Applied Machine Learning

Lecture 1
Introduction to Machine Learning

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Learning outcomes

1. Have a good understanding of the fundamental issues and challenges of machine learning.
2. Have an understanding of the strengths and weaknesses of various machine learning approaches.
3. Be able to design and implement various machine learning algorithms in a range of real-world applications.

Learning steps of this course

Course Outline

1. Introduction to Machine Learning
2. Linear Regression single var. (Gradient Descent)
3. Linear Regression multiple vars + Polynomial
4. Workshop 1: Simple ML app (Train and deploy your own model on web application), Introduction to Kaggle
5. Bayes Classification
6. Logistic regression
7. Regularization: Ridge, Lasso, and Elastic Net
8. Workshop 2: Evaluation

Midterm exams

9. Decision Tree & k-NN
10. Neural network
11. SVM
12. Workshop 3
13. K-mean
14. Dimensionality reduction
15. Workshop 4

Final exam

Week1 Outline

1. Introduction to Machine Learning
2. Types of Machine Learning
   (1) Supervised learning
   (2) Unsupervised learning
   (3) Reinforcement learning
3. Machine learning Applications
4. Machine learning process

1. Introduction to Machine Learning

Machine Learning definition

https://machinelearningmastery.com/basic-concepts-in-machine-learning/

Machine Learning definition

- Arthur Samuel (1959). Machine Learning: Field of study that gives computers the ability to learn without being explicitly programmed.

Machine Learning definition

- Tom Mitchell (1998) Well-posed Learning Problem:

- A computer program is said to *learn* from experience E with respect to some task T and some performance measure P, if its performance on T, as measured by P, improves with experience E.

Machine Learning definition

- Task T: classifying handwritten digits from images
- Training experience E: dataset of digits given classifications, e.g., MNIST[4]
- Performance measure P : percentage of digits classified correctly

Image captured from “STAT 479: Machine Learning Lecture Notes Sebastian Raschka”

"A computer program is said to *learn* from experience E with respect to some task T and some performance measure P, if its performance on T, as measured by P, improves with experience E."

T: Playing checkers
P: Percentage of games won against an arbitrary opponent
E: Playing practice games against itself

T: Driving on four-lane highways using vision sensors
P: Average distance traveled before a human-judged error
E: A sequence of images and steering commands recorded while observing a human driver.

T: Categorize email messages as spam or legitimate.
P: Percentage of email messages correctly classified.
E: Database of emails, some with human-given labels

Types of Machine Learning

- **Supervised learning**
  - Given: training data + desired outputs (labels)
- **Unsupervised learning**
  - Given: training data (without desired outputs)
- **Reinforcement learning**
  - Rewards from sequence of actions

Based on slide by Pedro Domingos

2.1 Supervised learning

Supervised Learning: Regression

- Given $(x_1, y_1), (x_2, y_2), \ldots, (x_n, y_n)$
- Learn a function $f(x)$ to predict y given x

  y is real-valued == regression

Data from G. Witt. Journal of Statistics Education, Volume 21, Number 1 (2013)

Supervised Learning: Classification

- Given $(x_1, y_1), (x_2, y_2), \ldots, (x_n, y_n)$
- Learn a function $f(x)$ to predict y given x

  y is categorical == classification

Based on example by Andrew Ng

2.2 Unsupervised learning

Unsupervised Learning

- Given $x_1, x_2, \ldots, x_n$ (without labels)
- Output hidden structure behind the x's
  - E.g., clustering

Organize computing clusters

Social network analysis

Market segmentation

Astronomical data analysis

2.3 Reinforcement learning

Reinforcement Learning

- Given a sequence of states and actions with rewards, output a policy
  - Policy is a mapping from states → actions that tells you what to do in a given state
- Examples:
  - Credit assignment problem
  - Game playing
  - Robot in a maze
  - Balance a pole on your hand

The Agent-Environment Interface

Agent and environment interact at discrete time steps : $t = 0, 1, 2, \ldots$

Agent observes state at step t: $s_t \in S$

produces action at step t: $a_t \in A(s_t)$

gets resulting reward : $r_{t+1} \in \Re$

and resulting next state : s_{t+1}

Slide credit: Sutton & Barto

Reinforcement Learning

https://www.youtube.com/watch?v=4cgWya-wjgY

3. Machine Learning Applications

- Email spam detection
- Face detection and matching (e.g., iPhone X, Windows laptops, etc.)
- Web search (e.g., DuckDuckGo, Bing, Baidu, Google)
- Sports predictions
- Post office (e.g., sorting letters by zip codes)
- ATMs (e.g., reading checks)
- Credit card fraud
- Stock predictions
- Smart assistants (Apple Siri, Amazon Alexa, . . .)
- Product recommendations (e.g., Walmart, Netflix, Amazon)
- Self-driving cars (e.g., Uber, Tesla)
- Language translation (Google translate)
- Sentiment analysis
- Drug design
- Medical diagnoses
- . . .

Image captured from “STAT 479: Machine Learning Lecture Notes Sebastian Raschka”

Applied machine learning to problems

- What is the desired outcome?
- What could the dataset look like?
- Is this a supervised or unsupervised problem?
- What algorithms would you use?
- How would you measure success?
- What are potential challenges or pitfalls?

Image captured from “STAT 479: Machine Learning Lecture Notes Sebastian Raschka”

ML applications

1. Implement Lab kit for electronics company

https://patents.google.com/?inventor=Ivan+Bachelder

inventor:(Ivan Bachelder)

About 37 results

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Decoding barcodes

US CN DE *HK* • US20190087619A1 • **Ivan Bachelder** • Cognex Corporation

Priority 2014-10-09 • Filed 2018-07-23 • Published 2019-03-21

Systems and methods are provided for decoding barcodes. A scan signal is acquired along a scan through a barcode. A first character unit grid for a unit width pattern within the barcode along the scan is determined. At least one set of sampling coefficients relating the unit width pattern to a …

Methods and apparatuses for detecting classifying and measuring spot defects in …

~~US~~ • US7162073B1 • **Ivan Bachelder** • Cognex Technology And Investment Corporation

Priority 2001-11-30 • Filed 2001-11-30 • Granted 2007-01-09 • Published 2007-01-09

A method is provided for detecting spot defects on an object when an allowable variation (called the "background") in the appearance of the object can be modeled. Methods are also provided for measuring and classifying detected spot defects. An alignment model is used to align the image of the …

Method for generating a focused image of an object

US • US7221805B1 • **Ivan Bachelder** • Cognex Technology And Investment Corporation

Priority 2001-12-21 • Filed 2001-12-21 • Granted 2007-05-22 • Published 2007-05-22

A method is provided for computing a composite image representing a focused image of an object in an application of machine vision in an optical inspection system. An image tessellated into focus regions is evaluated by region for fine feature sharpness. A sharpness image is computed for each …

Method for extracting features from an image using oriented filters

~~US~~ • US6983065B1 • **Ivan Bachelder** • Cognex Technology And Investment Corporation

Priority 2001-12-28 • Filed 2001-12-28 • Granted 2006-01-03 • Published 2006-01-03

A method of analyzing machine vision images to identify low contrast features such as scratches or cracks on the polished ends of optical fibers. A bank of oriented filters having incremental angles of orientation are tuned to respond to the frequency characteristics of oriented scratches or …

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5,532,739;	5,548,326;	5,550,763;	5,581,632;	5,583,954;	5,602,937;	5,640,199;	5,640,200;	5,642,158;
5,657,403;	5,673,334;	5,676,302;	5,717,785;	5,742,037;	5,751,853;	5,754,679;	5,757,956;	5,768,443;
5,793,899;	5,796,868;	5,801,966;	5,805,722;	5,818,443;	5,825,483;	5,825,913;	5,835,622;	5,845,007;
5,850,466;	5,859,923;	5,861,909;	5,861,910;	5,872,870;	5,878,152;	5,900,975;	5,901,241;	5,909,504;
5,912,768;	5,912,984;	5,918,196;	5,933,523;	5,943,441;	5,949,901;	5,949,905;	5,953,130;	5,960,125;
5,964,844;	5,970,166;	5,974,169;	5,978,080;	5,978,081;	5,978,502;	5,978,521;	5,982,395;	5,982,927;
5,987,159;	5,987,172;	5,991,436;	5,995,220;	5,995,648;	6,002,793;	6,005,965;	6,005,978;	6,011,586;
6,025,854;	6,025,905;	6,026,176;	6,035,066;	6,055,328;	6,061,467;	6,061,476;	6,064,388;	6,067,376;
6,067,379;	6,075,881;	6,078,700;	6,092,059;	6,115,042;	6,118,893;	6,124,889;	6,130,959;	6,134,343;
6,137,893;	6,141,009;	6,141,033;	6,148,120;	6,151,406;	6,154,567;	6,157,732;	6,157,751;	6,167,150;
6,170,973;	6,173,070;	6,175,644;	6,175,652;	6,178,262;	6,191,850;	6,215,915;	6,219,461;	6,236,769;
6,240,208;	6,240,218;	6,249,602;	6,252,986;	6,252,986;	6,259,827;	6,269,194;	6,269,197;	6,278,796;
6,282,328;	6,289,117;	6,289,492;	6,297,844;	6,298,149;	6,301,396;	6,307,210;	6,307,588;	6,317,513;
6,324,299;	6,327,393;	6,341,878;	6,353,676;	6,362,875;	6,381,366;	6,381,375;	6,396,942;	6,396,949;
6,408,109;	6,408,429;	6,411,734;	6,421,458;	6,424,734;	6,442,291;	6,457,032;	6,459,820;	6,469,734;
6,483,935;	6,483,950;	6,490,375;	6,490,600;	6,516,092;	6,526,165;	6,531,707;	6,539,107;	6,563,324;
6,567,542;	6,571,006;	6,574,358;	6,577,758;	6,577,775;	6,584,231;	6,587,582;	6,594,623;	6,606,402;
6,608,647;	6,614,926;	6,636,298;	6,639,624;	6,647,132;	6,658,145;	6,671,049;	6,678,394;	6,681,037;
6,681,039;	6,681,151;	6,683,682;	6,684,402;	6,687,402;	6,690,842;	6,697,535;	6,701,005;	6,714,670;

ML Theory: Real-time data analytics

Fast and Accurate Least-Mean-Squares Solvers

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Figure 1: Overview of Algorithm 2 and the steps in Section 1.3. Images left to right: Steps I and II (Partition and sketch steps): A partition of the input weighted set of $n = 48$ points (in blue) into $k = 8$ equal clusters (in circles) whose corresponding means are $\mu_1, \ldots, \mu_8$ (in red). The mean of P (and these means) is x (in green). Step III (Coreset step): Caratheodory (sub)set of $d + 1 = 3$ points (bold red) with corresponding weights (in green) is computed only for these $k = 8 \ll n$ means. Step IV (Recover step): the Caratheodory set is replaced by its corresponding original points (dark blue). The remaining points in P (bright blue) are deleted. Step V (Recursive step): Previous steps are repeated until only $d + 1 = 3$ points remains. This takes $O(\log n)$ iterations for $k = \Theta(d)$.

ML jobs in Thailand

Machine Learning Developer

bit.studio - Entry-Level, Full time - กรุงเทพมหานคร

฿30,000-฿60,000

Responsibilities

- Design and develop applications using machine learning techniques
- Design the interface to other applications using TCP / web sockets
- Design and develop tools for training data collection for ML models
- Evaluate and constantly improves trained models to achieve better accuracy and performance
- Deploying ML applications on EC2 web servers / Google Cloud

Requirement

- Experience working in C/C++ and python
- A passion for building machine learning models
- Strong working knowledge of machine learning algorithms such as classification, regression, clustering, anomaly detection, and model evaluation.
- Practical understanding of statistics and optimizations
- Ability to constantly improve ML model based on its previous performance
- Creativity in problem solving and the ability to think outside of the established solutions
- Be forward thinking keeping up to date on current techniques and research.
- Good teamwork skill

https://bit.studio/

ML jobs in Thailand

Shopee (Thailand) Co., Ltd.

ต่างประเทศ

Job Description:

- Analyse data from various sources, find patterns and provide solutions
- Write high-quality, clean, elegant, and reusable code; build common libraries
- Build high performance, high availability, scalability, and easy to maintain services
- Communicate with other team, deep understand data from different sources and product architecture, optimise the data process pipeline
- Design and implement various supporting tools as needed

Requirements:

- Passionate about coding and programming, innovation, and solving challenging problems
- Bachelor's or higher degree in Computer Science or related fields
- In-depth understanding of data structures and other computer science fundamentals
- Hands-on experience in at least one of the programming languages: Go, Python or C++
- Machine learning algorithms such as clustering, classification algorithms and data processing tools such as tensorflow, scikit
- Hands-on experience in distributed data platforms and processing frameworks such as Hadoop, Spark, Map-Reduce
- Hands-on experience in Linux development environments and Shell Scripting
- **Applicants must be willing to work in Singapore**
- **Fresh graduates are welcome to apply**
- **Applicants must be able to speak and write in English and Native Thai**

https://th.jobsdb.com/TH/TH/Search/FindJobs?KeyOpt=COMPLEX&JSRV=1&RLRSF=1&JobCat=1&SearchFields=JobDetails&Key=machine%20learning&JSSRC=CSBAS&posFix=1

4. Machine learning process

Source: https://hackernoon.com/a-brief-overview-of-automatic-machine-learning-solutions-automl-2826c7807a2a

ML in a Nutshell

- Tens of thousands of machine learning algorithms
  - Hundreds new every year

- Every ML algorithm has three components:
  - **Representation**
  - **Optimization**
  - **Evaluation**

Slide credit: Pedro Domingos

Representations

- Numerical functions
  - Linear regression
  - Neural networks
  - Support vector machines
- Symbolic functions
  - Decision trees
  - Rules in propositional logic
  - Rules in first-order predicate logic
- Instance-based functions
  - Nearest-neighbor

- Probabilistic Graphical Models
  - Naïve Bayes

Slide credit: Ray Mooney

Optimization

- Gradient descent
- Dynamic Programming
- Divide and Conquer
- Evolutionary Computation

Slide credit: Ray Mooney

Evaluation

- Accuracy
- Precision and recall
- Squared error
- …

Slide credit: Pedro Domingos

A Brief History of Machine Learning

1950 — **Alan Turing** creates the "**Turing Test**" to determine if a computer has real intelligence. To pass the test, a computer must be able to fool a human into believing it is also human.

1952 — **Arthur Samuel** wrote the first computer learning program. The program was the game of checkers, and the IBM computer improved at the game the more it played, studying which moves made up winning strategies and incorporating those moves into its program.

1957 — **Frank Rosenblatt** designed the first **neural network** for computers (the perceptron), which simulate the thought processes of the human brain.

1967 — The "**nearest neighbor**" algorithm was written, allowing computers to begin using very basic **pattern recognition**. This could be used to map a route for **traveling salesmen**, starting at a random city but ensuring they visit all cities during a short tour.

Source: https://www.forbes.com/sites/bernardmarr/2016/02/19/a-short-history-of-machine-learning-every-manager-should-read/#49b98c7f15e7

http://cyberneticzoo.com/cyberneticanimals/1960-stanford-cart-american/

1979 — Students at Stanford University invent the "**Stanford Cart**" which can navigate obstacles in a room on its own.

1981 — **Gerald Dejong** introduces the concept of **Explanation Based Learning (EBL)**, in which a computer analyses training data and creates a general rule it can follow by discarding unimportant data.

1985 — **Terry Sejnowski** invents **NetTalk**, which learns to pronounce words the same way a baby does.

1990s — Work on machine learning shifts from a knowledge-driven approach to a data-driven approach. Scientists begin creating programs for computers to analyze large amounts of data and draw conclusions — or "**learn**" — from the results.

1997 — IBM's **Deep Blue** beats the world champion at chess.

Source: https://www.forbes.com/sites/bernardmarr/2016/02/19/a-short-history-of-machine-learning-every-manager-should-read/#49b98c7f15e7

2006 — Geoffrey Hinton coins the term "**deep learning**" to explain new algorithms that let computers "see" and distinguish objects and text in images and videos.

2010 — The Microsoft **Kinect** can **track 20 human features at a rate of 30 times per second**, allowing people to interact with the computer via movements and gestures.

2011 — IBM's Watson beats its human competitors at **Jeopardy**.

2012 – Google's X Lab develops a machine learning algorithm that is able to autonomously browse YouTube videos to identify the videos that contain **cats**.

Source: https://www.forbes.com/sites/bernardmarr/2016/02/19/a-short-history-of-machine-learning-every-manager-should-read/#49b98c7f15e7

2014 – Facebook develops **DeepFace**, a software algorithm that is able to recognize or verify individuals on photos to the same level as humans can.

2015 – **Amazon** launches its own machine learning platform.

2015 – Over 3,000 AI and Robotics researchers, endorsed by **Stephen Hawking,** Elon Musk and Steve Wozniak (among many others), sign an open letter warning of the danger of autonomous weapons which select and engage targets without human intervention.

2016 – Google's artificial intelligence algorithm beats a professional player at the **Chinese board game Go**, which is considered the world's most complex board game and is many times harder than chess. The AlphaGo algorithm developed by Google DeepMind managed to win five games out of five in the Go competition.

2018 — a self-driving car from Uber failed to detect a pedestrian, who was killed after a collision

2019 — Springer Nature published the first research book created using machine learning

Source: https://www.forbes.com/sites/bernardmarr/2016/02/19/a-short-history-of-machine-learning-every-manager-should-read/#49b98c7f15e7

The cover of Springer Nature's AI-generated research book. Image: Springer Nature

Image by Jake VanderPlas; Source: https://speakerdeck.com/jakevdp/the-state-of-the-stack-scipy-2015- keynote?slide=8