# Machine Learning Overview

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# Outline of Machine learning overview

1. **Affect of machine learning (ML)**
2. **ML definition & history**
3. **Examples of ML problem**
4. **Process of building a ML model**
5. **The main components of the ML problem**
6. **Problems in ML**
7. **Learning Outcomes and prerequisites**

# Affect of Machine learning


- Machine learning (ML) is one of the most exciting recent technologies:
  - Google or Bing search engine
  - spam emails
  - photo tagging
- Why is machine learning so prevalent today?
  - Grew of work in AI
  - New capability for computers

# Autonomous Driving

Volvo's driverless truck

Mahindra

Ford

WAYMO

Volkswagen

TESLA

UBER

VOLVO

Audi

BMW intel MOBILEYE

Mercedes-Benz

GM

lyft

# Natural and Spoken Language Processing

## Conversational Agents and Translators


Apple Siri

Google Assistant


Microsoft Cortana

Google Translate

Microsoft Translator

iTranslate

## Optical Character Recognition and Translation


Screenshot from the movie Cars 3 on Netflix India

# Image Analysis and Computer Vision


iPhone Xs vs. Pixel 3's Night Sight Mode

Source: XDA Dev. review

Pixel 3

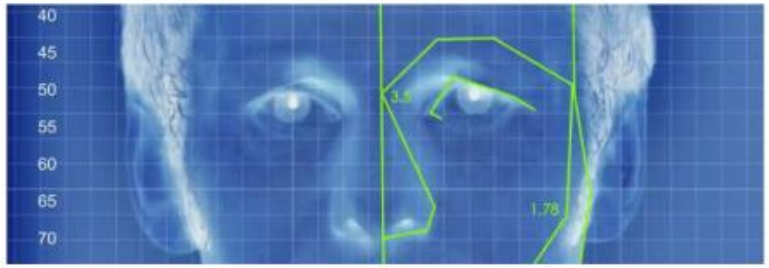
Google Cloud Vision

# Pitfalls & Perils of ML

- Claim: Machines have a better "gaydar"
  - If true: privacy breach
  - If false: reinforces prejudice

New AI can guess whether you're gay or straight from a photograph

An algorithm deduced the sexuality of people on a dating site with up to 91% accuracy, raising tricky ethical questions




[1]Source: The Guardian

- Uber hits and kills a pedestrian in Tempe, Arizona, US


Source: the Medium

- "DeepFakes" used to generate fake porn using Hollywood celebrity facial images

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# ML definition

- **It is an important sub-area of AI that seeks to answer the following question**:
  *How can we build computer systems that automatically improve with experience?*

- **Arthur Samuel (1959)**:

"Field of study  that gives computers the ability to learn without being explicitly programmed"

- **Tom Mitchell (1998):**

"A computer program is said to learn from experience *E* with respect to some class of tasks *T* and performance measure *P*, if its performance at tasks in *T*, as measured by *P*, improves with experience *E*."

# Clarify the ML definition

- **ML Task (T)**: Classification (pattern recognition), regression (prediction), clustering, retrieval…

- **Experience (E)**:
  - Supervised learning: Labeled data, target value (Decision Tree, SVMs,… )
  - Unsupervised learning: Unlabeled data (K-mean, DB scan,…)
  - Reinforcement learning: A reward function (Q-learning,…)

- **Performance measure (P)**:
  - Accuracy or Error rate
  - Confusion matrix: Precision, Recall…

# Example Systems that use ML

- Google Search
- Google Car
- Amazon’s recommendation system
- Adobe’s Optical Character Recognition (OCR)
- Facebook’s face tagging, news feed
- Apple’s Siri, Microsoft’s Cortana, Amazon’s Echo (Speech Recognition)
- Auto-parking and Advanced Driver Assistance Systems (ADAS)

# An Incomplate History of ML

- Turing Test (1950)
  - Machines do very poorly
- Rosenblatt's Perceptron (1960's)
  - Kickstarted the mathematical analysis of the learning process
  - Key idea behind Support Vector Machines (SVMs) and Neural Networks
- Construction of Fundamentals of Learning Theory (1960-70's)
  - Focus on generalization capability of learning machines
    - Performance on unseen data
  - Regularization for ill-posed problems
    - e.g., linear equations for ill-conditioned matrices
- Neural Networks (1980's)
  - Connectionism
  - Back-propagation [LeCun, `86]
  - CNNs, RNNs
- SVMs (1990's)
  - Margin Maximization
  - Kernel Methods to handle non-linearity
- Deep Learning (>2006)
  - Hinton, Bengio, LeCun at forefront
- (>2012) Craziness!!

# What Should You Learn

- Modelling a learning problem
- Various algorithms (techniques) for solving ML problems
- Pitfalls while designing ML systems
  - Modelling, Generalization, Regularization & Model Selection, (hyper)-Parameter tuning, Overfitting, Underfitting
- Importance of Domain Knowledge
  - Not treating ML techniques as a black box
  - Simplify the learning problem by using domain knowledge
- Engineering Tricks
  - Debugging ML systems
- Tools
  - Scikit-learn, PyTorch, TensorFlow, OpenCV, etc

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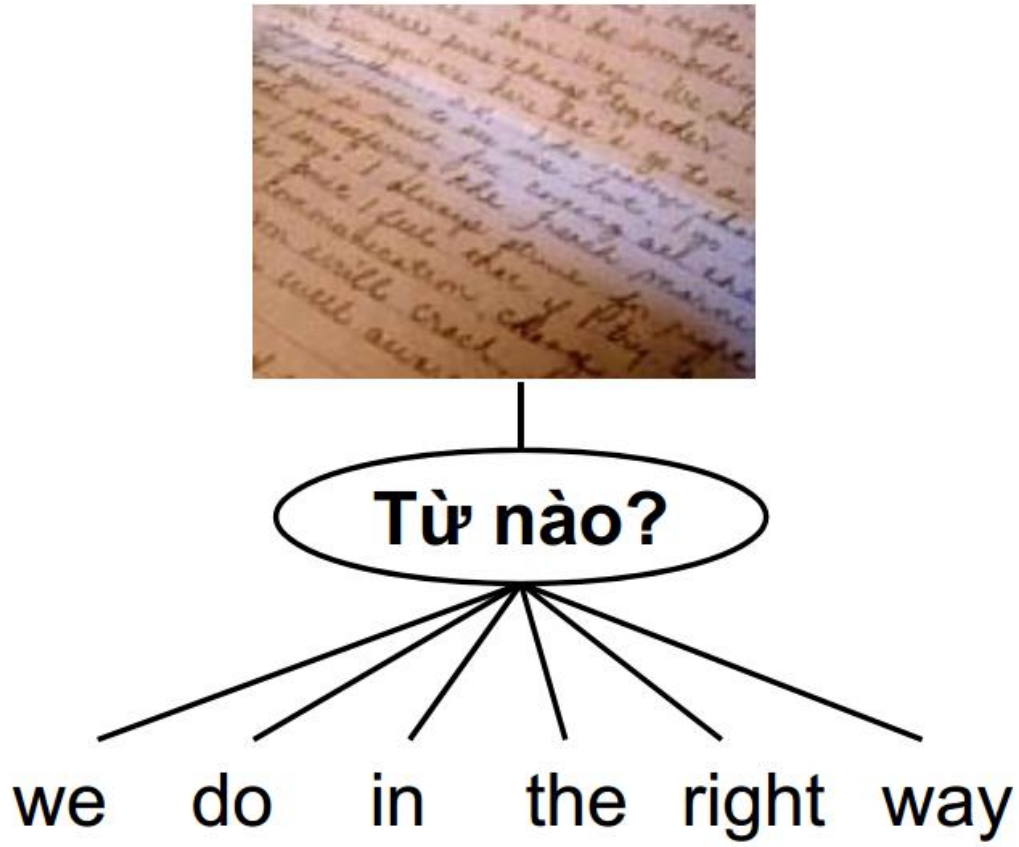
# Email Spam Filtering

- **T**: Predict (to filter) emails which one is spam?
- **P**: % of emails are classify exactly
- **E**: A set of sample emails, each of which is represented with a corresponding set of attributes (eg keyword set) and class labeled (email/spam)

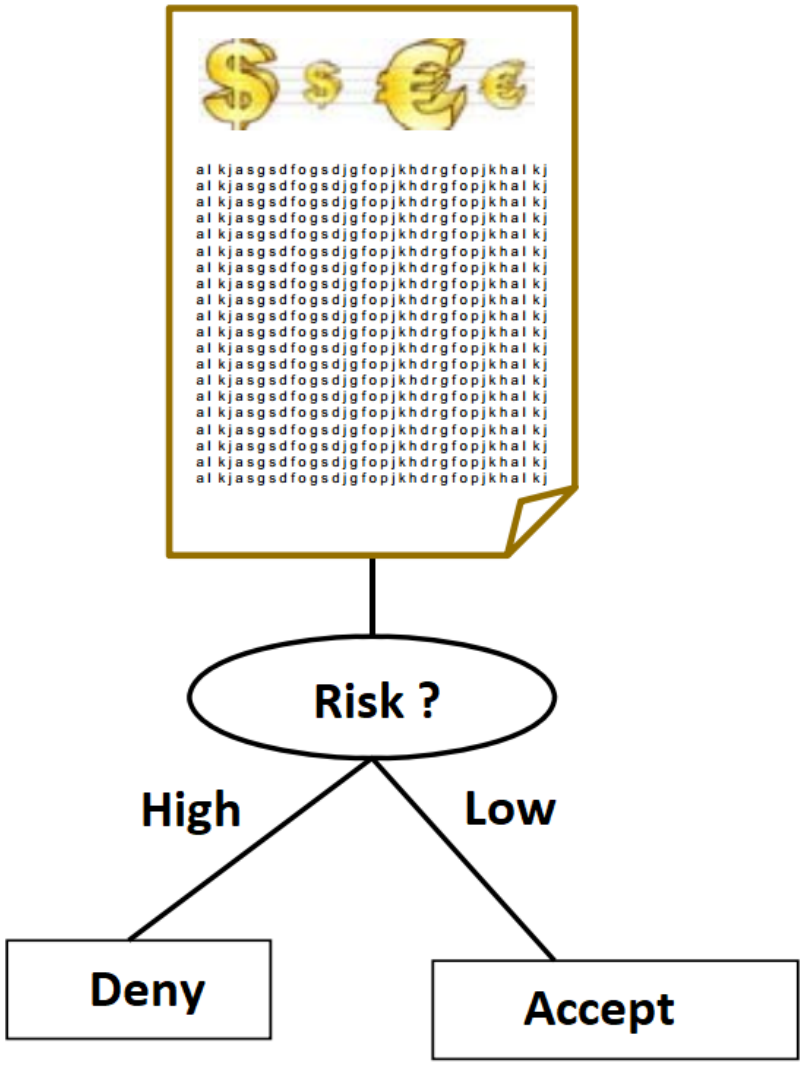
# Handwriting recognition

- **T**: Identify and classify thewords in handwritten pictures
- **P**: % of words are recognized and classified correctly
- **E**: A set of handwritten images, in which each image is attached with an identifier of a word



# Financal loan risk prediction

- **T**: Determine the level of risk (eg: high/low) for loan applicationsfinance
- **P**: % of of loan applications with high risk (no return) are determined exactly
- **E**: A set of loan applications, each represented by a set of attributes and risk (high/low)



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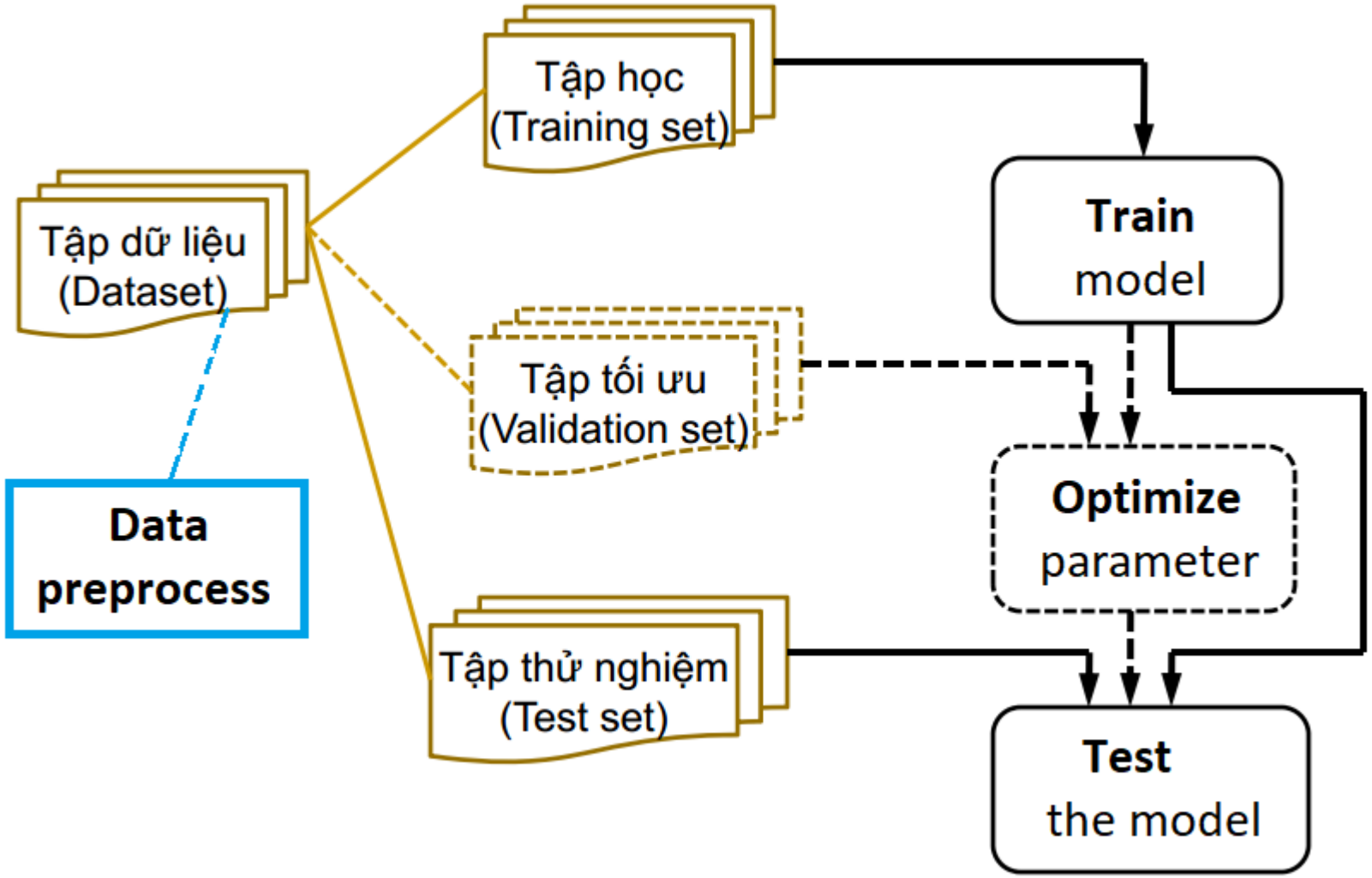
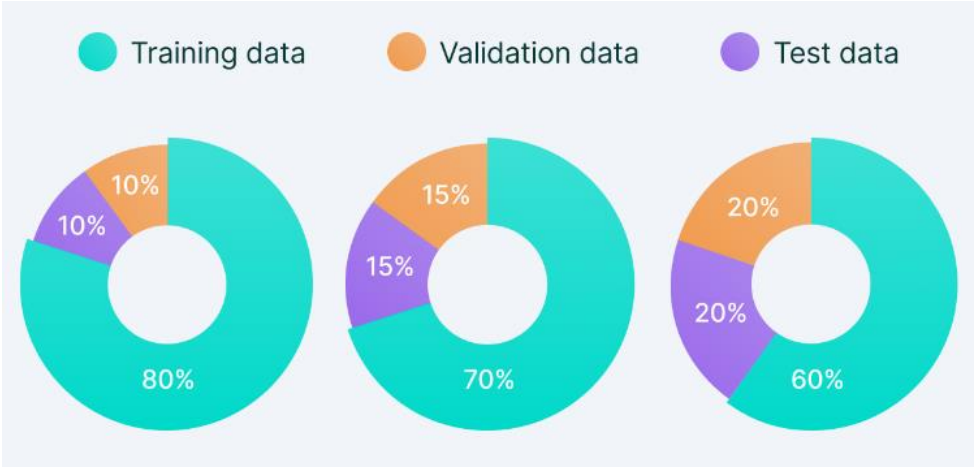
# Building a ML model



# Data set

- Preprocess:
  - Remove noise (icons, stickers…), and stopword (if need)
  - Decode the abbreviations, native language
  - Lower case and Upper case problems
  - Fill the missing values of features
  - Vietnamese: single or complex word
  - …
- Train/Validation/Test set:
  - Train: for train model
  - Validation: for optimize model
  - Test: for test model



# ML paradigms

- Supervised Learning:
  - learn a function that can be used to predict the output associated with new inputs
  - training data is labeled
  - Ex: Classification, Regression…
- Unsupervised Learning:
  - identify commonalities in the data and react based on the presence or absence of such commonalities in each new piece of data
  - training data is unlabeled
  - Ex: Clustering, Community detection…
- Reinforcement learning:
  - take actions in an environment in order to maximize the notion of cumulative reward
  - the environment is typically stated in the form of a Markov decision process (MDP)
  - training data is set of all possibilities and corresponding rewards

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# The main components of the ML problem

- **Training data:**
  - Labeled or unlabeled
  - compatible with the examples to be used by the system in the future
- **Objective function F:**
  - Determine function F:
    - F: X -> {0,1}
    - F: X -> {Set of classes: $c_1$ ,$c_2$ ,…,$c_n$}
    - …
  - Choose the way to present F:
    - a polynomial function
    - a set of rules
    - a decision tree
    - an artificial neural network)
- **ML Algorimth:** can learn (approximately) the objective function F
  - Regression-based
  - Back-propagation

  …

# Problems in Machine Learning

- **Training Examples (Datas)**
  - How many is enough?
  - How do error (noise) and/or missing-value examples affect accuracy?
  - Affects of data imbalance
- **Learning algorithm (LA)**
  - Under what conditions, a LA will converge (asymptotically) the objective function need to be learned?
  - Which LA is the best for the specific conditions?
- **Learning process**
  - What is the optimal strategy for choosing the order of using training examples?
  - How can problem-specific knowledge (besides training examples) contribute to the learning process?

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# Learning Outcomes

- Explain the different types of learning problems along with some techniques to solve them
- Model real-world problems, apply different learning techniques and quantitatively evaluate the performance
- Identify and use advanced techniques with the help of existing machine learning tools and libraries
- Analyze performance of ML techniques and comment on their limitations

# Prerequisites

- **Required**
  - Linear Algebra
  - Probability and Statistics
  - Advanced Calculus (mainly, vector differentiation)
  - Introduction to Programming (Python)
    - In reality you would need much more than an introduction
- **Desired**
  - Optimization
    - At least knowledge of gradient descent used for function minimization

# Q&A - Thank you!