산업문제 해결을 위한 AI

윤성호 (Andre)

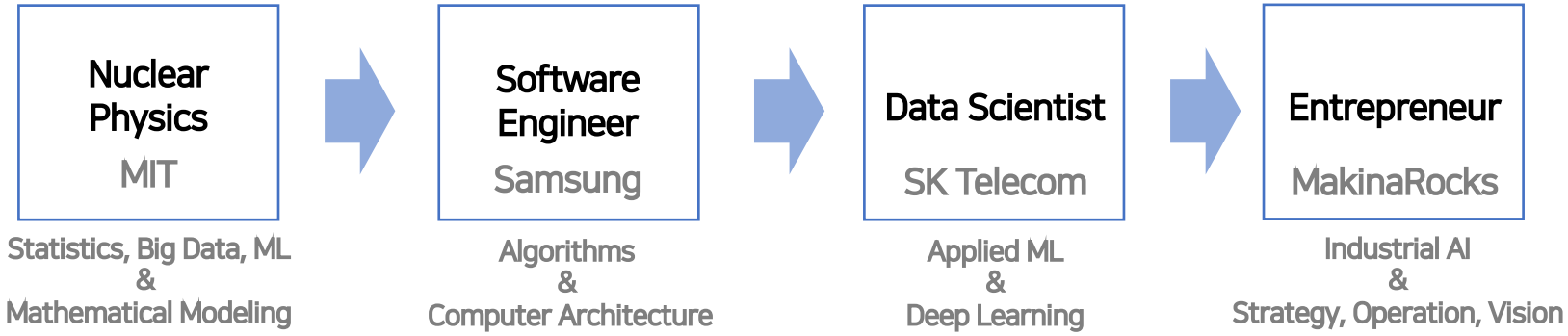

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Image from: https://metrology.news/smart-factory-concepts-can-be-achieved-today-with-current-technology/

OUTLINE

1. Why AI for industrial applications?
2. REAL-WORLD AI challenges
3. REAL-WORLD AI cases
4. Why startup?

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Image from: https://metrology.news/smart-factory-concepts-can-be-achieved-today-with-current-technology/

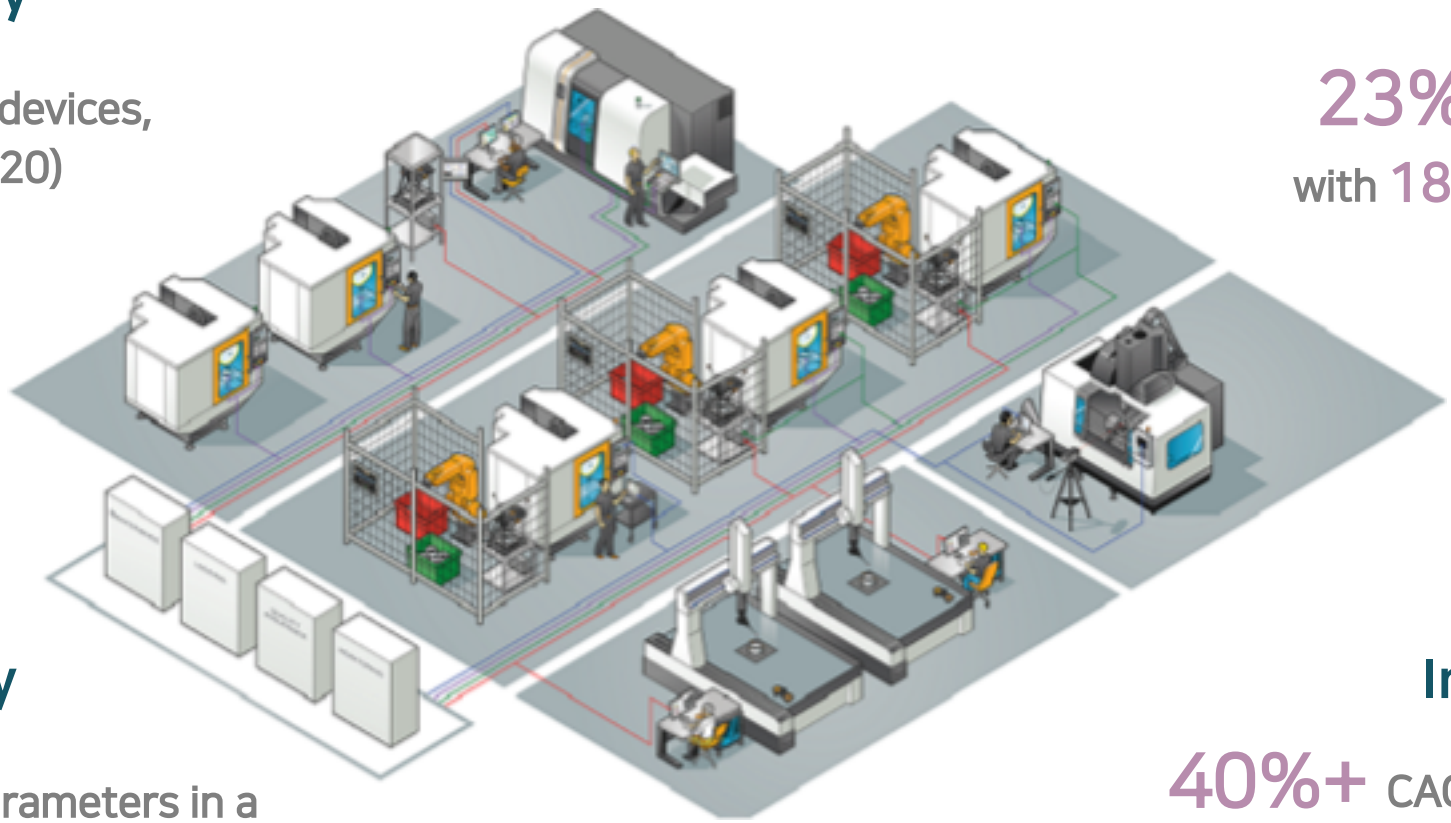
Image from: https://wccftech.com/globalfoundries-puts-7nm-on-hold-indefinitely-spins-off-asic-division-as-subsidiary/

Globalfoundries Semiconductor Fab1 Clean Room

INDUSTRY ADOPTION OF AI

Connectivity

50B+ Connected devices,
600 ZB/yr (by 2020)



Benefits

23% revenue increase
with **18%** reduction in cost

Technology

10M+ learnable parameters in a
Deep Learning architecture

Investment

40%+ CAGR with $17B+ market in
2025 (AI in Manufacturing)

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Image from: https://metrology.news/smart-factory-concepts-can-be-achieved-today-with-current-technology/

HOWEVER,

Almost 2 in 3 companies that are adopting digital manufacturing solutions find themselves stuck at the pilot phase.

#McKinseyHM19 #HM19

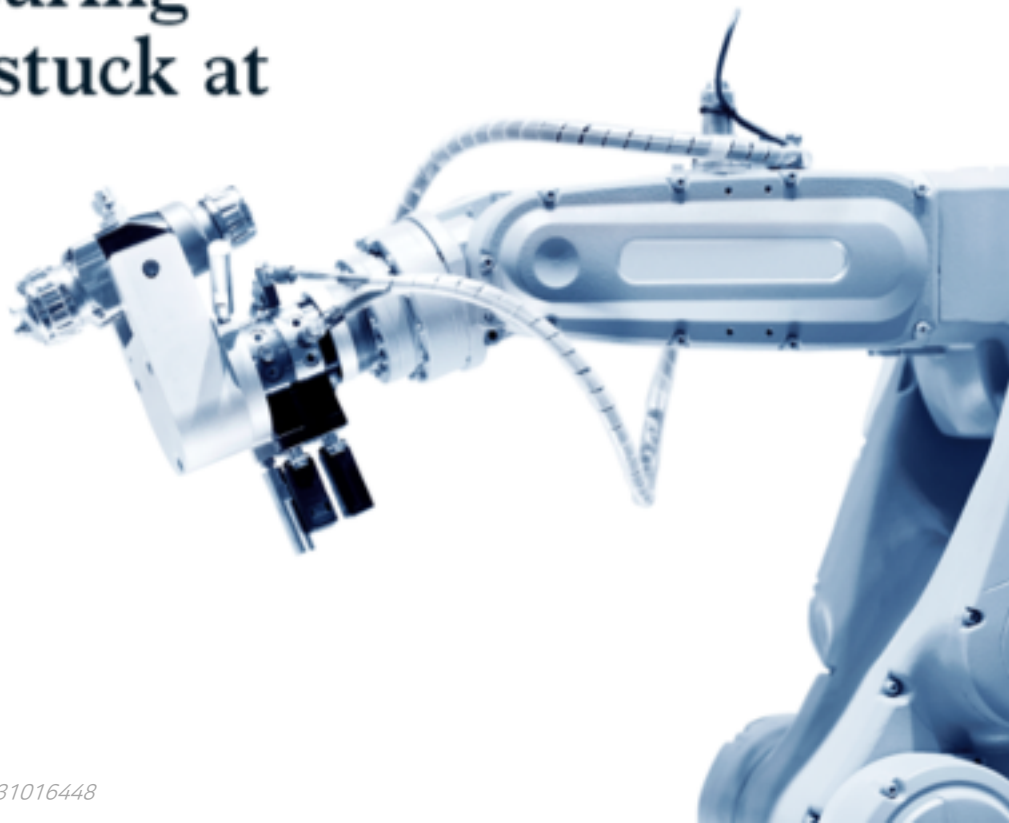

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Image from: https://twitter.com/McKinsey/status/1112735689031016448

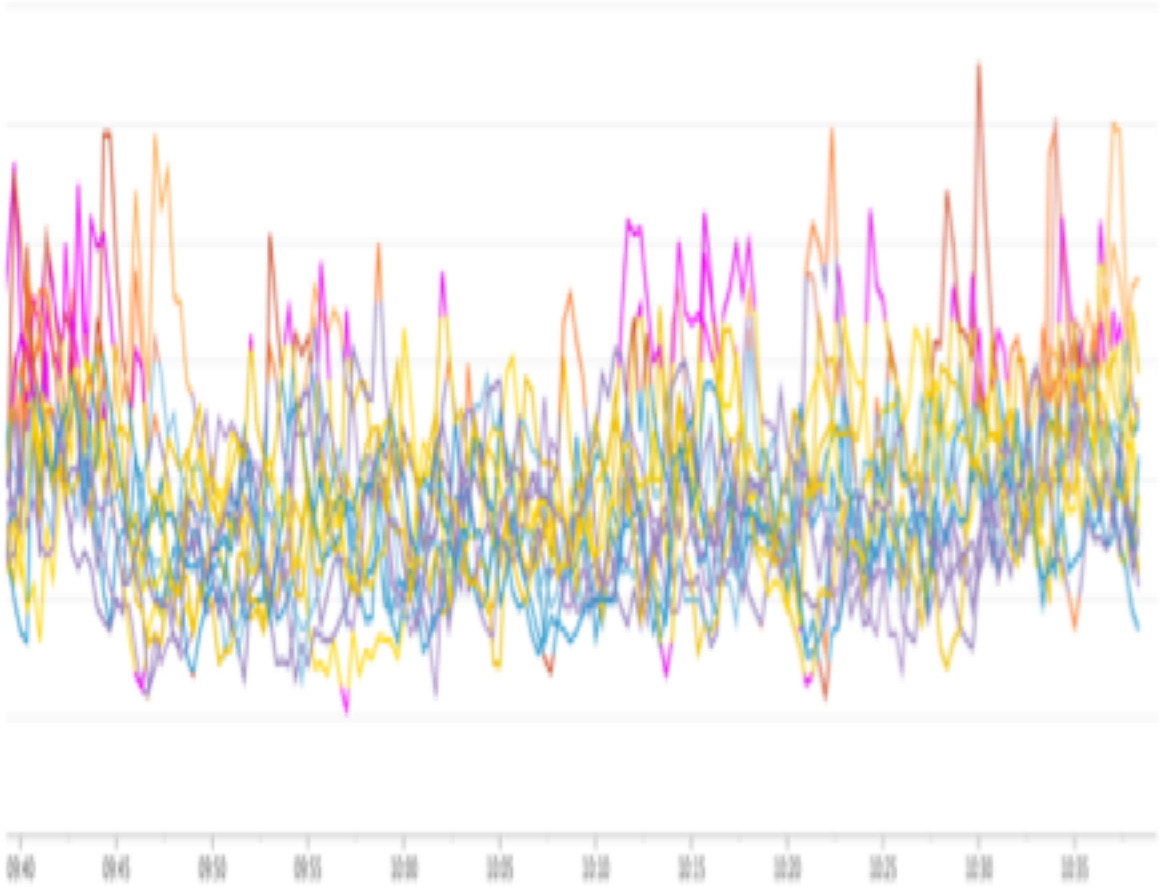

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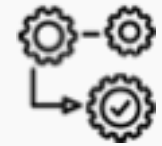
Image from: http://vjourneyman.com/vmware-wavefront-acquisition

INDUSTRIAL AI FOR INDUSTRY-SPECIFIC PROBLEMS

	Consumer-oriented Applications	Industrial AI Applications
Goal	▪ Mostly focusing on tasks related to **natural intelligence** 	▪ Mostly focusing on **industrial problems** such as yield improvement, optimization that human intelligence can hardly handle 
Applications	▪ Language translation ▪ Autonomous driving ▪ Video surveillance ▪ … 	▪ Predictive Maintenance ▪ Defect Detection ▪ Process Optimization ▪ … 
Data	▪ **Human interpretable** - Photo, video, text, voice, and etc. - Customer profile, activity, and etc. 	▪ **Mostly not human-interpretable** - Sensor values, process images, and etc. - Field engineer's work log 

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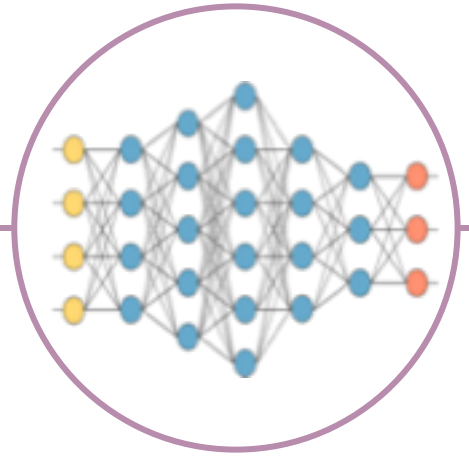
THE CHALLENGE: A LOT TO OVERCOME

Problem definition

- Increasing complexity
- Higher expectation
- High risk in adoption

Algorithmic aspects



- Unintuitive machine data
- Imbalanced and/or noisy labels
- Incorporating domain knowledge

Operational aspects

- System integration
- Continual Learning
- Model management

Image from: https://aws.amazon.com/machine-learning/what-is-ai/

- **Limited human intuition**

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- **Limited human intuition ⇒ Heavy EDA relying on domain knowledge!**

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- Limited human intuition ⇒ Heavy EDA relying on domain knowledge!

- Domain expertise matters

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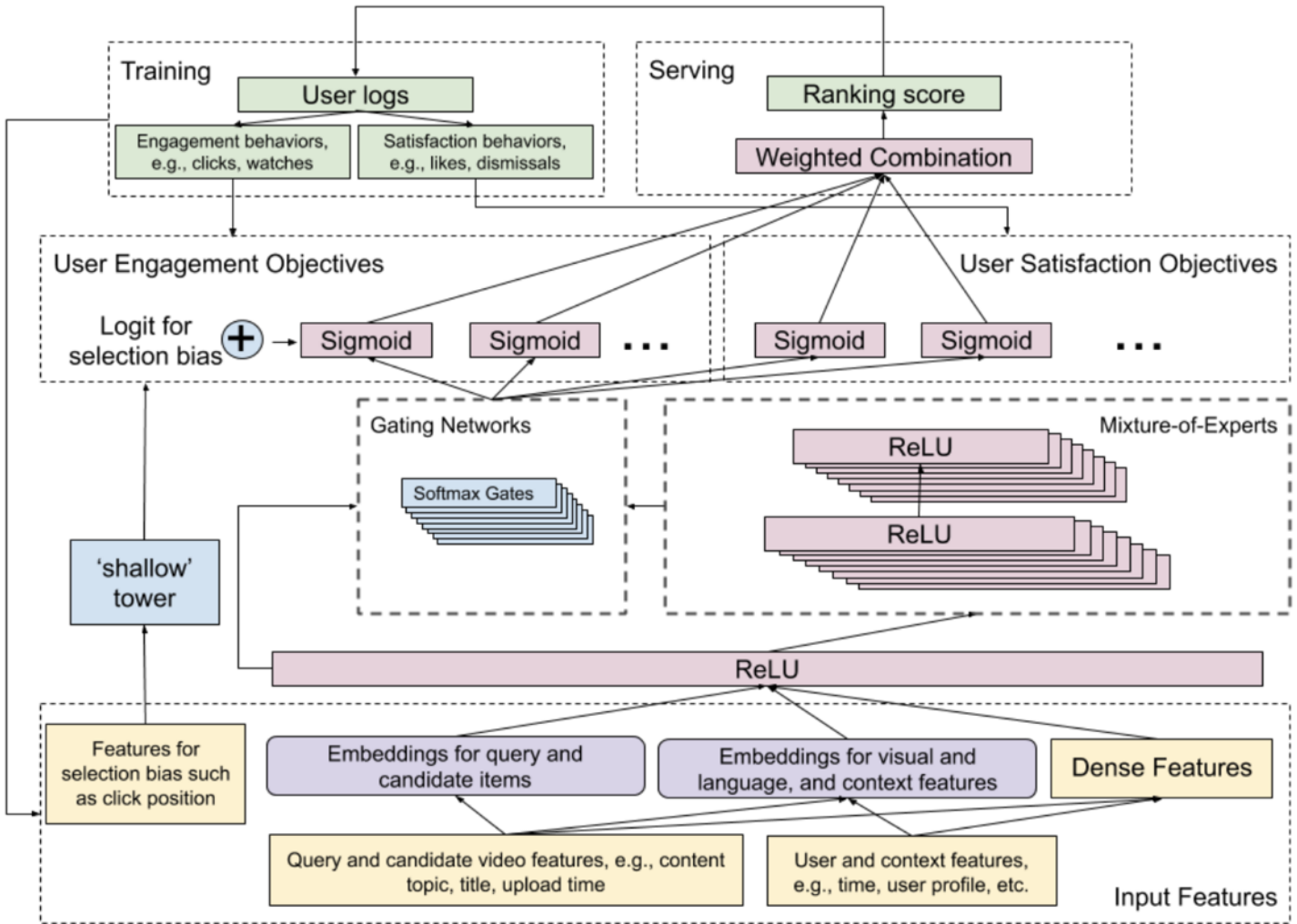

"How Youtube is recommending your next video"

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- Limited human intuition ⇒ Heavy EDA relying on domain knowledge!

- Domain expertise matters ⇒ E2E AI approach is limited!

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- Limited human intuition ⇒ Heavy EDA relying on domain knowledge!
- Domain expertise matters ⇒ E2E AI approach is limited!
- Challenge with small & imbalanced data

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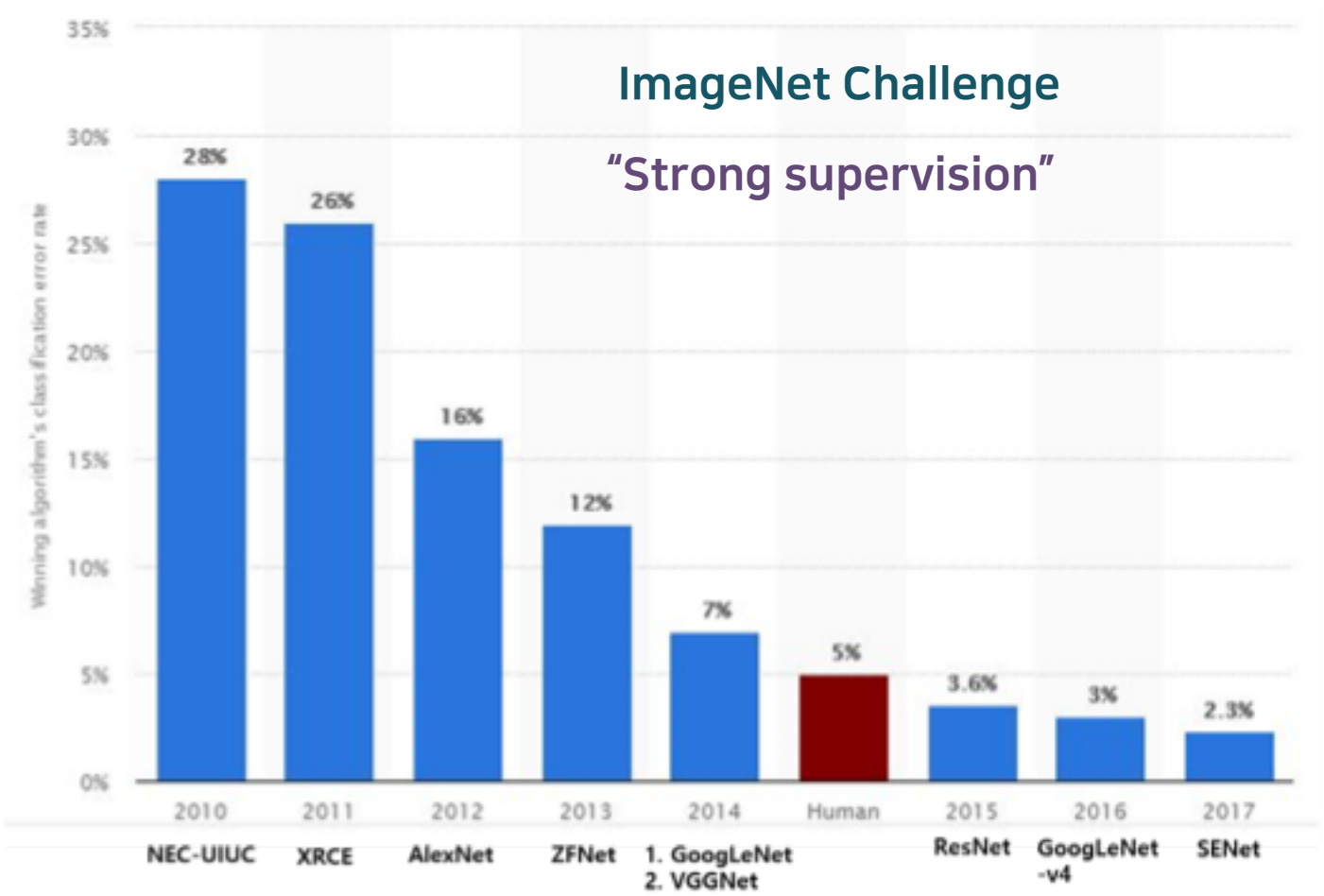
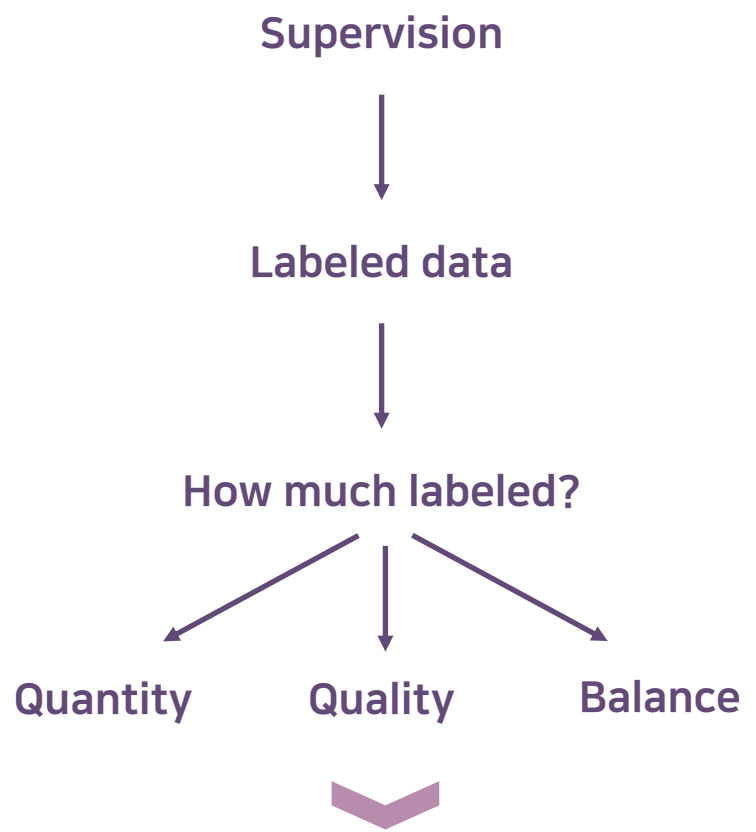
WHY LABEL MATTERS?





Almost all industrial ML applications require unsupervised, semi-supervised and/or weakly supervised approaches

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- Limited human intuition ⇒ Heavy EDA relying on domain knowledge!
- Domain expertise matters ⇒ E2E AI approach is limited!
- Challenge with small & imbalanced data ⇒ Usual classification approaches won't work

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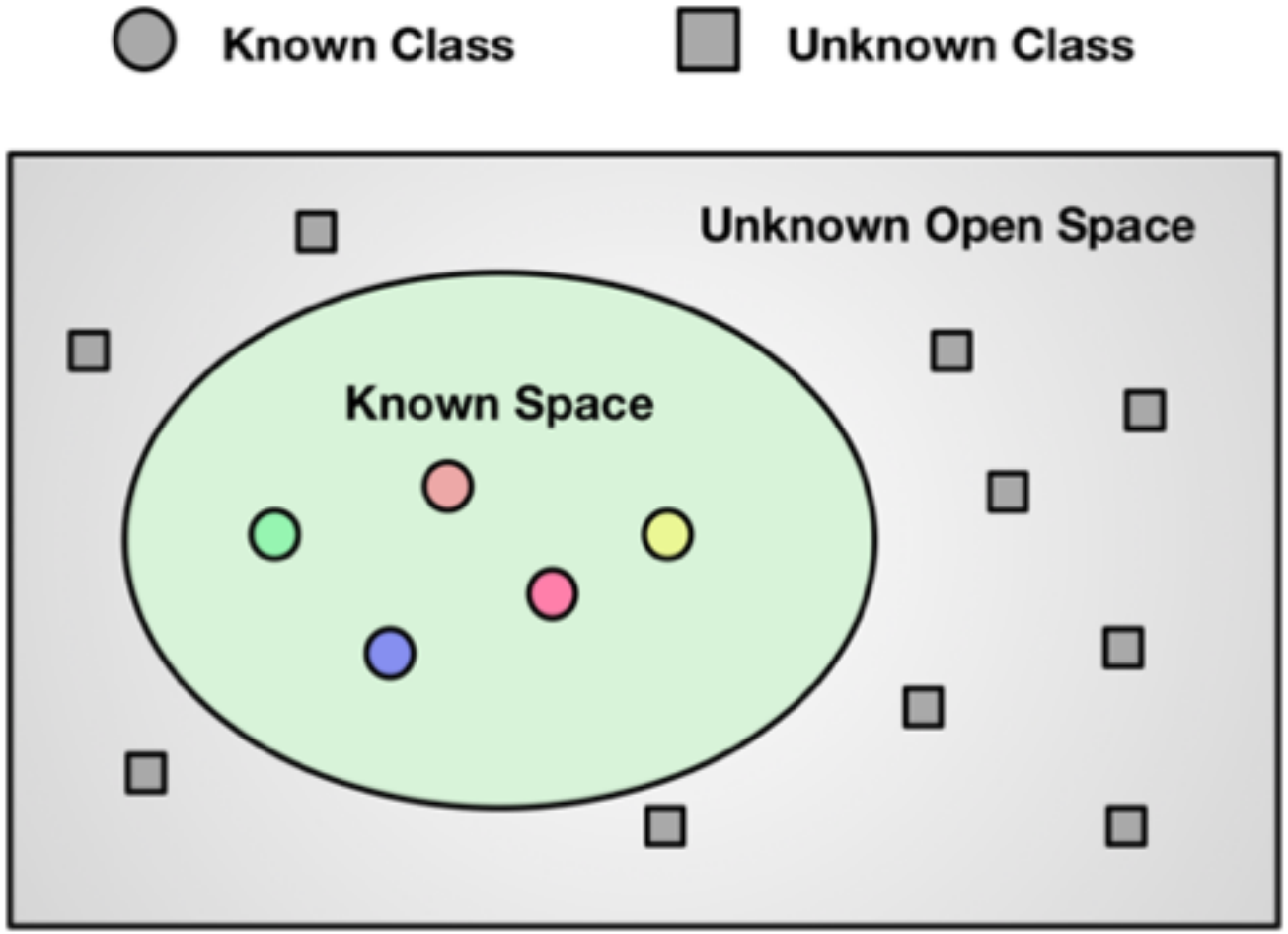
OPEN CLASS CLASSIFICATION (OCC)



- Model Uncertainty
- Continual Learning

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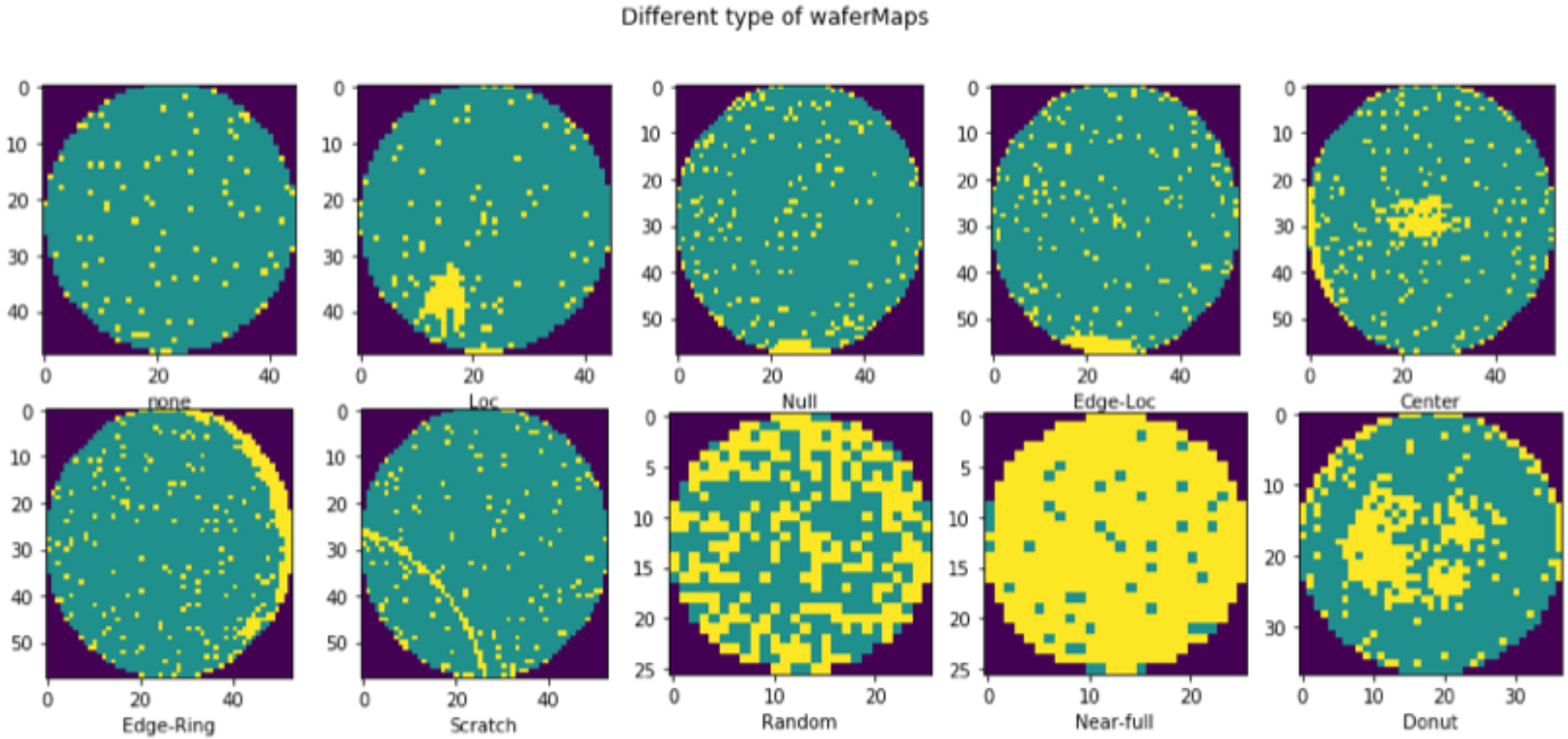
OPEN CLASS CLASSIFICATION (OCC)



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- Limited human intuition ⇒ Heavy EDA relying on domain knowledge!
- Domain expertise matters ⇒ E2E AI approach is limited!
- Challenge with small & imbalanced data ⇒ Usual classification approaches won't work + Model uncertainty & CL matter!

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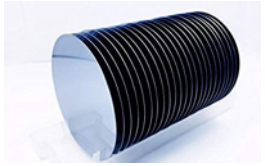
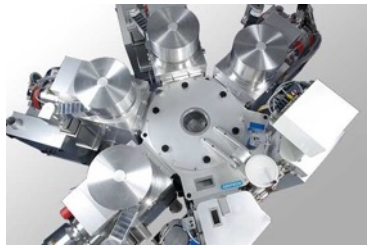
A WIDE RANGE OF INDUSTRIAL APPLICATIONS

Semiconductor & Display



Equipment PdM



Virtual Metrology

Wafer Defect Detection

Power Generation Prediction

Battery Health Magmnt.

Generation Optimization

Power & Energy

Oil & Gas

Product Forecasting

Drilling Optimization

Chemical & Pharma.

Industrial AI

Automotive & Steel

Robot arm PdM

Welding Optimization

Body Defect Detection

Predictive Process Control

Composition Optimization

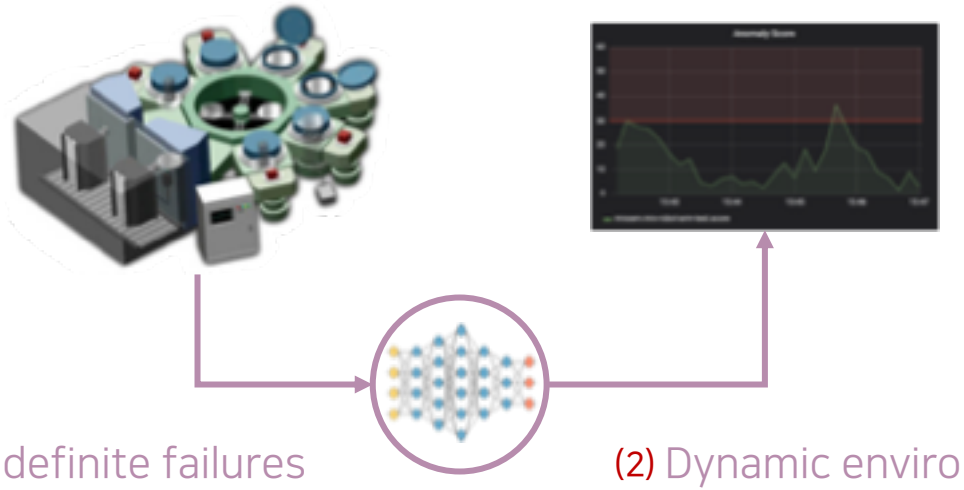
Quality Inspection

This document is strictly confidential

Image from: https://asia.nikkei.com/Business/Samsung-Electronics-new-chief-puts-competitors-on-edge

반도체 생산 장비 PdM AI

반도체 장비의 고장을 사전에 예측할 수 있을까?



(1) Indefinite failures

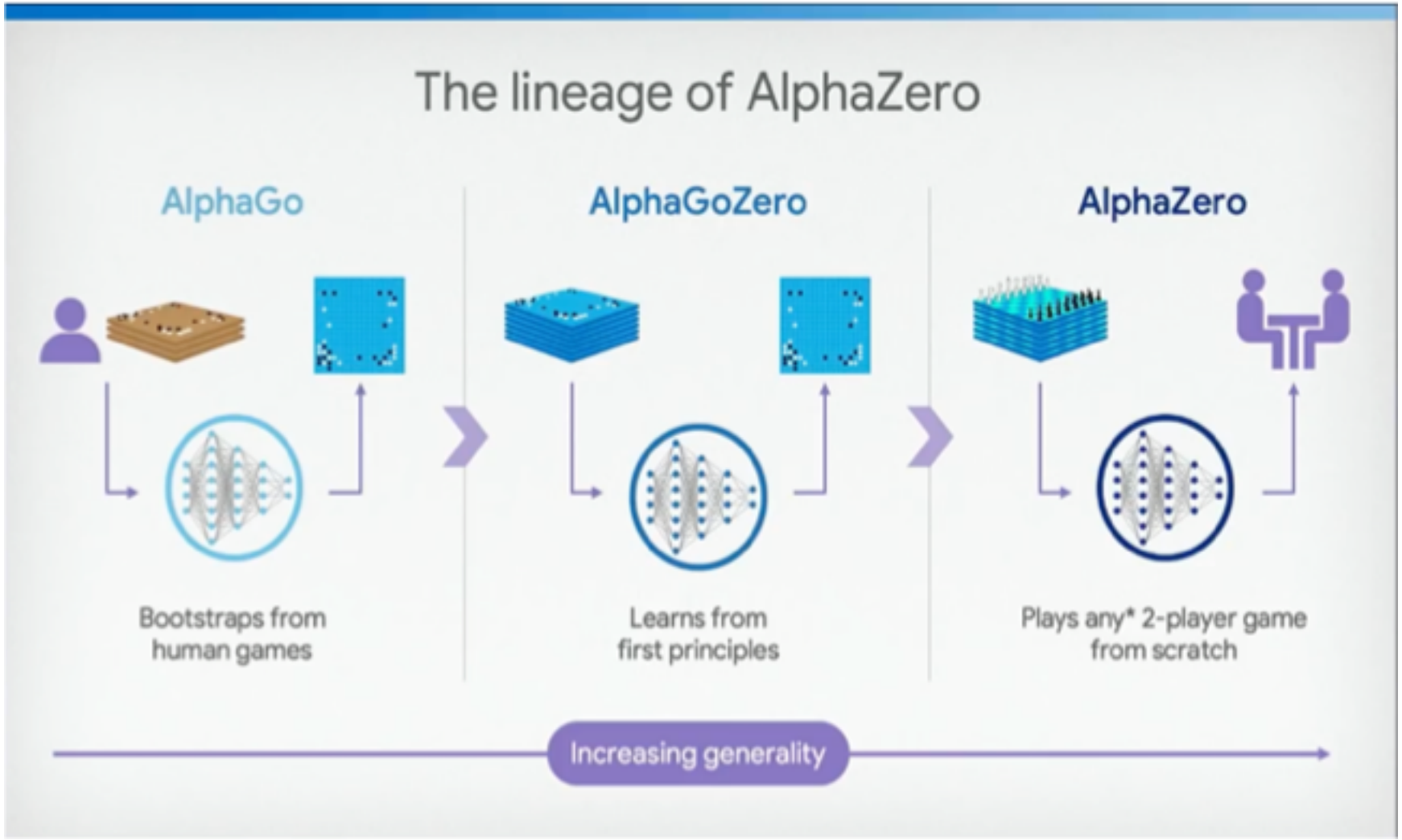
(2) Dynamic environment

(3) Catastrophic forgetting

Semi-supervised Novelty Detection + TTF + Continual Learning

90%, 1% , 12~24시간, 20~30%

GENERALIZATION OF AI: ALPHAGO



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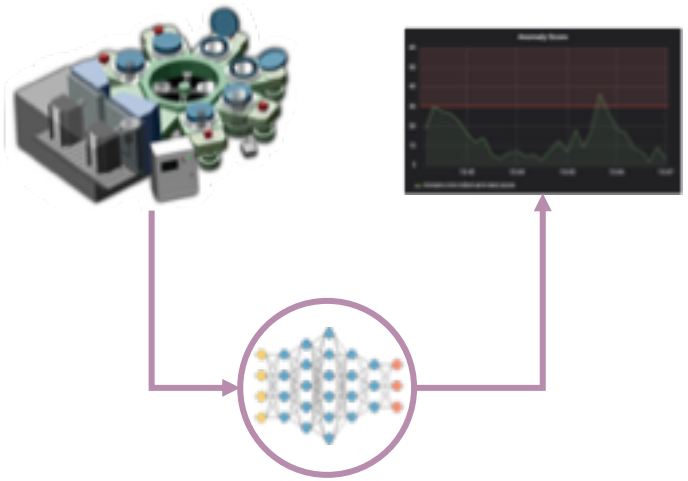
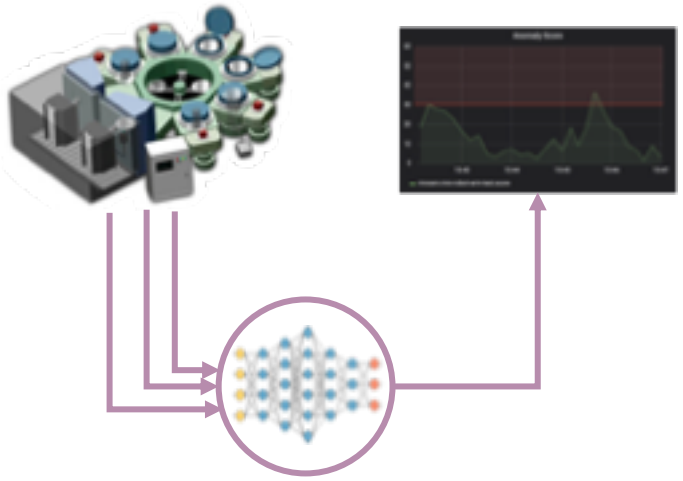
확장성 측면의 딥러닝 기반 예지정비 기술

Single-recipe, Single-chamber



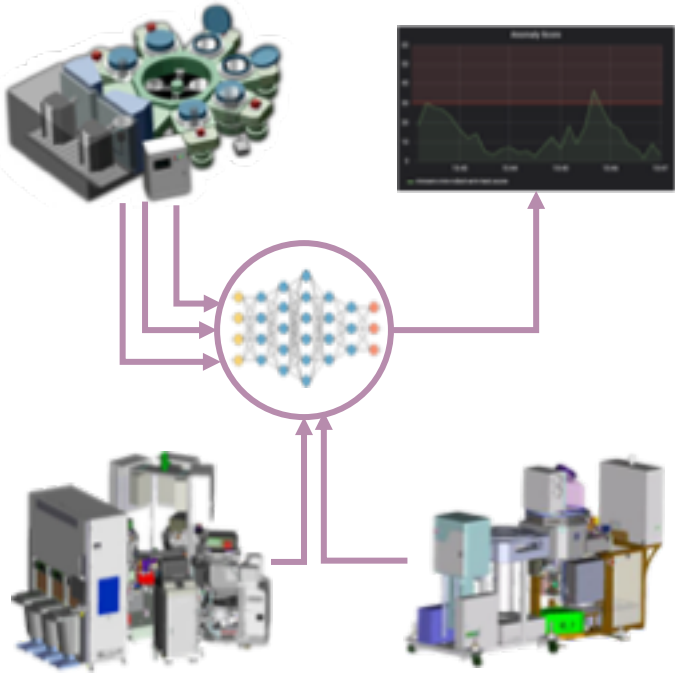
Single Deep Neural Network Model

Multi-recipes, Multi-chambers



Recipe & Chamber-agnostic Model

Multi-recipes, Multi-equipments



Equipment-agnostic Model

Increasing applicability

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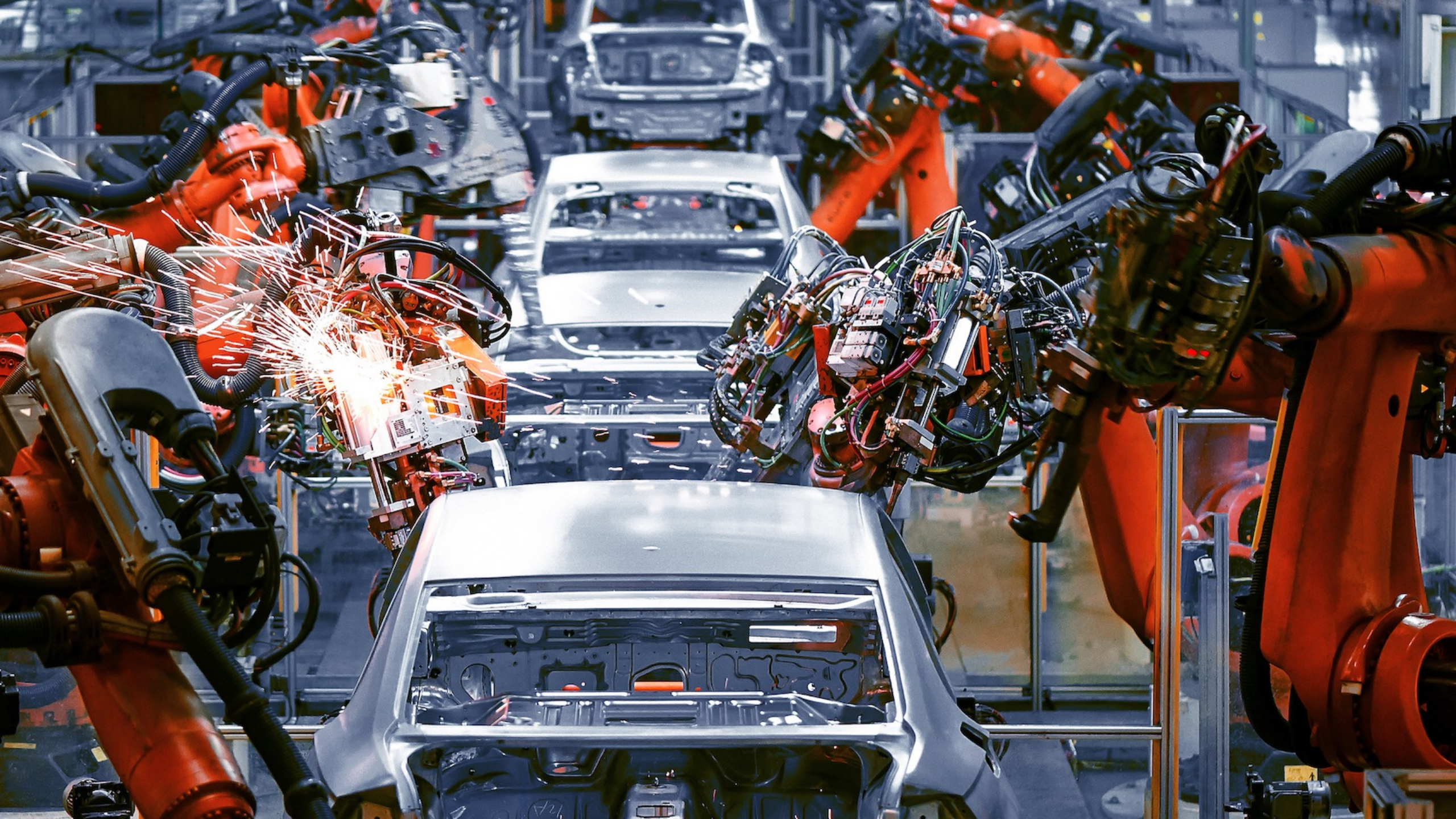
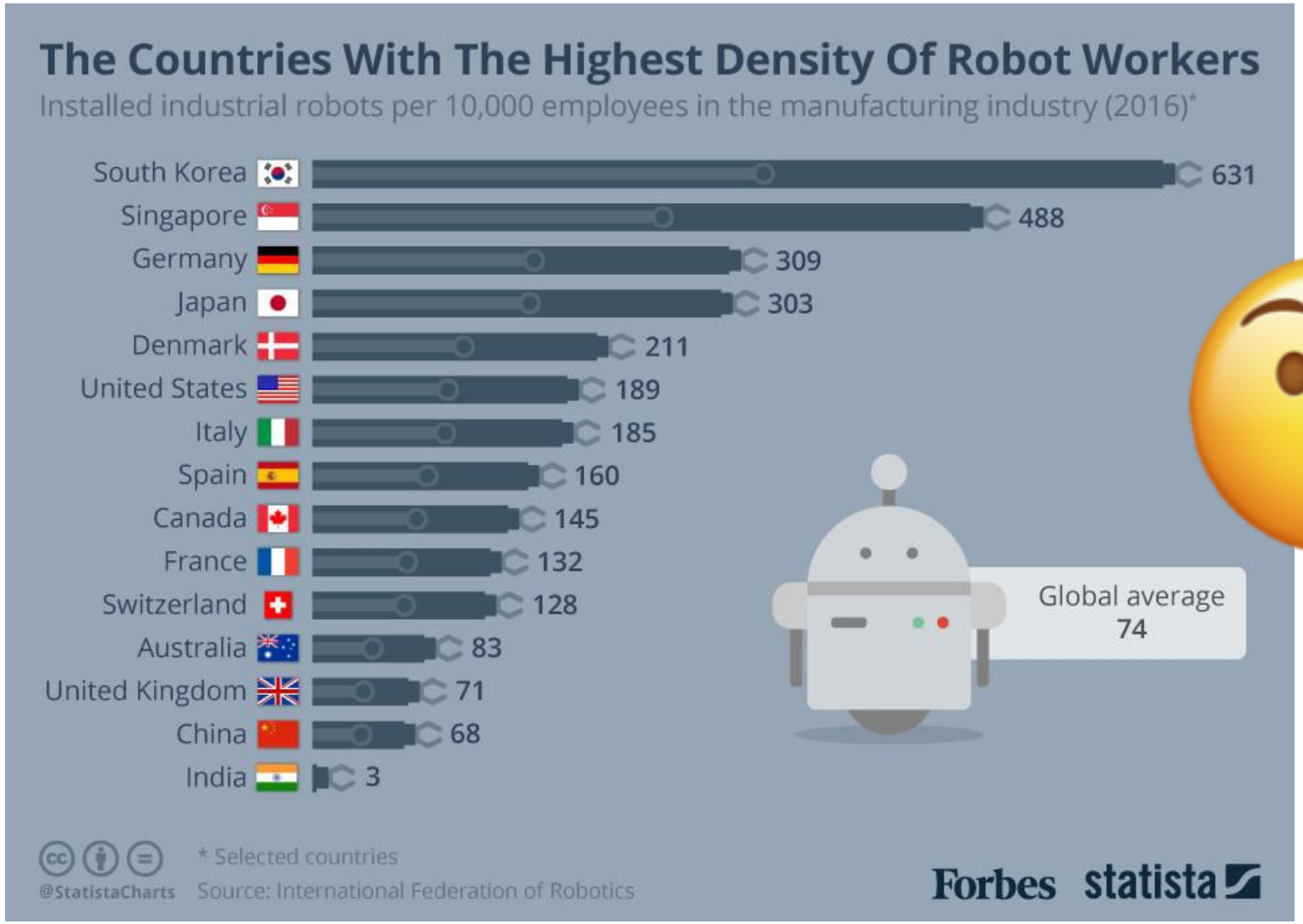
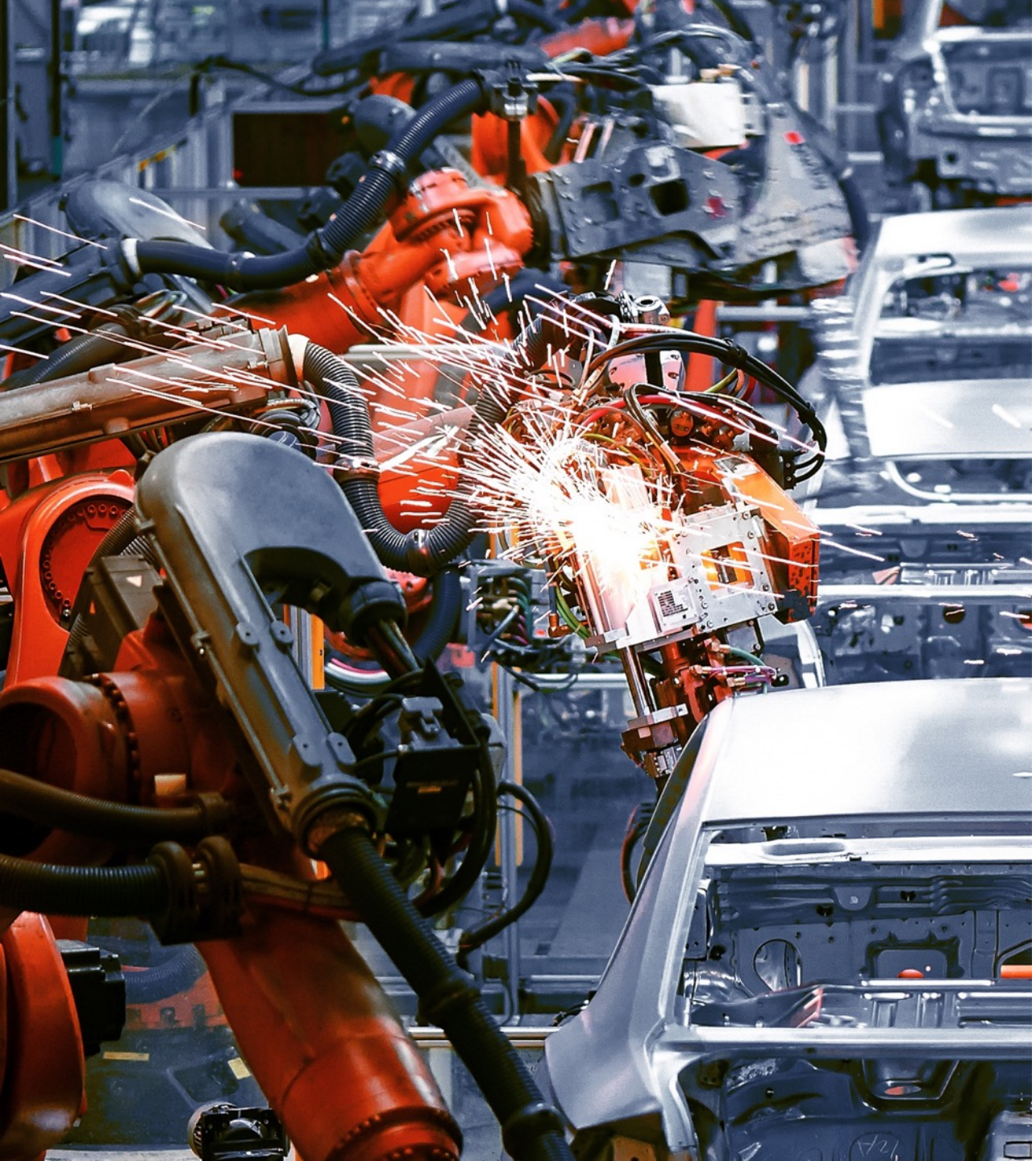
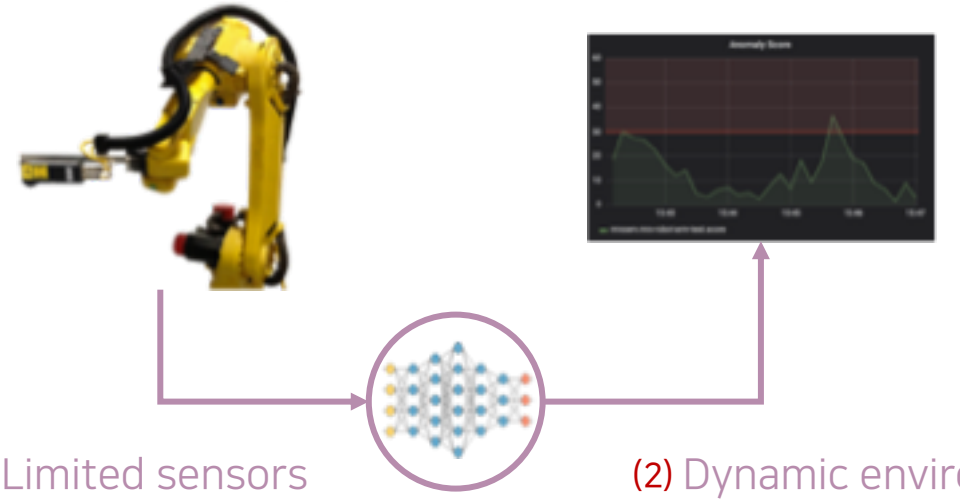



The Countries With The Highest Density Of Robot Workers
Installed industrial robots per 10,000 employees in the manufacturing industry (2016)*
South Korea 631
Singapore 488
Germany 309
Japan 303
Denmark 211
United States 189
Italy 185
Spain 160
Canada 145
France 132
Switzerland 128
Australia 83
United Kingdom 71
China 68
India 3
Global average
74
* Selected countries
@StatistaCharts
Source: International Federation of Robotics
Forbes
statista



산업로봇 고장 예지 AI

산업용 로봇의 고장을 사전에 탐지할 수 있을까?



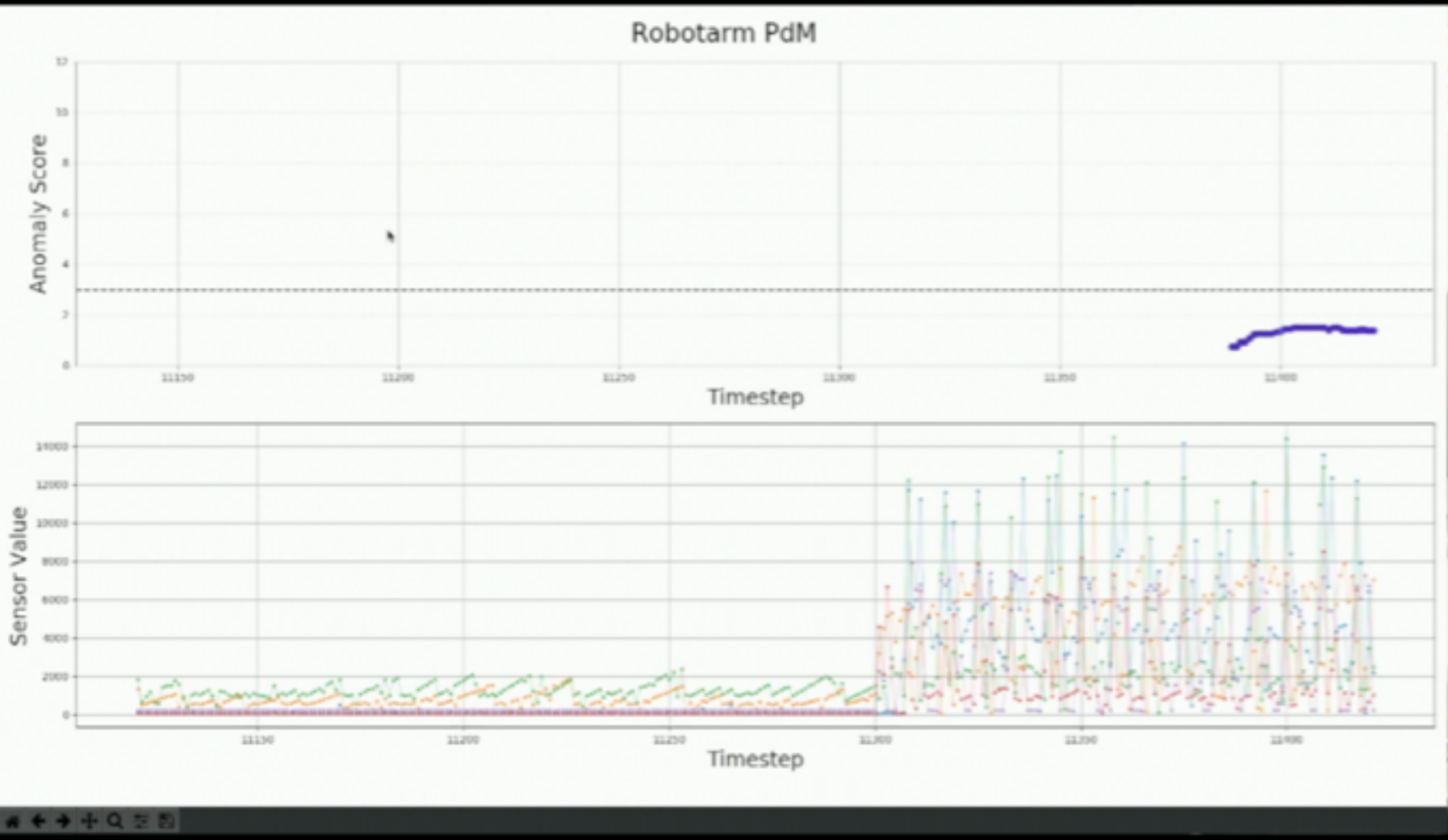
(1) Limited sensors

(2) Dynamic environment

(3) Catastrophic forgetting

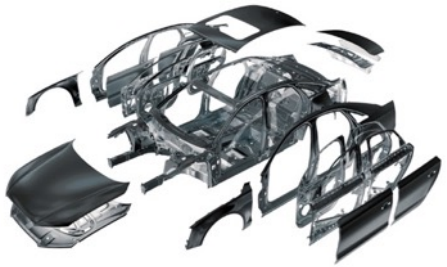
Semi-supervised Novelty Detection + Continual Learning

90%, 1% , 5일, 10억


Robotarm PdM
Anomaly Score
Timestep
Sensor Value
Timestep

차체 결함 검출 AI

이미지 기반으로 공정내 차체 불량을 검출할 수 있을까?



(1) small samples

(3) image variability

(2) class imbalance

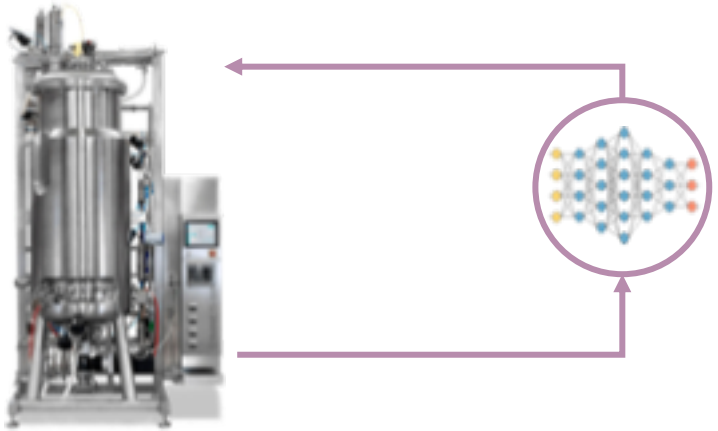
Novelty Detection & Pixel-Based Defect Detection (PBDD)

95%, 5% , 다중 이미지 소스 활용 가능, 70억

Image from: https://bionet.com/technology/bioreactors-and-fermenters/

미생물 공정 Autopilot AI

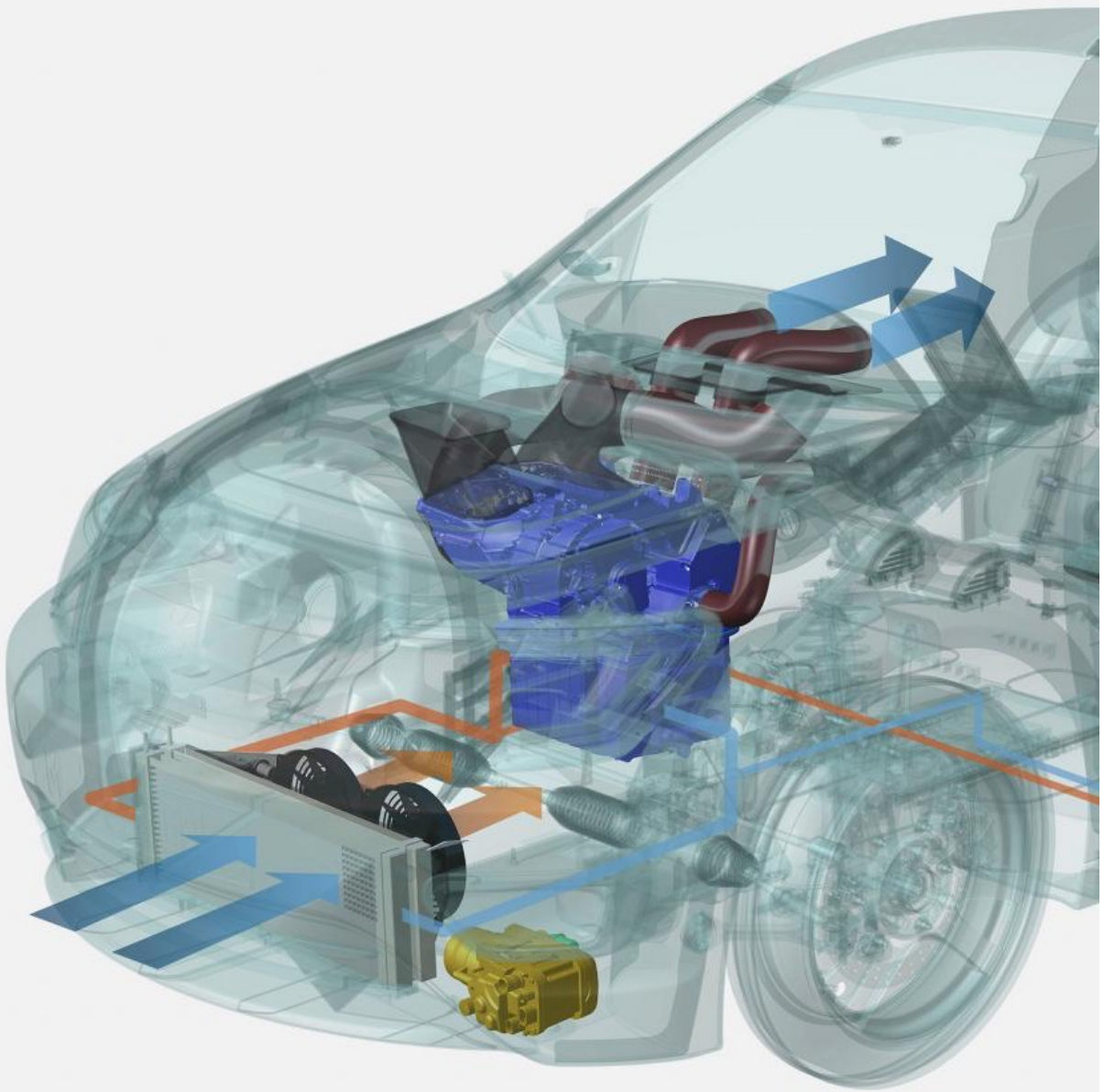
바이오 생산 공정 운전을 자동화 할 수 있을까?



Can AI learn human operations?

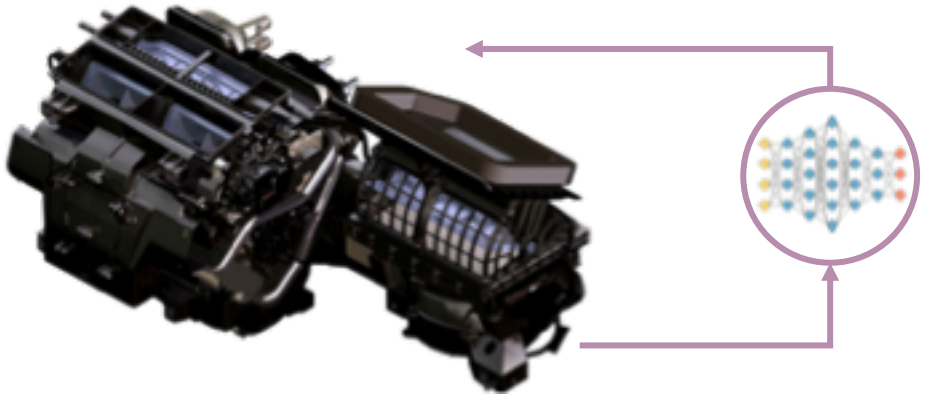
Gaussian Process + Recurrent Neural Networks

부분 → 완전 자동화, 생산조건, 생산성



강화학습 기반 공조시스템 최적화

공조시스템 최적화를 통한 연료 저감이 가능할까?



How to better control HVAC to optimize operating power

Deep Reinforcement Learning (DRL)

최적화를 통한 연료저감 및 탑승자 쾌적도 최적화

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Improving wind power

Wind is an unpredictable energy source

Started applying ML algorithms to **700 megawatts** of wind capacity in Google's wind farms in the US

Predicting wind power output **36 hours** ahead of actual generation

This is important because energy sources that can be scheduled are often more valuable to the grid

ML has boosted the value of our wind energy by roughly 20%

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- Limited human intuition ⇒ Heavy EDA relying on domain knowledge!
- Domain expertise matters ⇒ E2E AI approach is limited!
- Challenge with small & imbalanced data ⇒ Usual classification approaches won't work + Model uncertainty & CL matter!
- Operational challenges

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- Challenge with small & imbalanced data ⇒ Usual classification approaches won't work + Model uncertainty & CL matter!
- Operational challenges ⇒ CL, MM, and who runs it?

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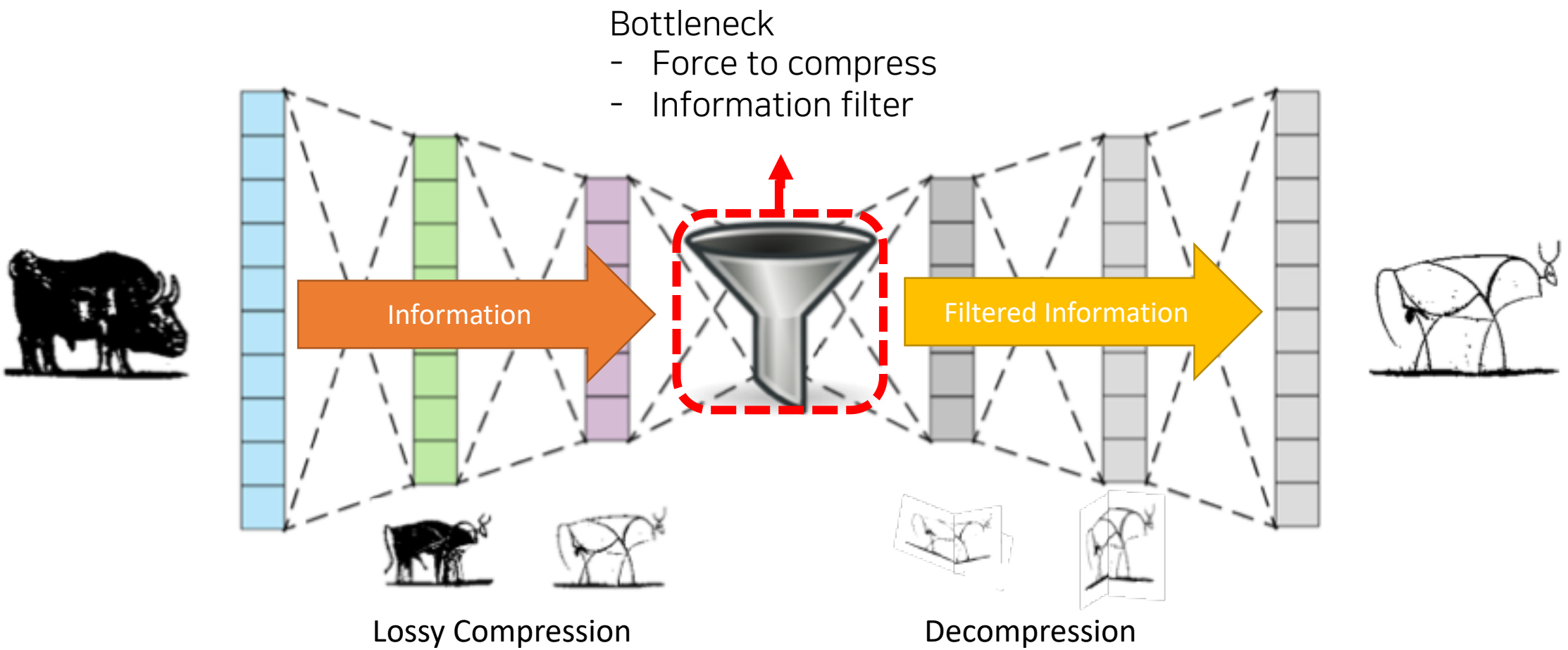
마키나락스가 고민하는 문제들

https://github.com/makinarocks

- 지도, 비지도, 준지도 딥러닝을 기반으로 이상 탐지(Novelty/Anomaly Detection)를 수행할 수 있는 효과적인 방안은 무엇일까? State-of-the-art (SOTA) 성능은 어떠하며, 이를 뛰어넘을 수 있는 방법은?
- 극심한 레이블 불균형 데이터 셋 (Extreme class imbalance) 상황에서 어떻게 하면 효과적으로 딥러닝 모델을 학습하고 이상 탐지 및 분류에 활용할 수 있을까?
- Catastrophic forgetting을 극복하고 지속적으로 학습 가능한 온라인 딥러닝 모델 및 알고리즘을 만들 수 있을까?
- 딥러닝 모델의 추론(Inference)에 대한 적절한 불확실성(Uncertainty) 측정 방법은 무엇일까? (베이지안 딥러닝?)
- 모델 학습에 있어 불확실한 레이블 값 (Noisy label)의 효과적인 처리 방안은 무엇일까?
- 기존에 학습된 결과로부터 잘못된 레이블 정보를 효과적으로 폐기 학습 (manifold unlearning) 할 수 있는 방법은 무엇일까?
- Novel/Anomaly 정보가 없거나 극도로 적을 때 Novelty/Anomaly Detection 모델의 성능은 어떻게 평가할 수 있을까?
- Data Scientist가 좀 더 빠르고 효과적으로 데이터를 분석할 수 있도록 Exploratory Data Analysis (EDA)를 체계화하는 방안은 무엇일까? 과연 어디까지 자동화할 수 있을까?
- 강화 학습을 활용하여 개선할 수 있는 산업 최적화 문제들을 어떤 것들이 있을까? (예: 데이터 센터, 자동 운송 시스템 최적화 등)
- 온라인 환경에서 데이터의 양이 늘어남에 따라 모델 학습의 Regularization을 자동으로 조정하는 방법은 무엇일까? (Dynamic adjustment 방안)
- 온라인 환경에서 레이블 데이터양이 증가함에 따라 비지도에서 준지도로, 준지도에서 지도학습 방식으로 자연스럽게 전환할 수 있는 방법은 무엇일까?
- Multi-modality를 갖는 Multi-context 데이터를 효과적으로 모델링 할 수 있는 단일 딥러닝 모델을 만들 수 있을까?

Autoencoder-based Novelty Detection



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Autoencoder-based Novelty Detection

- Similar to PCA-based detection, but capable of learning non-linearity as well

Anomaly digit	VAE	AE	PCA	kPCA
0	0.917	0.825	0.785	0.694
1	0.136	0.135	0.205	0.231
2	0.921	0.874	0.798	0.801
3	0.781	0.761	0.632	0.638
4	0.808	0.727	0.682	0.702
5	0.862	0.792	0.627	0.598
6	0.848	0.812	0.733	0.720
7	0.596	0.508	0.512	0.560
8	0.895	0.869	0.493	0.502
9	0.545	0.548	0.41	0.420

Variational Autoencoder based Anomaly Detection using Reconstruction Probability, Jinwon An and Sungzoon Cho. 2015

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Can we do better?

Is reconstruction error really the best way to measure “normality”?

What about the information from hidden spaces hierarchically identified by the deep architecture?

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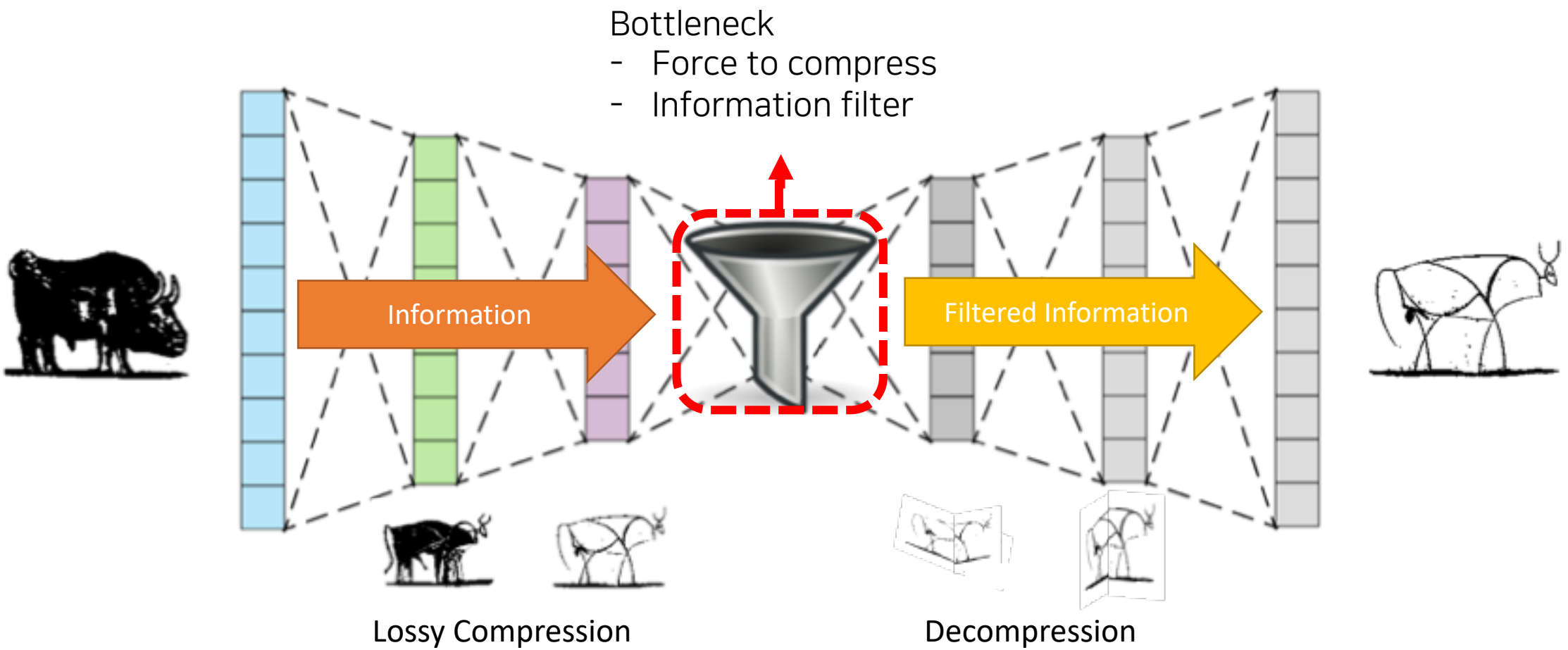
Autoencoder-based Novelty Detection



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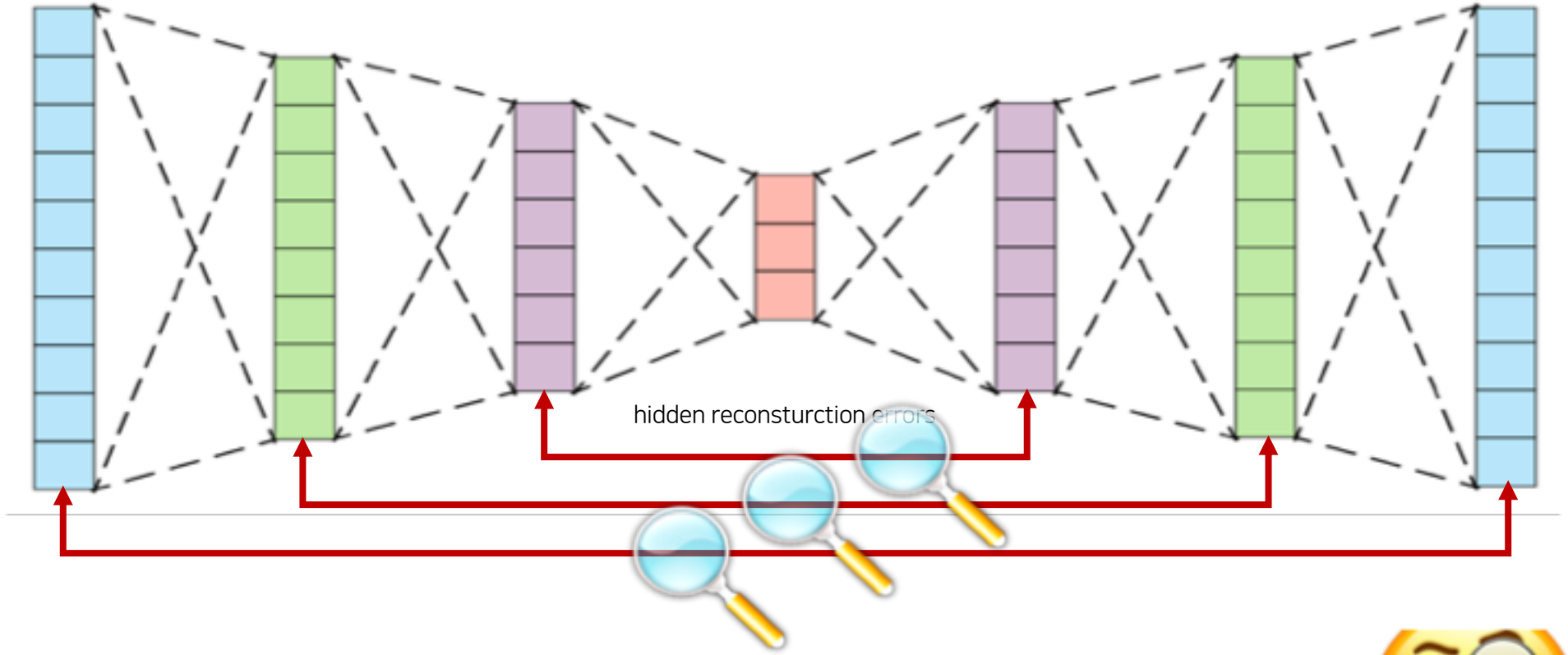
Using information in lower-dimensional latent space?



Q. Can we compute reconstruction errors in hidden spaces?

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RaPP compared to the *previous* SOTA

- AUROC measured in both multimodal normality case as well as unimodal normality case and compared to SOTA

ICML 2018! NIPS 2018! **Our work!**

Normal Type	Novelty %	VAE	DOSVDD [1]	GPND [2]	RaPP
Multimodal	35	0.8687±0.1823	-	0.5006±0.1722	**0.9427**±0.0406
Unimodal	50	0.9573±0.0324	0.9370±0.0428	0.9709±0.0226	**0.9736**±0.0179

[1]: Ruff, L., Vandermeulen, R., Goernitz, N., Deecke, L., Siddiqui, S.A., Binder, A., Mu¨ller, E., Kloft, M.: Deep one-class classification. In: ICML (2018)
[2]: Pidhorskyi, S., Almohsen, R., Doretto, G.: Generative probabilistic novelty detection with adversarial autoencoders. In: NeurIPS. pp. 6823–6834 (2018)

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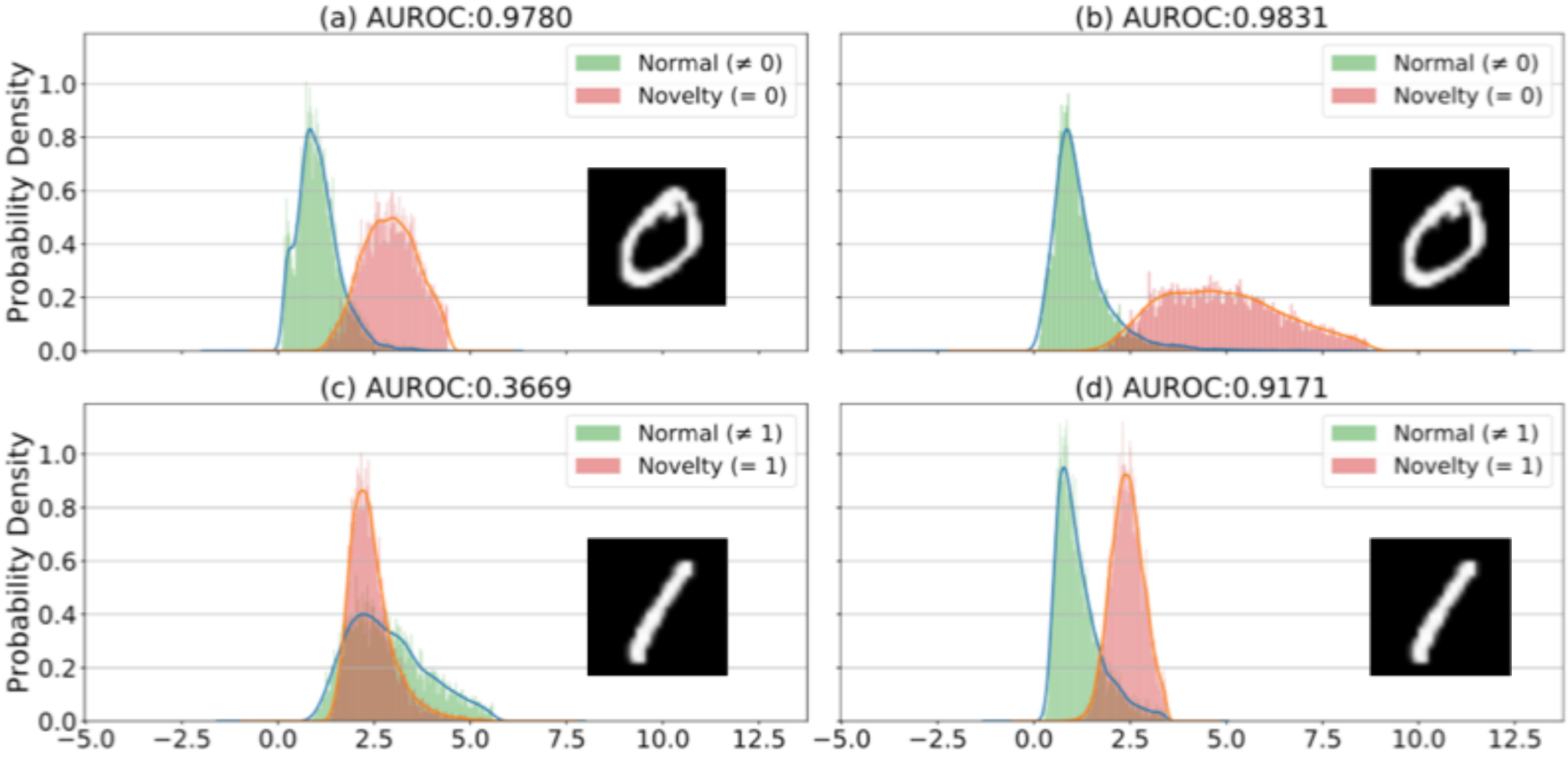
1-as-novelty case



Previous

Our work

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startup?

COMPANY OVERVIEW

OUR VISION

- **Operationalize AI and make industries more efficient**

WHAT WE DO

- We develop **industrial AI solutions** and a **platform** that bring **measurable improvements** for **manufacturing** and **energy** industries.

KEY FACTS

- Incorporated in December 2017 (Korea) and March 2018 (US)
- 4 Co-founders from SK Telecom and Samsung Electronics (3 Data Scientists + 1 Industry expert)
- **Seed-round funding** from SK Telecom, NAVER and Hyundai Motor Company in May 2018
- Currently **17 members** in Seoul & Silicon Valley offices

SK telecom (1st Telco in Korea)

NAVER (1st Internet Portal in Korea)

HYUNDAI (Global top 5 automaker)

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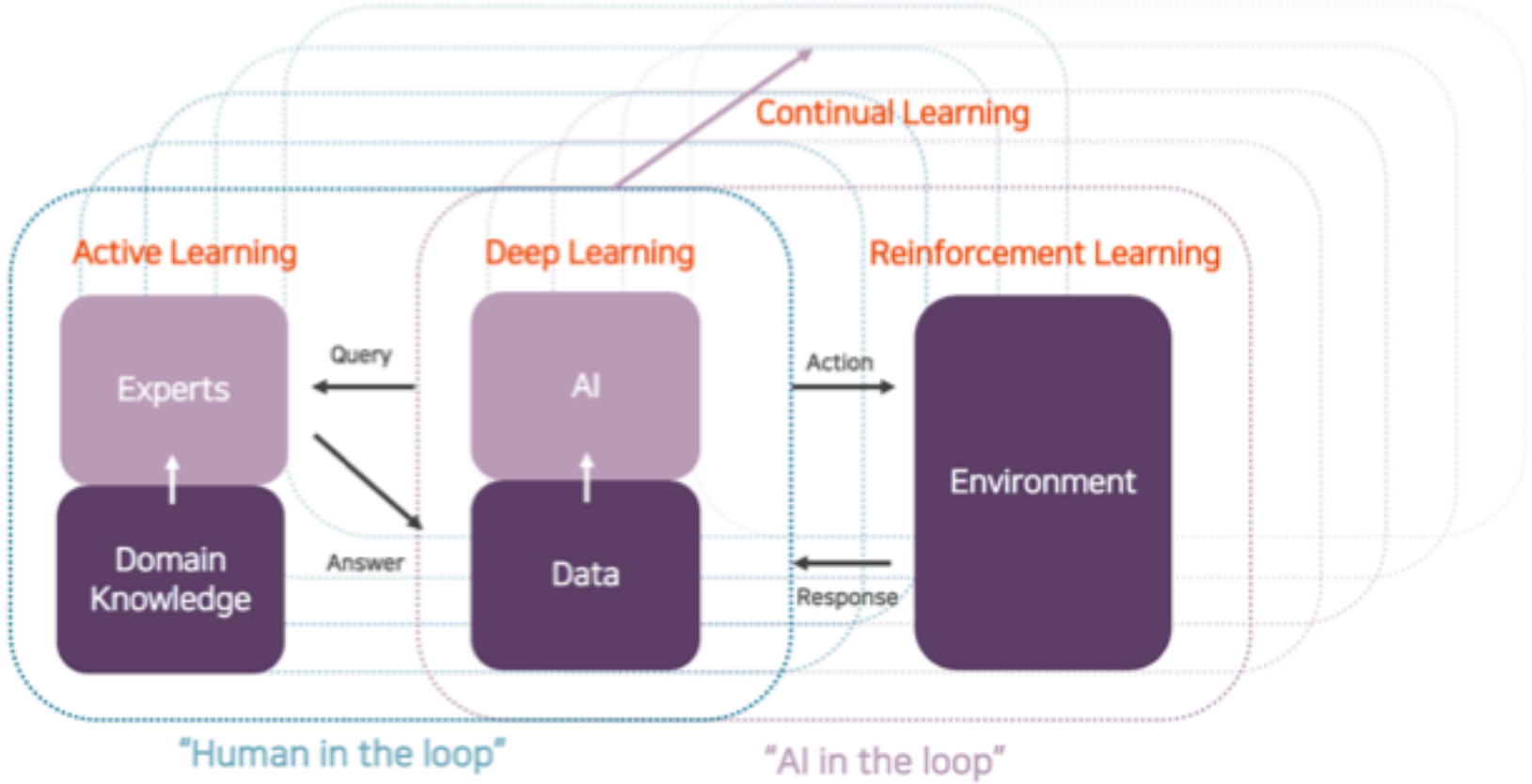
MRX Industrial ML Focus



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The Korea Herald

2018년 06월 14일
05면 (경제)

Redefining manufacturing with machine intelligence

By Song Su-hyun

HERALD INTERVIEW

MakinaRocks, a fresh startup spun out from South Korea's No.1 mobile carrier SK Telecom, has as bold an ambition as its name: To shake the manufacturing world with machine intelligence.

"We are applying artificial intelligence to the high-tech manufacturing sector with a mission to make manufacturing more productive by harnessing the power of data and AI," Andre. S. Yoon, a co-founder of MakinaRocks told The Korea Herald on Tuesday.

Among many in the broad manufacturing industry, the Korean startup is targeting the high-tech sector, including manufacturing of semiconductor products and equipment, automobiles, steel products and specialty chemicals, which requires complex technical processes.

Established by two data scientists and an industry expert at SK Telecom's ICT R&D Center in December 2017, the start-up brought on another data scientist from Samsung Electronics to its team. MakinaRocks was spun out from the telecom firm in May with the goals of contacting the world's top players in high-tech industries and providing intelligent manufacturing solutions for them.

By collecting and analyzing machine data from sensors, manufacturers can detect erroneous factors in processes early and prevent defects, thus improving efficiency in production, according to Lee Jae-hyuk, another co-founder of the startup.

"In the semiconductor industry, complexity of high-tech processes is enormously increasing with the rising number of new technical methods by around 50 to 100 each year," Lee said. "Early fault detection and prediction of equipment failure are key to winning in the world of the hawk-dove game."

Applying AI technologies to production lines doesn't mean automation nor replacement of human workers with machines, Lee said. Rather, the technologies enable predictions of optimal operations of machines.

Despite being a month-old spin-out, the startup has the country's most powerful industrial players as investors. It has received seed funding from SKT, No. 1 portal operator Naver and top automaker Hyundai Motor Company.

It has also clinched a contract with one of Korea's industrial players, and another one with a US company.

Eyeing the US market with huge potential demand, MakinaRocks has also set up a subsidiary in Silicon Valley in the US, which will start operations next month with an estimated workforce of four to six, with an aim to hire up to 10 employees with multidisciplinary expertise in data science, AI and industries.

"While the Seoul head office will focus on developing solutions for automakers and steelmakers with strong players here, the US office will serve mainly for chipmakers and equipment builders, oil exploration and production businesses, and specialty chemicals makers," Lee said.

(song@heraldcorp.com)

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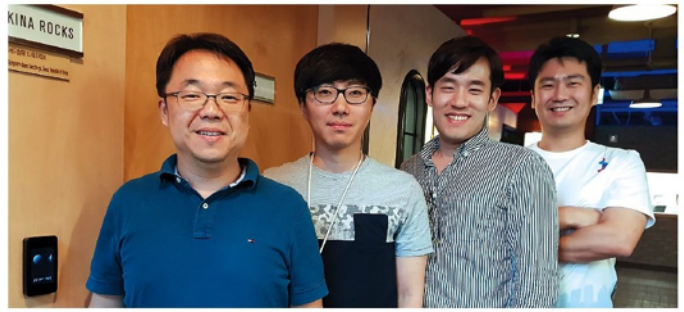

Four founders of Makina Rocks pose at their office in southern Seoul on Tuesday.
Song Su-hyun /The Korea Herald

이데일리

마키나락스 인턴팀, 한국동서발전 AI활용 공모전 최우수상

[이데일리 김현아 기자]네이버의 기술 스타트업 액셀러레이터 D2SF가 지원하는 마키나락스 인턴 연구원들이 한국동서발전 주최의 '발전산업 빅데이터 분석 AI 활용 공모전'에서 최우수상을 수상했다. 문제해결형 분야 최우수상을 수상한 것이다.

HOME > INVESTMENT

네이버 D2SF, 마키나락스 등 AI 및 자율주행 분야 스타트업 3곳에 투자

서 혜인 POSTED ON 2018/06/28

SK telecom NAVER HYUNDAI


HANNOVER
MESSE

제조업을 비롯한 산업의 Digitalization 은 더욱 빨라질 것...

Thank you!

SNS: Andre Sungho Yoon in facebook

MakinaRocks Github: https://github.com/makinarocks

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