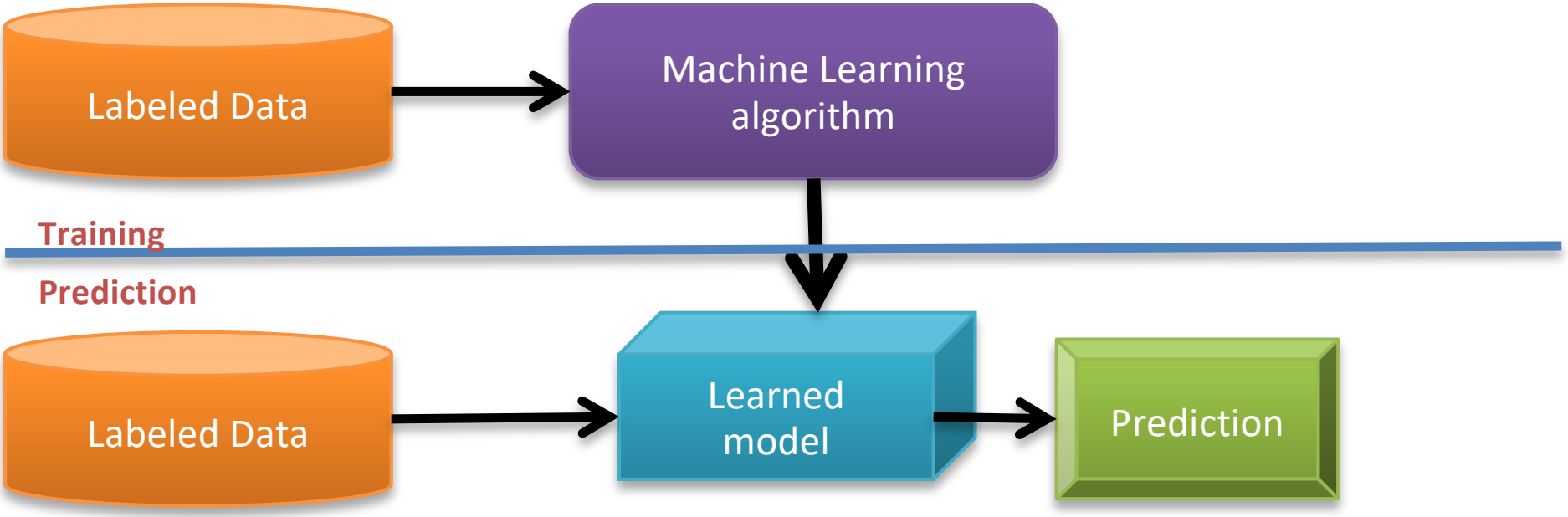
Introduction to Deep Learning

Machine Learning Basics

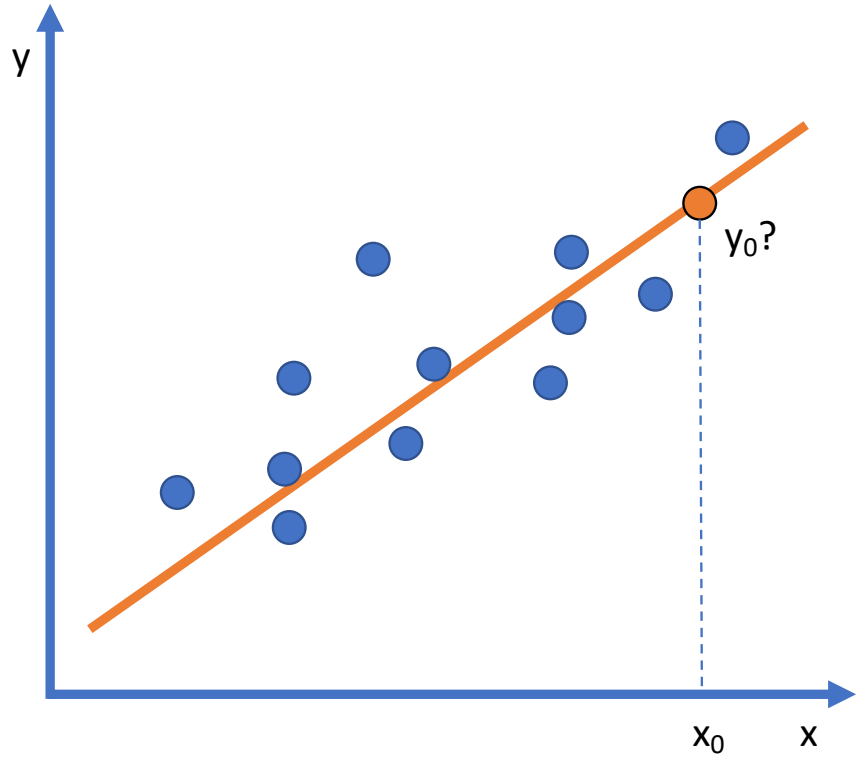
Machine learning is a field of computer science that gives computers the ability to **learn without being explicitly programmed**



Methods that can learn from and make predictions on data

Machine Learning Basics

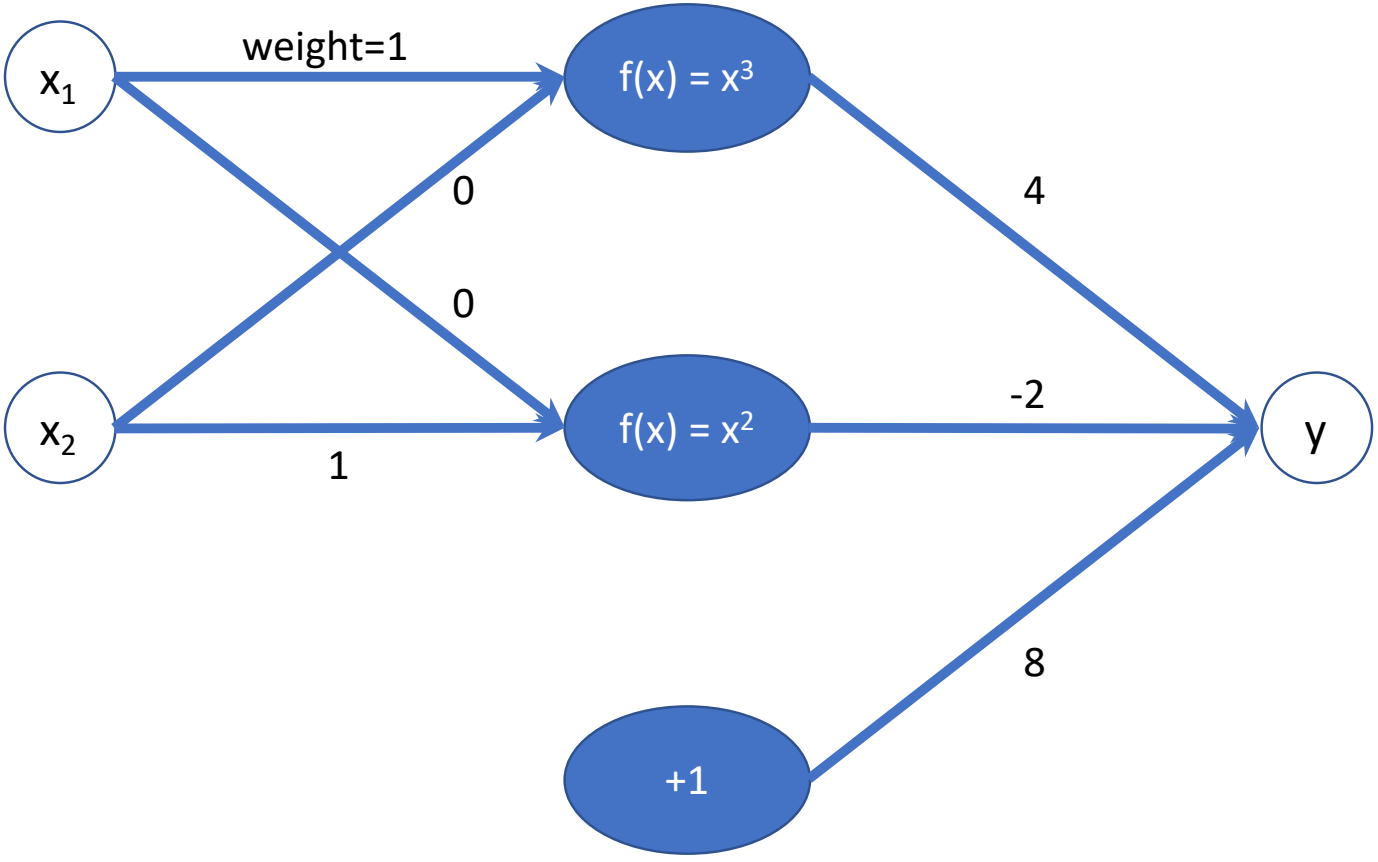
Input data → **prediction model** → output label



$y = F(x)$

Machine Learning Basics

$$y = 4x_1^3 - 2x_2^2 + 8$$

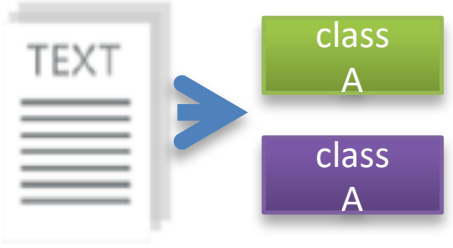


Types of Learning

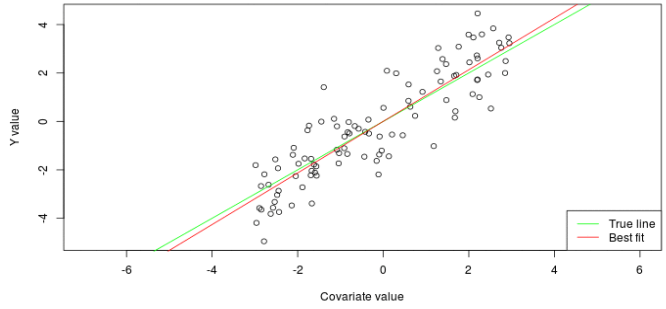
Supervised: Learning with a **labeled training** set
Example: email *classification* with already labeled emails

Unsupervised: Discover **patterns** in **unlabeled** data
Example: *cluster* similar documents based on text

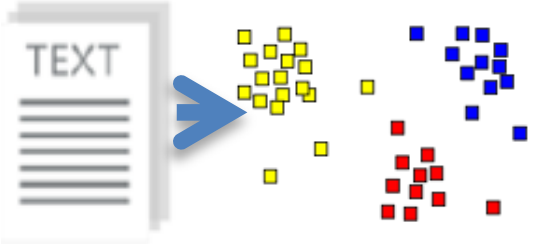
Reinforcement learning: learn to **act** based on **feedback/reward**
Example: learn to play Go, reward: *win or lose*



Classification



Regression



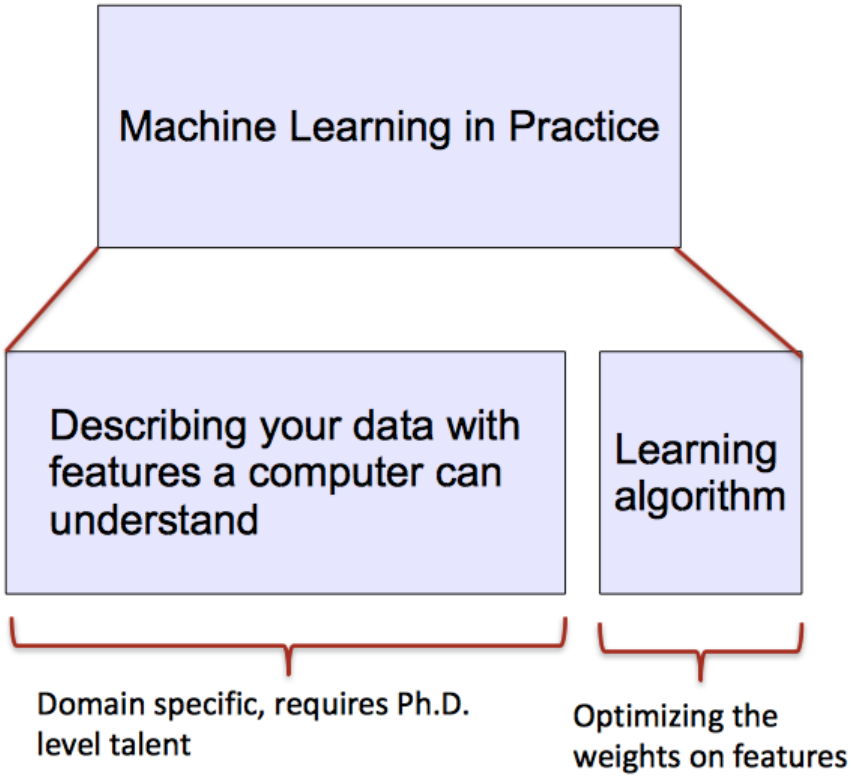
Clustering

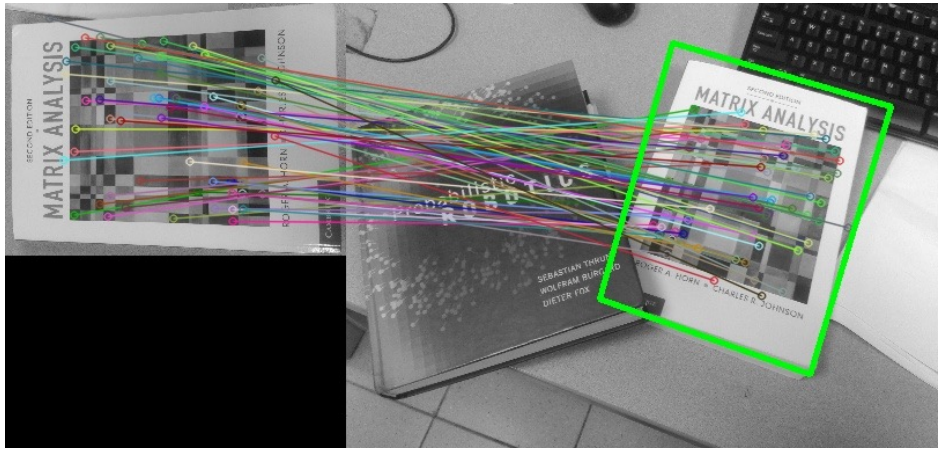
Anomaly Detection
Sequence labeling
…

http://mbjoseph.github.io/2013/11/27/measure.html

ML vs. Deep Learning

Most machine learning methods work well because of **human-designed representations** and **input features**
ML becomes just **optimizing weights** to best make a final prediction





SURF feature matching

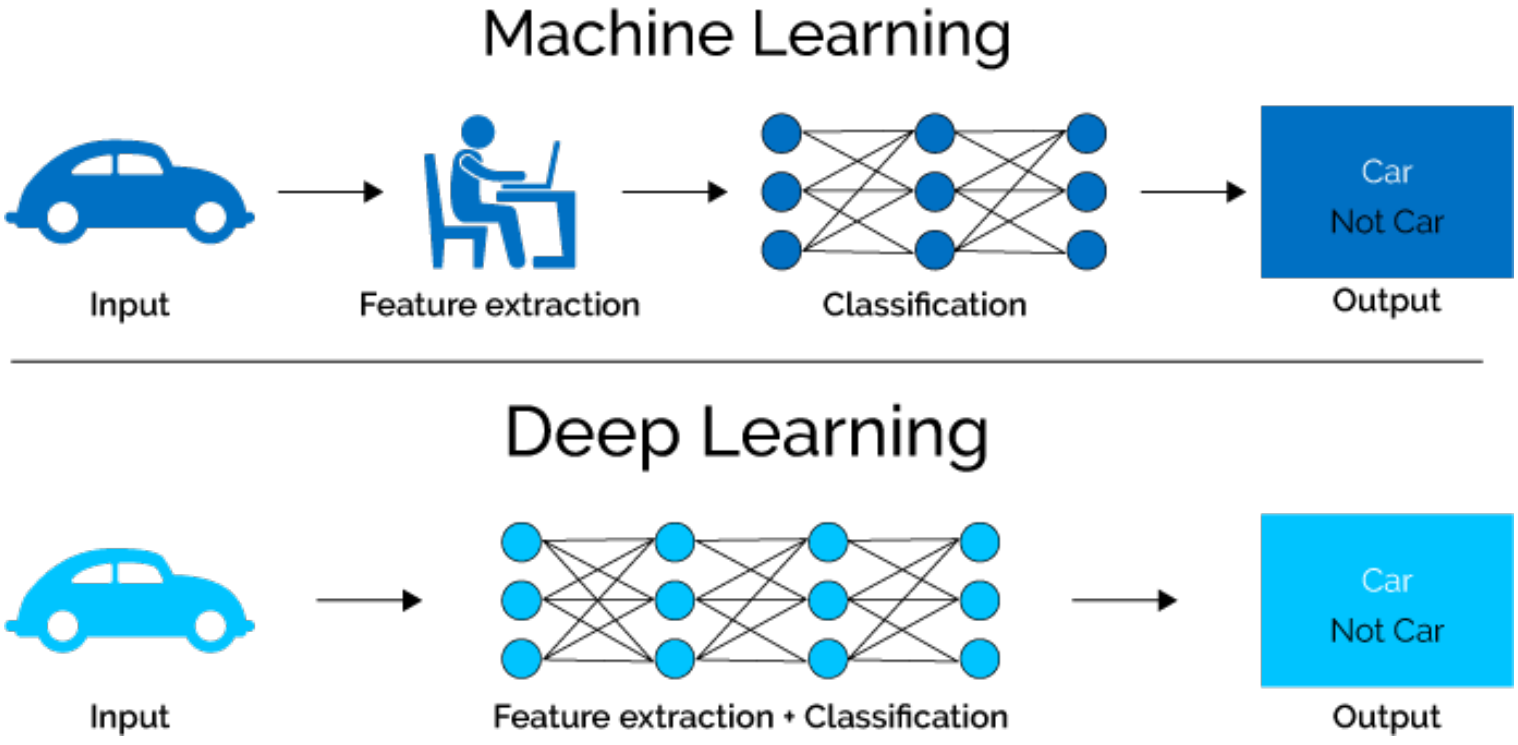
Challenges of general Machine Learning

Challenges of general ML:

- Relevant data acquisition
- Data preprocessing
- Feature selection
- Model selection: simplicity versus complexity
- Result interpretation.

What is Deep Learning (DL) ?

A machine learning subfield of learning **representations** of data. Exceptional effective at **learning patterns**.
Deep learning algorithms attempt to learn (multiple levels of) representation by using a **hierarchy of multiple layers**
If you provide the system **tons of information**, it begins to understand it and respond in useful ways.

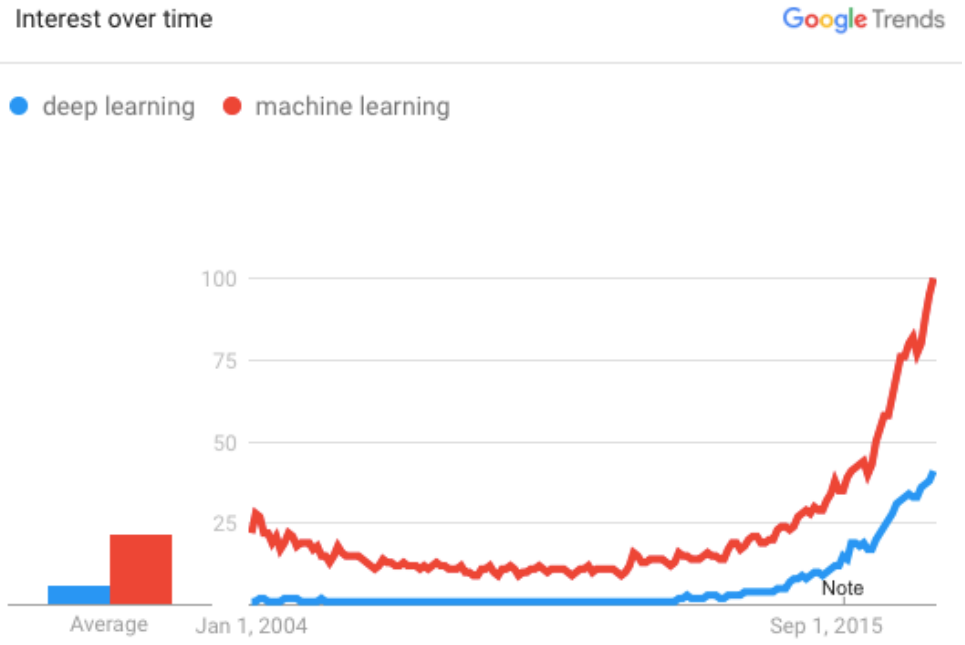


https://www.xenonstack.com/blog/static/public/uploads/media/machine-learning-vs-deep-learning.png

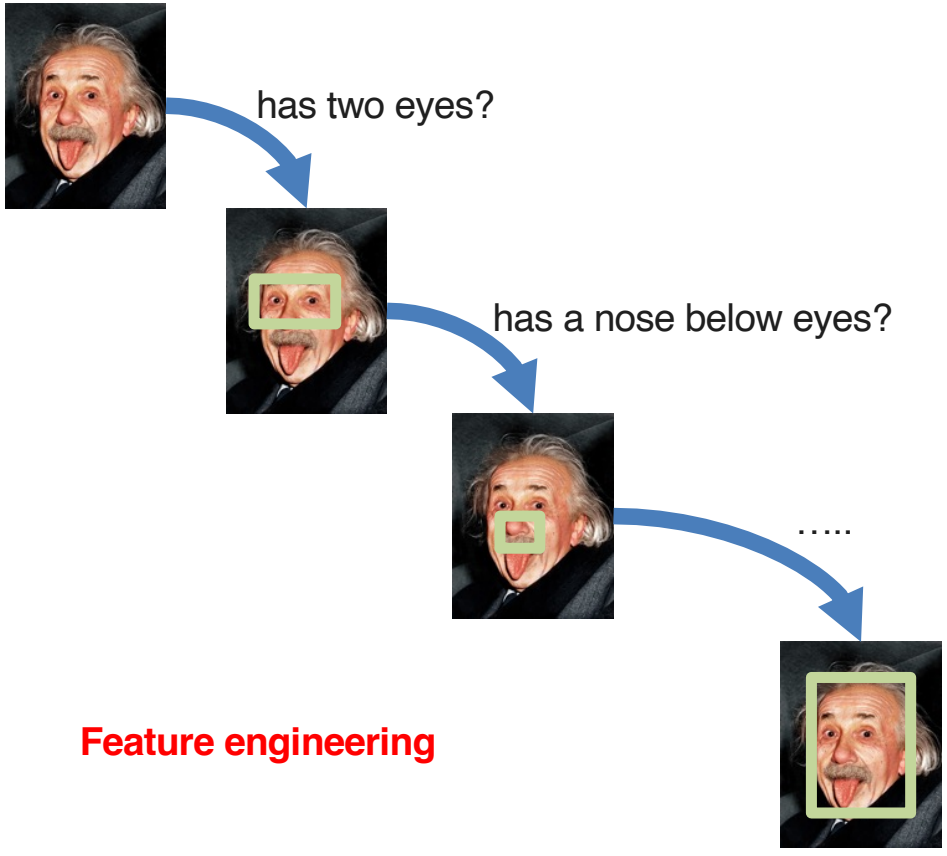
Why is DL useful?

- Manually designed features are often **over-specified**, **incomplete** and take a **long time to design** and validate
- Learned Features are **easy to adapt**, **fast** to learn
- Deep learning provides a very **flexible**, (almost?) **universal**, learnable framework for representing world, visual and linguistic information.
- Can learn both unsupervised and supervised
- Effective **end-to-end** joint system learning
- Utilize large amounts of training data

In ~2010 DL started outperforming other ML techniques
first in speech and vision, then NLP

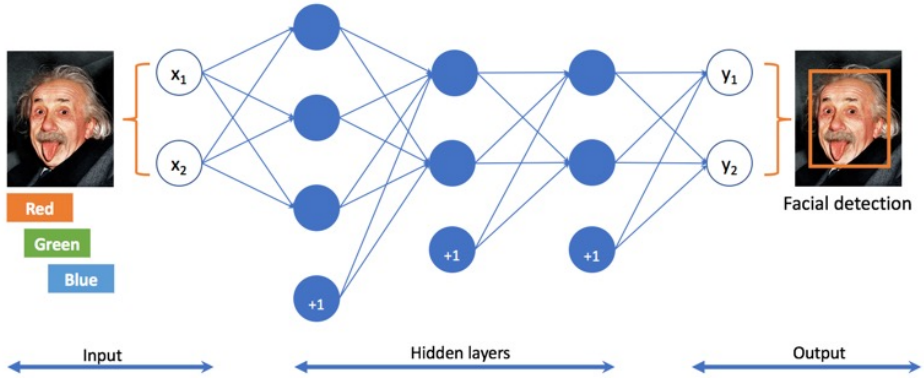


Traditional approach



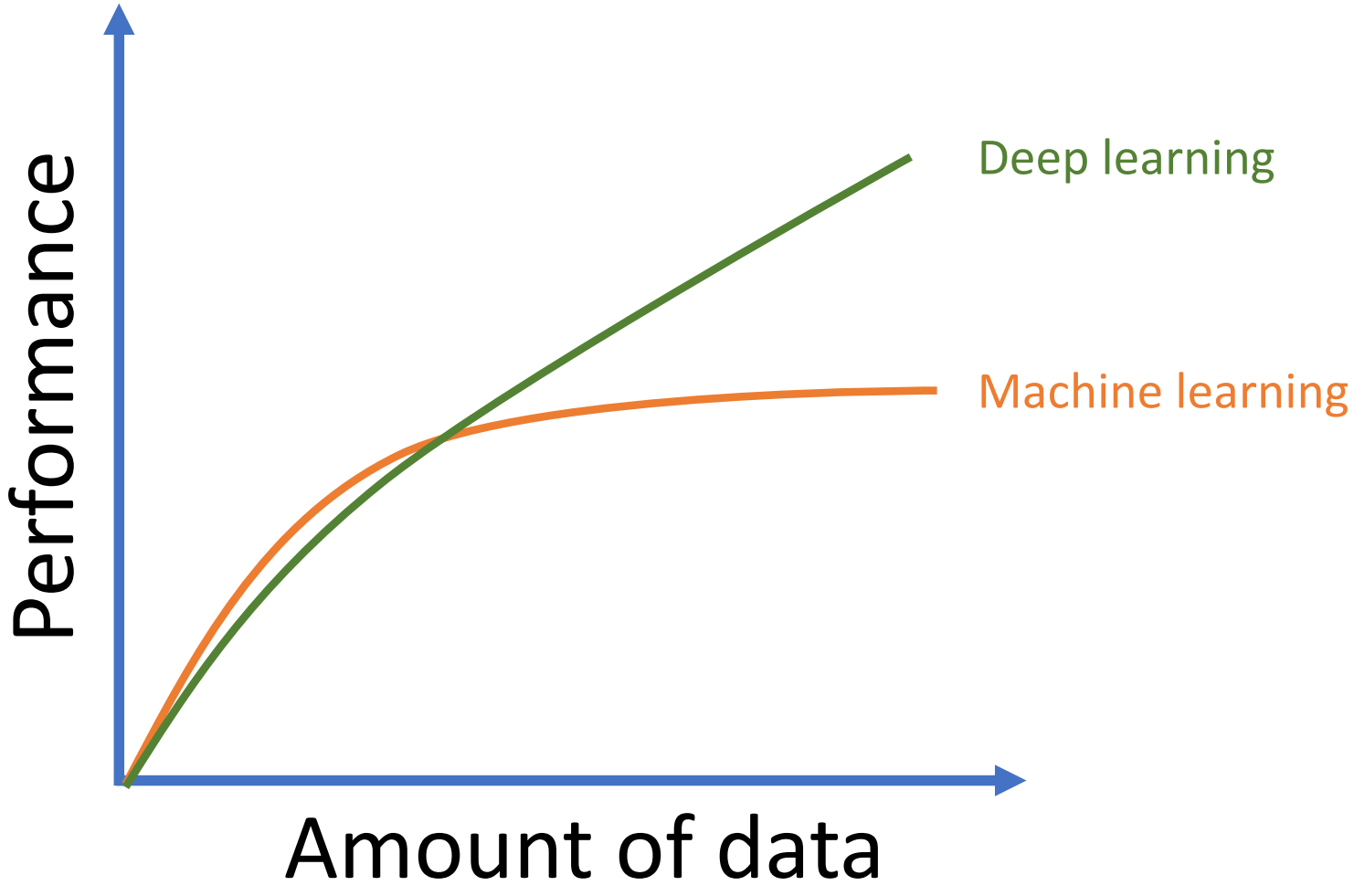
Feature engineering

Deep learning approach

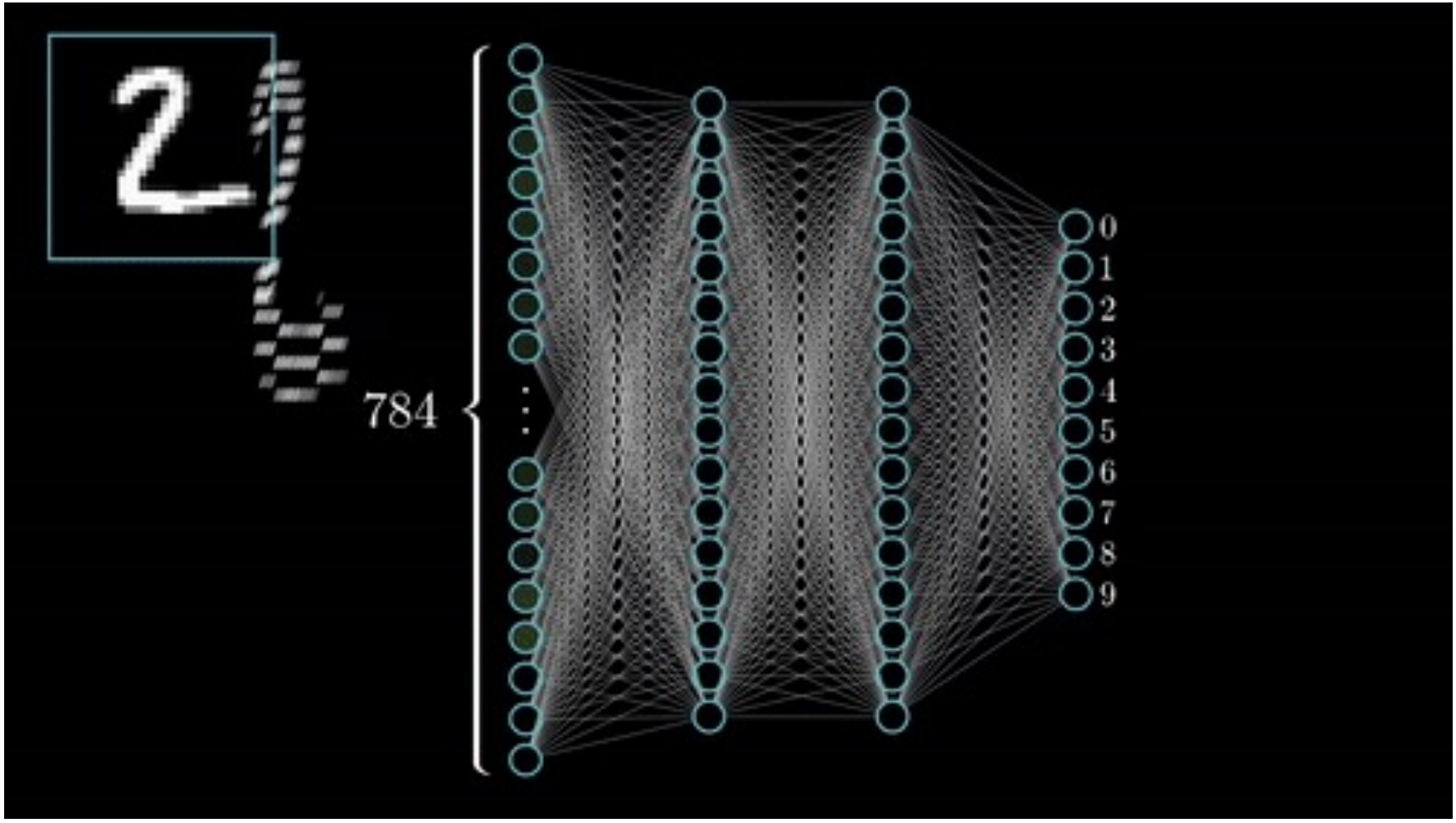


NO feature engineering

Why is DL useful?

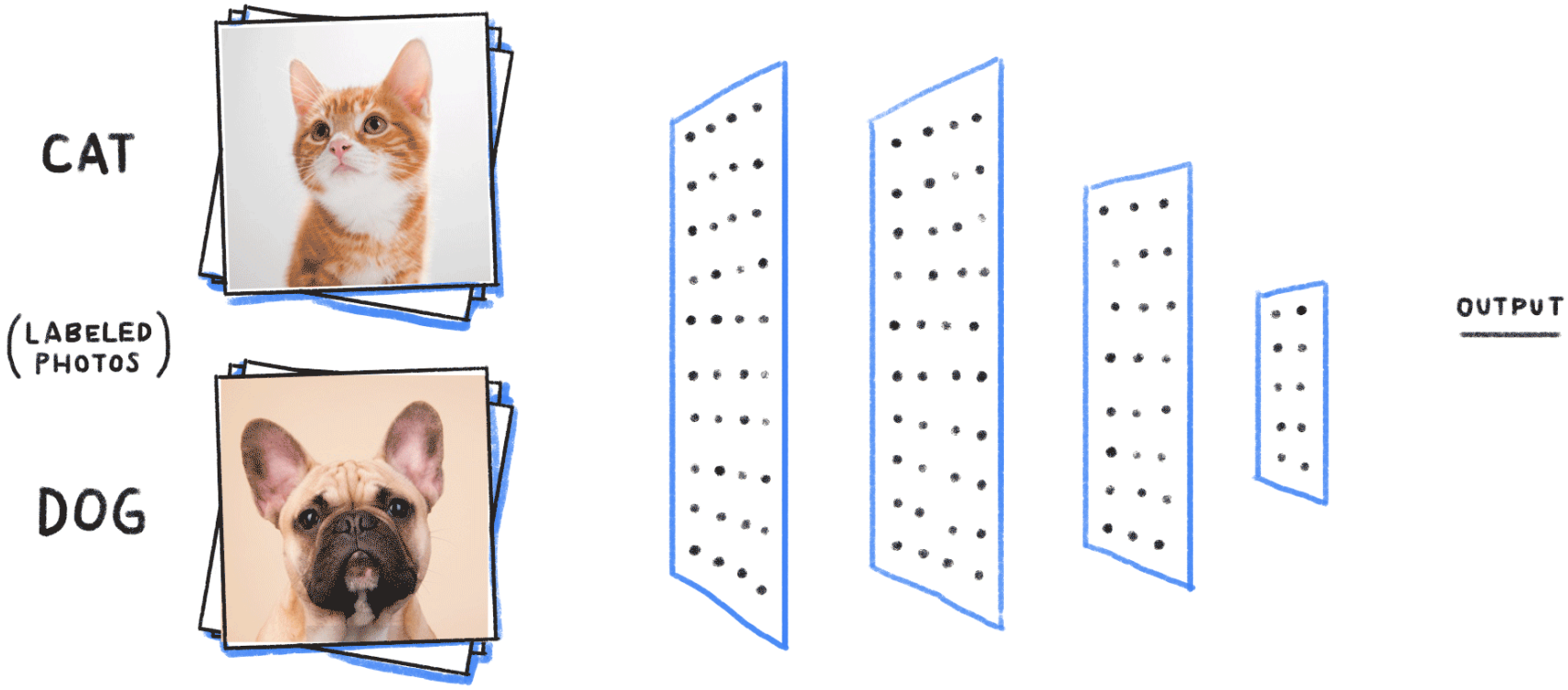


Deep Learning as a classifier



Neural Network is trying to predict the image (data sample) that given to it. it predicts that the number is 2 here.

Deep Learning as a classifier



Neural network is predicting cat/dog image

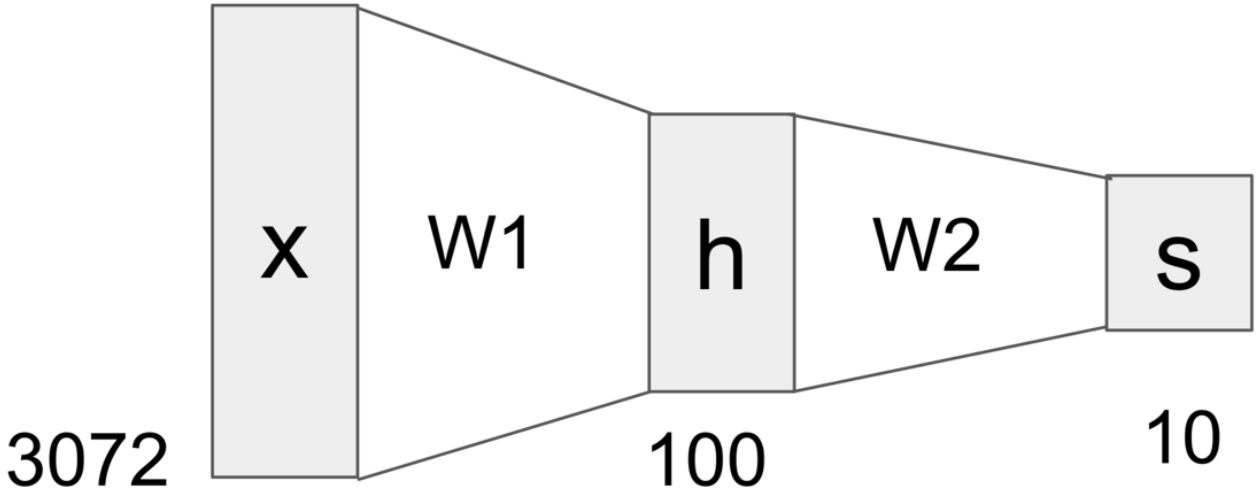
Neural Network

Linear score function:

$$f = Wx$$

2-layer Neural Network

$$f = W_2 \max(0, W_1 x)$$



Neural Network

Linear score function:

$$f = Wx$$

2-layer Neural Network

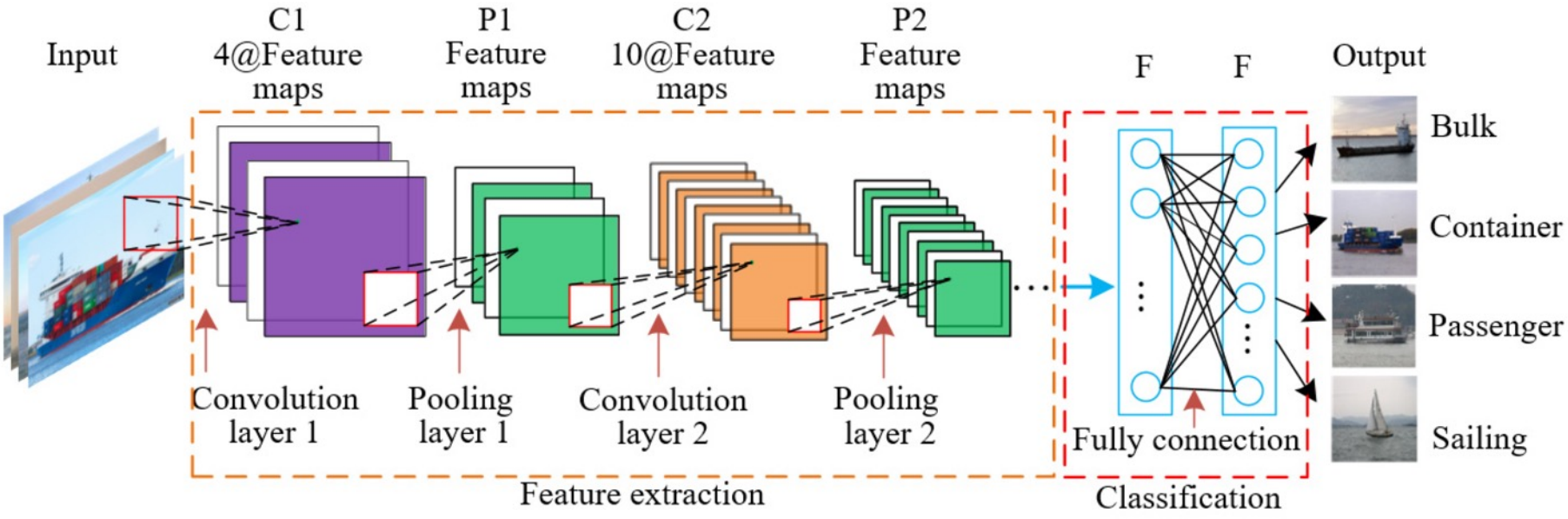
$$f = W_2 \max(0, W_1 x)$$

3-layer Neural Network

$$f = W_3 \max(0, W_2 \max(0, W_1 x))$$

... and so on.

Deep Learning as a classifier



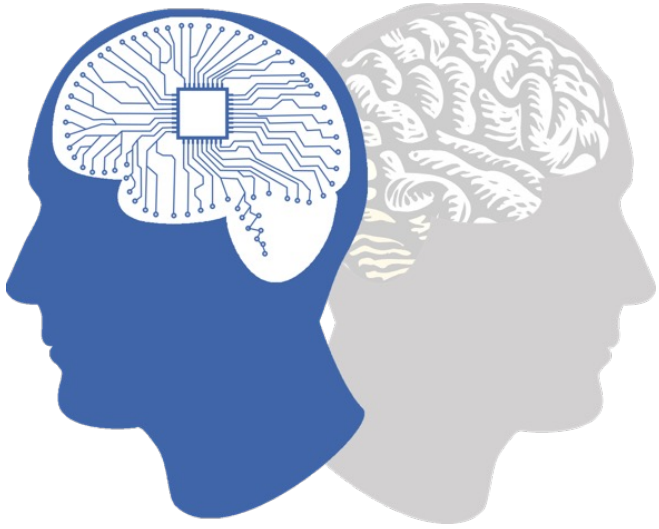
A typical neural network architecture for image classification task.

Deep learning layers as Lego blocks

Applications of AI

AI applications

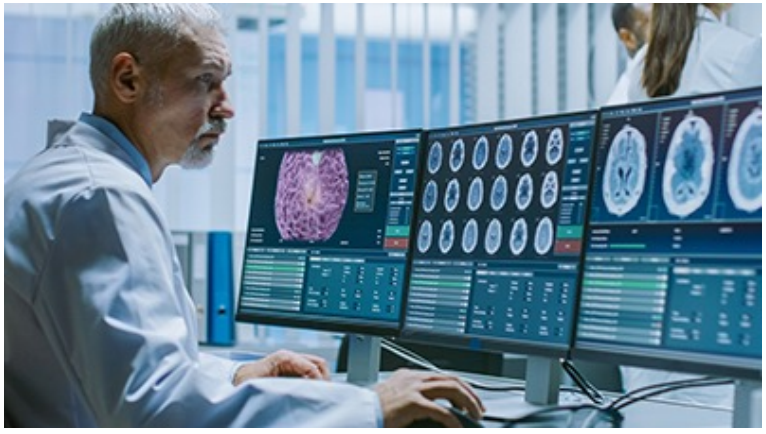
- Healthcare
- Automobile
- Banking, Finance
- Surveillance
- Social Media
- Entertainment



- Education
- Space Exploration
- Gaming
- Robotics
- Agriculture
- E-commerce

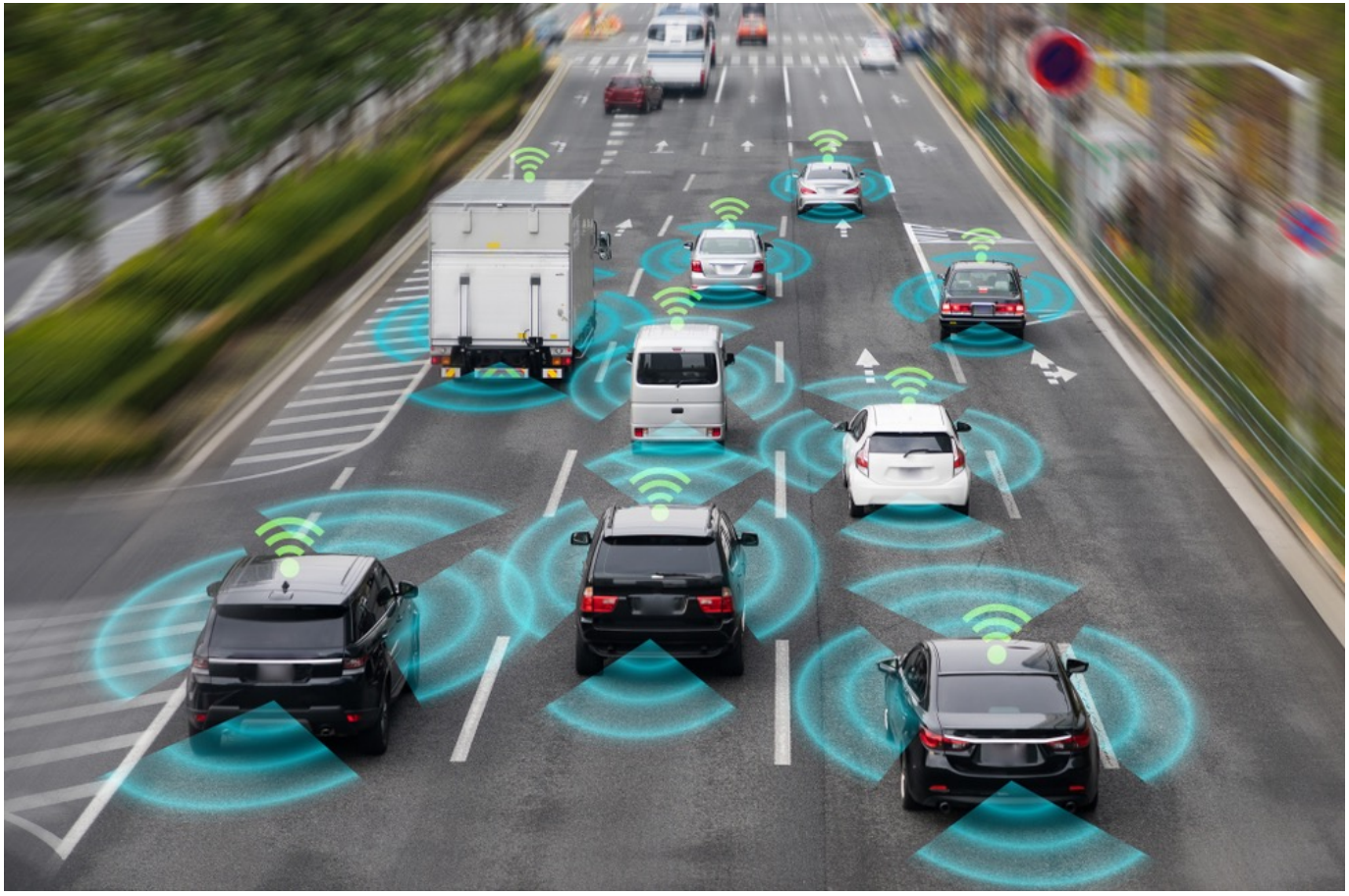
Healthcare

- Wearable devices that can analyze sleep patterns, calories burned, heart rate.
- Medical image diagnosis.



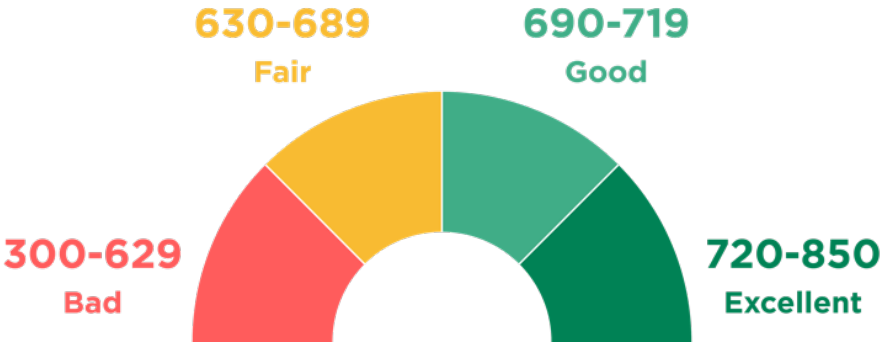
Automobile

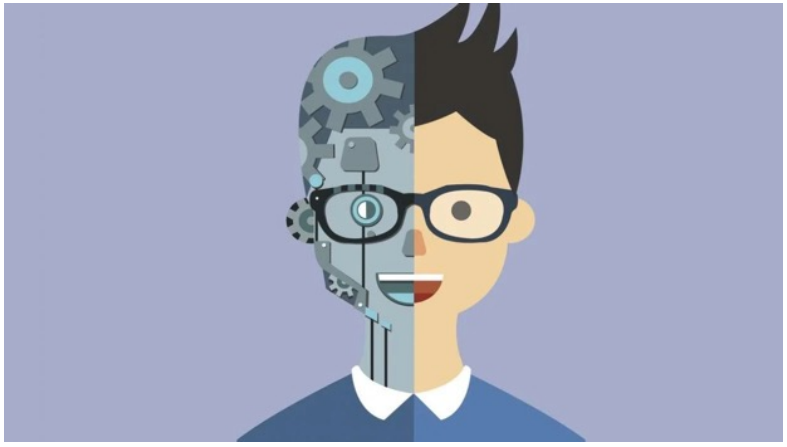
- Autonomous driving (a.k.a. self-driving) cars: avoid obstacles, communicate with near-by cars, etc., by applying Machine Vision and IoT technologies.



Banking and Finance

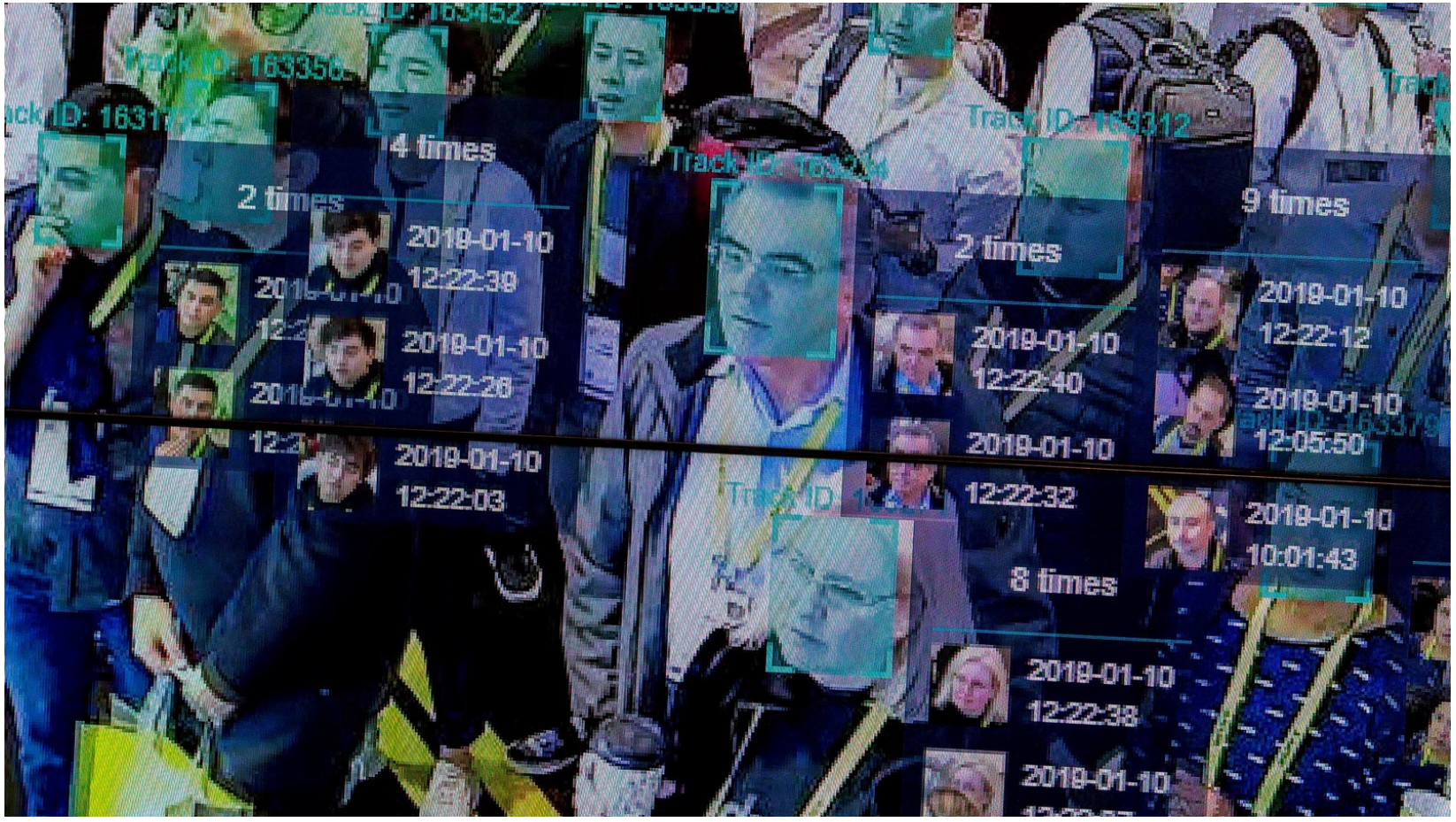
- Credit scoring.
- Automatic customer support.





Surveillance

- Facial recognition.
- Public safely.

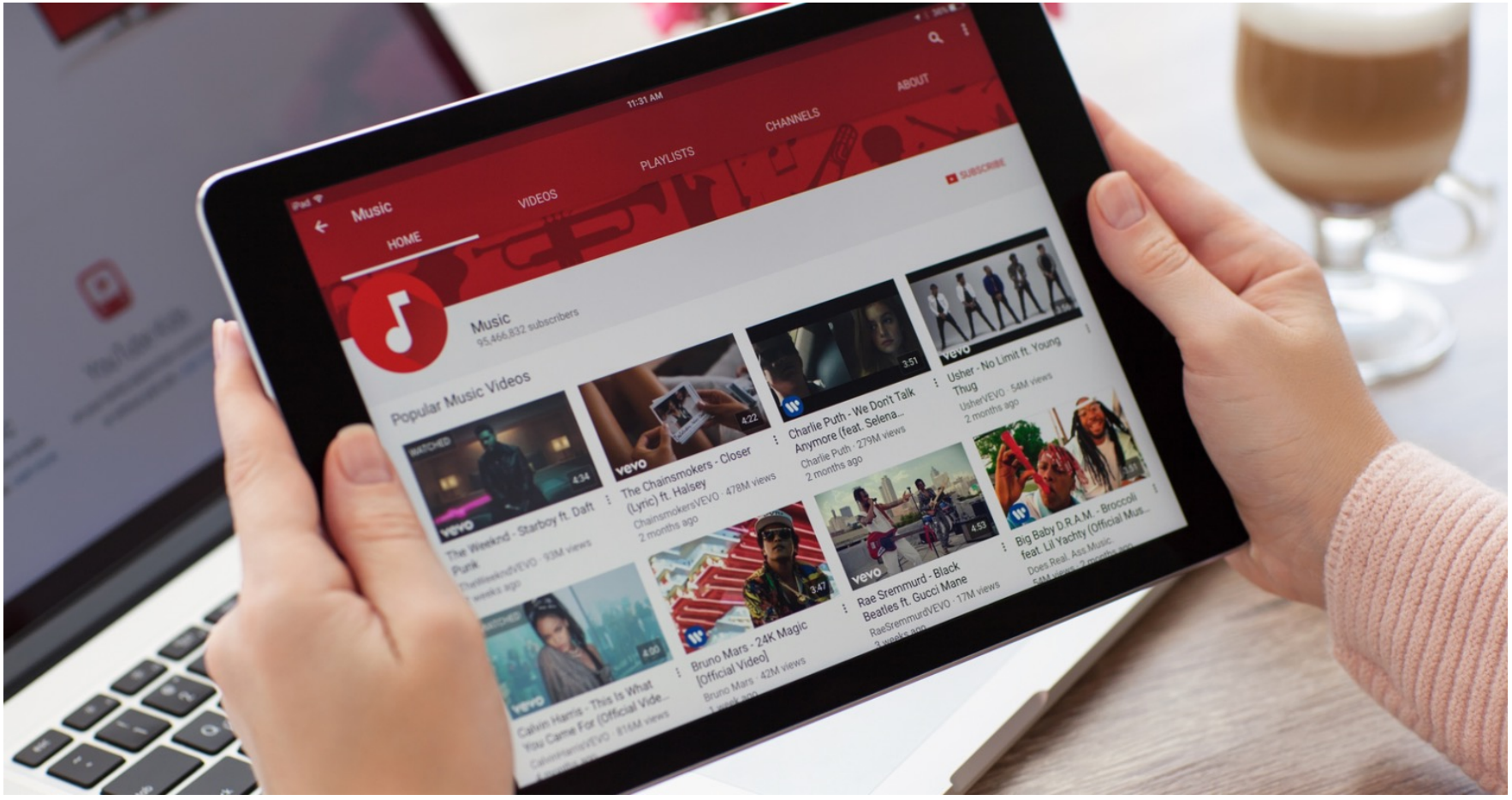


Social media

- Social trends detection (social listening).
- User behavior understanding (for marketing/advertising purpose).

Entertainment

- User data collection and analysis.
- Recommendation engine.



Education

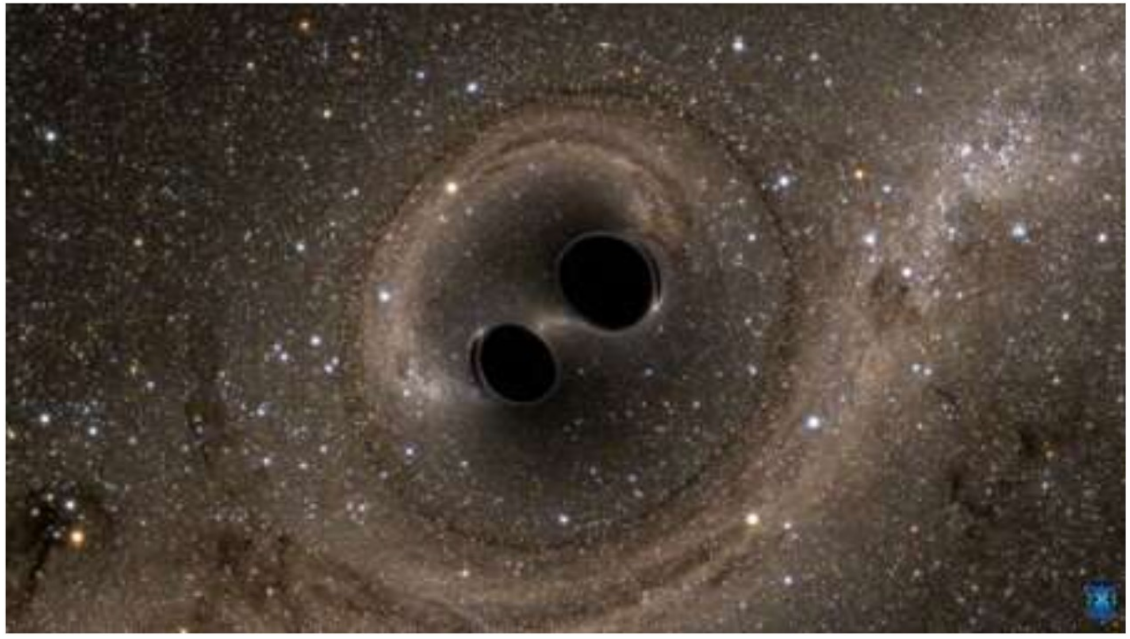
- AI-powered tutoring.
- Personalized education.

Space exploration

JANUARY 24, 2019

Physicists use supercomputers and AI to create the most accurate model yet of black hole mergers

by Whitney Clavin



https://phys.org/news/2019-01-physicists-supercomputers-ai-accurate-black.html

Gaming

- Reinforcement Learning

Robotics

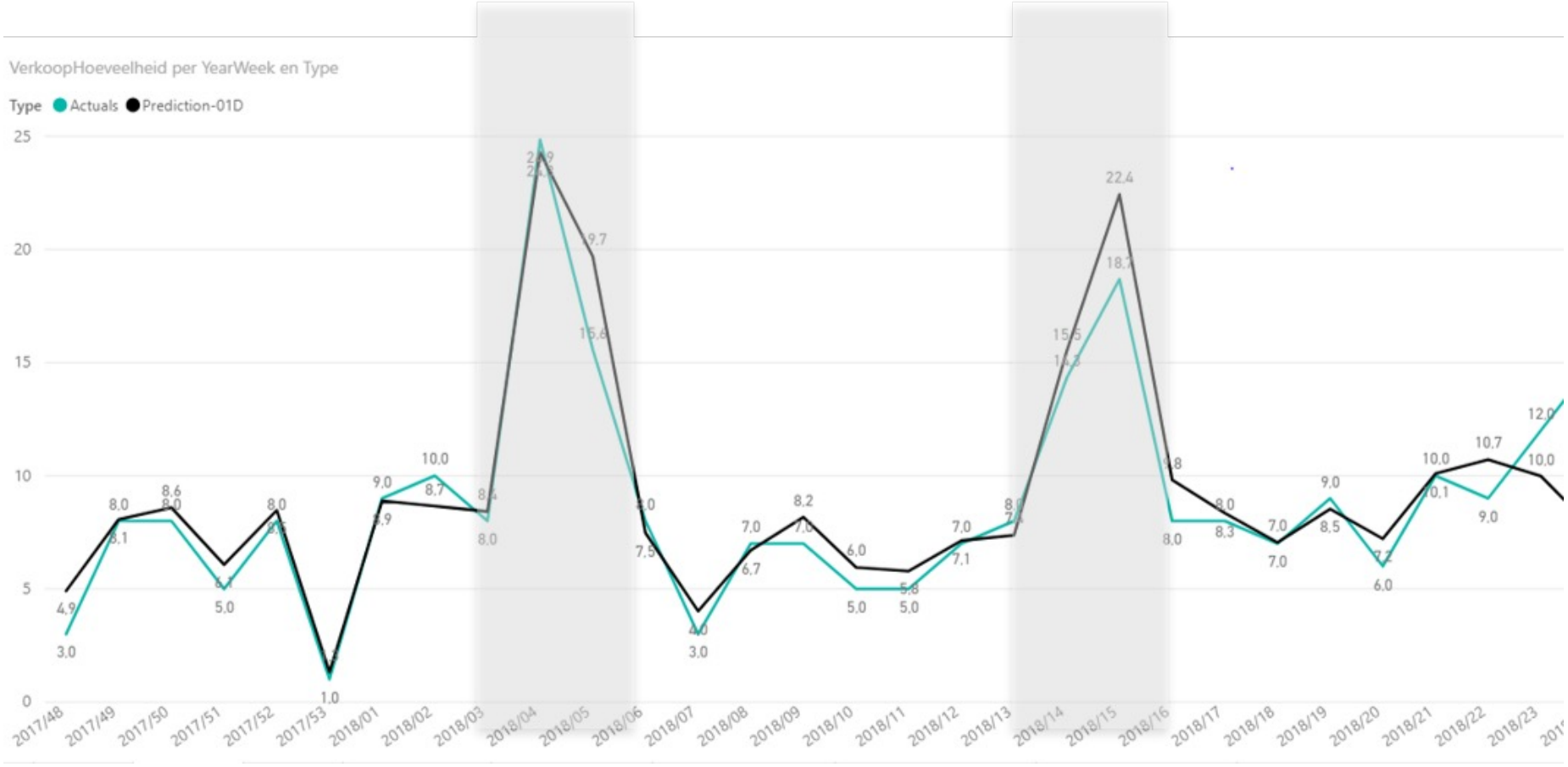
- Automate the works in factory.

Agriculture

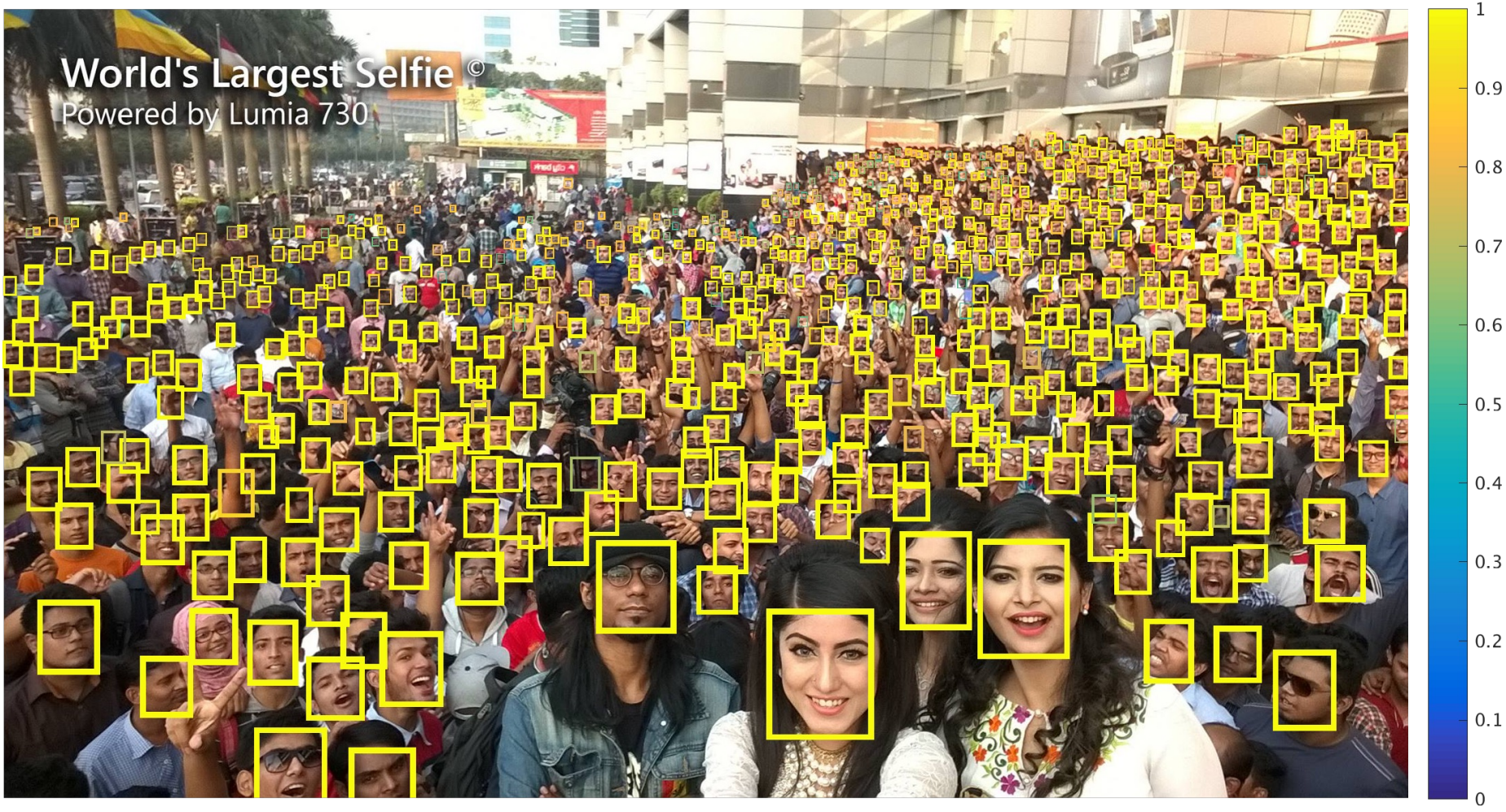
- Use of drone for spraying insecticide.
- Detect weed formation in large farms.

E-commerce

- Logistics.
- Demand forecasting.
- Intelligent marketing

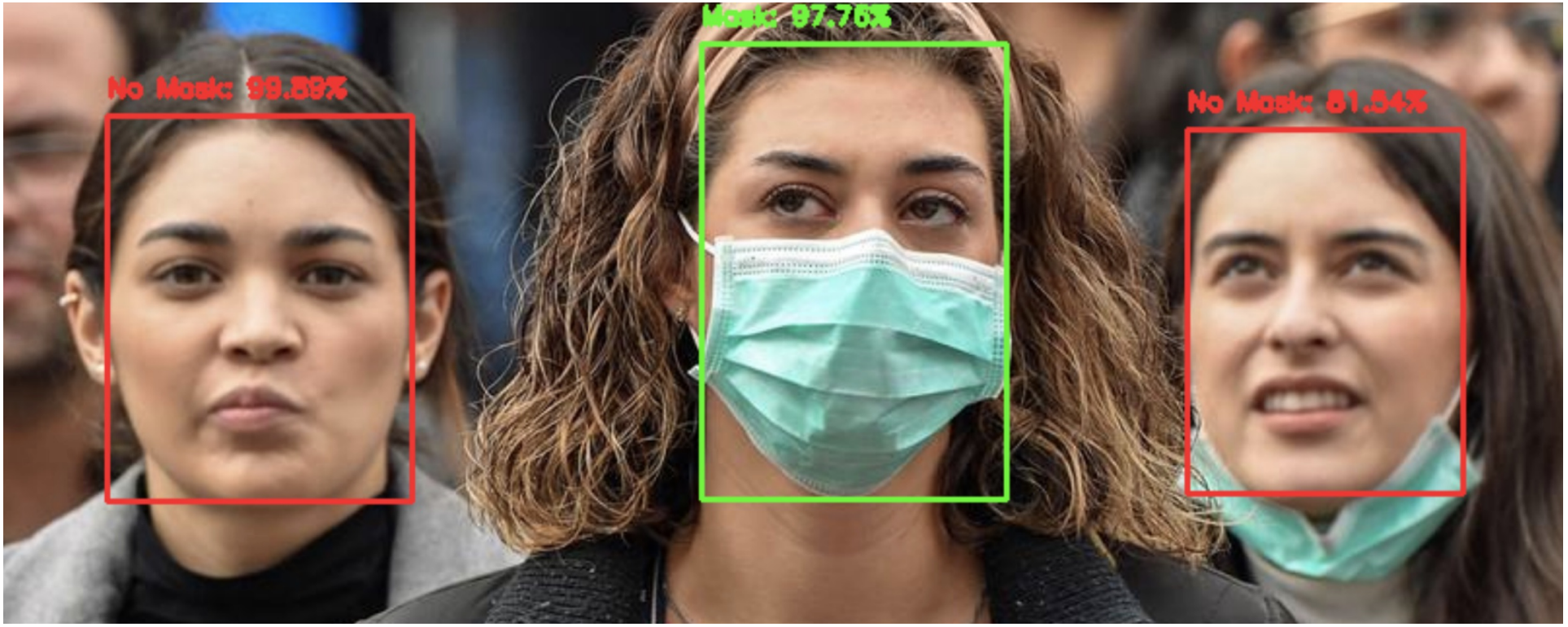


Face detection



Hu, Peiyun and Ramanan, Deva, "*Finding Tiny Faces*", CVPR'17

Face detection

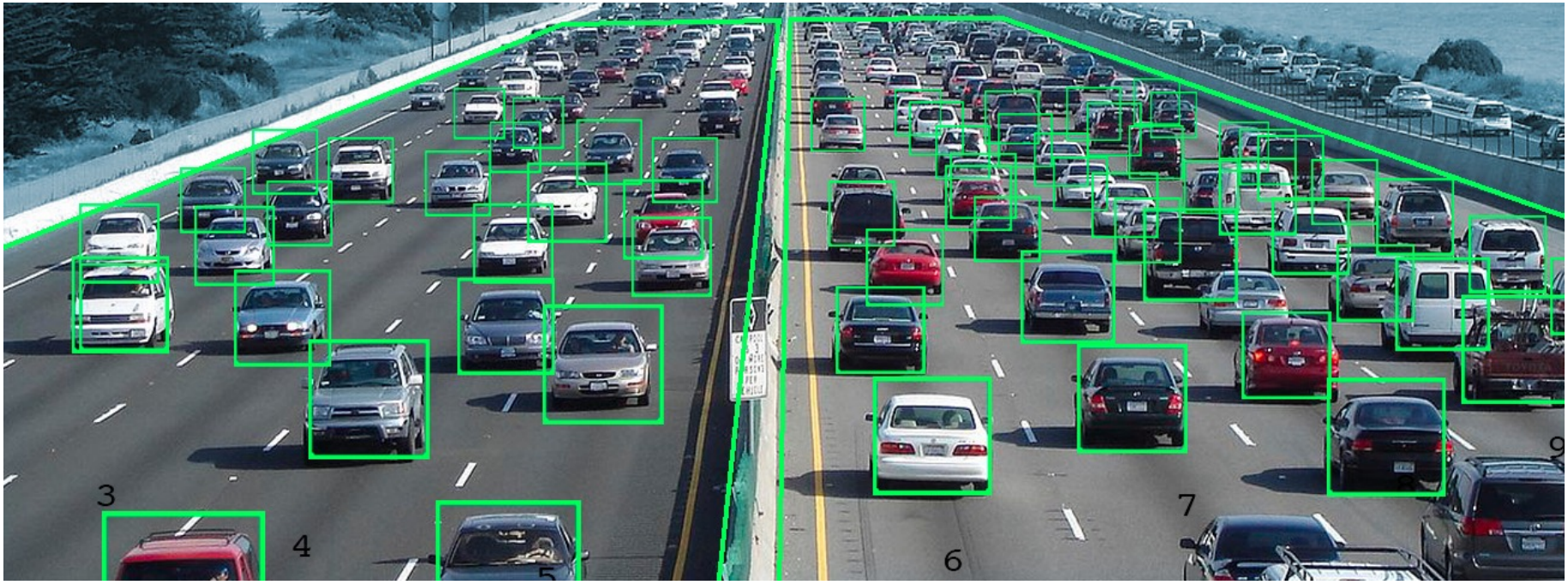


https://devpost.com/software/face-mask-detection

Face generation

Tero Karras, Samuli Laine, Miika Aittala, Janne Hellsten, Jaakko Lehtinen and Timo Aila, "*Analyzing and Improving the Image Quality of StyleGAN*", CVPR'20

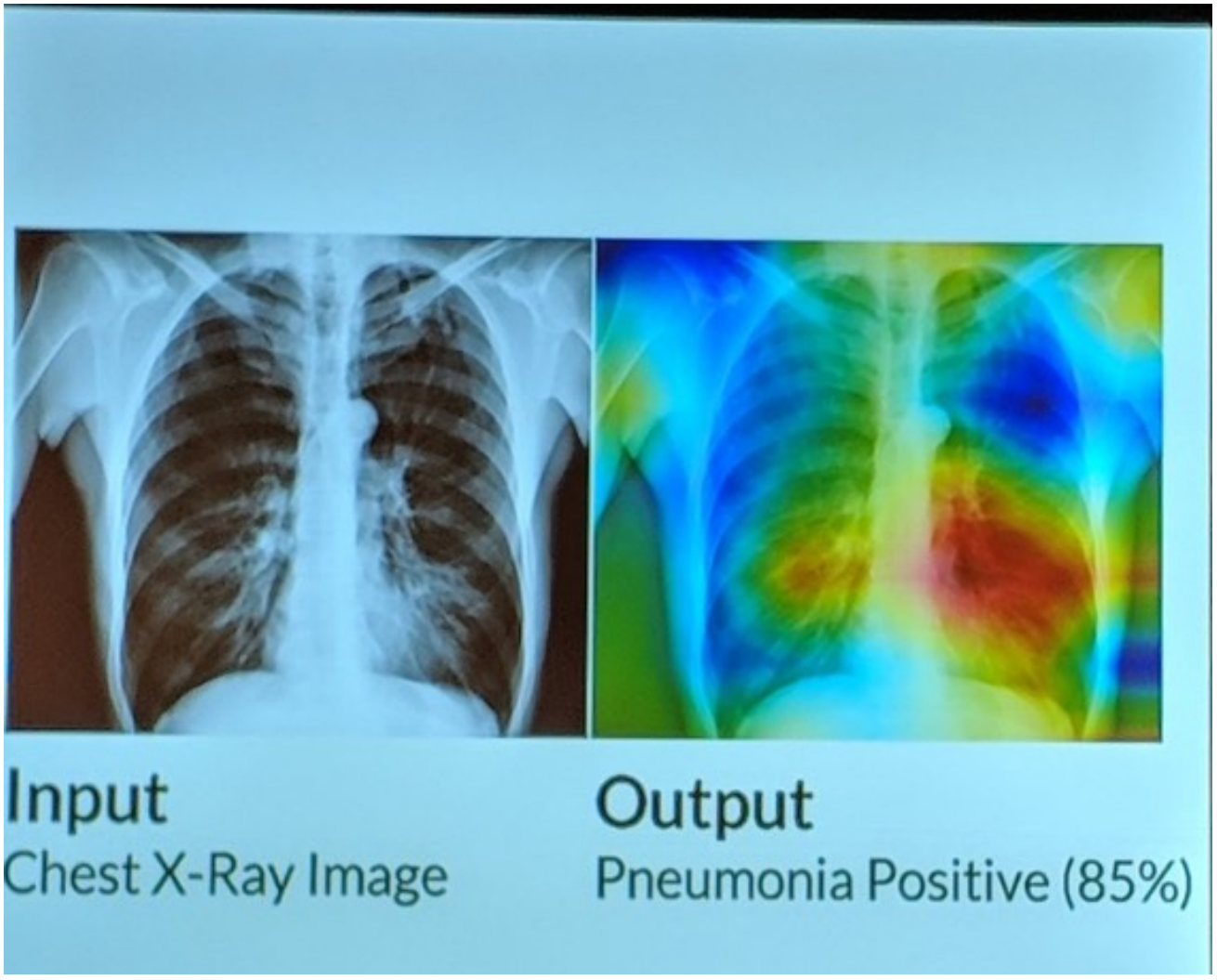
Traffic monitoring



Self-driving car

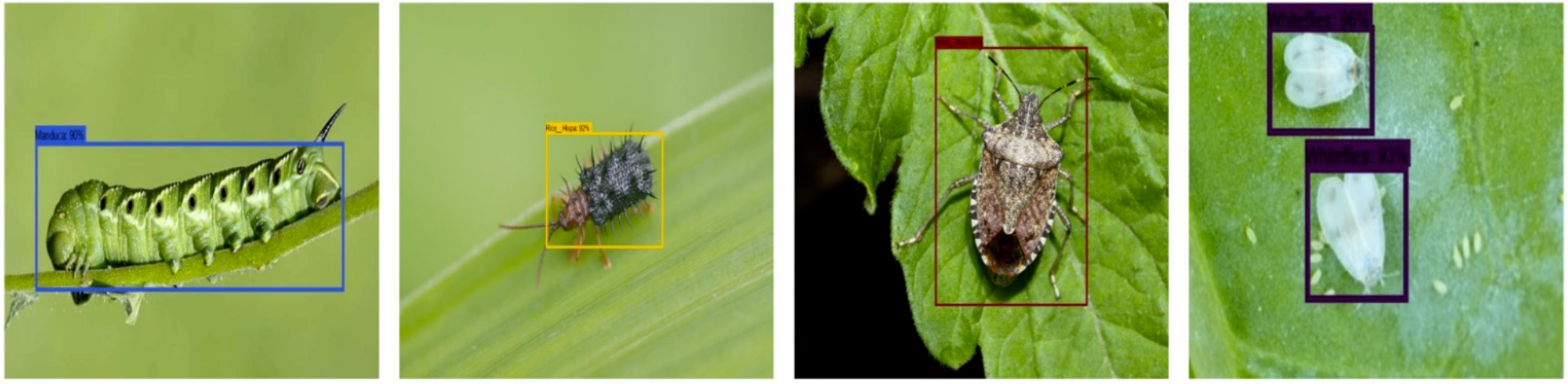
https://www.inc.com/kevin-j-ryan/self-driving-cars-powered-by-people-playing-games-mighty-ai.html

Healthcare



https://medium.com/@anushka.da3/application-of-computer-vision-in-health-care-9144899e2c54

Agriculture



Balakrishnan Ramalingam,,Rajesh Elara Mohan,Sathian Pookkuttath,Braulio Félix Gómez,Charan Satya Chandra Sairam Borusu,Tey Wee Teng and Yokhesh Krishnasamy Tamilselvam, *"Remote Insects Trap Monitoring System Using Deep Learning Framework and IoT"*, MDPI journal.

Retail

https://aws.amazon.com/blogs/industries/seeing-dollar-signs-ways-to-leverage-computer-vision-in-retail-stores/

Artificial Intelligence: Theory vs. Reality

Performance vs. Portability

Theory

Reality

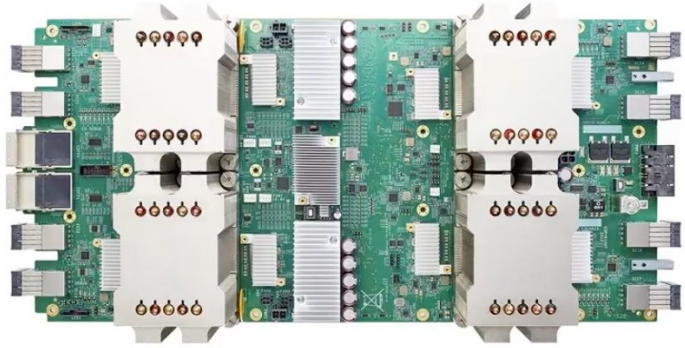
Performance vs. Power Consumption

Theory

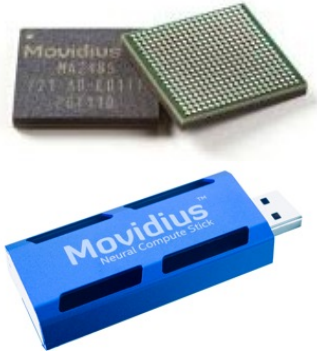
Reality

Special Hardware for Deep Learning

Jetson TX2
(NVDIA)



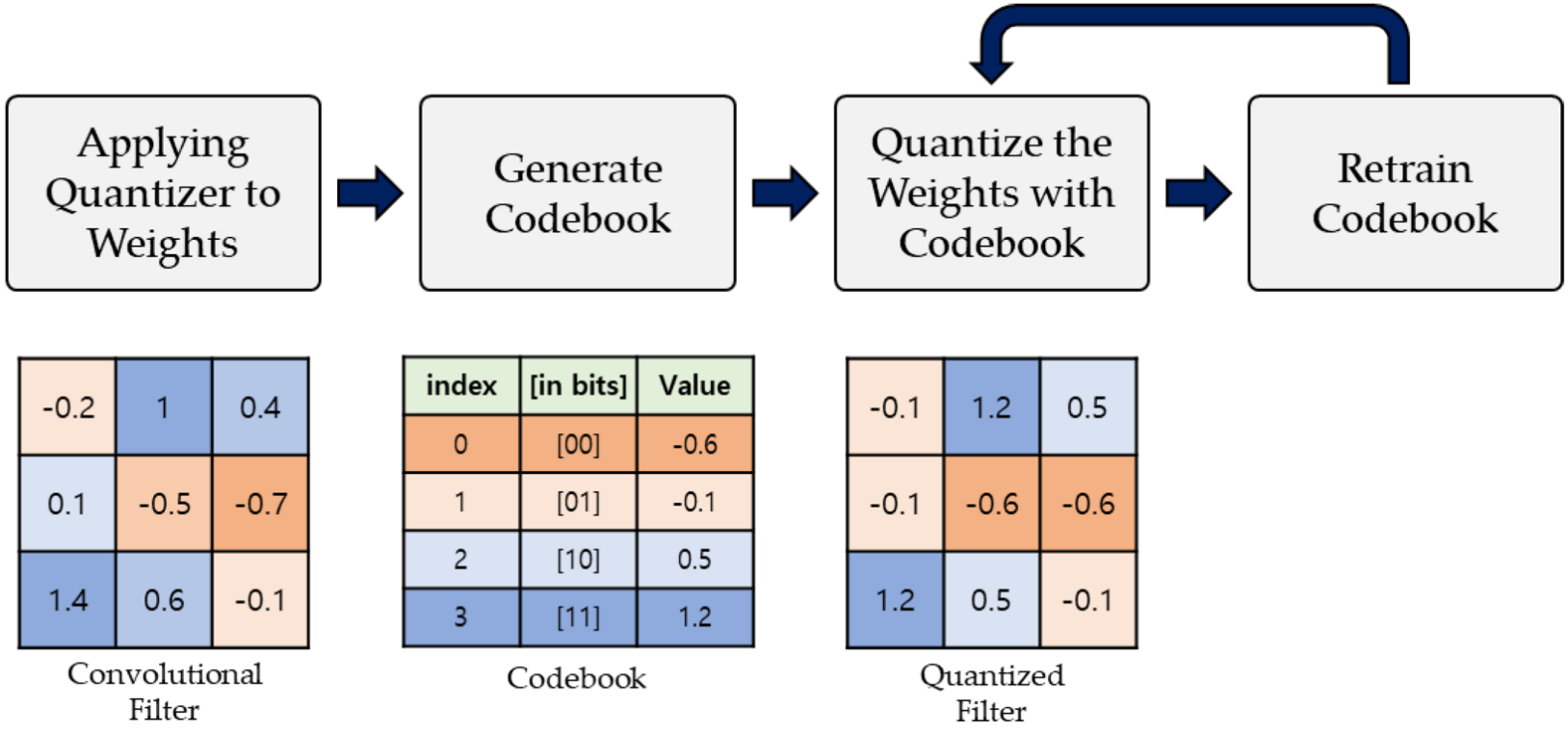
Google
TPU



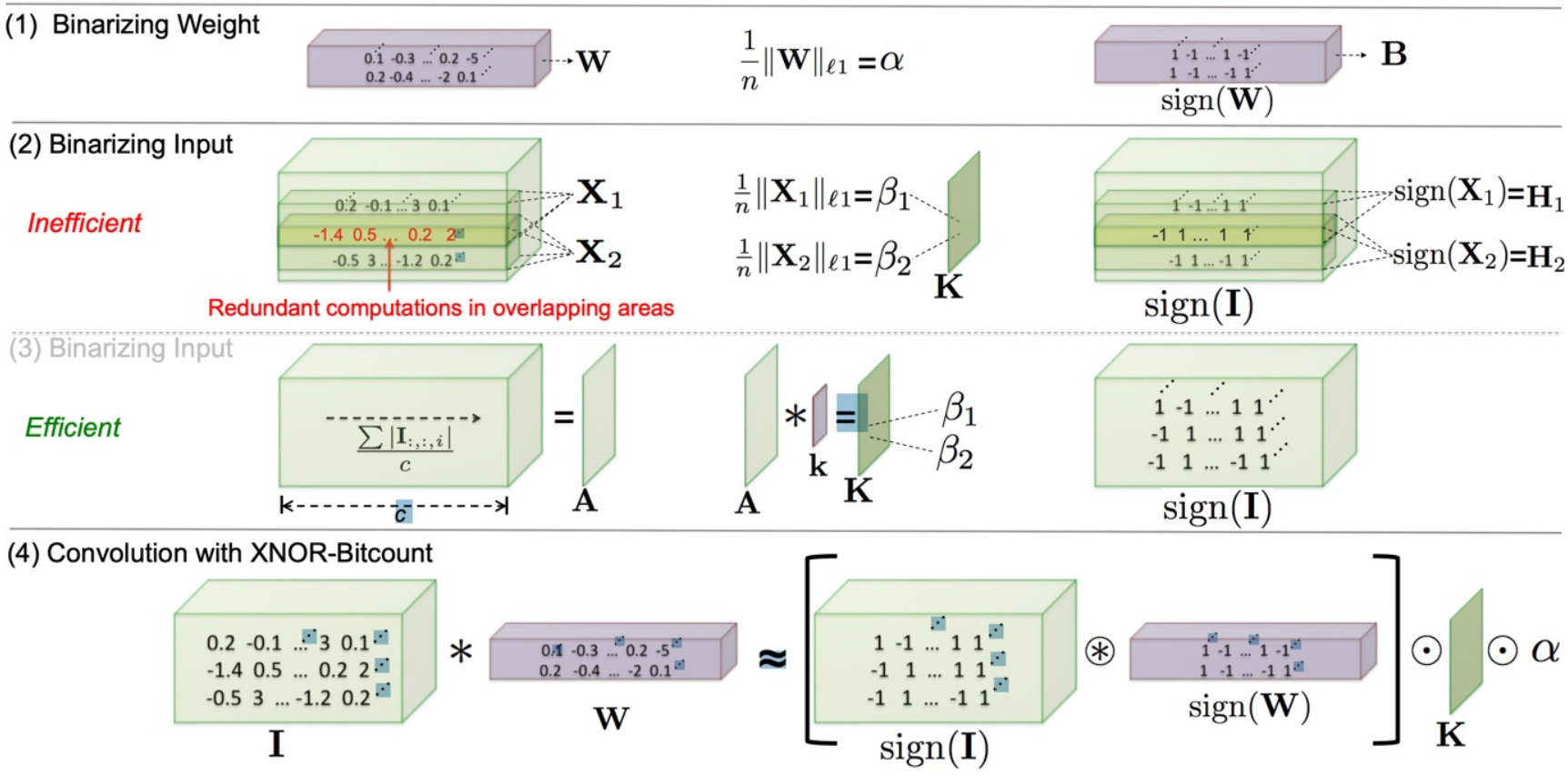
- Optimized for specific use case.
- Not plug-and-play, need good engineers to make it work.

Still far from consumer…

Network quantization

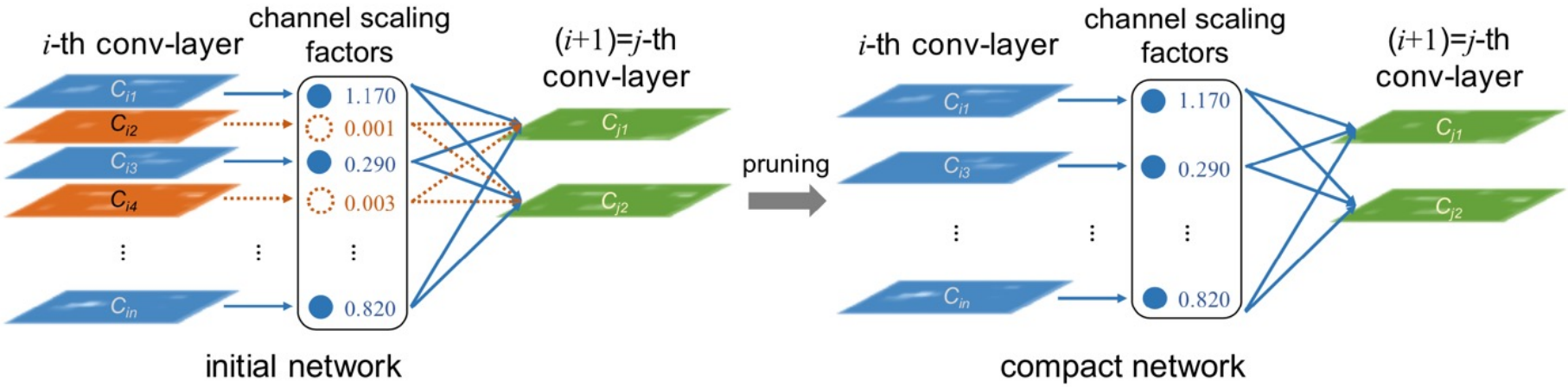


Network binarization



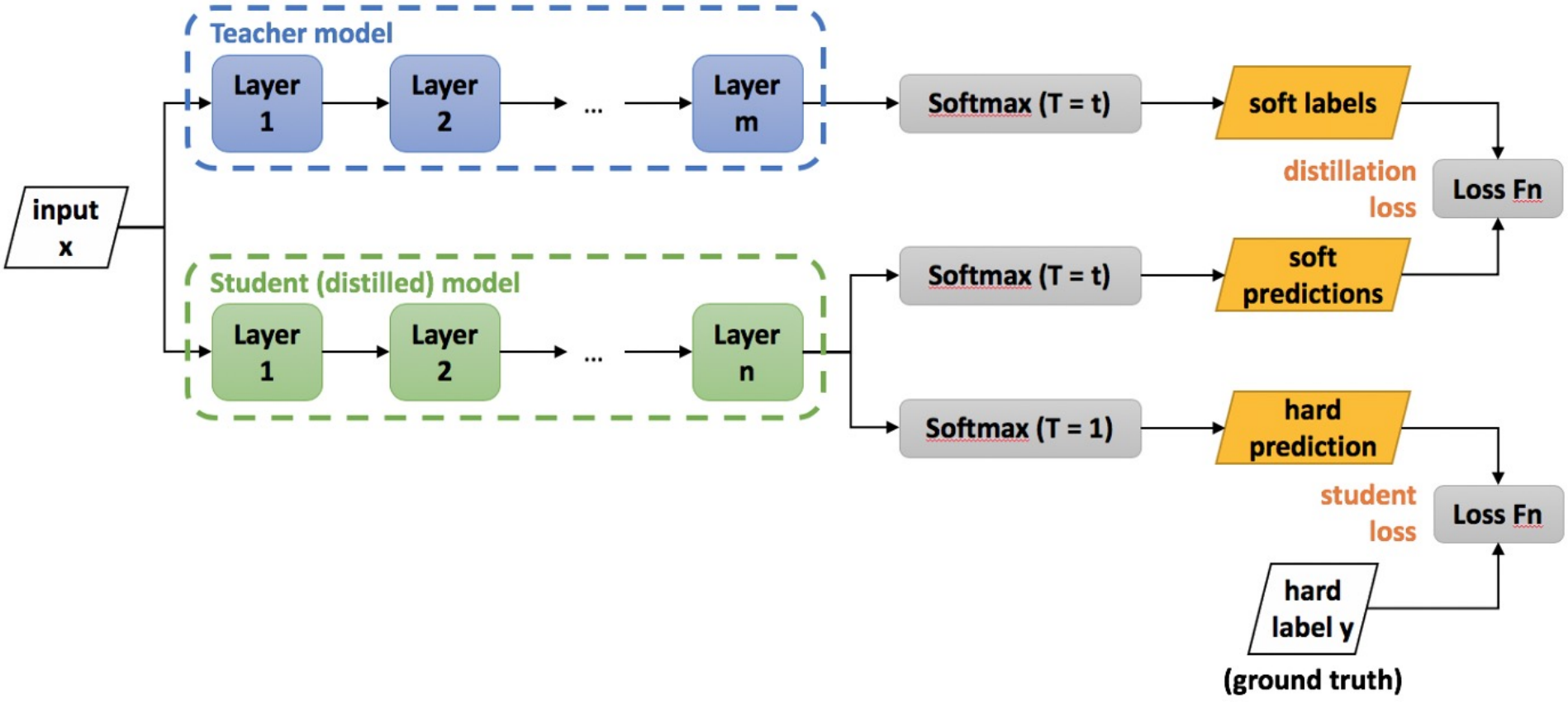
Mohammad Rastegari, Vicente Ordonez, Joseph Redmon, Ali Farhadi, "XNOR-Net: ImageNet Classification Using Binary Convolutional Neural Networks"

Network pruning

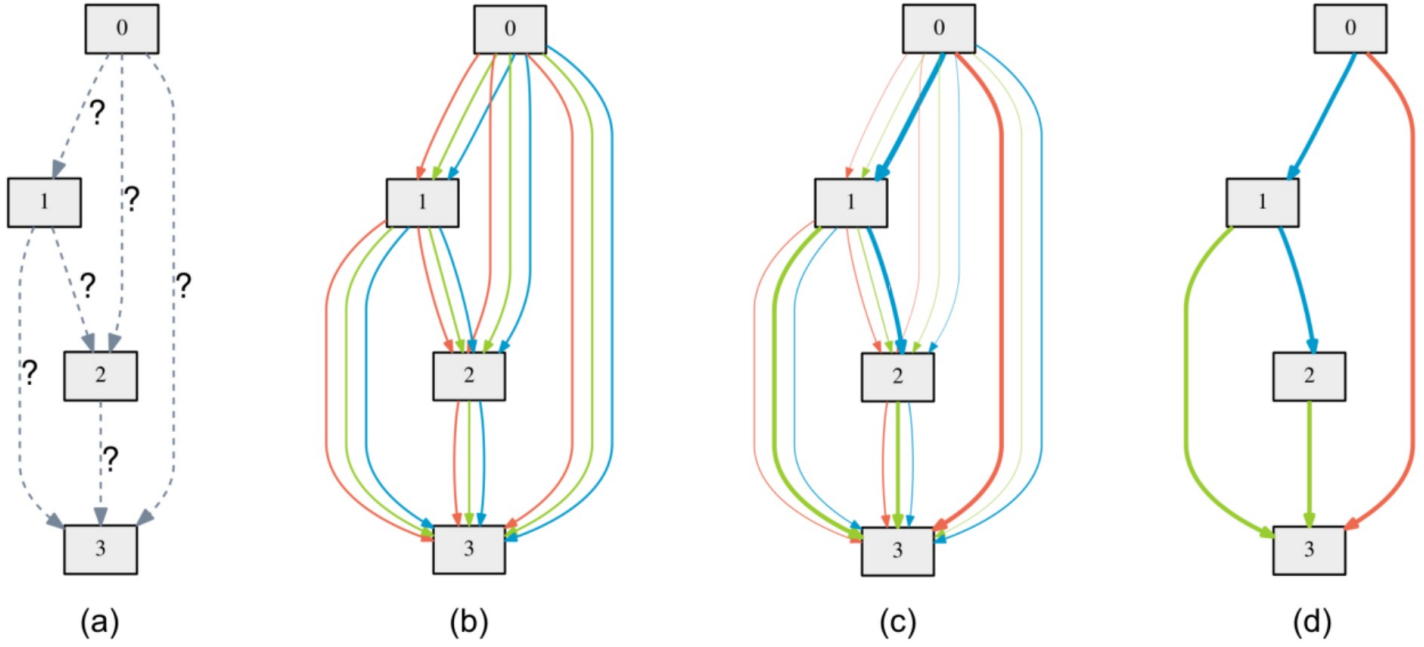


Zhuang Liu, Jianguo Li, Zhiqiang Shen, Gao Huang, Shoumeng Yan, Changshui Zhang, “Learning Efficient Convolutional Networks through Network Slimming”.

Knowledge Distillation



Network Architecture Search (NAS)



Hanxiao Liu, Karen Simonyan, Yiming Yang, “DARTS: Differentiable Architecture Search”

Summary

- Introduction to deep learning and neural networks.
- Feature engineering in machine learning and deep learning.
- Challenges in machine learning and deep learning.
- Applications of AI.
- AI: Theory vs. Reality.

Q&A

Thank you