Mahindra École Centrale
COLLEGE OF ENGINEERING

Introduction to Machine Learning

Venkateswara

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- Course Instructors
  - Venkateswara Rao Kagita
  - Prof. Arya Kumar Battacharya

Marks Distribution

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• Mid 1	20 %
• Mid 2	20 %
• Assignments	10 %
• Project and poster presentation	20 %
• End-semester exam	30 %

Reference Books

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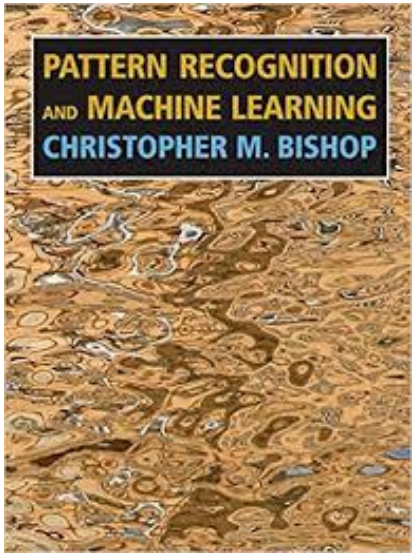

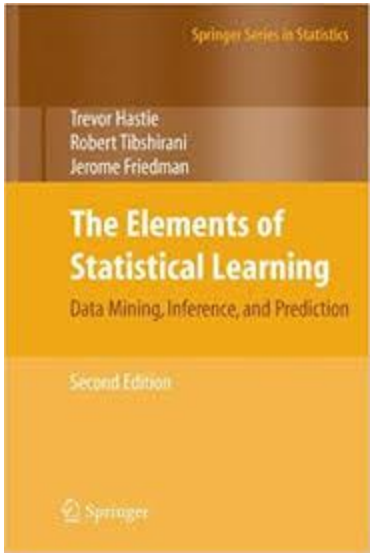

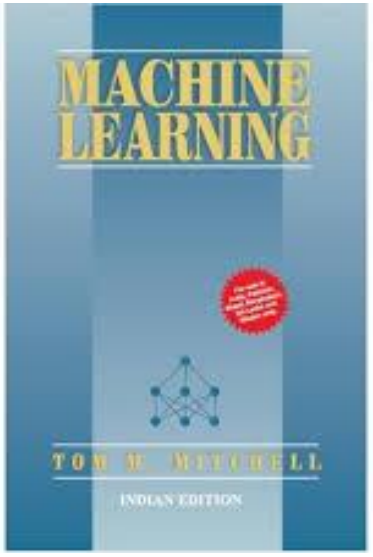

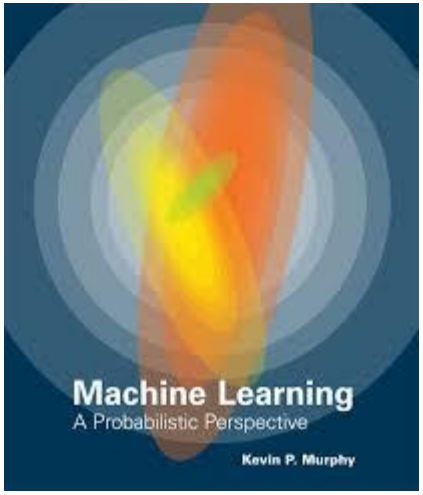

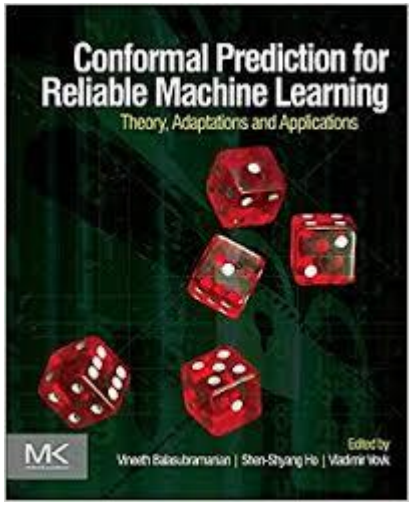

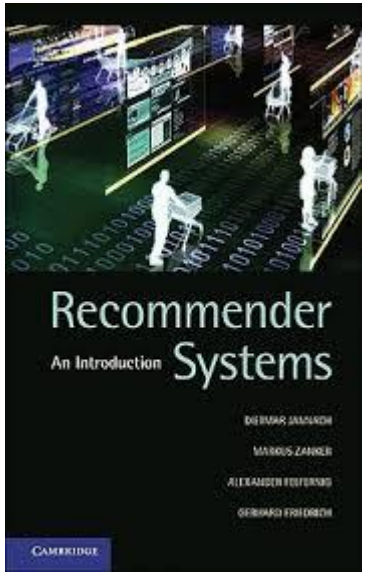

Syllabus/Schedule

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Topic	Instructor	#hours	Source(s)
Introduction, types of learning	Venkat	1	[1], [2],
Regression, Linear, Ridge, Lasso, Polynomial and ElasticNet Regression Techniques	Venkat	2/3	[1], [3],
Classification, Logistic Regression	Venkat	1	[1], [3]
SVM, Kernal SVM, and Multi-class SVM	Venkat	3	[1], [3],
Decision trees and Random forests	Venkat	2/3	[5], [1]
K-NN and feature scaling techniques	Venkat	1	[5], [3]
Ensemble approaches, Bagging	Venkat	1	[1], [6]
Boosting, Ada, and Gradient boosting	Venkat	2	[1], [6]
Bias and Variance	Venkat	1	[1], [6],[3]
Error representation, Gradient and Stochastic gradient descent	Venkat	1	[1], [3],

Syllabus/Schedule

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Topic	Instructor	#hours	Source(s)
Evolutionary and Swarm Algo's: GA, DE, PSO	Prof. Arya	2	
Genetic Programming – S/W for automatic synthesis of prog's. Introduction to game theory	Prof. Arya	2	
K-means and Fuzzy C-Means clustering	Prof. Arya	1	
Dimensionality reduction, PCA	Venkat	1	[1], [3],
LDA, SVD	Venkat	1/2	
Feature extraction from multi-media data	Venkat	1	
Uncertainty, Bayes theorem, Naïve Bayes, Bayesian networks and problems	Venkat	2/3	[1], [4],
Markov and Hidden Markov models, and problems	Venkat	1/2	[4],
Fuzzy logic and applications	Venkat	1	
Expectation, Maximum likelihood, KL-Divergence (if time permits)	Venkat	1	[1], [4]

Syllabus/Schedule

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Topic	Instructor	#hours	Source(s)
Neural Networks basics	Venkat	2	[1], [5], [6]
Introduction to Multi-label Classification*	Venkat	1	[7]
Introduction to Transfer Learning *	Venkat	1	
Introduction to Conformal Prediction	Venkat	2	[8]
Introduction to Recommender Systems	Venkat	3	[9]
Statistical Evaluation of Models and Algorithms	Venkat	1	[6]

*-We will cover these topics if time permits

Total number of hours: At least 38 and At most 47

Learning ?

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- We say, we are learning something when the performance is improving with our experience.
- Learning = Improving with experience at some task.
- Machine Learning?
  - Improve over task *T*.
  - With respect to performance measure *P*.
  - Based on experience *E*.
- What are *T*, *P*, *E* ? How do we formulate a machine learning problem ?

Machine Learning

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- Handwriting recognition
  - *T* – classifying handwritten words within images.
  - *P* – percent of words correctly classified.
  - *E* – database of handwritten words with given classifications.
- Robot Driving
  - T – Driving on public four-lane highways using vision sensors.
  - P – Average distance traveled before an error (human supervisor).
  - E – sequences of images and steering commands recorded observing a human driver.

- Machine learning is an application of artificial intelligence (AI) that provides systems the ability to automatically learn and improve from experience without being explicitly programmed.

- **The primary aim is to allow the computers learn automatically** without human intervention or assistance and adjust actions accordingly.

Why is Machine Learning Important?

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- Data is the lifeblood of all business.
- Data-driven decisions increasingly make the difference between keeping up with competition or falling further behind.
- Machine learning can be the key to unlocking the value of corporate and customer data and enacting decisions that keep a company ahead of the competition.

- **Machine Learning Use Cases**
- **Manufacturing.** Predictive maintenance and condition monitoring
- **Retail.** Upselling and cross-channel marketing
- **Healthcare and life sciences.** Disease identification and risk satisfaction
- **Travel and hospitality.** Dynamic pricing
- **Financial services.** Risk analytics and regulation
- **Energy.** Energy demand and supply optimization
- And many more.

Types of ML algorithms

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- **Supervised learning**
- **Unsupervised Learning**
- **Semi-supervised Learning**
- **Reinforcement Learning**

Supervised Learning

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- Applications in which the data comprises examples of the input variables along with their corresponding target values/vectors are known as supervised learning problems.

- Supervised learning algorithms try to model relationships between the target prediction output (y) and the input features (**x**) such that we can predict the output values for new data based on those relationships.

- **Problem:** Given a the training set of pairs $(x_1, y_1), (x_2, y_2), \ldots, (x_n, y_n)$, where $\mathrm{x_i} \in R^d$ and $\mathrm{y_i}$ is a target variable, the task is to predict for $x_{n+j}, \mathrm{j} \geq 1$.

- The main types of supervised learning problems include regression and classification problems

- List of Common Algorithms include Nearest Neighbor, Naive Bayes, Decision Trees, Linear Regression, Support Vector Machines (SVM), etc.

Unsupervised Learning

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- The computer is trained with unlabeled data.
- Useful in cases where the human expert doesn't know what to look for in the data.
- Family of machine learning algorithms which are mainly used in pattern detection and descriptive modeling.
- No output categories or labels here based on which the algorithm can try to model relationships.
- These algorithms try to use techniques on the input data to mine for rules, detect patterns, and summarize and group the data points which helps in deriving meaningful insights and describe the data better to the users.
- The main types of unsupervised learning algorithms include Clustering algorithms and Association rule learning algorithms.

Semi-supervised Learning

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- Semi-supervised learning falls in between previous two learning techniques.
- Few instances have labels and few does not have.
- Why ?
  - In many practical situations, the cost to label is quite high.
  - Requires human expertise.
- So, in the absence of labels in the majority of the observations but present in few, semi-supervised algorithms are the best candidates for the model building.
- These methods exploit the idea that even though the group memberships of the unlabeled data are unknown, this data carries important information about the group parameters.
- The main types of semi-supervised learning algorithms include semi-supervised clustering and semi-supervised classification.

Reinforcement Learning

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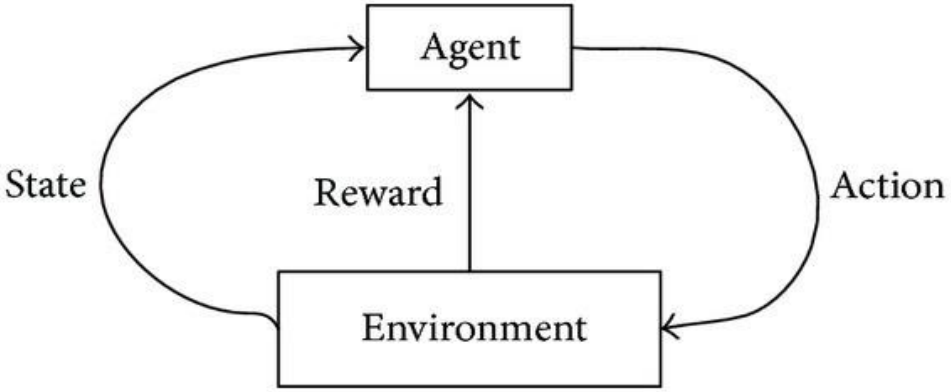
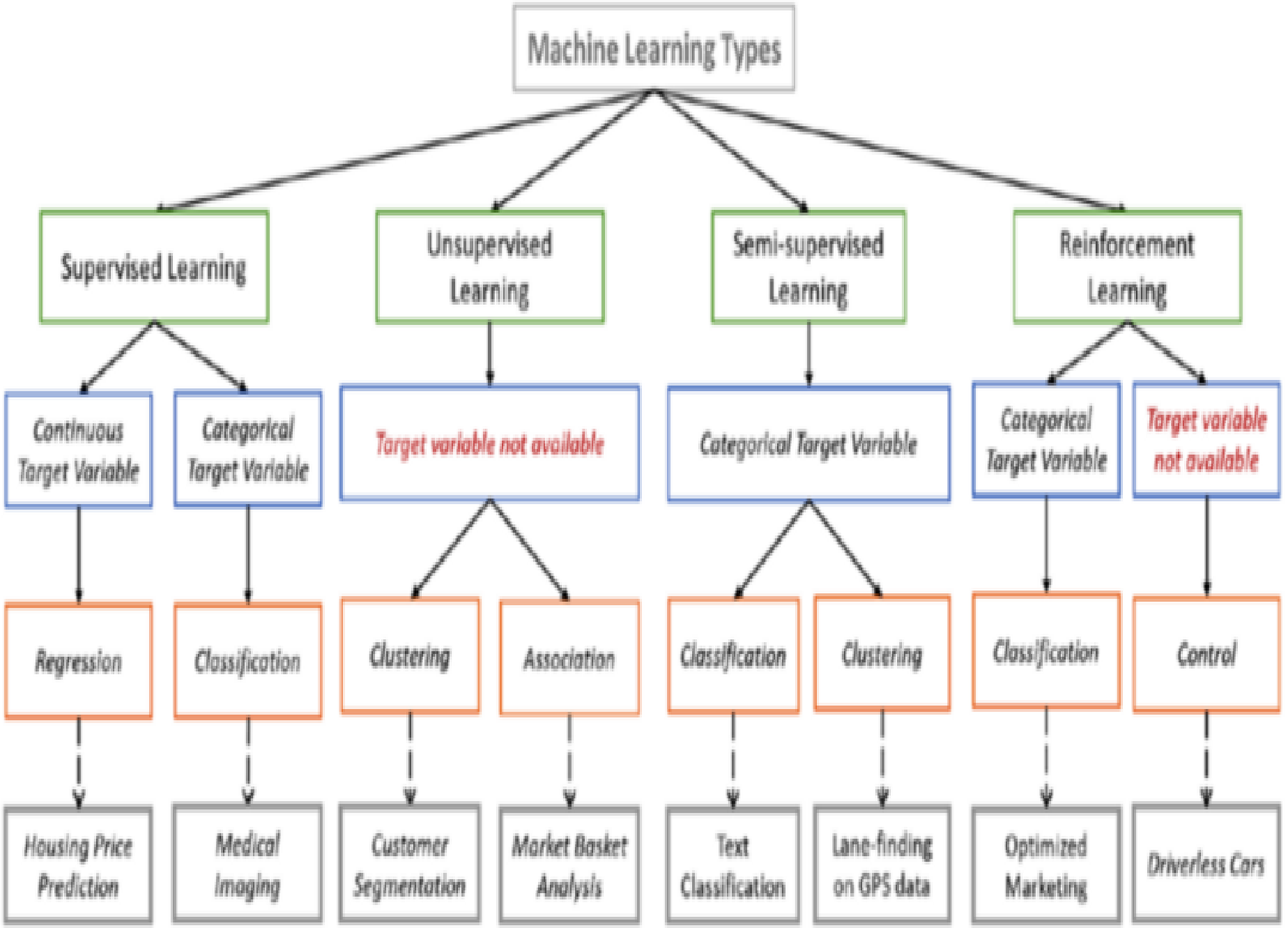
- Aims at using observations gathered from the interaction with the environment to take actions that would maximize the reward or minimize the risk.
- Reinforcement learning algorithm (called the agent) continuously learns from the environment in an iterative fashion.
- It allows machines and software agents to automatically determine the ideal behavior within a specific context, in order to maximize its performance.
- Simple reward feedback is required for the agent to learn its behavior; this is known as the reinforcement signal.
- Reinforcement Learning is defined by a specific type of problem, and all its solutions are classed as Reinforcement Learning algorithms.
- In the problem, an agent is supposed to decide the best action to select based on his current state.

Reinforcement Learning



- Input state is observed by the agent.
- Decision making function is used to make the agent perform an action.
- After the action is performed, the agent receives reward or reinforcement from the environment.
- The state-action pair information about the reward is stored.
- List of Common Algorithms: Q-Learning, Temporal Difference (TD), Deep Adversarial Networks.
- Some applications of the reinforcement learning algorithms are computer played board games (Chess, Go), robotic hands, and self-driving cars.


Machine Learning Types
Supervised Learning
Unsupervised Learning
Semi-supervised Learning
Reinforcement Learning
Continuous Target Variable
Categorical Target Variable
Target variable not available
Categorical Target Variable
Categorical Target Variable
Target variable not available
Regression
Classification
Clustering
Association
Classification
Clustering
Classification
Control
Housing Price Prediction
Medical Imaging
Customer Segmentation
Market Basket Analysis
Text Classification
Lane-finding on GPS data
Optimized Marketing
Driverless Cars

References

1) Bishop, Christopher M. "Pattern recognition and machine learning, 2006." Spinger 60.1 (2012): 78-78.
2) https://towardsdatascience.com/types-of-machine-learning-algorithms-you-should-know-953a08248861
3) http://www.holehouse.org/mlclass/
4) urphy, Kevin P. Machine learning: a probabilistic perspective. MIT press, 2012.
5) Mitchell, Tom M. "Machine learning. 1997." *Burr Ridge, IL: McGraw Hill* 45.37 (1997).
6) Trevor Hastie, Robert Tibshirani, Jerome Friedman, The Elements of Statistical Learning: Data Mining, Inference, and Prediction. Springer Series in Statistics.
7) De Carvalho, Andre & Freitas, Alex. (2009). A Tutorial on Multi-label Classification Techniques.
8) Balasubramanian, Vineeth, Shen-Shyang Ho, and Vladimir Vovk, eds. Conformal prediction for reliable machine learning: theory, adaptations and applications. Newnes, 2014.
9) Ricci, Francesco, Lior Rokach, and Bracha Shapira. "Recommender systems: introduction and challenges." Recommender systems handbook. Springer, Boston, MA, 2015. 1-34.