

한국기술교육대학교 능력개발교육원
4차 산업혁명 핵심
기술 컨퍼런스
2020년 1월 21일

4차 산업혁명 인재양성을 위한 인공지능 (AI) 교수 방법

임성규
(조지아 공대)

1. 인공지능 (AI) 기계학습이란?

2. 기계학습의 종류

- CNN, RNN GAN, Autoencoder, Unet

3. 기계학습 교수법 및 코딩 실습의 예

- RNN으로 주가 변동 예측하기
- Azure로 붓꽃 판별하기

4. 기계학습 관련 진행 연구

- 회로설계에 적용된 기계학습

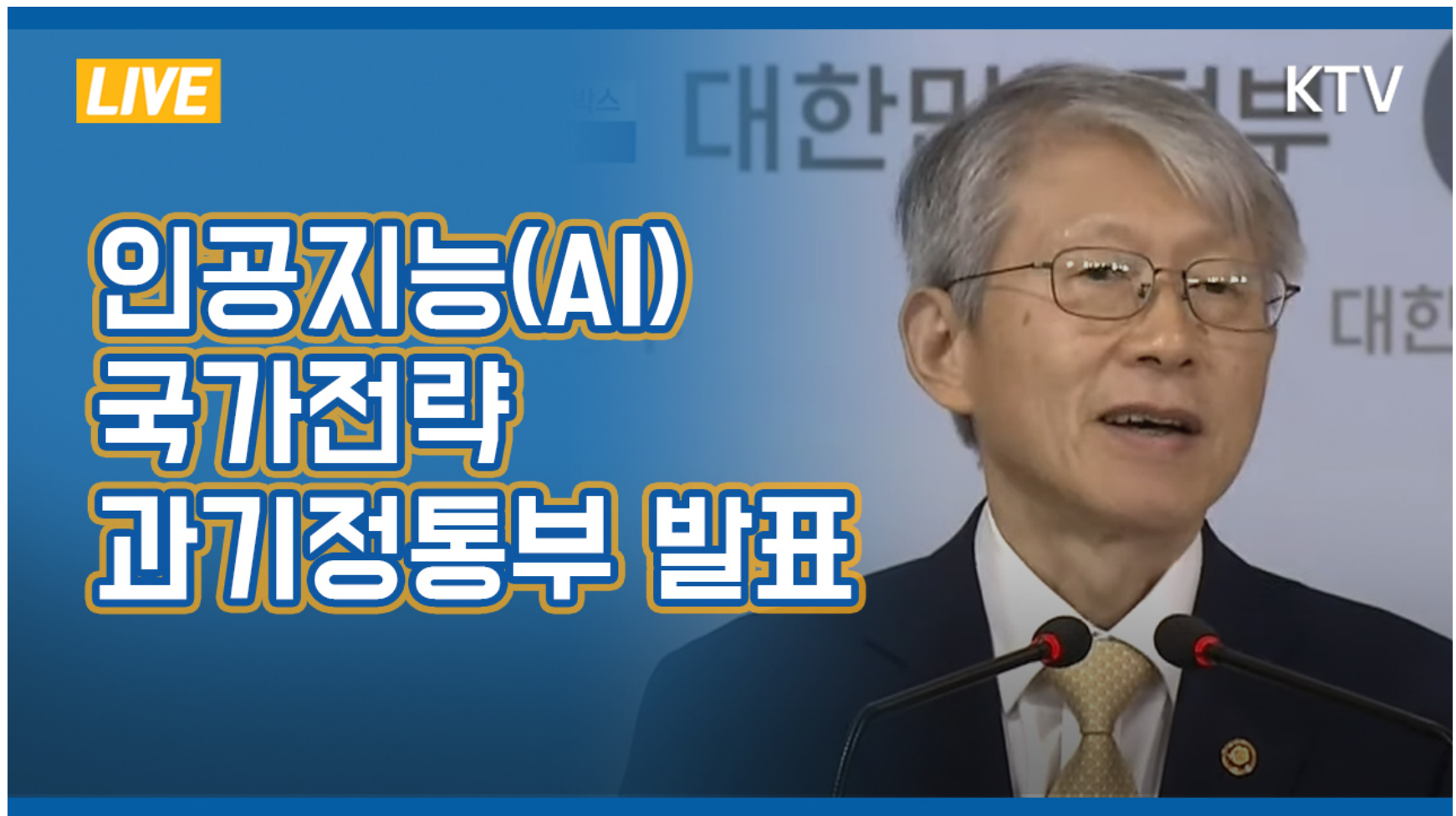
인공지능 (AI) 국가전략

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인공지능 (AI) 국가전략

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제 2의 석유

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- **Who has the world's largest photo DB?**
 - How do we make \$\$\$ out of this?
- **Who has the world's largest video DB?**
 - How do we make \$\$\$ out of this?
- **Who has the world's largest shopping DB?**
 - How do we make \$\$\$ out of this?
- **Who has the world's personal DB?**
 - How do we make \$\$\$ out of this?



글로벌 시가총액 5대 기업

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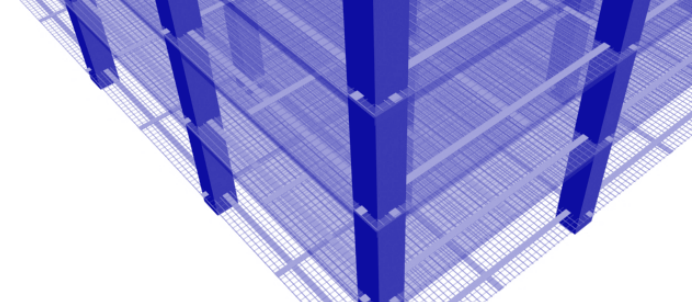
	2007년	2017년
1위	페트로 차이나	애플
2위	엑손 모빌	구글
3위	제너럴 일렉트릭	마이크로 소프트
4위	차이나 모바일	아마존
5위	중국 공상 은행	페이스북

https://en.wikipedia.org/wiki/list_of_public_corporations_by_market_capitalization

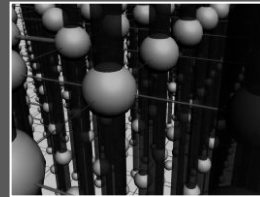
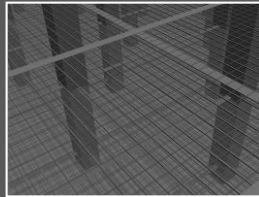
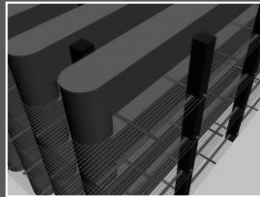
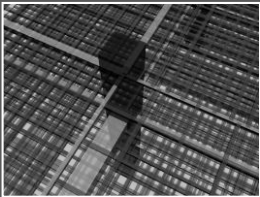
日 GDP 급 시총 5조달러 테크기업 빅5, '70년 美 패권' 이어나가는 힘이다



↳ 인터넷→모바일→ 이젠 플랫폼으로 21세기도 움켜쥐는 美



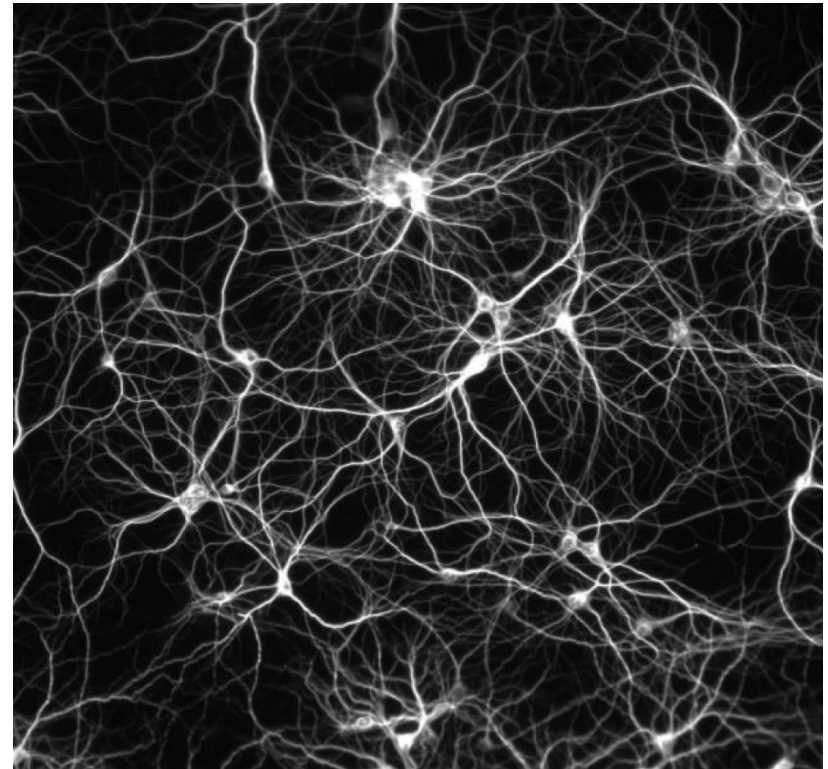
1. 인공지능 (AI) 기계학습이란?



Human Brain

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- **Amazing structure**



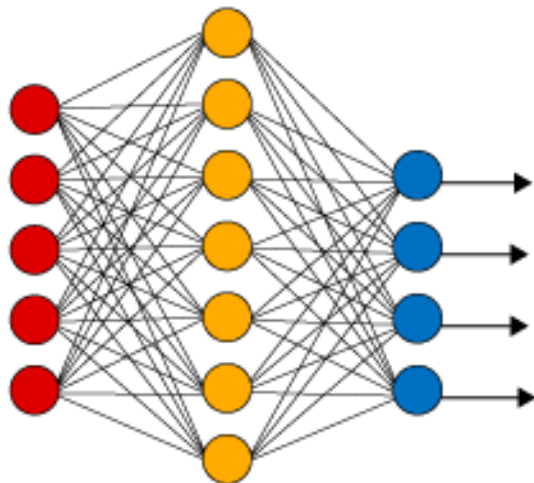
천억개의 뉴런들이 백조개의 시냅스로 연결

Deep Neural Network

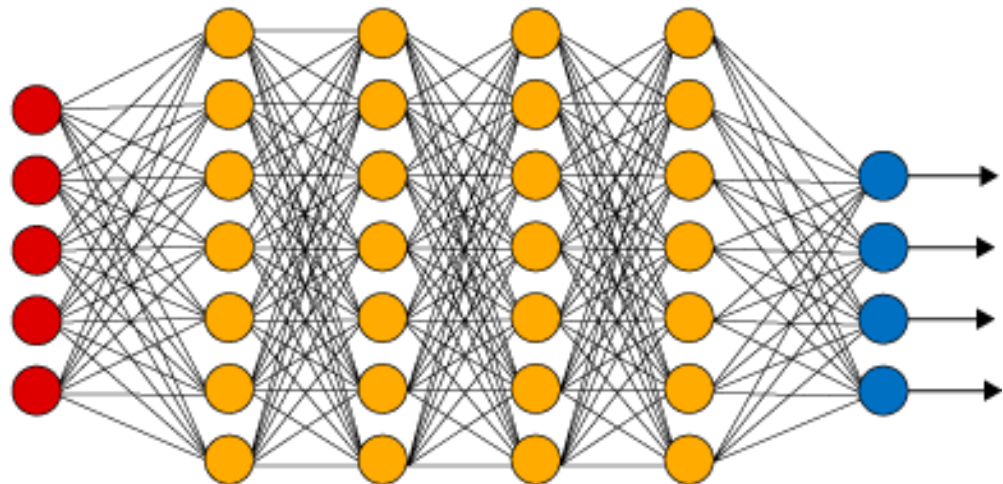
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- **DNN simply has more hidden layers than ANN**
 - More weights to tune
 - Becomes more powerful

Simple Neural Network



Deep Learning Neural Network



● Input Layer

● Hidden Layer

● Output Layer

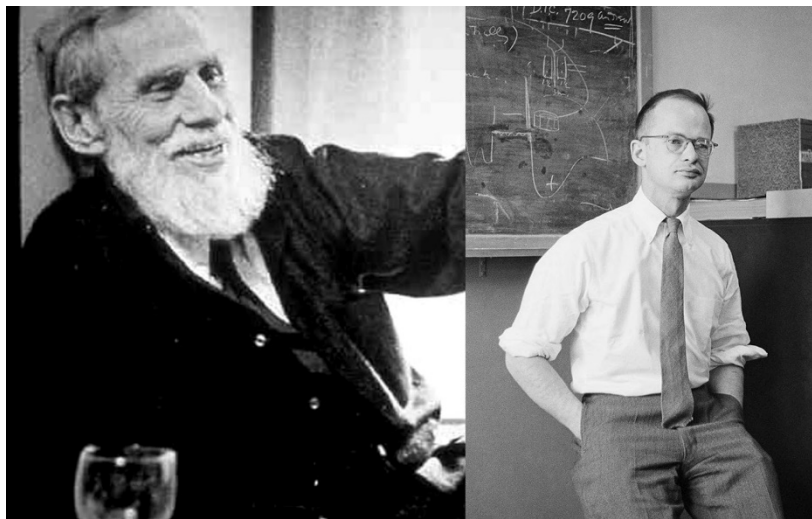
<https://www.youtube.com/channel/UCvX15F7CzUMqf8P7sHtWATA>

deep learning mouse



딥러닝의 계보

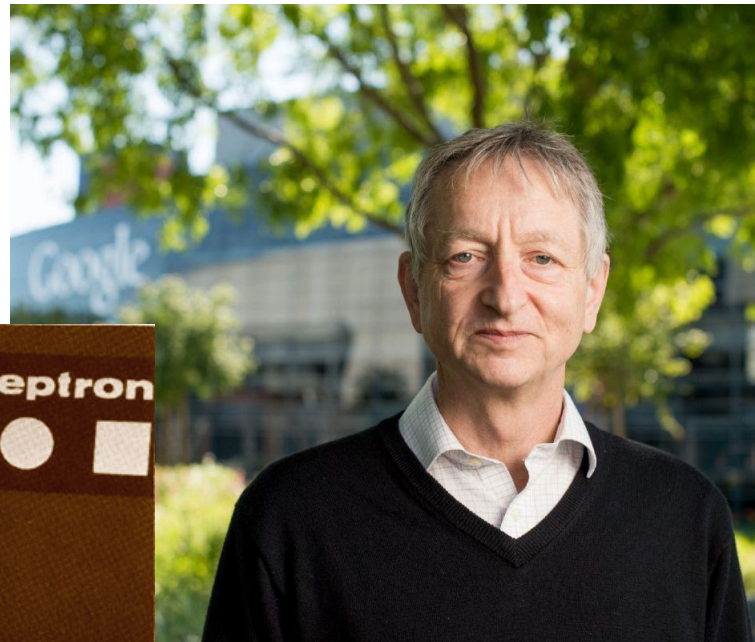
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McCulloch & Pitts
math model



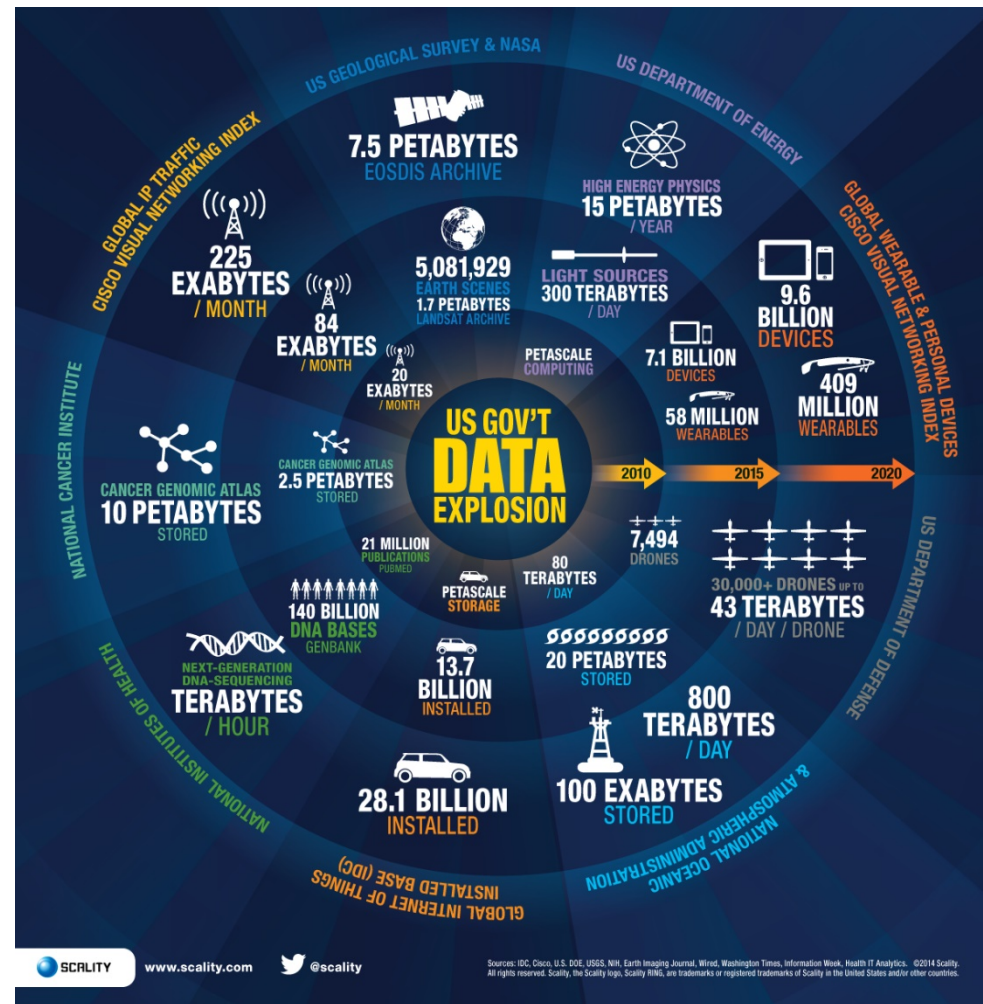
Rosenblatt
computer simulation

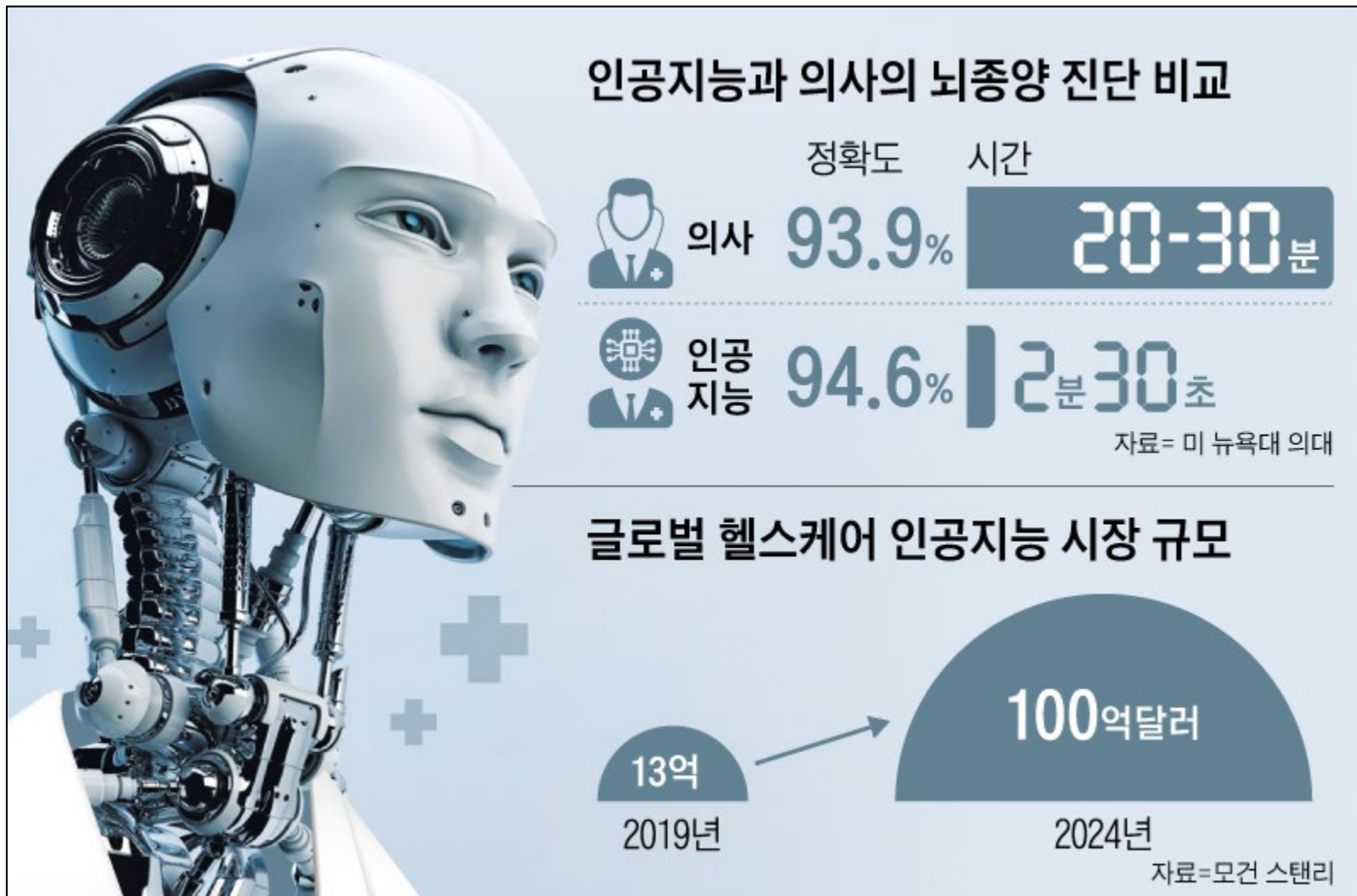


Hinton
DNN, back propagation

인공지능/딥러닝 부활의 이유

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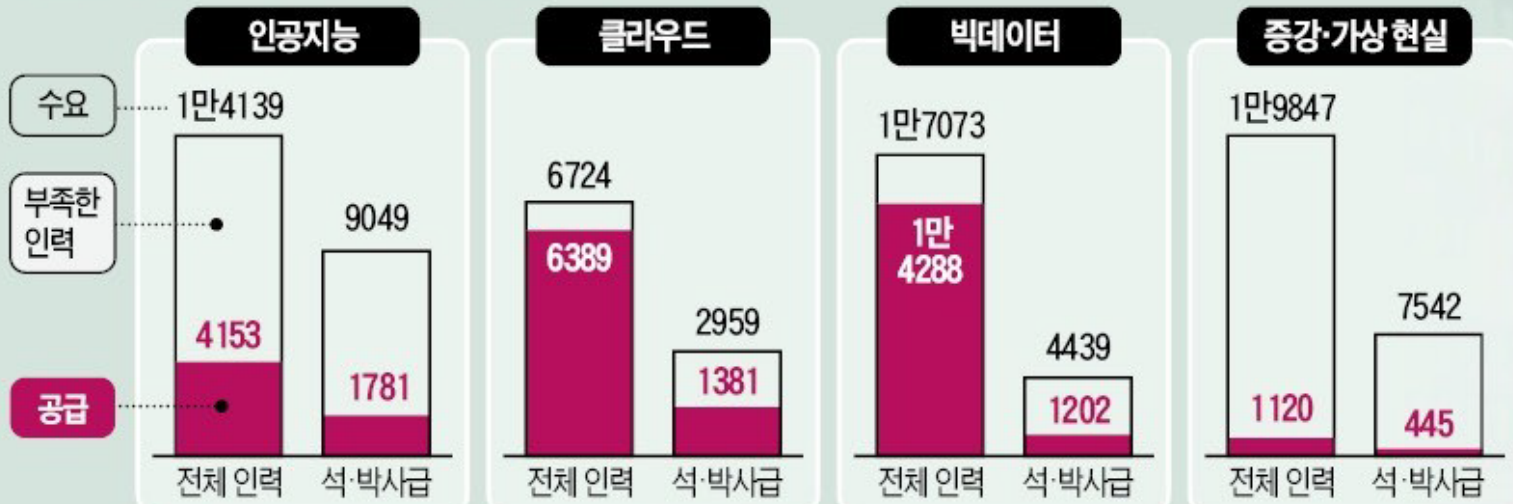




AI Human Resources In **Great** Need

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빨간불 들어온 4대 유망 분야 개발자 수급 (단위:명)



※2018~2022년 사이 국내 산업계 소프트웨어 인력의 수요와 공급을 예측

자료:소프트웨어정책연구소

천정부지로 치솟은 AI 개발자 연봉

(단위:달러)



※미국 2019년 1월 기준
※평균 연봉

자료:인디드닷컴

머신러닝 개발자

딥러닝 개발자

연구개발 인력

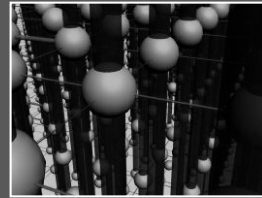
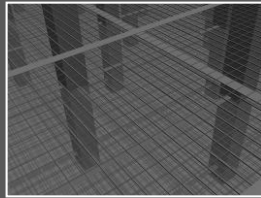
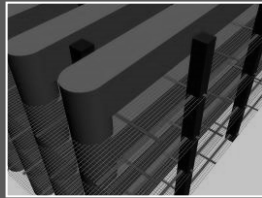
일반 SW 개발자

한국 AI 인재 구축의 문제점

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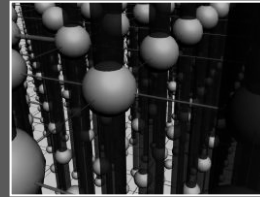
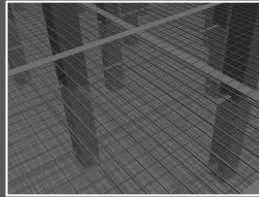
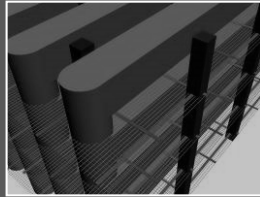
- AI 인력을 확보하는 데 가장 큰 애로 요인
 - **실무형 기술인력 부족 (36.7%)**
 - 선진국 수준의 연봉 지급이 어렵다 (25.5%)
 - 대학원 등 전문 교육기관 및 교수 부족 (22.2%)
 - 근로시간 등 경직된 근무환경 및 조직문화 (6.7%)
 - 예산지원, 규제 완화 등 정부 지원 부족 (6.7%)
- 국내 AI 인재 육성을 위해 가장 필요한 것
 - **교육 인프라 확대 (37.8%)**
 - 기술혁신 및 신산업 창출을 저해하는 규제 완화'(21.1%)
 - AI 관련 스타트업 창업 및 기업의 AI 인재 육성 제도적 지원'(13.3%)
 - AI 인재 유치를 위한 근로환경 및 기업문화 조성'(12.2%)

2. 기계학습의 종류



CNN, RNN GAN, Autoencoder, Unet

Convolutional Neural Network (CNN)



Yann LeCun's Job @ Facebook

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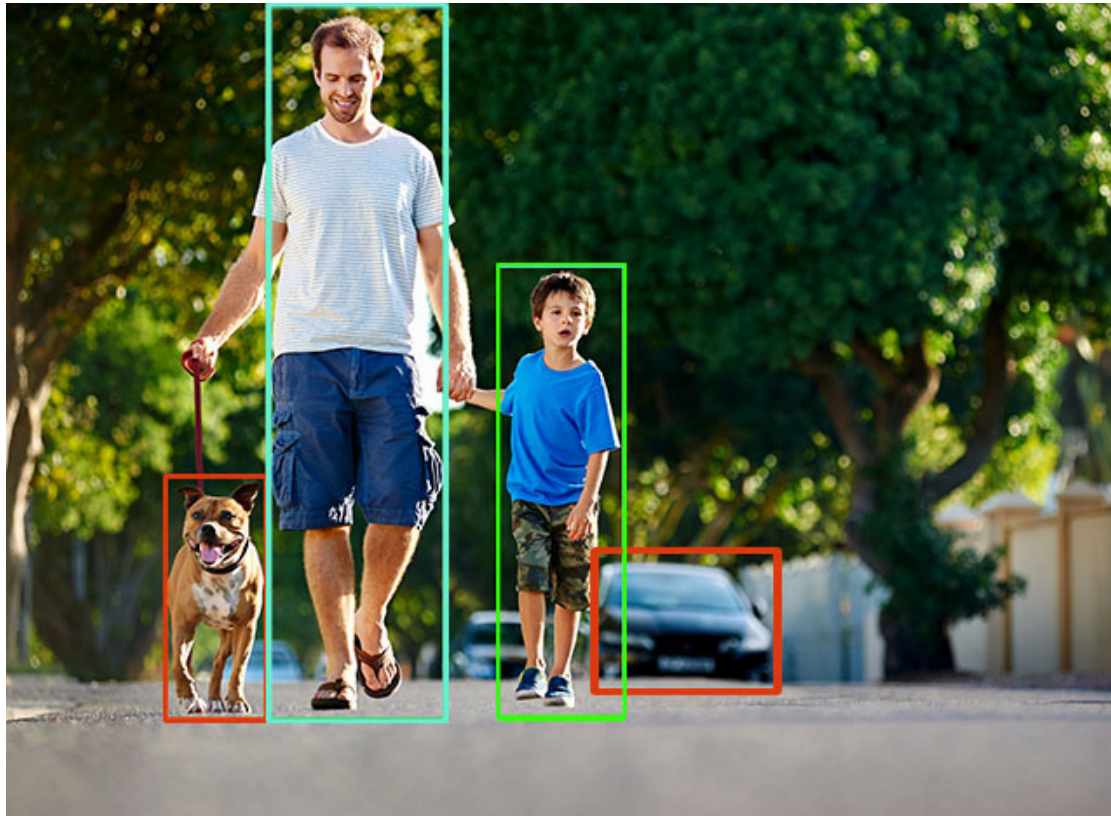
The screenshot shows a Facebook interface. At the top is a comment bar with a profile picture, a text input field "Write a comment...", and icons for emojis, photos, GIFs, and stickers. Below this is a "Suggested Post" section. The first post is from "Wayfair" (Sponsored), featuring a dark wood console table. The text says: "Don't let these items pass you by! Save up to 70% OFF and free shipping on orders over \$49 at Wayfair!". The image shows a dark wood console table with a mirror, books, and a vase. Below the image, it says "Starting at \$293.99" and "Maitland Console Table" with a "Shop Now" button. To the right of the Wayfair post is a banner ad for "UPLIFT Desk" showing a person sitting at a desk. The text says: "The Best Tee Shirt In Your Closet buckmason.com Butter-soft tees that fit perfectly and hold their shape after every wash." Below this is another banner ad for "UPLIFT Desk" showing a person sitting at a desk. The text says: "UPLIFT Desk upliftdesk.com \$495 Full Desk (not a converter). Entire desktop rises with you. Free shipping!". At the bottom of the interface are links for "Like", "Comment", and "Share".

Suggested Post, Banner Ads

Image Recognition

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- Crucial in many ML applications



- Main challenge: # of pixels!!!!!!

Convolutional Neural Network (CNN)

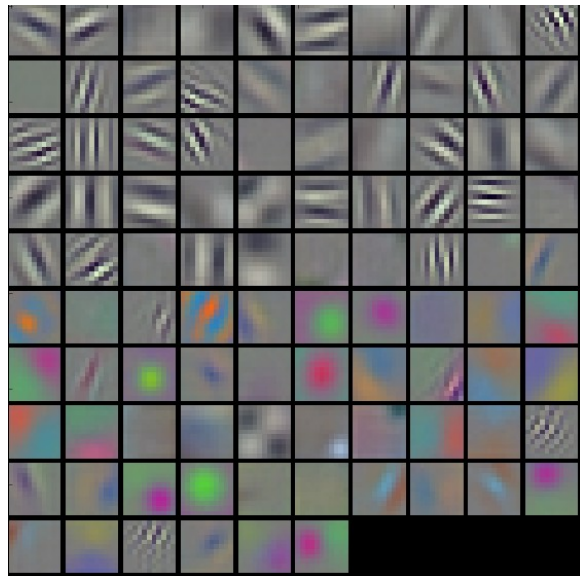
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- **What is Convolution?**

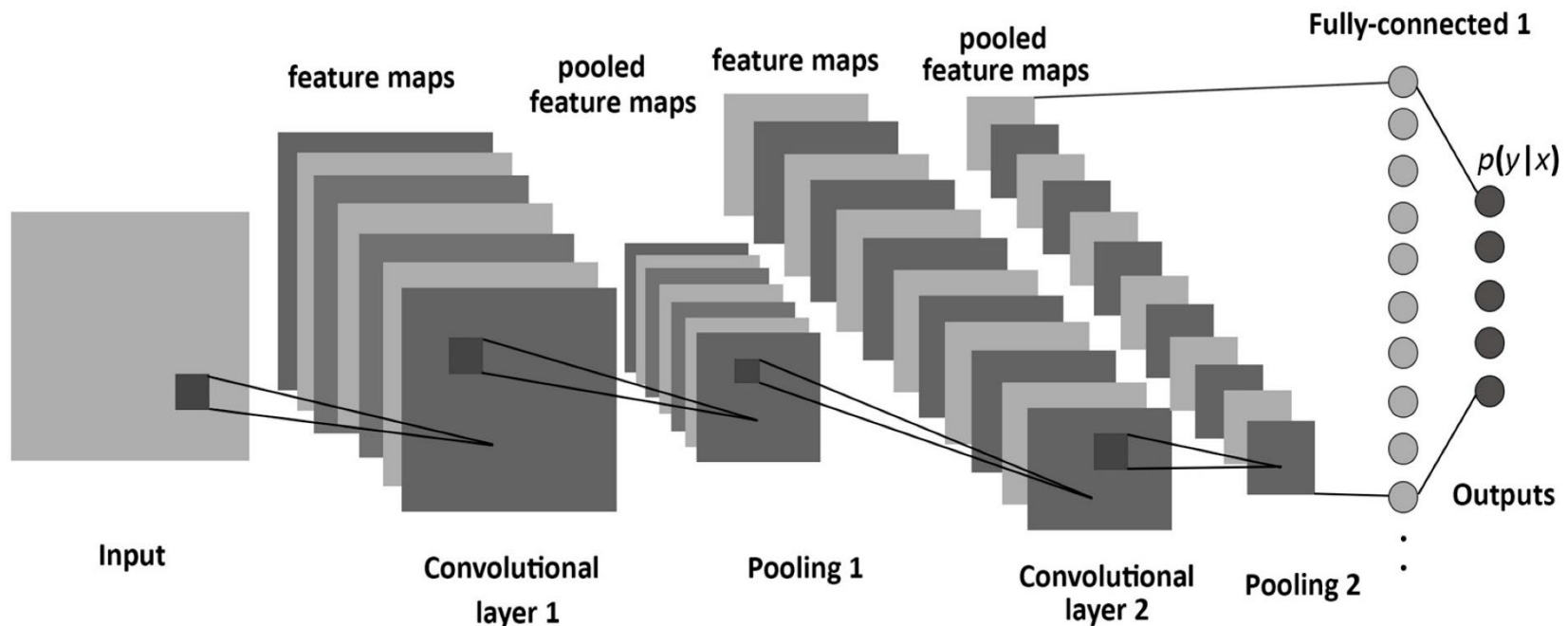
- 영상으로부터 특정 feature들을 추출하기 위한 필터를 구현할 때 convolution을 사용

- **Why CNN?**

- Yann LeCun (1998)
- 이미지 인식에서 MLP (Multi-Layer Perceptron)를 사용하게 되면, MLP는 모든 입력이 위치와 상관없이 동일한 수준의 중요도를 가짐
- 이를 이용해 fully-connected neural network를 구성하게 되면 model 크기가 엄청나게 커지는 문제가 생김
- 이에 대한 해결책으로 탄생한 것이 CNN



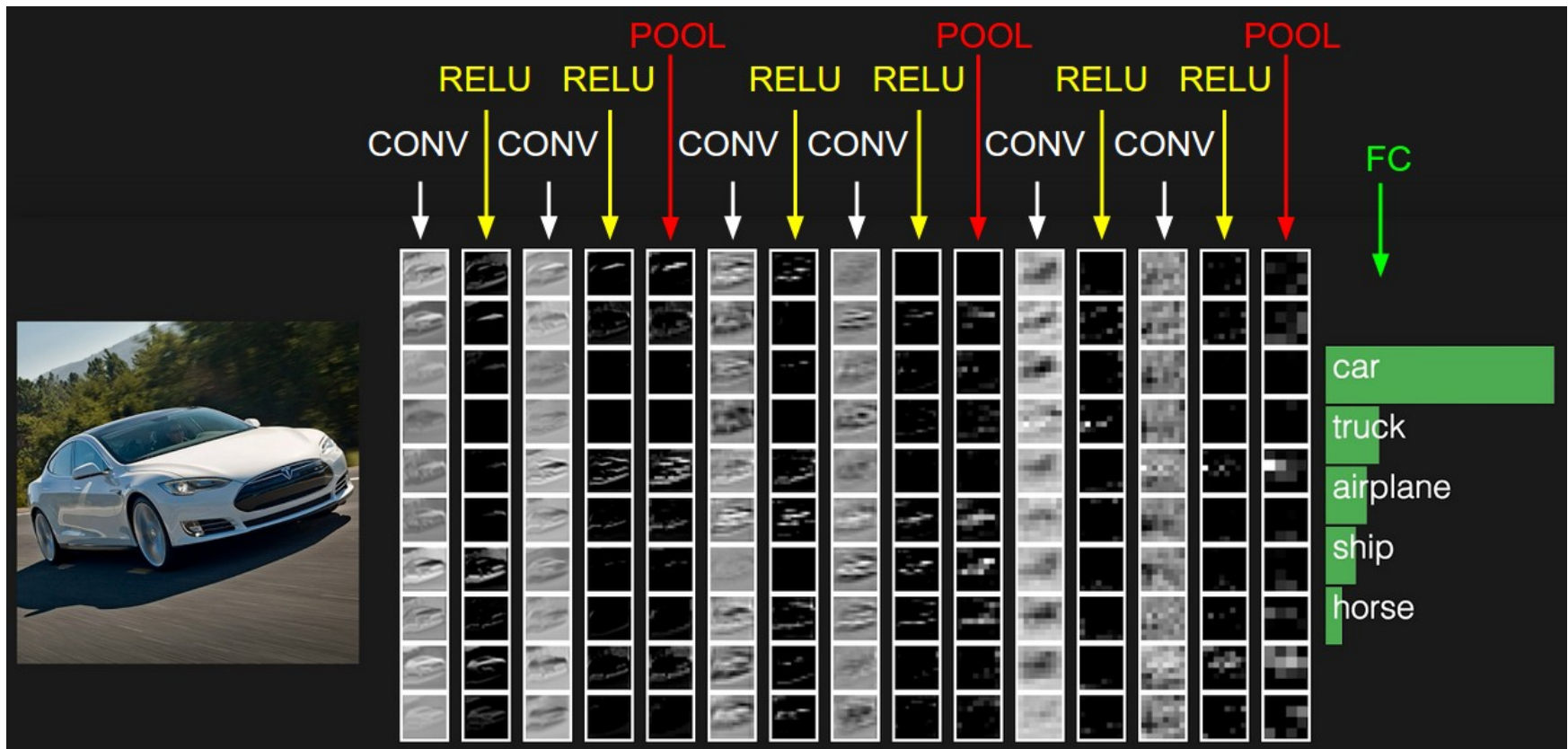
- Feature Extraction
 - **Key idea** to manage complexity while maintaining accuracy
 - Features are extracted via CONV:RELU:POOL



CNN Deep Learning Example

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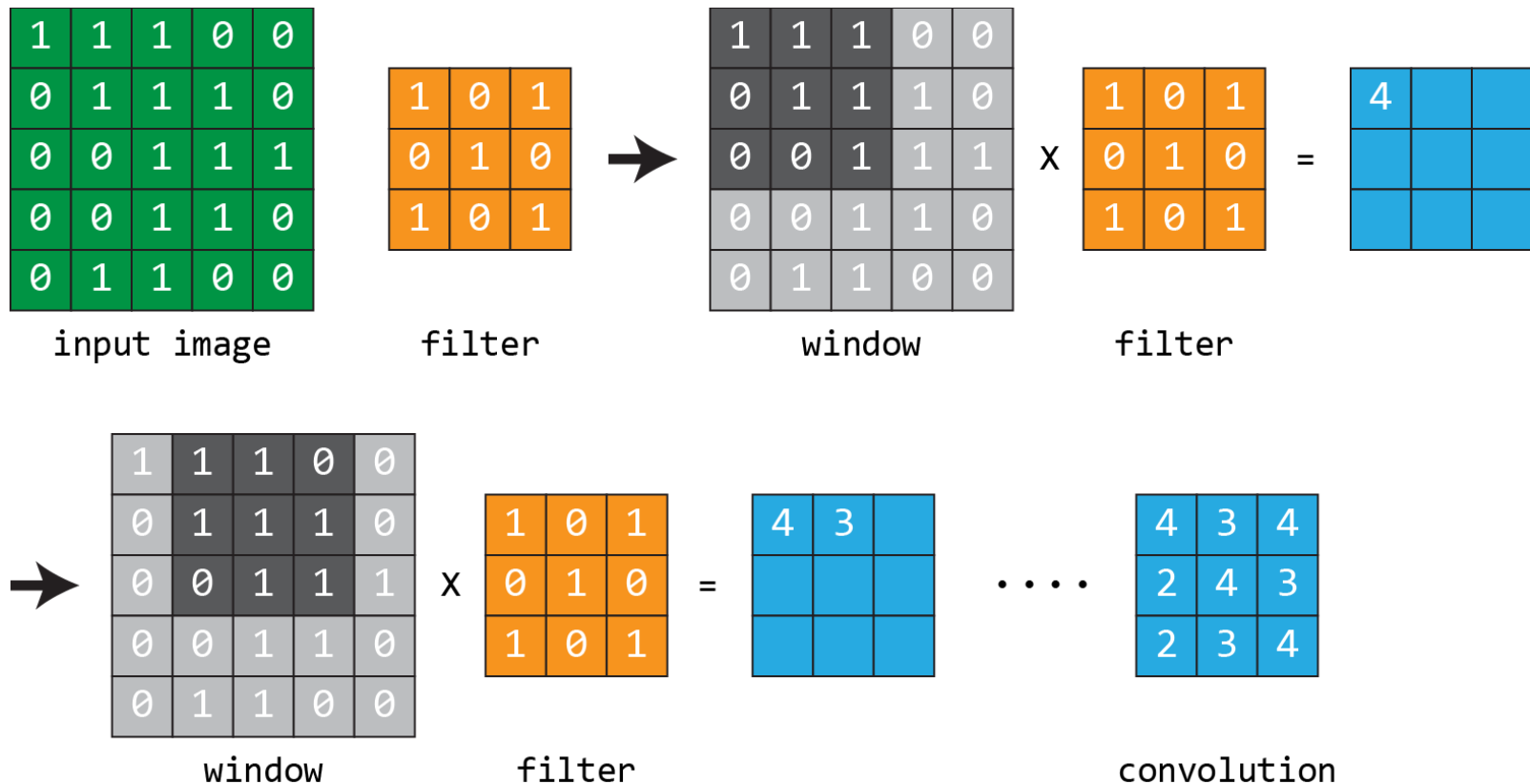
- Hugely popular in image recognition



Convolution Example

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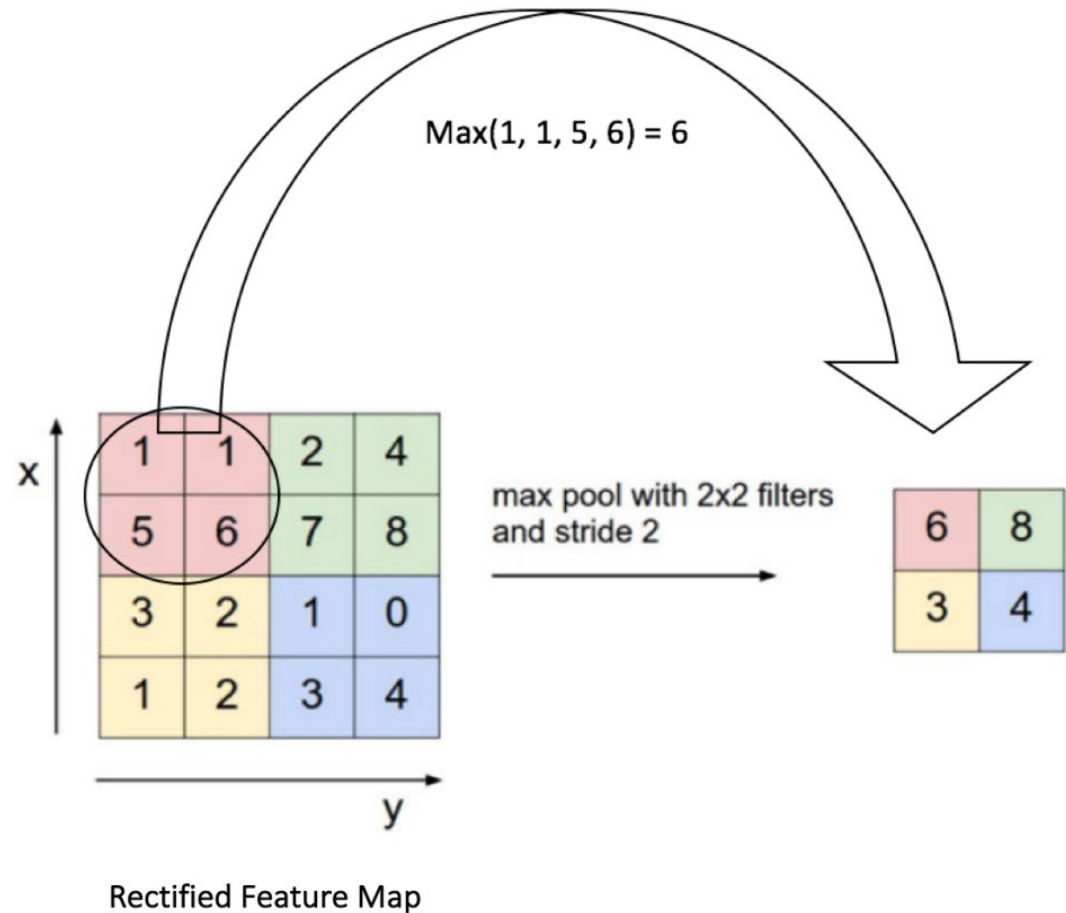
- Objective: to extract features from the input data

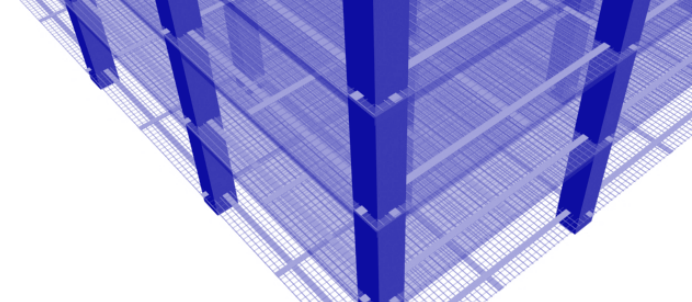


Pooling

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- **objective**
 - reduce the feature map dimension and keep the important information
 - types: max, average, sum, etc.





Recurrent Neural Network (RNN)

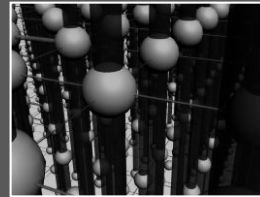
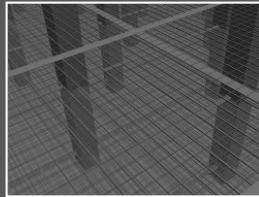
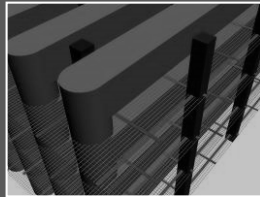
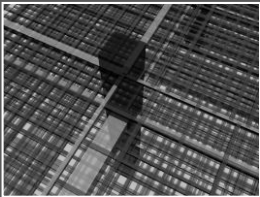


Image **Description** (not Recognition)

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- Describe a given image using a **sentence**
 - Harder than image recognition/classification
 - Competition is ongoing and fierce among researchers



man in black shirt is playing guitar.



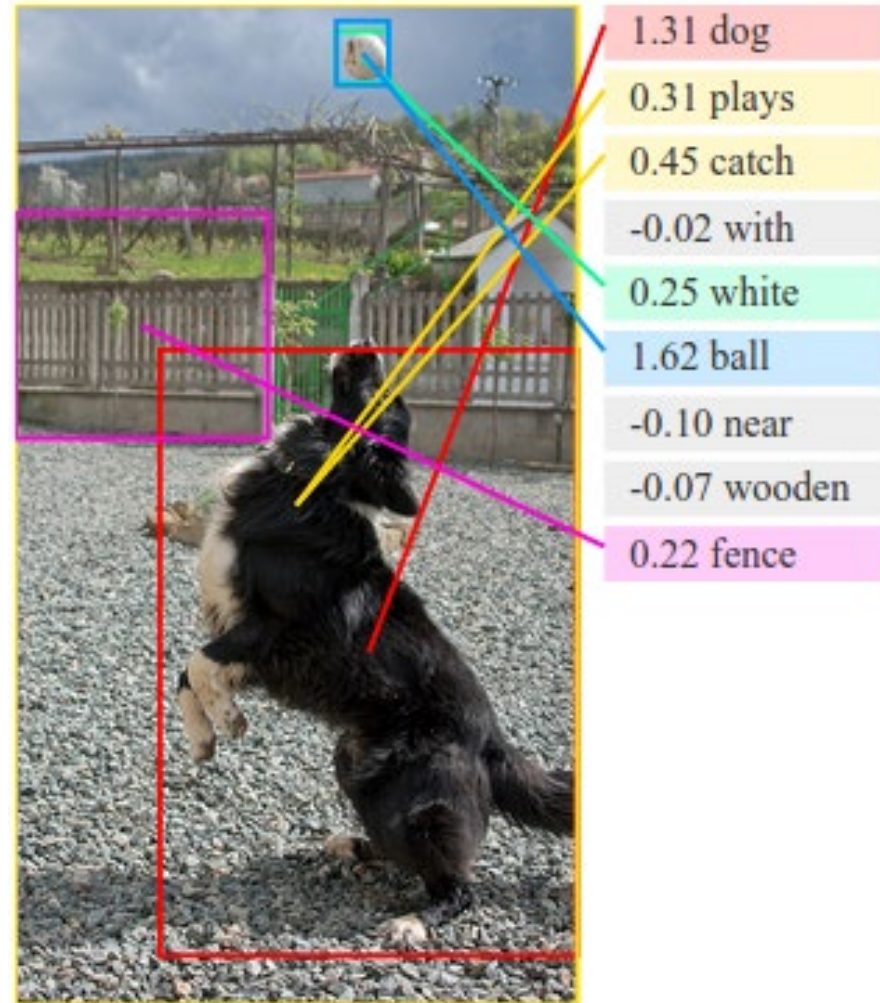
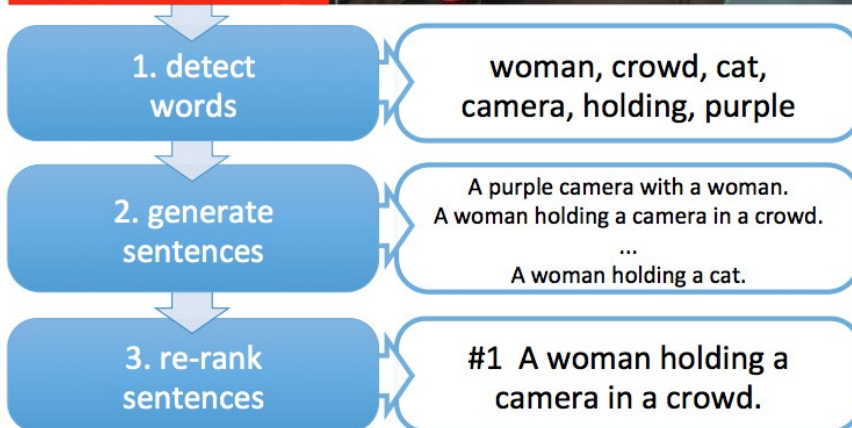
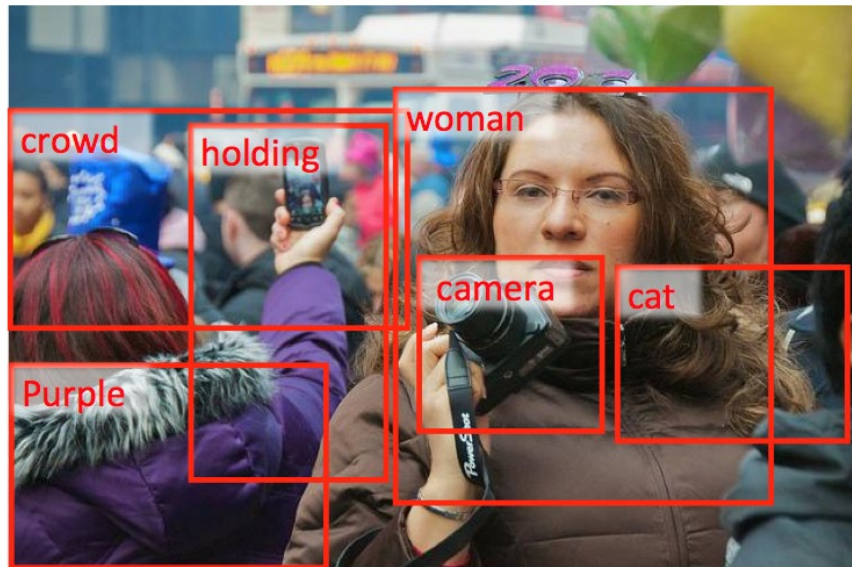
a young boy is holding a baseball bat.



two young girls are playing with lego toy.

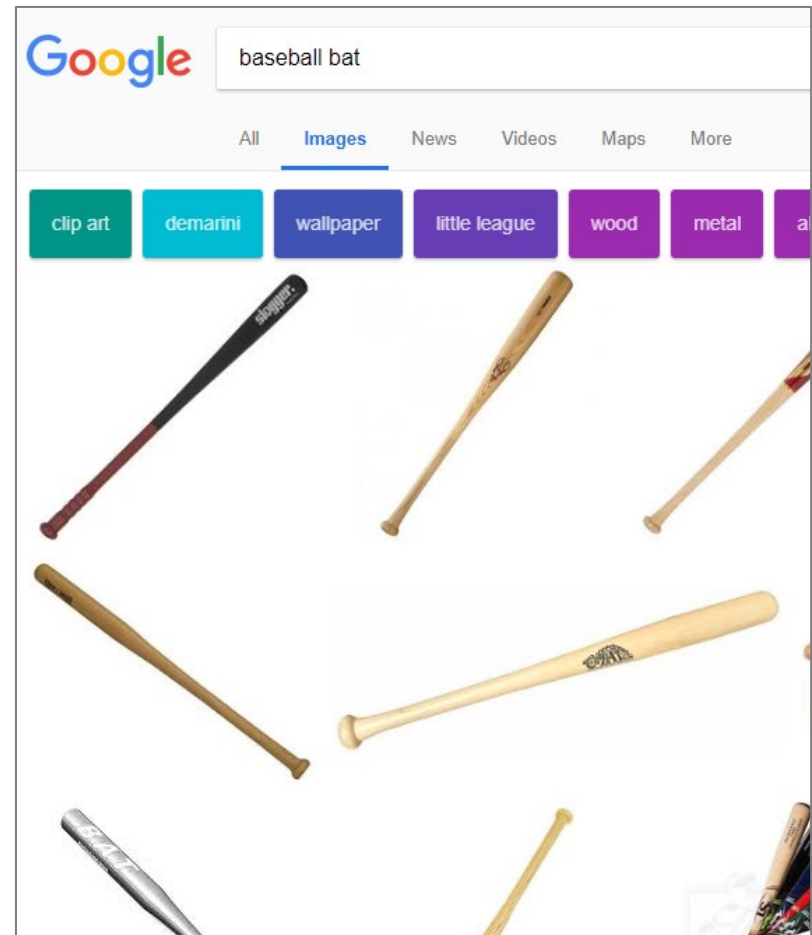
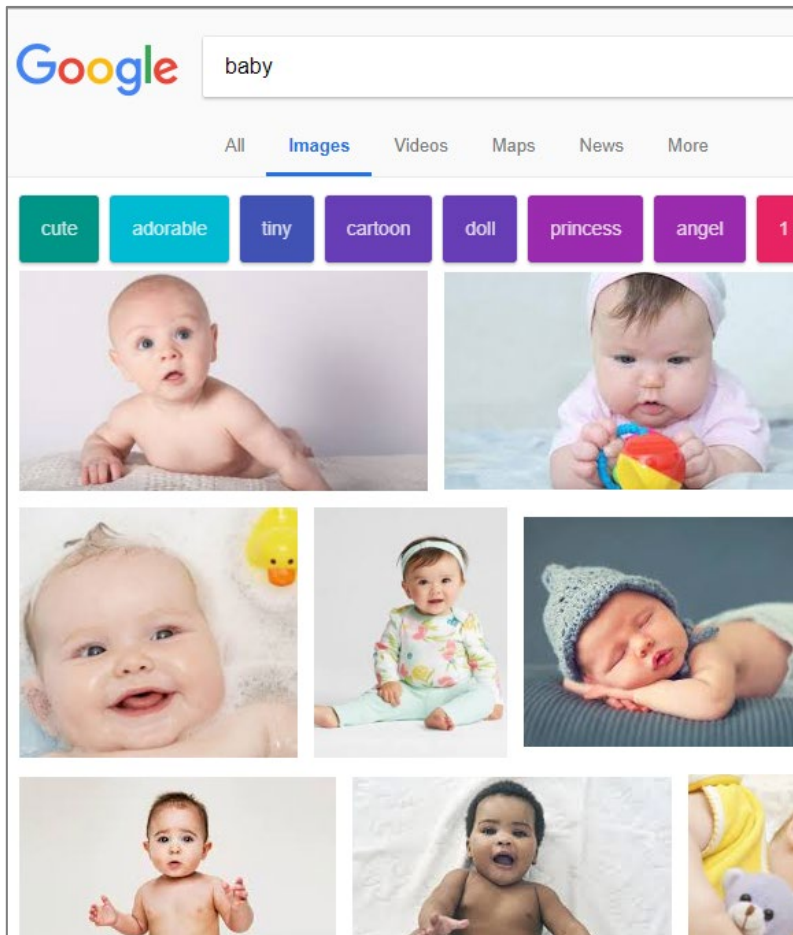
RNN Applications

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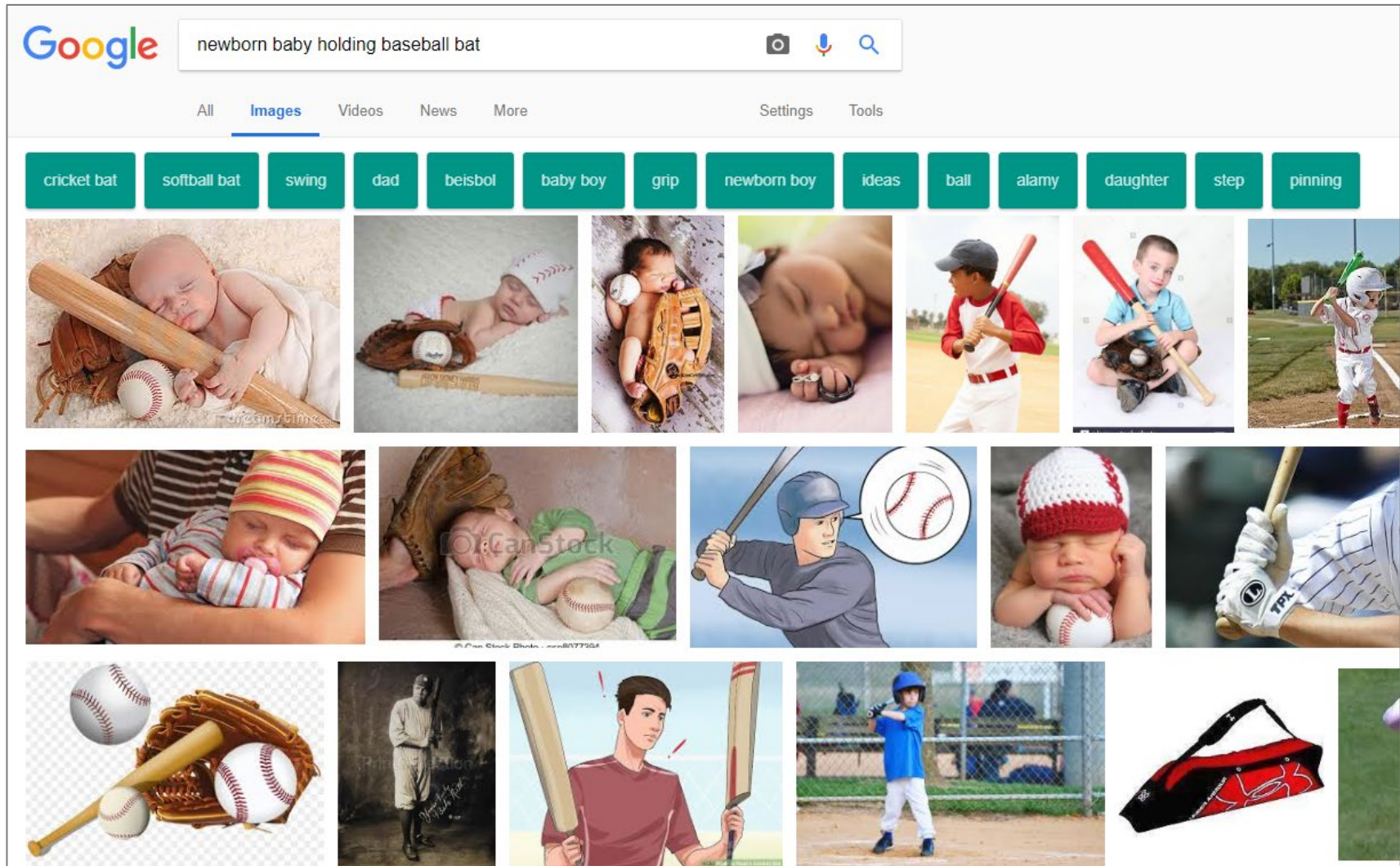
Simple Image Search

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Complex Image Search

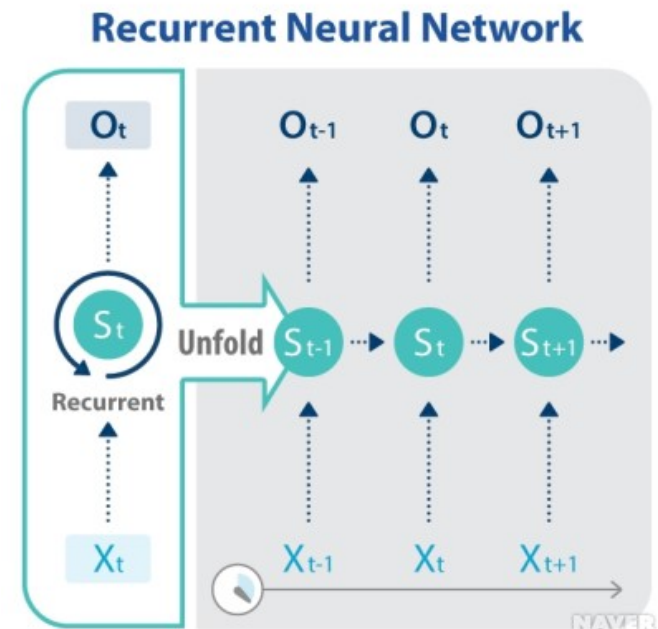
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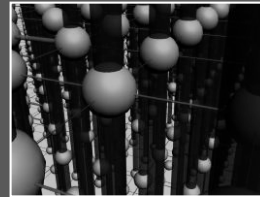
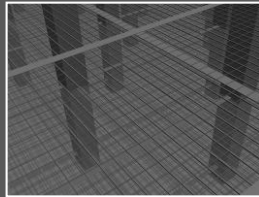
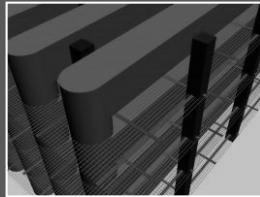
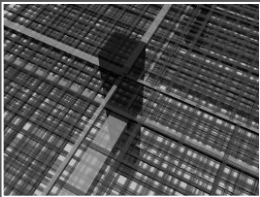
Recurrent Neural Network (RNN)

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- What is RNN?
 - Hochreiter & Schmidhuber (1997)
 - A class of ANN where connections between units form a directed cycle.
 - This allows it to exhibit dynamic temporal behavior
- Why RNN?
 - Unlike feedforward neural networks, RNNs can use their **internal memory** to process arbitrary sequences of inputs
 - Applicable to tasks such as translation, speech recognition, etc

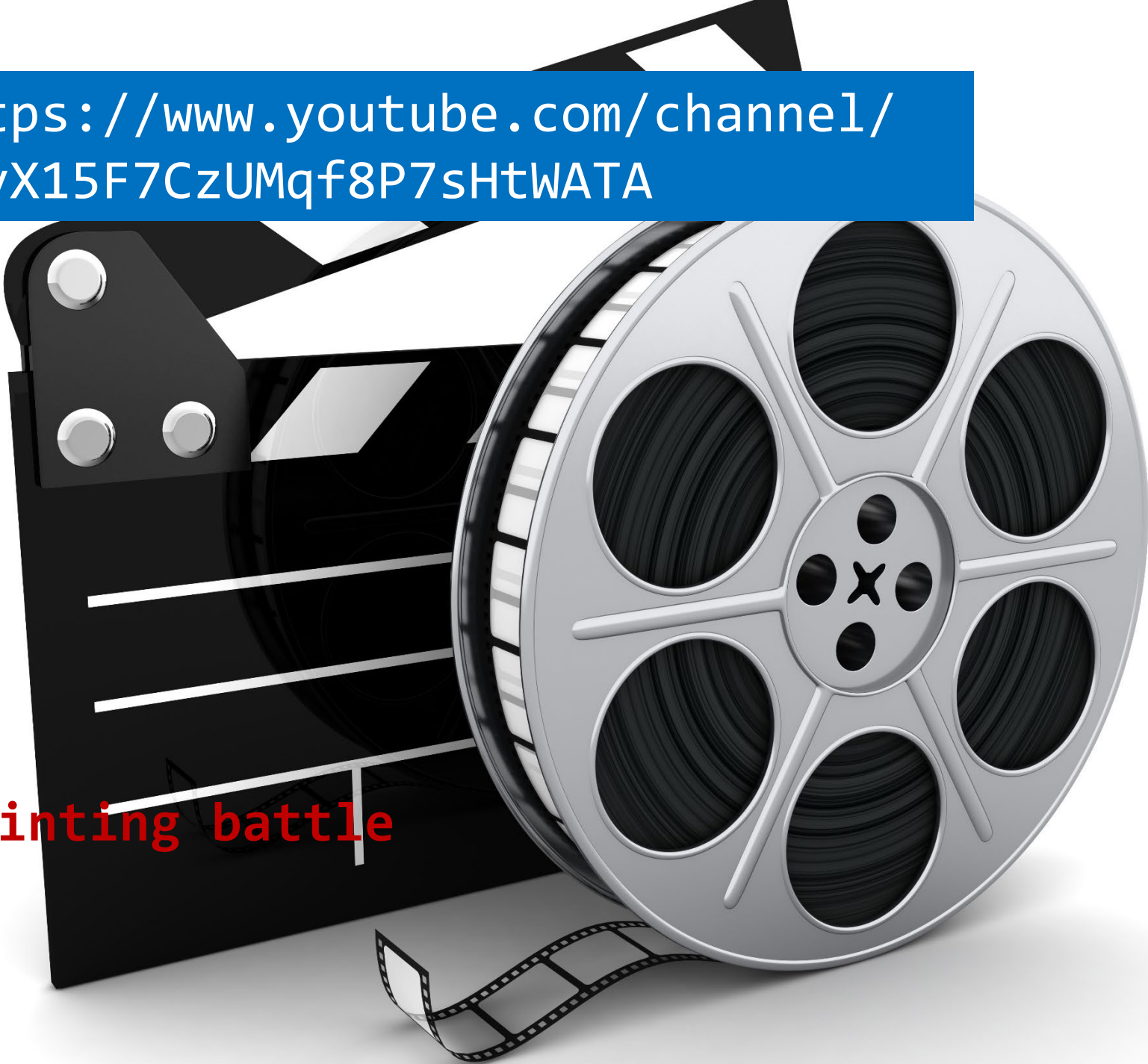


Generative Adversarial Network (GAN)



<https://www.youtube.com/channel/UCvX15F7CzUMqf8P7sHtWATA>

painting battle



Ian Goodfellow: Inventor of GAN

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Ian J. Goodfellow, Jean Pouget-Abadie, Mehdi Mirza, Bing Xu, David Warde-Farley, Sherjil Ozair, Aaron Courville, and Yoshua Bengio

“Generative Adversarial Nets”

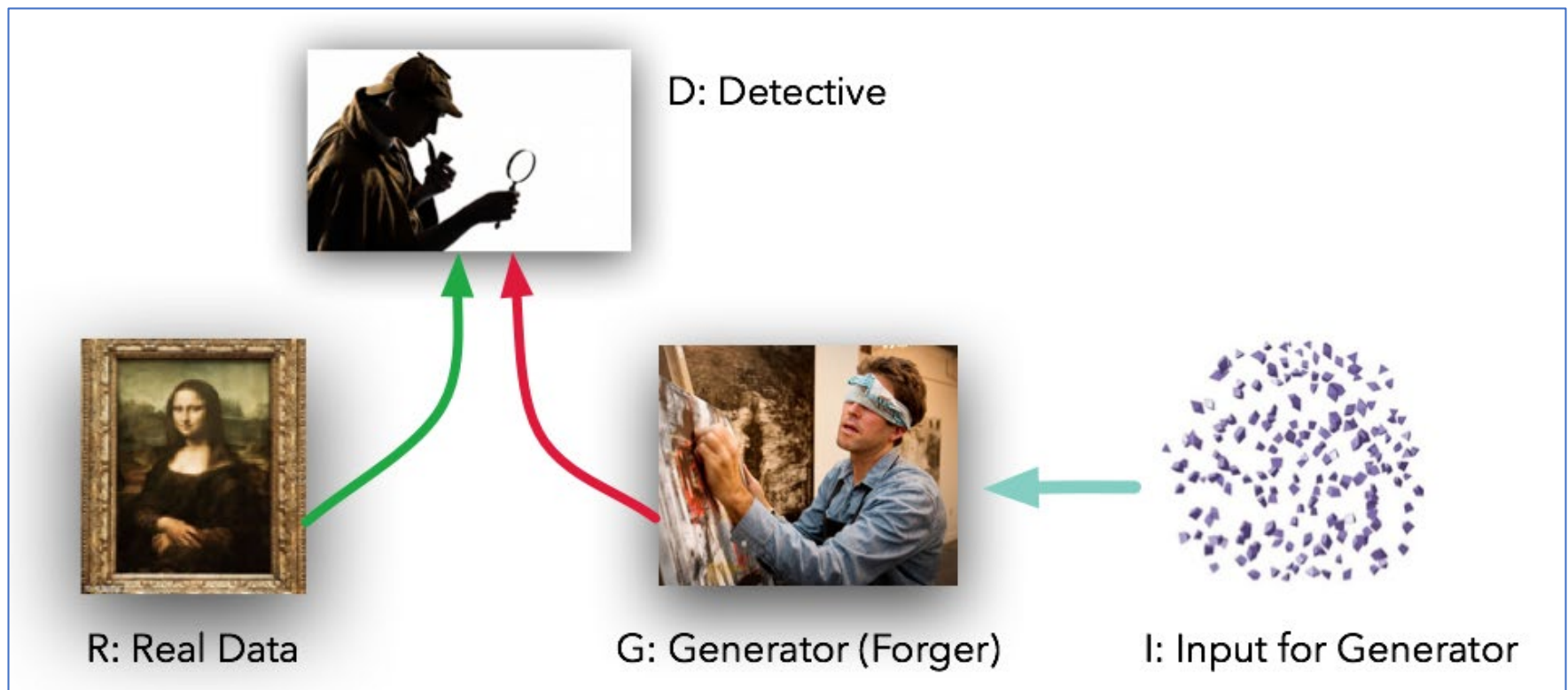
Int. Conf. on Neural Information Processing Systems, 2014.



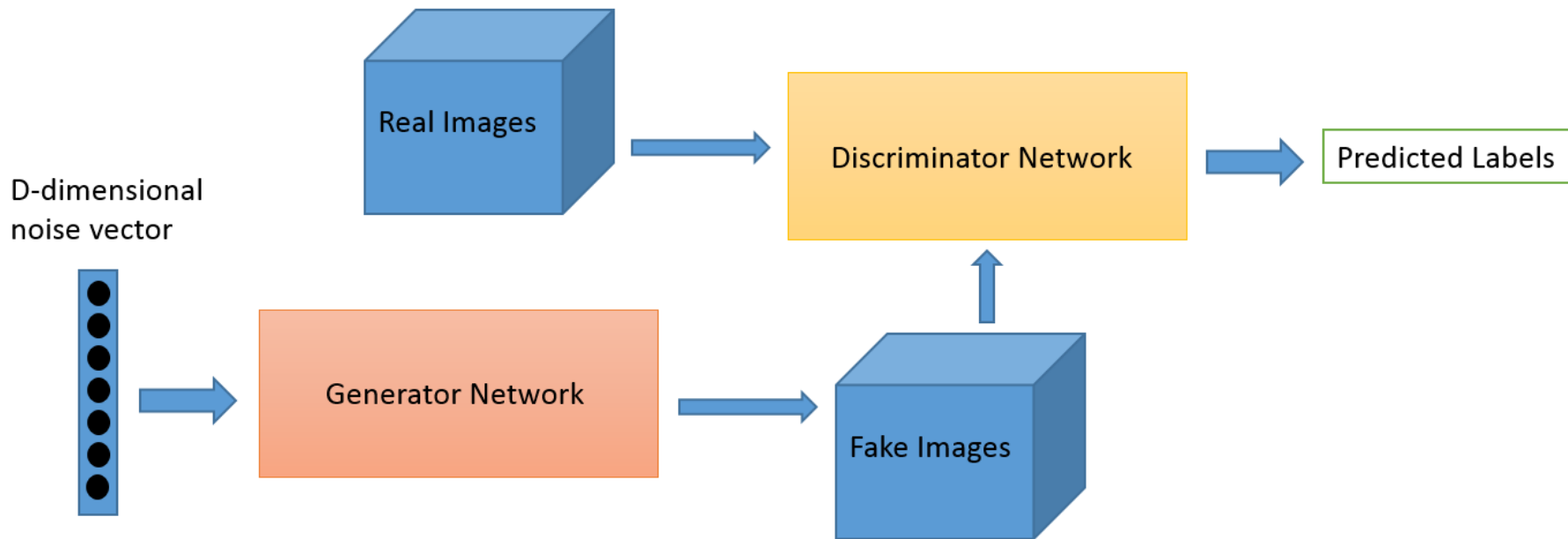
Main Idea

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- **Two neural networks contest with each other in a game**
 - **Generator generates fake data, hoping to fool discriminator**
 - **Discriminator evaluates them for authenticity**



- In case we deal with image data:
 - The generator takes in a random vector and returns a fake image.
 - This fake image and the real dataset are fed to the discriminator.
 - The discriminator picks one real image and the fake image and returns probabilities, a number between 0 (fake) and 1 (real).



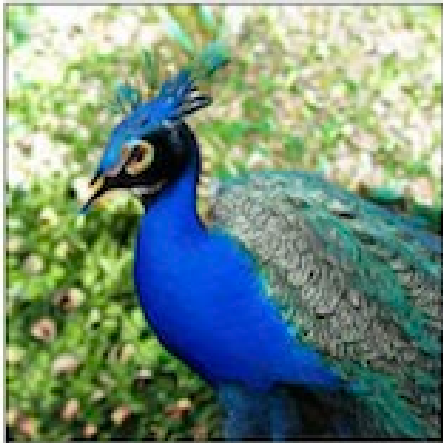
These Are **Fake** Photos by GAN

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GAN Can Do Others, Too

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Text-to-Image Translation with GAN

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The small bird has a red head with feathers that fade from red to gray from head to tail

Stage-I
images



Stage-II
images



This bird is black with green and has a very short beak

Stage-I
images



Stage-II
images



GAN Can Cross Domains

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Monet $\leftrightarrow$ Photos



Monet $\rightarrow$ photo

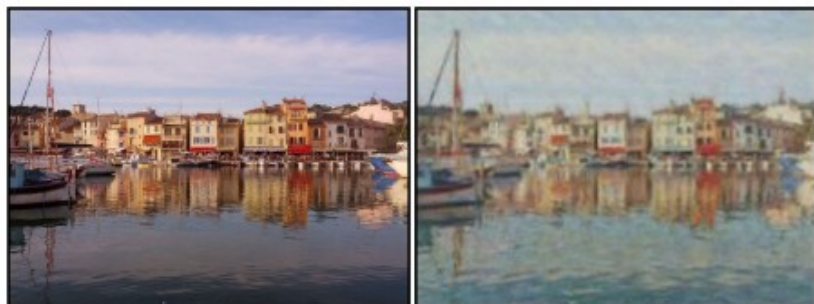
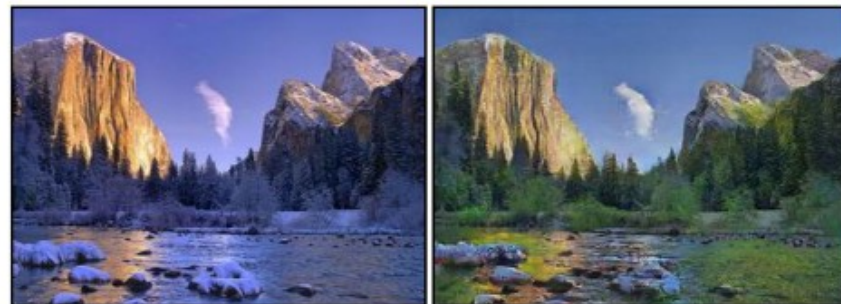


photo $\rightarrow$ Monet

Summer $\leftrightarrow$ Winter



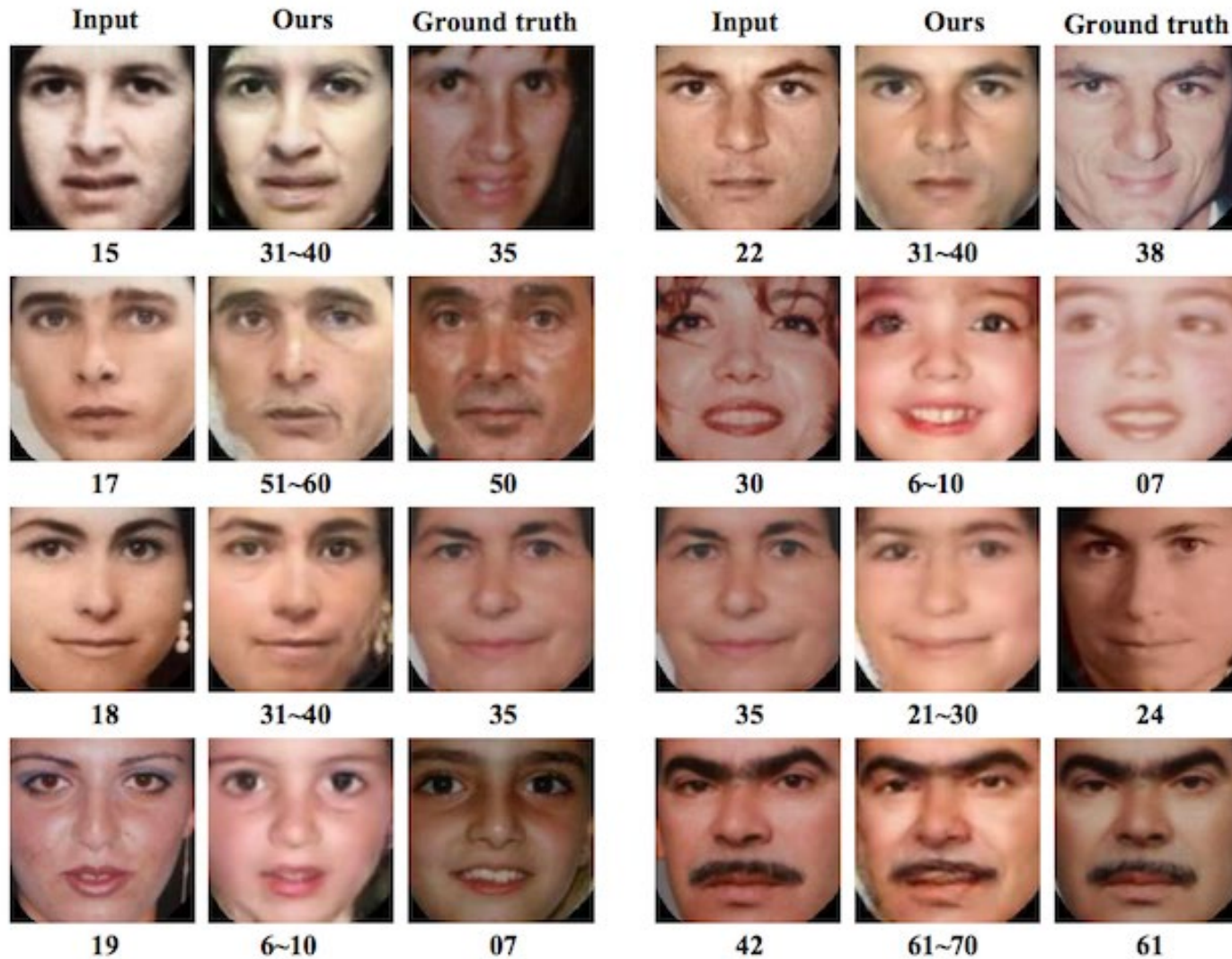
summer $\rightarrow$ winter



winter $\rightarrow$ summer

Face Aging Prediction

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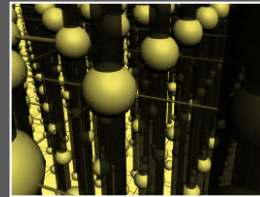
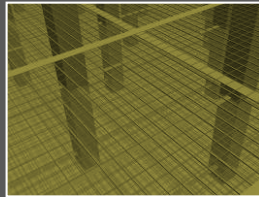
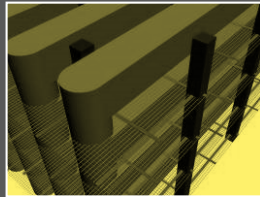
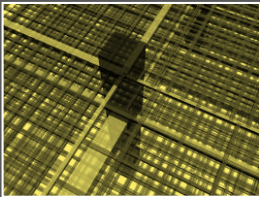
Next? Yup, **Videos**

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<https://www.youtube.com/watch?v=8AZBuyEuDqc>



Autoencoder

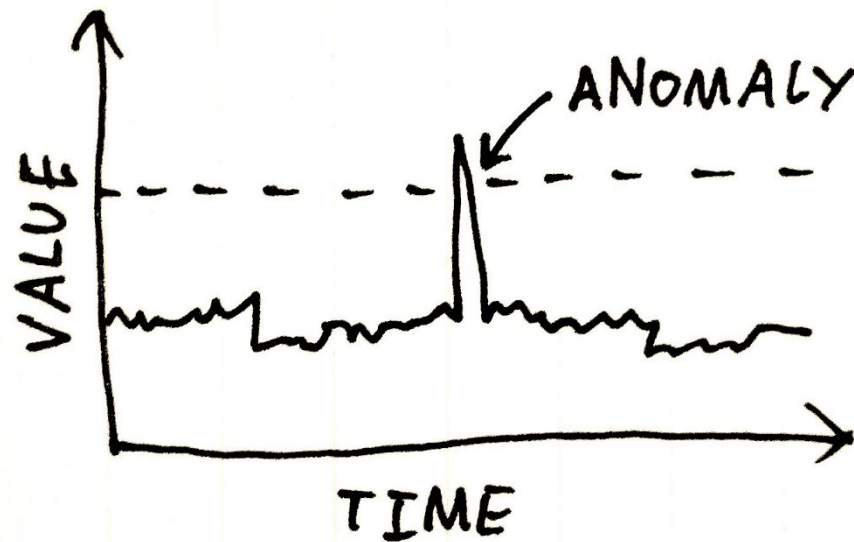


Anomaly Detection

45/96

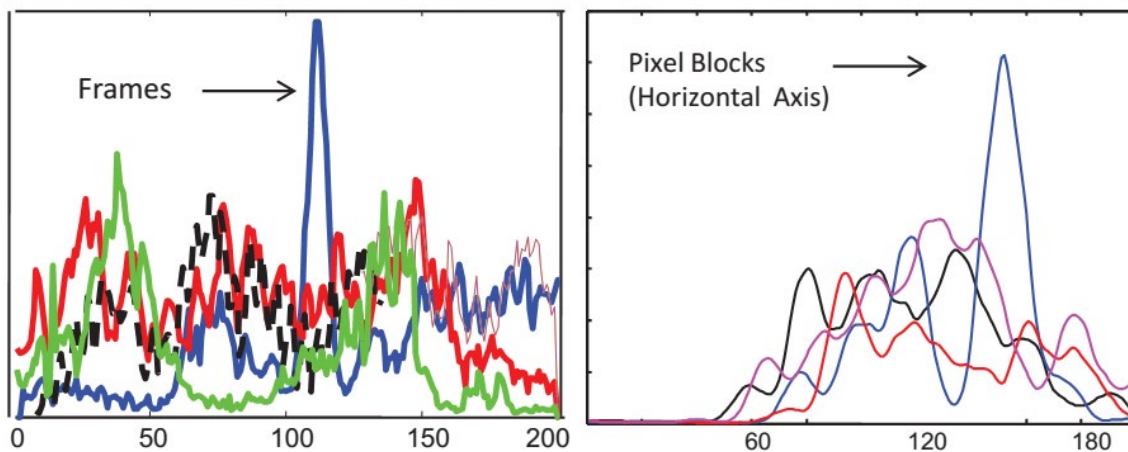
- **Definition**

- Identification of rare items, events or observations
- They raise suspicions by differing significantly from the majority of the data
- Typically the anomalous items will translate to some kind of problem
- **Can you think of killer apps?**



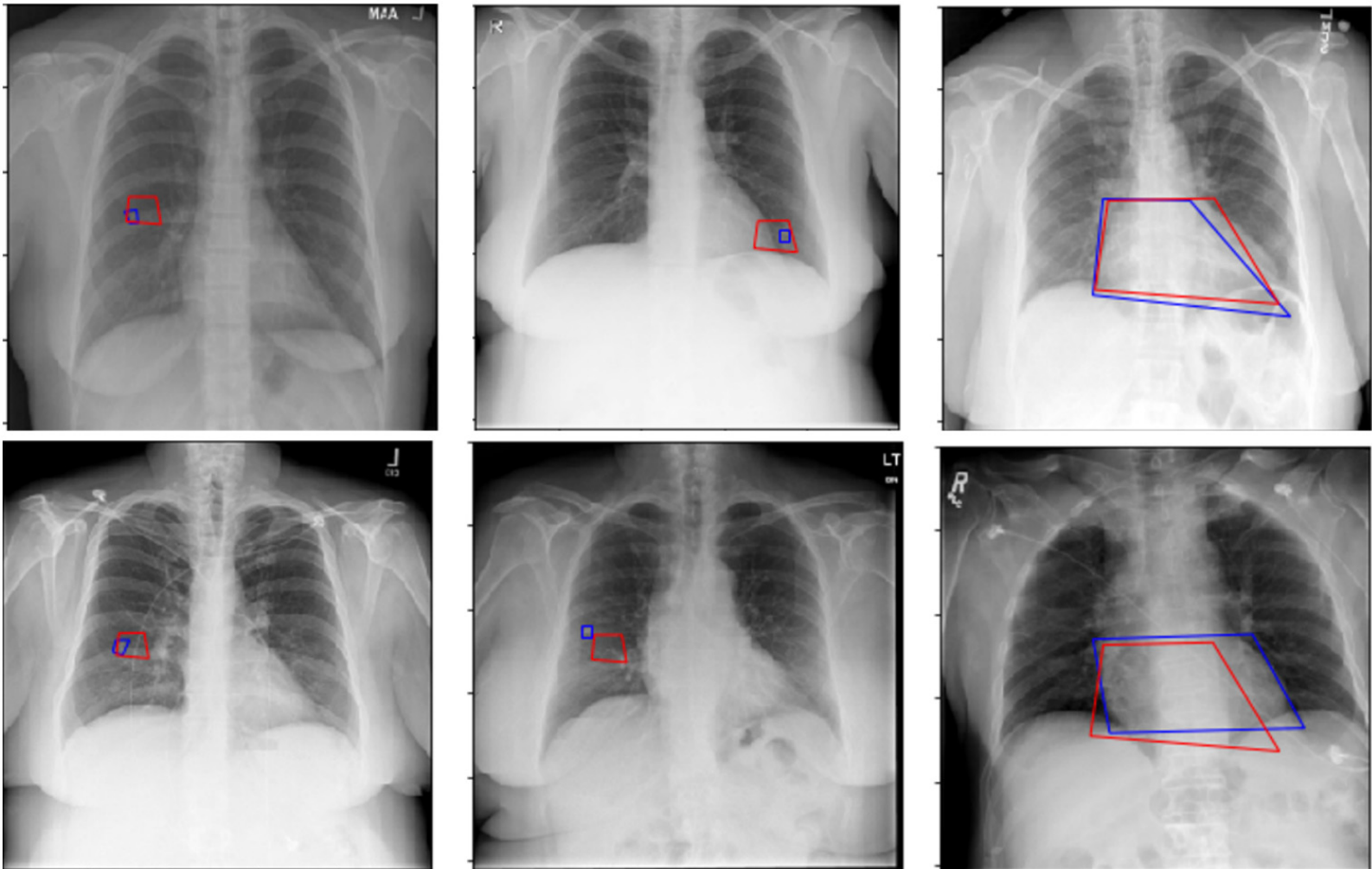
Video Analytics with ML

46/96



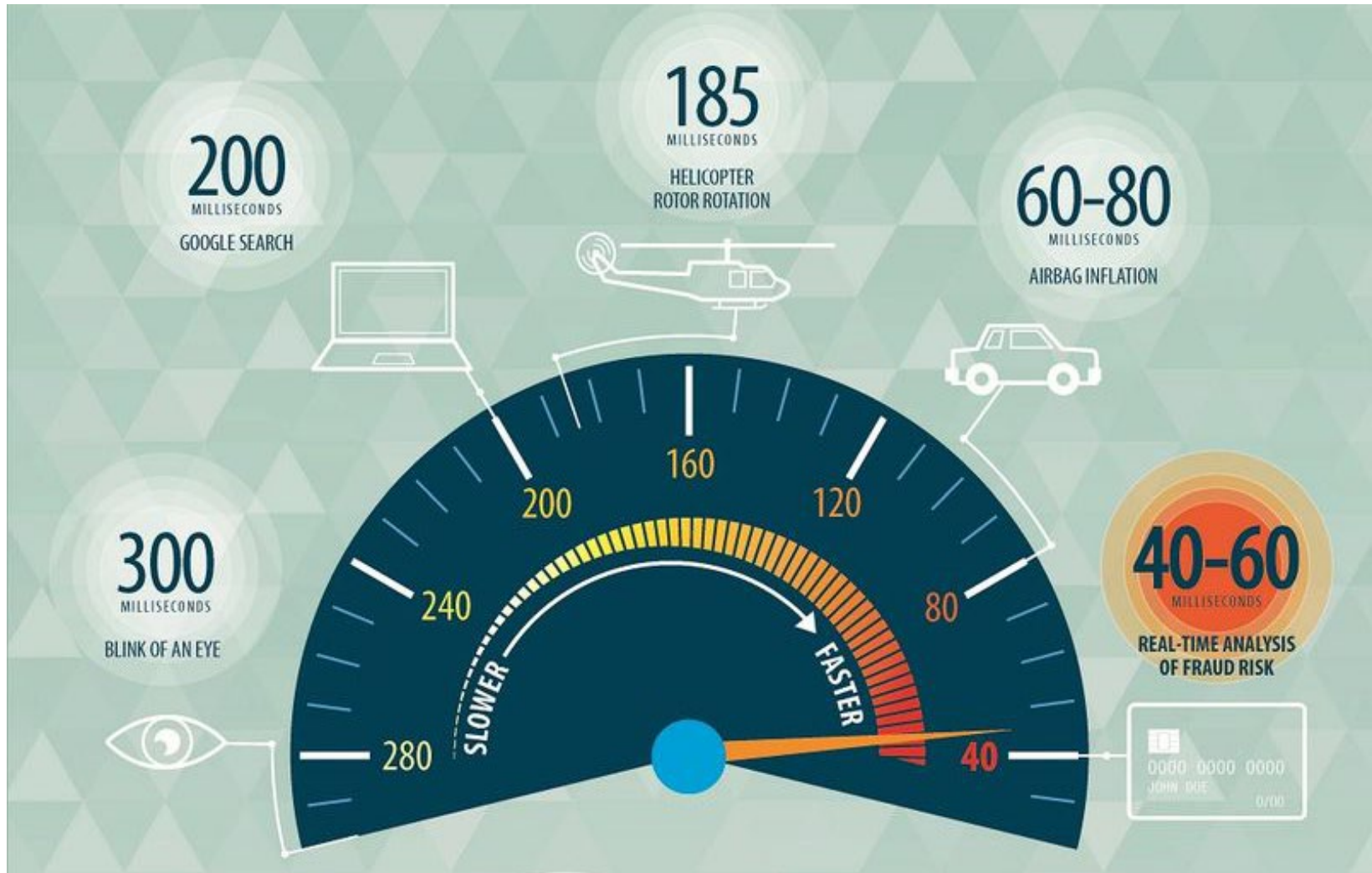
Applications in Medical Imaging

47/96



How Fast Is Credit Card Fraud Detection?

48/96



Credit Card Fraud Detection DB

49/96

- **Offered by Kaggle**
 - September 2013 by European cardholders
 - Transactions occurred in two days
 - 492 frauds out of 284,807 transactions
 - Highly unbalanced, the positive class (frauds) account for 0.172%
 - Due to confidentiality issues, details for 28 features are hidden

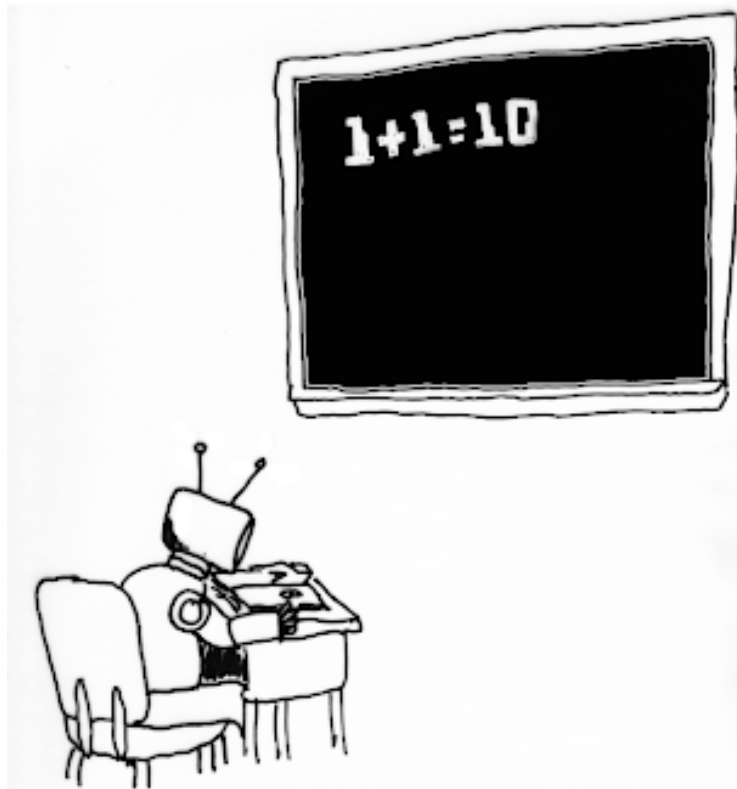


Unsupervised Learning

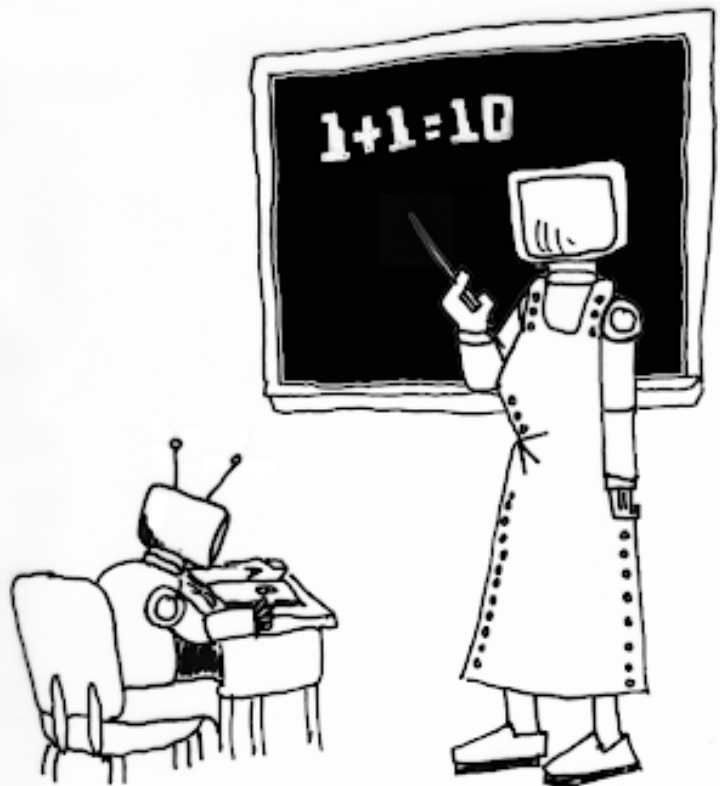
50/96

- No labels in the database, but it learns by itself!

UNSUPERVISED MACHINE LEARNING

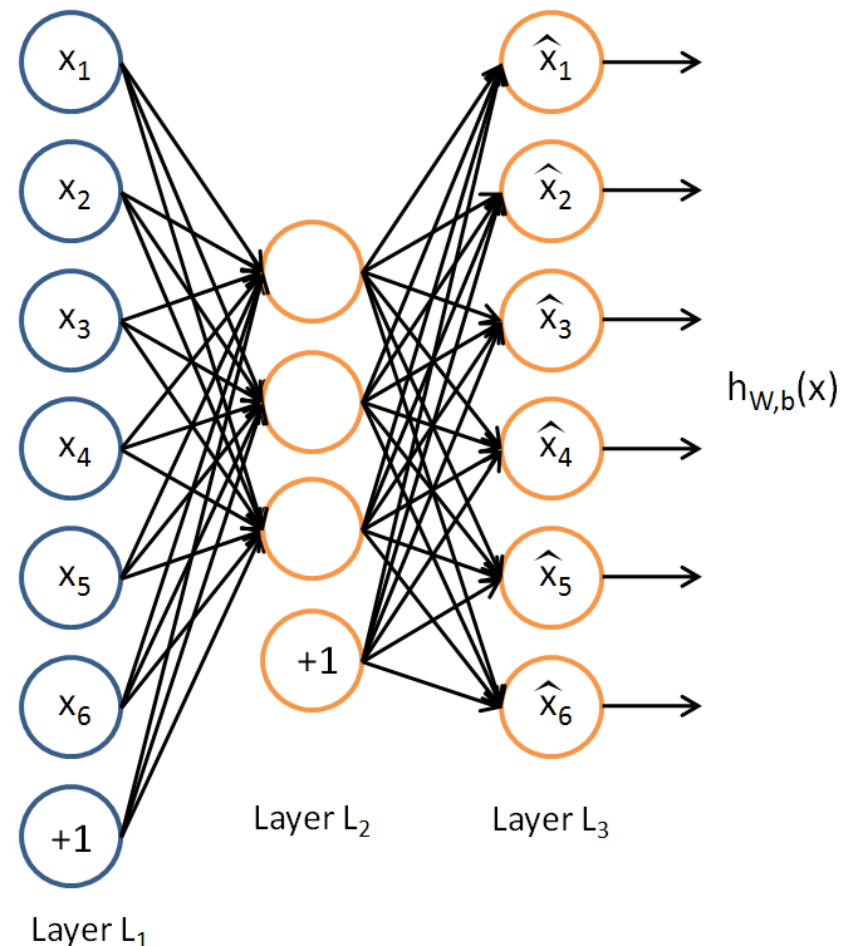


SUPERVISED MACHINE LEARNING

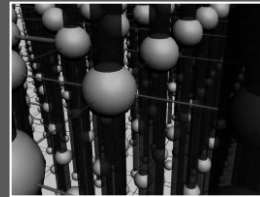
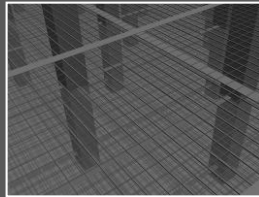
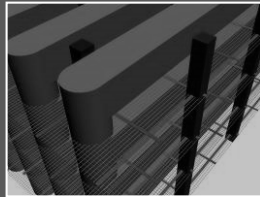
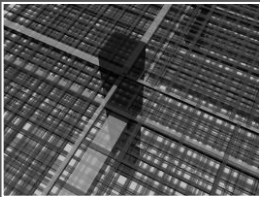


PROOFREADBYWIMMY.BLOGSPOT.COM

- **Hidden layer is smaller**
 - For dimensionality reduction
 - Divided in to encoder (first half) and decoder (second half)
 - Useful in feature extraction (encoder)
 - Useful in data reconstruction (decoder)
 - Killer apps in image processing
 - Word imbedding uses AE!



Unet



Semantic Segmentation

53/96

- Smart compute vision application
 - Label **each pixel** with a corresponding class of what is being represented
 - Commonly referred to as dense prediction.



Person
Bicycle
Background

Application in Autonomous Vehicle

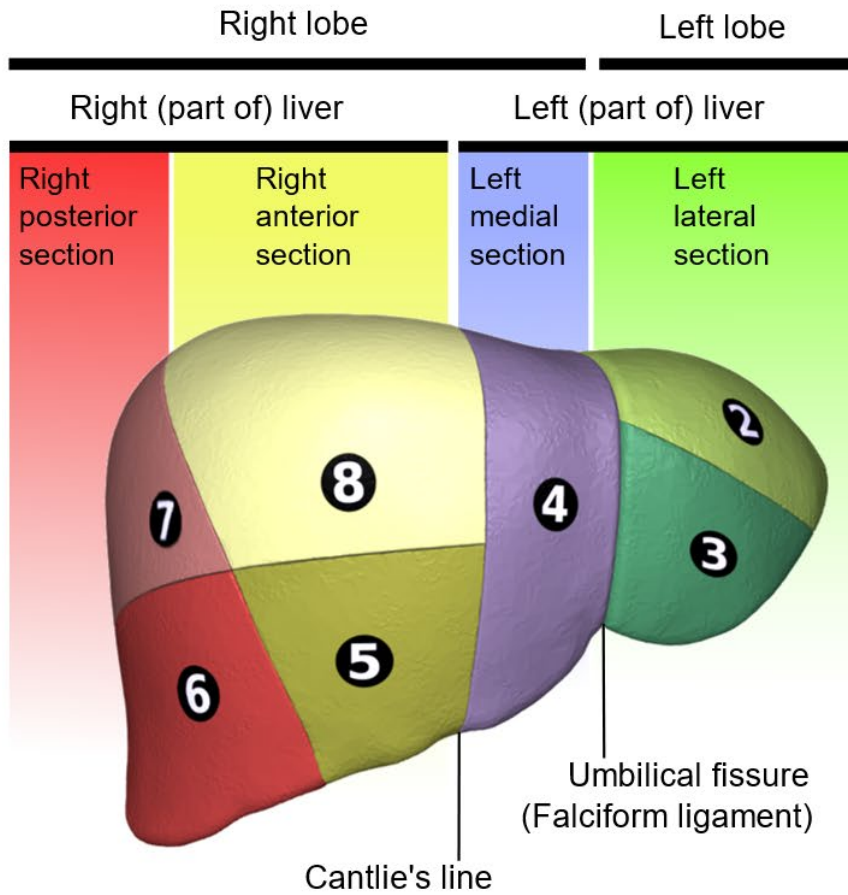
54/96

- Needs to be done really **fast and accurately!**

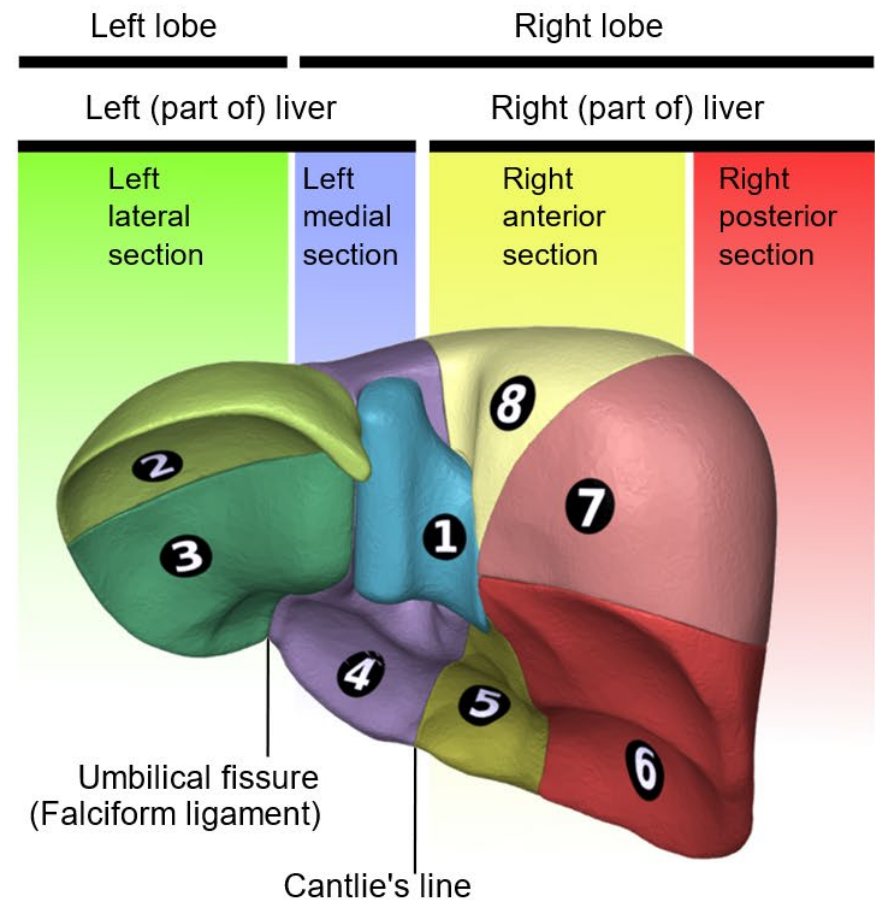


Liver Segmentation

55/96



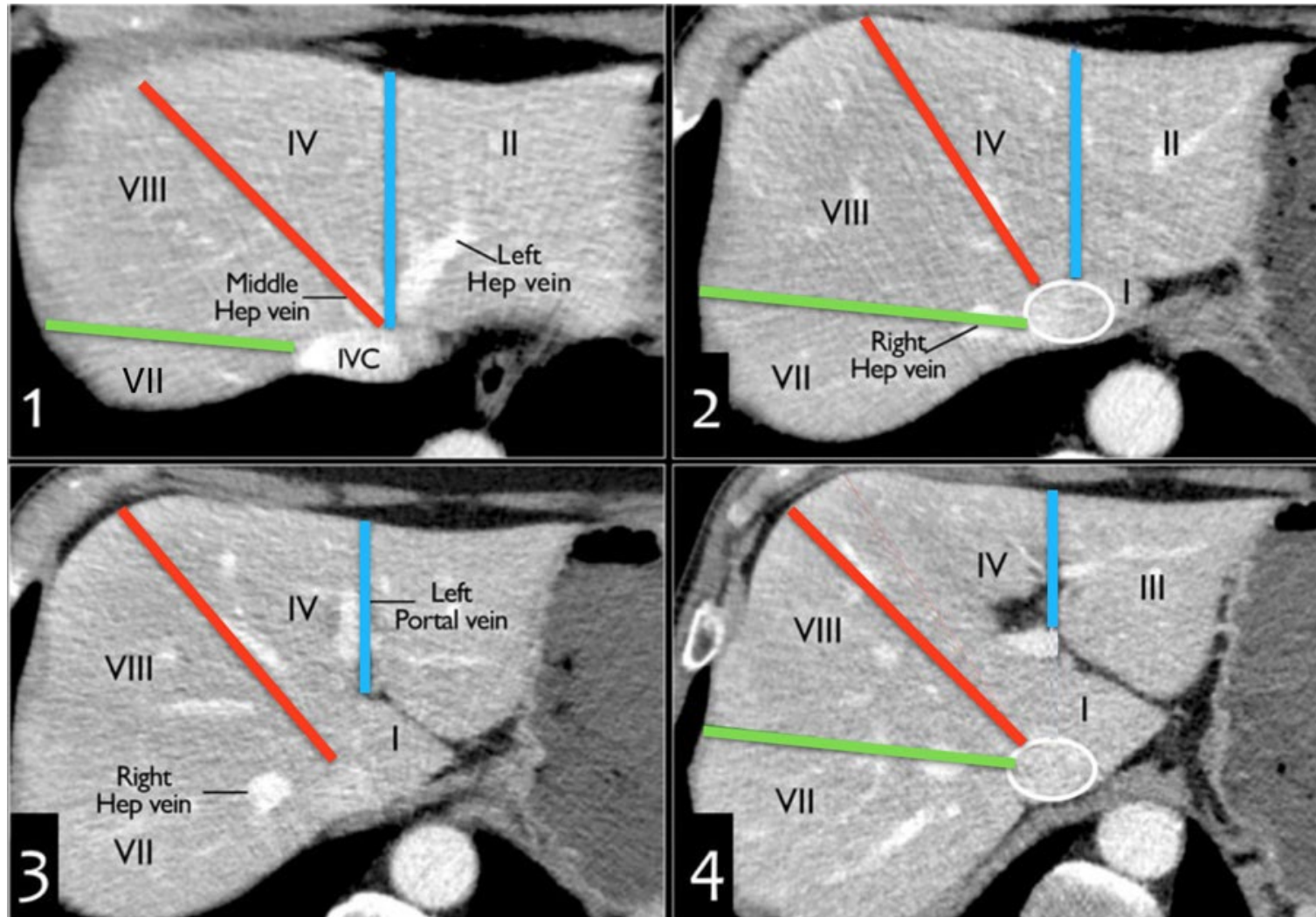
Anterior view



Posterior view

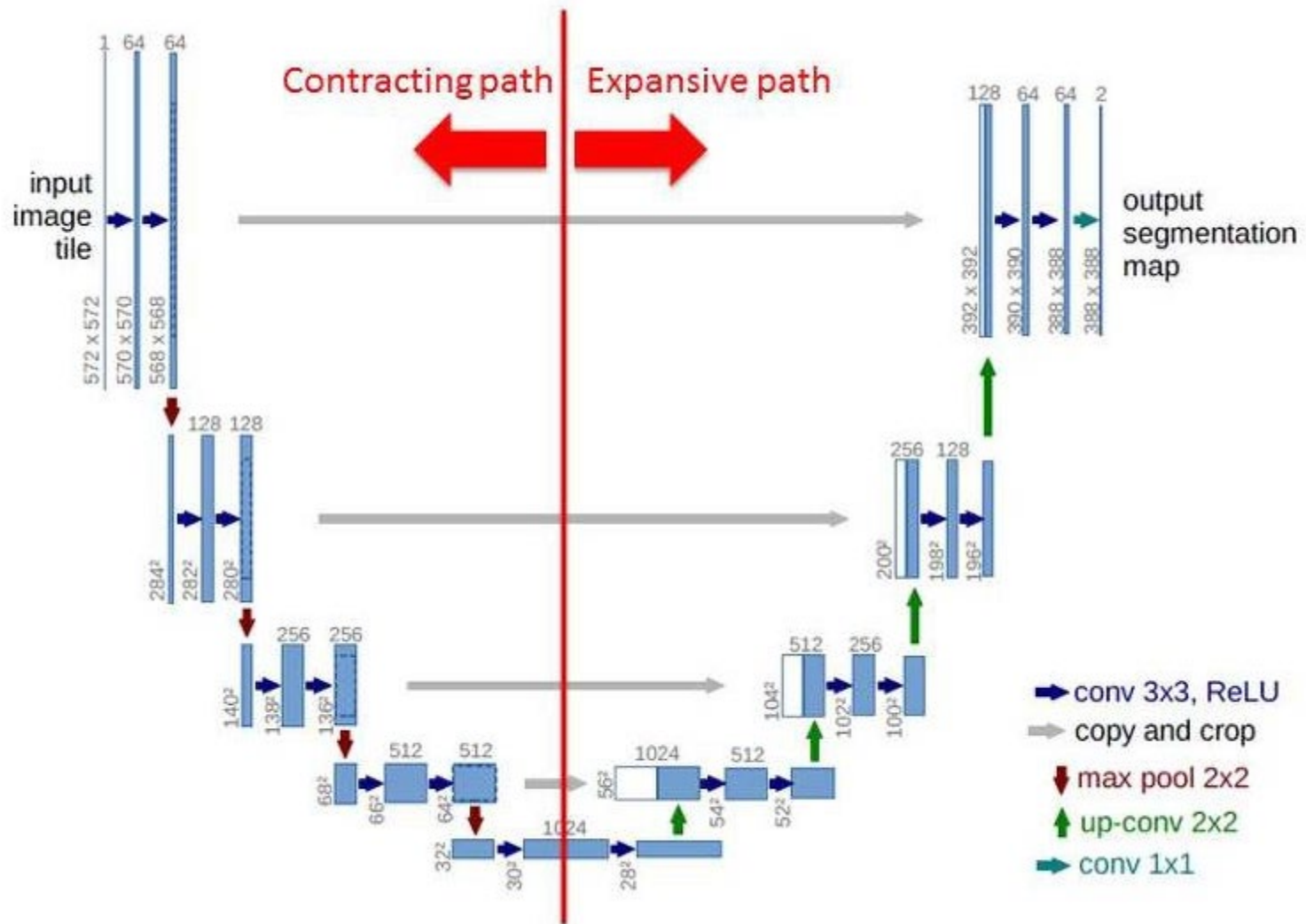
CT and MRI-based Imaging

56/96

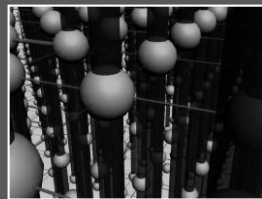
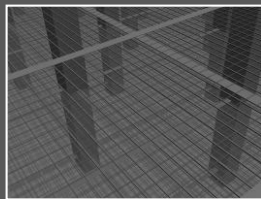
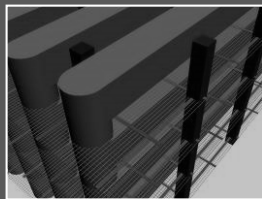
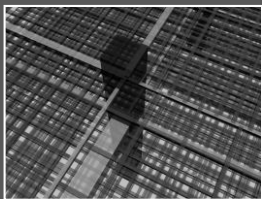


Unet: U-shaped CNN Autoencoder

57/96

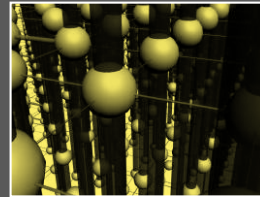
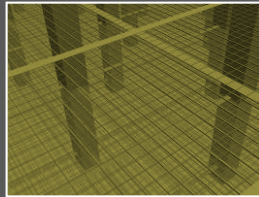
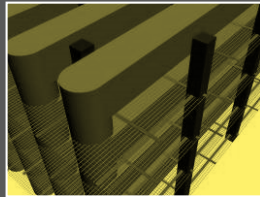
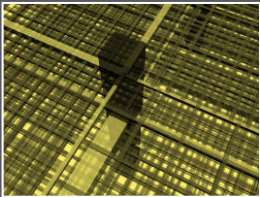


3. 기계학습 교수법 및 코딩 실습의 예



- RNN으로 주가 변동 예측하기
- Azure로 붓꽃 판별하기

RNN으로 주가 변동 예측하기



Amazon

60/96



Some Hate Amazon...

61/96

AMAZON VS LOCAL BUSINESS



BEFORE YOU CLICK — WHY YOUR CHOICE MATTERS

JOBS

For every \$10 million in sales made in North American, Amazon employs just 19 people.

In contrast, independent retailers create 47 jobs for every \$10 million in sales.

19

47



Amazon creates less than half as many jobs as local brick-and-mortar stores do.

This means **the more Amazon grows** and crowds out other businesses, **the fewer jobs available.**

LOCAL ECONOMY



Headquartered in Seattle, Amazon spends **next to nothing in the communities where most of its customers live.** It doesn't need local printers, designers, lawyers, or bankers. Except for a small amount the company pays to delivery drivers and third-party sellers, **all of the money that people spend at Amazon leaves their local economy.**

Locally owned businesses are by definition headquartered in their community, and they have a **proven record of growing the local economy.** Studies have found that as **local retailers add employees** and create local supply chains (by buying goods and services locally), **they channel about half of every dollar in sales back into the area.**

While **local retailers are engines of economic activity**, spending their revenue at a wide variety of other businesses in the community, **Amazon merely extracts money**, leaving little behind.

TAXES



In most communities, Amazon has **no facilities and therefore pays no property taxes.** In nearly half the states, it does not collect state and local sales taxes.

Local retailers occupy valuable storefront locations and **pay substantial property taxes.** They also **collect sales taxes** in every community that levies them.

Property and sales taxes are the main source of funds for our schools and public services. **If local businesses are squeezed out by Amazon, households will have to shoulder a higher tax burden.**

COMMUNITY



Amazon isn't involved in the communities where the majority of its customers live. **It doesn't give to local charities** or help solve local problems in these places. **It contributes nothing** to the vitality of our streets and neighborhoods.

Most small businesses are **deeply engaged in their communities**, giving almost twice as much to local causes as big businesses. Studies show that places with vibrant local businesses have **livelier streets, stronger social networks, and more active citizens.**

How we choose to direct **our spending shapes the future of the place we live** — and how interesting, special, and healthy it will be.

Amazon's New Cash Cow

62/96



Competitive Positioning of Players in the Cloud



Amazon Stock

63/96



Amazon Stock Price Database

64/96

- 4,529 daily stock price info
 - From 11/21/2000 to 11/21/2018
- Columns
 - **Date: Daily Date**
 - **Open:** Opening price of day
 - **High:** High price of day
 - **Low:** Low price of day
 - **Close:** Closing price of day
 - **Adj Close:** Adjusted close



1. stock-price.py (1/13)

65/96

```
# import packages
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
from keras.models import Sequential
from keras.layers import LSTM, Activation, Dense

# global constants and hyper-parameters
TIME_STEP = 3
MY_NUM_NEURON = 256
MY_CUTOFF = 0.7
MY_EPOCH = 10
MY_BATCH = 64
```

1. stock-price.py (4/13)

66/96

```
# display the logarithm of returns
change = raw_DB.pct_change()
log_return = np.log(1 + change)
print('\n== LOG-RETURN OF THE LAST 10 DAYS ==')
print(log_return.tail(10))

plt.show()

# scaling with z-score:  $z = (x - u) / s$ 
from sklearn.preprocessing import MinMaxScaler
scaler = MinMaxScaler()

scaled_DB = scaler.fit_transform(raw_DB)
```

fit_transform()

67/96

```
# conducts data centering
from sklearn.preprocessing import MinMaxScaler
scaler = MinMaxScaler()

# we must use 2D array
my_array = [[1], [2], [3], [6]]
x = scaler.fit_transform(my_array)
print(x)

# converts scaled data back to original
y = scaler.inverse_transform(x)
print(y)
```

1. stock-price.py (10/13)

68/96

```
# model training and saving

model.compile(loss = 'mse', optimizer = 'adam',
              metrics = ['accuracy'])

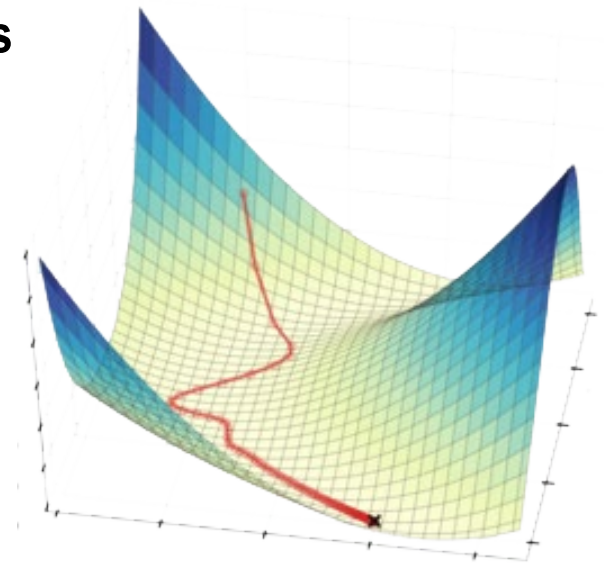
model.fit(X_train, Y_train, epochs = MY_EPOCH,
          batch_size = MY_BATCH, verbose = 1)

model.save('chap1.h5')
```

Adam Optimizer

69/96

- **Adam: Adaptive moment estimation**
 - Keeps separate learning rates for each weight
 - Exponentially decay average of previous gradients
 - Fairly memory efficient since it doesn't keep a history of anything
 - Work well for both sparse matrices and noisy data
 - Seems promising for the stock market data.
 - Works well with little tuning of hyperparameters

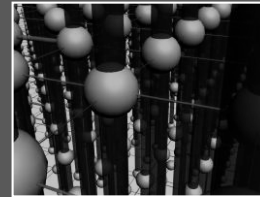
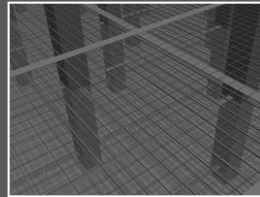
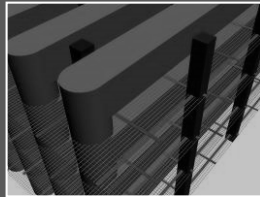
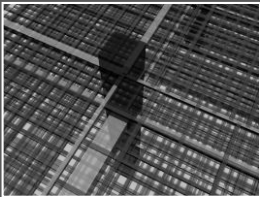


Exercise Questions

70/96

- **Q1: Examine the chap1.h5 file.**
- **Q2: Try other company stock data (GE, Microsoft, Apple, Google).**
- **Q3: Try sigmoid activation. What is the impact?**
- **Q4: Tune the MY_NUM_NEURON parameter. What is the impact?**
- **Q5: Tune the TIME_STEP parameter. What is the impact?**

Azure로 붓꽃 판별하기



Iris Classification

72/96

- Perhaps the best-known example in the field of machine learning
 - The aim is to classify iris flowers among three species
 - From measurements of length and width of sepals and petals

iris setosa



petal

sepal

iris versicolor



petal

sepal

iris virginica

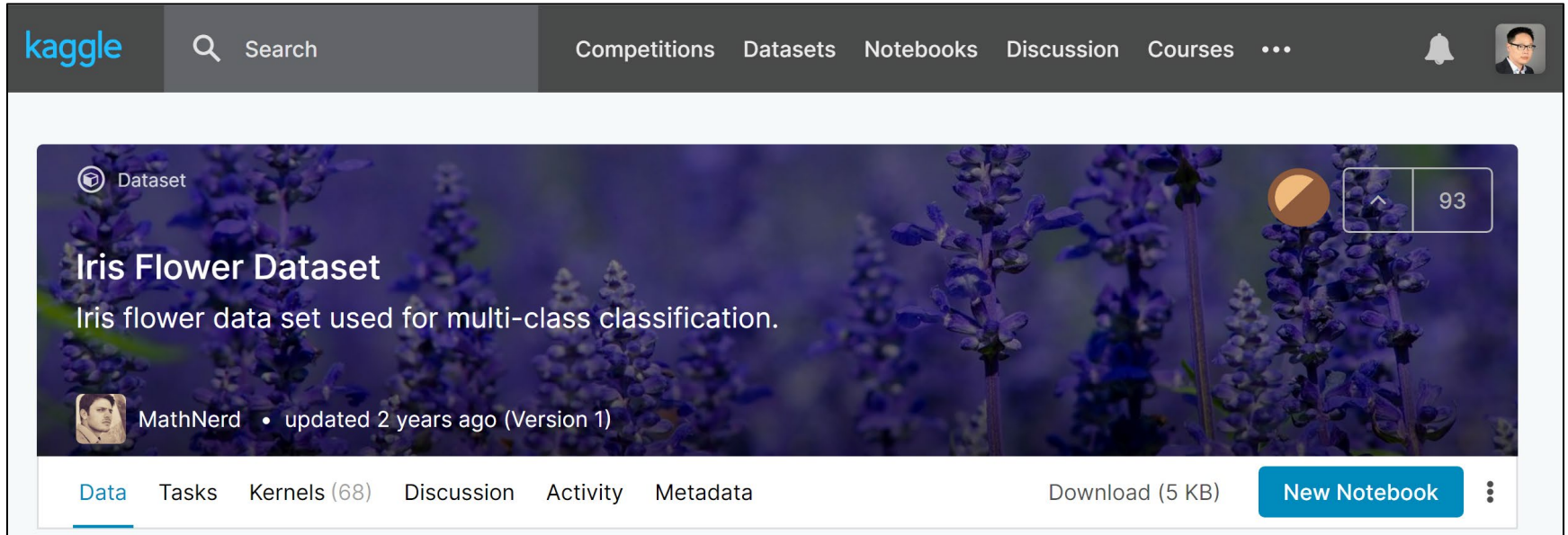


petal

sepal

UCI Iris Flower Dataset

73/96

A screenshot of the Kaggle website showing the 'Iris Flower Dataset' page. The page header includes the Kaggle logo, a search bar, and navigation links for Competitions, Datasets, Notebooks, Discussion, and Courses. The dataset card features a background image of purple iris flowers, the title 'Iris Flower Dataset', a description 'Iris flower data set used for multi-class classification.', the creator's profile 'MathNerd', and the update date 'updated 2 years ago (Version 1)'. At the bottom of the card, there are tabs for Data, Tasks, Kernels (68), Discussion, Activity, and Metadata, along with a 'Download (5 KB)' link and a 'New Notebook' button.

kaggle Search Competitions Datasets Notebooks Discussion Courses ...

Dataset

Iris Flower Dataset

Iris flower data set used for multi-class classification.

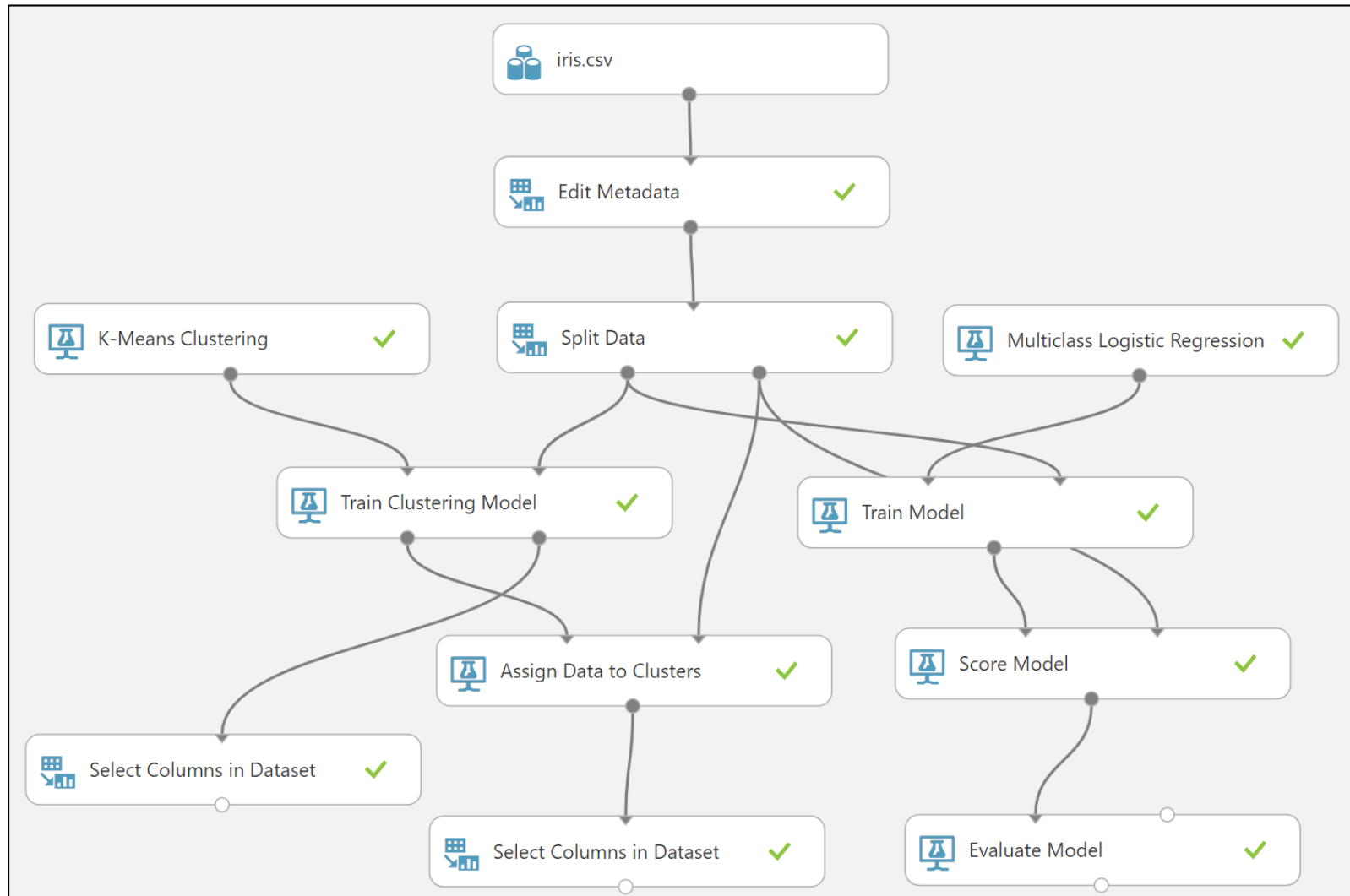
MathNerd • updated 2 years ago (Version 1)

Data Tasks Kernels (68) Discussion Activity Metadata Download (5 KB) New Notebook

- **150 data with 5 features**
 - Petal Length, Petal Width, Sepal Length, Sepal width and Class (Species)
- **Goal is to predict class given the 4 dimensions**
 - Classical classification problem

Overview of the Model

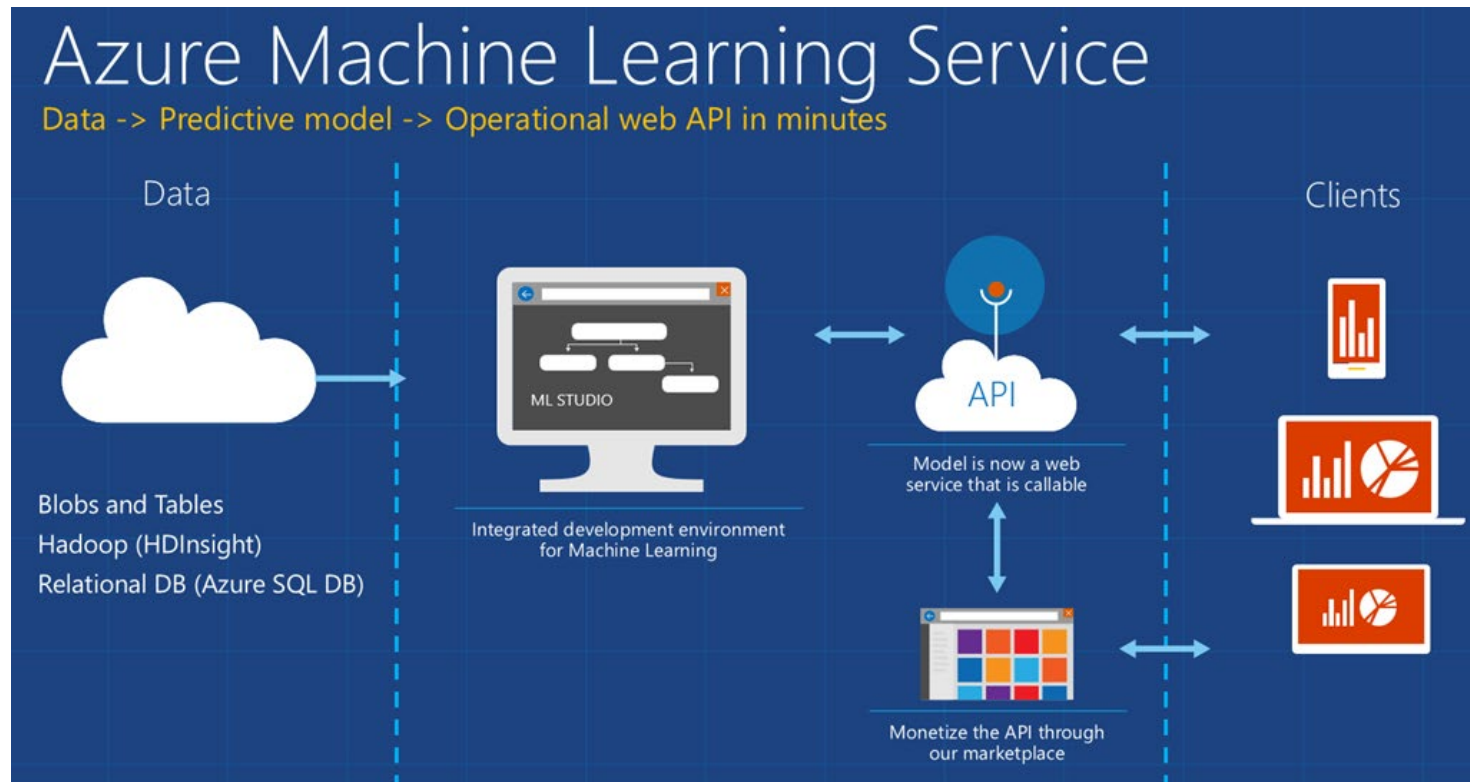
74/96



Azure ML Design Flow

75/96

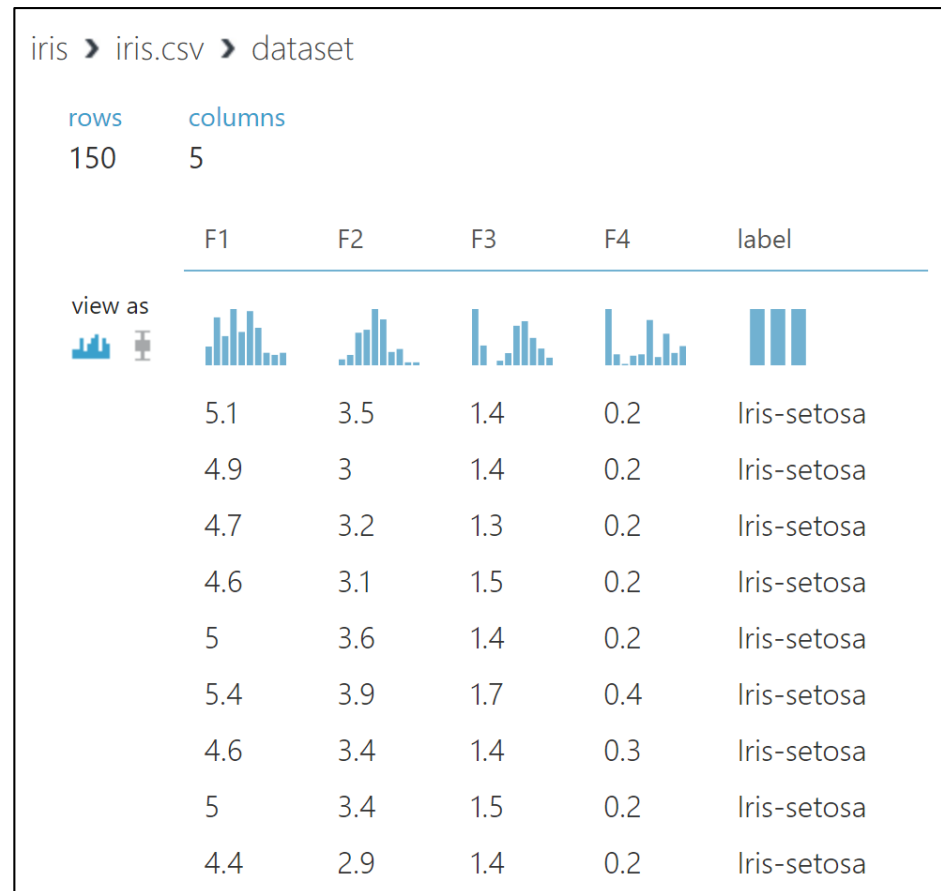
- 4 major steps
 - Data acquisition > Data preparation > Model training and evaluation > web deployment



Data Acquisition

76/96

- Search for **My Datasets** menu in the search window.
- Drag and drop **iris.csv** module onto the canvas on the right.
- Right click **iris.csv** module and select **dataset > visualize**. Examine the dataset stats.



Model Training and Evaluation

77/96

- Click **K-Means Clustering** module.
- Change the number of centroids to 3.
- Leave other options as default.

Properties Project

▲ K-Means Clustering

Create trainer mode

Single Parameter ▼

Number of Centroids

3

Initialization

K-Means++ ▼

Random number seed

Metric

Euclidean ▼

Iterations

200

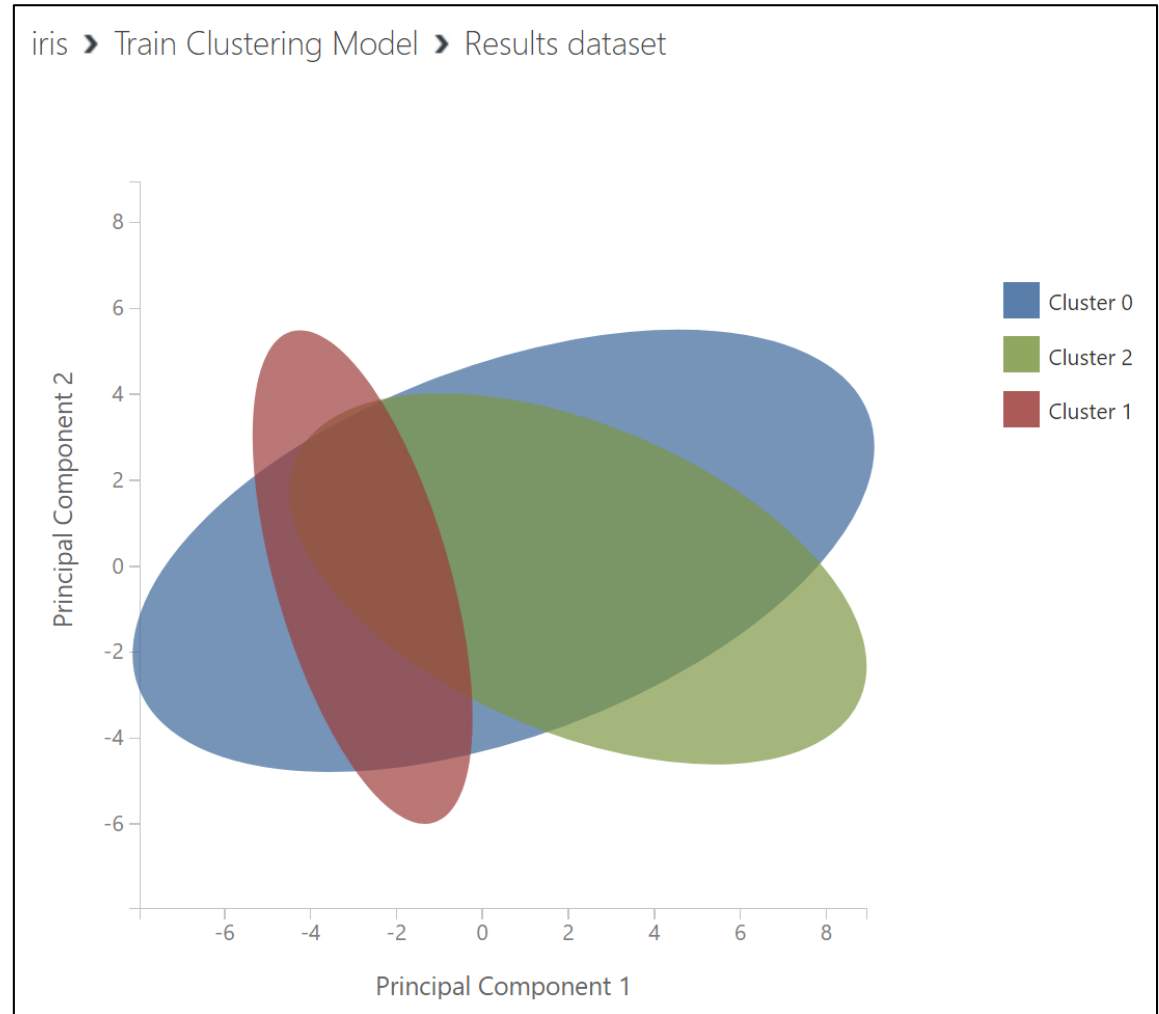
Assign Label Mode

Ignore label column ▼

Model Training and Evaluation

78/96

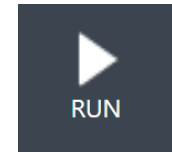
- Right click Train
Clustering Model
module and
visualize the result.



Model Training and Evaluation

79/96

- Run the experiment.
- Right click Select Columns in Dataset module and visualize the result.



iris > Select Columns in Dataset > Results dataset

rows	columns
45	2

view as	label	Assignments
		
	Iris-virginica	2
	Iris-setosa	1
	Iris-setosa	1
	Iris-versicolor	0
	Iris-versicolor	0
	Iris-setosa	1
	Iris-setosa	1
	Iris-setosa	1
	Iris-virginica	2
	Iris-versicolor	0

Model Training and Evaluation

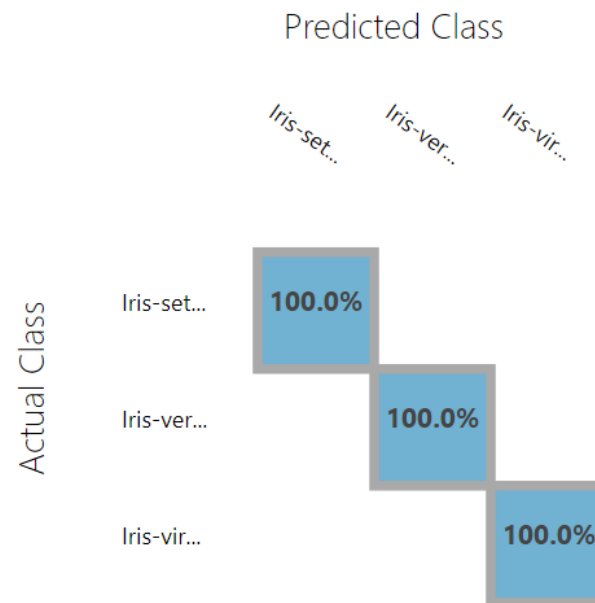
80/96

- Right click Evaluate Model module to visualize the result.

Metrics

Overall accuracy	1
Average accuracy	1
Micro-averaged precision	1
Macro-averaged precision	1
Micro-averaged recall	1
Macro-averaged recall	1

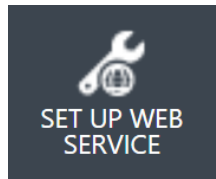
Confusion Matrix



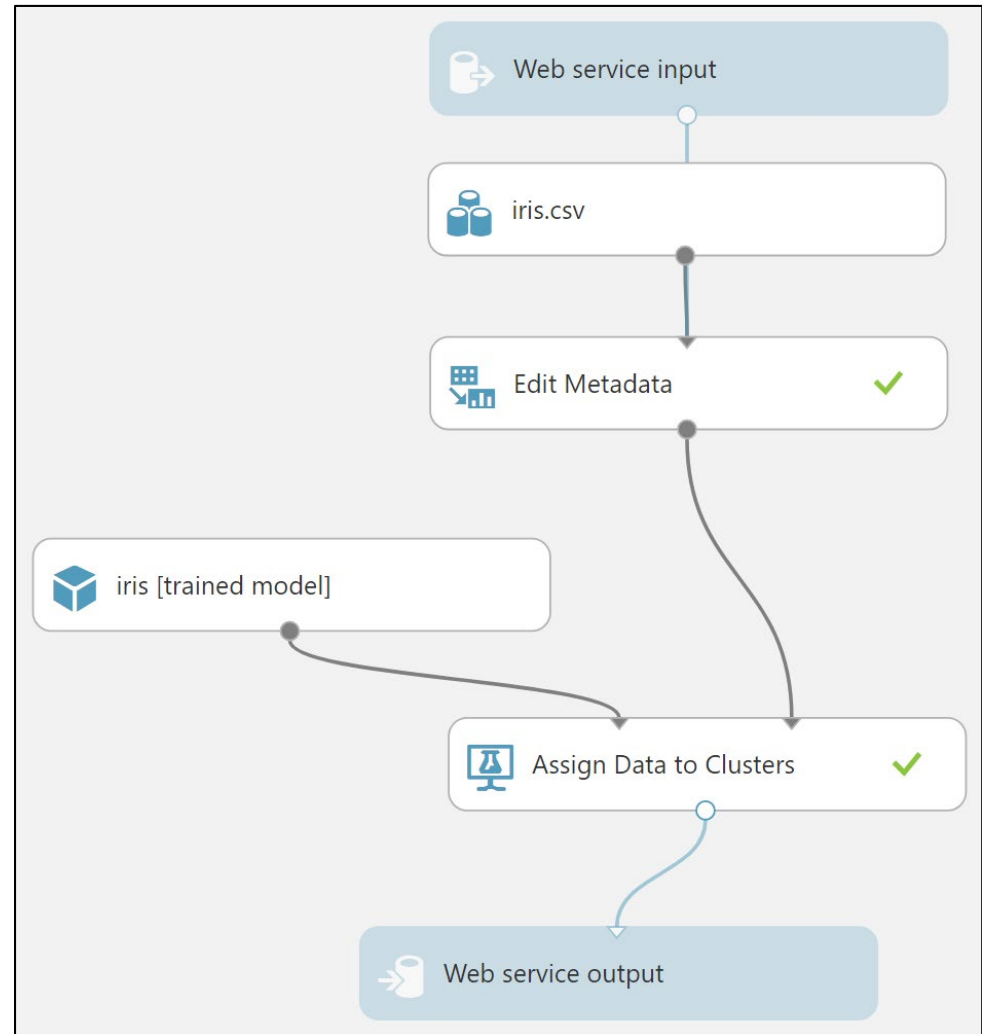
Web Deployment

81/96

- Click **SET UP WEB SERVICE** button on the bottom and select **Predictive Web Service** menu.



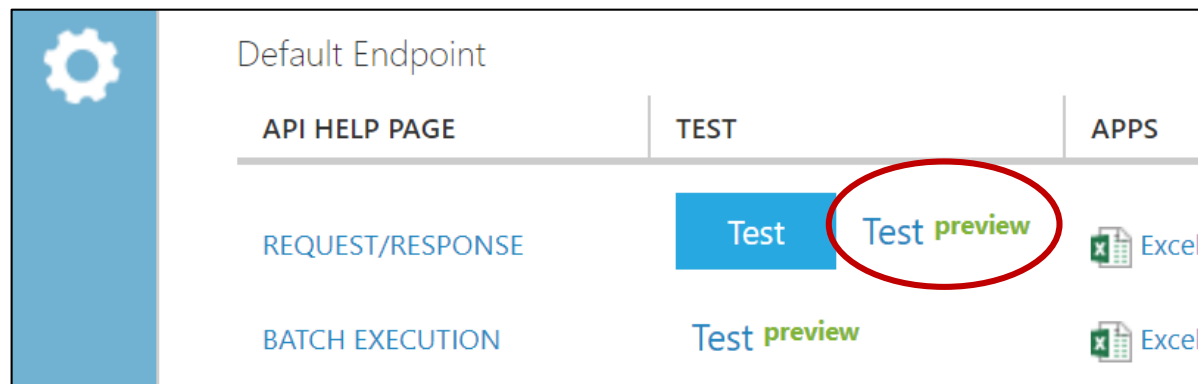
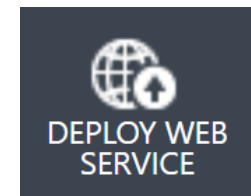
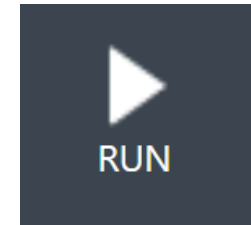
- Newly built model is shown.



Web Deployment

82/96

- Run the experiment.
- Click **DEPLOY WEB SERVICE** button on the bottom.
- Click Test-preview button.

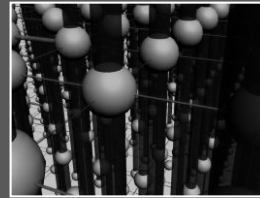
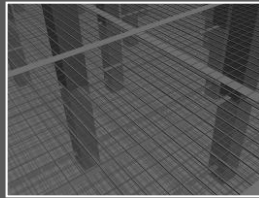
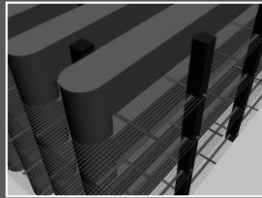


Homework

83/96

1. Use Edit Metadata module to drop F4 column while running K-means clustering. What is the impact?
2. Replace Multiclass Logistic Regression module with Multiclass Neural Network module. Which one performs better?
3. Replace Multiclass Logistic Regression module with Multiclass Decision Forest module. Which one performs better?
4. Use Select Columns in Dataset module to drop F4 column while running multi-class logistic regression. What is the impact?
5. Try changing the split ratio and see the impact.
6. What happens if we do not randomize the split process?

4. 기계학습 관련 진행 연구

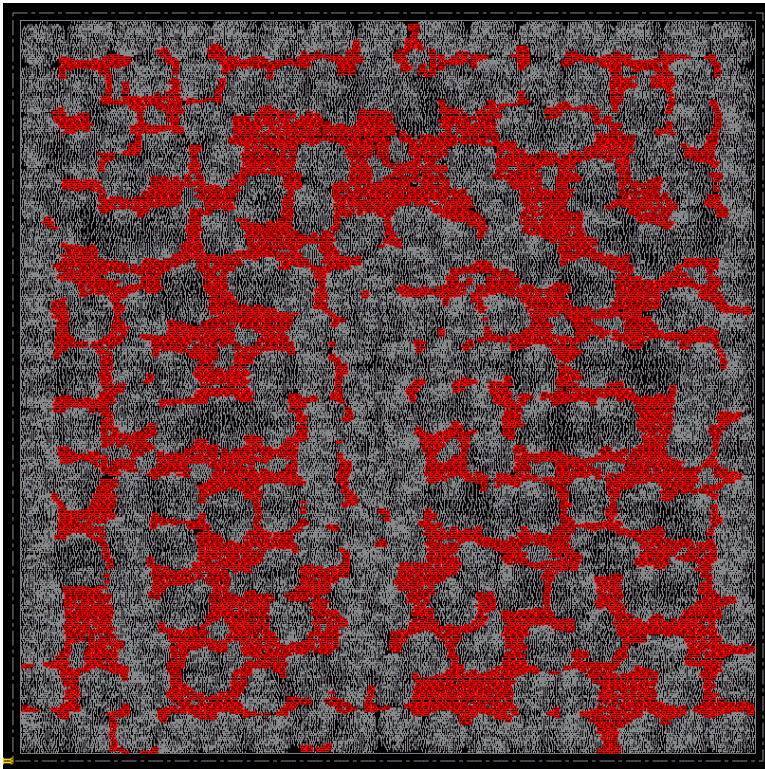


- 회로설계에 적용된 기계학습

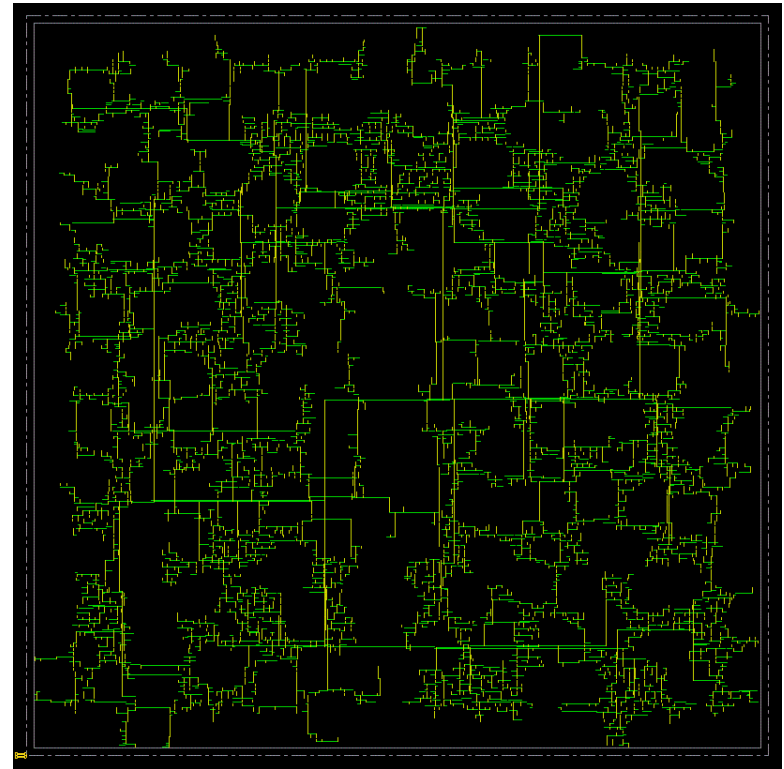
Clock Routing In Digital Circuit

85/96

- Make electrical connects to all sequential elements in the circuit



sequential elements (red)



clock tree (green)

Two Clock Trees

86/96

- Setting is **VERY** important and requires years of experience

feature	value
Target skew	0.13ns
Max fanout	195
Max cap (trunk)	0.04pF
Max cap (leaf)	0.10pF
Target slew (trunk)	0.23ns
Target slew (leaf)	0.26ns
Target latency	0.4ns
eGR metal usage	1, 2, 3, 4
Cell density	0.6

tree 1 settings

feature	value
Target skew	0.08ns
Max fanout	175
Max cap (trunk)	0.03pF
Max cap (leaf)	0.07pF
Target slew (trunk)	0.21ns
Target slew (leaf)	0.03ns
Target latency	0.2ns
eGR metal usage	1, 2, 3
Cell density	0.7

tree 2 settings

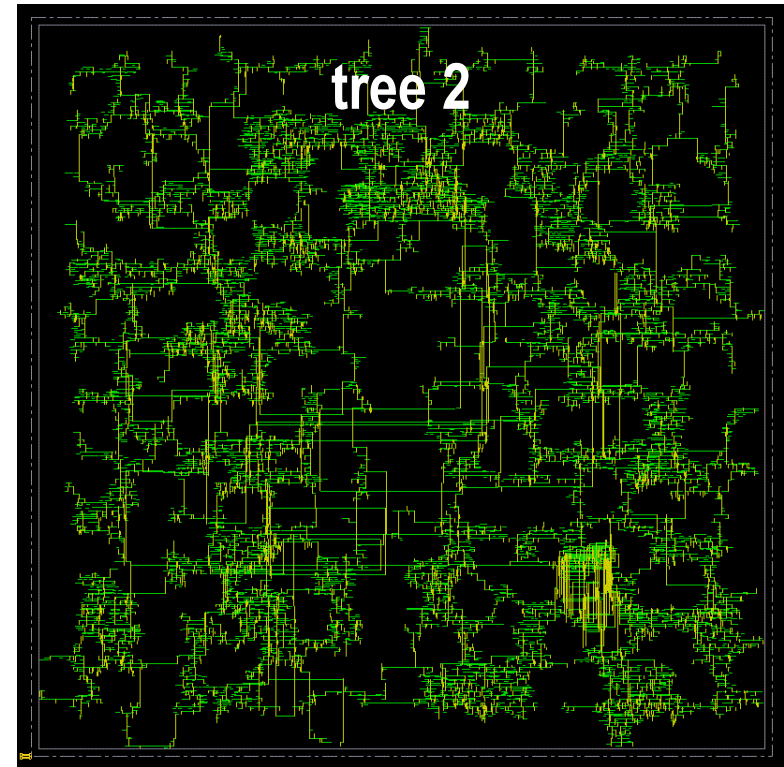
Very Different Outcome

87/96

- Quality is very different



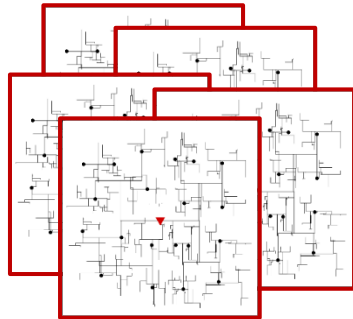
Power: 21.8mW	WL: 37.5mm
Skew: 0.15ps	Latency: 0.55ps



Power: 72.3mW	WL: 76.4mm
Skew: 0.13ps	Latency: 0.87ps

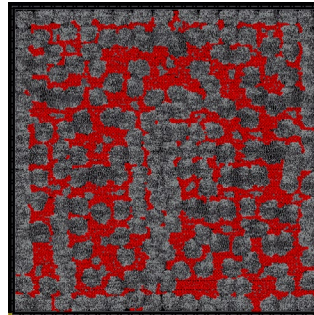
ML-based CTS Prediction

88/96



clock tree DB

+



placement (FF in red)



**prediction:
how do I build
the best CLK?**



**better CTS than human &
commercial auto-setting**

power,
skew,
WL...

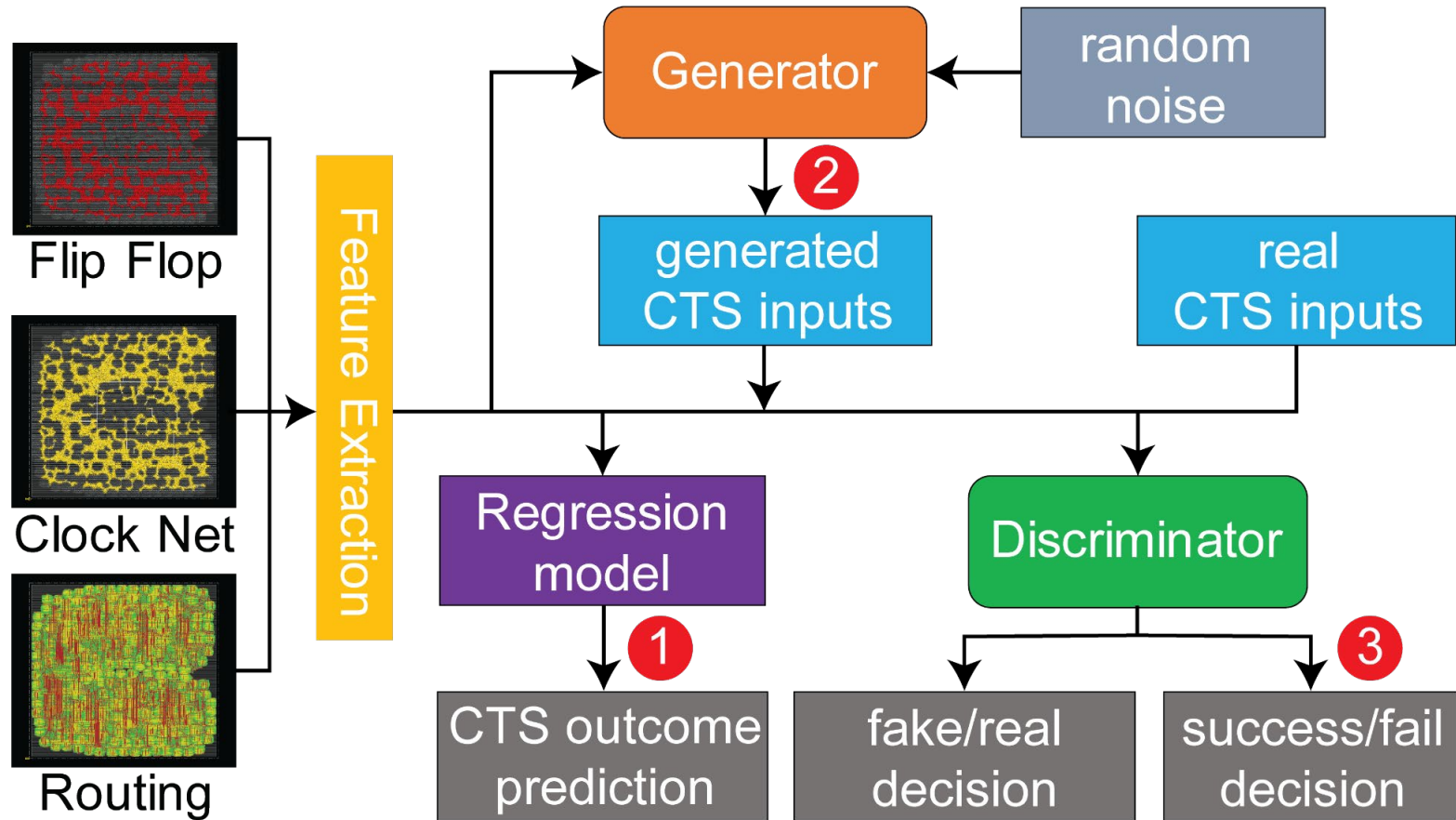


CTS
parameters
used



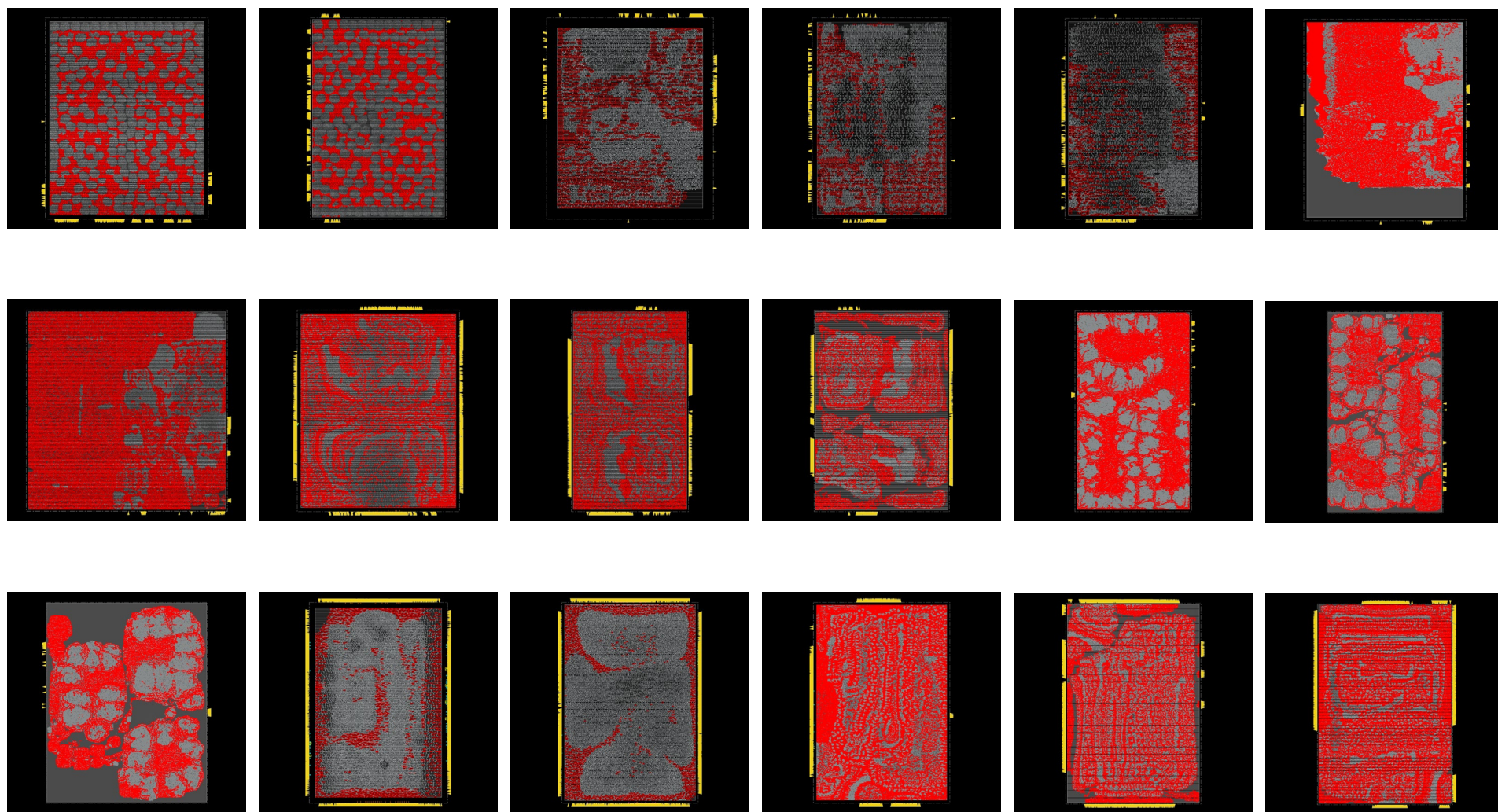
Our GAN-based Flow

89/96



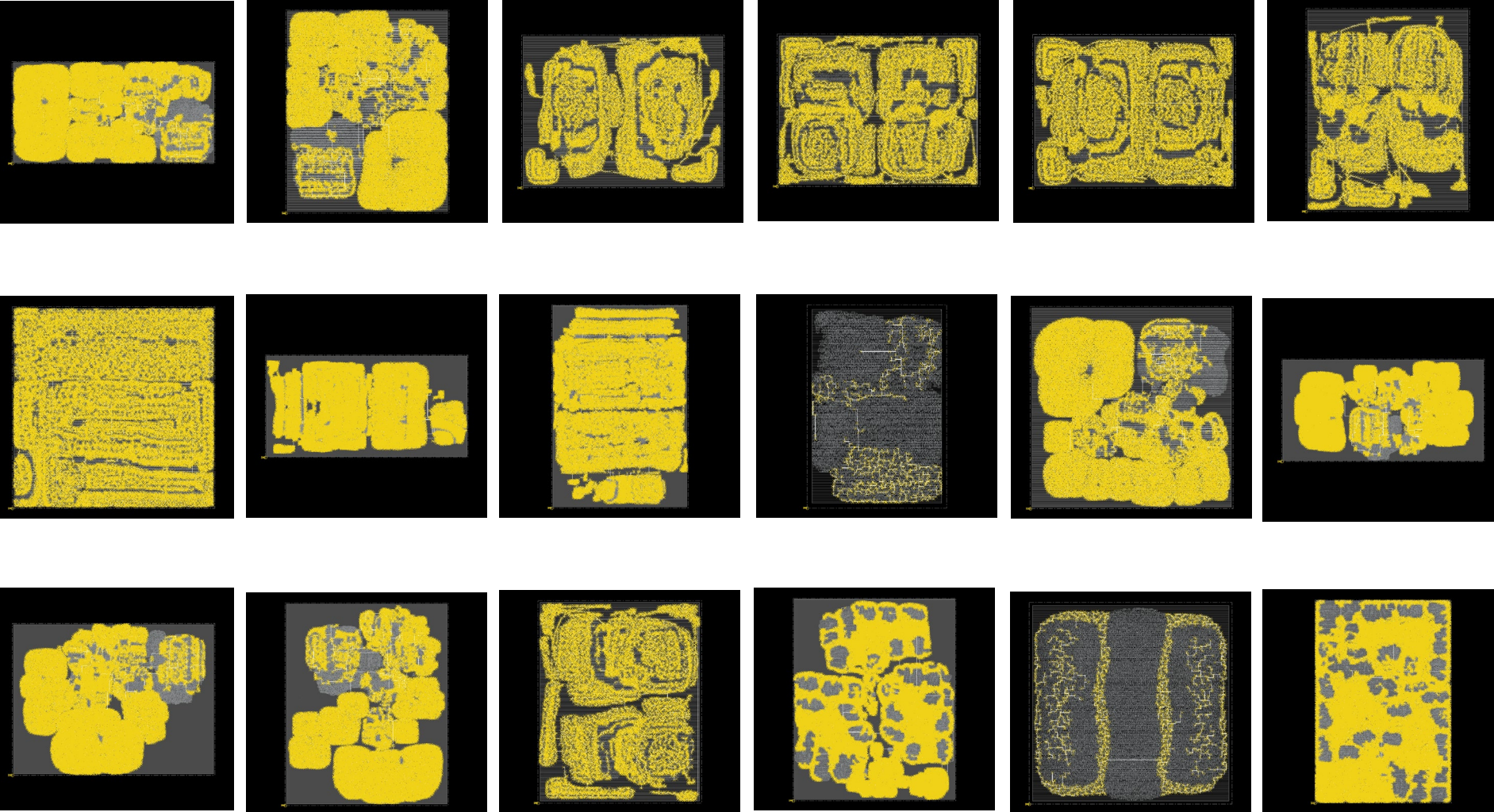
Our DB: 3000 Placements from 7 Ckts

90/96

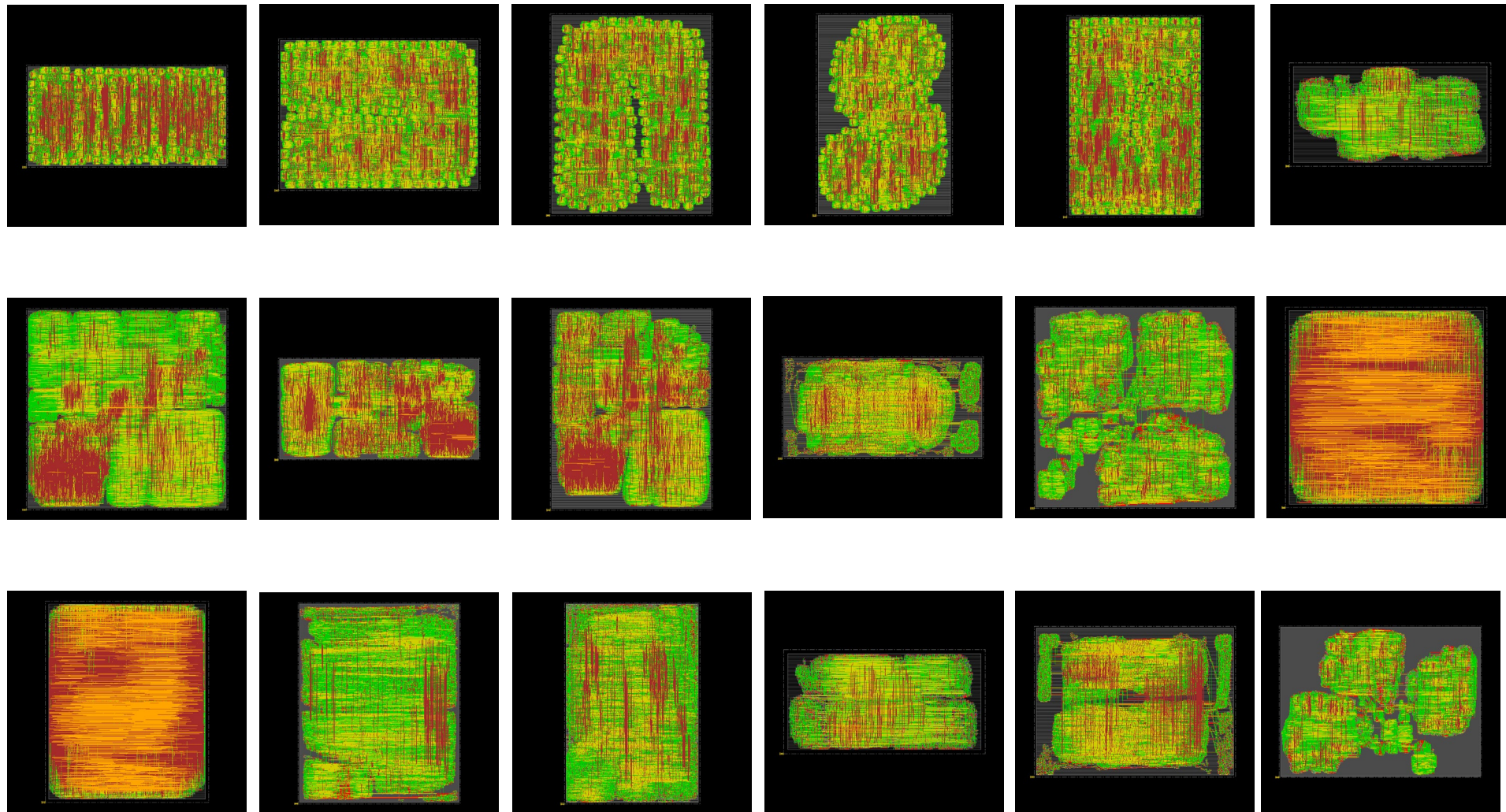


Our DB: 3000 Clock Net from 7 Ckts

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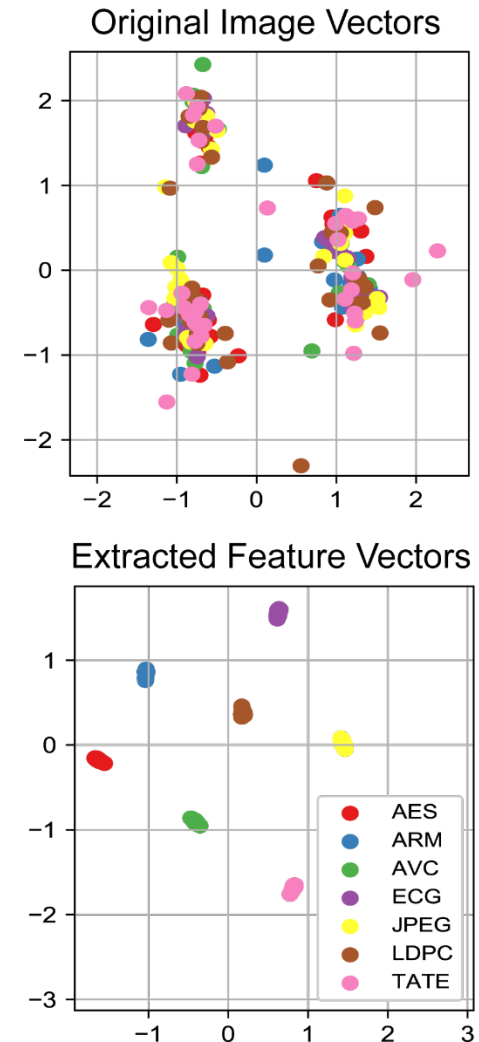
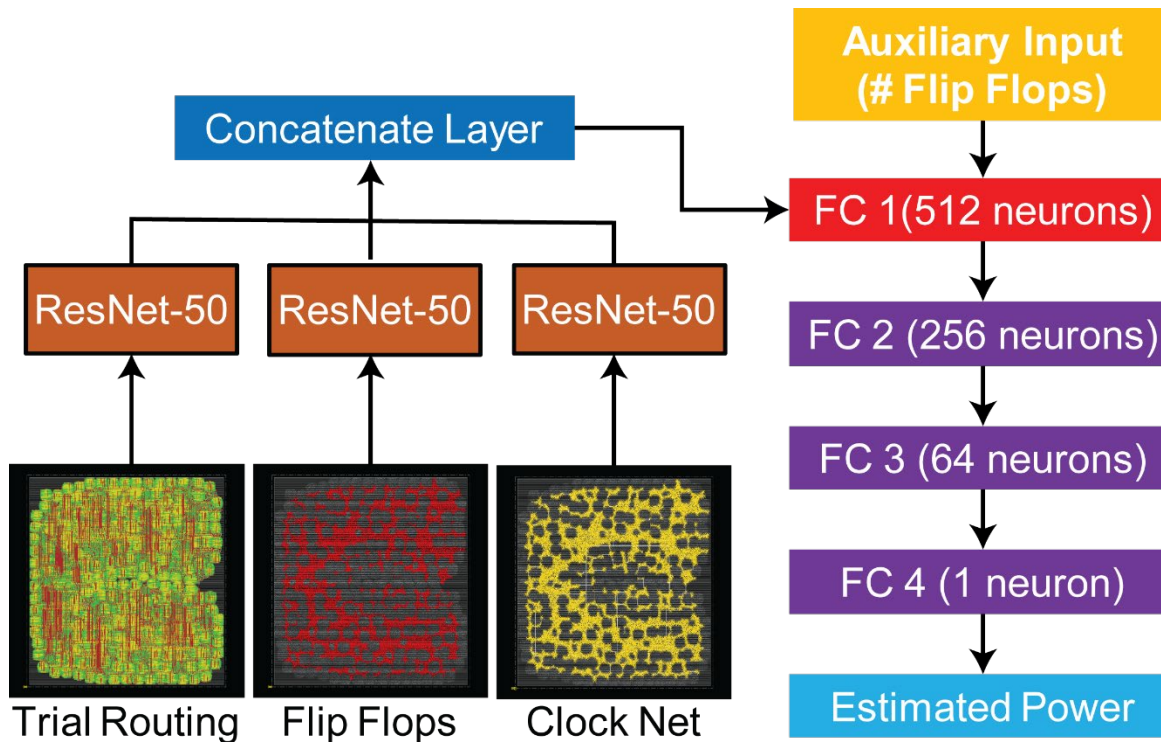
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Why Images?

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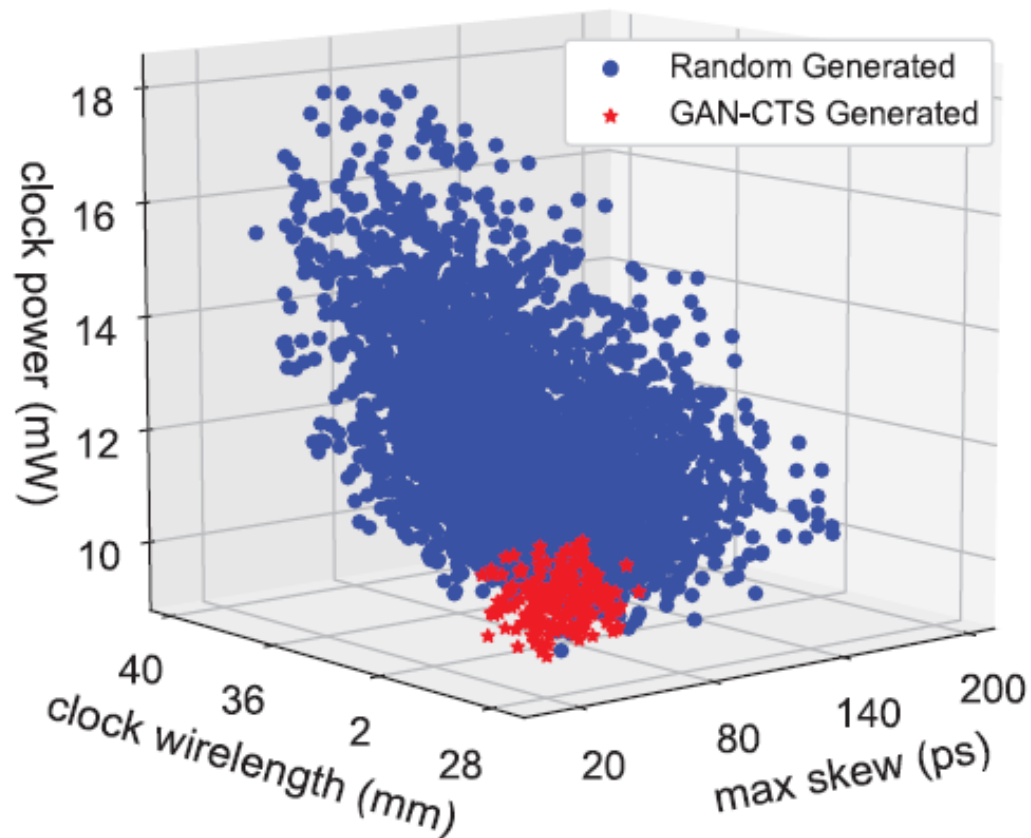
- **Extremely useful**
 - In handling **unseen** netlist



GAN-Generated Data

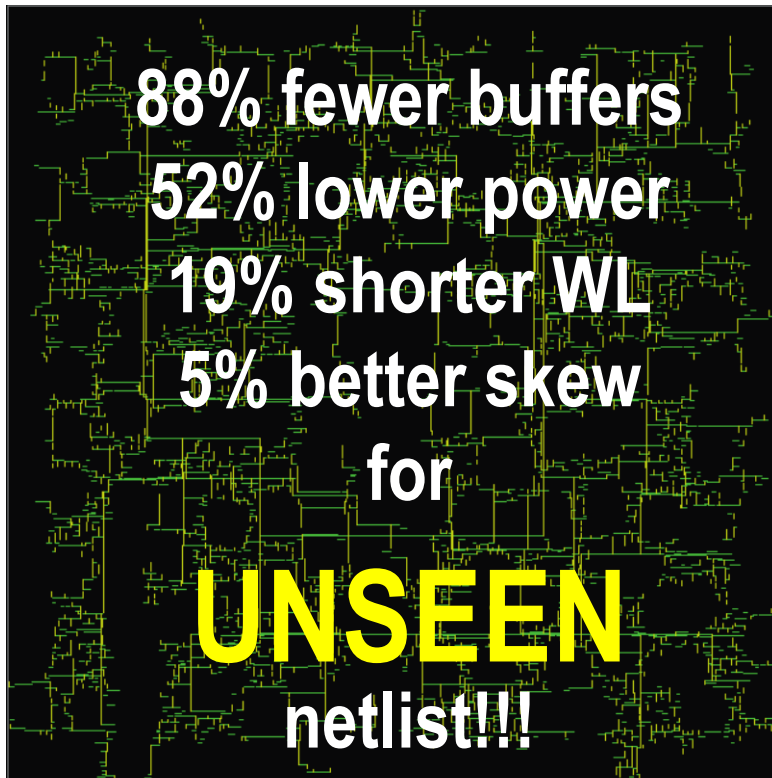
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- Our generator became **very** smart

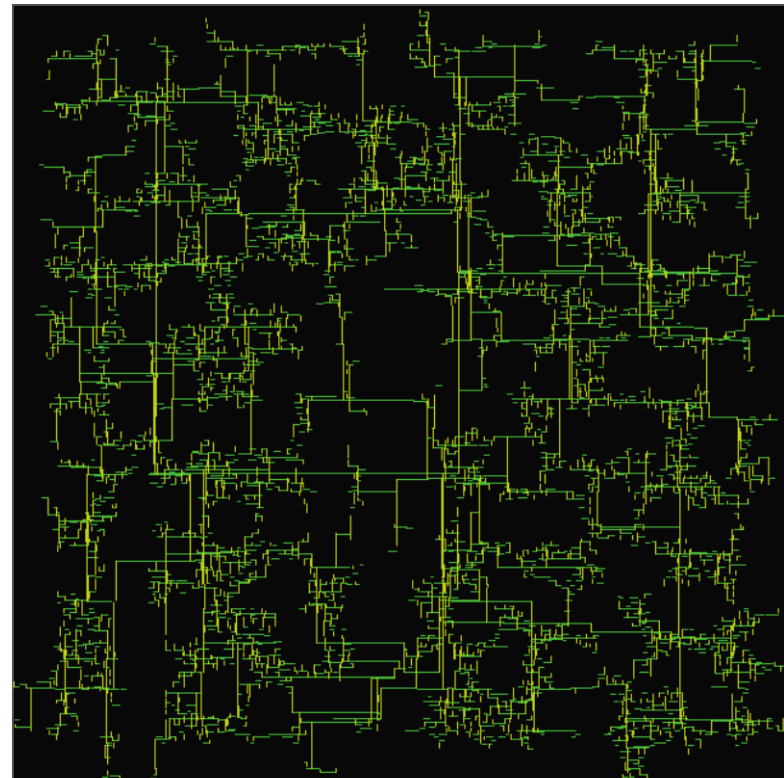


Gan-Optimized Clock Tree

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(a) GAN-CTS optimized



(b) commercial auto-setting

1. 인공지능 (AI) 기계학습이란?

2. 기계학습의 종류

- CNN, RNN GAN, Autoencoder, Unet

3. 기계학습 교수법 및 코딩 실습의 예

- RNN으로 주가 변동 예측하기
- Azure로 붓꽃 판별하기

4. 기계학습 관련 진행 연구

- 회로설계에 적용된 기계학습