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Machine Learning Basics

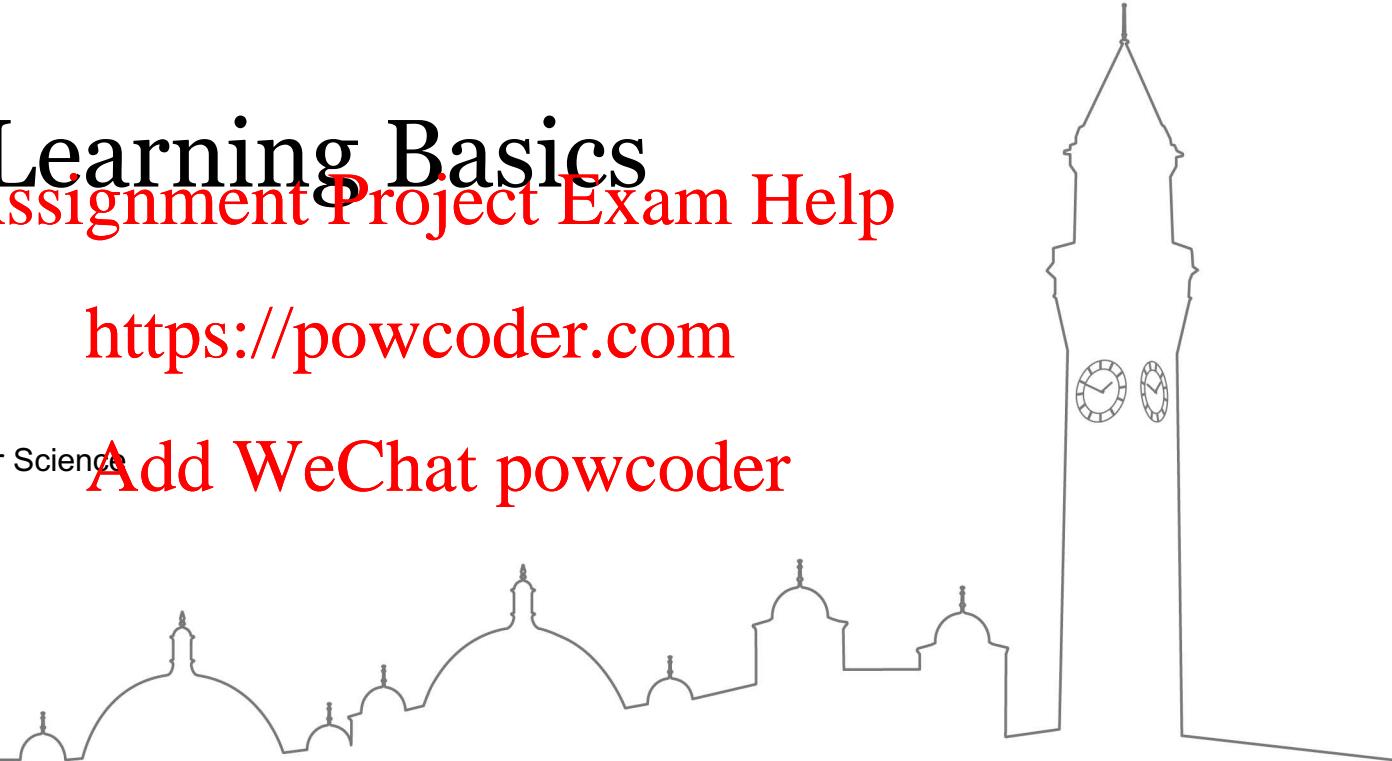
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Lecture Overview

- What is machine learning?
- Categories of machine learning
- How does machine learning work?
Supervised learning workflow
- Machine learning algorithms
- Model evaluation



What is machine learning?

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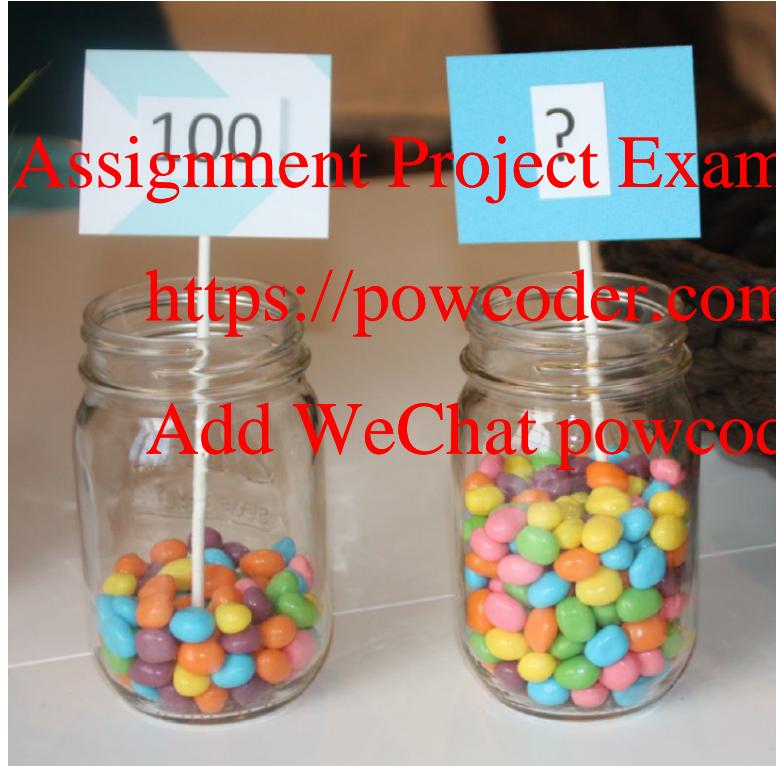
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What is machine learning?



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What is machine learning?



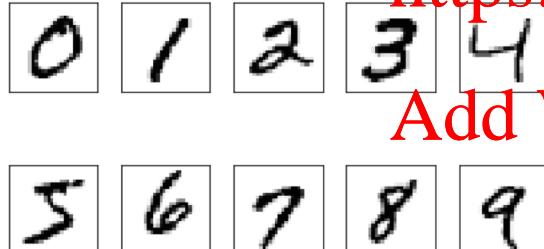
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What is machine learning?

"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."

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-- Tom Mitchell, Professor at Carnegie Mellon University



Examples of digits from
the MNIST database

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- Task T: classifying handwritten digits from images
- Performance measure P : percentage of digits classified correctly
- Training experience E: dataset of images of handwritten digits



Applications of machine learning

- Email spam detection
- Face detection and matching in smart phones
- Stock predictions
- Product recommendations (e.g. Netflix, amazon)
- Sentiment analysis
- Self-driving cars
- Post office (e.g. sorting letter by post code)
- Medical diagnoses
- Etc.

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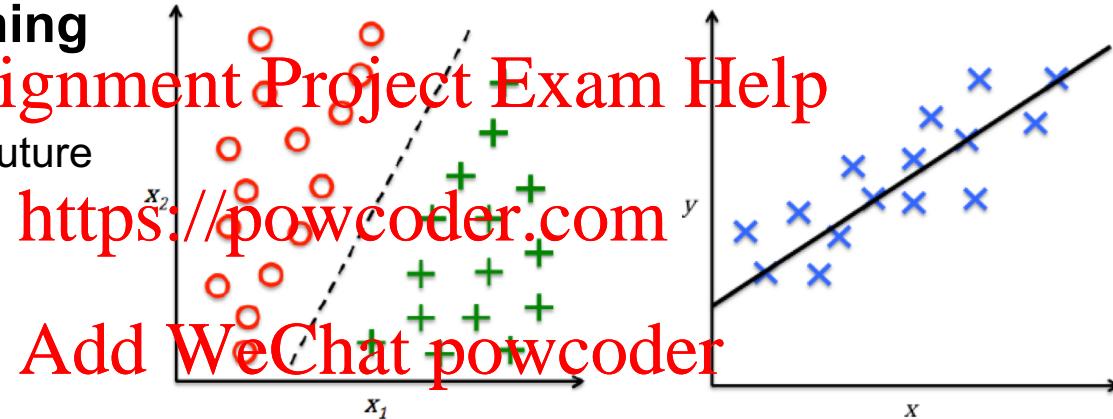
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Categories of machine learning

- **Supervised learning**

- Labeled data
- Predict outcome/future



Classification

predict categorical class labels
e.g. the handwritten digit (multi-class)

Regression

Prediction of continuous outcomes
e.g. students' grade scores

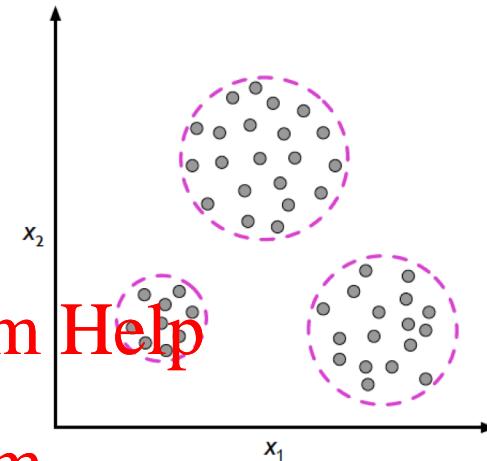
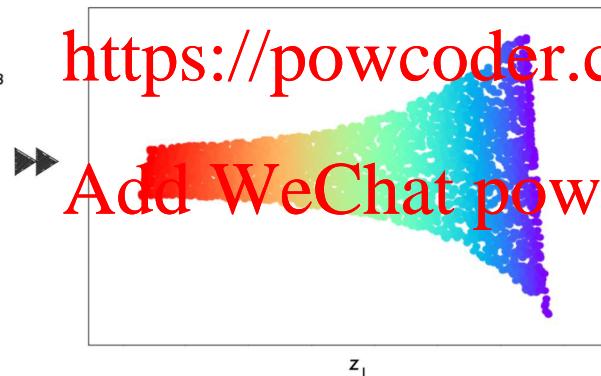
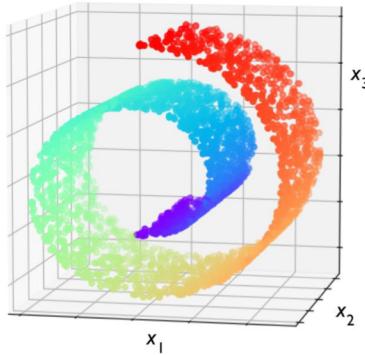


Categories of machine learning

- **Unsupervised learning**

- No labels/targets
- Find hidden structure/insights in data

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Clustering

Objectives within a cluster share a degree of similarity.
e.g. product recommendation

Dimensionality Reduction

- reduce data sparsity
- reduce computational cost



Categories of machine learning

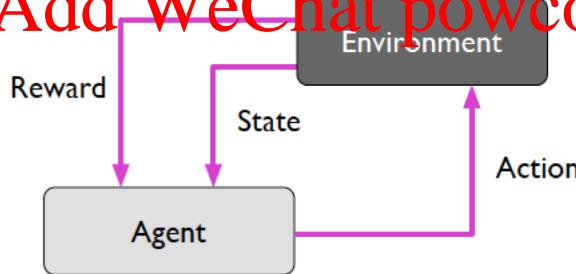
- **Reinforcement learning**

- Decision process
- Reward system
- Learn series of actions
- Applications: chess, video games, some robots, self-driving cars

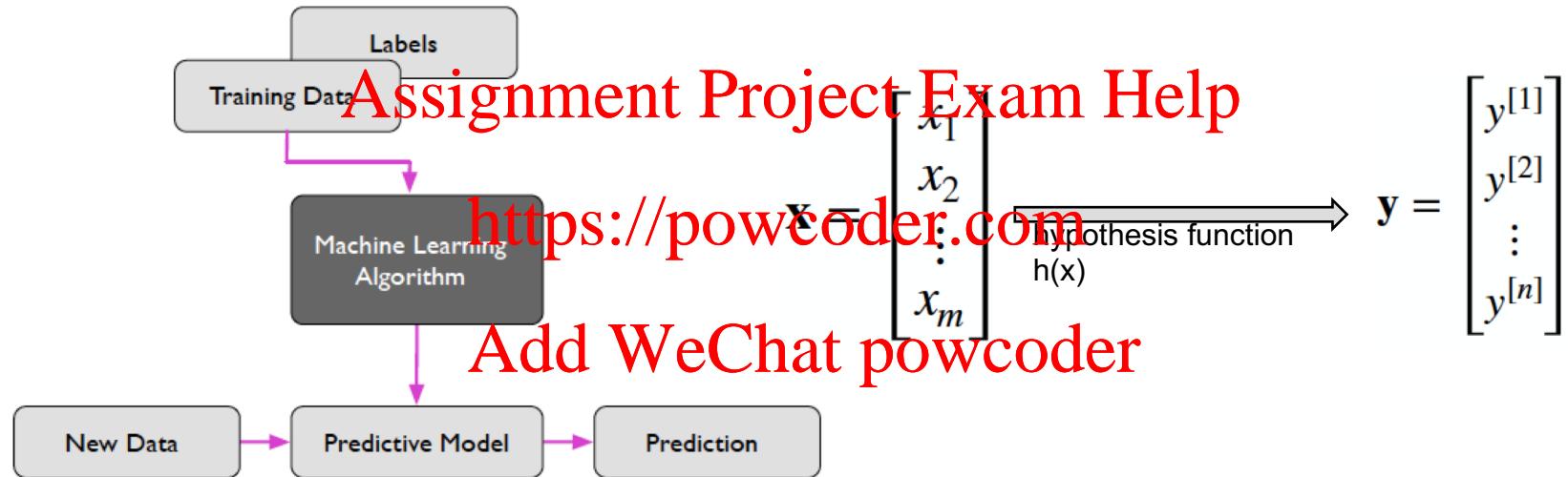
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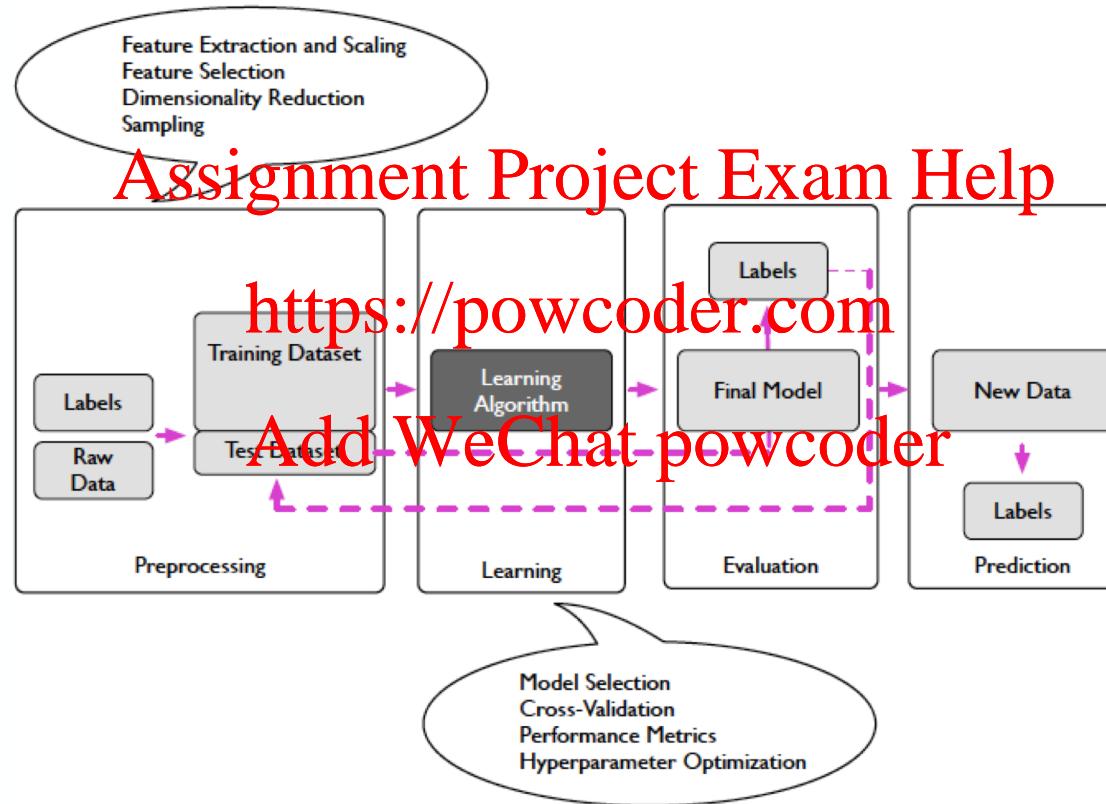
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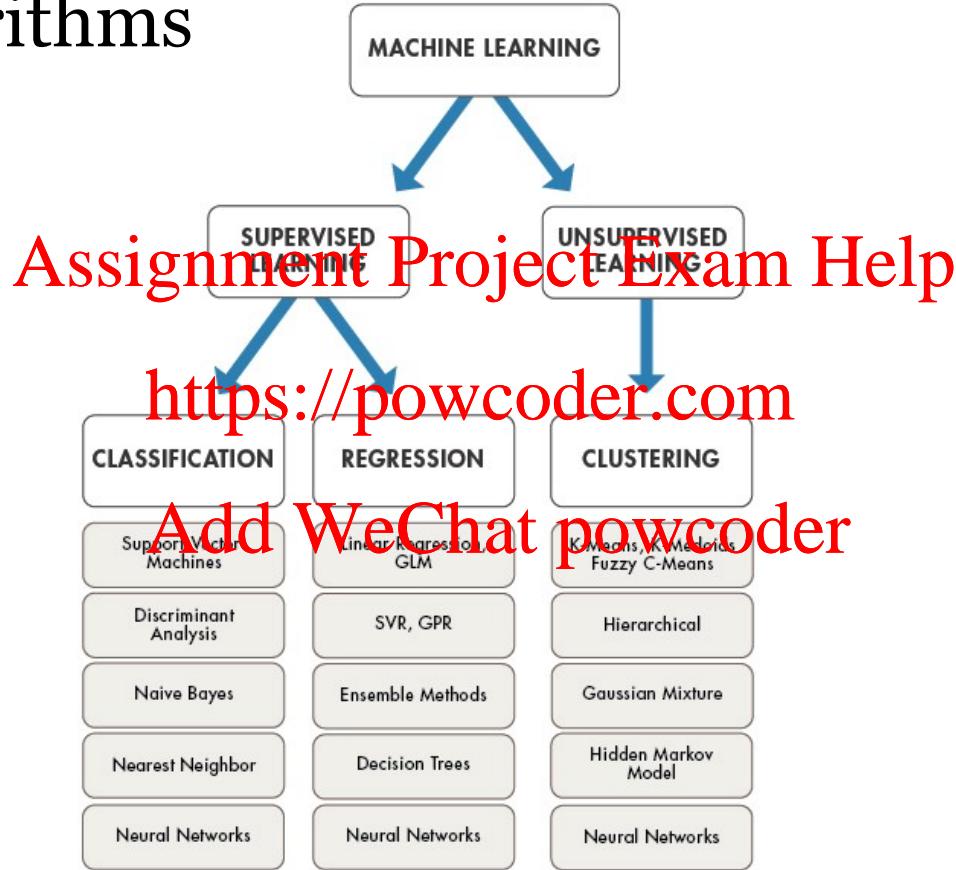
Supervised learning workflow



Supervised learning workflow



Some algorithms



Model evaluation – misclassification error

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 $L(\hat{y}, y) = \begin{cases} 0 & \text{if } \hat{y} = y \\ 1 & \text{if } \hat{y} \neq y \end{cases}$
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$$ERR_{\mathcal{D}_{\text{test}}} = \frac{1}{n} \sum_{i=1}^n L(\hat{y}^{[i]}, y^{[i]})$$



Model evaluation – other metrics

- Accuracy (1-Error)
- ROC, AUC
- Precision, Recall
- F-measure, G-mean
- (Cross) Entropy
- Likelihood
- Squared Error/MSE
- R^2
- etc.

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Summary

- Major concepts of machine learning at a high level.
- Different types of machine learning tasks.
- The major steps of supervised learning: the workflow
- Machine learning algorithms and evaluation

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Learning Resources

- Free machine learning eBooks
https://github.com/rasbt/pattern_classification/blob/master/resources/machine_learning_ebooks.md
- 10-min Video by Kevin Markham:
<https://www.youtube.com/watch?v=elojMnjn4kk&list=PL5-da3qGB5ICeMbQuqbbC1UWCS6DVBwA&index=1>
If you cannot access the video https://github.com/justmarkham/scikit-learn-videos/blob/master/01_machine_learning_intro.ipynb
- Recommended reading:
 - Raschka and Mirjalili: Python Machine Learning, 2nd ed., Ch 1
 - Trevor Hastie, Robert Tibshirani, and Jerome Friedman: The Elements of Statistical Learning, Ch 01
https://web.stanford.edu/~hastie/ElemStatLearn/printings/ESLII_print12.pdf

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If you cannot access the video https://github.com/justmarkham/scikit-learn-videos/blob/master/01_machine_learning_intro.ipynb

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