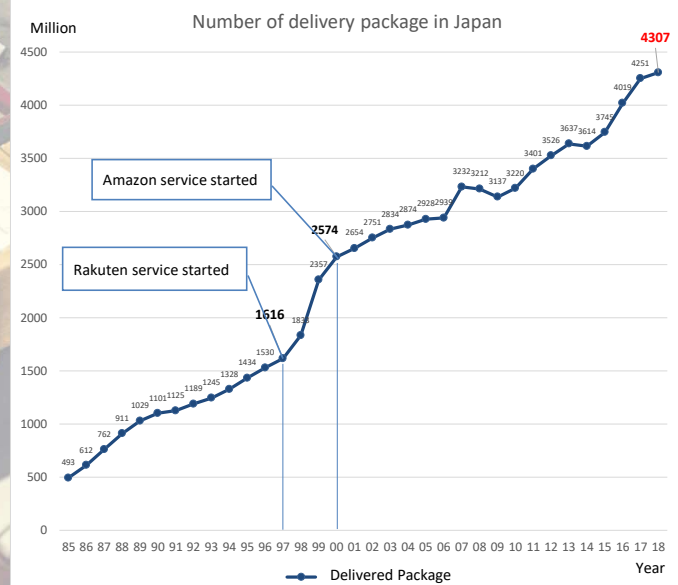
- Trend number eight is everything you ever wanted to know about hardware.

Physical Constraints Hampering IT Growth

Growing IT services faces the limits of the physical world

The cargo volume reached 4.3 billion pieces per year in 2018.

We are foreseeing workforce reduction resulting from an aging society.



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- First, let's set the stage. The requirements are growing but the potential labor pool to fulfill those needs is shrinking.
- For example in Japan in 2018, cargo volumes reached around 4.3 billion pieces per year.
- This is problematic when you think about delivery, or perhaps processes such as picking and processing orders in warehouses. Contributing to making these types of bottlenecks of greater significance, we are also foreseeing an aging society in Japan, with the workforce materially reduced in the future.

[Source]

<https://www.mlit.go.jp/report/press/content/001310399.pdf>

<https://www.nikkei.com/article/DGXMZO15318770U7A410C1XV3000/>

<https://ecnomikata.com/ecnews/18264/>

<https://ironna.jp/article/6346>

Vision Usage for Robot

Technology to capture outside environment has been drastically improved

Vision for moving



Vision for grasping



- So how do we address these challenges? One important advancement is in the area of computer vision.
- In terms of robots or other things that must be controlled, one of the most important factors required is to capture any situation precisely whenever you're moving in real time. Following that, the machine must be able to efficiently interact with something. For instance, the operation of grasping requires robots to understand materials and how to handle them appropriately.

Acquisition of Vision for Movement

Recognition of the surrounding situation from the camera image



Movie :

<https://www.tesla.com/jp/autopilotAI?redirect=no>

Source : Tesla
Explanation of Autopilot (Nural Networks)

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- As you know, one of most widely discussed applications for capabilities such as vision is now self-driving cars.
- Capturing many things, processing them, and reacting in real time is now becoming easier and more accurate. Another application for such technology is an automatic delivery service.
- Such businesses, still in limited places, will soon become commonplace.

[Source]

<https://www.tesla.com/jp/autopilotAI?redirect=no>

Automated Picking at the Warehouse

Realization of logistics: robots that pick up specific products in variety of situations



Movie :

<https://www.youtube.com/watch?v=8-YyKyecy-s>

Source : MUJIN

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- Another application of such capability is picking.
- It is very difficult for robots in warehouses to pick items because products come in very different shapes, sizes, materials and weights. However, some machines are becoming quite adept at picking in warehouses when similar products are grouped together in placement and general location.
- But as you can imagine, generic picking remains a very challenging competency for machines.

[Source]

<https://www.youtube.com/watch?v=8-YyKyecy-s>

Solving a Rubik's Cube One-Handed

Dexterity achieved by learning variations gathered by simulation



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- This is a very interesting video of progress we observed this year from OpenAI, which involves manipulating a Rubik's cube. What's significant is how such movements were learned.
- It's usually relatively easy for computers to solve a Rubik's cube. There are already algorithms to do it. What's difficult is to process the image and then translate it into appropriate movements of the hand in real-time. That's because minor differences in image size, angles and forces and friction required is continuously changing.
- To solve this issue of manipulating a Rubik's cube by a robotic hand, simulations were used in multiple synthesized "realities," capturing many variances through different Rubik's cubes, camera images and associated applied forces and frictions. This was done so that the robot hand and AI could become robust enough to actually adapt to the changing reality.

[Source]

<https://www.youtube.com/watch?v=QyJGxc9WeNo>

How Soft Robot Changes Physical Contact Points

Softness and generic purpose training realize robots to physically contact with human



Movie :
<https://www.youtube.com/watch?v=RCQNIgySaYw>

Source : IEEE Spectrum

Blue Is a New Low-Cost Force-Controlled Robot Arm from UC Berkeley

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- One very different direction for robots is coexisting together with people. Usually industrial robots are very precise and hard, and are programmed to move in a specific and defined way. When those robots are moving, you don't want to be close to them since they can be very dangerous.
- Many types of robots, however, are now becoming soft and flexible physically making them far easier to teach what needs to be done. In this video, Robot "Blue" is learning appropriate actions and using its physically looser joints to implement them. Such flexibility of movement in conjunction with AI is very important in coexisting with humans. In many cases, such malleability is required for robots to support humans if they reside together.

[Source]

<https://www.youtube.com/watch?v=RCQNIgySaYw>

Robots exceeding current limits and physical constraints expanding the potential of IT

Elderly Care



Food



Agriculture



- The applications for robots with advanced capabilities that we foresee will be of great importance in many advanced economies and for adapting to an ageing society. In elder care, robots and AI must be flexible enough to interact with people. That translates to being flexible and soft with an understanding of situations that arise when working with the elderly.
- Supporting agriculture also requires flexibility because the product itself is always different in shapes, sizes, colors and placements. Because of this, many farmers and others are discovering that automation is very difficult to do, but that robotics is useful.
- The middle image, if you can think about bento factory in Japan sorting fried chicken like Kentucky Fried Chicken in the US. What is significant is that fried chicken results in pieces of different sizes and shapes, yet robots can capture these variables and sort and place the food correctly in the bento box.
- In summary, robots and AI can over time be adapted to accomplish many physical things. This means what we think of as robots in the future may be a lot closer than you think.



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