Fundamentals of Machine Learning



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Research Interests:

- Big Data, Predictive & Adaptive Analytics
- Artificial Intelligence, Machine Learning
- Performance Modelling and Analysis
- Information Assurance and Cybersecurity.

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Objectives

Objectives

- What Machine Learning is
- When to Leverage Machine learning
- Machine Learning algorithms
- Machine Learning methodology

What is Machine Learning



Machines are taking over!

But Seriously, What is Machine Learning?



"Machine Learning is the science of getting computers to act without being explicitly programmed." – Andrew Ng (Coursera)

"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 task in T, as measured by P, improves with experience E." – Tom M. Mitchell (1997)

What are AI and ML?

- Artificial Intelligence (AI) is a branch or Computer Science that uses algorithms and techniques to mimic human intelligence
- Machine Learning (ML) is one of several AI techniques for sophisticated cognitive tasks



Machine Learning

• Machine Learning is a particularly interesting technique because it represents a paradigm shift within AI

Traditional AI techniques



- Static hard-coded set of steps and scenarios
- Rule Based expert knowledge
- No generalization handling special cases is difficult



- **Dynamic** evolves with data, finds new patterns
- Data driven discovers knowledge
- Generalization adapts to new situations and special cases

Machine Learning - Example

• Example - Excelling at playing the game of chess



Symbolic Al

Mathematical/Statistical AI

Machine Learning Approach

"Let us sit down with the world's best chess player, Ekpe Okorafor, and put his knowledge into a computer program" "Let us simulate all the different possible moves and the associated outcomes at each single step and go with the most likely to win" "Let us show millions of examples or real life and simulated games (won and lost) to the program, and let it learn from experience"

Machine Learning – When to use

 Machine learning is particularly good at solving 2 types of problems where other AI techniques fail



Machine Learning – Breaking it down

Supervised and Unsupervised Learning

• **Supervised learning** - we already know the answers we want (found in past or completed data).



• **Unsupervised learning** - we want to find unknown structures or trends.

Supervised Learning





Supervised and Unsupervised Learning

Supervised Learning:

Predicting values. **Known** targets. User inputs correct answers to learn from. Machine uses the information to guess new answers.

> REGRESSION: Estimate continuous values (Real-valued output)

CLASSIFICATION: Identify a unique class (Discrete values, Boolean, Categories)

Unsupervised Learning:

Search for structure in data. Unknown targets. User inputs data with undefined answers. Machine finds useful information hidden in data

CLUSTER ANALYSIS: Group into sets **DENSITY ESTIMATION:** Approximate distribution **DENSITY REDUCTION:** Select relevant variables

Supervised and Unsupervised Learning

Supervised Learning:

Regression

- Linear Regression
- Ordinary Least Squares Regression
- LOESS (Local Regression)
- Neural Networks

Classification

- Decision Trees
- K-Nearest Neighbors
- Support Vector Machine
- Logistic Regression
- Naïve Bayes
- Random Forests

Unsupervised Learning:

Cluster Analysis

- K-Means Clustering
- Hierarchical Clustering

Dimension Reduction

- Principal Component Analysis (PCA)
- Linear Discriminant Analysis (LDA)

What About Reinforcement Learning?



Machine Learning Application – Recommender Systems

 Recommender systems deal with making recommendations based upon previously collected data and leveraging ML techniques.



Non-content Based (No Features) Collaborative Filtering

Matrix Factorization



Train & Test Methodology

 ML techniques use a train + test system (commonly known as crossvalidation) before using findings in real situations.

whatever necessary



Additional Resources

- ML course at Coursera: https://www.coursera.org/learn/machine-learning/
- Toolbox scikit-learn: <u>http://scikit-learn.org/stable/user_guide.html</u>
- Caret Package: http://topepo.github.io/caret/index.html
- Python and R codes: <u>http://www.analyticsvidhya.com/blog/2015/09/full-</u> <u>cheatsheet-machine-learning-algorithms/</u>
- Introductory Primer to Machine Learning: <u>http://www.toptal.com/machine-learning/machine-learning-theory-an-introductory-primer</u>

Summary

- Machine Learning (ML) is one of several AI techniques for sophisticated cognitive tasks
- Machine Learning is a particularly interesting technique because it represents a paradigm shift within AI
- Machine learning is particularly good at solving 2 types of problems where other AI techniques fail
 - Tasks programmers can't describe
 - Complex multidimensional problems that can't be solved by numerical reasoning
- Machine Learning employs supervised and unsupervised learning approaches
- ML techniques use a train + test system (commonly known as crossvalidation) before using findings in real situations.