# CS 316: Introduction to Deep Learning

## Logistics and Introduction
## Week 1

Dr Abdul Samad

# Lecture Outline

- Idea of Machine Learning Software
- Key Components of Machine Learning
- Kinds of Machine Learning Problems
- Road to Deep Learning
- Examples of Deep Learning Problems

# How to Design Software Solutions.

- **Can we write programs for the following:**
  - To predicts weather given geographic information, satellite images, and a trailing window of past weather.
  - That takes in a question, expressed in free-form text, and answers it correctly.
  - Given an image can identify all the people it contains,
    - drawing outlines around each.
  - Presents users with products that they are likely to enjoy but unlikely, to encounter.

# Training Process in Machine Learning

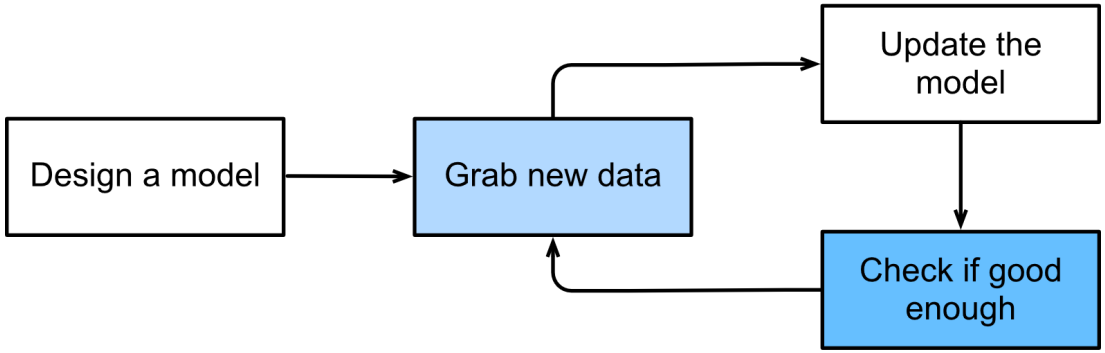



Figure taken from d2l.ai

# Key Components of Machine Learning

- Data
- Model
- Objective Function
- Optimization Algorithm

# Data

- A collection of examples consists of sets of attributes called features.
- In each example, there is a designated label attribute to predict.
- Features can have a fixed or variable length.
- The quantity of data available determines the effectiveness of deep learning models.
- It is important to ensure high-quality data because the output depends on the input.
- The data can be biased, such as through CV filtering.

# Model

- The computational machinery for ingesting data of one type and spitting out predictions of a possibly different type.
- Can be estimated from the data.
- Deep learning models are much more complicated than traditional models.

# Objective Function

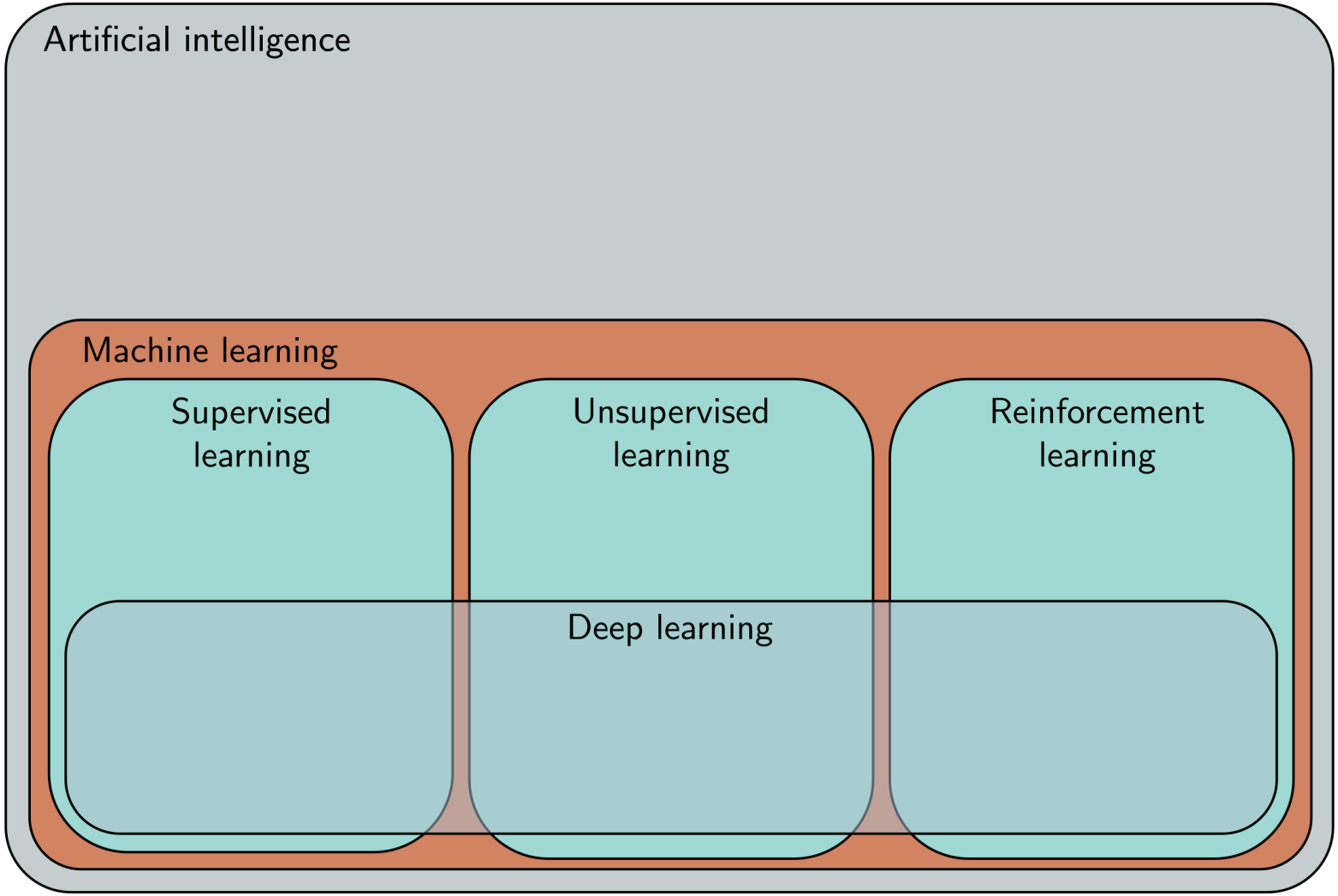
- To improve our ability to perform a task over time, we need to learn from our experiences.
- Objective function evaluates the quality of our models.
- The lower the objective function value, the better the model is considered to be.
- It is also known as the loss function.
- Mean Squared Error is used for numerical data whereas accuracy is used for categorical data.
- To avoid overfitting, we keep track of both the training and test losses.

# Optimization Algorithm

- Given a data source, a model, and a well-defined objective function, we need an algorithm capable of searching for the best possible parameters that minimize the loss function.
- Gradient Descent
- Stochastic Gradient Descent
- Mini Batch Gradient Descent
- Adam

# Types of Machine Learning Problems

- Supervised Learning
  - Regression
  - Classification
- Unsupervised Learning

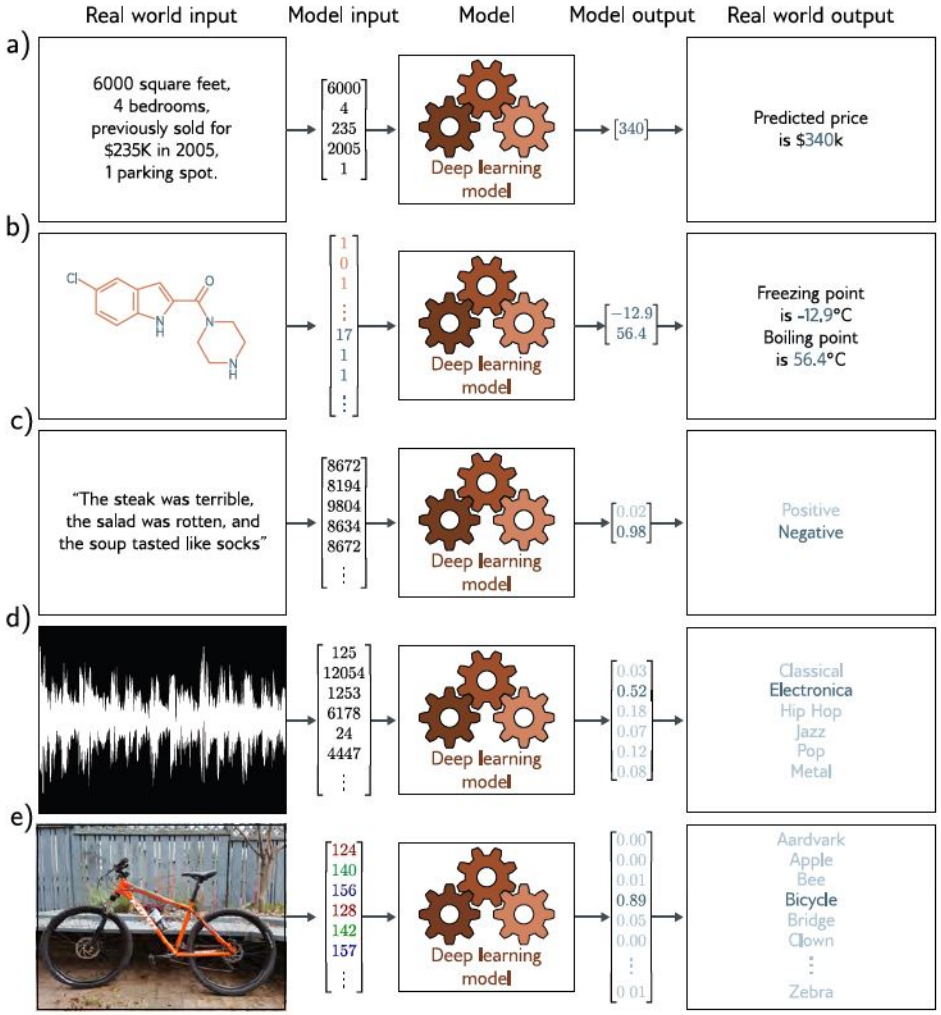

Artificial intelligence
Machine learning
Supervised learning
Unsupervised learning
Reinforcement learning
Deep learning

# Supervised Learning

- We aim to develop a model that maps input features to labels.
- An example consists of a pair of features and a corresponding label.
- For instance, "heart attack" or "no heart attack" is a label, while vital signs are input features.
- In probabilistic terms, we're interested in estimating the conditional probability of a label based on input features.

# Examples of Supervised Learning

- Predict cancer vs. not cancer, given a computer tomography image.
- Predict the correct translation in French, given a sentence in English.
- Predict the price of a stock next month based on this month’s financial reporting data.


Real world input
Model input
Model
Model output
Real world output
a)
6000 square feet,
4 bedrooms,
previously sold for
$235K in 2005,
1 parking spot.
6000
4
235
2005
1
Deep learning model
340
Predicted price
is $340k
b)
Cl
O
N
H
N
N
H
1
0
1
17
1
1
Deep learning model
−12.9
56.4
Freezing point
is -12.9°C
Boiling point
is 56.4°C
c)
"The steak was terrible,
the salad was rotten, and
the soup tasted like socks"
8672
8194
9804
8634
8672
Deep learning model
0.02
0.98
Positive
Negative
d)
125
12054
1253
6178
24
4447
Deep learning model
0.03
0.52
0.18
0.07
0.12
0.08
Classical
Electronica
Hip Hop
Jazz
Pop
Metal
e)
124
140
156
128
142
157
Deep learning model
0.00
0.00
0.01
0.89
0.05
0.00
0.01
Aardvark
Apple
Bee
Bicycle
Bridge
Clown
Zebra

# Supervised Learning System Diagram

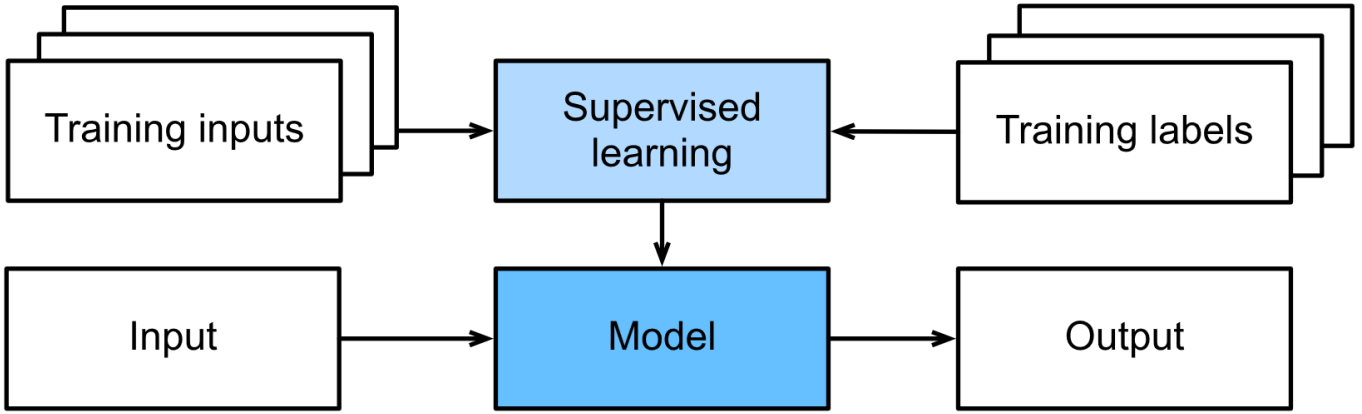
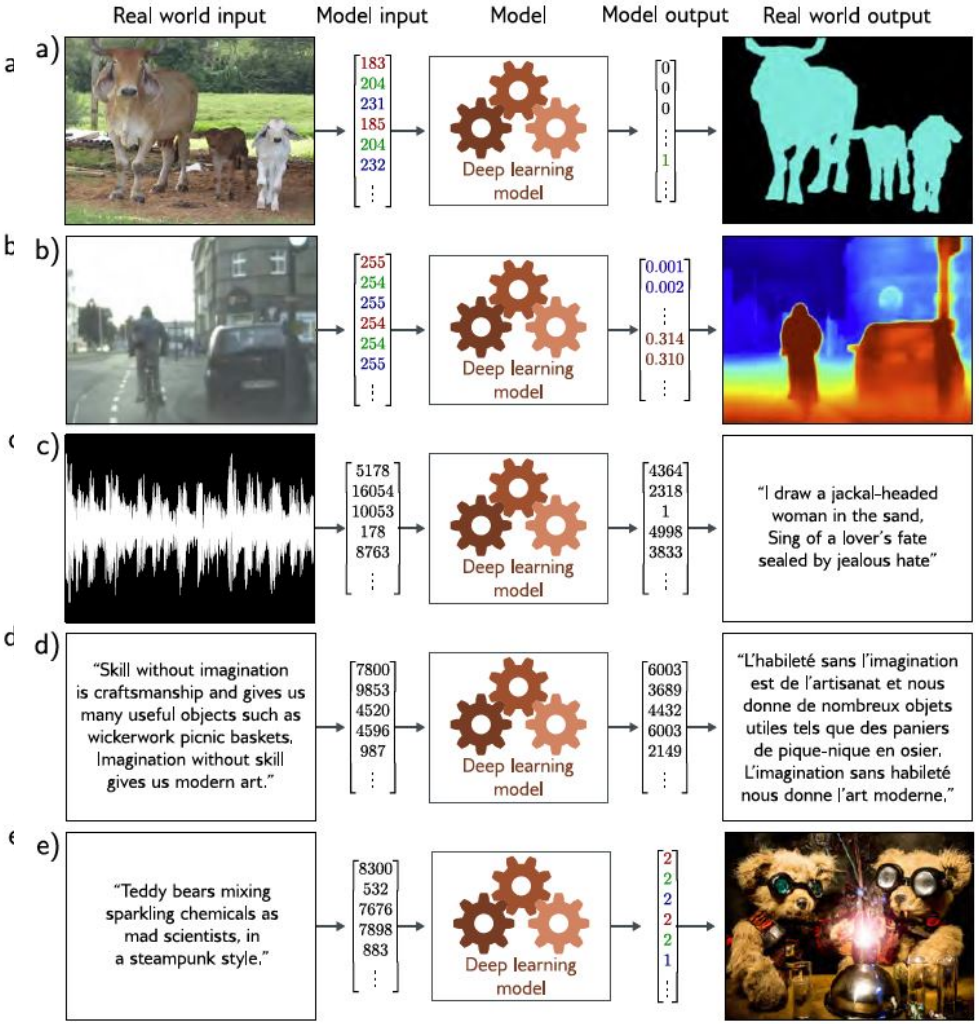


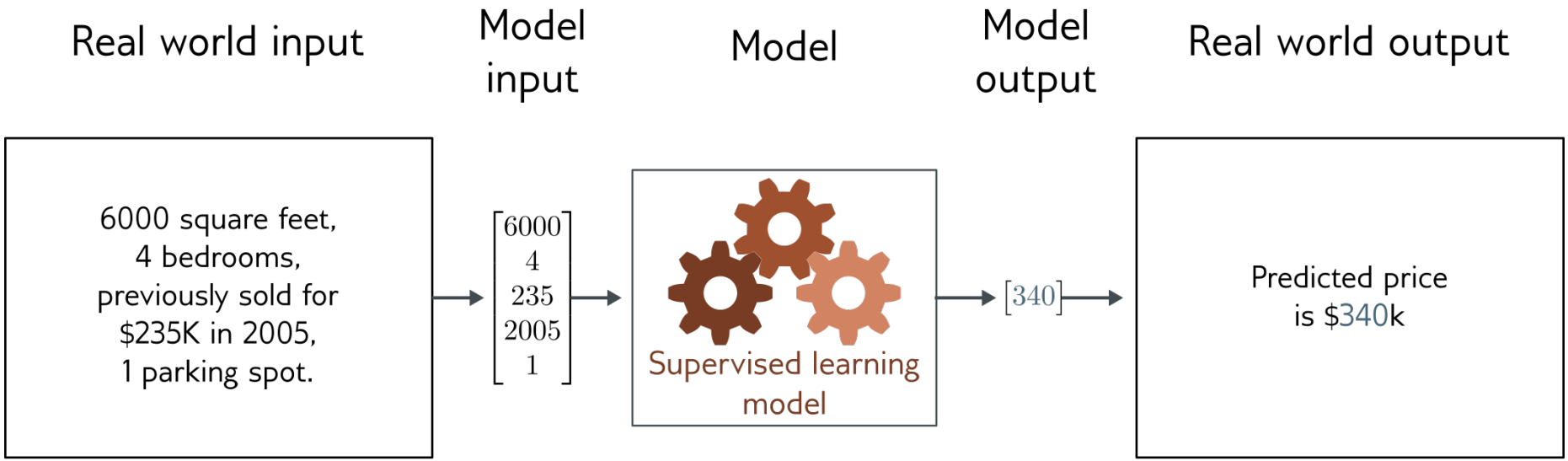

Figure taken from d2l.ai


Real world input
Model input
Model
Model output
Real world output
a)
183
204
231
185
204
232
Deep learning model
0
0
0
1
b)
255
254
255
254
254
255
Deep learning model
0.001
0.002
0.314
0.310
c)
5178
16054
10053
178
8763
Deep learning model
4364
2318
1
4998
3833
"I draw a jackal-headed woman in the sand, Sing of a lover's fate sealed by jealous hate"
d)
"Skill without imagination is craftsmanship and gives us many useful objects such as wickerwork picnic baskets. Imagination without skill gives us modern art."
7800
9853
4520
4596
987
Deep learning model
6003
3689
4432
6003
2149
"L'habileté sans l'imagination est de l'artisanat et nous donne de nombreux objets utiles tels que des paniers de pique-nique en osier. L'imagination sans habileté nous donne l'art moderne."
e)
"Teddy bears mixing sparkling chemicals as mad scientists, in a steampunk style."
8300
532
7676
7898
883
Deep learning model
2
2
2
2
2
1

# Supervised Learning - Regression

- Label to predict is a numerical value.
- House Price prediction
- Predict the price of stock next month based on this  month's financial reporting data
- How many hours will this surgery take?
- How much rainfall will this town have in the next six hours?

# Regression




- Univariate regression problem (one output, real value)
- Fully connected network

# Supervised Learning - Classification

- Label to predict is a category or class.
- Predict whether the image is of a cat or dog.
- Predict whether the email is a spam or not.
- Predict the author of a particular poem.

# Unsupervised Learning

- No specific labels have been assigned.
- Can we group a given set of photos into categories such as landscape, dogs, babies, cats, and mountain peaks ?
- Can we group a collection of users' browsing activities based on their similar behavior ?
- Subspace estimation
- Principal Component Analysis
- Generative Adversarial Networks (GANs)

# Road to Deep Learning

| Decade | Dataset | Memory | Floating point calculations per second |
|---|---|---|---|
| 1970 | 100 (Iris) | 1 KB | 100 KF (Intel 8080) |
| 1980 | 1 K (house prices in Boston) | 100 KB | 1 MF (Intel 80186) |
| 1990 | 10 K (optical character recognition) | 10 MB | 10 MF (Intel 80486) |
| 2000 | 10 M (web pages) | 100 MB | 1 GF (Intel Core) |
| 2010 | 10 G (advertising) | 1 GB | 1 TF (NVIDIA C2050) |
| 2020 | 1 T (social network) | 100 GB | 1 PF (NVIDIA DGX-2) |

Figure taken from [d2l.ai]

# Classifying Images

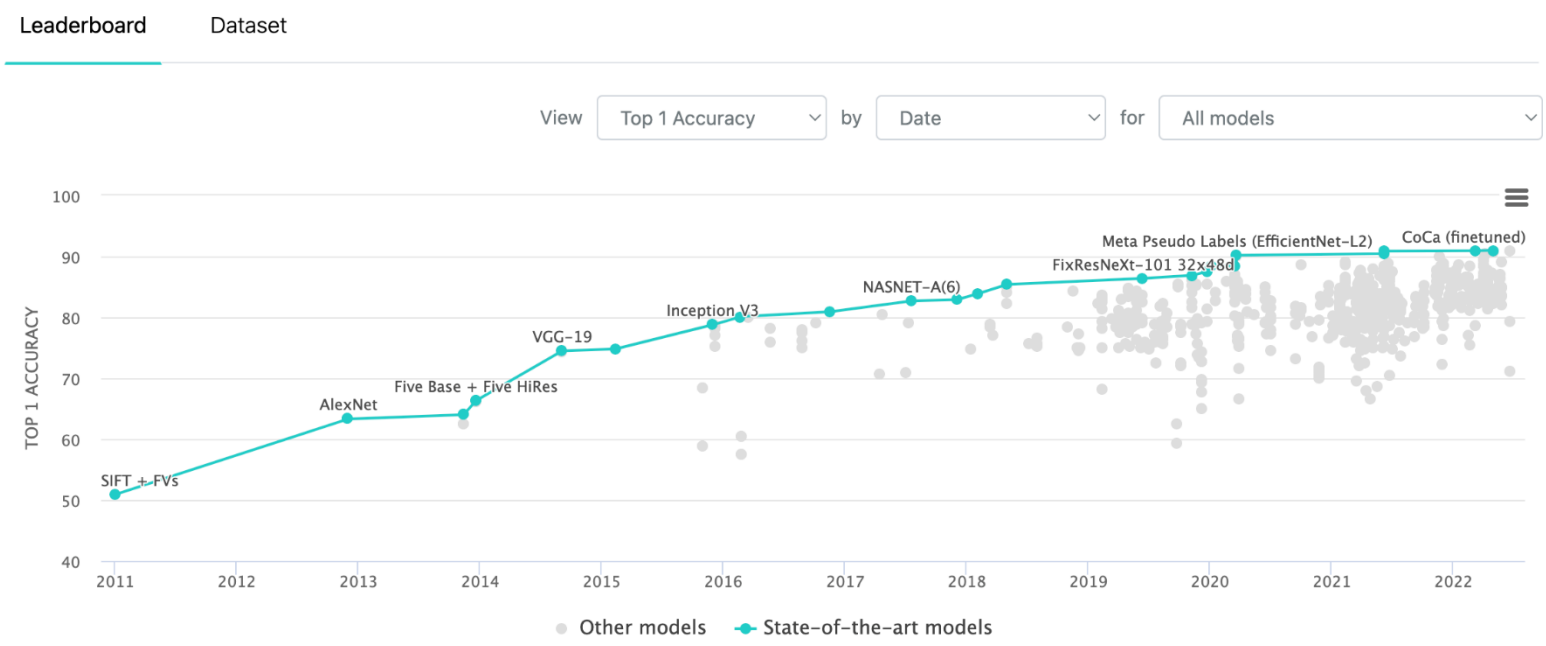



Figure taken from [thematic]

# Object Detection and Segmentation


Figure taken from [medium]

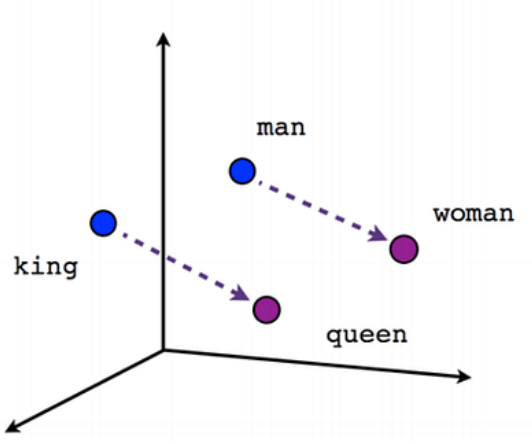
# Image Style transfer

Figure taken from [Analytics Vidhya]

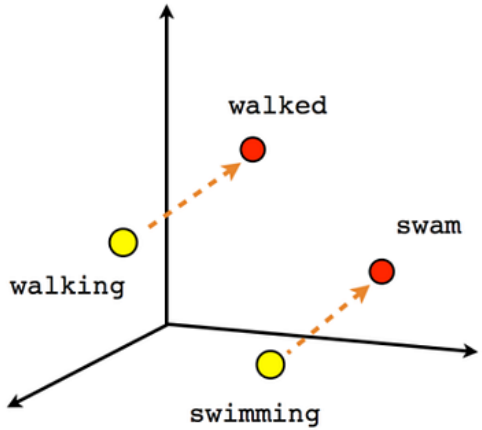
# Synthesize Faces

Figure taken from medium

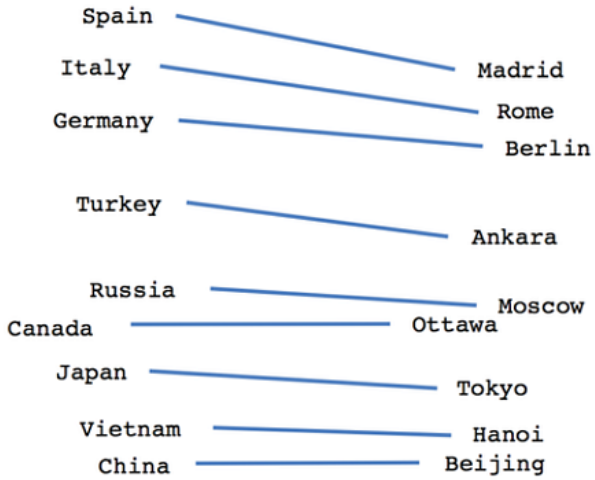
# Analogies




Male-Female




Verb tense




Country-Capital

Figure taken from [medium]

# Machine Translation

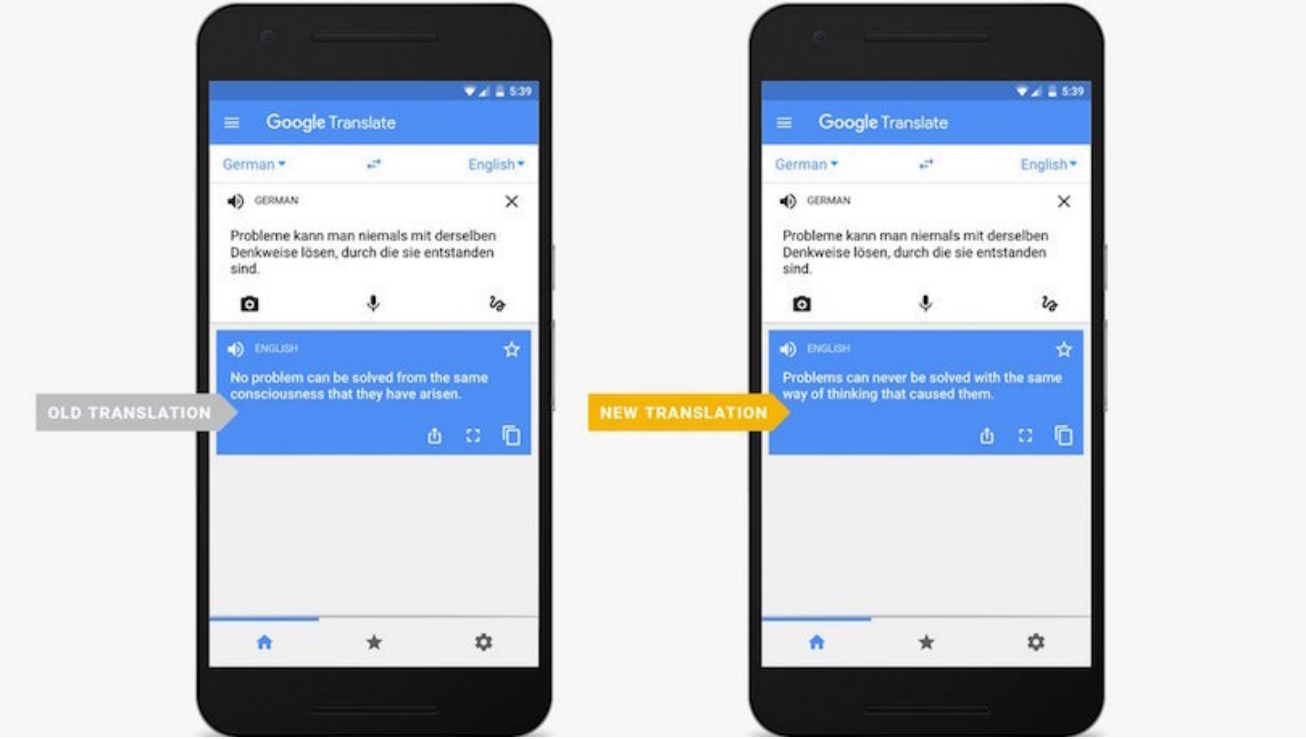



Figure taken from [pcmag]

# Image Captioning

"man in black shirt is playing guitar."

"construction worker in orange safety vest is working on road."

"two young girls are playing with lego toy."

Figure taken from [medium]

# References

- https://d2l.ai/chapter_introduction/index.html
- https://udlbook.github.io/udlbook/