Machine Learning

Lecture-1

(Introduction to Machine Learning)

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What is Machine Learning ?

- Machine learning (ML) is a branch of Artificial Intelligence (AI) that enables computers to self-learn and improve over time without being explicitly programmed. In short, machine learning algorithms are able to detect and learn from patterns in data and make their own predictions.

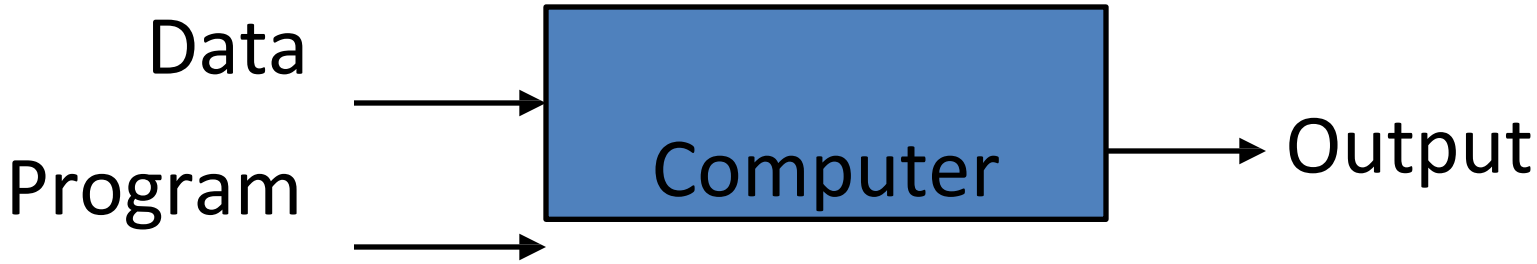
- While artificial intelligence and machine learning are often used interchangeably, they are two different concepts. AI is the broader concept – machines making decisions, learning new skills, and solving problems in a similar way to humans – whereas machine learning is a subset of AI that enables intelligent systems to autonomously learn new things from data.

- Instead of programming machine learning algorithms to perform tasks, you can feed them examples of labeled data (known as training data), which helps them make calculations, process data, and identify patterns automatically.

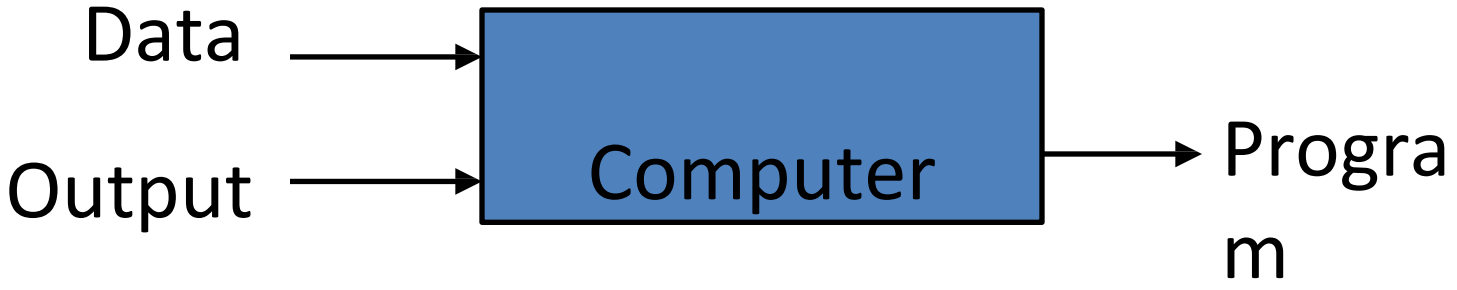
Samuel's Checkers-Player

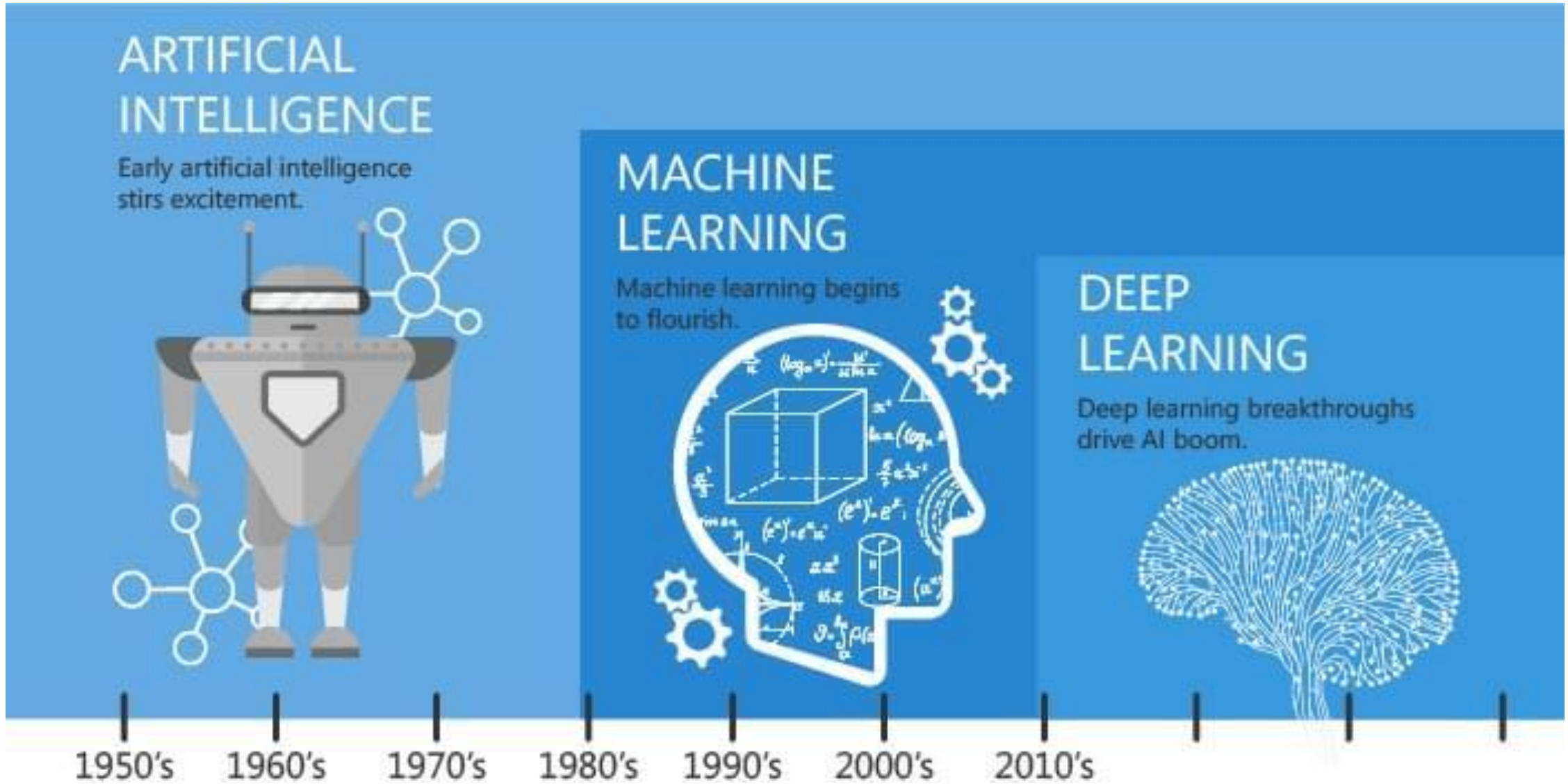
"Machine Learning: Field of study that gives computers the ability to learn without being explicitly programmed." -Arthur Samuel (1959)

Traditional Programming



Machine Learning




ARTIFICIAL INTELLIGENCE
Early artificial intelligence stirs excitement.
MACHINE LEARNING
Machine learning begins to flourish.
DEEP LEARNING
Deep learning breakthroughs drive AI boom.
1950's
1960's
1970's
1980's
1990's
2000's
2010's

The Importance of Machine Learning

- More and more companies are adopting machine learning to optimize internal processes in areas like customer service, marketing, and sales.
- By automating data analysis, machine learning helps businesses gain valuable insights in a fast and effective way. For example, businesses can find out:
  - *The main topics that customers are mentioning in product reviews*
  - *If tweets are talking about brands in a positive or negative way*
  - *The identity of a person in a picture*
  - *How likely a customer is to churn*

Other advantages of ML

1. It's cost-effective and scalable.

You only need to train a model once, and you can scale up or down depending on low or peak seasons. For example, if you see a surge in data, you don't need to hire more staff. A Chatbot or text analysis model can handle thousands of support requests in minutes.

2. Accuracy.

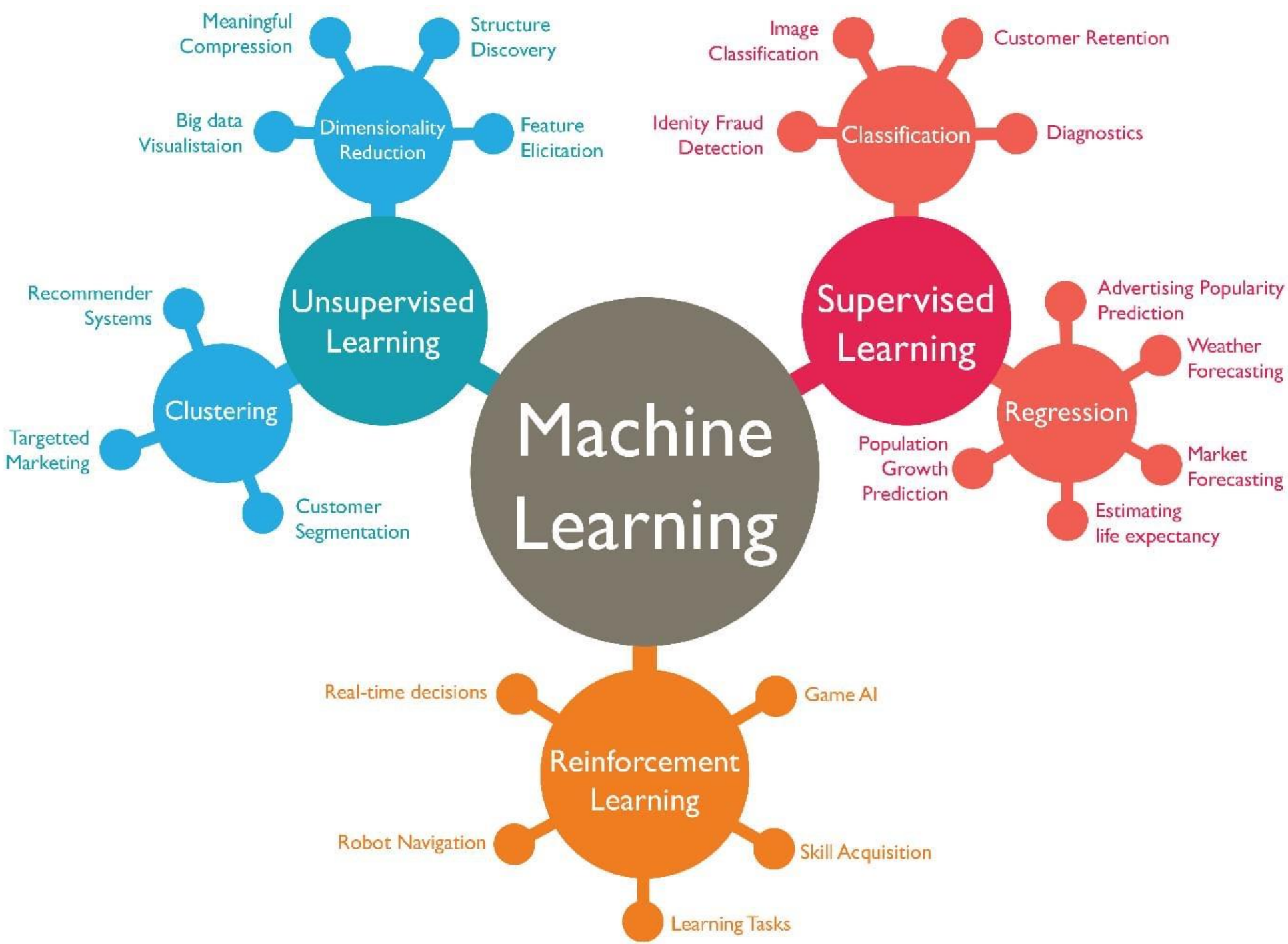
Machine learning models are trained with a certain amount of labeled data and will use it to make predictions on unseen data. Based on this data, machines define a set of rules that they apply to all datasets, helping them provide consistent and accurate results.

3. Works in real-time, 24/7.

Machine learning models can automatically analyze data in real-time, allowing you to immediately detect negative opinions or urgent tickets and take action.

Machine Learning Methods

- There are different machine learning methods, the most common of which are:
- Supervised Learning
- Unsupervised Learning
- Semi-Supervised Learning
- Reinforcement Learning


Machine Learning
Unsupervised Learning
Supervised Learning
Reinforcement Learning
Dimensionality Reduction
Clustering
Classification
Regression
Meaningful Compression
Structure Discovery
Big data Visualistaion
Feature Elicitation
Recommender Systems
Targetted Marketing
Customer Segmentation
Image Classification
Customer Retention
Idenity Fraud Detection
Diagnostics
Advertising Popularity Prediction
Weather Forecasting
Population Growth Prediction
Market Forecasting
Estimating life expectancy
Real-time decisions
Game AI
Robot Navigation
Skill Acquisition
Learning Tasks

Supervised Learning

- Supervised learning algorithms make predictions based on labeled training data. Each training sample includes an input and a desired output.
- A supervised learning algorithm analyzes this sample data and makes an inference – basically, an educated guess when determining the labels for unseen data.
- This is the most common and popular approach to machine learning. It's "supervised" because these models need to be fed manually tagged sample data so that they can learn from it.
- For example, if you want to automatically detect spam, you'll need to feed a machine learning algorithm examples of emails that you'd classify as spam and those that are important.

Classification

- In classification tasks, the output value is a category with a finite number of options. For example, with a sentiment analysis model , you can classify data as positive, negative, or neutral.
- Let’s say you want to analyze support conversations to understand your client’s emotions: are they happy or frustrated after contacting your customer service team? A sentiment analysis classifier can automatically tag responses for you.

Regression

- In regression tasks, the expected result is a continuous number. This model is used to predict quantities, such as the probability an event will happen. Predicting the value of a property in a specific neighborhood, or the spread of COVID19 in a particular region are examples of regression problems.

Unsupervised Learning

- Unsupervised learning algorithms uncover insights and relationships in unlabeled data.
- In this case, models are fed input data but the desired outcomes are unknown, so they have to make inferences based on circumstantial evidence, without any guidance or training.
- One of the most common types of unsupervised learning is clustering, which consists of grouping similar data. This method is mostly used for exploratory analysis and can help you detect hidden patterns or trends.
- For example, the marketing team of an e-commerce company can use clustering to improve customer segmentation .
- Given a set of income and spending data, a machine learning model can identify groups of customers with similar behaviors.

Semi-Supervised Learning

- In semi-supervised learning, training data is split into two. A small amount of labeled data and a larger set of unlabeled data.
- In this case, the model uses labeled data as an input to make inferences about the unlabeled data, providing more accurate results than regular supervised-learning models.
- This approach is gaining popularity, especially for tasks involving large datasets such as image classification.
- Semi-supervised learning doesn’t require a large number of labeled data, so it’s faster to set up, more cost-effective than supervised learning methods, and ideal for businesses that receive huge amounts of data.

Reinforcement Learning

- Reinforcement learning (RL) is concerned with how a software agent (or computer program) ought to act in a situation to maximize the reward.
- In short, Reinforced machine learning models attempt to determine the best possible path they should take in a given situation. They do this through trial and error.
- Since there is no training data, machines learn from their own mistakes and choose the actions that lead to the best solution or maximum reward.
- This machine learning method is mostly used in robotics and gaming. Video games demonstrate a clear relationship between actions and results, and can measure success by keeping score. Therefore, they're a great way to improve reinforcement learning algorithms.

Building the Machine Learning Model

Created by : Rocky Bhatia

Initial Dataset

MEAN MEDIAN STD Missing Values

Exploratory Data Analysis

Correlation

PCA

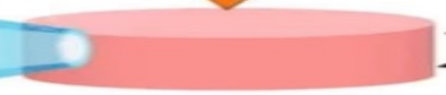
LDA

Input Variables

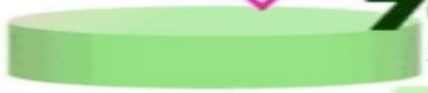
Output Variables

ID	Age	INCOME	SEX	Score	LOAN
1	42	5L	M	2.9	N
2	29	9L	F	3.1	N
3	28	17L	M	6.1	Y

Data cleaning
Data curation
Remove redundant features



Processed Dataset



70% Use as Training set

30% Use as Test set

SVM LR KNN

Learning algorithms

RF DT GB

Random Search Grid Search

Hyperparameter optimization

GB RF

Feature Selection

MCC
Specificity
Sensitivity
Accuracy

Classification

RMSE
R^2
MSE

Regression

Cross-Validation Model

Trained Model

Predicted Y values

Evaluate Model Perfomances

Machine Learning Algorithms

Naive Bayes Classifier

Text classification, spam filtering

Support Vector Machine (SVM)

Image recognition, text classification

Decision Tree

Classification and regression tasks

K-Means Clustering

Image compression, customer segmentation.

Linear Regression

Predicting house prices, stock prices

Logistic Regression

Binary classification problems

Mean Shift

Image segmentation and clustering

Principal Component Analysis

Dimensionality reduction, feature extraction

Markov Decision Process

Reinforcement learning, robotic control

Q Learning

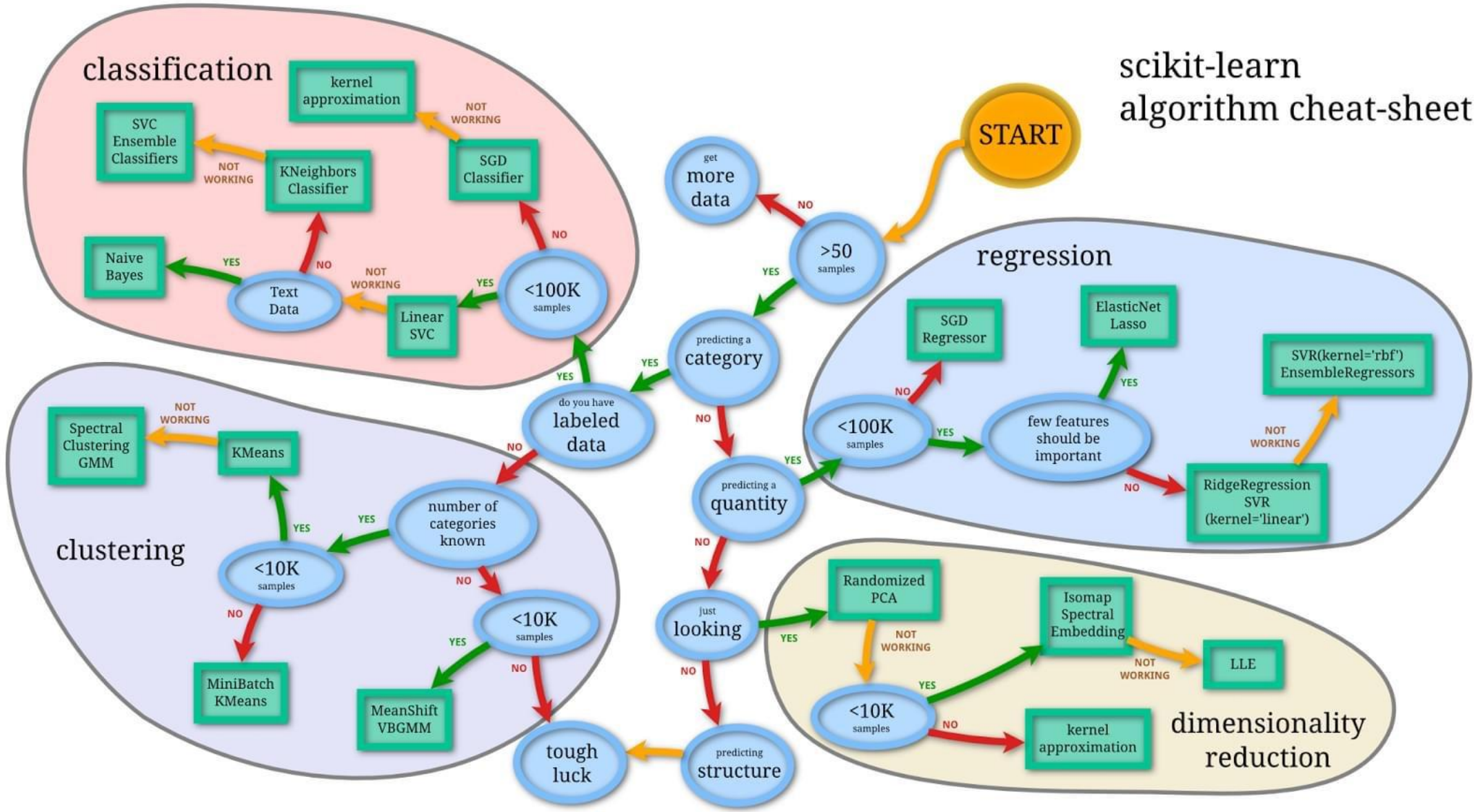
Reinforcement learning, game playing

Random Forest Algorithm

Classification, regression, and anomaly detection

Dimentionality Reduction Algorithms

Improving efficiency in large datasets, visualization


scikit-learn
algorithm cheat-sheet
START
get more data
NO
>50 samples
YES
predicting a category
YES
do you have labeled data
YES
<100K samples
NO
Naive Bayes
YES
Text Data
NO
Linear SVC
NOT WORKING
SVC Ensemble Classifiers
NOT WORKING
KNeighbors Classifier
NOT WORKING
kernel approximation
NOT WORKING
SGD Classifier
NO
classification
NO
Spectral Clustering GMM
NOT WORKING
KMeans
YES
number of categories known
YES
<10K samples
NO
MiniBatch KMeans
NO
<10K samples
YES
MeanShift VBGMM
NO
clustering
NO
predicting a quantity
YES
<100K samples
NO
SGD Regressor
YES
few features should be important
YES
ElasticNet Lasso
NO
RidgeRegression SVR (kernel='linear')
NOT WORKING
SVR(kernel='rbf') EnsembleRegressors
regression
NO
just looking
YES
Randomized PCA
NOT WORKING
<10K samples
YES
Isomap Spectral Embedding
NOT WORKING
LLE
NO
kernel approximation
dimensionality reduction
NO
predicting structure
tough luck

Some more examples of tasks that are best solved by using a learning algorithm

- Recognizing patterns:
  - Facial identities or facial expressions
  - Handwritten or spoken words
  - Medical images
- Generating patterns:
  - Generating images or motion sequences
- Recognizing anomalies:
  - Unusual credit card transactions
  - Unusual patterns of sensor readings in a nuclear power plant
- Prediction:
  - Future stock prices or currency exchange rates

Sample Applications

- Web search
- Computational biology
- Finance
- E-commerce
- Space exploration
- Robotics
- Information extraction
- Social networks
- Debugging software

Slide credit: Pedro

Defining the Learning Task

Improve on task T, with respect to performance metric P, based on experience E

T: Playing checkers

P: Percentage of games won against an arbitrary opponent E: Playing practice games against itself

T: Recognizing hand-written words

P: Percentage of words correctly classified

E: Database of human-labeled images of handwritten words

T: Driving on four-lane highways using vision sensors

P: Average distance traveled before a human-judged error

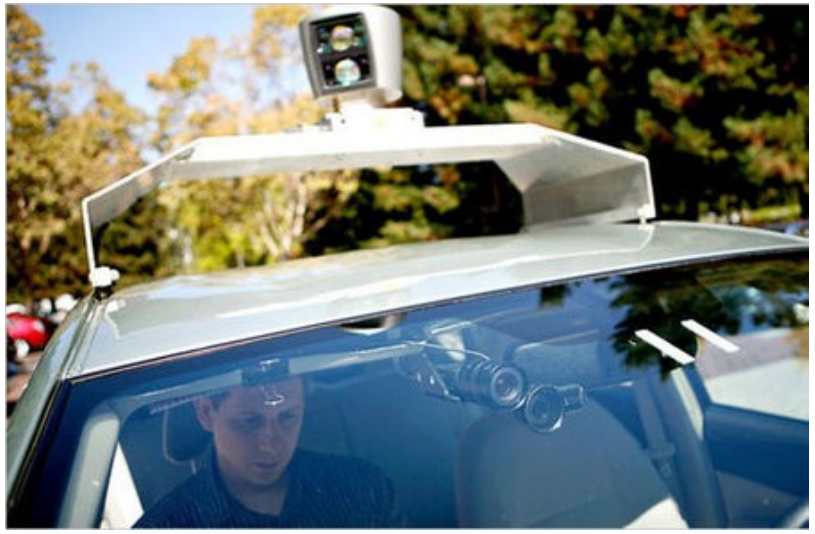
E: A sequence of images and steering commands recorded while observing a human driver.

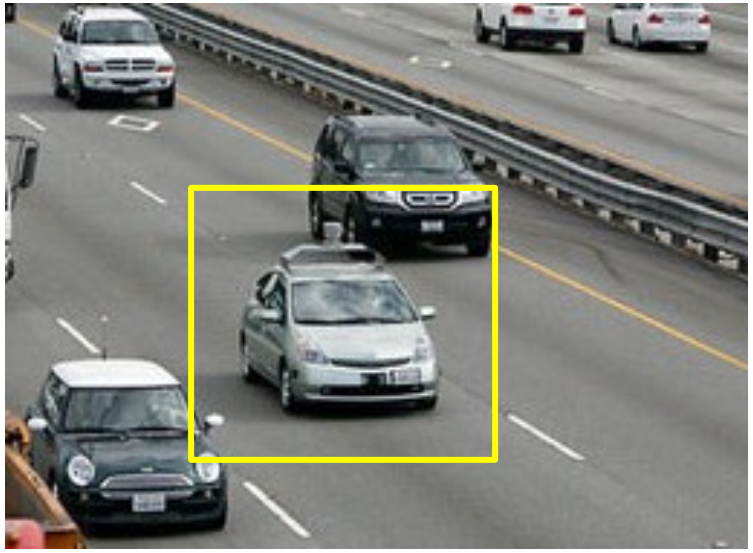
T: Categorize email messages as spam or legitimate.

Slide credit: Ray

State of the Art Applications of Machine Learning

Autonomous Cars

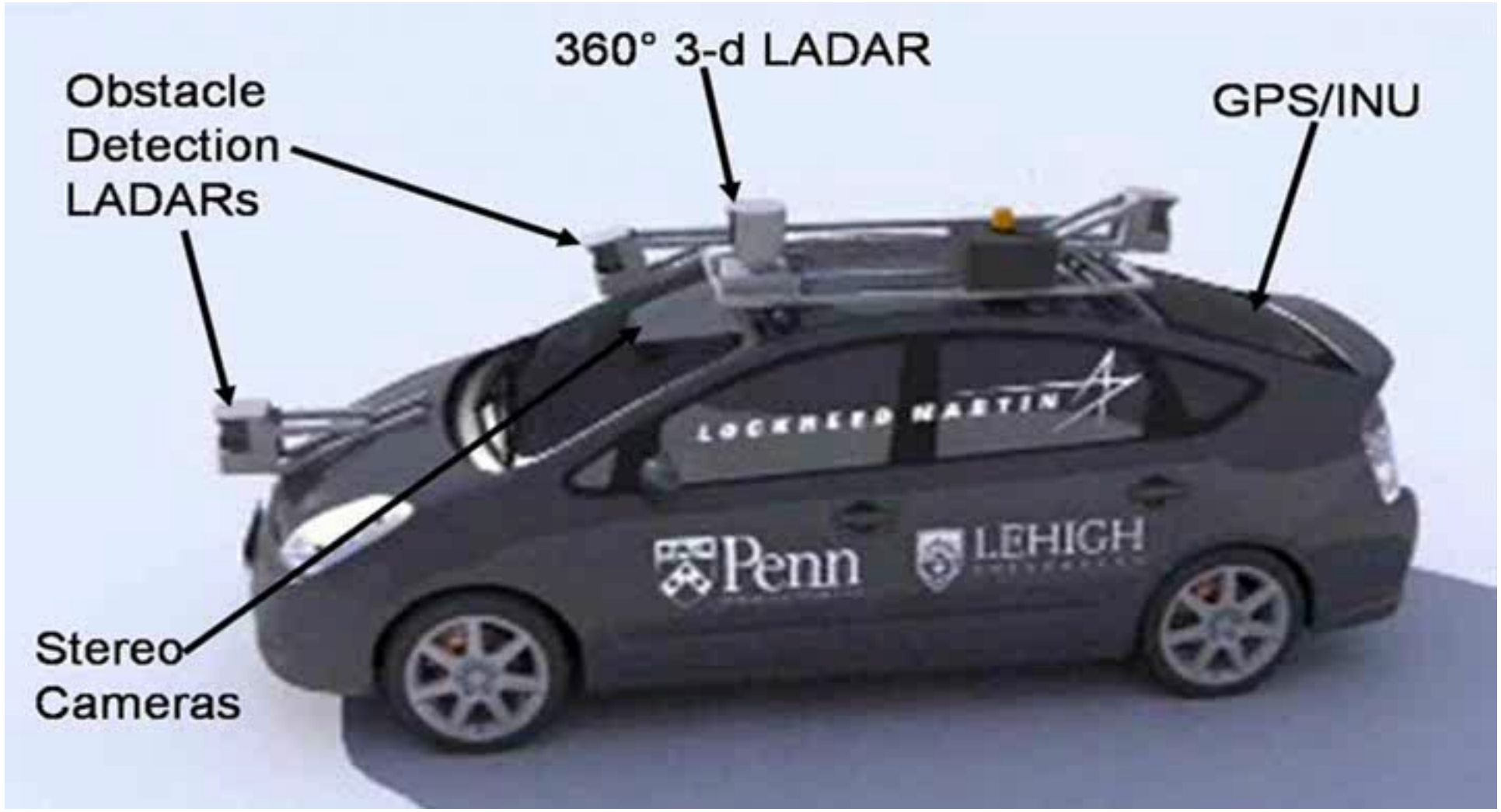




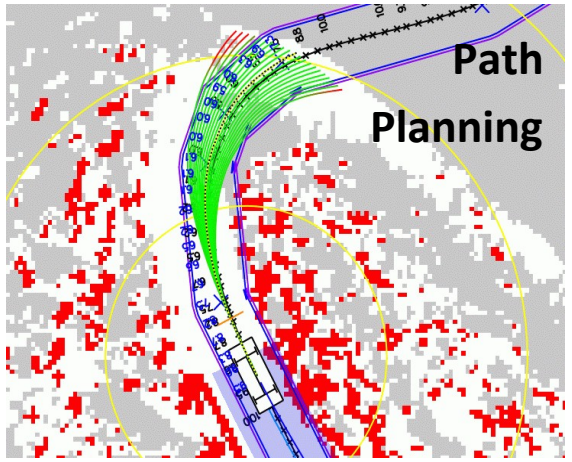
- Nevada made it legal for autonomous cars to drive on roads in June 2011
- As of 2013, four states (Nevada, Florida, California, and Michigan) have legalized autonomous cars

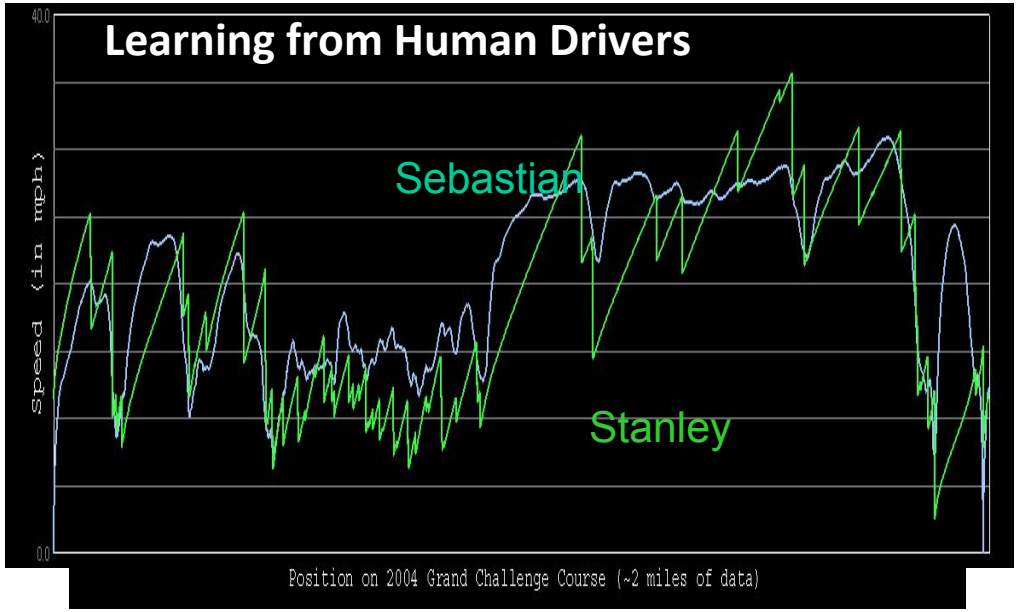
Penn's Autonomous Car
(Ben Franklin Racing

Autonomous Car Sensors



Autonomous Car Technology





Images and movies taken from Sebastian Thrun's multimedia website.

Deep Learning in the Headlines

BUSINESS NEWS

MIT Technology Review

Is Google Cornering the Market on Deep Learning?

A cutting-edge corner of science is being wooed by Silicon Valley, to the dismay of some academics.

By Antonio Regalado on January 29, 2014

How much are a dozen deep-learning researchers worth? Apparently, more than $400 million.

This week, Google reportedly paid that much to acquire DeepMind Technologies, a startup based in

BloombergBusinessweek Technology

Acquisitions

The Race to Buy the Human Brains Behind Deep Learning Machines

By Ashlee Vance | January 27, 2014

intelligence projects. “DeepMind is bona fide in terms of its research capabilities and depth,” says Peter Lee, who heads Microsoft Research.

According to Lee, Microsoft, Facebook (FB), and Google find themselves in a battle for deep learning talent. Microsoft has gone from four full-time deep learning experts to 70 in the past three years. “We would have more if the talent was there to

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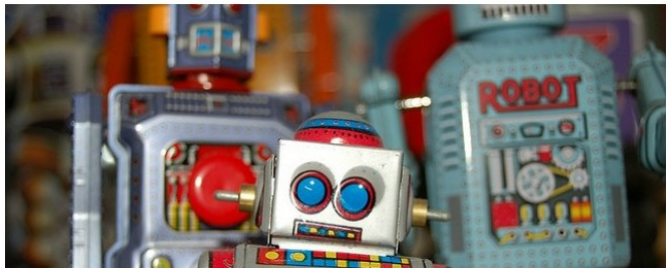
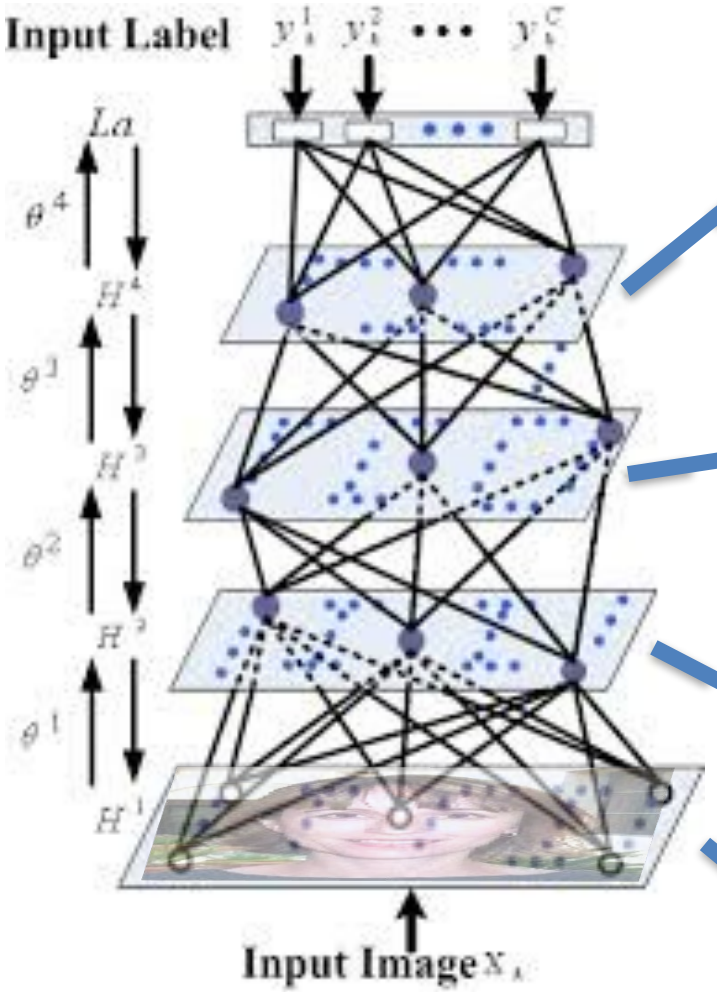
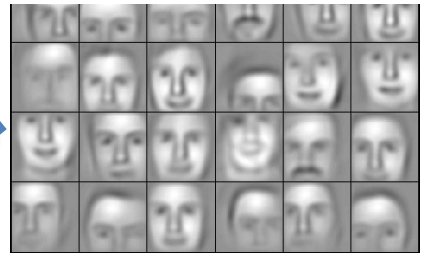
Deep Learning’s Role in the Age of Robots

BY JULIAN GREEN, JETPAC 05.02.14 2:56 PM

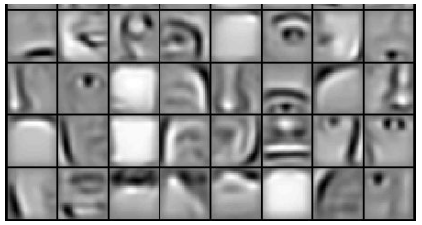


Deep Belief Net on Face Images

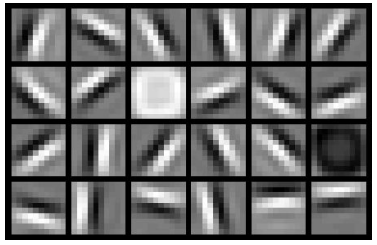




object models



object parts (combination of edges)

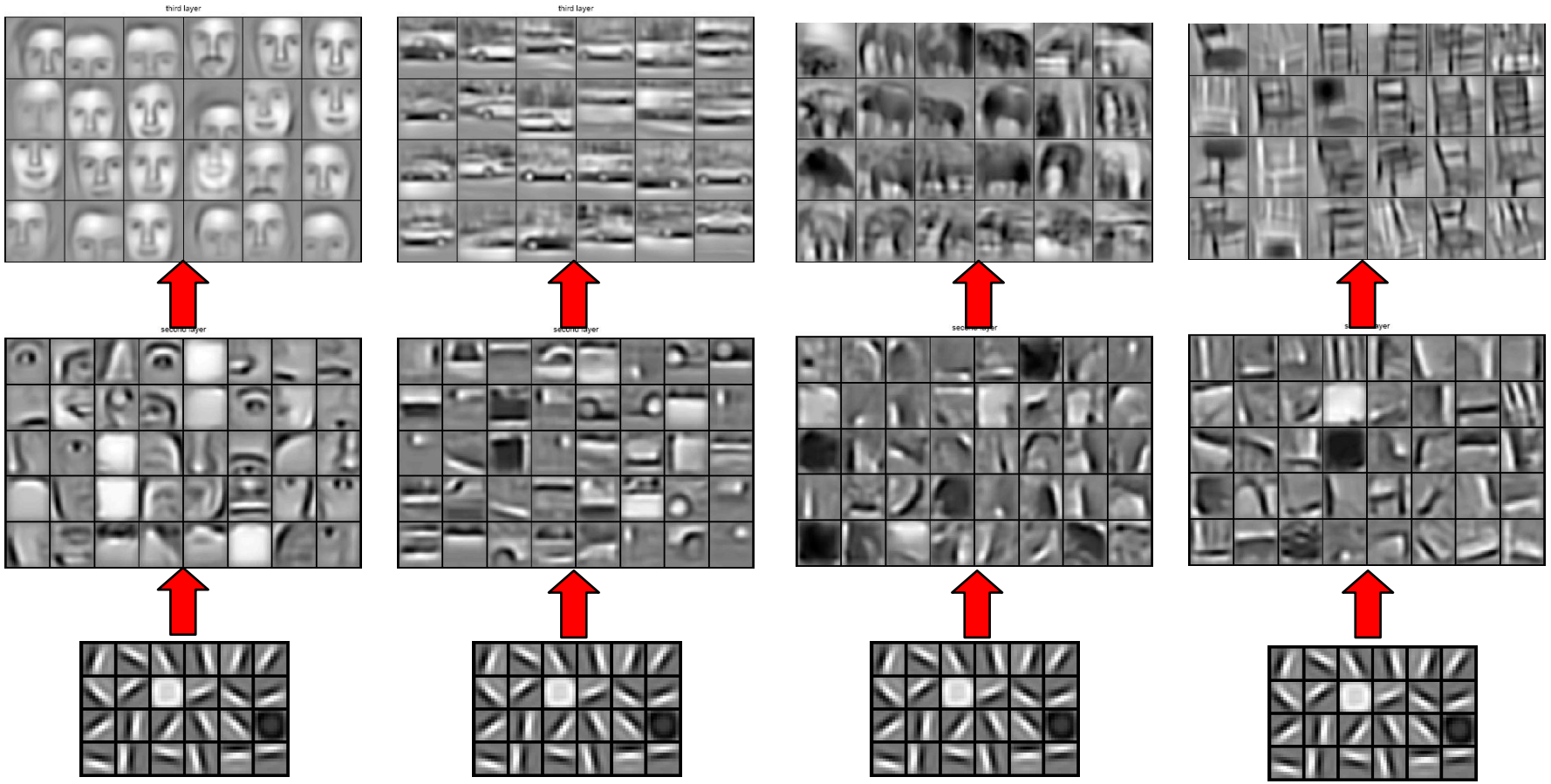


edges

pixels

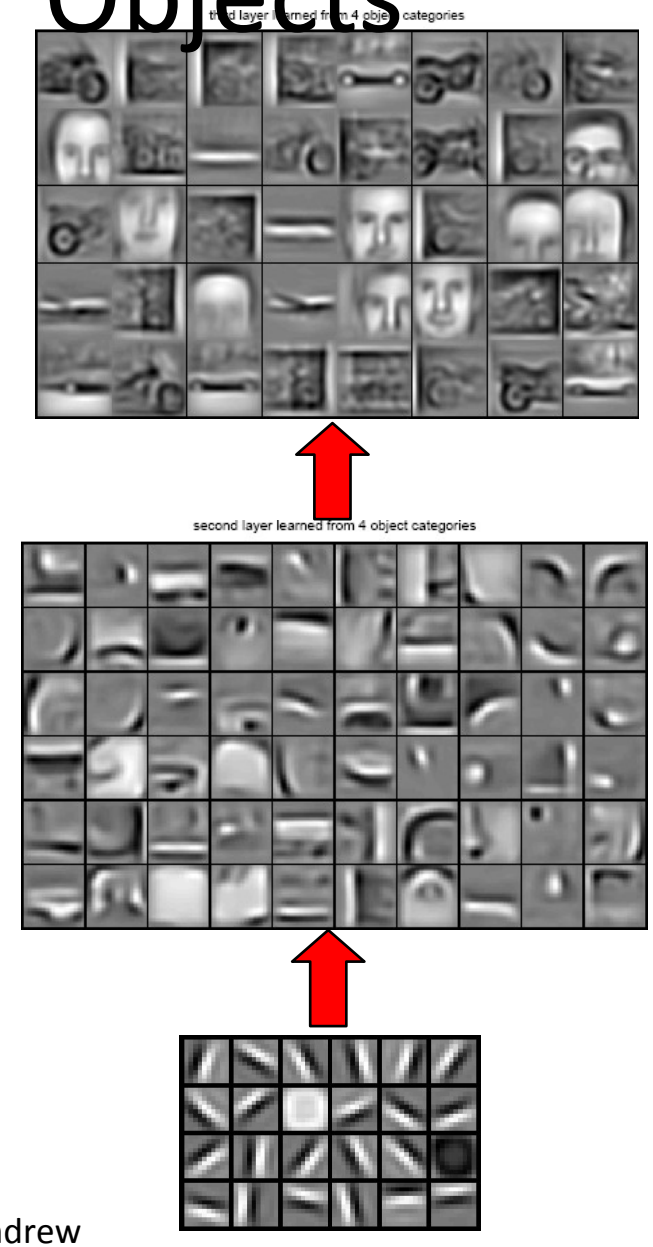
Based on materials by

Learning of Object Parts



Slide credit: Andrew

Training on Multiple Objects



Trained on 4 classes (cars, faces, motorbikes, airplanes).

Second layer: Shared-features and object-specific features.

Third layer: More specific features.

Slide credit: Andrew

Scene Labeling via Deep Learning

[Farabet et al. ICML 2012, PAMI 2013]

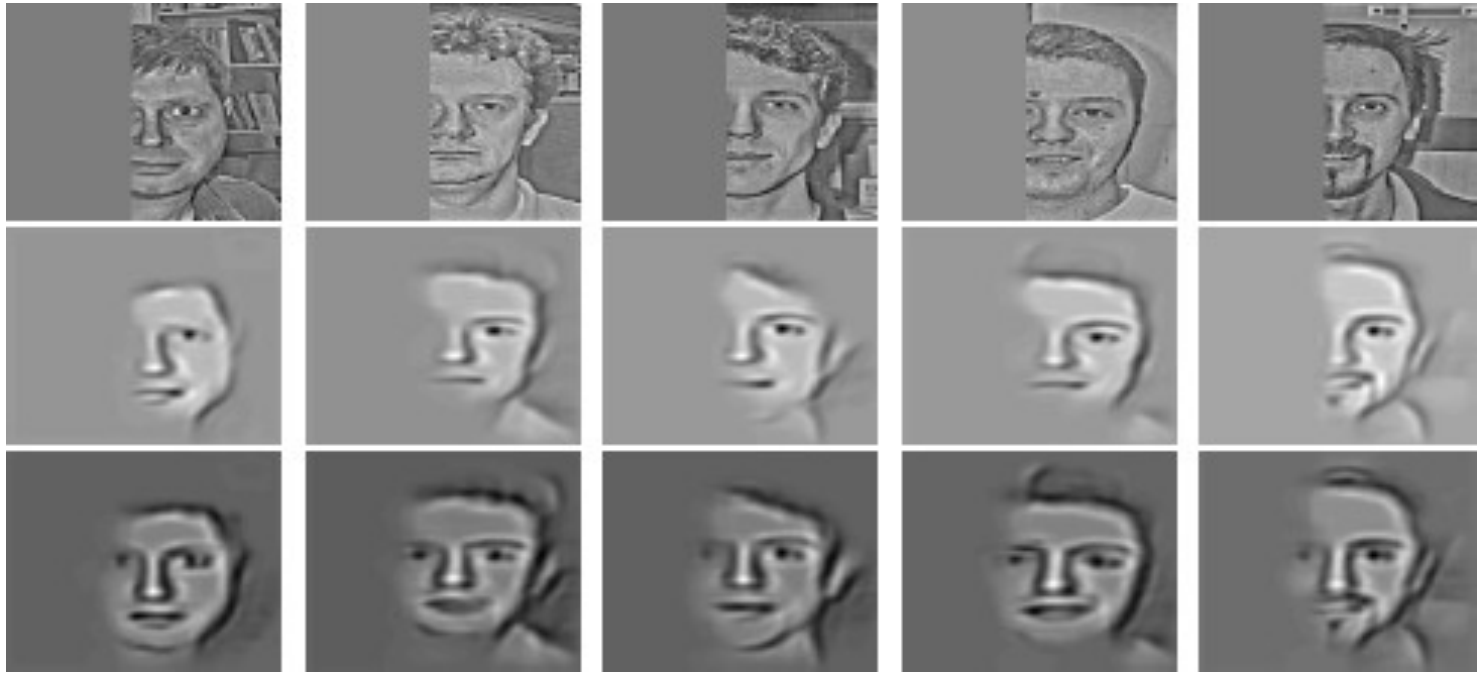
Inference from Deep Learned Models

Generating posterior samples from faces by “filling in” experiments
(cf. Lee and Mumford, 2003). Combine bottom-up and top-down inference.

Input images

Samples from feedforward Inference (control)

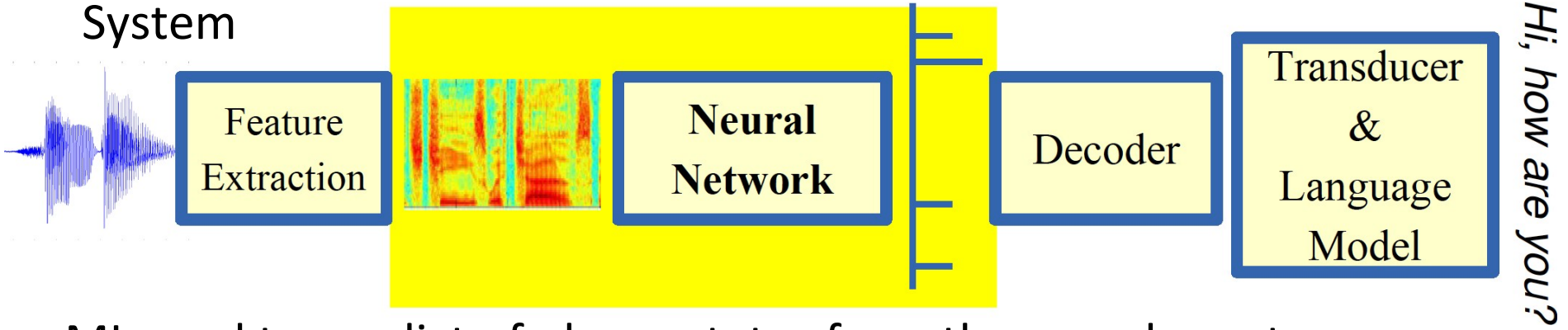
Samples from Full posterior inference



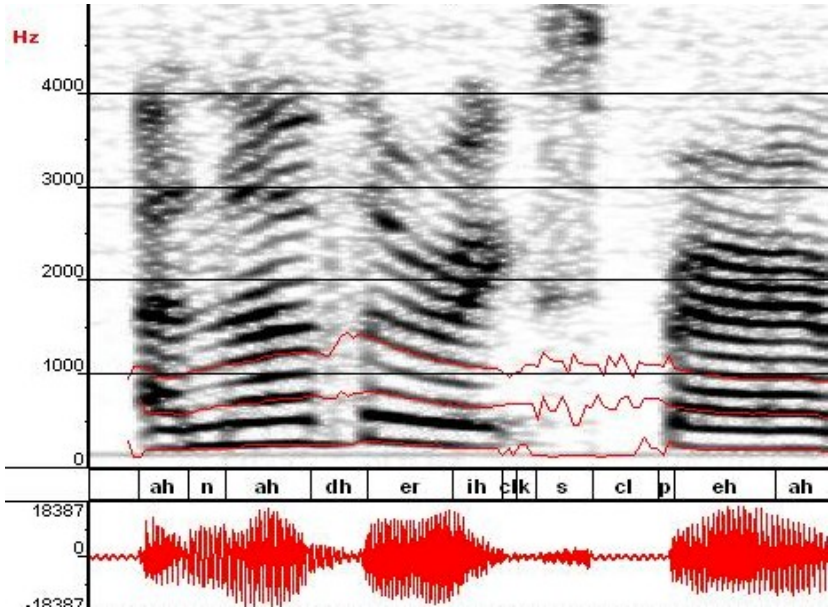
Slide credit: Andrew

Machine Learning in Automatic Speech Recognition

A Typical Speech Recognition System



ML used to predict of phone states from the sound spectrogram



Deep learning has state-of-the-art results

# Hidden Layers	1	2	4	8	10	12
Word Error Rate %	16.0	12.8	11.4	10.9	11.0	11.1

Baseline GMM performance = 15.4%

[Zeiler et al. "On rectified linear units for speech recognition" ICASSP 2013]

Impact of Deep Learning in Speech Technology

Slide credit: Li Deng, MS

Thanks for listening