SAMSUNG

Samsung Innovation Campus

Artificial Intelligence Course

Together for Tomorrow!
Enabling People
Education for Future Generations

Chapter 1.

Introduction to Artificial Intelligence

AI Course

Chapter Description

Chapter objectives

- ✓ Understand the concepts of artificial intelligence and machine learning, and learn about the types, procedures, and limitations of machine learning-based data analyses.
- ✓ Be able to analyze the internal and external environment of artificial intelligence-based corporations. And be able to analyze the commercialize business models for expanding the scope of artificial intelligence service applications in artificial intelligence-based industries.
- ✓ Be able to analyze trends in artificial intelligence-related technologies and changes in market demand.
- ✓ Learn about the entire artificial intelligence course roadmap.

Chapter contents

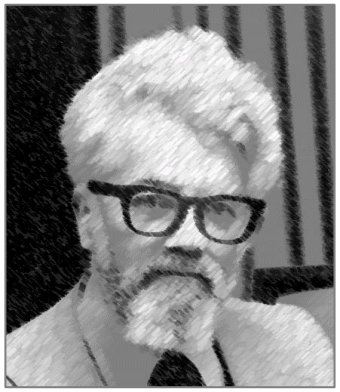
- ✓ Unit 1. The Concept of Artificial Intelligence
- ✓ Unit 2. Applications of Artificial Intelligence
- ✓ Unit 3. Techniques in Artificial Intelligence
- ✓ Unit 4. Artificial Intelligence: Trends and Markets
- ✓ Unit 5. Course Roadmap

Unit 1.

The Concept of Artificial Intelligence

What is Artificial Intelligence

Definition



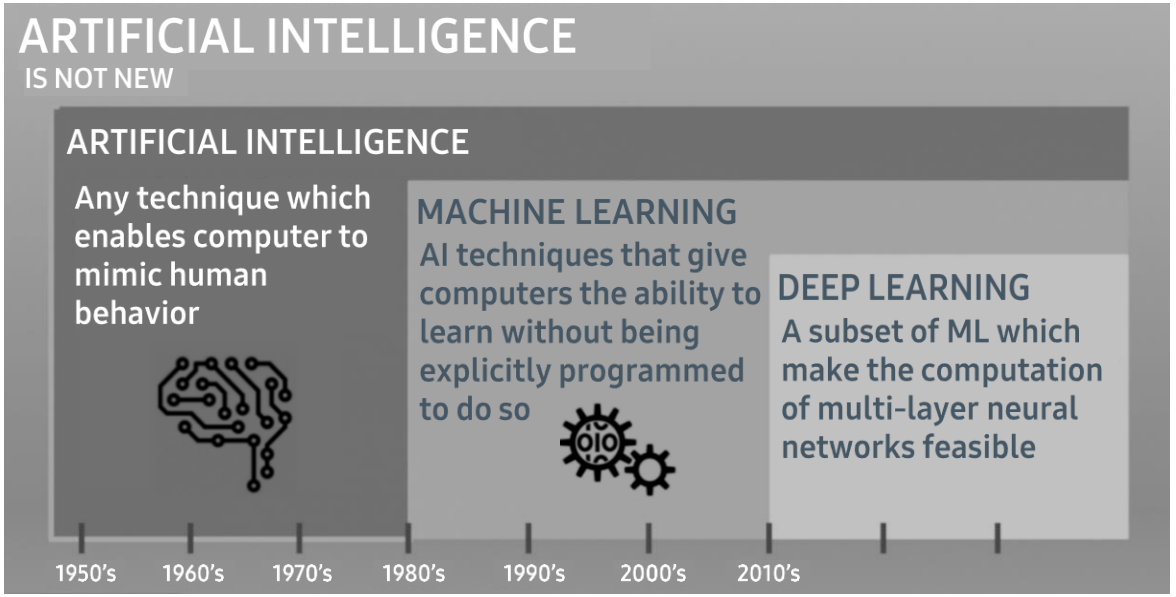
John McCarthy(1927–2011)

- Artificial intelligence (AI) is the ability of a computer program or a machine to think and learn. It is also a field of study that tries to make computers "smart." They work on their own without being encoded with commands. John McCarthy came up with the name "artificial intelligence" in 1955.
- These processes include learning (the acquisition of information and rules for using the information), reasoning (using rules to reach approximate or definite conclusions), and self-correction.

https://www.wired.com/2011/10/john-mccarthy-father-of-ai-and-lisp-dies-at-84/

Building an Intelligent System that Transforms Data into Knowledge

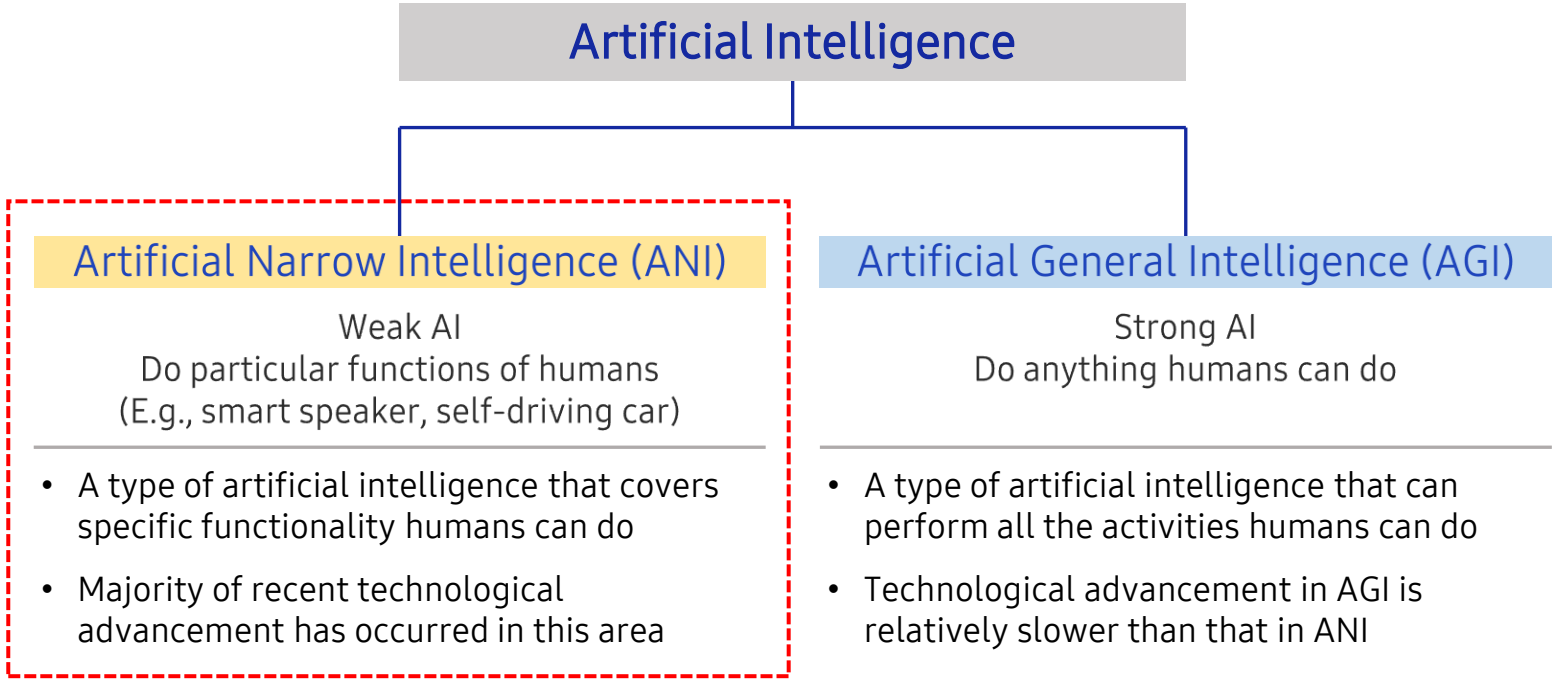
- There is an abundance of structured and unstructured data in the modern tech era.
- Machine learning emerged in the late 20th century as a sub-field of artificial intelligence (AI) related to self-learning algorithms that extract and predict knowledge from data.
- Humans manually analyze large amounts of data to induce rules and make models.
- Machine learning can gradually improve predictive models and data-based decision-making performance by extracting knowledge more efficiently from data.



Unit 1.

The Concept of Artificial Intelligence

Types of Artificial Intelligence



Main focus of this lecture and the entire course

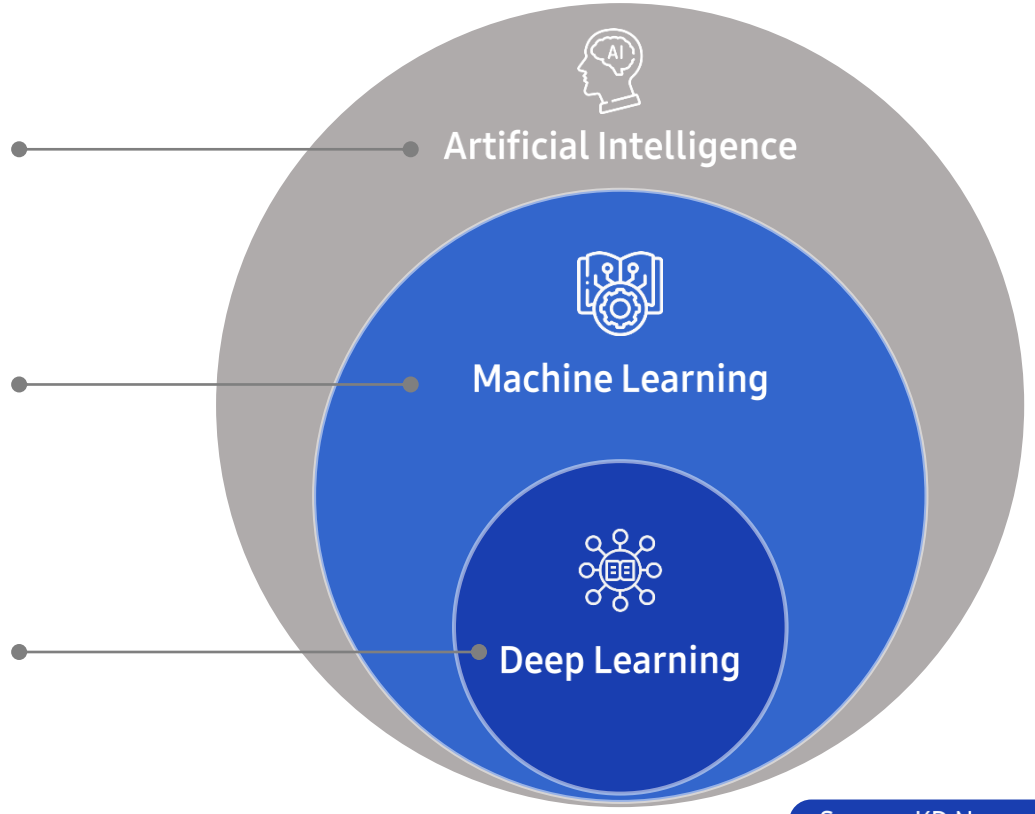
What are subsets of AI?

Subsets of Artificial Intelligence

Artificial Intelligence
Any technique that enables computers to mimic human behavior

Machine Learning
A subset of AI techniques that use statistical methods to enable machines to improve through experiences

Deep Learning
A subset of ML that makes the computation of multi-layer neural networks feasible



Source: KD Nuggets

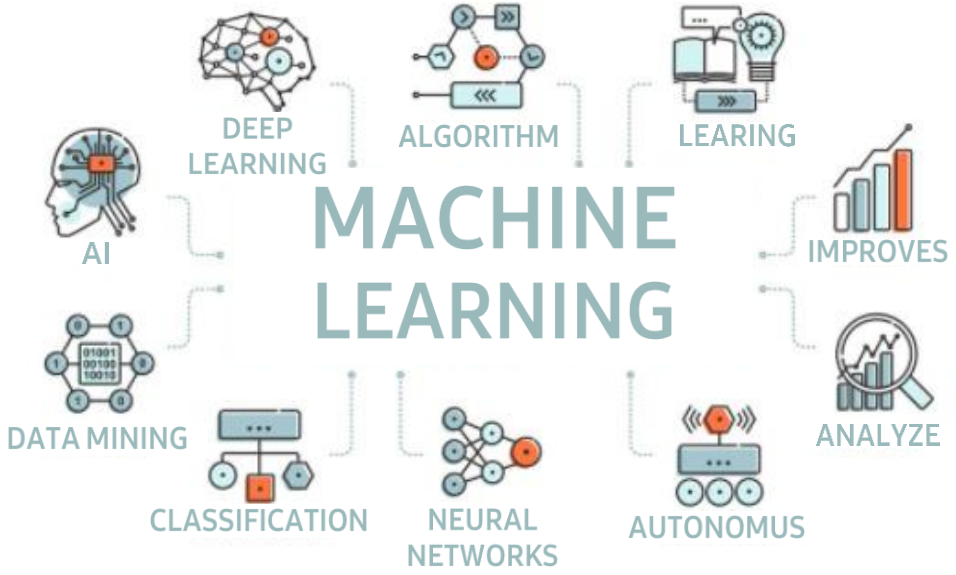
Unit 1.

The Concept of Artificial Intelligence

Definition of Machine Learning

Machine learning is a field of artificial intelligence and the study of computer algorithms that automatically improve through examples and experiences.

- "A field of research that develops algorithms that allow machines to learn from data and execute actions that are not explicitly specified by code" - Arthur Samuel, 1959
- "A computer program is said to learn from experience E with respect to some class of tasks T and performance measure P if its performance at tasks in T, as measured by P, improved with experience E." - Tom Mitchell, 1977



- “A field of research that develops algorithms that allow machines to learn from data and execute actions that are not explicitly specified by code“ - Arthur Samuel, 1959
- “A computer program is said to learn from experience E with respect to some class of tasks T and performance measure P if its performance at tasks in T, as measured by P, improved with experience E.“ - Tom Mitchell, 1977

- The task T is to classify dogs and cats, and the performance P represents a measure of classifying dogs and cats. E can be said to be “learning” if the performance of classifying dogs and cats gradually improves through experience, or data (10,000 photos).

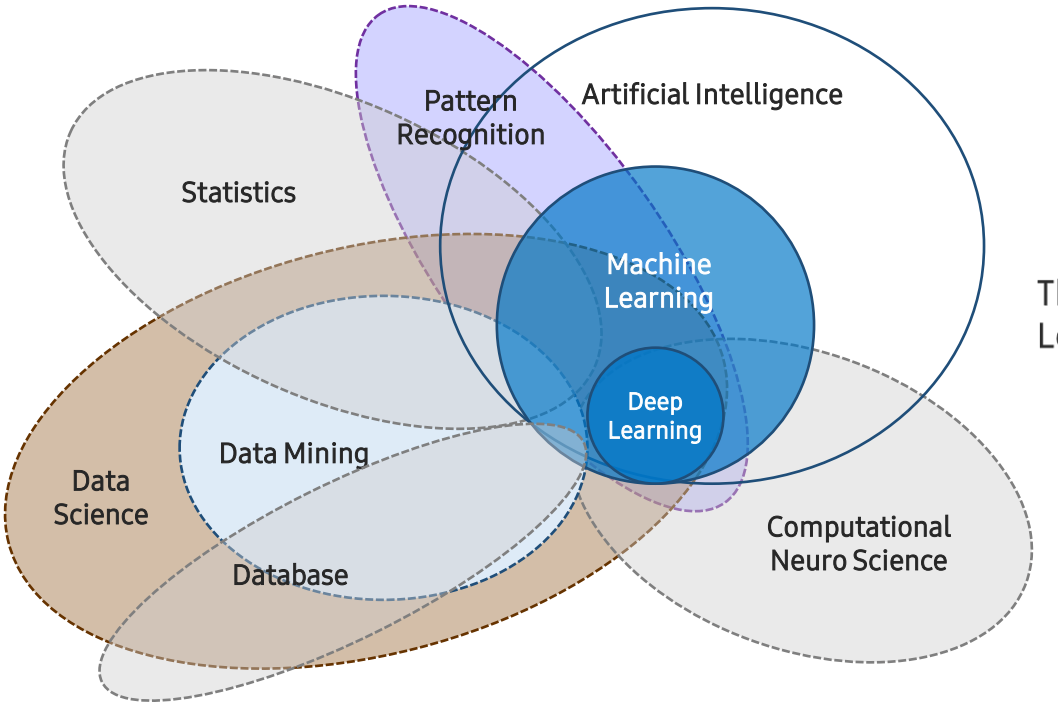
Unit 1.

The Concept of Artificial Intelligence

Disciplines Related to Machine Learning

Studies Related to Machine Learning

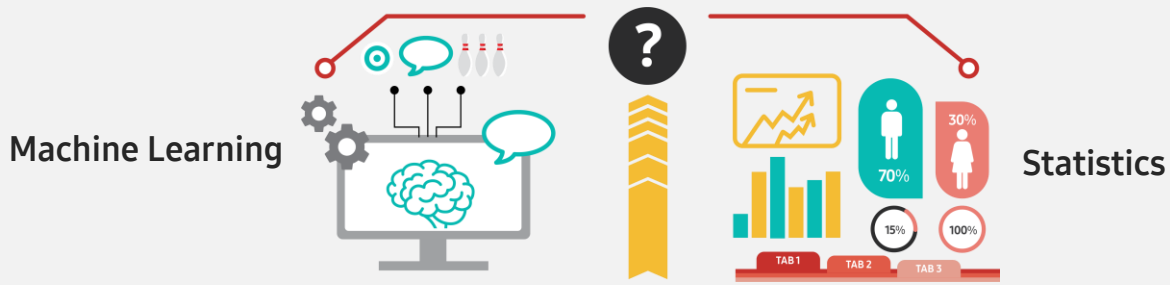
- Machine learning is an interdisciplinary study that combines academic backgrounds and achievements in various fields rather than limited to the technology or methodology in one area. These fields include probability and statistics, computer science, database theory, cognitive science, neuroscience, and pattern recognition.



The Relationship Between Machine Learning and Various Disciplines

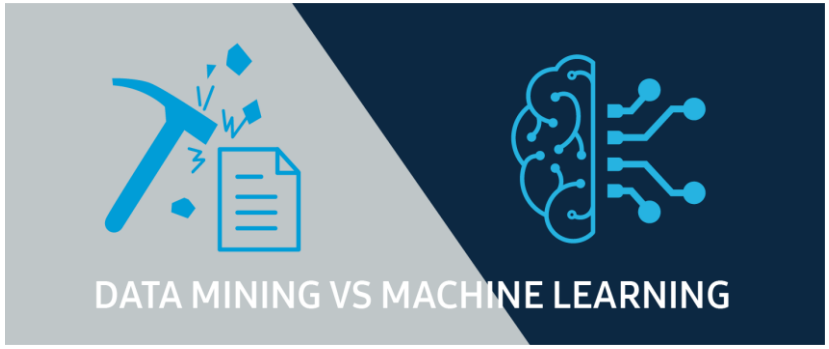
Machine Learning vs. Statistics

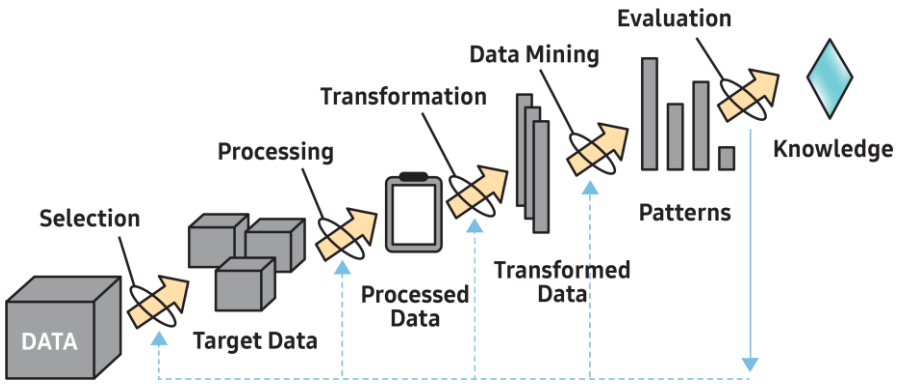
- Statistics are traditionally regarded as the theoretical foundation that provides a scientific and systematic method for converting data into information. The areas particularly emphasized in statistics are inference and verification. Various methodologies and theories have been established to explain how well the given data conform to the researcher's hypothesis and theory (or how accurately the values derived from observations estimate the actual population parameters).
- Meanwhile, machine learning is mainly used to solve tasks that are difficult to design or program explicit algorithms. Most machine learning algorithms are first used to quantify complex relationships by identifying the feature of potential mechanisms generated by data and then to make predictions on new data using this identified pattern.
- At first glance, the approaches of statistics and machine learning may look the complete opposite. But except for some aspects, the methodologies that form the basis of each discipline are very similar. In fact, it can be said that many methodologies of machine learning are based on statistical learning from statistics.



Machine Learning vs. Data Mining

- What is Data Mining?
  - It refers to a process of mining useful information [gold nuggets] from a large data warehouse [stone pile].
  - It is a series of processes that help companies make decisions to secure competitiveness. These processes involve finding and modeling relationships, patterns, and rules between data existing in large amounts of data.
- Machine learning is also deeply related to data mining because it extracts useful rules, knowledge expression, or judgment criteria from data.
- Data mining is a process of systematically and automatically discovering meaningful rules or patterns within large-scale stored data and intellectualizing them. Machine learning is somehow different as it is a process in which computer programs learn, make predictions, and research and build algorithms for said process.





Statistical Analysis vs. Data Mining

- Traditional Statistical Analysis
  - With a target group, analysis is conducted based on different assumptions on the distribution or model of a population.

    → The process of inferring the entire parameter of a population by observing a sample.
- Data Mining
  - There are no prerequisites for the distribution or model that is inevitably involved in the sample survey or experiment.

    → The process of extracting necessary information or knowledge using the entire data of a population.
  - Data mining requires a large amount of data.

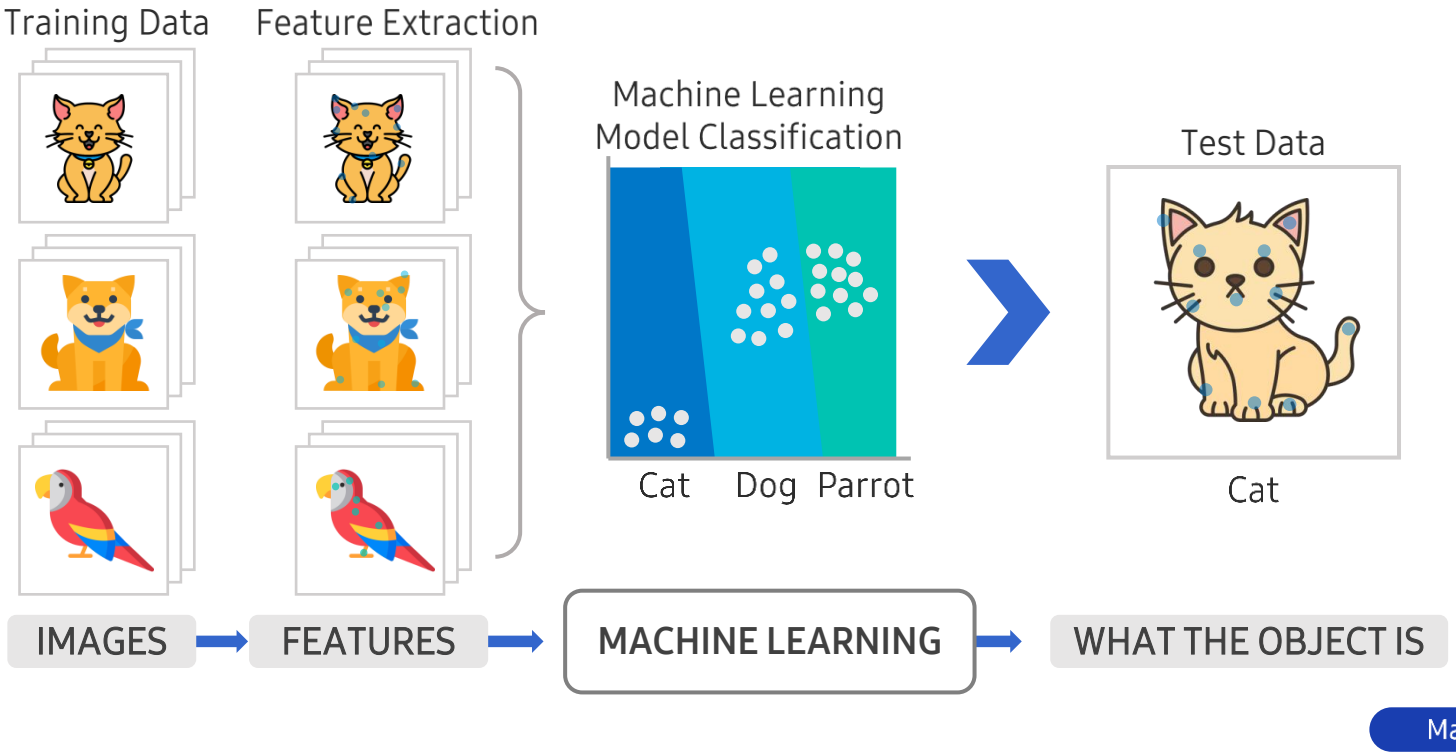
Unit 1.

The Concept of Artificial Intelligence

Types and Choices of Machine Learning-based Data Analysis

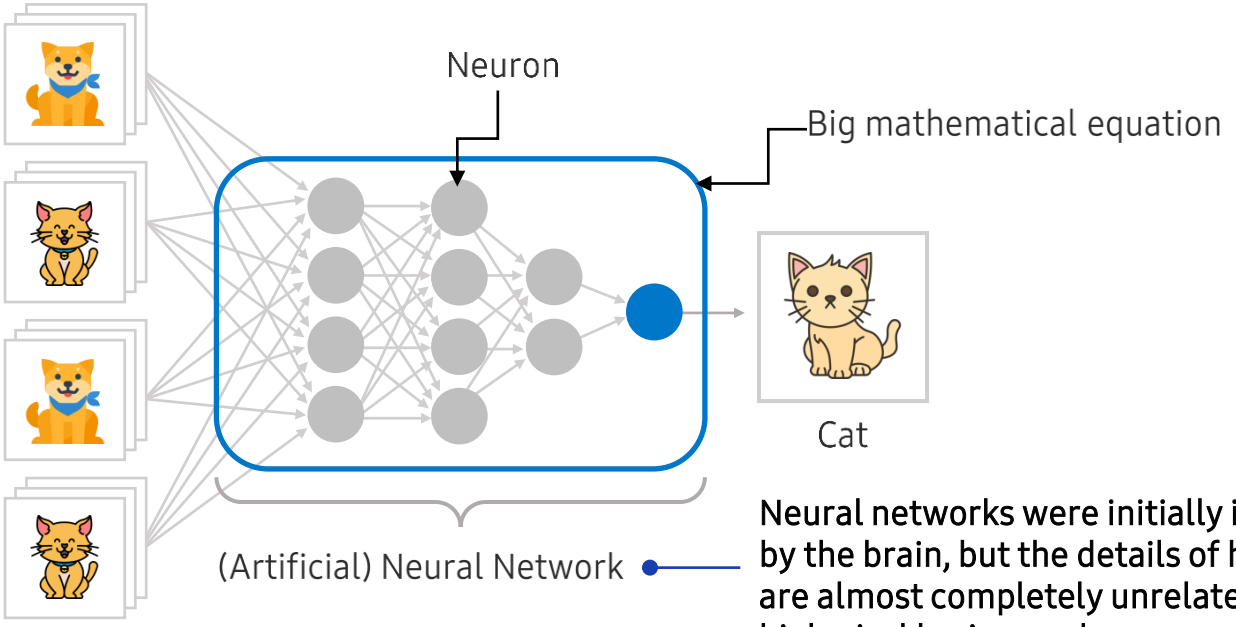
Machine Learning vs. Deep Learning

Machine Learning Workflow



Machine Learning vs. Deep Learning

Deep Learning Workflow



Neural networks were initially inspired by the brain, but the details of how they work are almost completely unrelated to how biological brains work.

MathWorks, Coursera

Types of Machine Learning-based Data Analysis

- When analyzing a large amount of data with machine learning technology, patterns that were invisible outwardly can be found, called data mining. Data mining deals with the following four problems.

Prediction

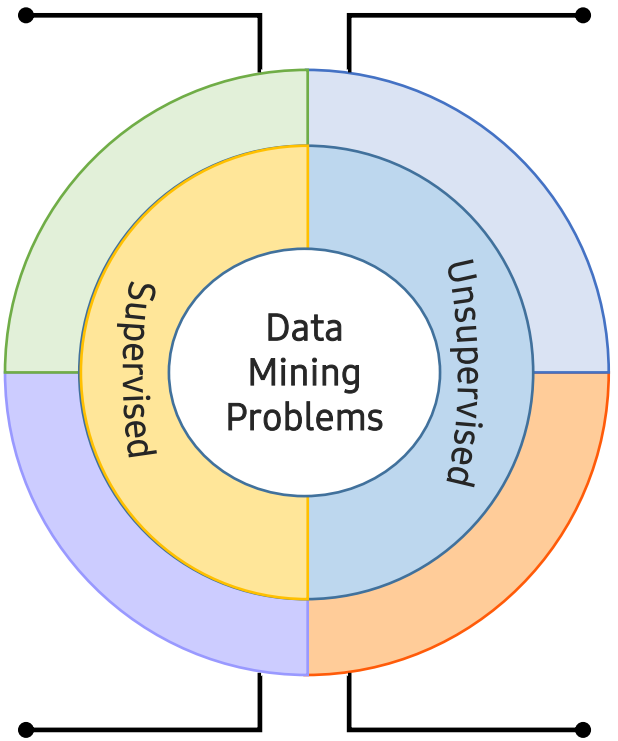
Making a model based on a given data, then applying the model to new cases for predictions

Ex Predicting the quality specifications from ingredients and environment (pressure, temperature, humidity, etc.) in the fishing industry

Classification

Determining where a particular case belongs in a given series of classified categories

Ex Quality Ratings from good/normal/bad, Determining the quality of new products



Clustering

Comparing the properties of the data and forming clusters based on similar characteristics

Ex Clusterization of processes with similar characteristics out of various processes

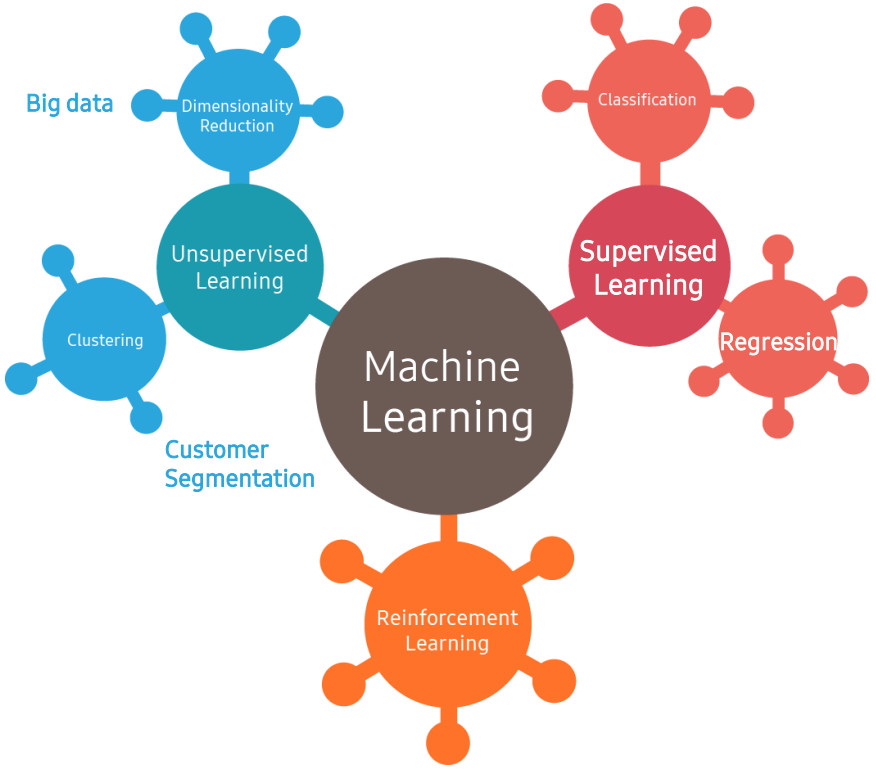
Association Rule

Identifying the attributes or relationships between items to which the appearance of a pattern implies the appearance of another pattern

Ex Predicting what will happen to the entire process when there is an abnormal pattern in one process

Types of Machine Learning-based Data Analysis

- There are various criteria and perspectives for classifying machine learning-based data analysis techniques. But in general, they are classified into supervised learning and self-learning (or unsupervised learning), depending on the existence of objective variables (or response variables, output target values, etc.). They can also be classified as reinforcement learning and semi-supervised learning.



Supervised Learning

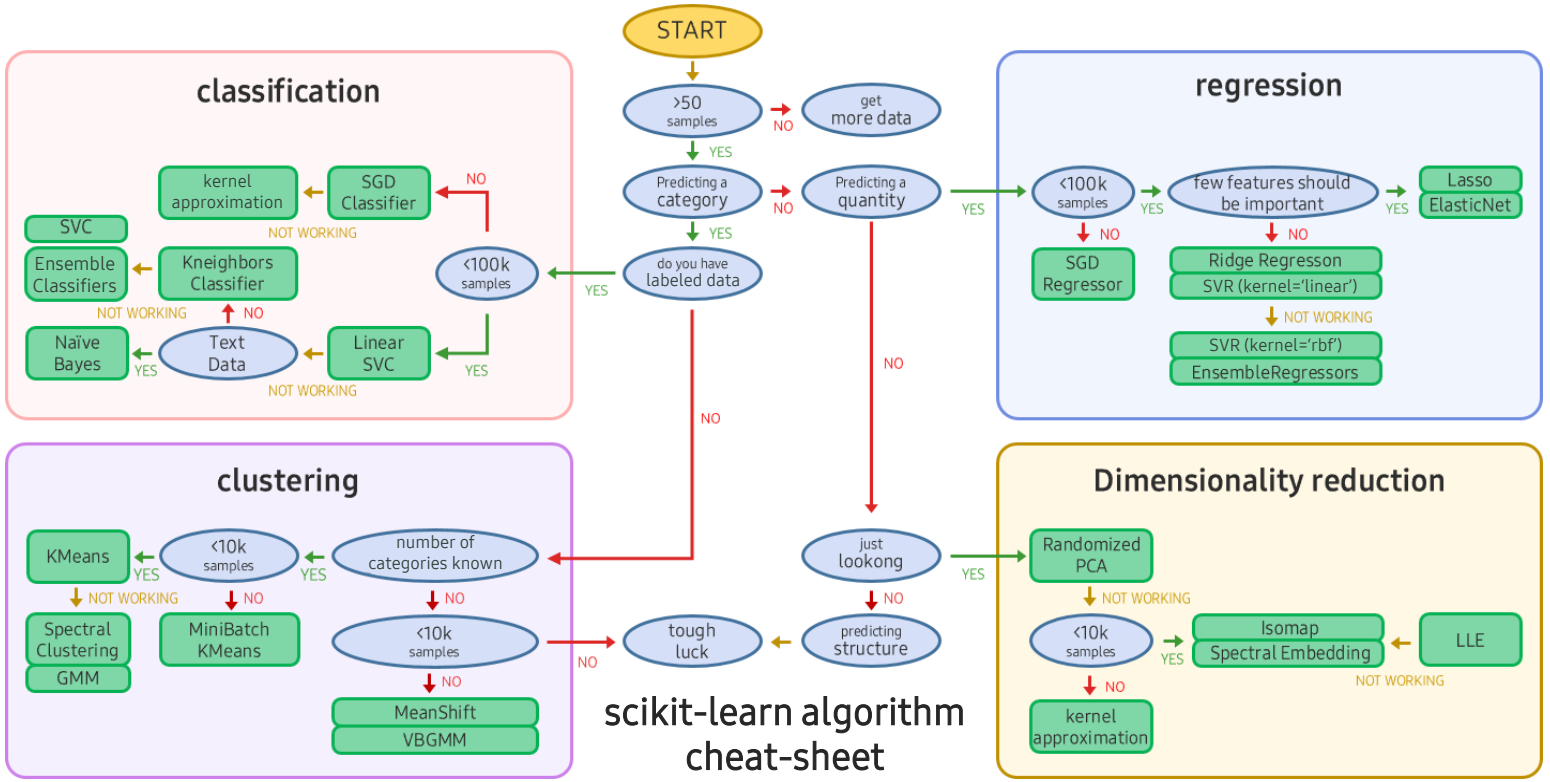
- Supervised learning focuses on expressing the relationship between explanatory variables (also known as independent variables, features, etc.) and objective variables (also known as response variables, dependent variables, target variables, output values, etc.) as well as predicting future observations. It is suitable for solving problems for recognition, classification, diagnosis, and prediction.
- Main techniques in supervised learning can be reclassified into classification and numerical prediction techniques. This depends on the form of the objective variable (or response variable, dependent variable), whether it is a numerical (quantitative variable) or categorical (qualitative variable).

Labeled Training Set for Spam Classification (Example of Supervised Learning)

- The training data injected into the algorithm includes a desired answer called the label.

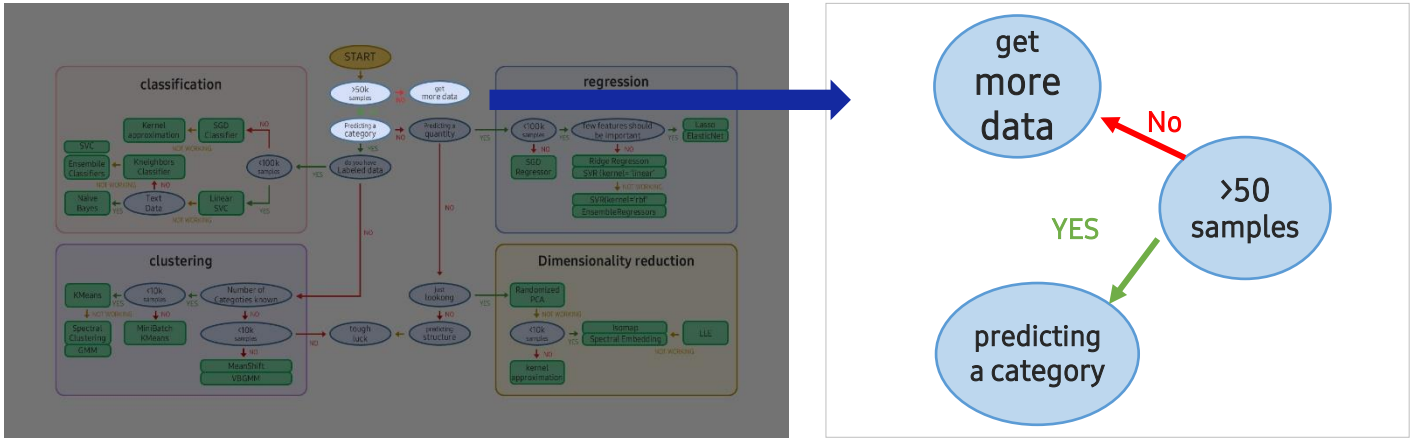
Supervised Learning

- Data mining is a combination of statistics and machine learning (or artificial intelligence). The problem to be solved by machine learning is in line with the problem of data mining.
- The figure below shows a guide to solving problems with Scikit-learn, a Python module for machine learning.



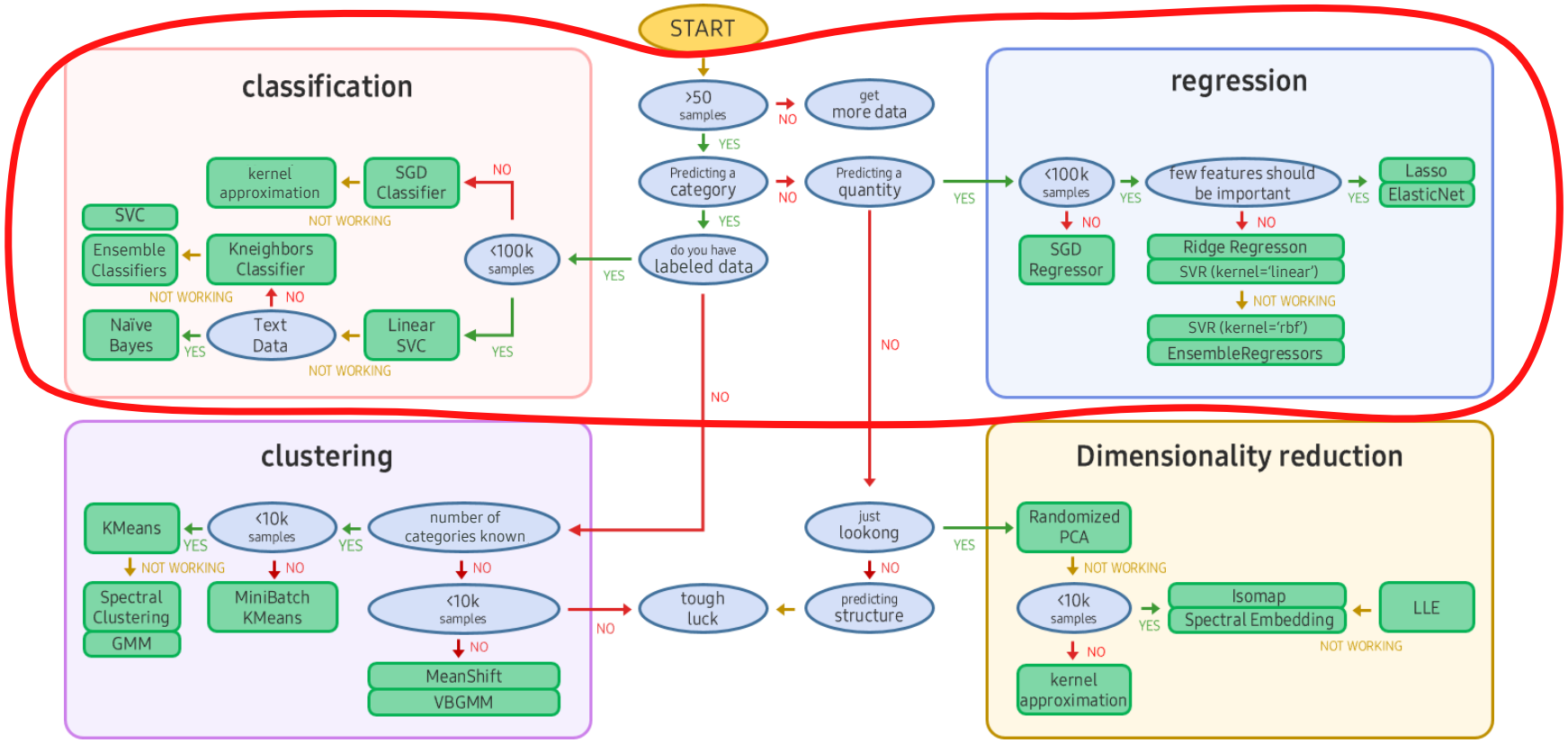
In the Case of Insufficient Data

- Looking at the figure below, statistics-based analysis is inevitable when there is a small amount of data.
- In statistics, at least 30 samples are needed to estimate the population's features (parameters).
- As the number of samples increases, they become closer to the parameters.
- Some assumptions can be made based on approximately 30 data. The assumption is that if there are more than 30 samples, the data will be normally distributed based on the law of large numbers.
- In data mining or machine learning, a large amount of data (100,000 or more) is essential.



Supervised Learning

- See the below figure. If there is an answer among the predicted questions, and the answer is a numerical type, it is a regression. If the answer is a categorical type, it is a classification.

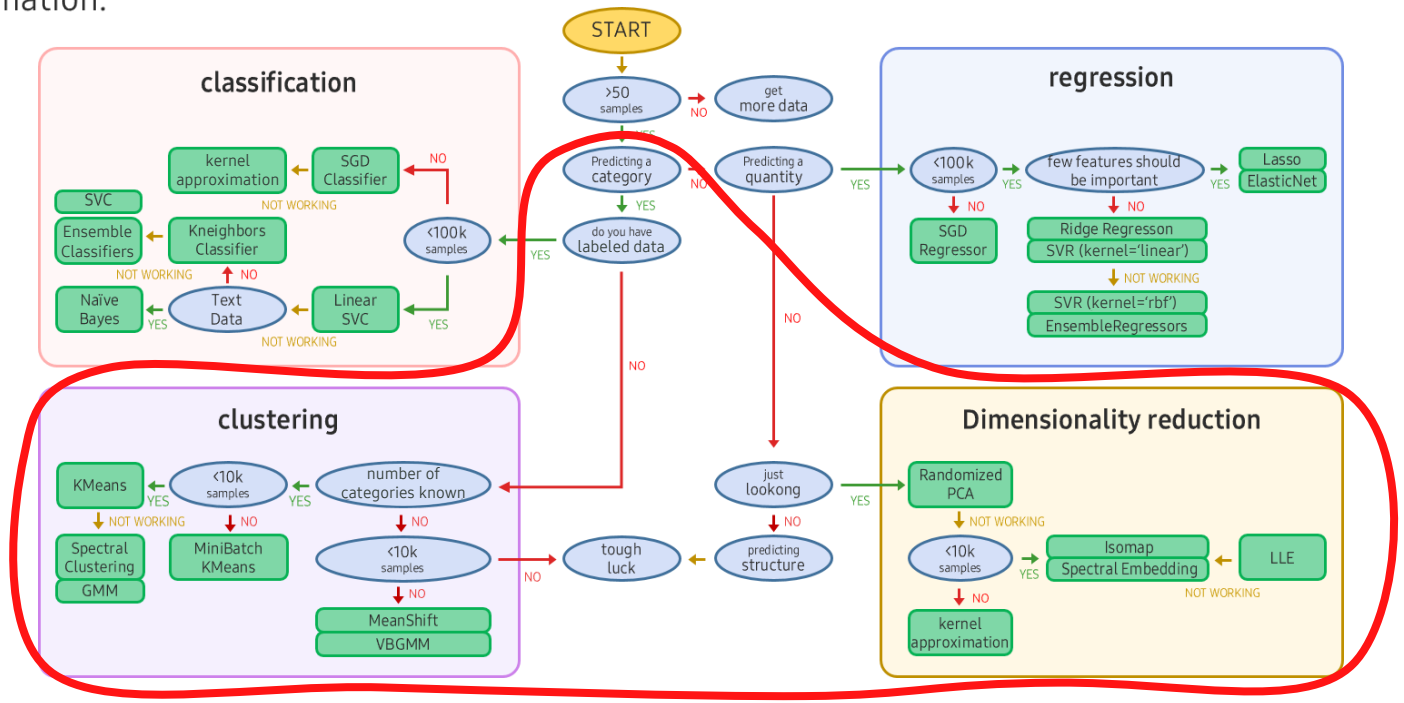


Main Techniques and Algorithms for Supervised Learning

Type	Regression (Numerical Prediction)
K-Nearest Neighbors	Linear Regression
Logistic Regression	Extended Regression Analysis (ex: Polynomial Regression, Nonlinear Regression, Penalized Regression, etc.)
Artificial Neural Network	Artificial Neural Network
Decision Tree	Decision Tree
Support Vector Machine	Support Vector Machine (Regression)
Naïve Bayes	PLS (Partial Least Squares)
Ensemble Method (Random Forest, etc.)	Ensemble Method (Random Forest, etc.)

Self-Learning (or Unsupervised Learning)

- Self-learning or unsupervised learning is a form in which learning is performed without information on objective variables (or response variables, dependent variables, target variables, and output values). It is mainly used for problems such as description, characteristic derivation, and pattern derivation.
- In general, supervised learning techniques have clear and distinct predictive purposes. Compared to those, self-learning techniques have a stronger nature of data mining to search for useful information or patterns without prior information.



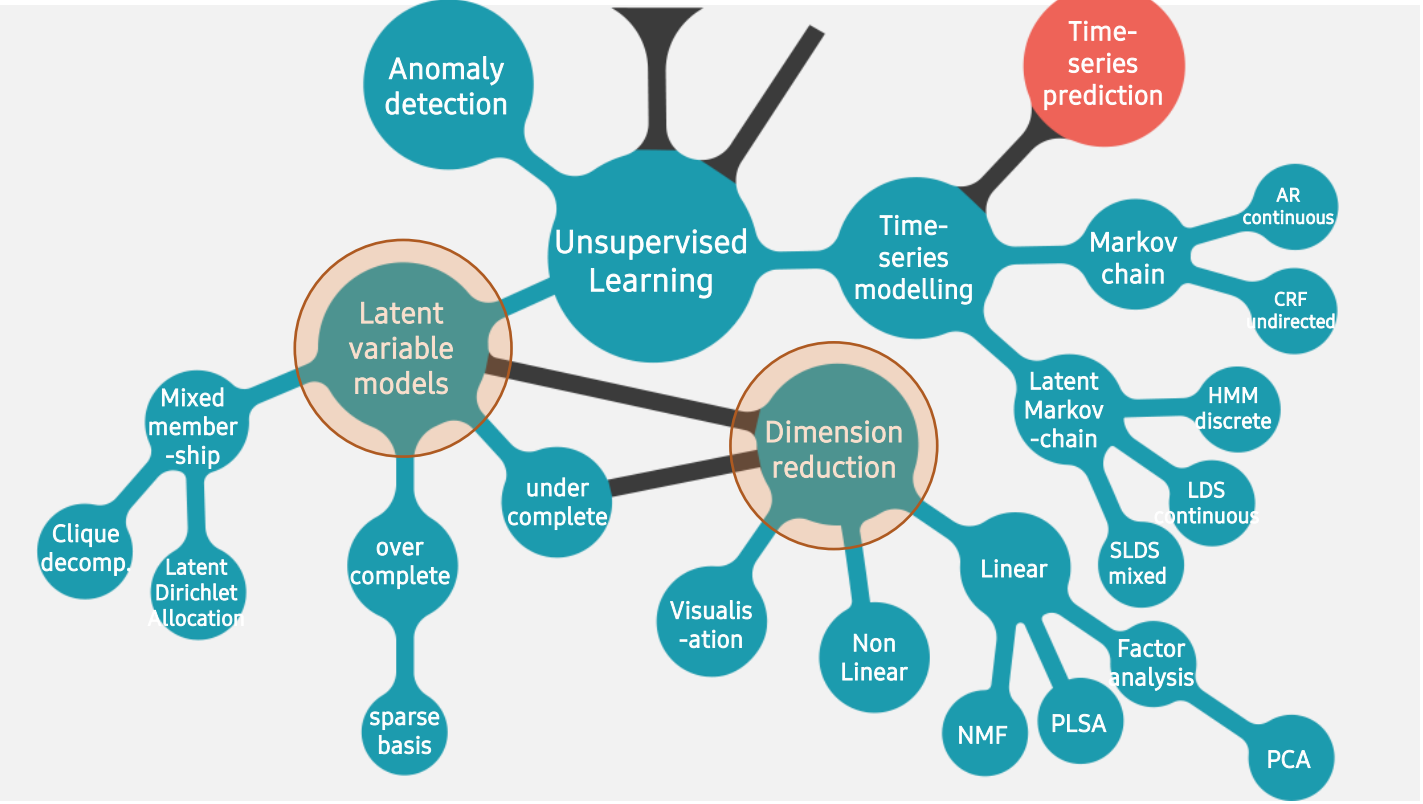
Unsupervised Learning

- Unsupervised Learning: No label in training data, so the system must learn without any help.
- Important Unsupervised Learning Algorithms

Cluster	Visualization and Dimension Reduction	Association Rule Learning
• K-Means • DBSCAN • Hierarchical Clustering Analysis (HCA) • Anomaly Detection and Outlier Detection • One-Class SVM • Isolation Forest	• Principal Component Analysis(PCA) • Kernel PCA • Local Linear Embedding • t-SNE	• Apriori • Eclat

Self-Learning (or Unsupervised Learning)

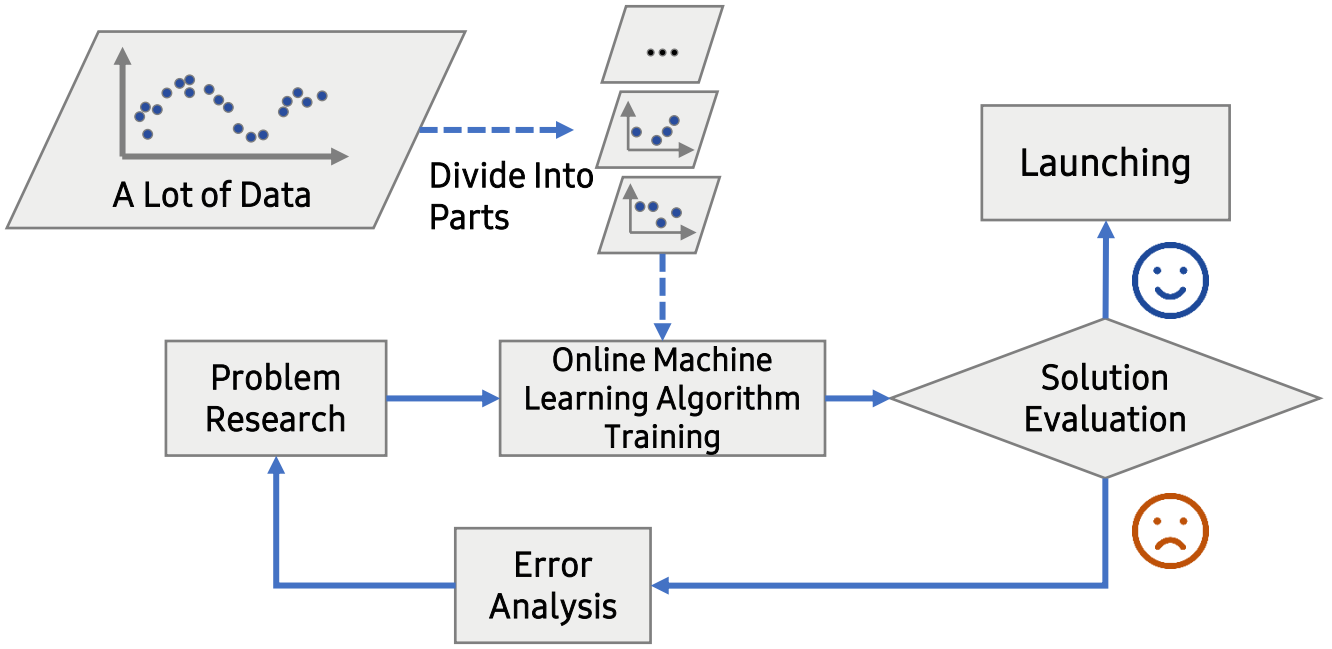
- Main techniques of self-learning, or unsupervised learning, include clustering, dimensional reduction, correlation analysis, and self-learning artificial neural network (ex. SOM). They can be used for different purposes, for example, applying them in deep learning for dimension reduction of input features.



Batch Learning and Online Learning

- **Batch Learning:** The system cannot learn gradually.
- **Online Learning:** The system is trained by sequentially injecting data one by one or in a small batch unit called a mini-batch.

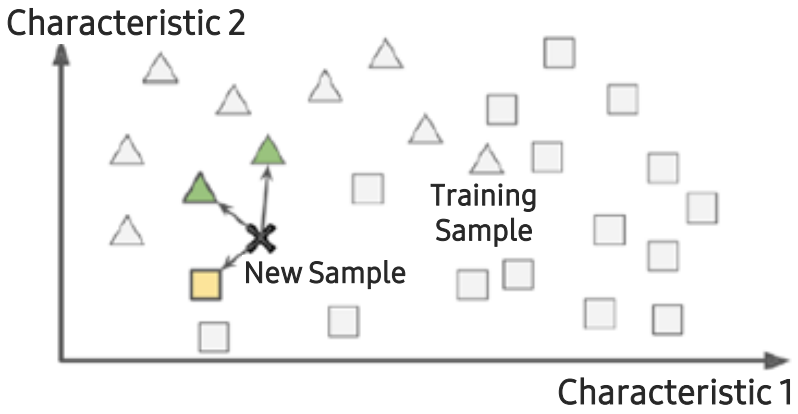
Processing Large Amounts of Data Using Online Learning



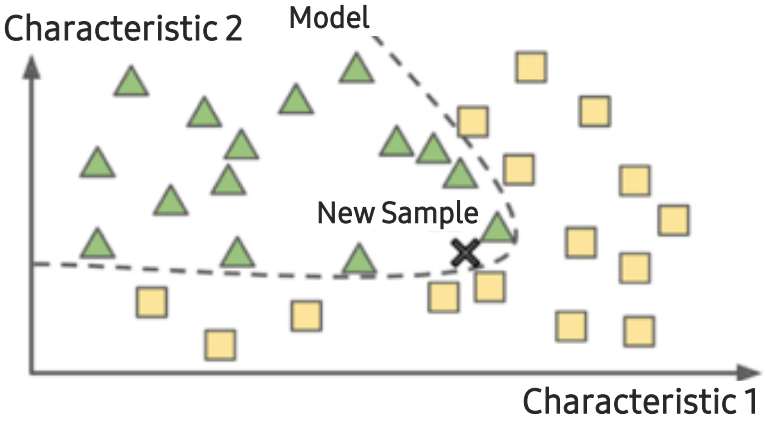
Instance-based Learning Vs. Model-based Learning

- **Instance-based Learning:** The system learns by remembering training samples. It is generalized by comparing new data and learned samples using similarity measurements.
- **Model-based Learning:** The system creates a model from a sample and uses it for prediction.

Instance-based Learning



Model-based Learning



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Machine Learning-based Data Analysis: Plans and Procedures

When performing machine learning-based data analysis, the following procedure is generally followed.

01. Understanding the Business and Defining the Problem

02. Collecting Data

03. Data Pre-processing and Searching

04. Data for Model Training

05. Model Performance Evaluation

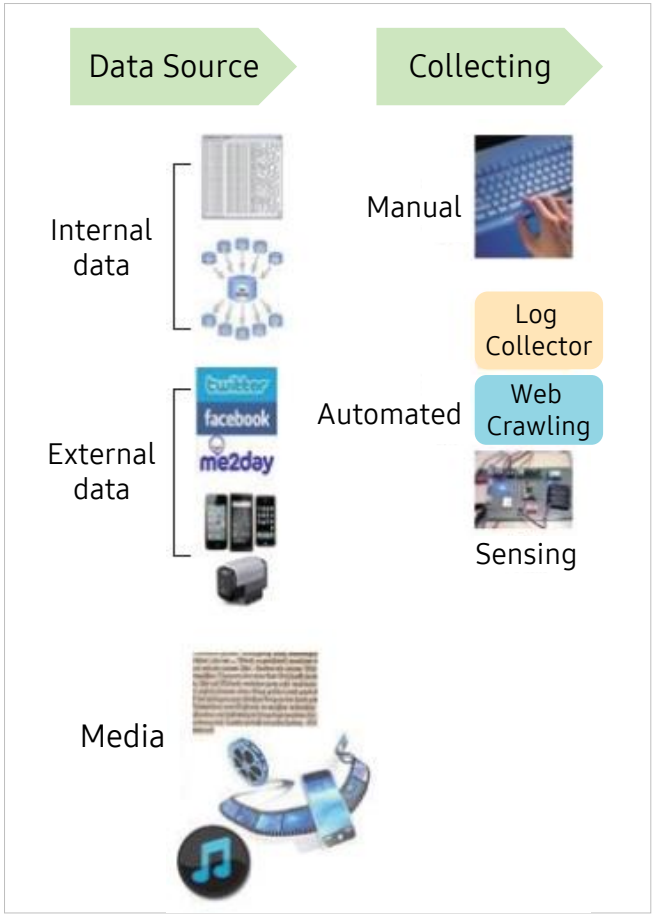
06. Improving Model Performance and Market Application

01. Understanding the Business and Defining the Problem

- The top priority in machine learning-based data analysis is to define the problem to be solved.
- Identify the problem by repeating the process of understanding the problem you are trying to solve, understanding the business domain, and grasping the concepts of the problem. Through repeatedly redefining the problem and finding solutions, your understanding of the specific purpose and necessary data will become clear.
- Also, in the process of defining the problem and brainstorming the required data types, it naturally leads to a tentative decision-making process on which machine learning techniques will be applied.

02. Collecting Data

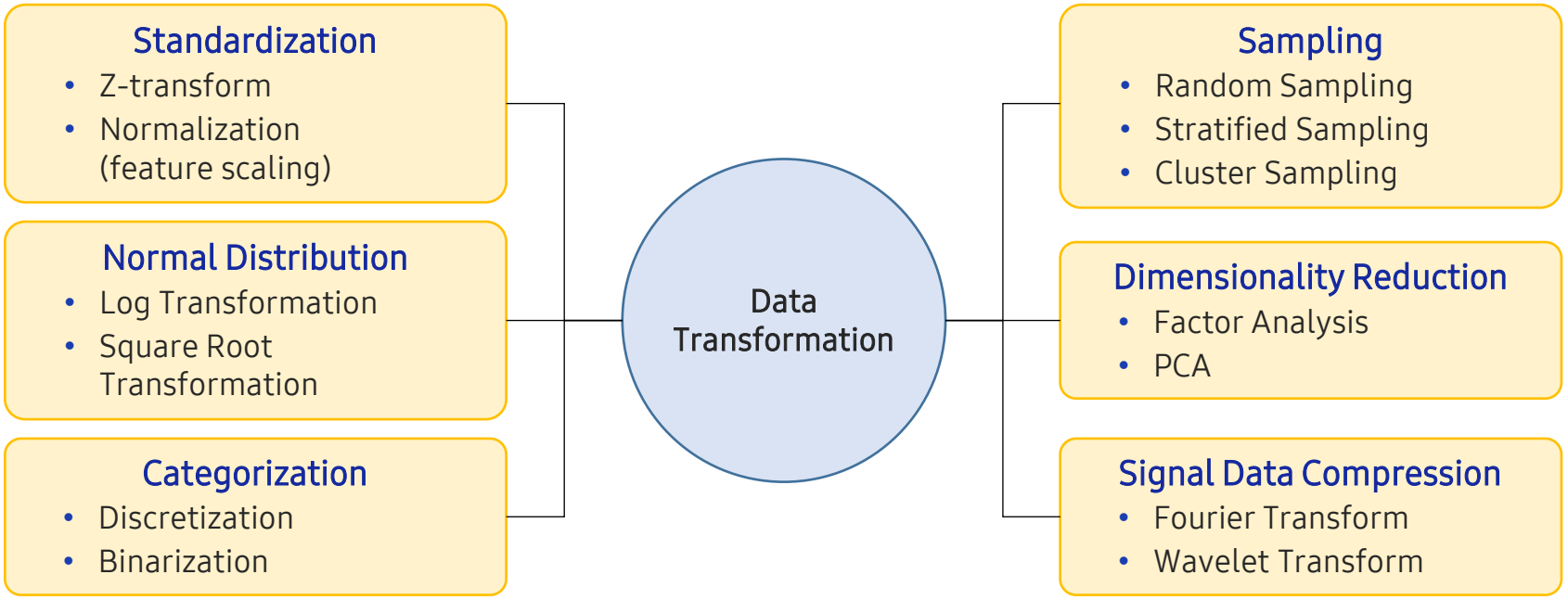
- When the analysis issue is clear, necessary data must be collected.
- If the data is already given, you may directly consider the appropriate analysis. But even in those cases, additional data may be generated. Collecting necessary data always needs to be considered for proper analysis.
- It is common to extract data from an internal data store (data warehouse or data mart) through SQL or from a Hadoop-based big data platform. Collecting data through web scraping or API may be necessary if external data is required.



03. Data Pre-Processing and Searching

- When the necessary data is collected, the data is preprocessed and converted into a form suitable for machine learning. The quality of machine learning-based data analysis results depends on the required techniques or algorithms. Yet, data preprocessing, conversion, and search steps are critical as they affect the data quality.
- In fact, like most analyses, this stage can take the most time and effort among machine learning-based data analysis processes.

03. Data Pre-Processing and Searching

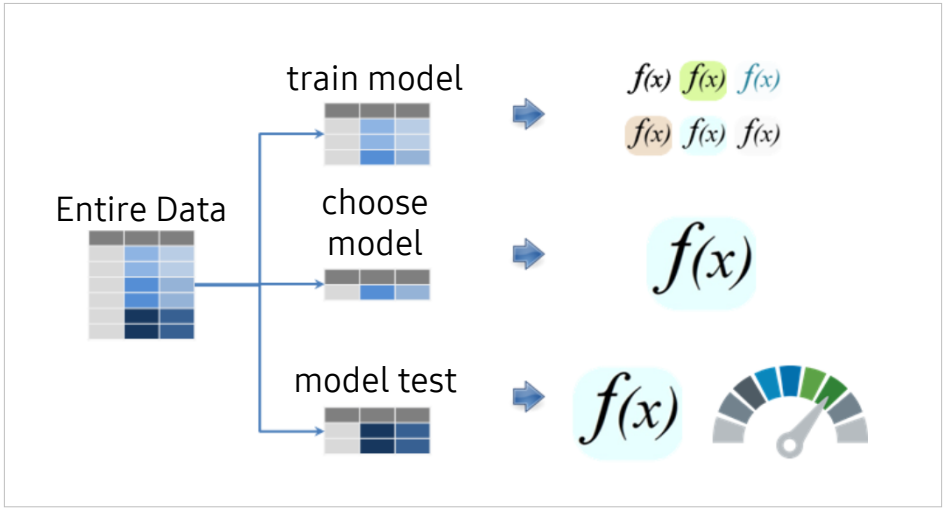


03. Data Pre-Processing and Searching

- Normal Distribution
  - **Log Transform:** If the input data represents an inverse function distribution, convert it to a normal distribution using a log.
  - **Square Root Transform:** Transforming non-normal distribution data into a normal distribution using square roots
- Categorization
  - **Discretization:** Categorizing continuous variables into multiple sections
  - **Binarization:** Transforming into dummy variables with two values of 0 and 1
- Sampling
  - Simple Randomization
  - Systematic Sampling
  - Stratified Randomization
  - Cluster Sampling
  - Multistage Sampling
- Dimensionality Reduction
  - **Factor Analysis:** Finding common factors by finding potential variables
  - Principle Component Analysis

04. Data for Model Training

- After data preprocessing and searching, this step learns data by applying the intended machine learning technique.
- In the case of supervised learning, data can be divided into learning data and verification/evaluation data for model training. Otherwise, model training can be conducted after designing for cross-validation.
- In the case of self-learning (or unsupervised learning), it is a process of deriving patterns through analysis rather than model training since it does not have a target value.



05. Model Performance Evaluation

- In general, machine learning-based learning models tend to produce biased results in training data. Thus, machine learning algorithms use evaluation datasets to evaluate the model's accuracy.
- In the case of self-learning, it is common not having an evaluation data set. Rather than cross-validation, performance is evaluated with the interpretation of statistics or rules derived from the analysis process.

		True/Actual		
		Cat	Fish	Hen
Predicted	Cat	4	6	3
	Fish	1	2	0
	Hen	1	2	6

https://towardsdatascience.com/multi-class-metrics-made-simple-prat-i-precision-and-recall-9250280bddc2

06. Improving Model Performance and Market Application

- An issue that needs a single machine learning analysis process is rarely solved at once. The model's performance is improved by continuously changing model parameters and prediction methods.
  - Sometimes, other algorithms are applied to compare the performance with the initial algorithms.
  - Judging model performance: The judgment on how satisfactory the model performance is can vary depending on the issue or business domain. In any case, there is no absolute criterion to judge that the model performance has improved sufficiently.
  - Improving model performance: Analysts should compare and apply various algorithms and change parameters and prediction methods even within the same algorithm. They need to seek to improve model performance until they are considered satisfactory.
  - Application of the satisfied model to the market: If the derived results satisfy the model after this process, it can be applied to the initial business issue. Additional development for automation or system linkage may be required in some cases.

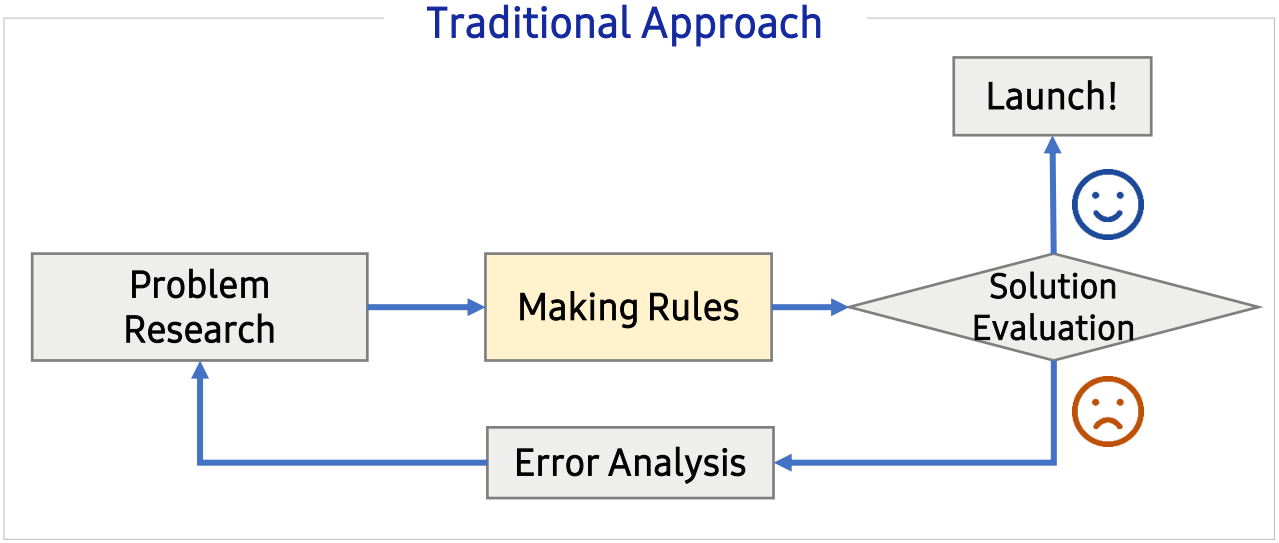
Unit 1.

The Concept of Artificial Intelligence

Reasons For Machine Learning

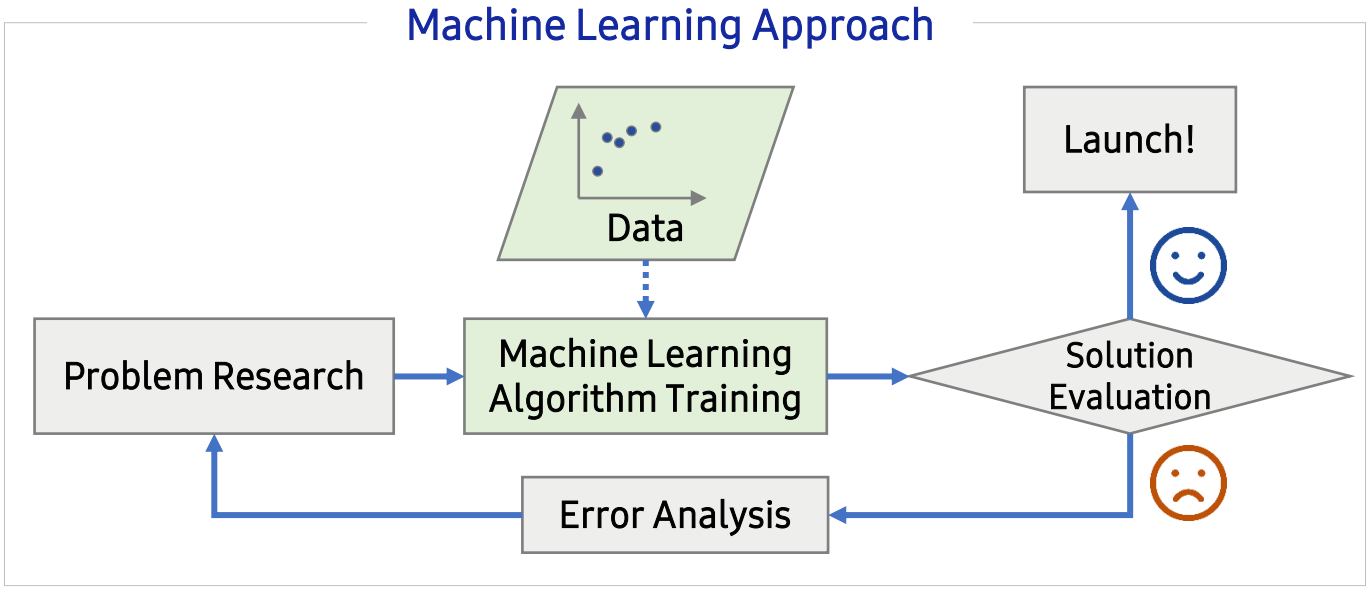
Why Use Machine Learning?

- With traditional programming techniques, the rules become longer and more complex, making them very difficult to maintain. However, spam filters based on machine learning techniques detect patterns that appear more frequently in spam mail. They automatically learn which words and phrases are good criteria for judging spam.
- Machine learning is suitable for fields that are too complex or have no known algorithms in traditional ways (e.g., speech recognition).



Strengths of Machine Learning

- Problem: Existing solutions require a lot of manual adjustment and rules. ML: One machine learning model can simplify the code and increase performance compared to traditional methods.
- Problem: Complex problems cannot not be solved in traditional ways. ML: Solutions can be found with the best machine learning techniques.
- Fluid Environment: Machine learning systems can adapt to new data.
- Gain insight from complex problems and large amounts of data.



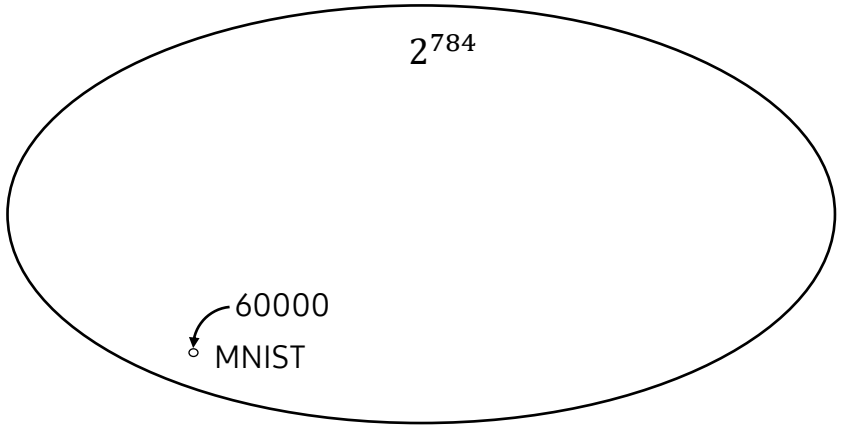
Unit 1.

The Concept of Artificial Intelligence

Limitations of Machine Learning

Insufficient Training Data

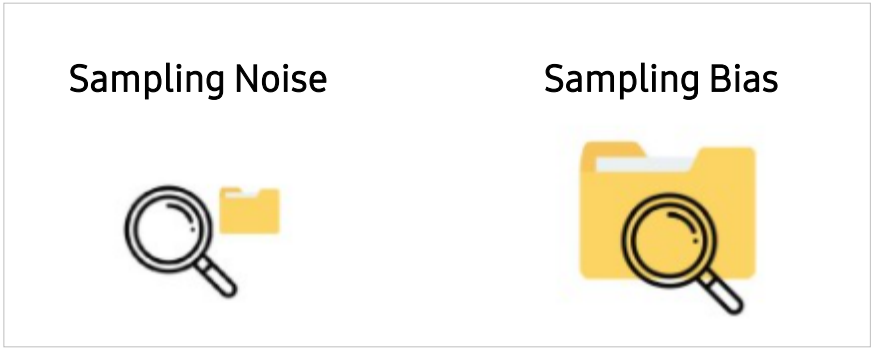
- Most machine learning algorithms require a lot of data to work well.
- Even in simple problems, thousands of data are needed, and millions of complex problems such as image or voice recognition may be needed (In the case you cannot reuse a model that has already been made).
- Since collecting additional training data is not always easy or cheap, the algorithm cannot yet be ignored.



Rare Database in a Vast Space

Training Data Without Representation

- **Sampling Noise:** Coincidental data without representation by chance
- **Sampling Bias:** Very large samples are not representative when the sampling method is wrong



Poor Quality Data

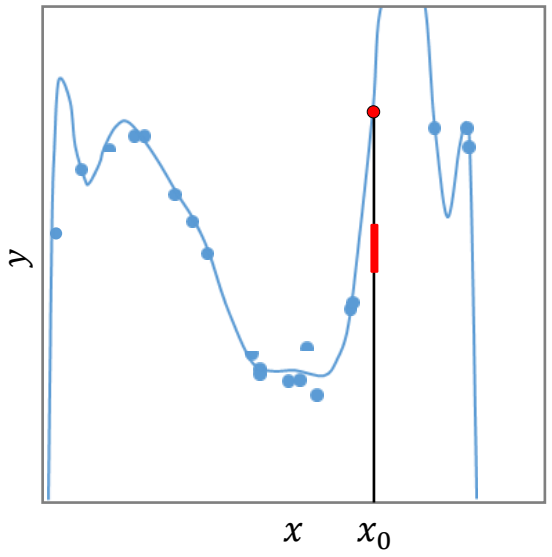
- When the training data is full of errors, outliers, and noise, the machine learning system will not work well because it is difficult to find the inherent patterns.
- **When cleaning is needed:** If it is clear that some samples are outliers, it is better to ignore or fix them.

Irrelevant Features

- The system can only learn when the features and those related to the training data are sufficient.
- A vital element of a successful machine learning project is finding good features to use for training, known as feature engineering.
- Feature selection: Choose the most useful feature for training
- Feature extraction: Combining features creates a more useful feature (dimension reduction)

Overfitting Training Data

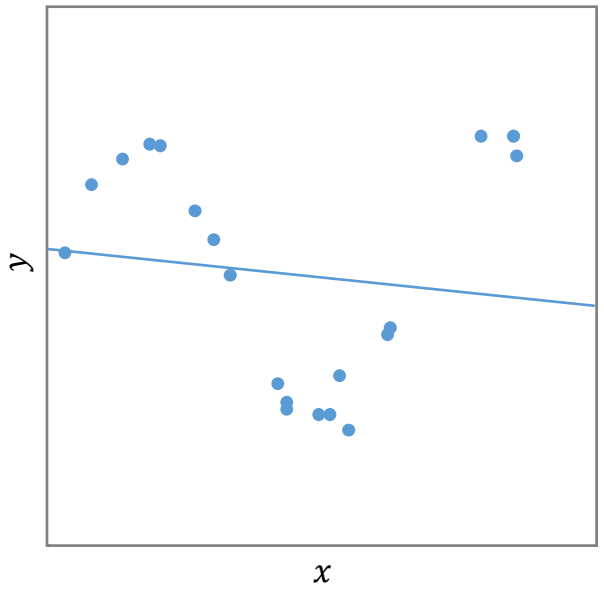
- Regularization: Putting constraints on the model to simplify it and reduce the risk of overfitting.



Graph of an Inaccurate Prediction Due to Overfitting

Underfitting Training Data

- Select a more powerful model with more model parameters.
- Provide better features in learning algorithms (feature engineering).
- Reduce model constraints (reduce the regulation hyperparameters).



Unit 2.

Applications of Artificial Intelligence

Applications of Artificial Intelligence

- Thanks to machine learning, email spam filters, convenient text and voice recognition software, reliable web search engines, and safe and efficient autonomous vehicles are available.
- There has also been great progress in medical applications.

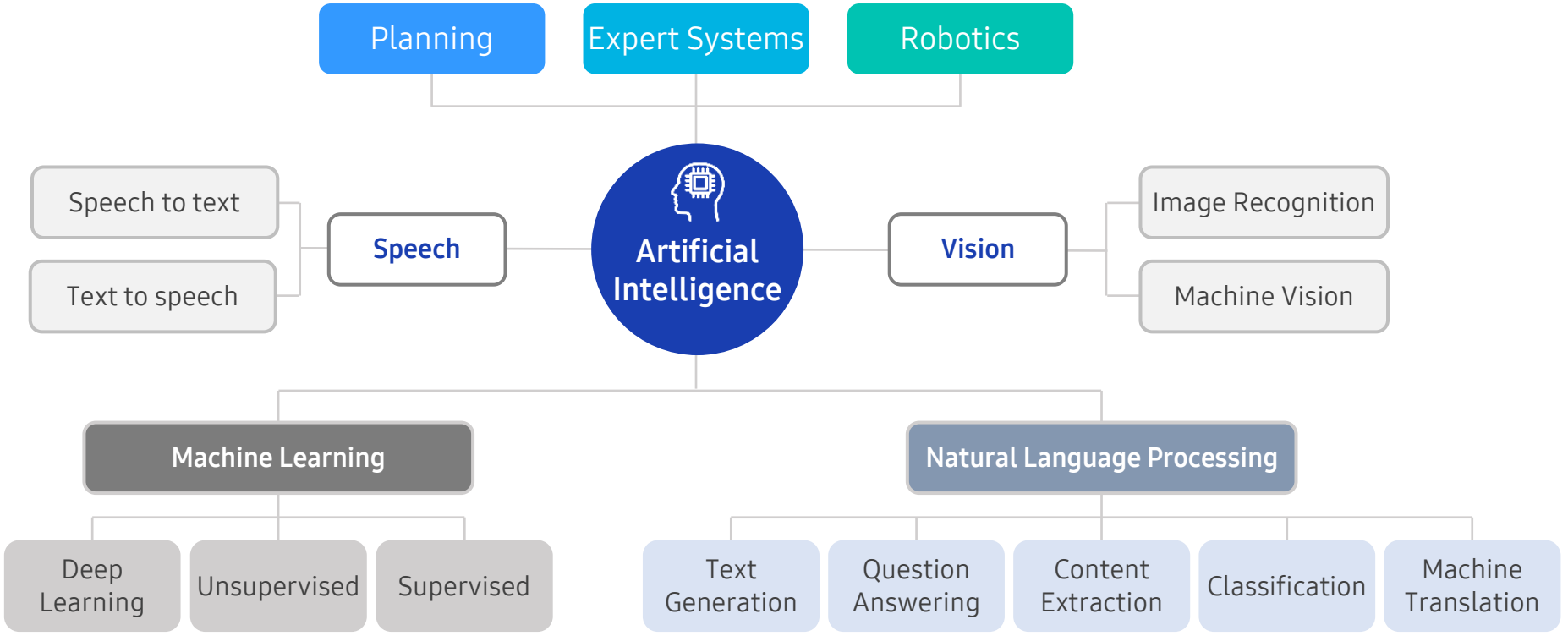
  Ex A deep learning model can diagnose skin cancer with a near-human accuracy.

  Andre Esteva, et al., "**Dermatologist-level classification of skin cancer with deep neural networks**", *Nature,* volume 542(2017), pages 115–118

  https://www.nature.com/articles/nature21056

- Deep learning predicted the 3D protein structure, surpassing the performance of physics-based methods for the first time.

Machine learning plays a huge role in our daily lives and will become increasingly important. The following are the various applications of artificial intelligence.

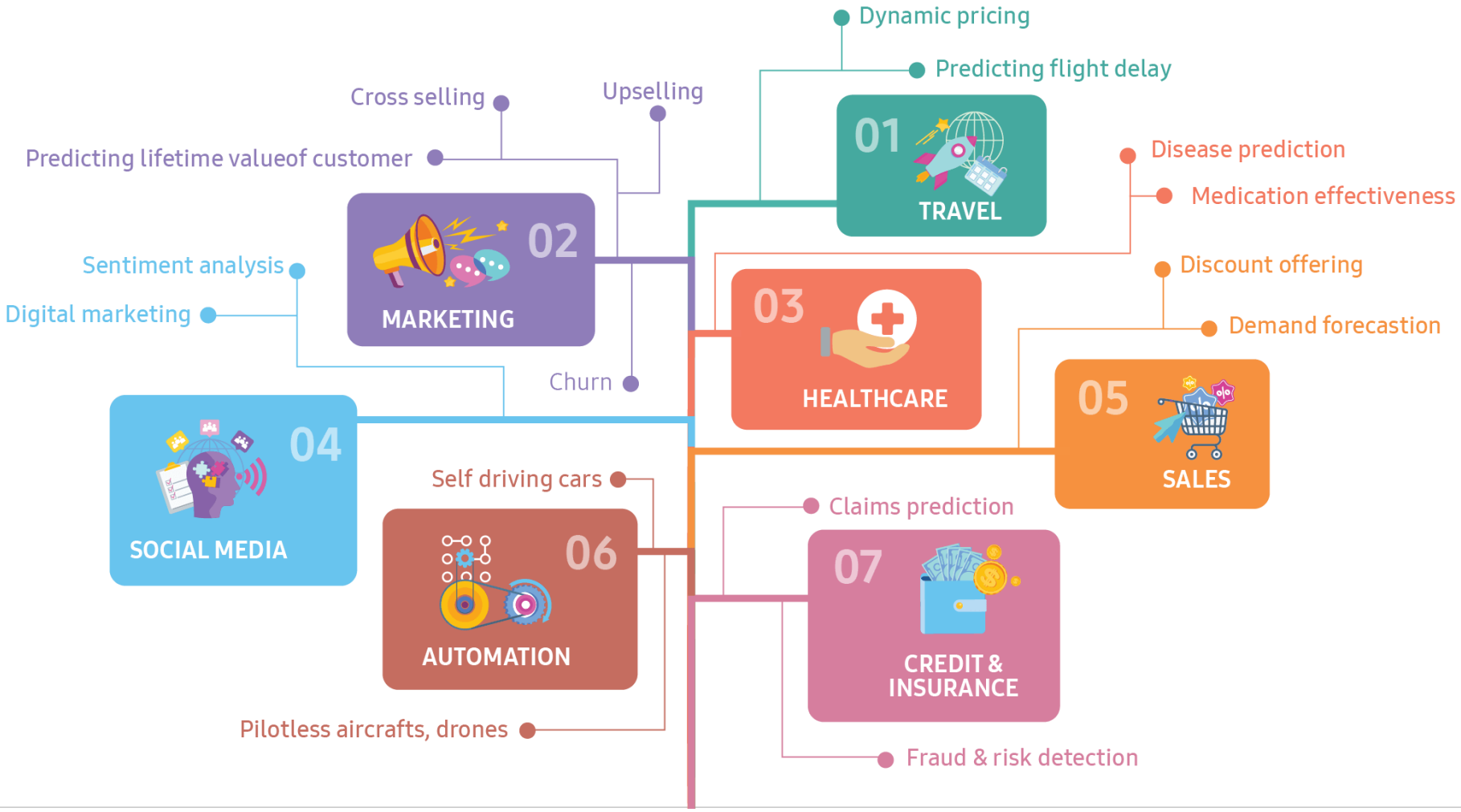


Hackernoon

Applications of Artificial Intelligence

- Image Classification: Automatically classify product images by analyzing them on the production line.
- Semantic Segmentation: Scan the brain to diagnose tumors.
- Text Classification (Natural Language Processing): Automatically classify news articles.
- Text Classification: Automatically distinguish negative comments in the discussion forum.
- Text Summary: Automatically summarize a long document.
- Understanding Natural Language: Make a chatbot or a personal secretary.
- Regression Analysis: Predict the company's revenue for next year.
- Voice Recognition: The app responds to voice commands.
- Outlier Detection: Detect fraudulent credit card transactions.
- Cluster Work: Divide customers based on purchase history and plan different marketing strategies for each set.
- Data Visualization: Express a complex dataset in a clear and meaningful graph.
- Recommendation System: Recommend products a customer may be interested in based on purchase history.
- Reinforcement Learning: Make intelligent game bots.

Applications of Artificial Intelligence



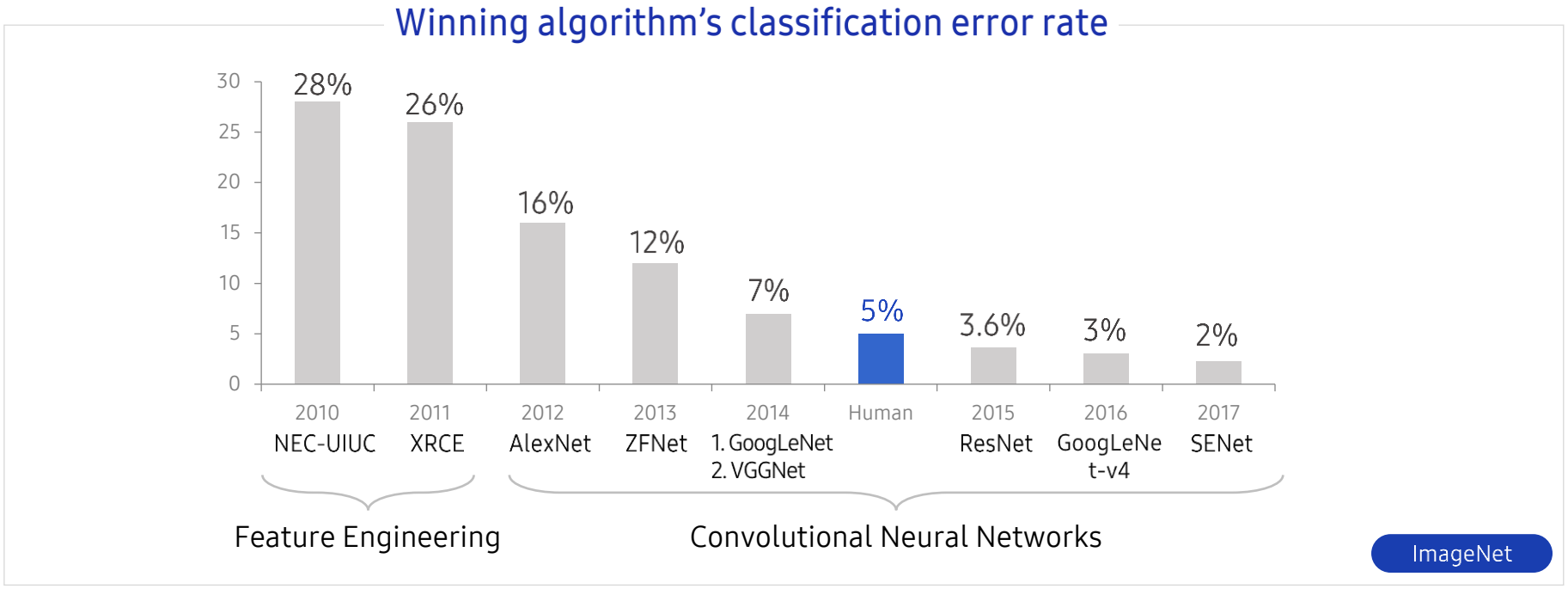
Unit 2.

Applications of Artificial Intelligence

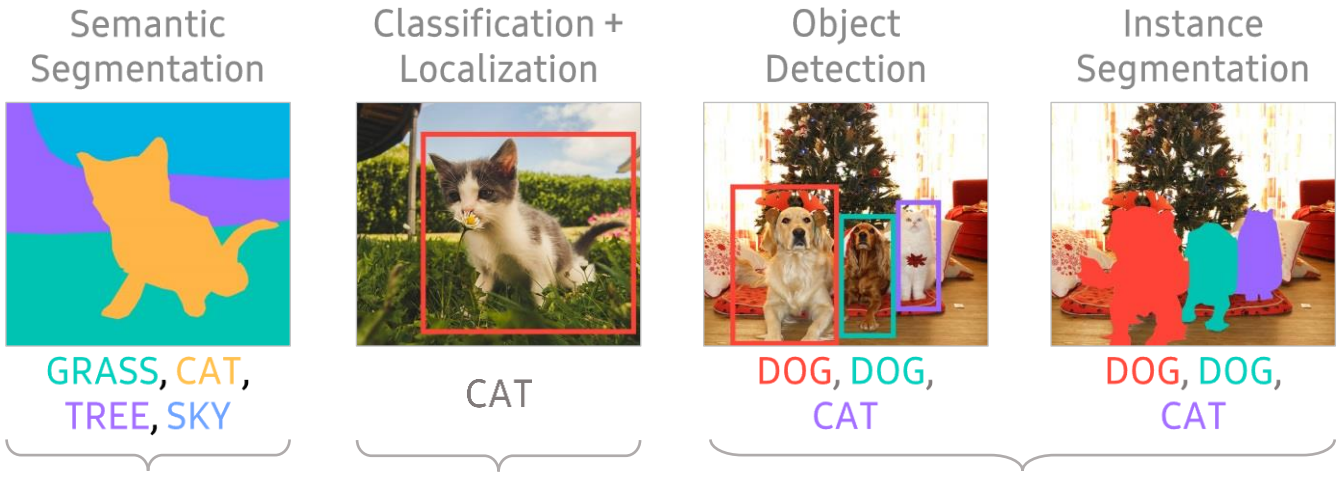
- 2.1. Applications of Artificial Intelligence
- **2.2. Image Recognition**
- 2.3. Computer Vision & Machine Vision
- 2.4. Speech Intelligence

Image Recognition

- The benchmark ImageNet classification error rate fell from 26 percent in 2011 to 3.1 percent in 2016, surpassing far beyond the human capability of a 5% error rate.
- It was not until the adoption of Convolutional Neural Networks that the image recognition's accuracy was dramatically improved.



- Image recognition refers to technologies that identify places, logos, people, objects, buildings, and other variables in images.
- Besides image recognition, computer vision also includes event detection, object recognition, learning, image reconstruction, and video tracking.



https://mlwhiz.com/blog/2018/09/22/object_detection/

Unit 2.

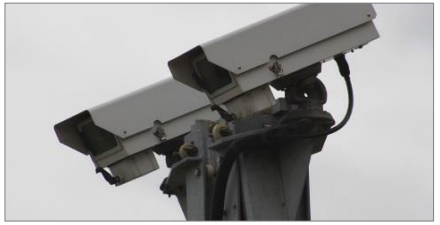
Applications of Artificial Intelligence

Computer Vision & Machine Vision

- Computer vision is an interdisciplinary scientific field that deals with how computers can be made to gain a high-level understanding of digital images or videos.
- Computer vision tasks include acquiring, processing, analyzing, and understanding digital images and extracting high-dimensional data from the real world to produce numerical or symbolic information.
- The applications of computer vision are various. They include agriculture, geoscience, biometrics, augmented reality, medical image analysis, robotics, industrial quality inspection, security, and surveillance.

Scientific Research

Natural Resources Management



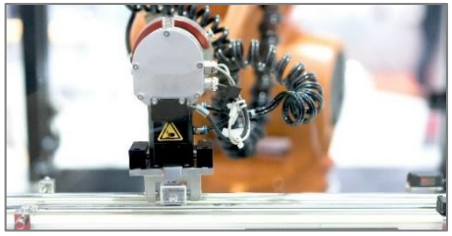
Protection and Security

Marketing

Wikipedia, Vidolab

Computer Vision & Machine Vision

- Machine vision as a systems engineering discipline is distinct from computer vision, a form of computer science. It attempts to integrate existing technologies in new ways and apply them to solve real-world problems.
- Machine vision refers to many technologies, software and hardware products, integrated systems, actions, methods, and expertise.
- Machine vision (MV) is a technology and method often used in industry to provide imaging-based automatic inspection and analysis for such applications as automatic inspection, process control, and robot guidance.



Guidance

Gauging

Defect Detection

Packaging Inspection

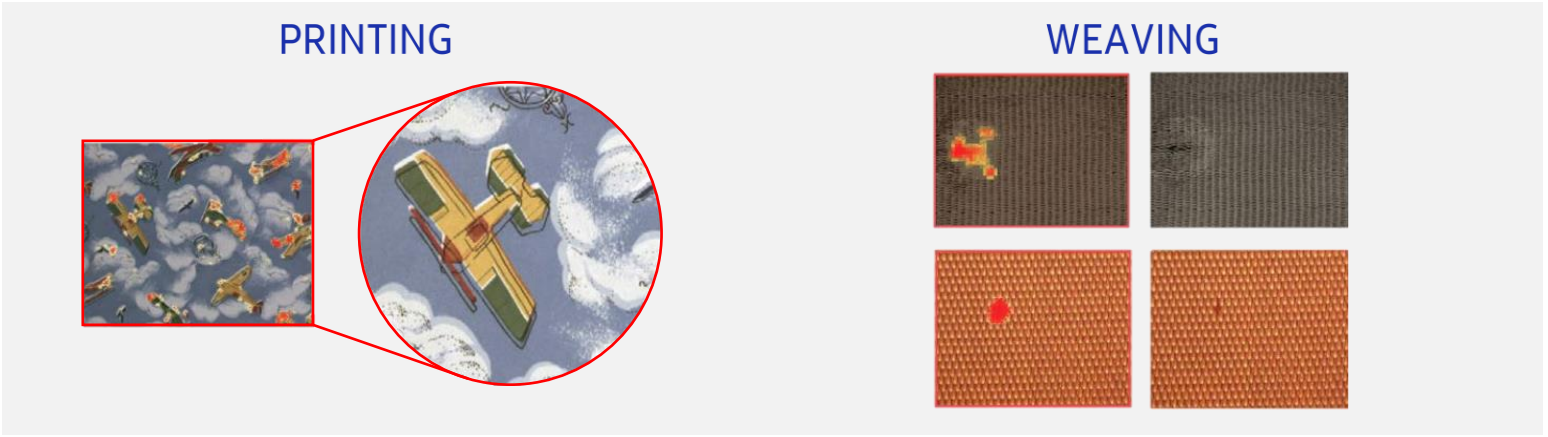
Wikipedia, Vidolab, DevisionX

Acquire Automation - Machine Vision

- Acquire Automation has a wide range of automated vision solutions that can ideally pack and verify a company's product quality at the level required by the government or regulatory body.
- For example, the manufactured bottle is inspected at 360 degrees to ensure that the product is packaged correctly and that all components are properly included.
- In detail, functions such as whether the cap is closed, seal, position and inclination, label identification, color, and barcode checks are performed.
- It also collects and provides data through machine vision technology to provide real-time production statistics and facilitate process control.

Cognex - VisionPro ViDi

- Cognex is a machine vision systems, software, and sensor manufacturer. It has launched Vision Pro ViDi, a deep learning-based image analysis software optimized for factory automation.
- VisionPro ViDi can solve defect detection, texture and material classification, assembly inspection, and text deciphering, which are difficult to program with rule-based algorithms.
- Since it is used for the special purpose of analyzing industrial images, only a few hundred images are required, and the training and verification time is short. The computing costs are also low.
- It was targeted for non-expert use in the visual field and developed according to actual factory conditions.



Cognex's brochure

Focal

- Focal is an AI and computer vision-based stock detection systems service.
- Small and inexpensive cameras are installed in each store passage, and photos are taken once every 30 minutes.
- They detect and recognize out-of-stock products in the image and provide a chart to the employees.
- It claims that it takes about four hours daily for human employees to recognize out-of-stock products.
- As labor costs increase, the number of unmanned retail stores is growing. Still, the reality is that checking and replenishing inventory has become slower as manpower decreases.
- Furthermore, instead of a barcode scan, items can be scanned and calculated with a local camera on the conveyor belt when checking out. Transaction time can be reduced by 60% when employees focus on packaging.
- By providing a comparative analysis of the inventory status of sold-out products and competitive products by the hour in the form of a chart, we can obtain insights into the store operation.

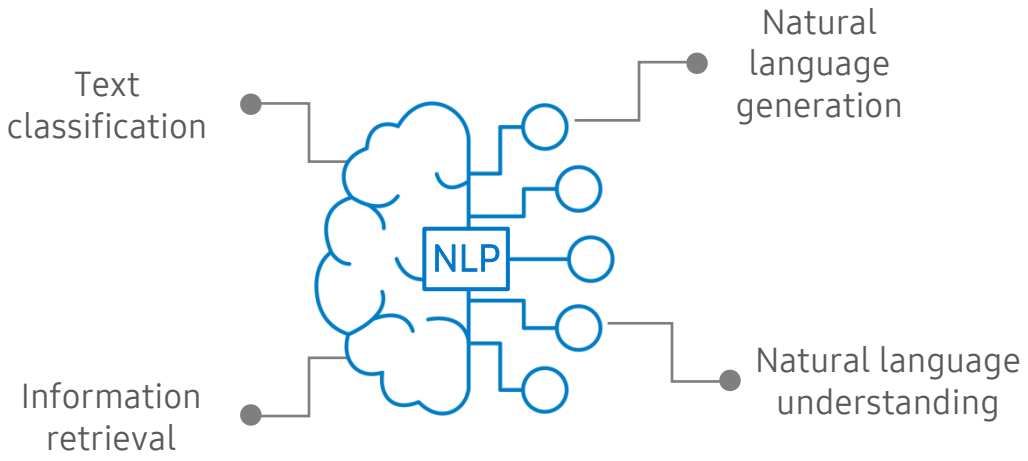
Unit 2.

Applications of Artificial Intelligence

- 2.1. Applications of Artificial Intelligence
- 2.2. Image Recognition
- 2.3. Computer Vision & Machine Vision
- **2.4. Speech Intelligence**

Natural Language Processing

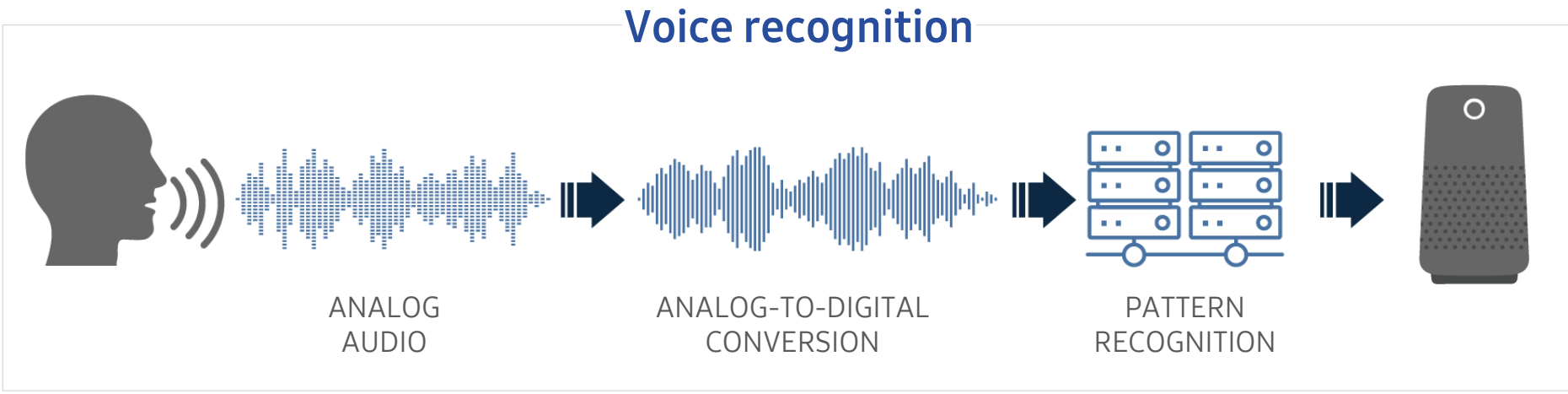
- Natural language processing (NLP) is a subfield of linguistics, computer science, information engineering, and artificial intelligence concerned with the interactions between computers and human (natural) languages, particularly how to program computers to process and analyze large amounts of natural language data.
- Challenges in NLP frequently involve speech recognition and natural language understanding and generation.
- Machine Translation, Information Retrieval, Question Answering, Information Extraction, and Summarization are the main applications of natural language processing techniques.



Wikipedia, Expert System

Speech & Voice Recognition

- Speech Recognition: Recognize words, sentences, and contents spoken by anyone.
  - General dictation, transcribing, using a computer hands-free, medical transcription, automated customer service, etc.
- Voice Recognition: Recognize the accent, pitch, or intonation of a person regardless of the language spoken.
  - Speaker verification and speaker identification



Barbie - Hello Barbie

- Barbie, the world-renowned doll manufacturer, has developed an AI toy that can talk.
- Hello Barbie analyzes and responds to children's speech using natural language processing and AI.
- When you press the conversation button on the doll, the built-in microphone records what the child says, sends it to the server. The AI selects an appropriate response and sends it back to the doll's speaker.
- Hello Barbie can remember what the children said and respond again later.

  Ex If you say that Taylor Swift is your favorite singer, the AI will repeat the same answer a few weeks later.

- The AI can predict conversations of children aged 3 to 9 and exchange conversations with children up to 200 times.

Personetics - Assist

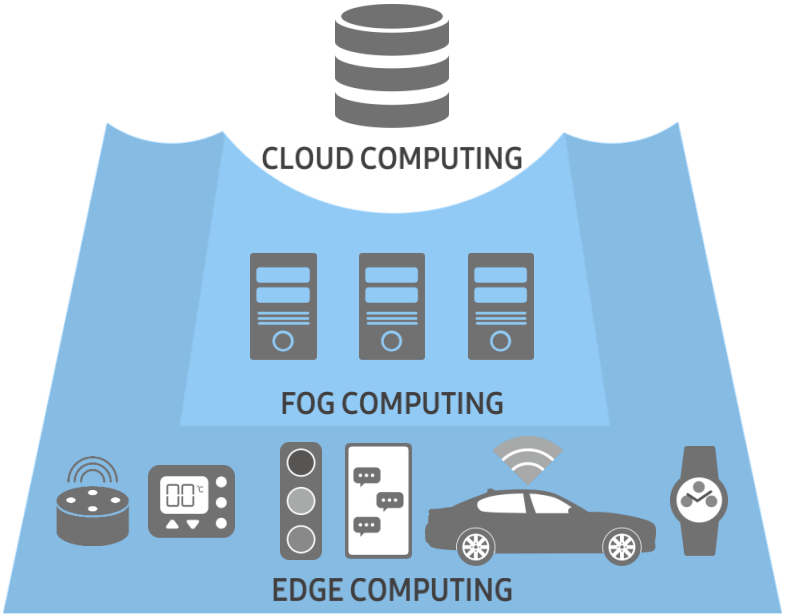
- Assist is a domain-specific advisory chatbot service that combines knowledge of consumer finance and financial industries with interactive AI functions.
- It is gaining popularity among global banks as it can conveniently provide 24-hour customer service without labor costs.
- Assist integrates the latest customer transaction data into the conversation to provide responses based on individual financial activities and banking history.
- It also uses predictive analysis to predict customer questions and problems. It provides timely insights and advice one step ahead of the customers.
- Assist is built based on natural language processing and can replace tasks such as remittance, reservation, and password change.
- It can also distribute customer interaction channels to message platforms like Facebook Messenger and AI assistant platforms like Amazon's Alexa.

Unit 3.

Techniques in Artificial Intelligence

Definition and Concept

- Instead of communicating with a central cloud or server, running AI algorithms on edge devices (ex., smartphones, cars, wearable devices, etc.) provides the ability to process information locally and respond to situations more quickly.
- For example, an autonomous vehicle must respond in real time to what's happening on the road and function in areas without internet connectivity. Decisions are time-sensitive, and latency could prove fatal.



CB Insights

Initiatives

				
Edge AI use case	In-home smart cameras that recognize persons entering an area	On-device facial recognition and object recognition, where user data does not leave the device	Instantaneous driving decisions	Vision for baby monitors, drones, robots, and other devices that can respond to situations without an internet connection
	nest aws IQ cameras, Deep Lens	HUAWEI AI processor	TESLA Custom AI chip	intel Myriad X

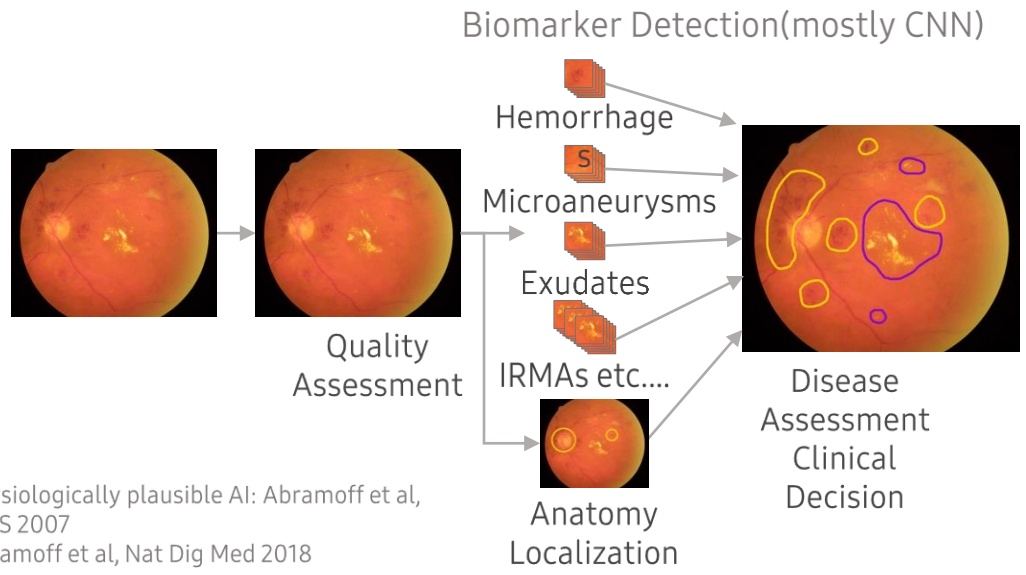
CB Insights

Unit 3.

Techniques in Artificial Intelligence

AI-as-a-medical-device

Autonomous AI algorithm based on biomarkers



Physiologically plausible AI: Abramoff et al, IOVS 2007
Abramoff et al, Nat Dig Med 2018

CB Insights, IDx

- In April 2018, the FDA approved AI-based software that screens patients for diabetic retinopathy without needing a second opinion from a medical specialist.
- The software, IDx-DR, correctly identified patients with “more than mild diabetic retinopathy” 87.4% of the time and those who did not have it 89.5% of the time.
- IDx is one of the many AI-based software products approved by the FDA for clinical and commercial applications recently.

AI-as-a-medical-device

Diabetic Retinopathy

- FDA clearance
- AI-based software that screens patients for diabetic retinopathy without confirmation from medical specialists

Liver and Lung AI Lesion

- FDA clearance
- GE Ventures-backed startup
- Oncology AI suite initially focused on spotting lung and liver lesions.

CT-Scan Analysis for Strokes

- FDA clearance
- Analyze CT scans and notify healthcare providers of potential strokes in patients
- $21M Series A round from Google Ventures and Kleiner Perkins Caufield & Byers

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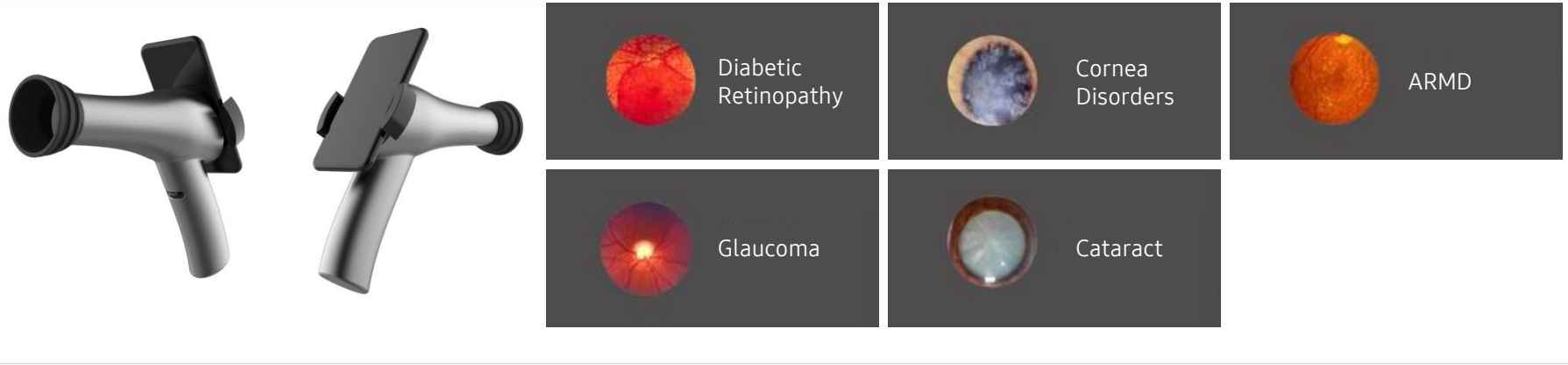
Portable Ophthalmoscope Based on AI (Project Powered by Samsung)

- Developed a portable diagnostic device and diagnosis support algorithm based on image processing for underserved people in Vietnam.
- 40,000 images are being accumulated per month.
- Detect anomalies from eye images based on Machine learning and classify the image for triage.



Samsung, Project BOM

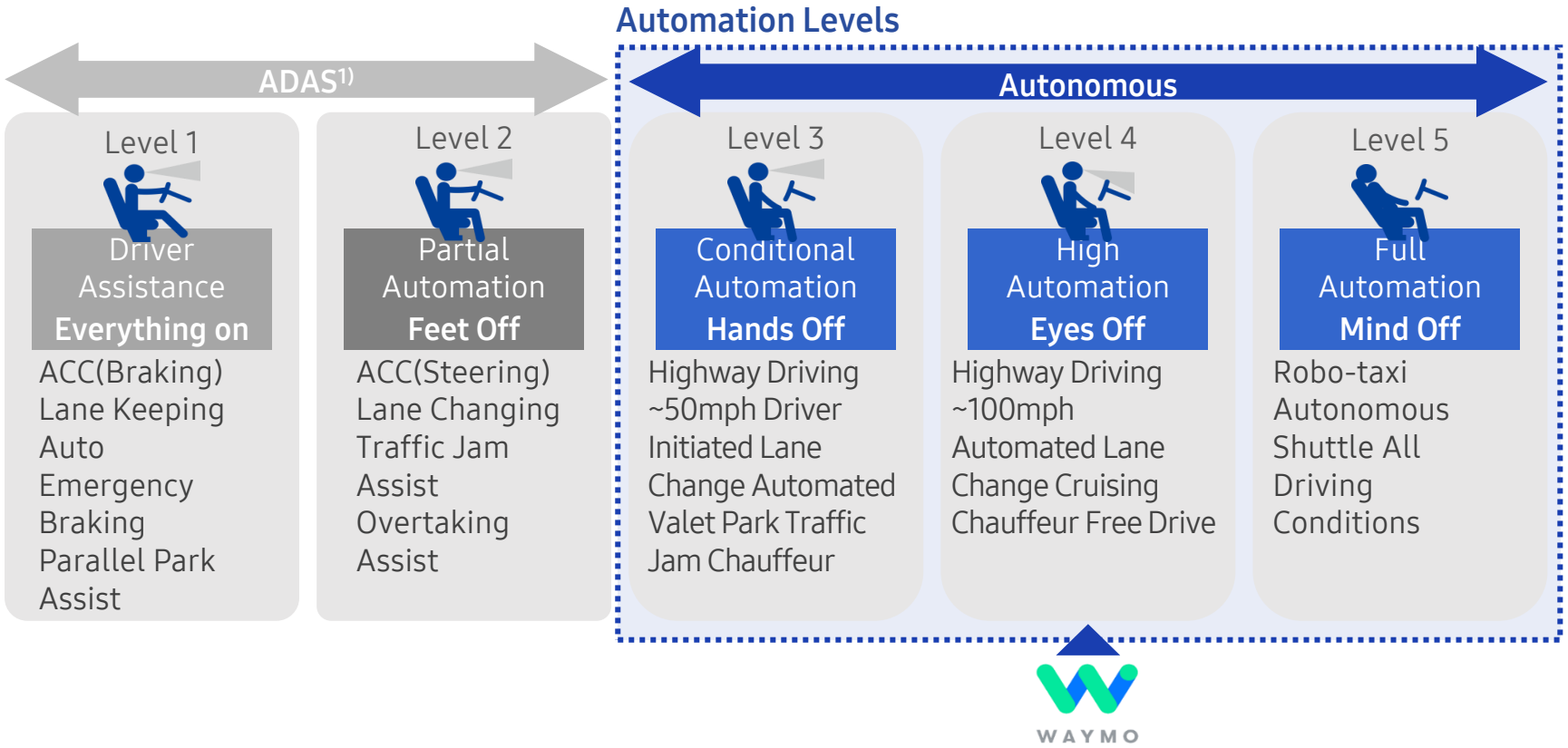
Unit 3.

Techniques in Artificial Intelligence

- 3.1. Edge AI
- 3.2. Medical Imaging & Diagnostics
- **3.3. Autonomous Vehicle**
- 3.4. Reinforcement Learning
- 3.5. Conversational AI
- 3.6. GAN, XAI, Synthetic Training Data

Autonomous Vehicle

Level of Automation

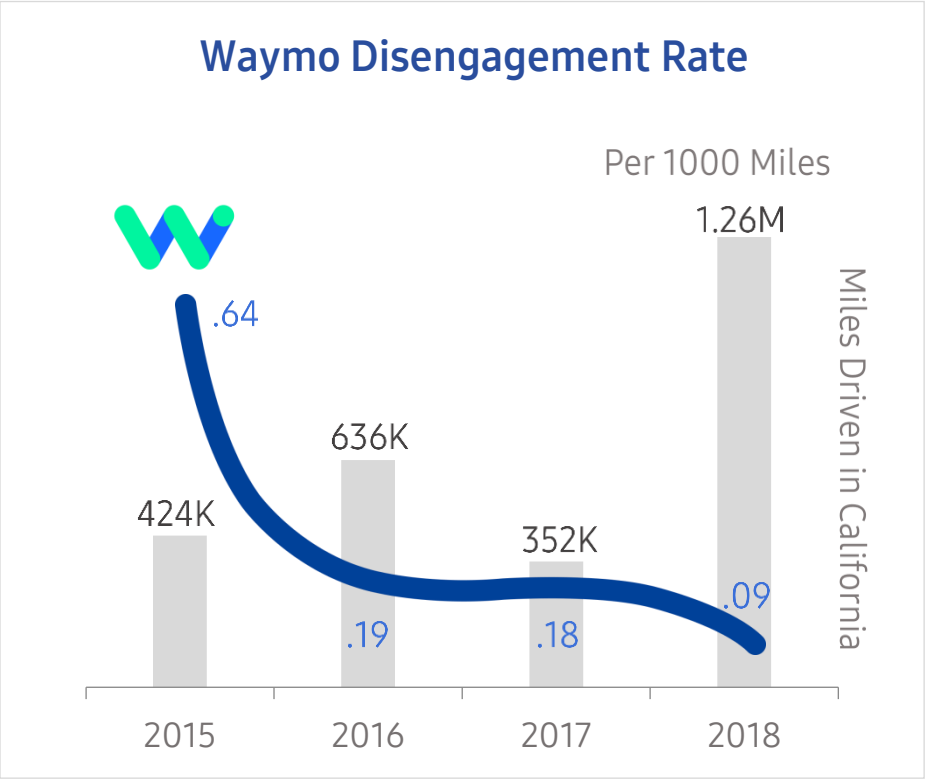


Note: 1) ADAS : Advanced Driver Assistance Systems

IEEE Spectrum, SAE International, Evercore ISI

Miles per Disengagement

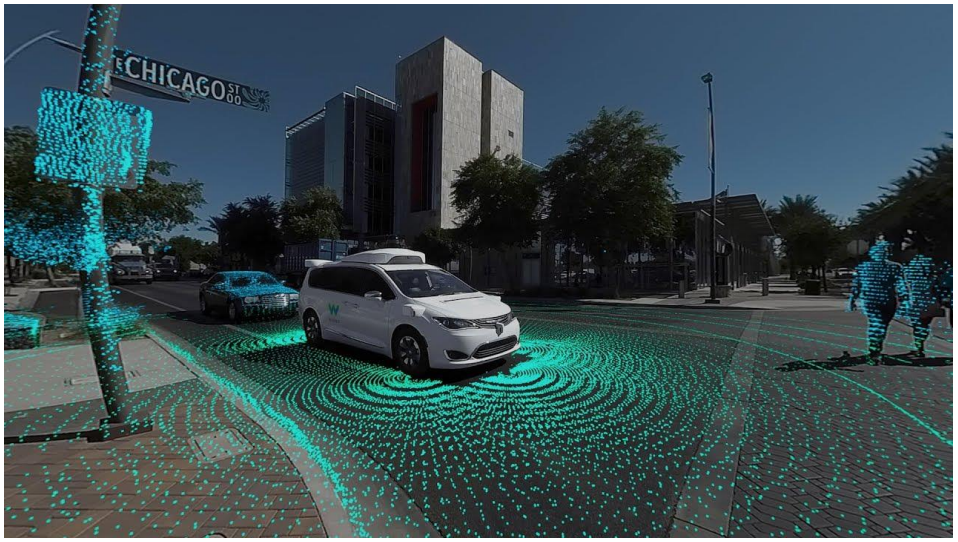
- All companies actively testing self-driving cars on public roads in California are required to disclose the number of miles driven and the frequency in which human drivers were forced to take control of their driverless vehicles - also known as a “disengagement.”
- Waymo said its autonomous system only disengaged at a rate of once every 11,017 miles. GM Cruise reported the second-lowest disengagement rate, with a safety driver taking over every 5,205 miles
- Other startups making progress include Zoox (0.50 disengagements per 1,000 miles), Nuro (0.97 disengagements per 1,000 miles), and Pony.ai (0.98 disengagements per 1,000 miles).



The Verge, Forbes

Miles per Disengagement

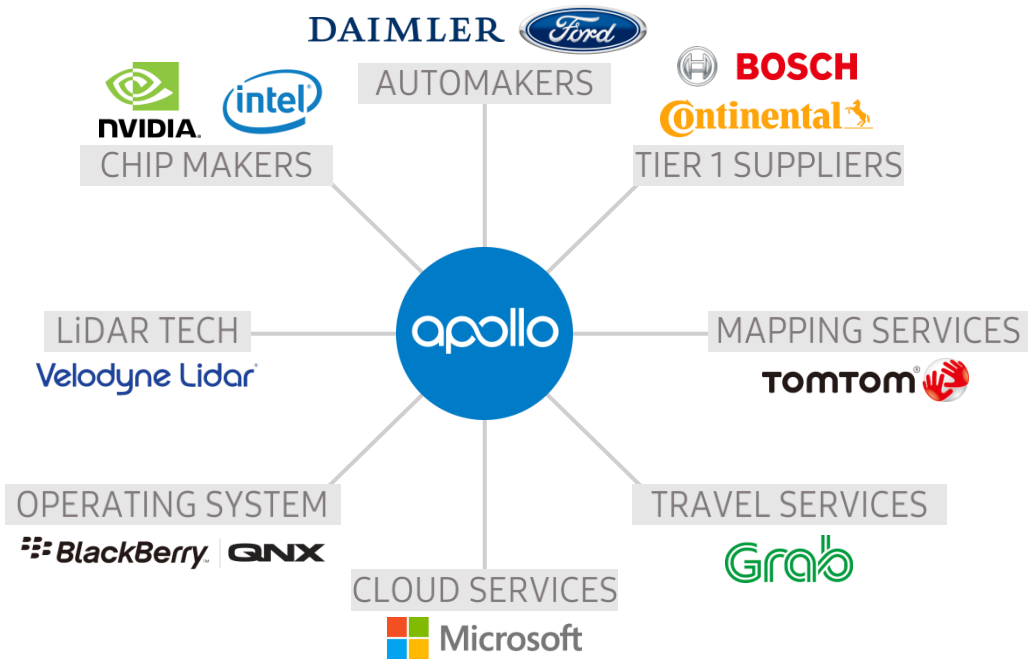
- Google has made a name for itself in the auto space. Its self-driving project Waymo is the first autonomous vehicle developer to deploy a commercial fleet of AVs.
- Investors remain confident in companies developing the full autonomous driving stack, pouring hundreds of millions of dollars into GM's Cruise Automation ($750M from Honda in October 2018 and $900M from SoftBank in May prior) and Zoox ($500M in July 2018). Other startups here include Drive.ai, Pony.ai, and Nuro.



https://www.forbes.com/sites/alanohnsman/2018/03/02/waymo-is-millions-of-miles-ahead-in-robot-car-tests-does-it-need-a-billion-more/#c854b381ef4c

China Market

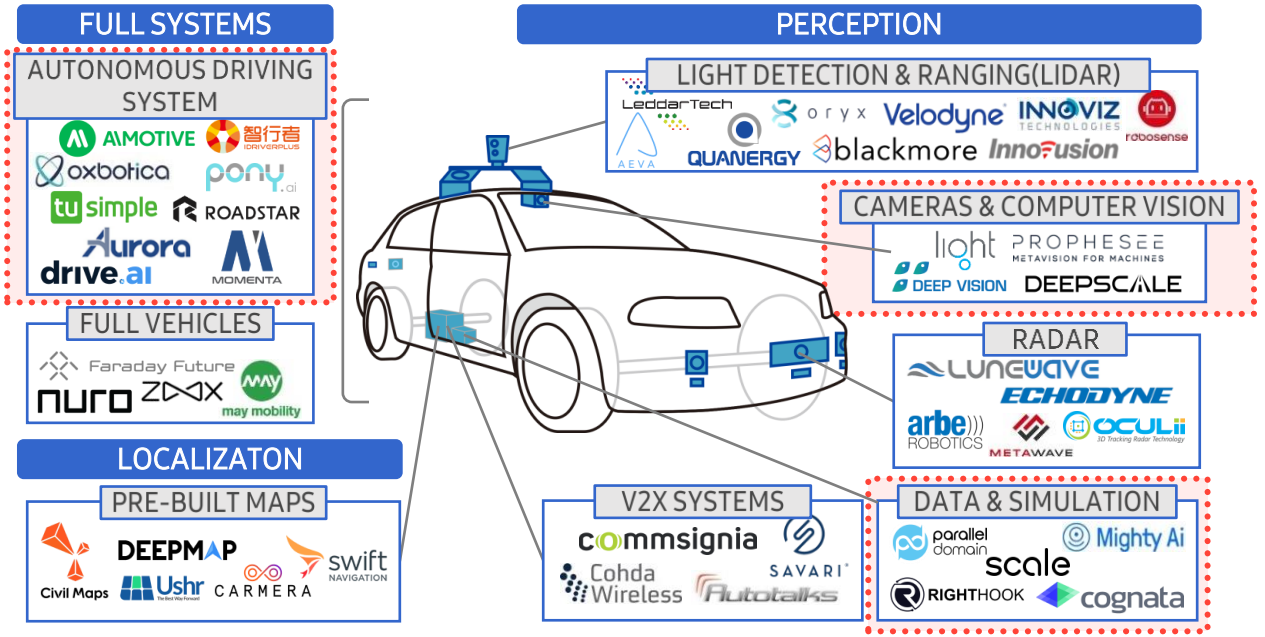
- The Chinese science ministry announced last year that the nation's first wave of open AI platforms will rely heavily on Baidu for autonomous driving
- In April 2017, Baidu announced a one-of-a-kind open platform called Apollo for autonomous driving solutions, roping in partners from across the globe



CB Insights

Unbundling the Autonomous Vehicle

AUTONOMOUS DRIVING SYSTEMS	COMPUTER VISION	DATA & SIMULATION
• Drive.ai • Momenta • Pony.ai	• DeepScale • Prophesee	• Cognata • NVIDIA



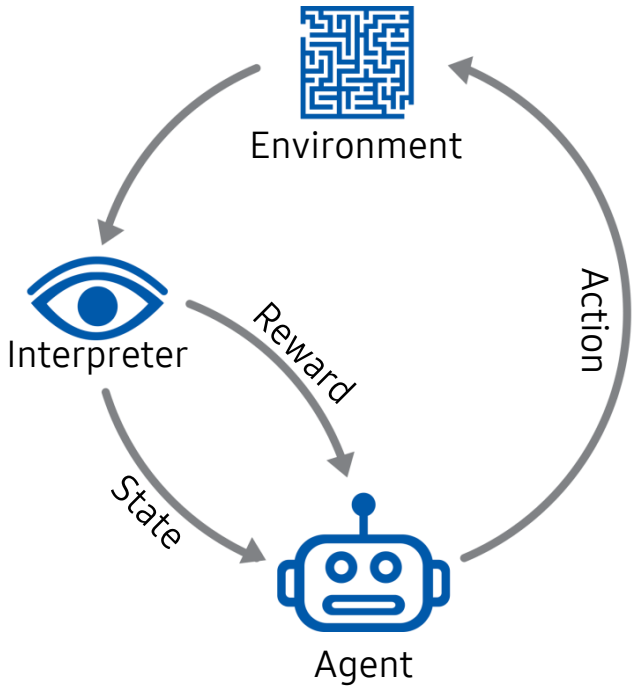
Insights

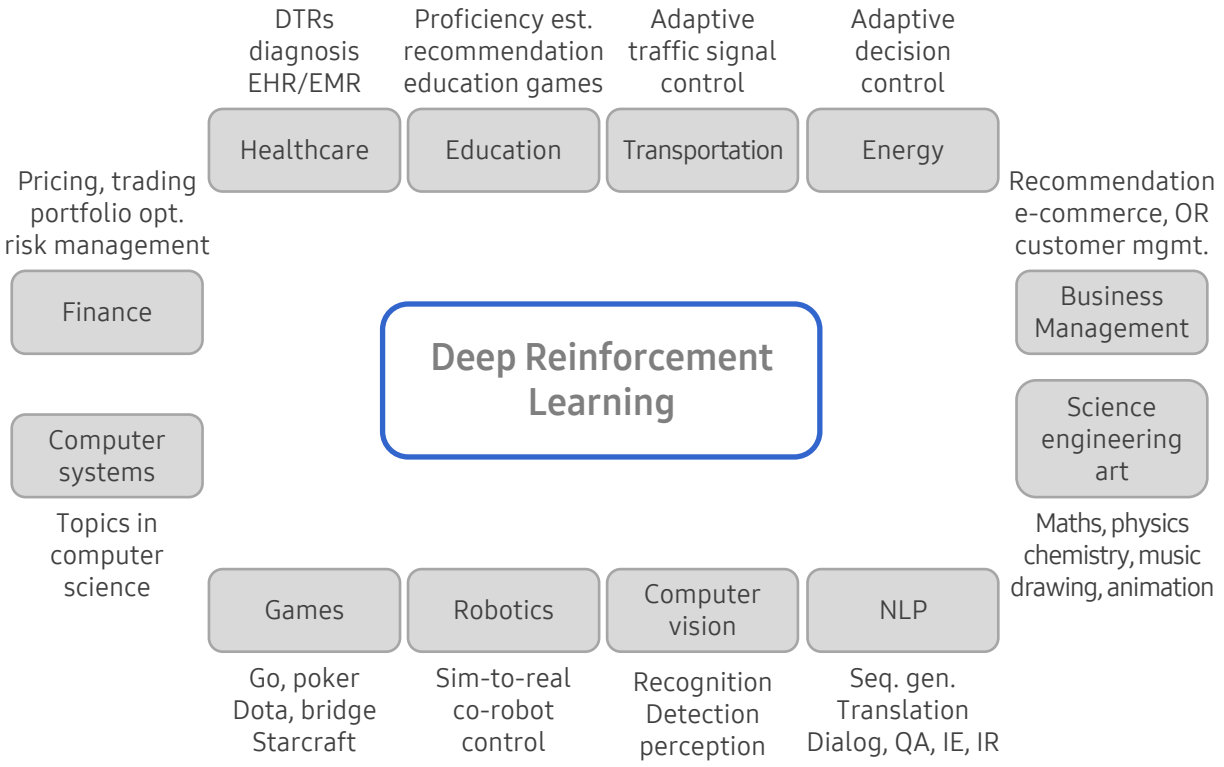
Unit 3.

Techniques in Artificial Intelligence

Reinforcement Learning

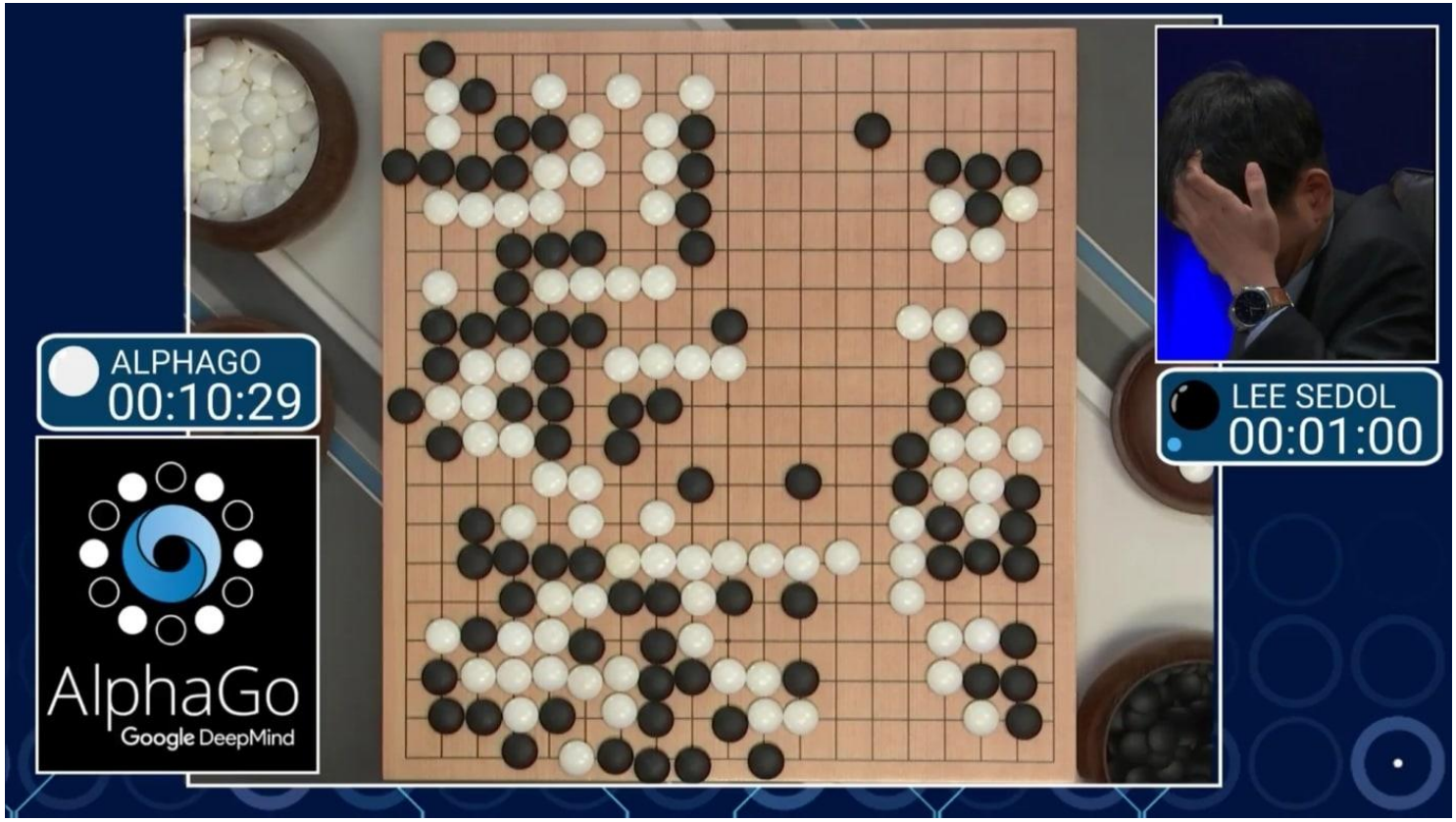
Definition and Application





Yuxi Li, Deep Reinforcement Learning, arXiv, 2018

Definition and Application



https://dimensionless.in/reinforcement-learning-super-mario-alphago/

Unit 3.

Techniques in Artificial Intelligence

- 3.1. Edge AI
- 3.2. Medical Imaging & Diagnostics
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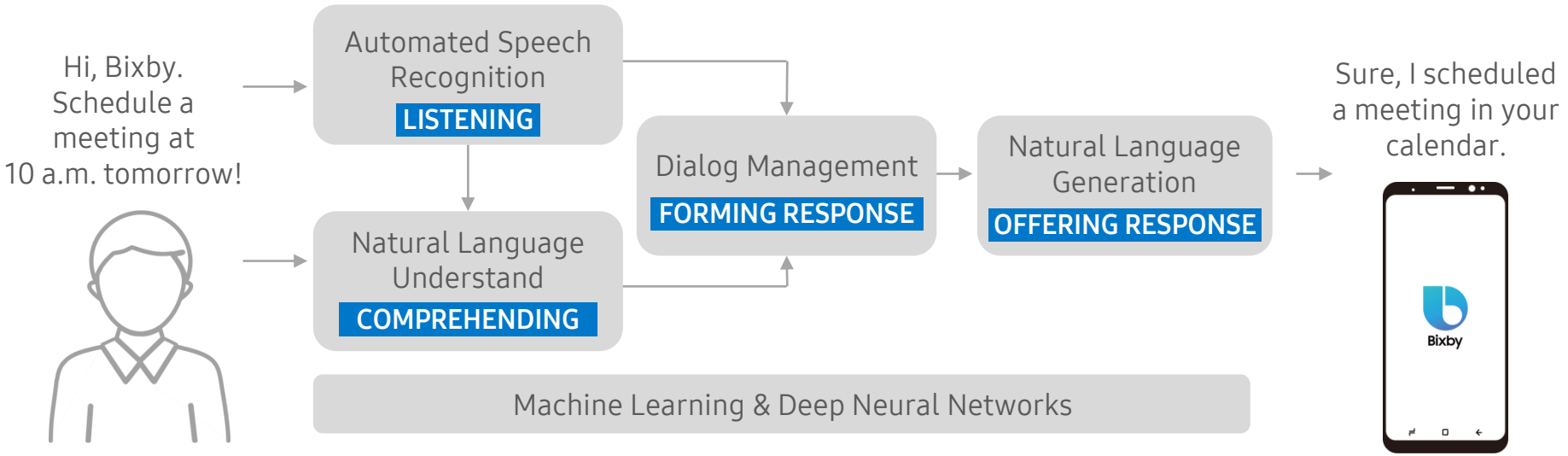
- **3.5. Conversational AI**
- 3.6. GAN, XAI, Synthetic Training Data

Conversational AI

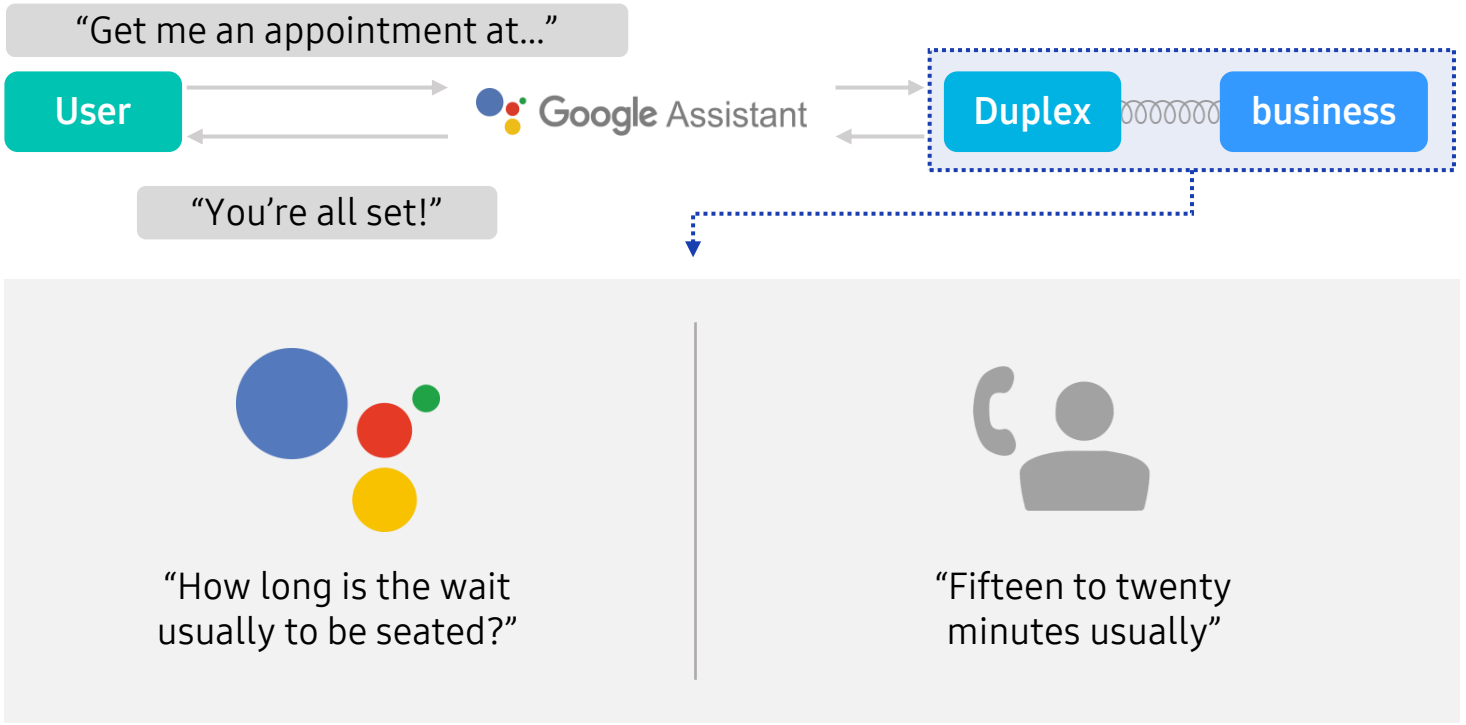
Voice Assistant



CB Insights, Interactions

Duplex

- Duplex can make phone calls and reservations on behalf of the user, communicating like a real human. Google added Duplex to its new phone, Pixel 3. It has turned the Pixel 3 into an AI powerhouse, including a “screen call” option that allows the Google Assistant to screen for spam callers.



CB Insights, Google

Unit 3.

Techniques in Artificial Intelligence

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- **3.6. GAN, XAI, Synthetic Training Data**

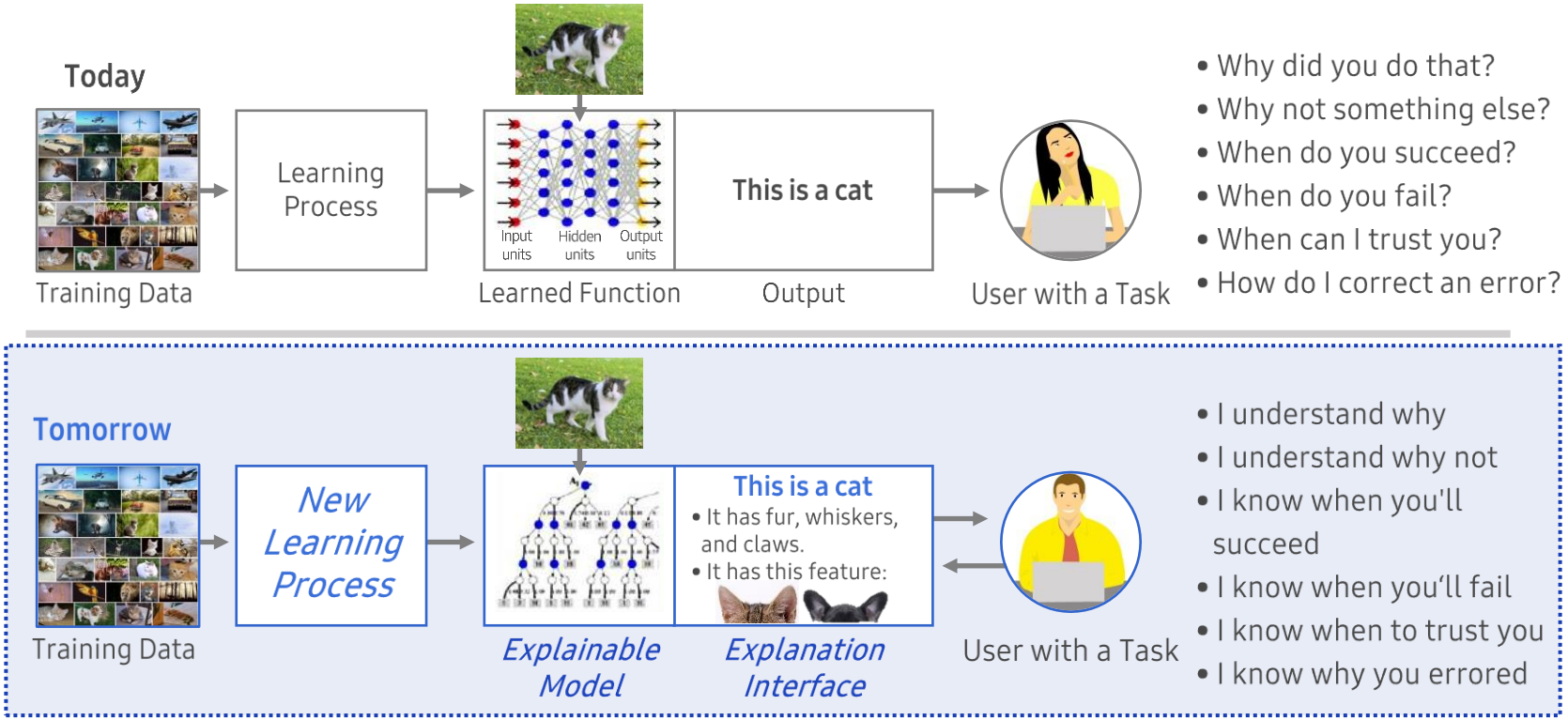
Generative Adversarial Network (GAN)

Deep fake

- Pictures on this page are all generated by artificial intelligence.
- Generative Adversarial Network, also known as GAN, brought groundbreaking innovations in artificial intelligence, especially in generating fake images and videos.
- In 2018, researchers at Carnegie Mellon University created a video in which two people showed exactly the same facial expression simultaneously – it is called deep fake.
- With the recycled-GAN algorithm, the quality of the fake video was significantly enhanced.

XAI (eXplainable AI)

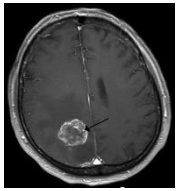
What are we trying to do?



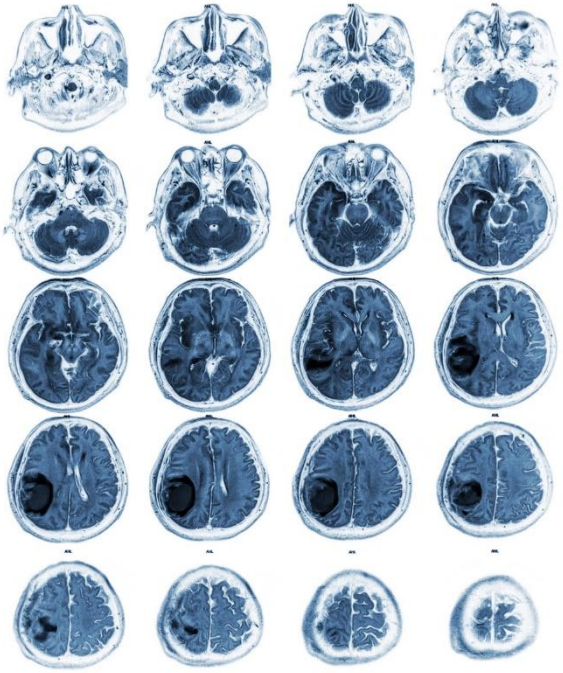
DARPA

Synthetic Training Data

Synthetic Brain Tumor MRI images



Original Brain Tumor Image



Synthetic Brain Tumor Image
for training tumor segmentation algorithm

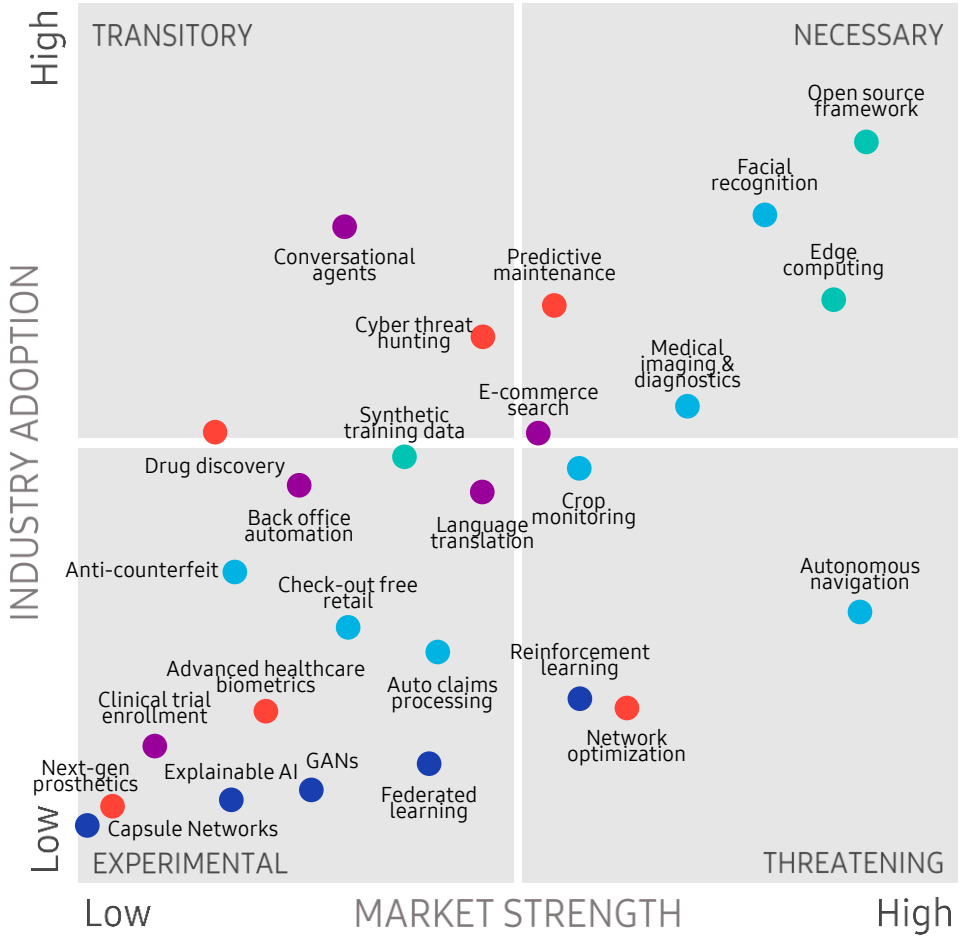
- Researchers generated synthetic medical images of brain tumors by training a generative adversarial network algorithm with publicly available MRI data
- With synthetically generated data,
  - they were able to improve the accuracy of tumor segmentation.
  - they used the generative model as an anonymization tool which mitigates the risk of using patients' medical data without permission.

DARPA

Unit 4.

Artificial Intelligence: Trends and Markets

Trend Matrix



- Application: Computer vision
- Application: Natural language processing / synthesis
- Application: Predictive intelligence
- Architecture
- Infrastructure

Artificial Intelligence Trends 2019, CB Insights

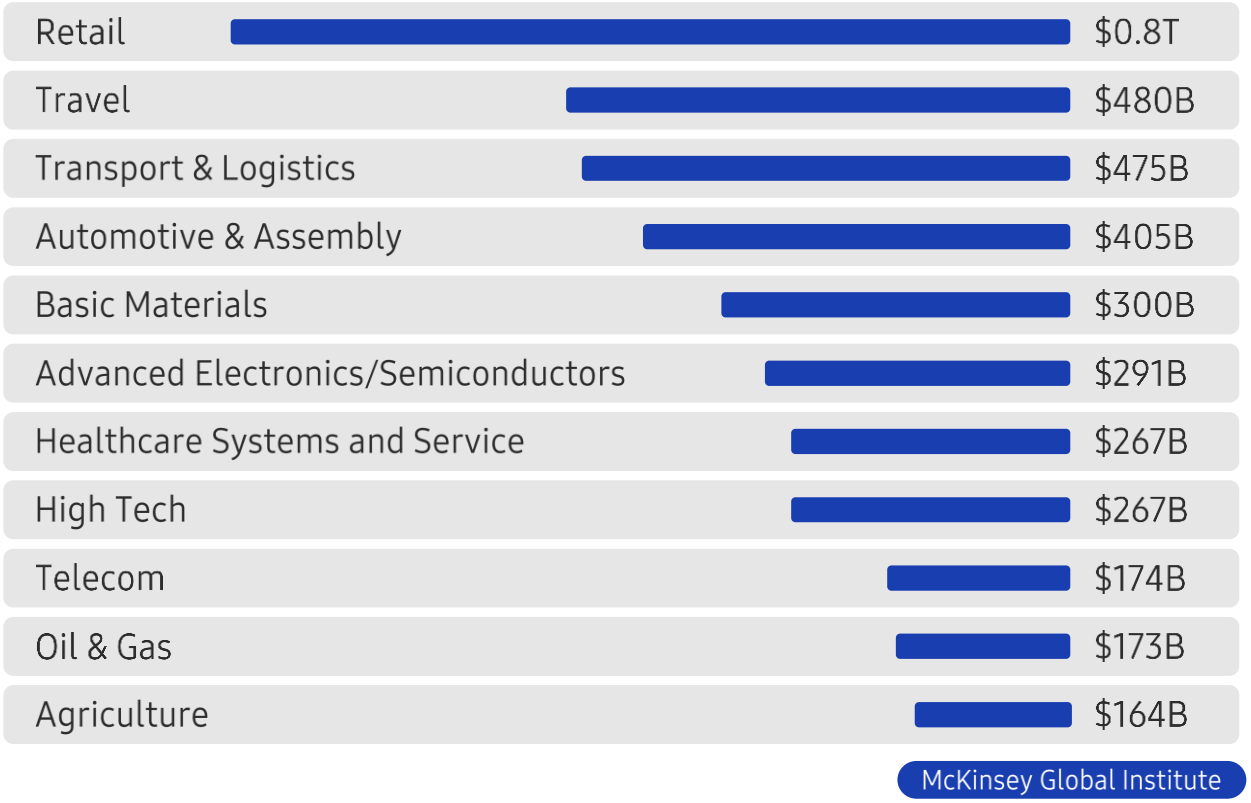
Unit 4.

Artificial Intelligence: Trends and Markets

AI Value Creation by 2030

Innovation created by artificial intelligence (AI) started in the software industry and will soon revolutionize all other industries. The value created by artificial intelligence will reach 13 trillion dollars by 2030.

$13 Trillion



Unit 4.

Artificial Intelligence: Trends and Markets

AI in Sustainable Energy

Green AI establishes a connection between computing power and carbon emissions, allowing one to manage the carbon cost of huge AI computing demands to some extent.

- Today, greenhouse emissions from the information and communication technology (ICT) industry account for 2% of total emissions (as much as all air traffic). Failure to confirm this will increase up to 14% of global emissions. AI itself can be used for eco-friendly projects.
- Examples

- Space Intelligence, a British startup, applies machine learning and AI to satellite data to solve environmental problems such as re-seasoning, allowing the industry to take corrective action.

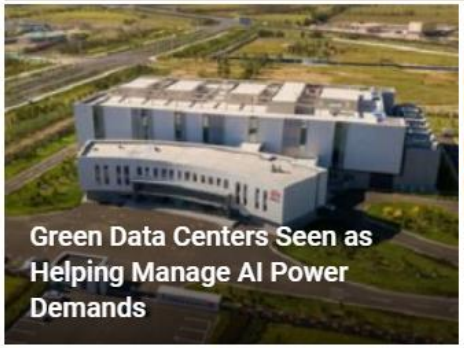
- Google has promised not to use carbon by 2030. At the recent Google I/O 2021 event, the company explained these efforts in detail by announcing plans to use geothermal energy to power data centers in Nevada.
- Kate Brandt, Google's head of sustainability, said, "We are the first company to sign a contract for next-generation geothermal power."

AI in Sustainable Energy

Green AI Seeks to Connect Compute Power to Carbon Emissions

May 27, 2021

AI is Helping Forecast the Wind, Manage Wind Farms



Green Data Centers Seen as Helping Manage AI Power Demands

Marine Battery Production Making Gains Through Automation

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Unit 4.

Artificial Intelligence: Trends and Markets

AI in Financial Services

Cyber-attacks and identity fraud losses increased sharply in 2020. The pandemic set the stage for combining AI and biometric recognition to make telecommuting a standard and achieve a higher level of protection.

- Banks worldwide saw a 238% surge in cyber attacks between February and April 2020.
- According to a Javelin Strategy & Research study, ID fraud losses rose to $56 billion last year. Fraudsters created synthetic IDs using stolen personal information, as accounted by Pymnts.com.
- In addition, the number of automated bot attacks increased by 100 million between July and December for companies in various industries.
- Companies that strive for better protection risk making their customers' lives more difficult. It has been reported about 40% of financial institutions often mistake legitimate customers' online behavior for fraudulent behavior.

Security Benefits of AI and Biometric Recognition

- AI can prevent digital identity fraud by providing higher accuracy and speed when verifying an individual's identity. Or it can integrate biometric data so that cybercriminals cannot access information simply by providing credentials.

Pandemic-changed Consumer Financial Behavior, Causes Identity Fraud

- The global pandemic has had a dramatic impact on consumer financial behavior. In 2020, consumers spent more time at home, there was less trading than the previous year, and they relied heavily on streaming services, digital commerce, and digital payments.
- They also communicated more via email and text about work and personal life.

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Unit 4.

Artificial Intelligence: Trends and Markets

AI in Government

- Wisconsin Department of Workforce Development (DWD) summarized the 2020 backlogs for thousands of unemployment insurance claims with the help of AI cloud computing tools that surged during the pandemic.
  - DWD handles an average of 157,000 claims per week and has paid a total of $2 billion in unemployment benefits since the pandemic outbreak. According to GCN's recent account, the agency can now release funds within three business days.
  - The process took weeks or months, according to Brent Mitchell, the head of state and local governments in Google's public sector. Recovery was helpful by DWD hiring, contracting, or rearranging 1,300 people to help with backlogs.
  - **DWD used Google Cloud's DocAI service along with AI and machine learning products.** DocAI is used to add value by suggesting ways to automate the extraction of sensitive data from documents and simplify workflows. **The Human-in-the-Loop AI function increases accuracy by adding human review.**

"With design thinking, close partnerships with state officials, and combination of modern technologies, DWD's solutions are customized to maximize benefits to components," said Mitchell.

AI in Government

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Unit 4.

Artificial Intelligence: Trends and Markets

AI in Healthcare

In February, the U.S. Food and Drug Administration (FDA) announced a plan regarding the direction for manufacturers that seek FDA approval for innovative medical devices using AI. As a part of this medical device execution plan, the FDA announced AI and machine learning software.

- "Artificial Intelligence (AI) and machine learning (ML) technologies have the potential to transform healthcare by drawing new and important insights from vast amounts of data generated during daily healthcare service," said the author of the report.
- This report is a follow-up to the FDA's 2019 efforts to begin discussions on how to proceed with medical devices using AI in response to a request to update the approval process. "The FDA's traditional paradigm for regulating medical devices is not designed for adaptive artificial intelligence and machine learning technologies," said the author of the FDA report.
- The FDA's action plans look for manufacturers' commitments to maintain device performance with processes for periodic updates as these devices develop. This way, the FDA and manufacturers can evaluate software products from pre-marketing development to post-marketing performance.
- This allows the FDA to accommodate the power of AI and ML-based software on medical devices while ensuring patient safety.

AI in Healthcare

The author identified promising target uses of AI SaMD in the field of medical devices, including the following:

- **Heart Disease Diagnosis**: A machine learning algorithm was used to train AI platforms using data from 3,013 patients. It integrated age and gender paired with high-sensitivity heart troponin I concentration (myocardial ischemic injury index).
  - The platform was then tested on 7,998 patients suspected of myocardial infarction. It surpassed doctors with 82.5% sensitivity and 92.2% specificity.
- **Detecting Retinopathy:** Diabetic retinopathy (DR) is one of the main causes of preventable blindness worldwide. The U.S. Academy of Research Ophthalmology tested an artificial intelligence engine that distinguishes healthy fundi in people with DRs using 75,137 public fundus images in diabetic patients. As a result, the sensitivity and specificity were at an impressive 94% and 98%, respectively.
- **Biosensors for Vital Sign Monitoring**: Biosensor-based devices generate vast data sets. AI can be used to predict trends and disease probabilities.
  - A good example is the integration of AI into a heart monitoring-based biosensor for field treatment (POC) diagnosis. Machine learning algorithms are used with microchip-based heart biosensors for real-time health monitoring and to provide timely and accurate clinical decisions.

AI in Healthcare

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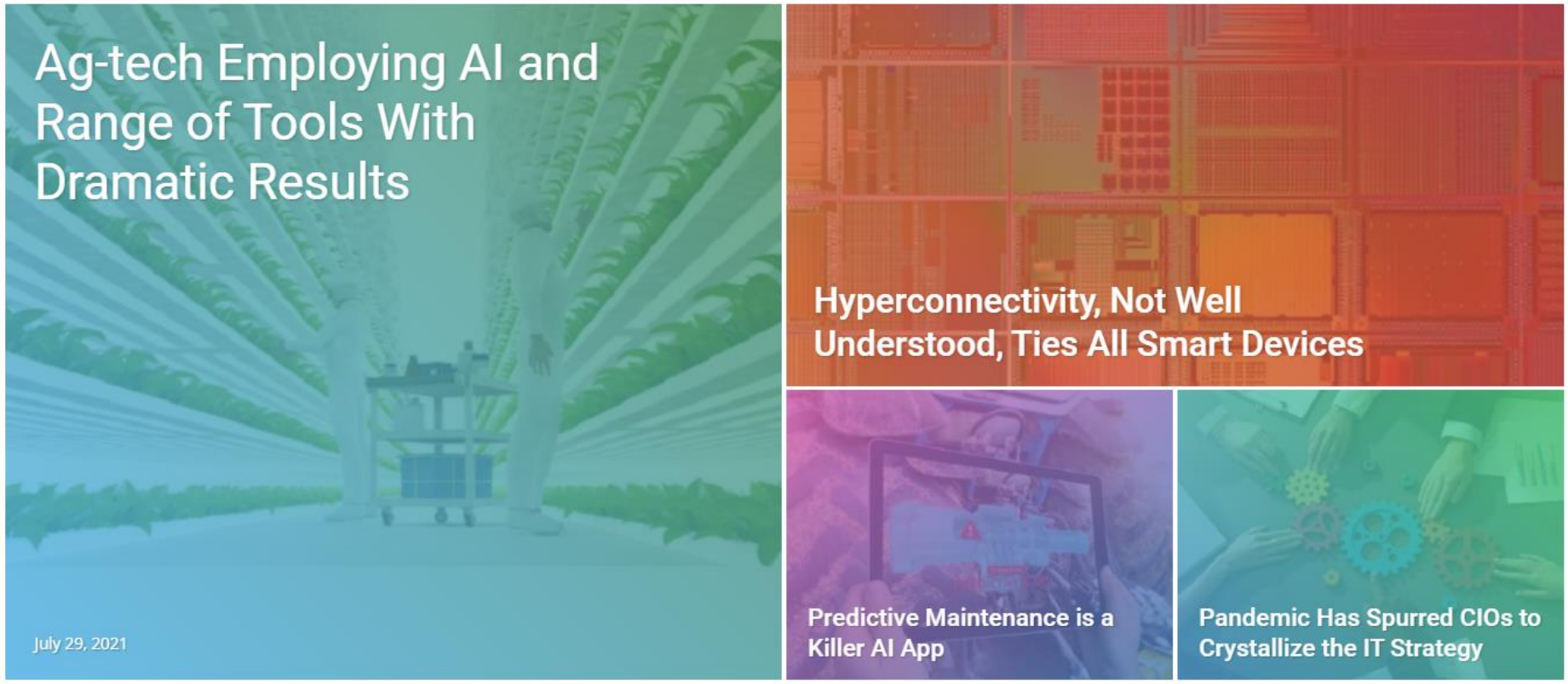
Unit 4.

Artificial Intelligence: Trends and Markets

IoT and AI in Agriculture

- Agricultural Technology (ag-tech) startups in Plenty, San Francisco, use AI and robots to plant crops vertically indoors throughout the year.
  - Plenty's vertical farm approach can produce the same amount of fruit and vegetables from only 2 acres compared to a flat farm of 720 acres.
  - Plenty is one of the hundreds of **ag-tech startups** that receive billions of dollars of investment in the capital market using new technology approaches. These include AI, drones, robots, and IoT sensors.
  - Plenty's climate-controlled farm is lined with vertically growing plants hanging from the ceiling. The LED lights imitating the sun illuminate plants, and robots move around them. AI manages all variables of water, temperature, and light. AI continues to learn and optimize how to grow better crops.
  - In addition, vertical farms are located in urban areas and can produce local food, removing the need for transport miles. Benefits of locally produced crops include reduced CO2 emissions from transport vehicles and potentially reduced consumer prices.
  - "The collapse of the supply chain caused by COVID-19 and natural turmoil, such as the fires in California this year, shows that the need for predictable and durable product supply can only come from vertical agriculture," said Storey.

IoT and AI in Agriculture



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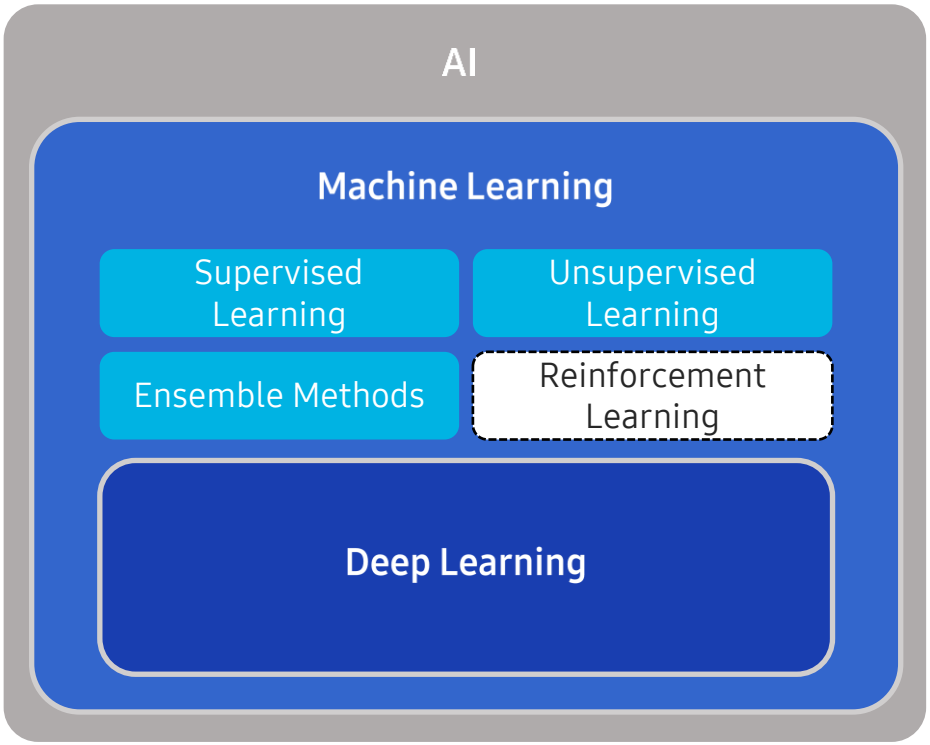
Unit 5.

Course Roadmap

- 5.1. Artificial Intelligence Course Roadmap
- 5.2. Category of Machine Learning Techniques (Full)

Artificial Intelligence Course Roadmap

Course Coverage



- Artificial Intelligence course in Samsung Innovation Campus will deal with the majority of key concepts and techniques of AI, except reinforcement learning.
- Since reinforcement learning is an advanced AI technique, it is not easy to learn in the short term. For those interested, starting to learn the topic by yourself during or after the course is highly recommended.
- The course will focus mainly on practical knowledge of how to code by yourself.

Unit 5.

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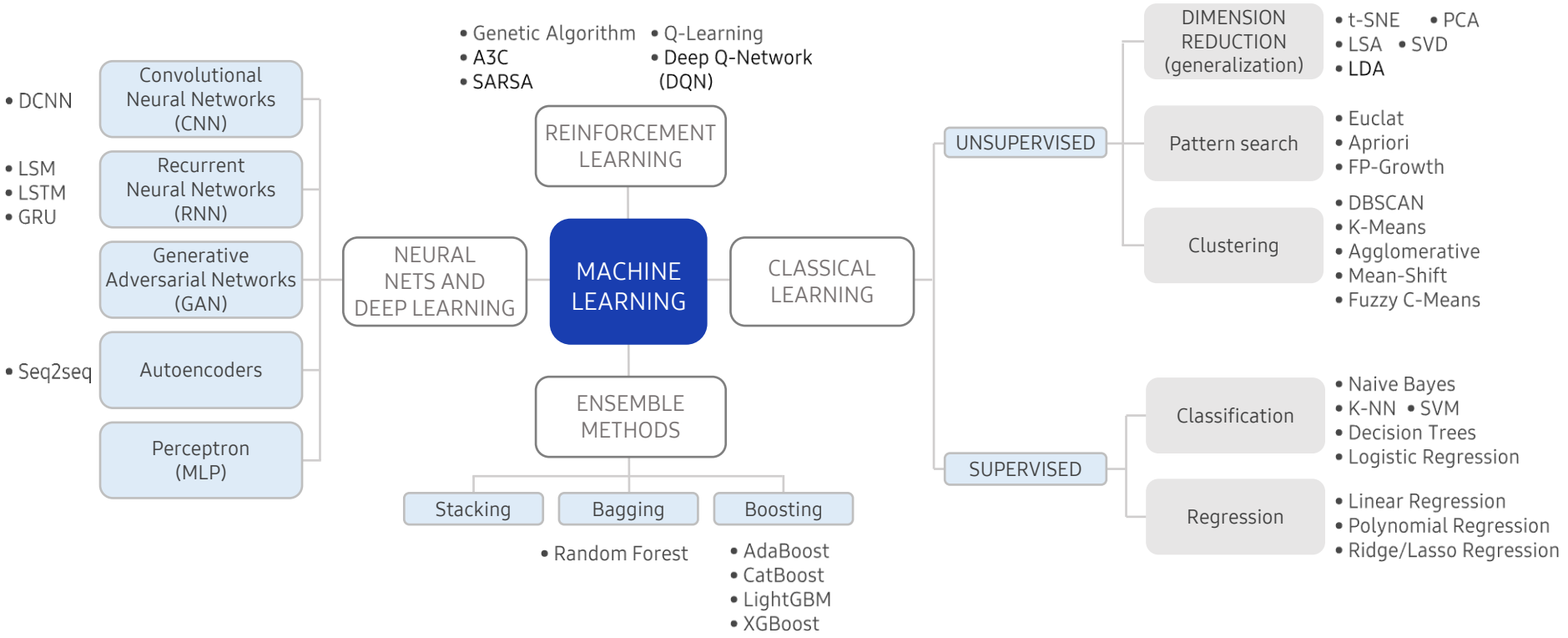


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