What is machine learning?

Lecture 01

Introductions

Wage data from workers in the mid-Atlantic region

Data source: James et al., 2013

setosa

versicolor

virginica

Data Source: Fisher Iris Data

Challenges

What is this?

Image by artist Hikaru Cho

We **generalize** from past experiences

Image: “It’s not what it seems” by artist Hikaru Cho

Predict which class x_{new} belongs to…

$f(\boldsymbol{x}) = 1$

$\boldsymbol{x}_0$

$\boldsymbol{x}_2$

$\boldsymbol{x}_4$

$f(\boldsymbol{x}) = 0$

$\boldsymbol{x}_1$

$\boldsymbol{x}_3$

$\boldsymbol{x}_5$

$\boldsymbol{x}_{new}$

$f(\boldsymbol{x}_{new}) = ?$

Example credit: Yaser Abu-Mostafa, 2012

1 Machine learning is an **ill-posed problem**

There are often **many** models that will fit your data – how do we choose which to use?

the best models

generalize well

Predict the next value in the sequence…

x	0	1	2	3	4
$f(x)$	**0**	**2**	**4**	**6**	**?**

$$f(4) = \boxed{\mathbf{0.530}}$$

Our guess:

$$f(x) = 16.2x - 6.36x^2 - 11.9x^3 - 4.77x^4 + 7.03x^5 + 8.32x^6 - 9.01x^7 + 2.75x^8 - 0.275x^9$$

setosa

versicolor

virginica

Data Source: Fisher Iris Data

2

Overfit works against generalization

We can use **regularization** to prevent overfit

What is machine learning?

A class of techniques where the **goal** is to **describe**, **predict**, and **strategize**…

…**based on** data, past experiences, and/or direct instruction…

…and do so **automatically**, with minimal human intervention.

Types of machine learning tools

Types of learning	Common use case
Unsupervised learning	**Describe**
Supervised learning	**Predict**
Reinforcement learning	**Strategize**

Types of machine learning

	Unsupervised Learning	Supervised Learning	Reinforcement Learning
Goal	**Describe** ...structure in data	**Predict** …from examples	**Strategize** learn through interaction
Data available	predictors, x	predictor and response pairs, (x, y)	predictors and delayed responses (called rewards)
Types	• Density estimation • Clustering • Dimensionality reduction • Anomaly detection	• Classification • Regression	• Model-free learning • Model-based learning

Sale Price Prediction

Input Data:
Home characteristics
(Numerical & Categorical)

Target Data:
Price estimate (numerical)

Learning Category:
Supervised Learning
Regression

1640 Marion Ave, Durham, NC 27705

5 beds · 4 baths · 3,264 sqft

SPACIOUS RANCH W FINISHED LL WALKOUT! 5 BEDROOMS AND 4 BRAND NEW BATHS! RENOVATED WITH CUSTOM FEATURES THRUOUT! CONTEMPORARY HOME WITH MANY HANDICAP ACCESSIBLE REQUIREMENTS ALREADY IN PLACE! VAULTED CEILINGS! SECLUDED TREED LOT! GREAT HOME FOR LIVING AND ENTERTAINING WITH LARGE REAR DECK! WONDERFUL CONTEMPORARY FEEL THAT LIVES LARGE WITH EASY ACCESS TO DUKE UNIVERSITY; SHOPPING; HEALTH CARE; PARKS; R SHOPPING; AND EASY HIGHWAY AC

FOR SALE
$599,900
Price cut: -$79,100 (6/17)
Zestimate®: $619,585

EST. MORTGAGE
$2,284/mo
Get pre-qualified

Zestimate®: $619,585

Video Recommendations

Input Data:
User video ratings
(numerical and categorical)

Target Data:
User rating of video
(numerical)

Learning Category:
Recommender Systems
~Supervised & Unsupervised

Spam Filters

From: Internal Revenue Service [mailto:yourtaxrefund@InternalRevenueService.com]

Sent: Tuesday, July 22, 2008 9:47 AM

Subject: Get your tax refund now

Importance: High

After the last annual calculations of your account activity we have determined that you are eligible to receive a tax refund of $479.30 .

Please submit the tax refund request and allow us 2-6 days in order to process it.

A refund can be delayed for a variety of reasons. For example submitting invalid records or applying after the deadline.

To access the form for your tax refund, please click here (http://e-dlogs.rta.mi.th:84/www.irs.gov/)

Note: Deliberate wrong inputs will be prosecuted by law.

Regards,

Internal Revenue Service

Spam example source: itservices.uchicago.edu

Input Data:
Email text (text)

Target Data :
Spam/not spam (category)

Learning Category:
Supervised Learning
Classification (binary)

Handwriting and Optical Character Recognition

Input Data:
Imagery

Target Data:
Text Characters

Learning Category:
Supervised Learning
Classification (multiclass)

Among the first handwritten addresses sorted automatically in October 1996

Image source: Sargur Srihari, SUNY

Where's Waldo = Computer Vision Problem

Input Data:
Color Imagery (Image)

Target Data:
Locations in an image
(label for each pixel)

Learning Category:
Supervised Learning
Classification (binary)

Image source: www.whereswaldo.com/

Object Recognition: Energy Systems

Input Data:
Imagery

Target Data:
Locations in an image

Learning Category:
Supervised Learning
Classification (binary)

Building
behind-the-meter
energy consumption

Car
transportation
energy consumption

Solar Array
distributed energy
resources

Light Pole
access to electricity

Types of machine learning

	Unsupervised Learning	Supervised Learning	Reinforcement Learning
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Credit Fraud

Input Data:
Account transactions, dates, locations, demographic information
(Numerical and categorical)

Target Data:
Anomalous transactions

Learning Category:
Unsupervised Learning
Clustering, Density Estimation

Anomalous Event Detection: NYC Taxis

Input Data:
Timeseries of taxis rides (numerical)

Target Data:
Anomalous events

Learning Category:
Unsupervised Learning

Data source: Numenta Anomaly Benchmark (NAB), from kaggle.com

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Learning a strategy to master games

Input Data:
Moves taken and occasional feedback on win/loss (Numerical and categorical)

Target Data:
Win/loss (Maximizing rewards)

Learning Category:
Reinforcement Learning

Manufacturing – learn to pick up iron cylinders

Input Data:
Actions taken and occasional feedback on success/failure (Numerical and categorical)

Target Data:
Success/failure (Maximizing rewards)

Learning Category:
Reinforcement Learning

Source: MIT Technology Review; Company: FANUC

Types of machine learning

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Course logistics

Learning objectives

- Fundamentals of **machine learning** and **data science**
- **Structure** a machine learning problem
- Automatically make **decisions** from data
- Understand the techniques/algorithms and when to use them
- **Communicate** and effectively **interpret** machine learning decisions

Through this course you will…

- **Apply** machine learning techniques and **communicate** findings
- Compete in a Kaggle **machine learning competition**
- Create an online data science portfolio
- Implement your own **end-to-end machine learning project**
- Create a **video** about your project

Graded Components

Class participation	5%
In-class quizzes	10%
Assignments (5 assignments)	35%
Kaggle competition	20%
Final project	30%

Course website

kylebradbury.github.io/ece590

Action items

- Get the textbook (also available free online)
- Log onto Piazza (make sure you can access it and ask questions)
- Complete the first reading
- Create an account at Poll Everywhere using this link. Be sure to use (a) your real name, and (b) your Duke netid-based email address (e.g. mjw8@duke.edu)
- Begin working on Assignment #1

Image: xkcd.com