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Basic Concept of Artificial Intelligence Algorithms

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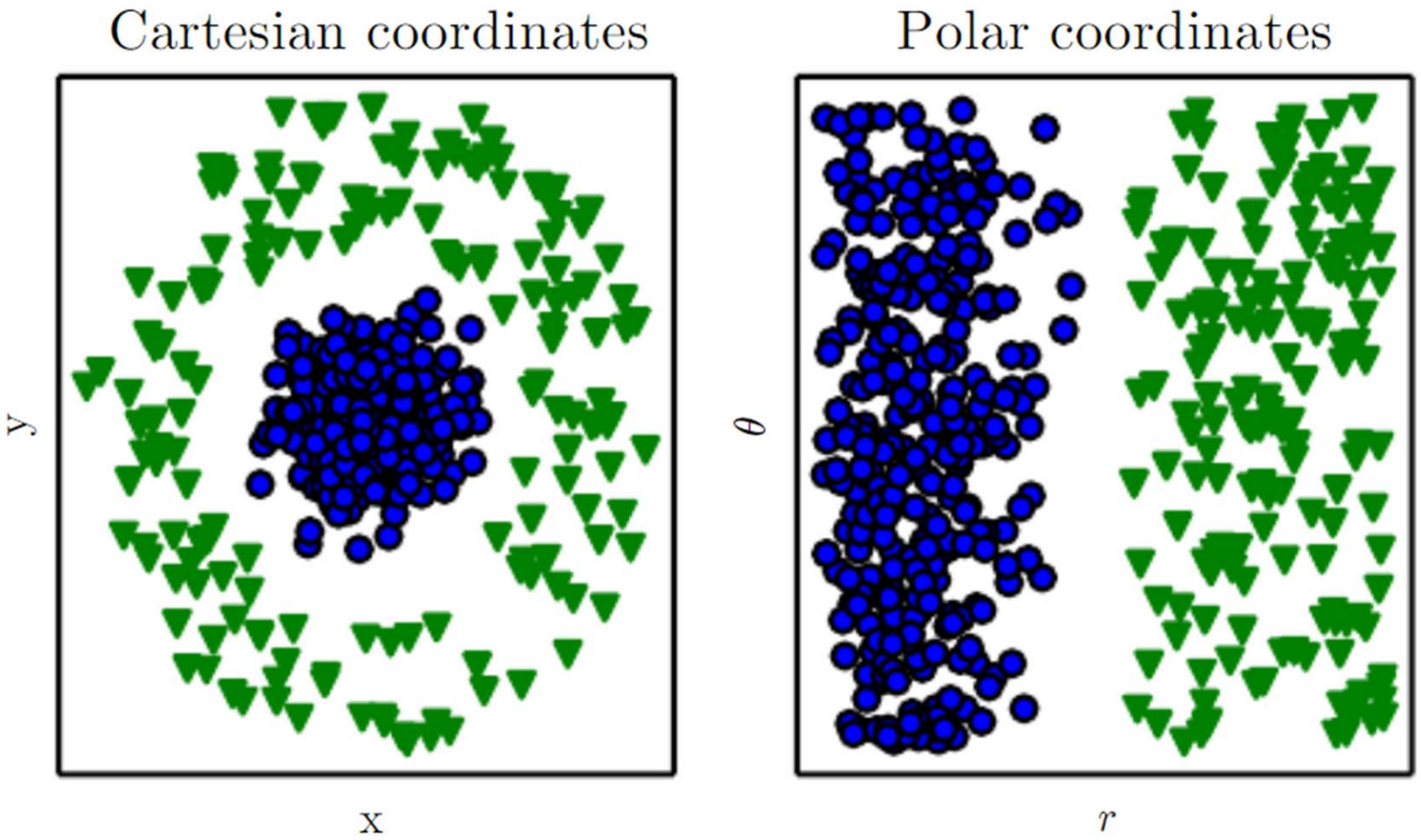
Outline

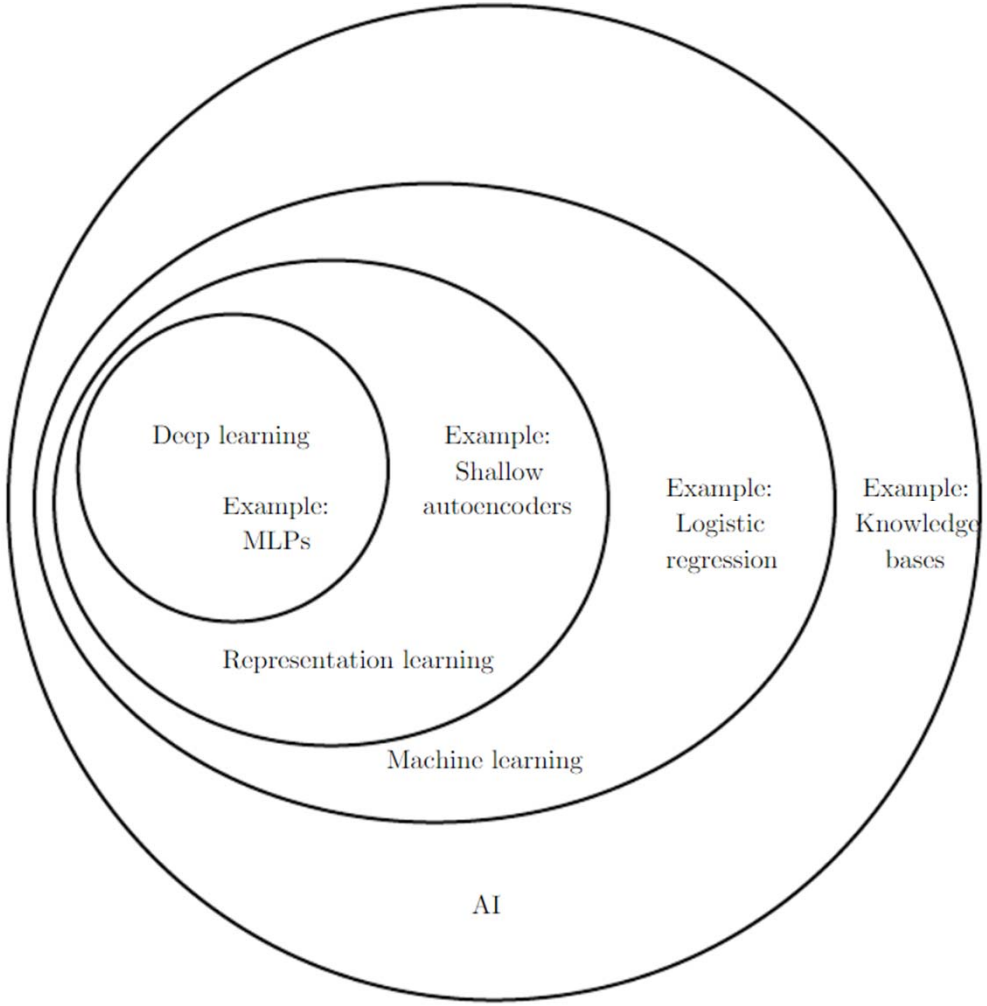
- Artificial Intelligence, Machine Learning, Representation Learning, and Deep Learning
- Applications of Machine Learning
- Basics of Machine Learning
- Main Challenges of Machine Learning
- Conclusions and Prospects

Importance of Data Representation



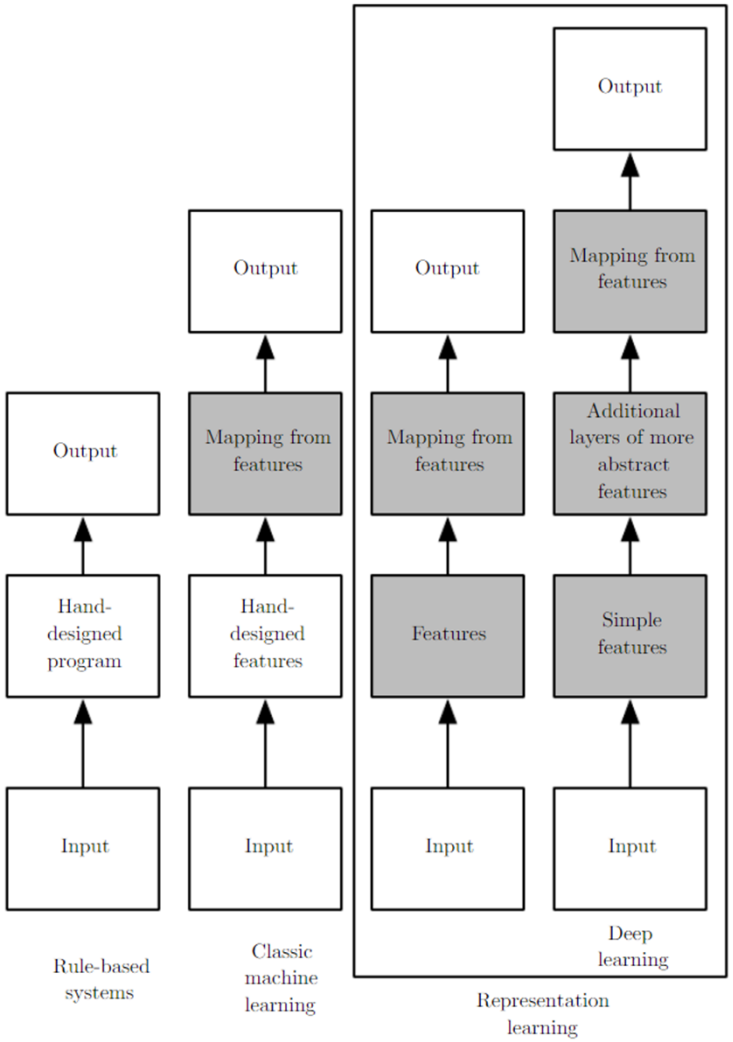
(Ian Goodfellow et al, Deep Learning, 2016)

Hierarchy of AI



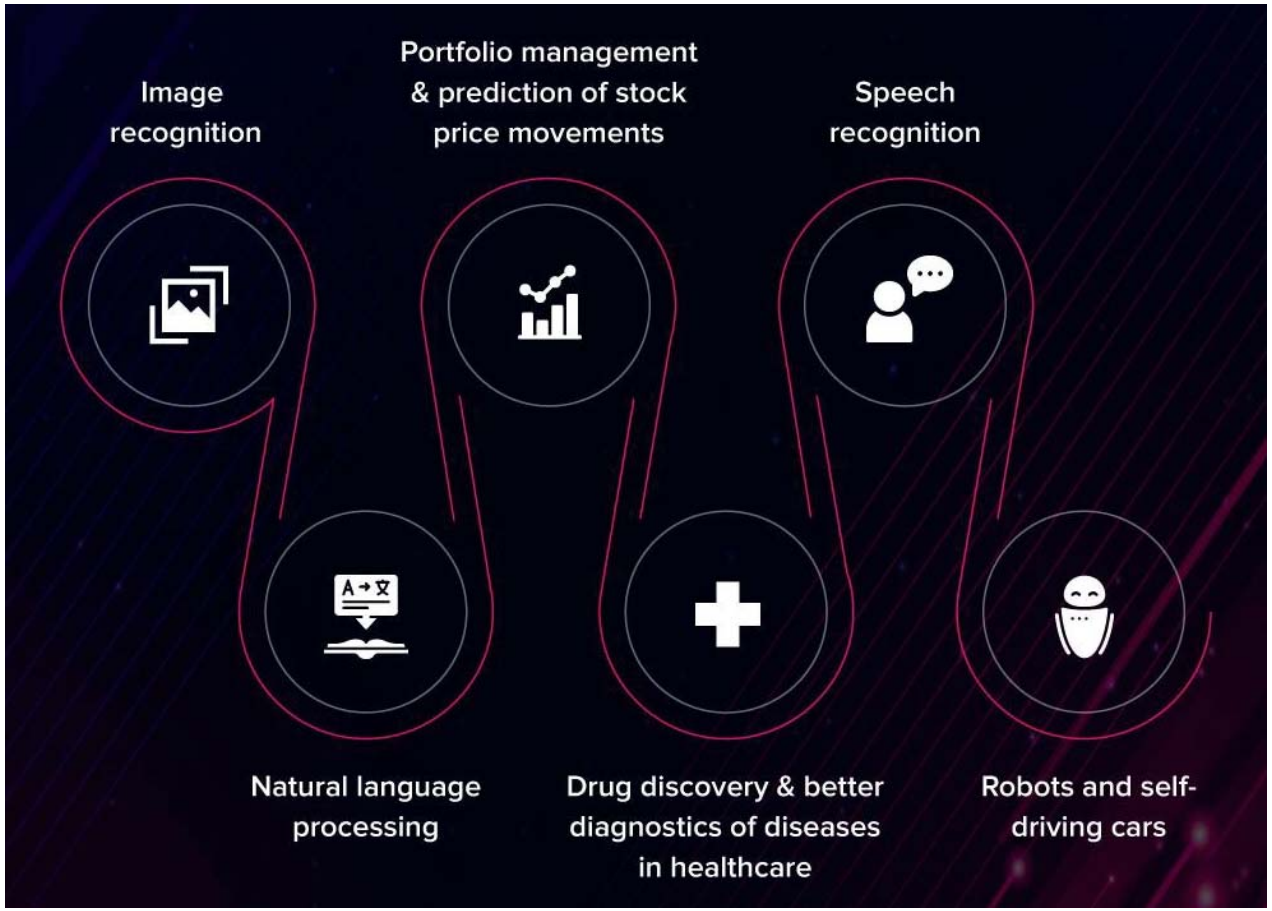
(Ian Goodfellow et al, Deep Learning, 2016)

AI Systems in Different AI Disciplines



(Ian Goodfellow et al, Deep Learning, 2016)

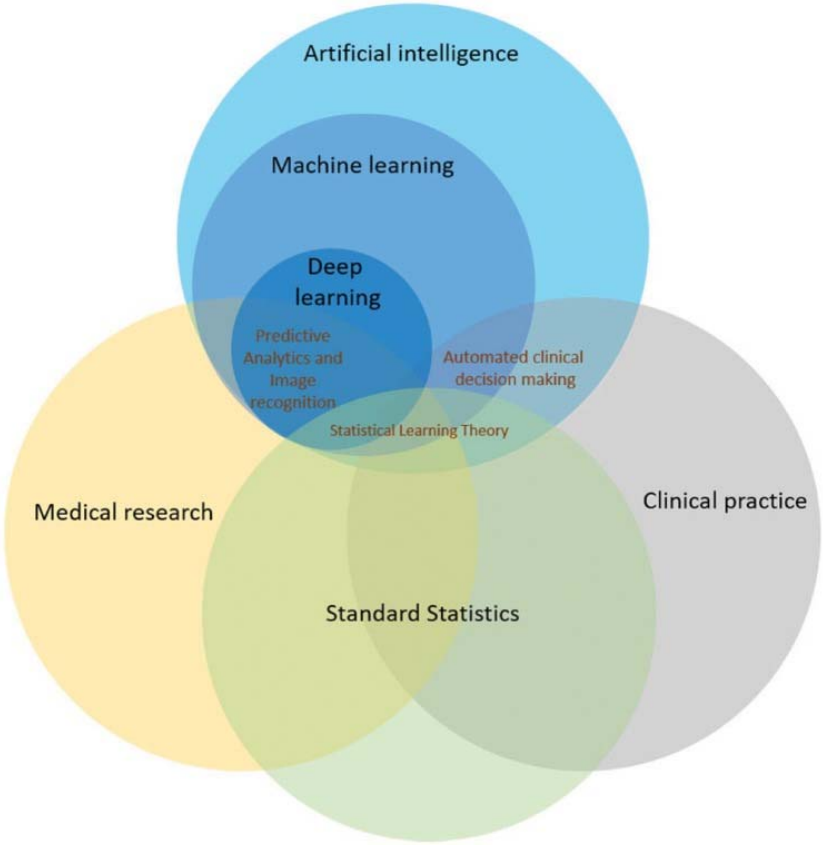
Applications of ML and DL



https://medium.com/ai-in-plain-english/artificial-intelligence-vs-machine-learning-vs-deep-learning-whats-the-difference-dccce18efe7f

Relationships with Medicine

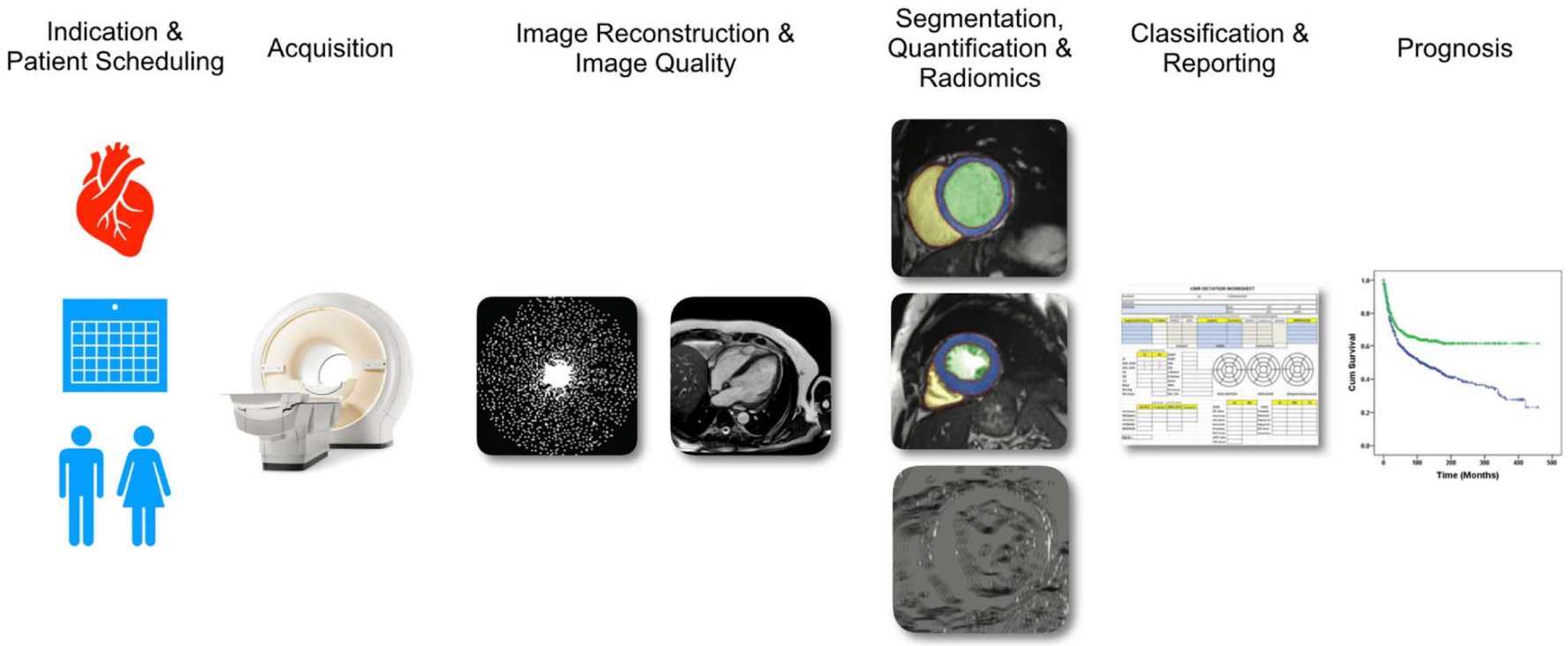
- Clinical practice
  - often uses statistical methods and automated decision making
  - Statistical learning theory and ML have intersection
- Statistical approach can be extended by analyzing large-scale multivariate data using DL
  - Suitable for problems involving complex interactions or difficult to formulate simple hypotheses
- DL has successfully been applied in the field of medical image recognition such as ECG, echocardiography, and MRI
  - Expected to improve decision-making process and results in the clinical field in the future



Chayakrit Krittanawong et al., Deep learning for cardiovascular medicine: a practical primer, European Heart Journal, Volume 40, Issue 25, 1 July 2019, Pages 2058–2073, https://doi.org/10.1093/eurheartj/ehz056

Using DL in Cardiovascular MRI Processes

- DL can be used to improve all aspects of the cardiovascular MRI process, from patient scheduling to image analysis and prognosis



Leiner, T., Rueckert, D., Suinesiaputra, A. *et al.* Machine learning in cardiovascular magnetic resonance: basic concepts and applications. *J Cardiovasc Magn Reson* **21,** 61 (2019). https://doi.org/10.1186/s12968-019-0575-y

Basics of ML Algorithms

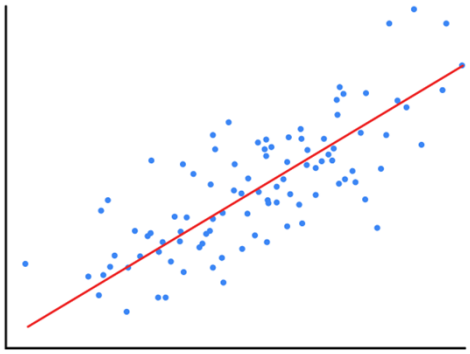
- ML algorithms are those that can learn from data
- What is learning? [Mitchell, T. M., Machine Learning, 1997]
  - A computer program is said to learn from experience *E*
  - with respect to some class of tasks *T*
  - and performance measure *P*,
  - if its performance at tasks *T*, as measured by *P*, improves with experience *E*
- The learning process is not the task itself
  - Learning is a means of obtaining the ability to perform tasks
  - If you want the robot to walk, walking is the task
  - Program the robot to learn to walk or write your own program manually to manipulate the robot's steps

Kinds of Tasks

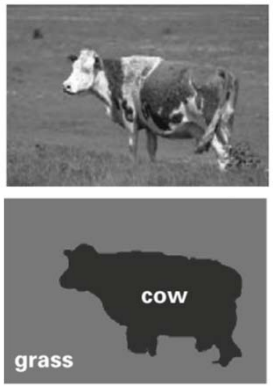
- Described in terms of how ML systems should process an input example (a collection of features)
  - Classification, Regression
  - Transcription, Machine Translation
  - Structured Output, Anomaly Detection
  - Missing Value Imputation, Denoising, etc.

classification

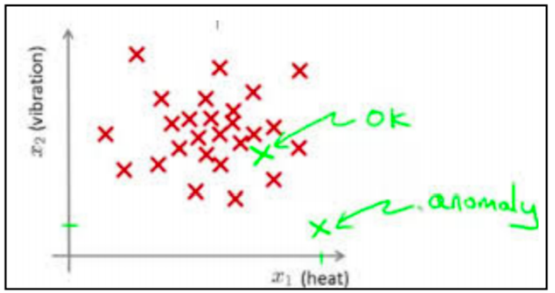
regression



structured output



anomaly detection



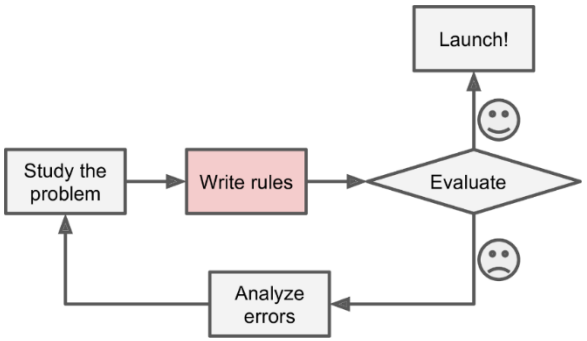
images from (Sargur Srihari, Deep Learning course materials)

Performance Measure and Experience

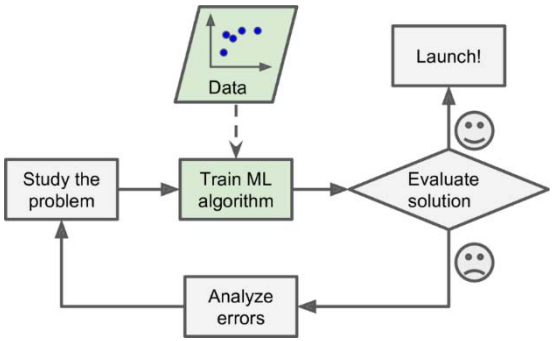
- Performance measure
  - Quantitatively evaluate the performance of ML algorithms
  - Specific to the given task
  - Accuracy, precision, recall, F1-score, AUC, average log probability, etc.
  - Measured using a test dataset (unseen data)
- Experience
  - Categorized by what kind of experience ML algorithms are allowed to have during the learning process (i.e. depending on which dataset is provided)
  - Supervised learning
  - Unsupervised learning
  - Reinforcement learning

Comparison with the Traditional Approach

- Traditional approach
  - Developers should identify words or patterns that frequently appear in spam mails (4U, credit card, free, amazing, etc.)
  - Need to develop an algorithm to detect the patterns and classify mails as spam when the patterns are found
  - The problem is not simple, so the rules are getting longer and more complicated => Difficult to maintain
- Machine learning approach
  - Automatically learn patterns frequently appearing in spam mails
  - Program is usually shorter, maintenance becomes easier, and accuracy is higher



Traditional approach

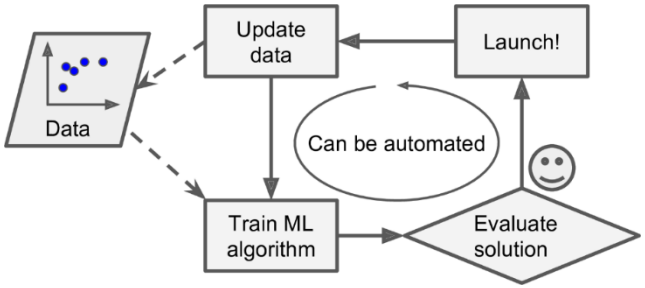


ML approach

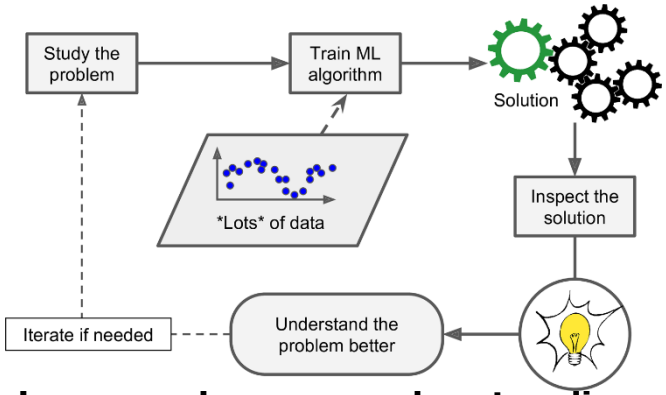
Aurélien Géron, Hands-On Machine Learning with Scikit-Learn and TensorFlow: Concepts, Tools, and Techniques to Build Intelligent Systems

Comparison with the Traditional Approach

- Automatically adapt to changes
  - If 'For U' is mainly used instead of '4U' in spam mails,
  - In the traditional approach, the spam filter needs to be modified to distinguish 'For U'
  - In the ML approach, the spam filter automatically recognizes frequent occurrences of 'For U' in emails designated as spam by the user and classifies them as spam
- Improve human understanding through ML
  - Possible to identify words and word combinations that are optimal for predicting spam from the machine learning model



Automatically adapt to changes

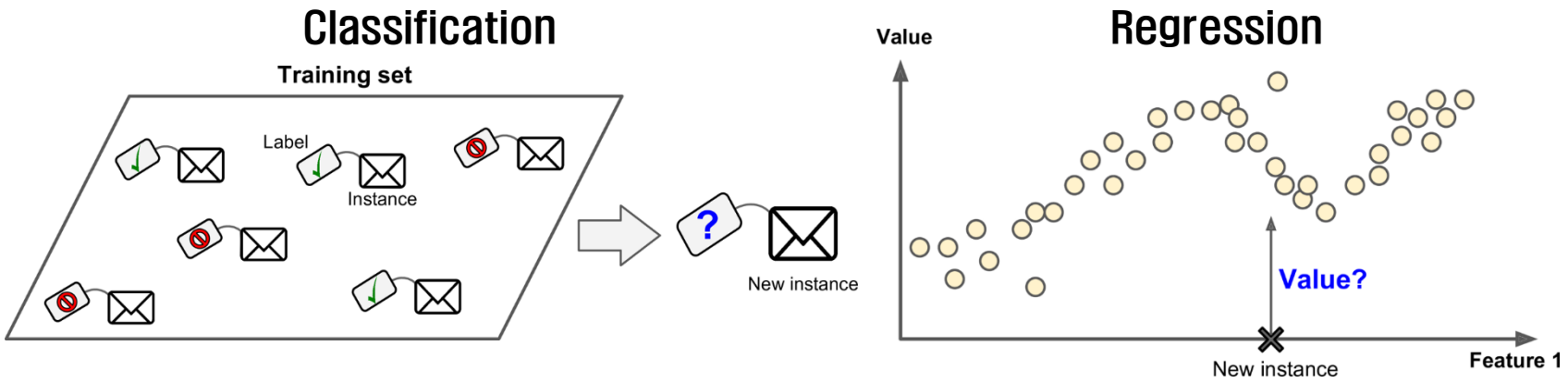


Improve human understanding

Aurélien Géron, Hands-On Machine Learning with Scikit-Learn and TensorFlow: Concepts, Tools, and Techniques to Build Intelligent Systems

Supervised Learning

- Training data contain the desired answer, called a label.
- Classification is typical supervised learning, e.g., spam filter.
- Regression: predicting values using features called predictors, e.g., prediction of used car prices.
- K-NN, linear/logistic regression, SVM, decision trees, random forests, neural networks, etc.



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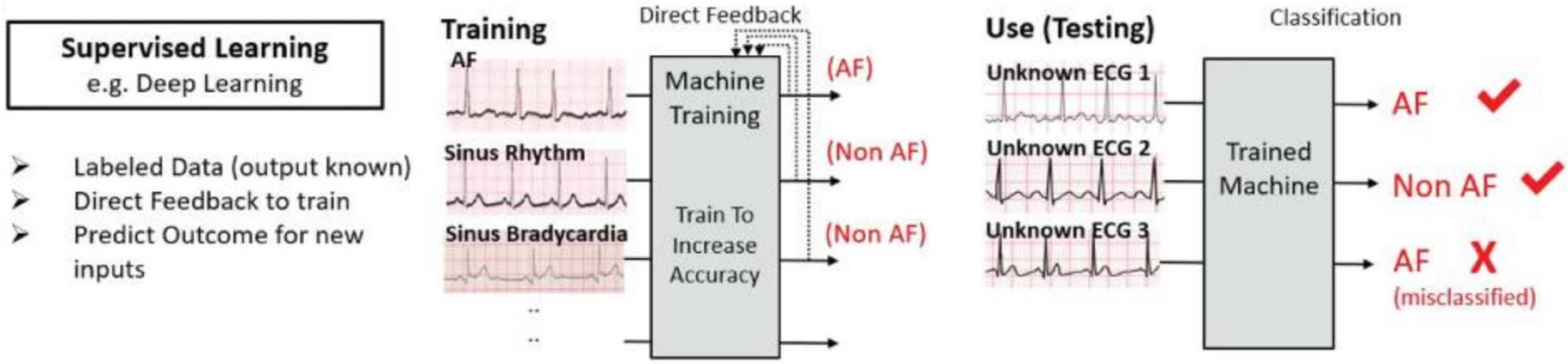
Prediction of AF

- Use an input (e.g., ECG) with a label (whether diagnosed with atrial fibrillation)
- Learning until the difference between the model's output value and the actual value is small by using a lot of training data
- Classify test ECGs (unseen data) using the trained model



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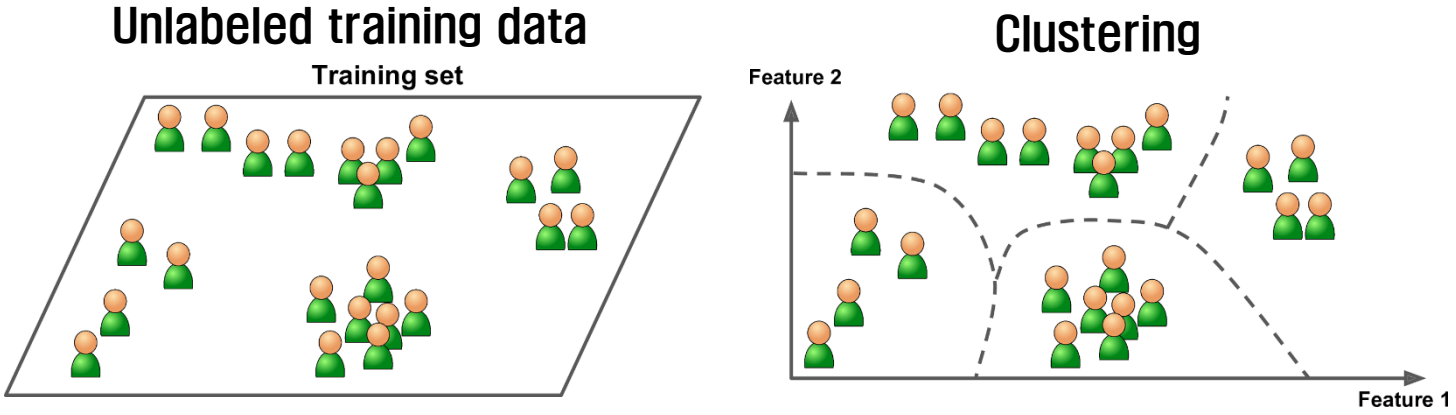
Unsupervised Learning

- No label in training data
- Clustering
  - E.g., grouping customers with similar characteristics
  - K-means, Hierarchical Cluster Analysis, Expectation Maximization
- Visualization, Dimensionality Reduction
  - Principal Component Analysis(PCA), Kernel PCA, Locally-Linear Embedding(LLE)



Aurélien Géron, Hands-On Machine Learning with Scikit-Learn and TensorFlow: Concepts, Tools, and Techniques to Build Intelligent Systems

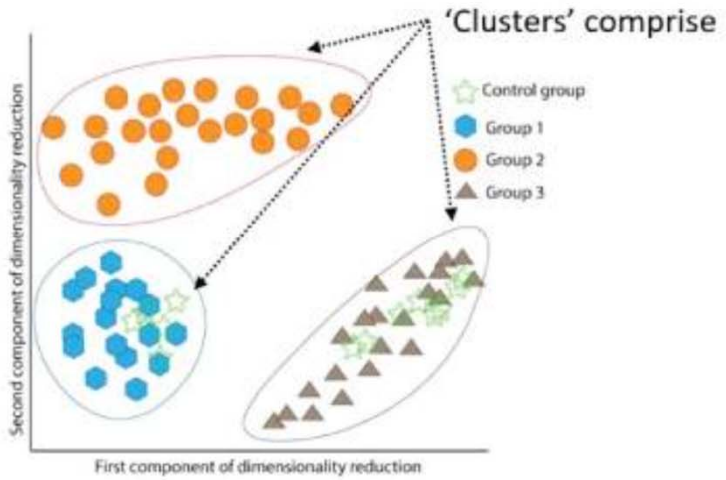
Identifying New Phenotypes for HCM

- Unsupervised learning uses unlabeled data to identify new patterns
- Identified new phenotypes (clusters) for hypertrophic cardiomyopathy (HCM) with distinct results using QRS parameters

Unsupervised Learning
e.g. Cluster Analysis

- No Labels/targets
- No Feedback
- Finds Hidden Structure in Data

- QRS parameters for each HCM case
- Plot parameters against one another



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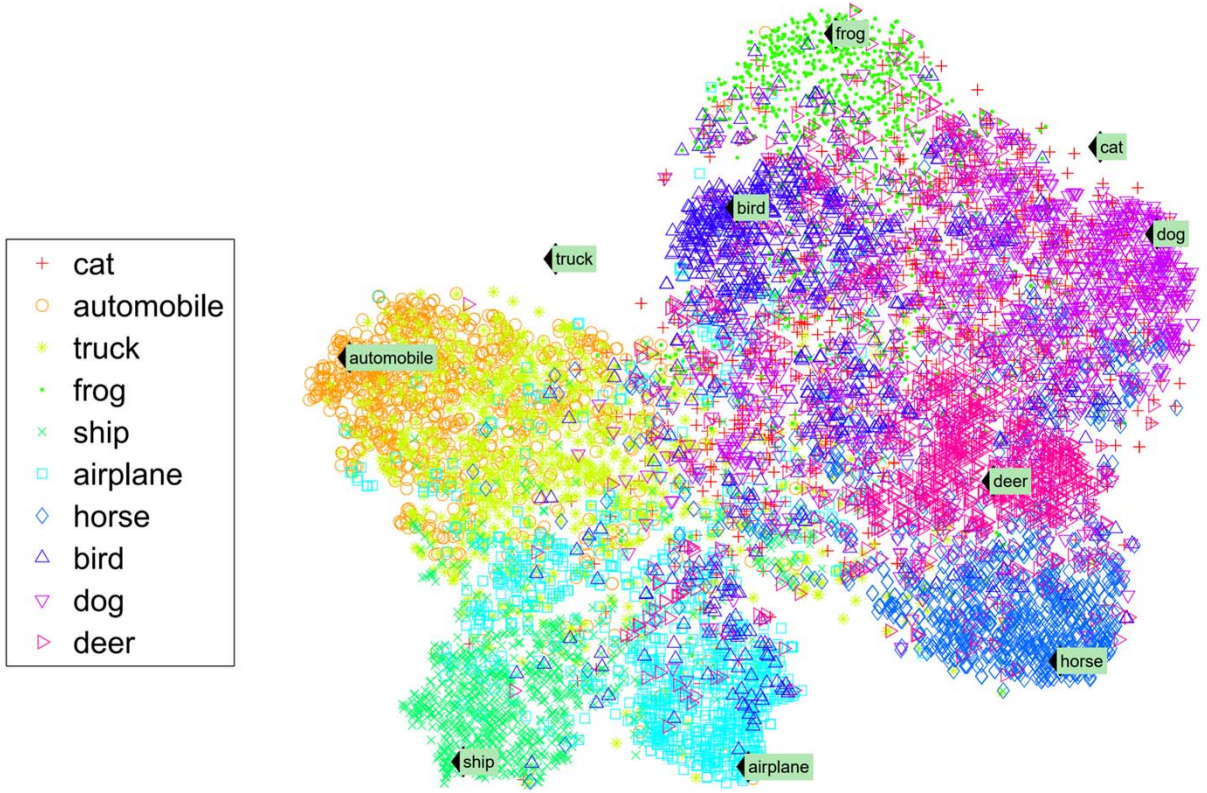
T-SNE Visualization of the Semantic Word Space

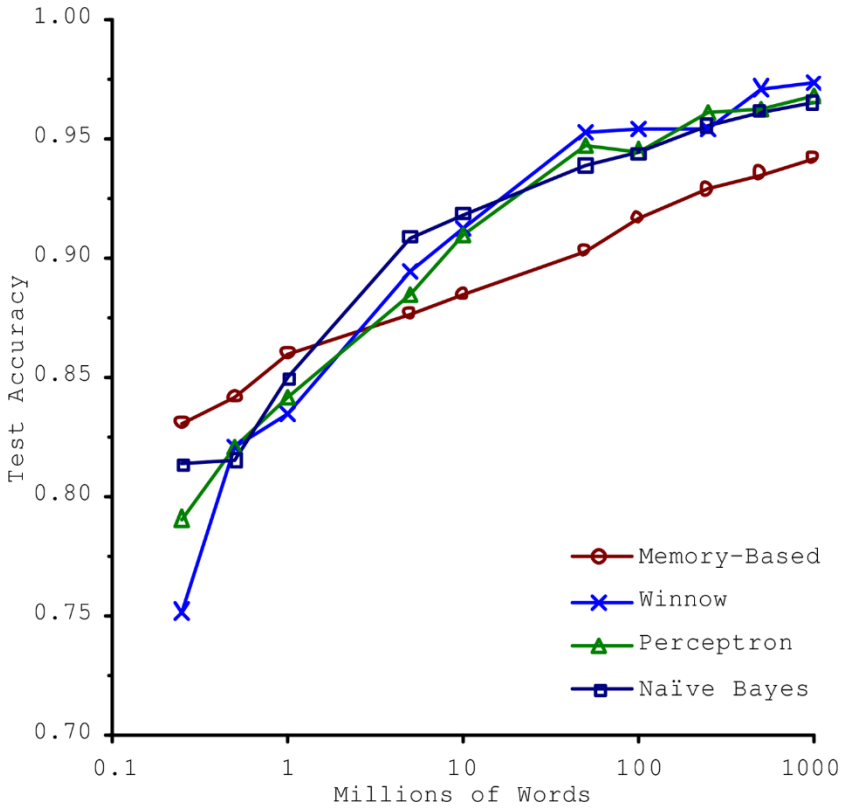
- Visualization example using dimensionality reduction
  - Animals are well separated from transports, horses are close to deer, but far from birds.



Richard Socher et al., Zero-Shot Learning Through Cross-Modal Transfer, NIPS'13

Main Challenges of ML

- Insufficient amount of data
  - Simple Problem: $\geq$ 1K
  - Image, speech recognition: $\geq$ 1M
- Unrepresentative training data
  - Not generalize well
- Low quality data
  - ML does not work well if there are many errors, outliers, and noise.
  - Need extensive data cleaning
- Irrelevant features
  - Need to find good features
  - Feature Engineering
    - Feature Selection
    - Feature Extraction

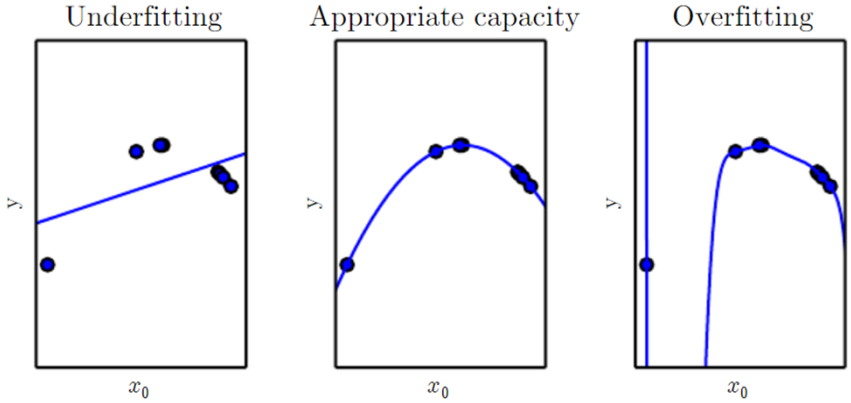


Importance of Data vs Algorithm

Michele Banko, Eric Brill, Scaling to Very Very Large Corpora for Natural Language Disambiguation, ACL'01
재인용: Aurélien Géron, Hands-On Machine Learning with Scikit-Learn and TensorFlow: Concepts, Tools, and Techniques to Build Intelligent Systems

Overfitting/Underfitting

- Overfitting
  - The model is complex and fits well the training data, but does not generalize
  - Use simpler models or collect more training data
- Underfitting
  - The model is too simple to learn the structure inherent in the data
  - Use more powerful models or better features



(Ian Goodfellow et al, Deep Learning, 2016)

Conclusion and Prospects

- AI is producing remarkable results not only in the field of computer science but also in the field of medicine
- Using AI for big data analysis, possible to identify hidden information in complex heterogeneous data
- Precision medicine is also possible by bridging the gap between disease onset and genotype, phenotype, etc.
- To improve the diagnosis and treatment of cardiovascular diseases, need to
  - collect a lot of labeled data,
  - improve interpretability of AI models, and
  - develop a standard approach for validation and testing
- Many automated machine learning (AutoML) tools available
  - Amazon SageMaker, Google Cloud AutoML, Microsoft Azure Machine Learning, etc.

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COI Disclosure

Name of First Author: Hyeonseung Im

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