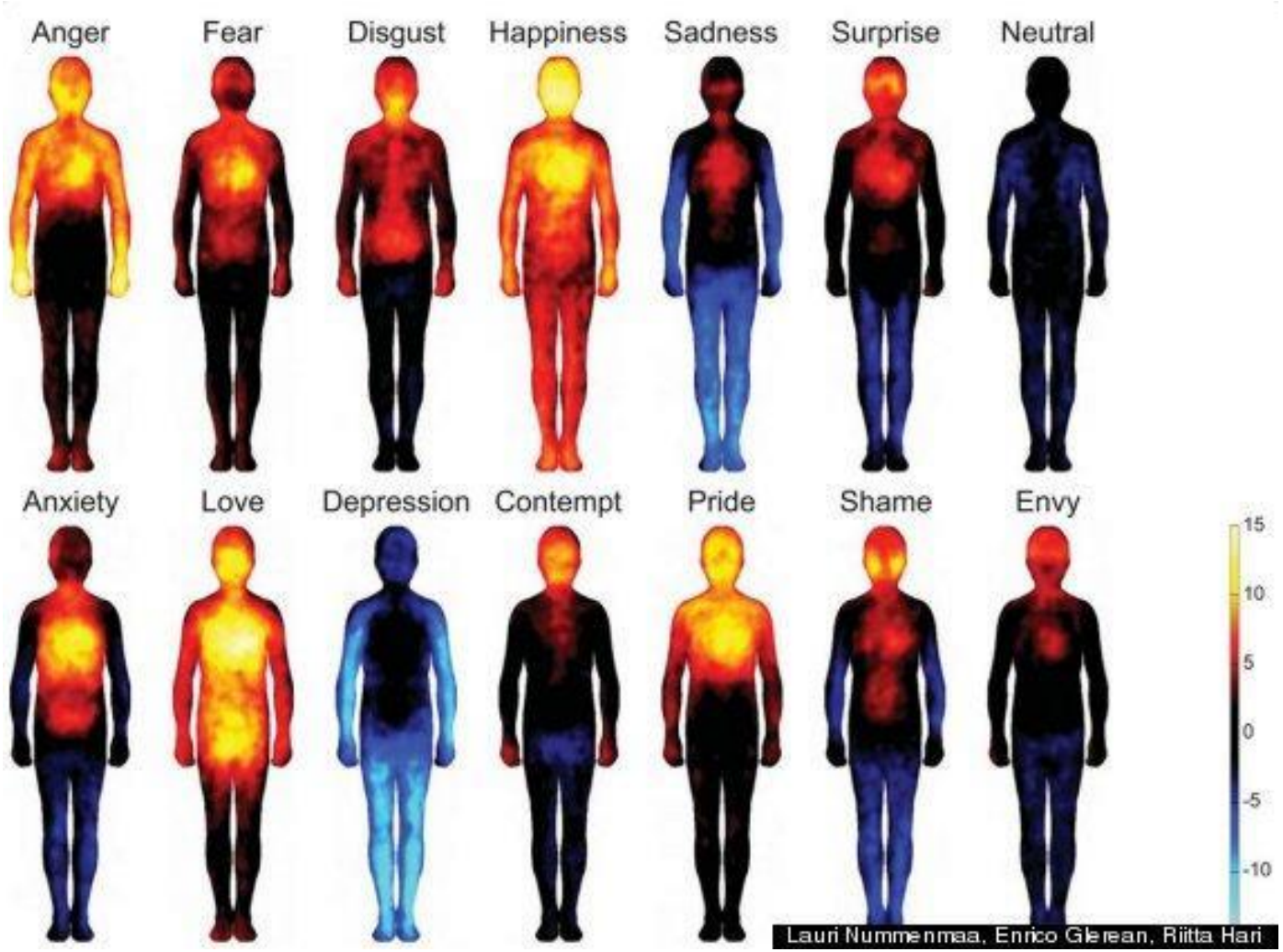
Introduction to machine learning

Human Body Temperature Distribution According to Their Emotional State



Source: http://www.huffingtonpost.co.uk/2014/01/06/body-temperature-changes-emotions-love-depression_n_4549145.html

Human emotions and postures

Source: “Recognizing Emotions Expressed by Body Pose: a Biologically Inspired Neural Model” by Schindler et al, Neural Networks, 2008, https://goo.gl/kJ3BNg

Threat Perception in Real Time Security Systems

- Can we recognize emotions
  - from posture and thermographs?
  - of an individual in a group or crowd?
- Can we link recognized emotions to predict possible threat from an individual in a crowd monitored using thermographs and gait analysis from video cameras?

What resolution?

Video camera

Correlate and Classify Acquired Images Into Predefined Set of Emotions Based on Temperature Distribution And Postures

Infrared camera

Storage devices

Data transfer speeds

Programmable chips

Data?

Good accuracy

Less uncertainty

Work for group of humans?

Programmable?

Execution time?

Is it scalable?

Algorithm

Identify Emotions from Body Temperature Distributions and Posture of humans

Threat Perception in Real Time Security Systems

- Desired features of an algorithm
  - Programmable/ Automate
  - Realistic computation time
  - Accurate and Precise, independent of data accuracy/precision
- Considerations for the data
  - Required accuracy and precision in thermograph and video resolution, magnification
- How can we automate/program this task?

➢ Possibly embed this into camera chip and link it to the security system?

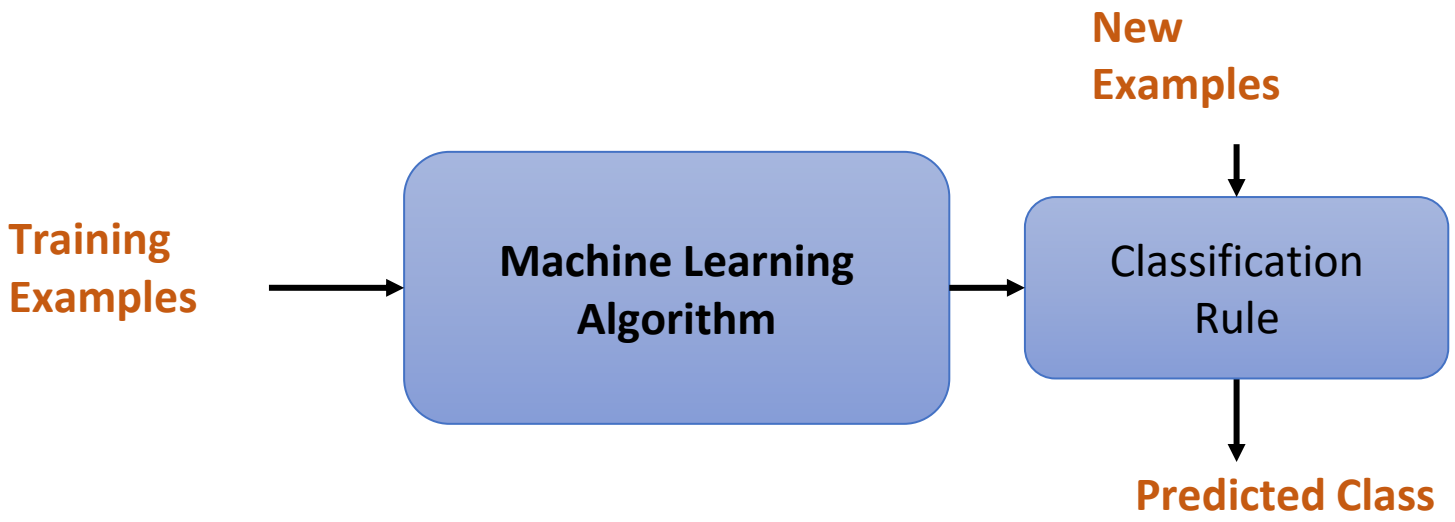
See: ***Multi-sensor Surveillance Systems: The Fusion Perspective, edited by*** Gian Luca Foresti, Carlo S. Regazzoni, Pramod K. Varshney, Google books URL: https://goo.gl/m10vAG

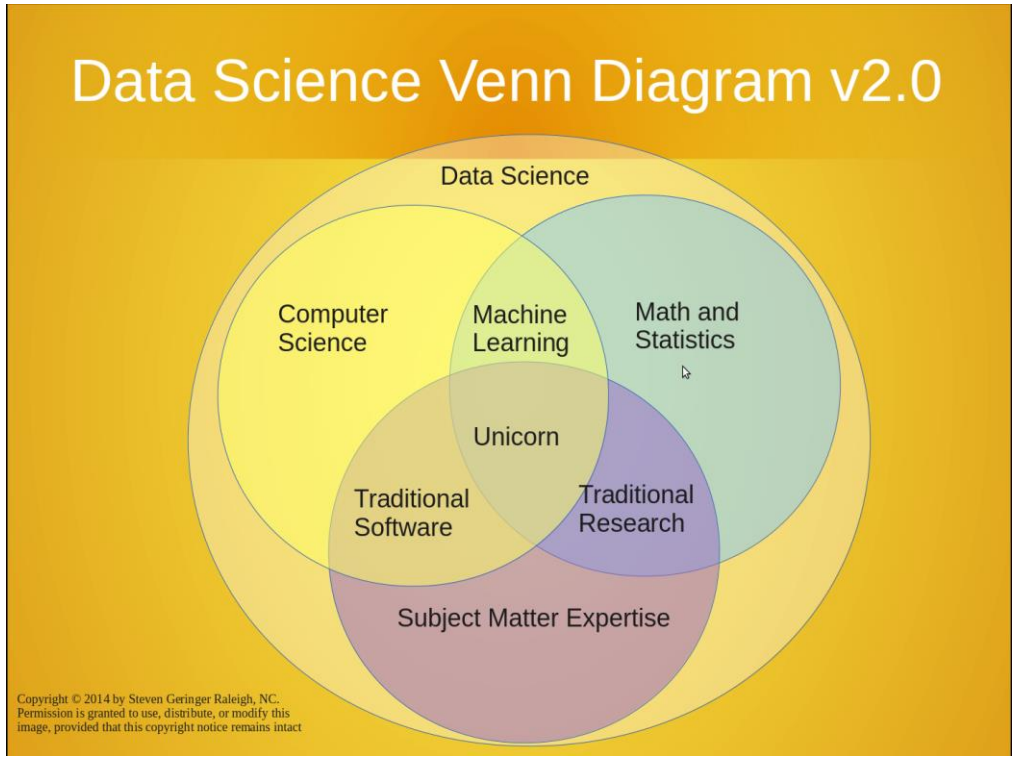
Outline

- What is Machine Learning?
- What machine learning can do?
- Machine learning models/algorithms
- Design of Machine Learning Study
- Goals and Objectives of This Module
- Summary and Comments

What is “Machine Learning”?

- Algorithms and techniques used for data analytics
- Studies how to **automatically learn** to make accurate predictions based on past observations
- Machine learning is programming computers to optimize a performance criterion by tuning set of parameters . These tuned programs then perform same task on unseen data.




Data Science Venn Diagram v2.0
Data Science
Computer Science
Machine Learning
Math and Statistics
Unicorn
Traditional Software
Traditional Research
Subject Matter Expertise
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Machine Learning is used when…

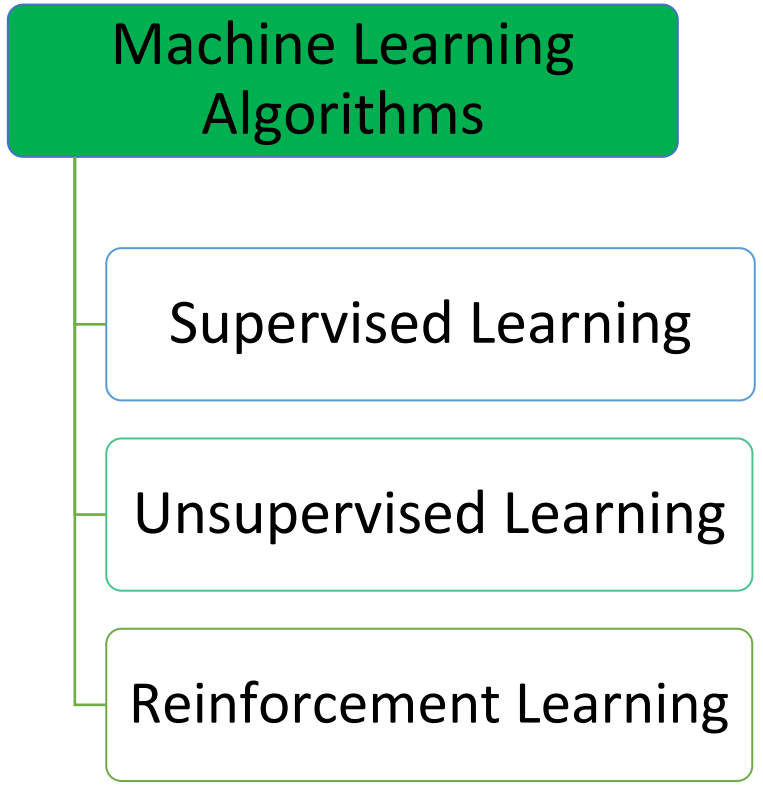
- **Human expertise does not exist**
  - Navigating on Mars
- **Humans are unable to explain their expertise**
  - speech recognition
  - mine detection
- **Solution changes or evolves in time**
  - routing on a computer network
- **Solution needs to be adapted to particular cases**
  - user biometrics, virtual agent based solutions)

Applications

- **Retail:** Market basket analysis, Customer relationship management (CRM)
- **Finance**: Credit scoring, fraud detection
- **Manufacturing**: Optimization, troubleshooting
- **Medicine**: Medical diagnosis, Prognosis
- **Telecommunications**: Quality of service optimization
- **Bioinformatics**: Motifs, alignment
- **Web mining**: Search engines
- And many more….

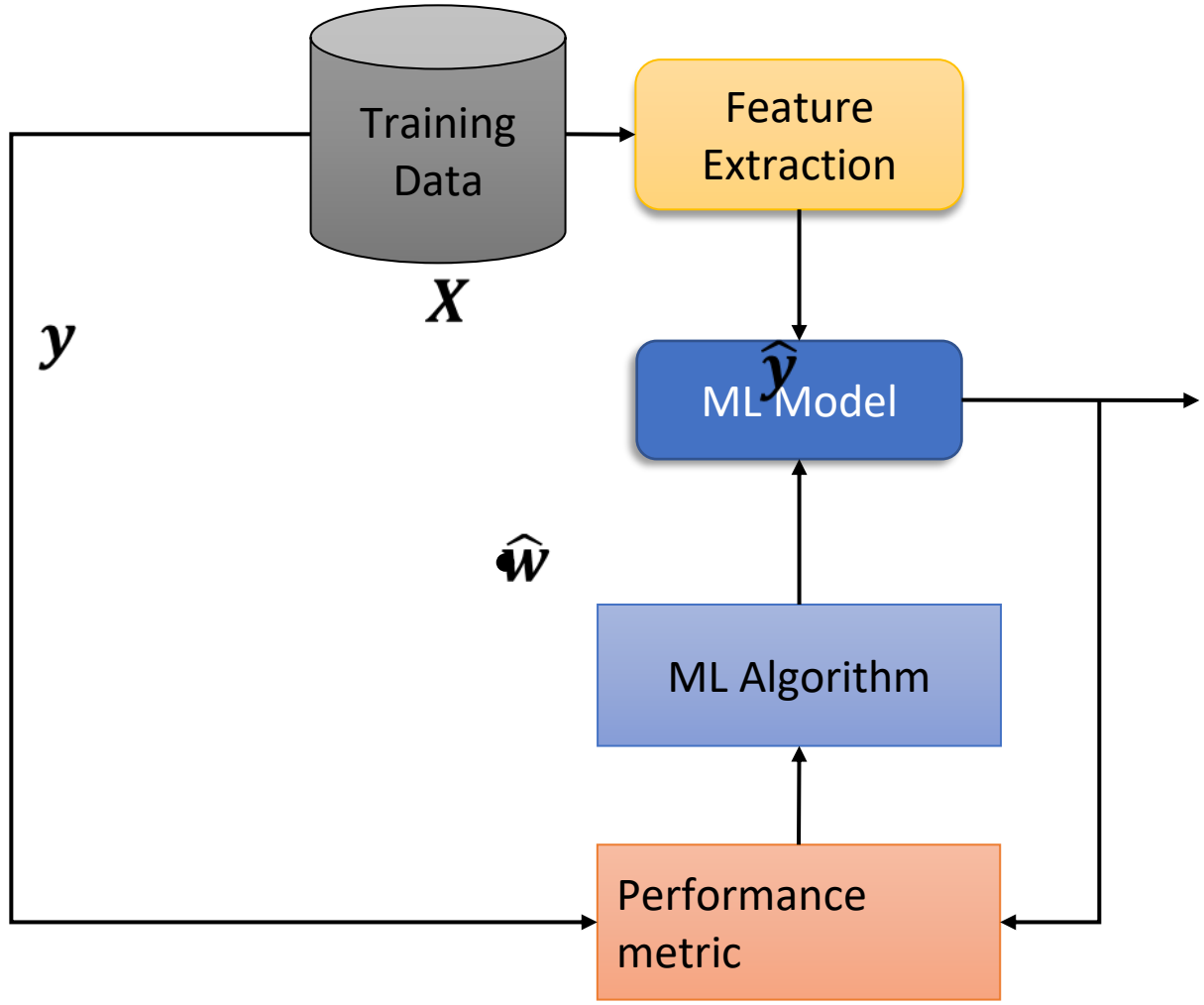
Algorithms

- The success of machine learning system also depends on the algorithms.
- The algorithms control the search to find and build the knowledge structures.
- The learning algorithms should extract useful information from training examples.



Supervised Learning

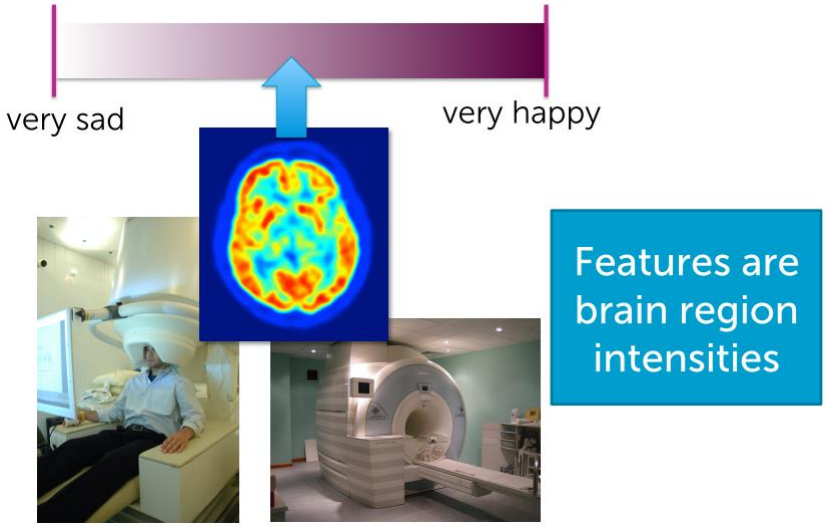
- Learning from examples
- We are given attributes, $\boldsymbol{X}$ and targets $\boldsymbol{y}$
- knowledgeable external supervisor
  - Regression
  - Classification
  - Decision trees
  - Random forest



Regression: Examples

Reading your mind

- Happiness state is related to brain region intensities



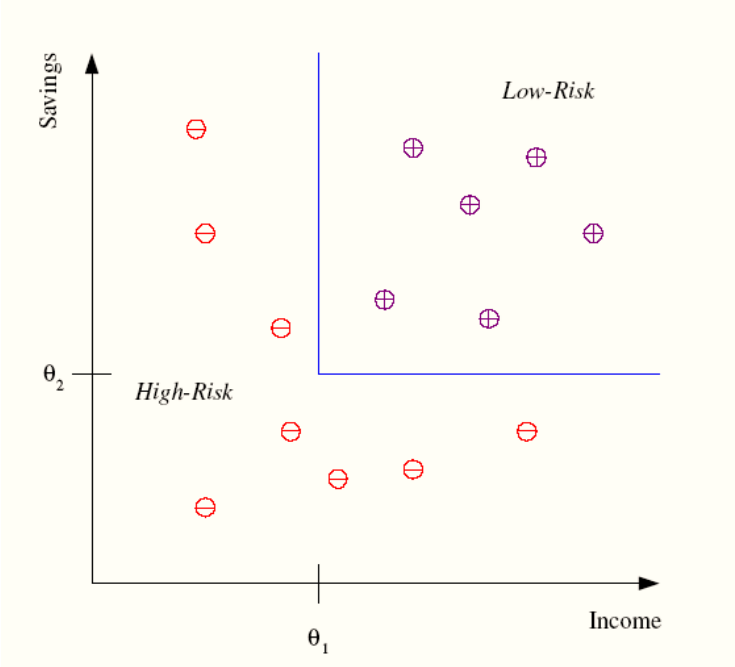
Predicting stock prices

- Depends on
  - Recent stock prices
  - News Events
  - Related commodities

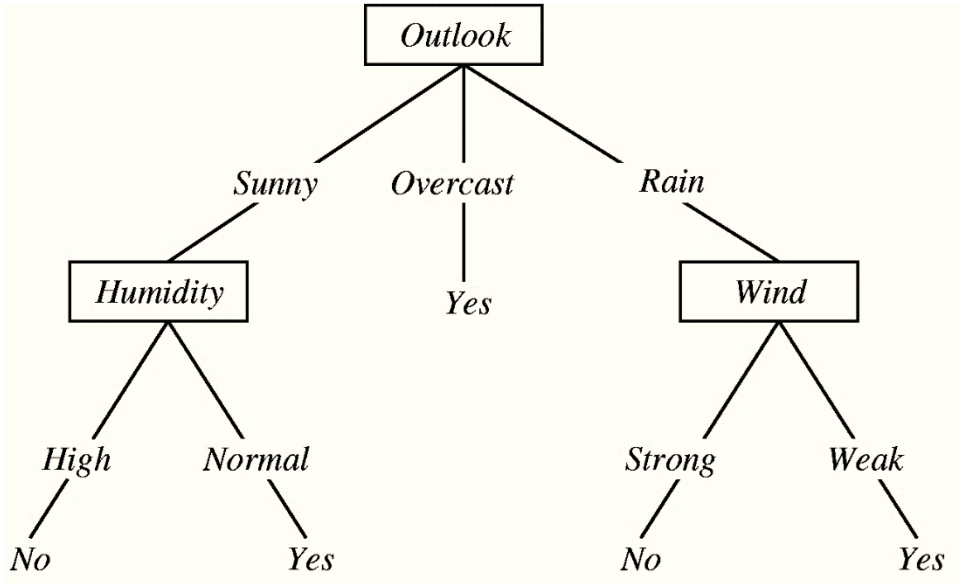
Classification: Examples

Credit scoring

- Differentiating between low-risk and high-risk customers from their *income* and



Outlook of the day and Weather derivatives



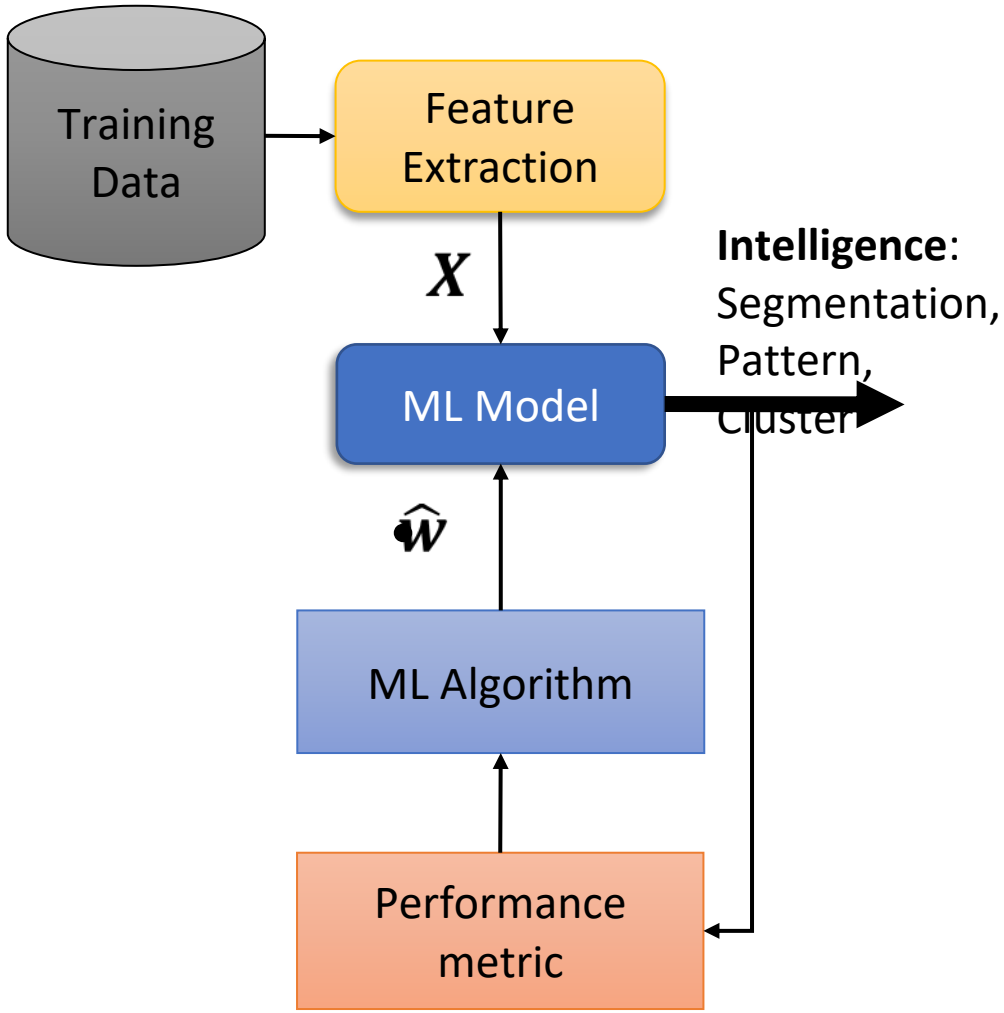
Classification: Applications

Also known as Pattern recognition

- Face recognition: Pose, lighting, occlusion (glasses, beard), make-up, hair style
- Character recognition: Different handwriting styles.
- Speech recognition: Temporal dependency.
- Use of a dictionary or the syntax of the language.
- Sensor fusion: Combine multiple modalities; eg, visual (lip image) and acoustic for speech
- Medical diagnosis: From symptoms to illnesses
- Web Advertising: Predict if a user clicks on an ad on the Internet.

Unsupervised Learning

- Learning from examples
- We are given only attributes, $\boldsymbol{X}$ and **no targets**
  - Clustering
  - Finding association (in features)
  - Image compression
  - Probability distribution estimation
  - Dimension reduction



Document Clustering and Text Mining

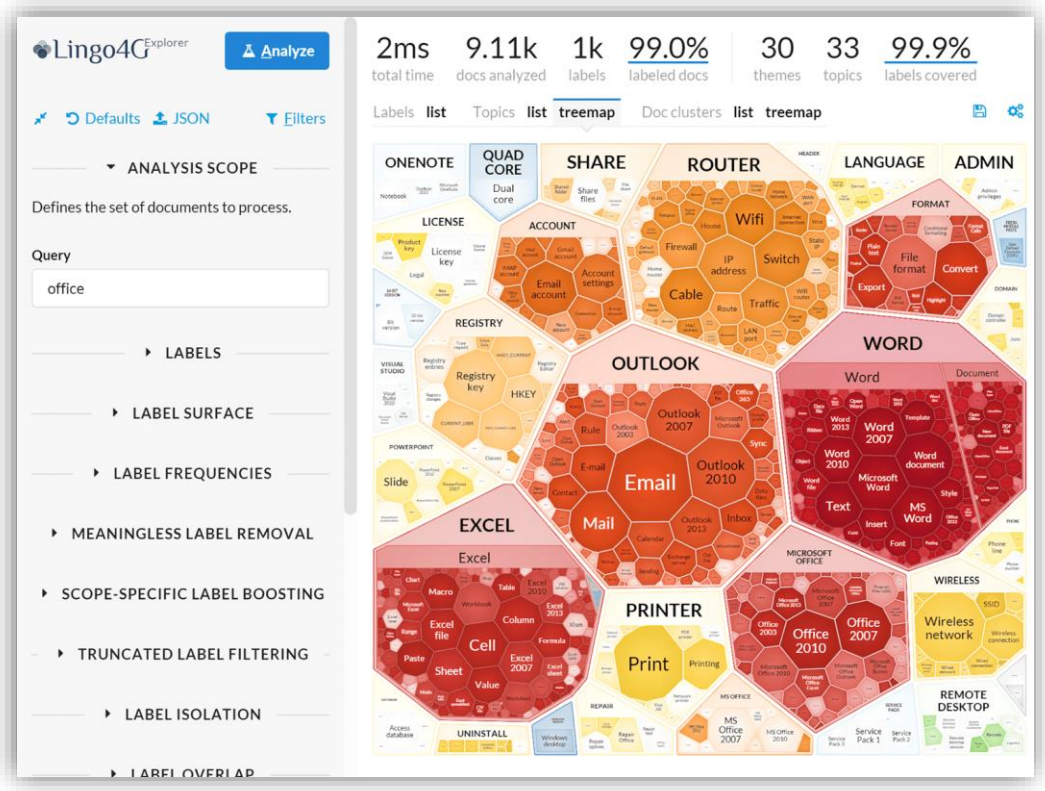


Image source: https://get.carrotsearch.com/lingo4g/latest/doc/#explorer-results-view

Lingo4G: Large-scale text clustering

- Topic discovery
- Document clustering
- Document retrieval
- No external taxonomies
- Scalable

Learning Associations

- Basket analysis:

  $P(Y \mid X)$ probability that somebody who buys X also buys Y where X and Y are products/services.

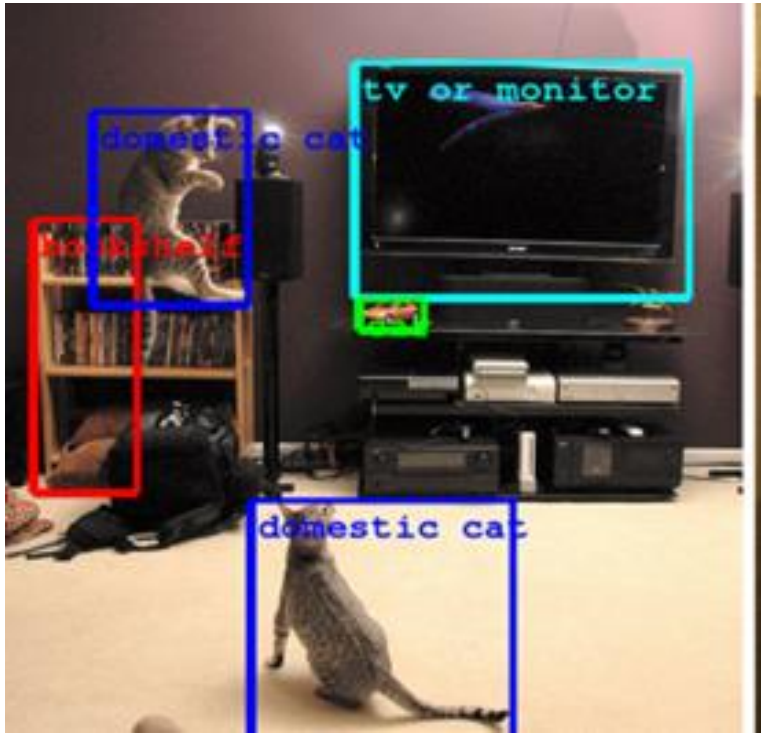
  Example: $P(\text{chips} \mid \text{beer}) = 0.7$

Market-Basket transactions

Object recognition

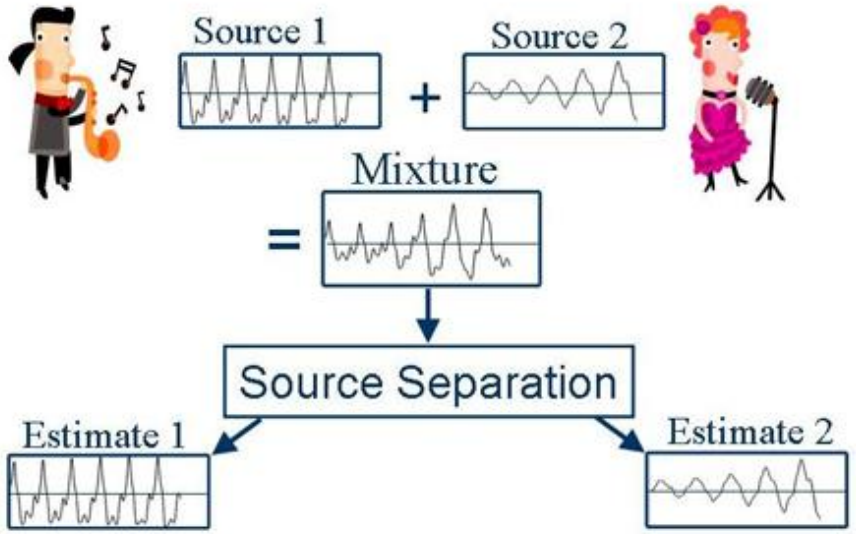
Image object recognition

- Recognize objects in the image



Blind source separation

- Recognize source/s in a mixed music signal



Reinforcement learning

- Mimics intelligent system
- Observers interaction of environment and system actions
- Optimize goal/rewards
- Continuous, self-learning
- It is not a method but a process as a whole to build knowledge
- Corrective action even if system sees a new situation

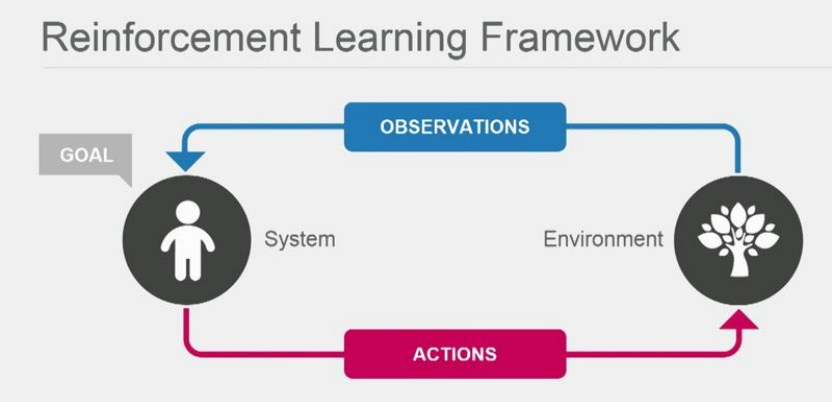


Image Source: http://www.33rdsquare.com/2015/05/demis-hassabis-theory-of-everything.html

- Applications
  - Decision making
  - Robot, Chess machine
  - Optimal control theory
  - Stochastic approximations

Machine Learning and Traditional Statistics

Machine Learning

- Emphasize predictions, usually no super-population model specified
- Evaluates results via prediction performance
- Concern for overfitting but not model complexity per se

Traditional Statistics

- Emphasizes super-population inference
- Focuses on a-priori hypotheses
- Simpler models preferred over complex ones (parsimony), even if the more complex models perform slightly better

Continued…

Machine Learning and Traditional Statistics

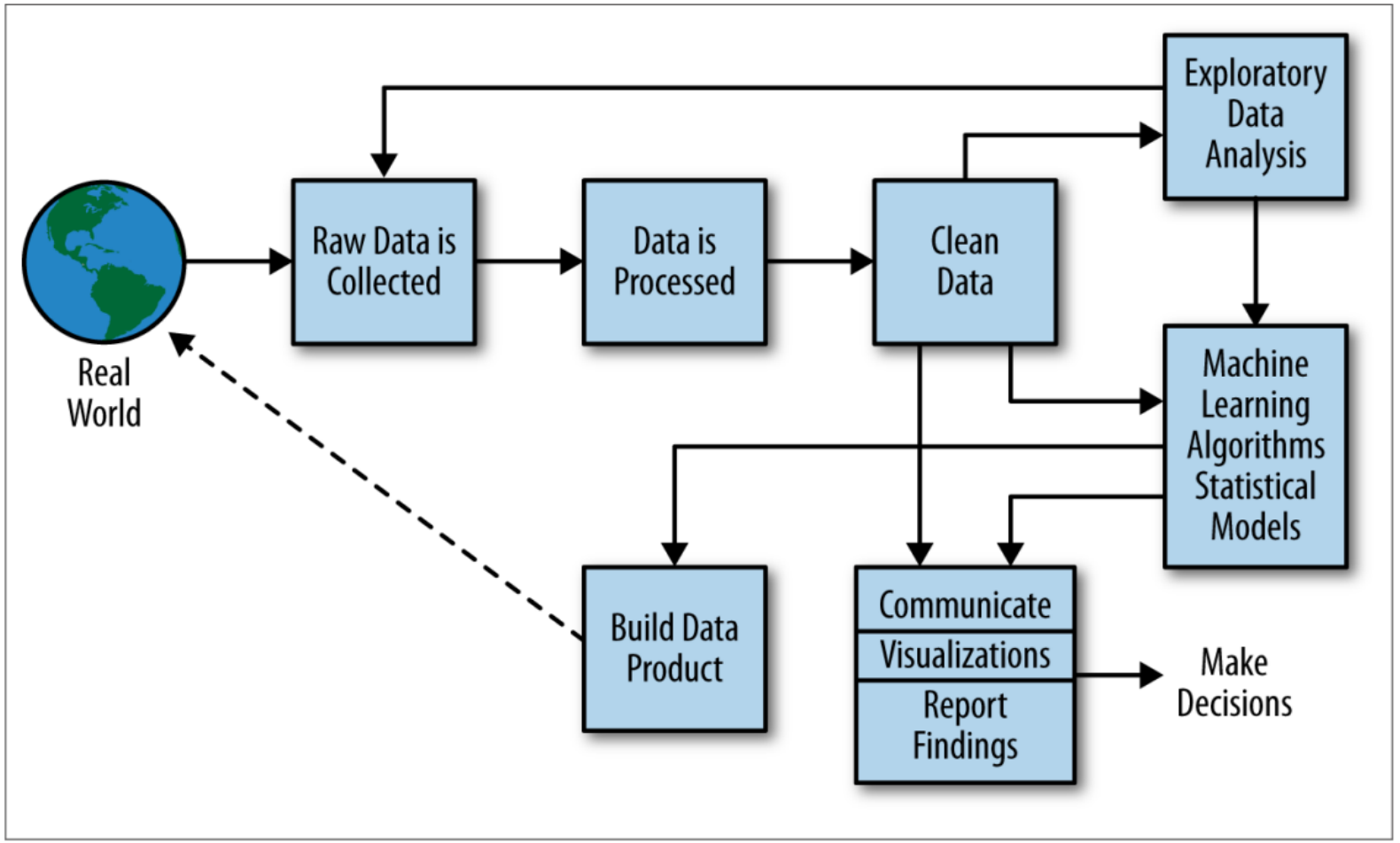
Machine Learning

- Emphasis on performance
- Generalizability is obtained through performance on novel datasets
- Concern over performance and robustness

Traditional Statistics

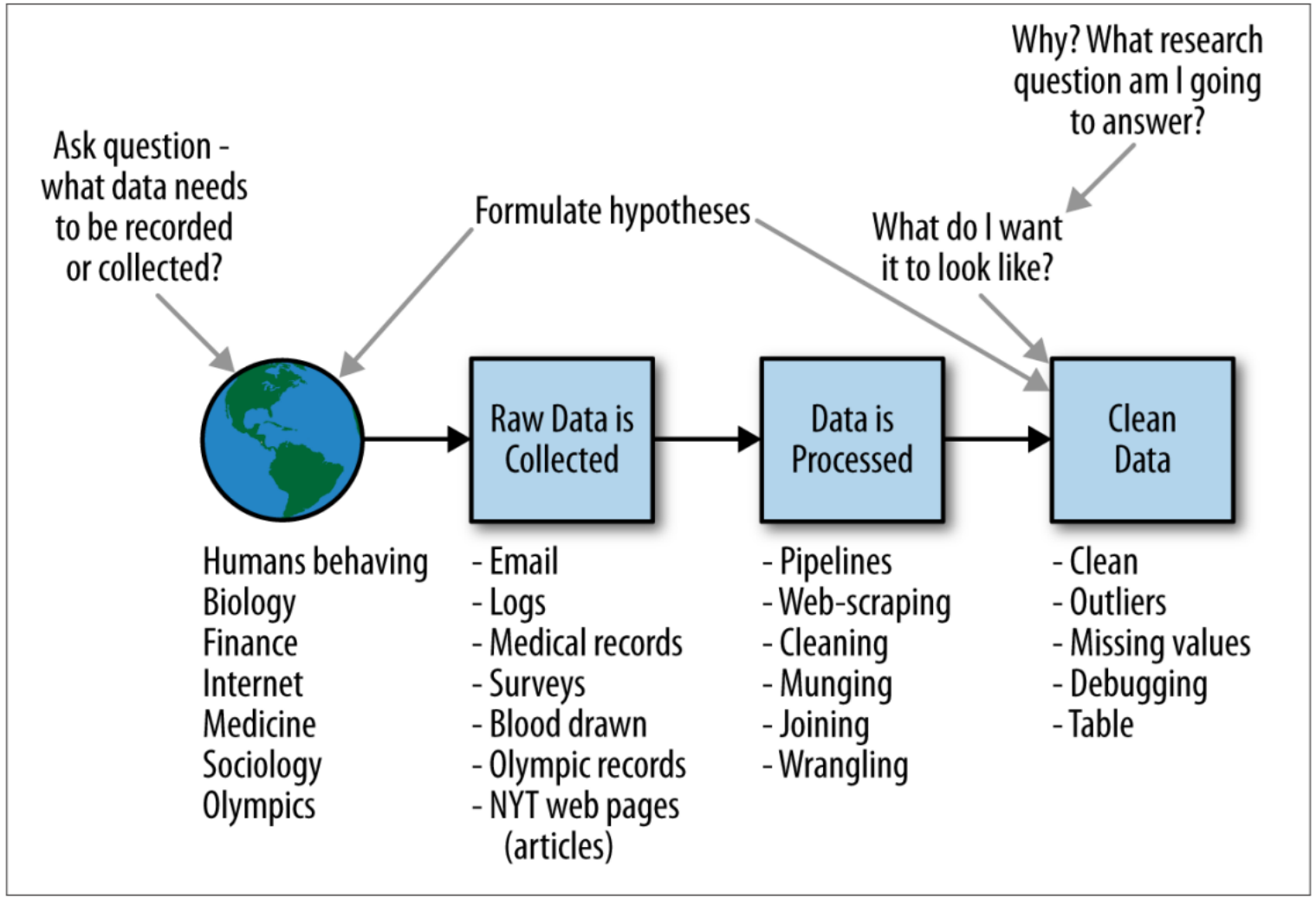
- Emphasis on parameter interpretability
- Statistical modelling or sampling assumptions connects data to a population of interest
- Concern over assumptions and robustness

Machine learning design study: Data science process



Source: "Doing data science" by Schutt, R and O'Neil, C

Machine learning design study: Data scientist role



Source: "Doing data science" by Schutt, R and O'Neil, C

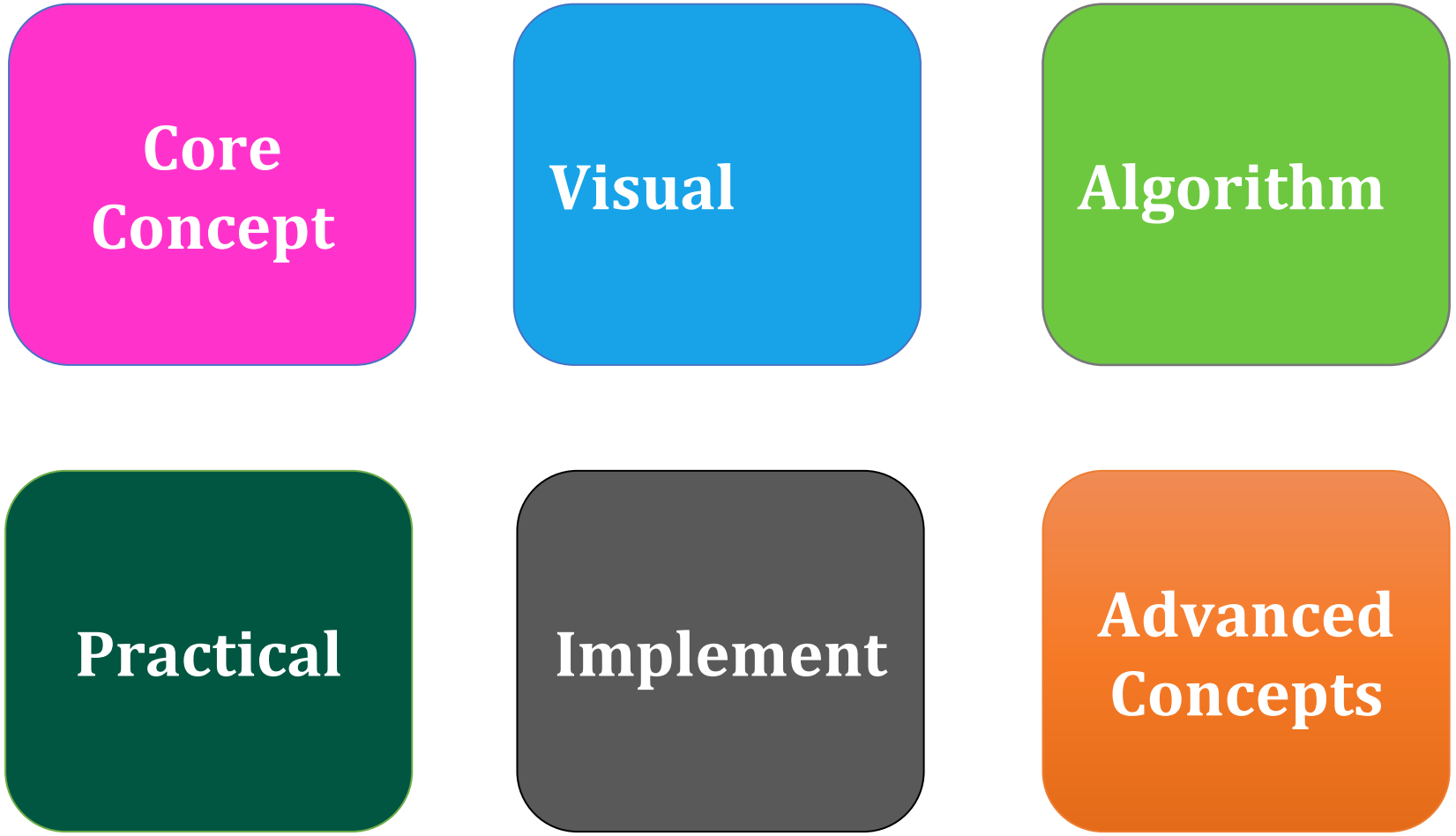
Course content: Machine learning Algorithms

	Supervised Learning	Unsupervised Learning

Continuous	• Regression
	  • Ordinary Least Squares
	  • Logistic
	• Decision Trees
	• Random Forests
		• Clustering & Dimensionality Reduction
		  • K-means
		  • SVD
		  • PCA
		• Association Analysis
		  • Apriori
		  • Market basket analysis
		• Hidden Markov Model

Categorical	• Classification
	  • K-Nearest Neighbour (KNN)
	  • Logistic Regression
	  • Trees
	  • Support Vector Machine (SVM)
	  • Naïve-Bayes	

Course philosophy: Always use case study and ..



Resources: Datasets

- UCI Repository: http://www.ics.uci.edu/~mlearn/MLRepository.html
- UCI KDD Archive: http://kdd.ics.uci.edu/summary.data.application.html
- Statlib: http://lib.stat.cmu.edu/
- Delve: http://www.cs.utoronto.ca/~delve/

Resources: Journals

- Journal of Machine Learning Research www.jmlr.org
- Machine Learning
- IEEE Transactions on Neural Networks
- IEEE Transactions on Pattern Analysis and Machine Intelligence
- Annals of Statistics
- Journal of the American Statistical Association
- ...

Resources: Conferences

- International Conference on Machine Learning (ICML)
- European Conference on Machine Learning (ECML)
- Neural Information Processing Systems (NIPS)
- Computational Learning
- International Joint Conference on Artificial Intelligence (IJCAI)
- ACM SIGKDD Conference on Knowledge Discovery and Data Mining (KDD)
- IEEE Int. Conf. on Data Mining (ICDM)

Summary

- We had a broad overview of
  - machine learning philosophy
  - Different algorithms
  - Application fields of machine learning
  - Examples
- Provided links to datasets, journals and conferences related to the machine learning.
- We also introduced
  - Course content
  - recommended approach to master machine learning techniques

Thank you!