Stats 170A/B, Project in Data Science

Chen Li[1] and Vladimir Minin[2]

[1]Department of Computer Science
[2]Department of Statistics
Bren School of Information and Computer Sciences
University of California, Irvine

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Plan for today

- Introductions
- Class organization and schedule
- Discussion about projects
- Python software
- Data science in the real-world

Introductions

- Instructors
  - Professor Chen Li

    Research: database systems, data management, … → “Big Data”

    Industry: Start-up experience

  - Professor Vladimir Minin

    Research: statistics, stochastic modeling

    Applications: consults/works with Fred Hutchinson Cancer Research Center

- Students
  - Introduce yourself
  - What do you hope to get out of the project class?
  - Programming skills you have vs. you want to improve

Philosophy behind this class

- Provide an experience of how data science works in the real-world
  - Defining a problem
  - Identifying, understanding, exploring relevant data
  - Extracting, cleaning, management of data
  - Exploration and analysis of data
  - Building models from data (e.g., via machine learning)
  - Evaluating models: how well do they predict
  - Communicating your results to others
- Tie together ideas from different courses you have taken and give you experience in applying these ideas to real-world data
  - Databases, software, algorithms, machine learning, statistics

Organizational Items

- Class Website
  - Class Canvas page: `https://canvas.eee.uci.edu/courses/22259`
  - This is where to find assignments, links to resources such as software, data sets, project guidelines, etc
- 2-quarter class (Winter and Spring)
  - Think of it as one 20-week class
  - Will propose and define your project this quarter and work on it in Spring
- No midterms or final exam
  - But there will be regular reporting and some presentations
  - Also, individual homework assignments during the first six weeks
- Textbook and Reading Materials
  - No official textbook
  - Links to relevant texts (available online via UCI library) on the class wiki page

Textbooks

- *Data Wrangling with Python: Tips and Tools to Make Your Life Easier* By Jacqueline Kazil and Katharine Jarmul, O'Reilly Media, 2016.
- *Python for Data Analysis: Data Wrangling with Pandas, NumPy, and IPython (2nd Edition)* By William McKinney, O'Reilly Media, 2017.
- *Principles of Data Wrangling: Practical Techniques for Data Preparation* By Joseph Hellerstein, Jeffrey Heer, Tye Rattenbury, Sean Kandel, and Connor Carreras, O'Reilly Media, 2017.
- *Mining the Social Web (2nd Edition, Chapters 1 and 9 in particular)* By Matthew Russell, O'Reilly Media, 2014.
- *Hands-On Machine Learning with Scikit-Learn and TensorFlow (Chapters 1 through 4 in particular)* By Aurelien Geron, O'Reilly Media, 2017.

All of these titles are available for free online via the UCI Library's subscription to Safari Books Online (`http://proquest.safaribooksonline.com/`).

Course outline

- **Winter**: Weeks 1 to 6: Lectures and Assignments
  - Review general principles of data science
  - Weeks 1 to 3: databases, data extraction, data cleaning
  - Weeks 4 to 6: text analysis, data exploration, machine learning and statistics
  - Combination of lectures, assignments, and background reading
- **Winter**: Weeks 7 to 10: Project Proposals
  - Project proposals from student teams
  - Feedback from instructors, refine proposal, oral presentation at end of quarter
- **Spring**: Work on Projects
  - Build and use a prototype system/pipeline
  - Develop ideas, implement algorithms, make use of libraries and packages
  - Conduct experiments with real data sets
  - Test and evaluate your system in a systematic manner
  - Communicate your results (presentations and reports)

Grading

- Only one grade, assigned at end of Spring quarter
- Winter quarter (50% of total grade)
  - 50% project proposal
  - 40% homeworks
  - 10% class participation
- Spring quarter (50% of total grade)
  - Distributed across project progress reports, final report, class presentations and participation
- Participation = attending class and participating in class discussion
- No grading of late homeworks

Academic integrity

- Students will be expected to adhere to the UCI and ICS Academic Honesty policies (see `https://aisc.uci.edu/policies/academic-integrity/index.php` and `https://www.ics.uci.edu/ugrad/policies/index.php%23academic_honesty` to read their details).

- Any student found to somehow be involved in cheating or aiding others in doing so will be academically prosecuted to the maximum extent possible: that means that you could fail this course in its entirety. (Ask around - it's happened.) Just say no to cheating!

- This information and associated links are also posted on the class Website

Questions outside class? use Canvas

- Use Canvas discussion board for questions (outside of class time) related to the class
  - Assignments, lectures, projects, data sets, ideas, etc
- Instructors will try to quickly answer questions
  - Students should also feel free to also answer questions
  - If you wish you can use “private mode” to ask questions that only the Professor will see
  - (This way you won’t get lost in our daily faculty e-mail overload)

Class projects

- 2-person teams
  - Note that Assignments in weeks 1 to 6 are not team-based ? these will be worked on and submitted individually
  - For 2-person teams we expect twice as much output and contributions of each individual to be clearly identified in reports
- Each team will propose its own project
  - Suggestions for multiple different projects will be provided
  - Extensive use of libraries (in addition to writing some of your own code)
- Projects will be graded based on
  - Initial proposal
  - Weekly updates
  - Intermediate and final reports
  - In-class presentation

We will discuss all of this in more detail in future lectures

Project expectations

- Required components
  - Automatically extract a large-scale data set from Twitter
  - Combine Twitter data with at least one other large-scale data set
  - Make use of data management, cleaning, exploration, visualization tools
  - Develop a prediction/forecasting system using the data sets
- Software development
  - You will make use of existing libraries and tools (e.g., PostgreSQL and Python)
  - You are also expected to implement some components of the pipeline yourself
- Evaluation
  - You will need to systematically evaluate your prototype
  - E.g., runtime, predictive accuracy, accuracy as a function of data set size, etc.
- Reporting
  - You will be required to generate reports, graphs, Jupyter notebooks, etc.

Sources of large data sets that could be used for projects

Twitter data: large streams of tweets via Twitter API

United States™ Census Bureau

WIKIPEDIA
The Free Encyclopedia

Text from 4 million Wikipedia articles

Google Dataset Search Beta

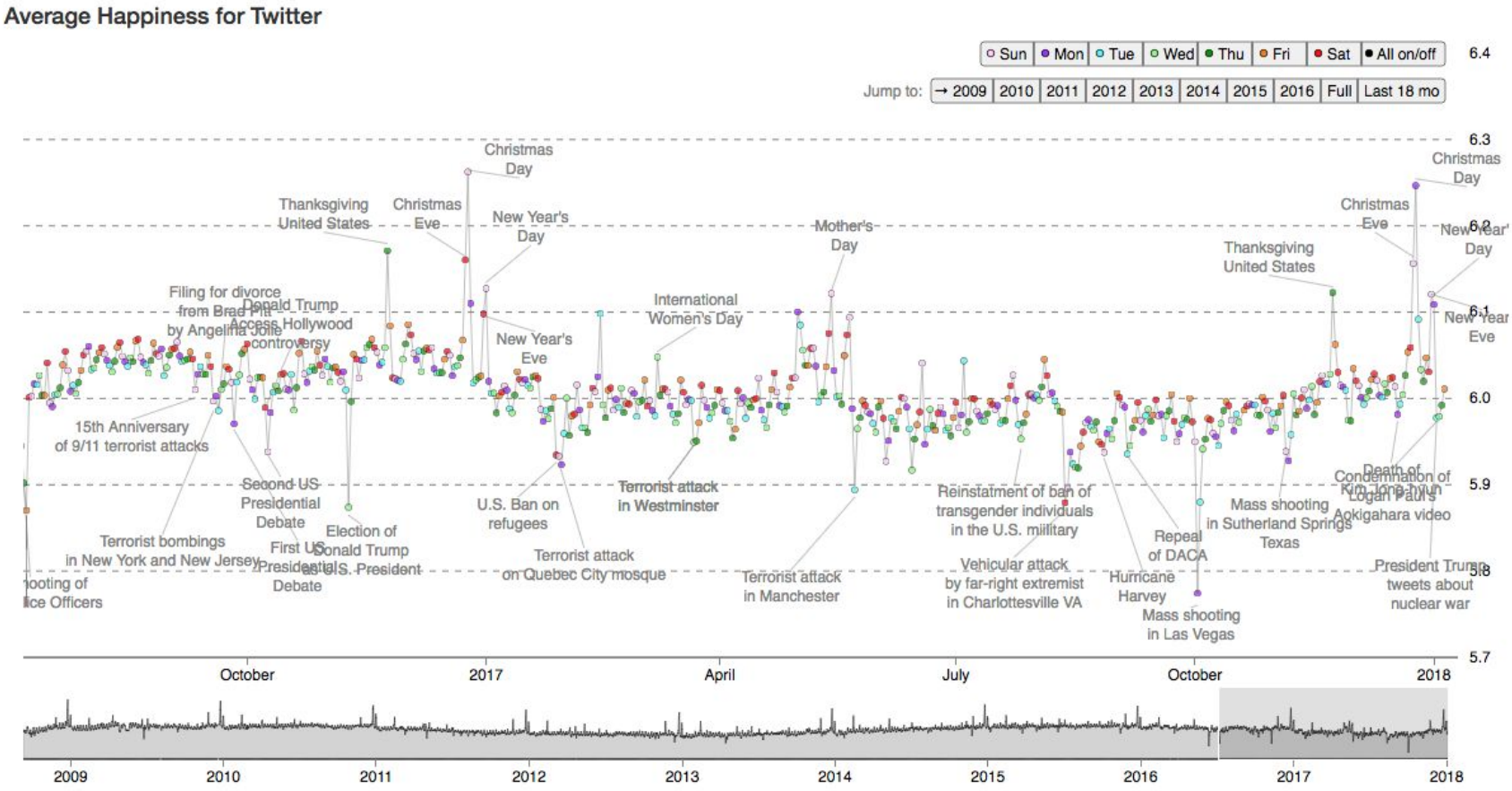
https://toolbox.google.com/datasetsearch

Try boston education data or weather site:noaa.gov

Learn more about including your datasets in Dataset Search.

Example of a class project

- Data sources
  - Twitter API: tweets mentioning certain keywords, over time, with metadata
  - Census or government maps of population by US county
  - Weather data over time for US locations
  - Historical data on consumer confidence over time
  - CDC FluView (Weekly U.S. Influenza Surveillance)
- Create query tool that can compute relative popularity of a keyword
  - over time (time-series plot)
  - Over space (tweets are mapped to location)
- Extension 1
  - Predict popularity of a keyword by week, given historical data
- Extension 2
  - Investigate correlation of keywords with weather data and/or Influenza activity (in time and space)
- Extension 3
  - How well can consumer confidence or Influenza activity be predicted from tweet sentiment over time?

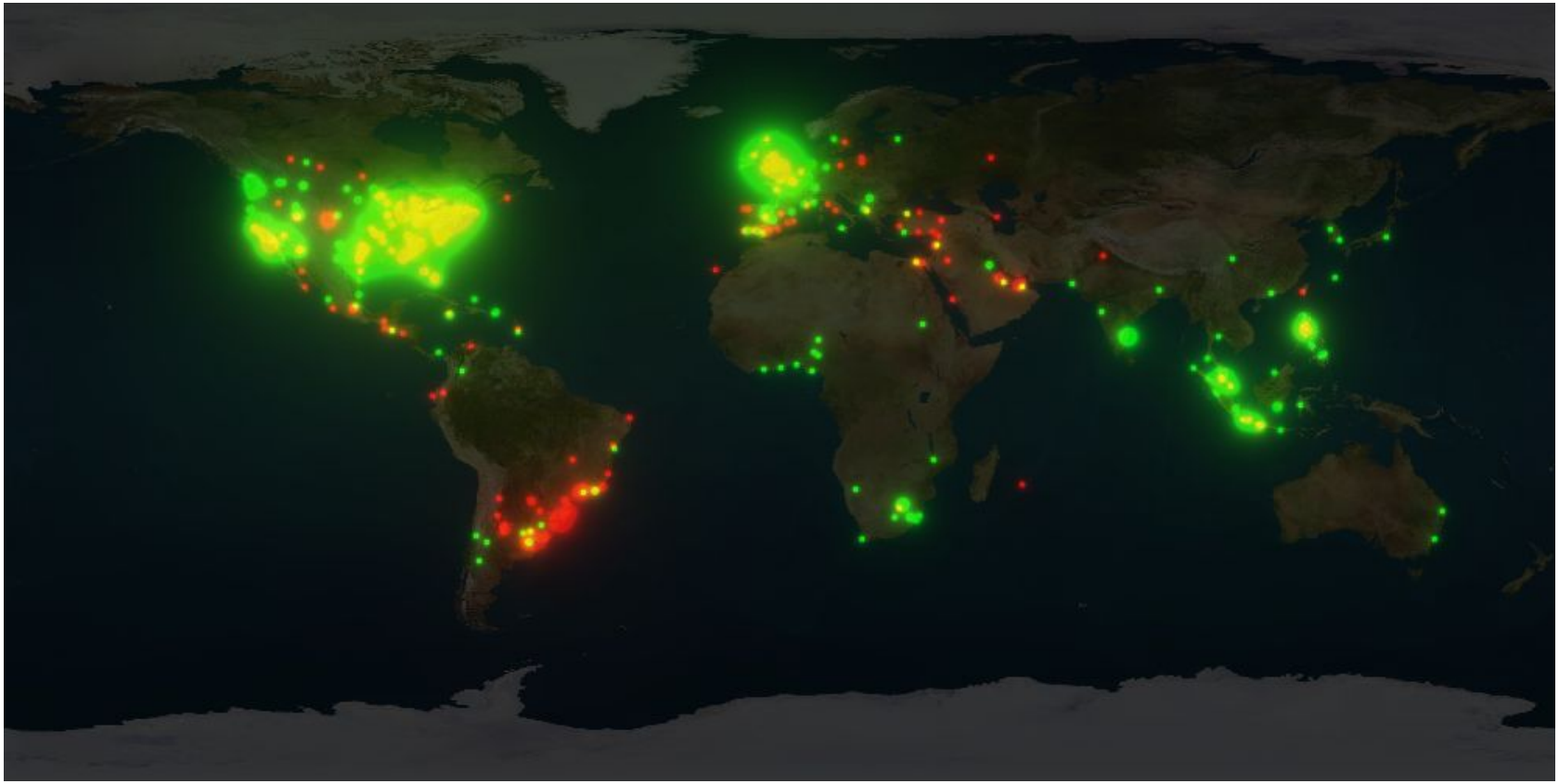


https://hedonometer.org/index.html

Another possible class project

- Define a set of entities of interest
  - E.g., movie stars listed in the IMDB data set (see Homework 1)
  - E.g., sports stars, musicians, etc, from Wikipedia
  - Weather data over time for US locations
  - E.g., products and brands (e.g., cars, shoes, phones, apps)
- Crawl Twitter for historical mentions of these entities
  - E.g., for all of 2014-2018
- Build a system that can answer queries and display results
  - E.g., how many tweets per week did entity A get versus entity B in state X
  - E.g., how many positive versus negative tweets did entity A get over time
- Use machine learning/statistics to forecast
  - Popularity (number of tweets) for any entity for week T, given data to T-1
  - Or predict tweet sentiment (proportion positive/negative) for an entity

Tweets mentioning Coke (green) and Pepsi (red)



from
chimpler.wordpress.com

Projects from last year

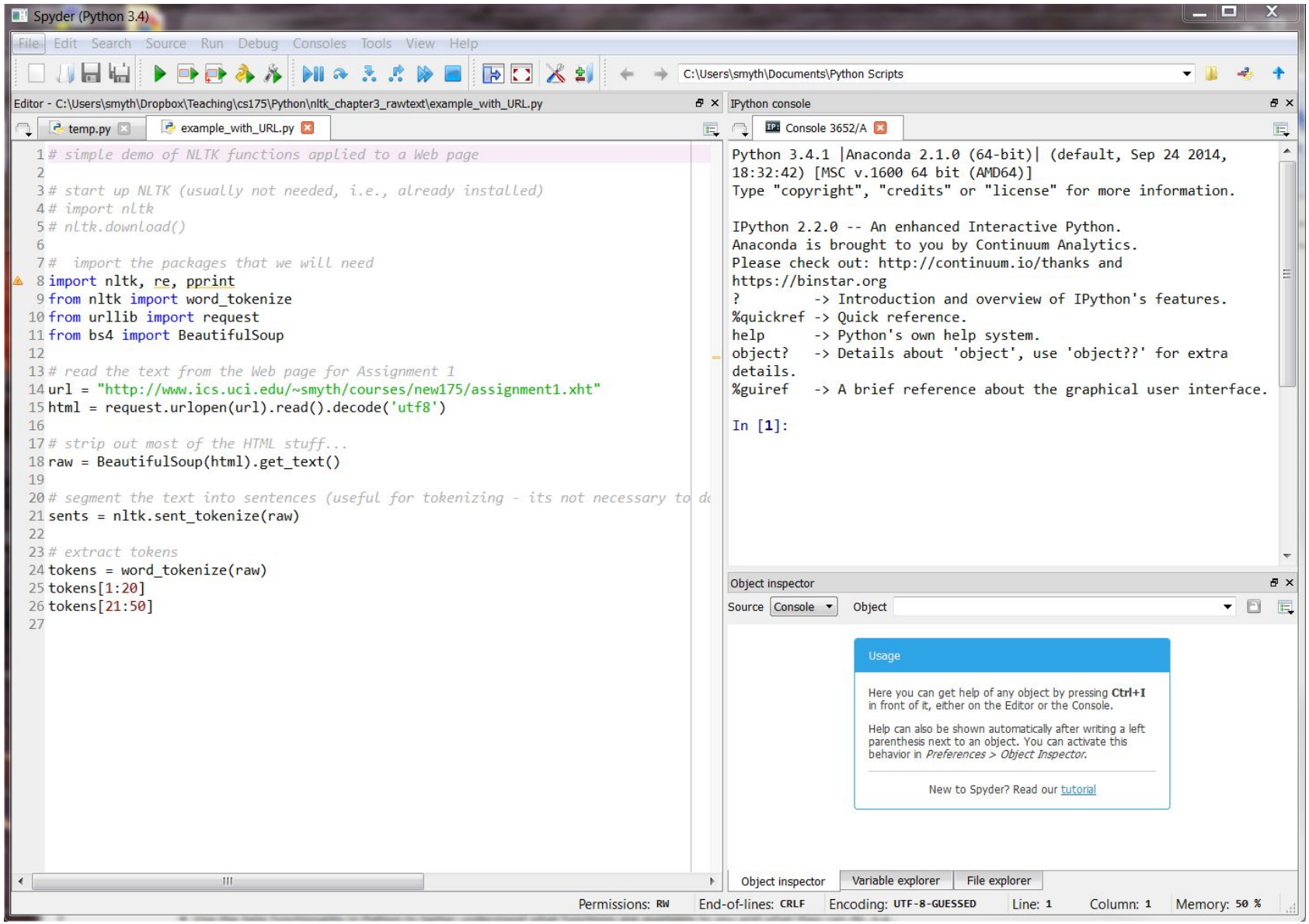
- Algorithmic Passive Investing
- Can Health Predict Violent Crimes?
- Tracing Fake News & Fact Checks on Reddit
- Rating Differences between??Yelp and Google
- Language and Partisanship: Predicting Partisanship with Tweets
- Impaired Water Quality Across the US
- Modeling Change in Song Topics Against Economic Data Using a Variety of BayesianApproaches

Software for Future Assignments and Projects

- Python
  - Python will be the primary language we will use in much of this class
  - Assume that all students have a working knowledge of Python 3
- Packages and Libraries
  - We will make extensive use of additional packages and libraries in Python, e.g.,
    - Pandas for data manipulation
    - Scikit-learn: machine learning library
    - Scientific computing/graphs/etc: matplotlib, numpy, scipy, etc

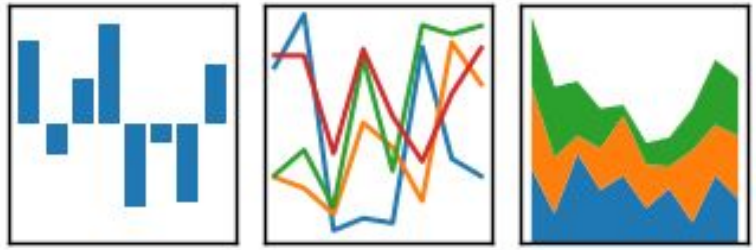
  You should download and install the Anaconda package: it contains many packages you need for this class

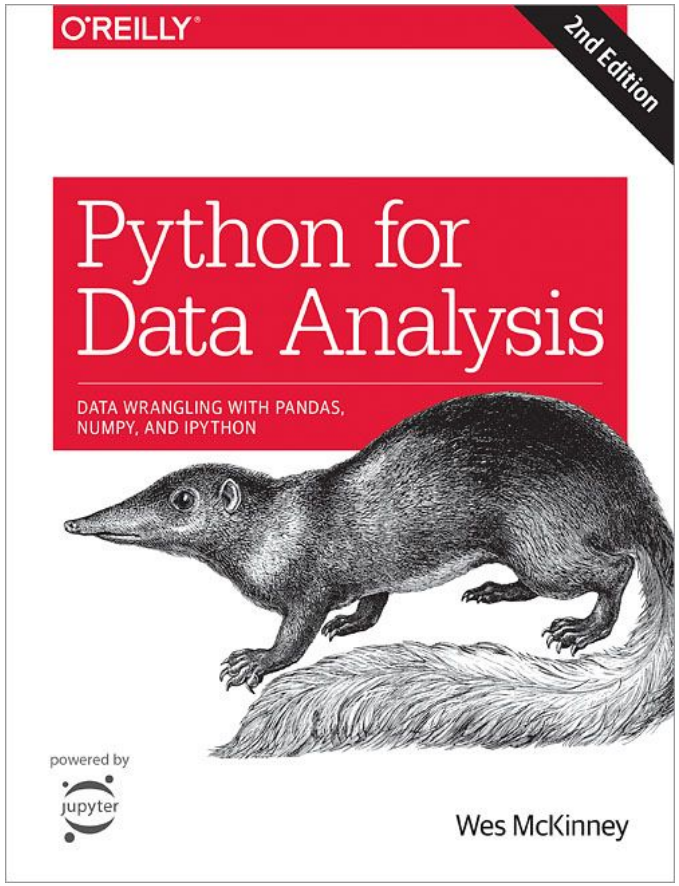
Screenshot of the Spyder IDE



pandas

$$y_{it} = \beta' x_{it} + \mu_i + \epsilon_{it}$$



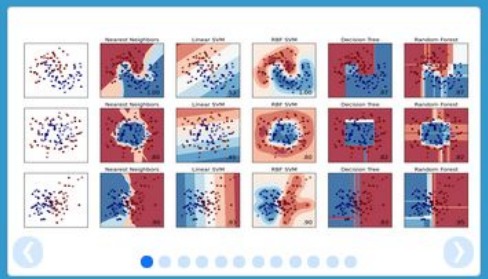


scikit learn

Home Installation Documentation Examples

Google Custom Search Search

Fork me on GitHub



scikit-learn

Machine Learning in Python

- Simple and efficient tools for data mining and data analysis
- Accessible to everybody, and reusable in various contexts
- Built on NumPy, SciPy, and matplotlib
- Open source, commercially usable - BSD license

Classification

Identifying to which set of categories a new observation belong to.

Applications: Spam detection, Image recognition.
Algorithms: *SVM, nearest neighbors, random forest, ...* — *Examples*

Regression

Predicting a continuous value for a new example.

Applications: Drug response, Stock prices.
Algorithms: *SVR, ridge regression, Lasso, ...* — *Examples*

Clustering

Automatic grouping of similar objects into sets.

Applications: Customer segmentation, Grouping experiment outcomes
Algorithms: *k-Means, spectral clustering, mean-shift, ...* — *Examples*

Dimensionality reduction

Reducing the number of random variables to consider.

Applications: Visualization, Increased efficiency
Algorithms: *PCA, Isomap, non-negative matrix factorization.* — *Examples*

Model selection

Comparing, validating and choosing parameters and models.

Goal: Improved accuracy via parameter tuning
Modules: *grid search, cross validation, metrics.* — *Examples*

Preprocessing

Feature extraction and normalization.

Application: Transforming input data such as text for use with machine learning algorithms.
Modules: *preprocessing, feature extraction.* — *Examples*

News

On-going development: What's new (changelog)

Community

Questions? See stackoverflow # scikit-learn

Mailing list: scikit-learn-

Who uses scikit-learn?

TensorFlow ™ Install Develop API r1.3 Deploy Extend Community Versions TFRC Search GITHUB

An open-source software library for Machine Intelligence

GET STARTED

Eager Execution

We're announcing eager execution, an imperative, define-by-run interface to TensorFlow. Check out the README to get started today.

LEARN MORE

TensorFlow 1.3 has arrived!

We're excited to announce the release of TensorFlow 1.3! Check out the release notes for all the latest.

UPGRADE NOW

The 2017 TensorFlow Dev Summit

Thousands of people from the TensorFlow community participated in the first flagship event. Watch the keynote and talks.

WATCH VIDEOS

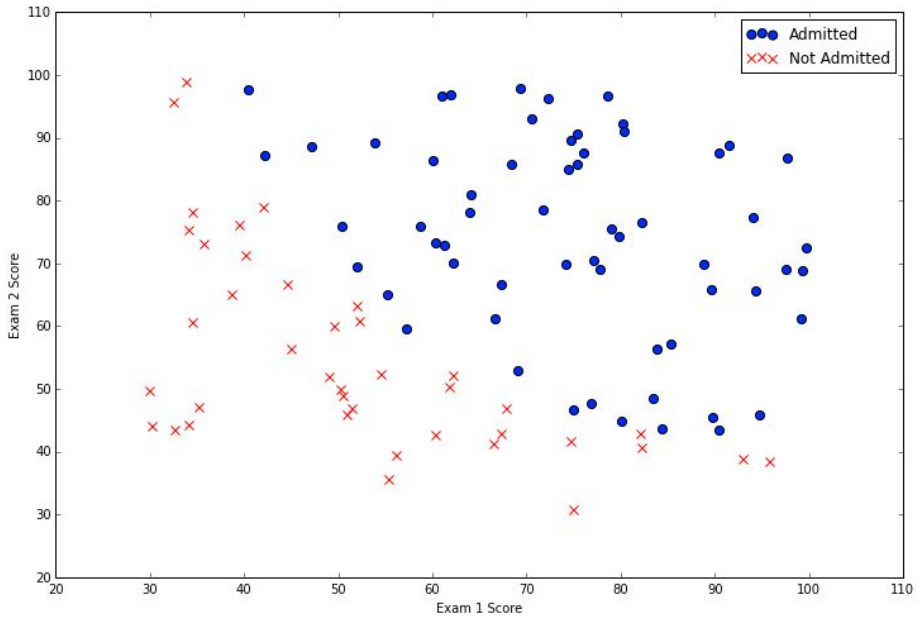
jupyter nbviewer

JUPYTER FAQ

In [3]:
```
positive = data[data['Admitted'].isin([1])]
negative = data[data['Admitted'].isin([0])]

fig, ax = plt.subplots(figsize=(12,8))
ax.scatter(positive['Exam 1'], positive['Exam 2'], s=50, c='b', marker='o', label='Admitted')
ax.scatter(negative['Exam 1'], negative['Exam 2'], s=50, c='r', marker='x', label='Not Admitted')
ax.legend()
ax.set_xlabel('Exam 1 Score')
ax.set_ylabel('Exam 2 Score')
```

Out[3]: <matplotlib.text.Text at 0xd17d7b8>



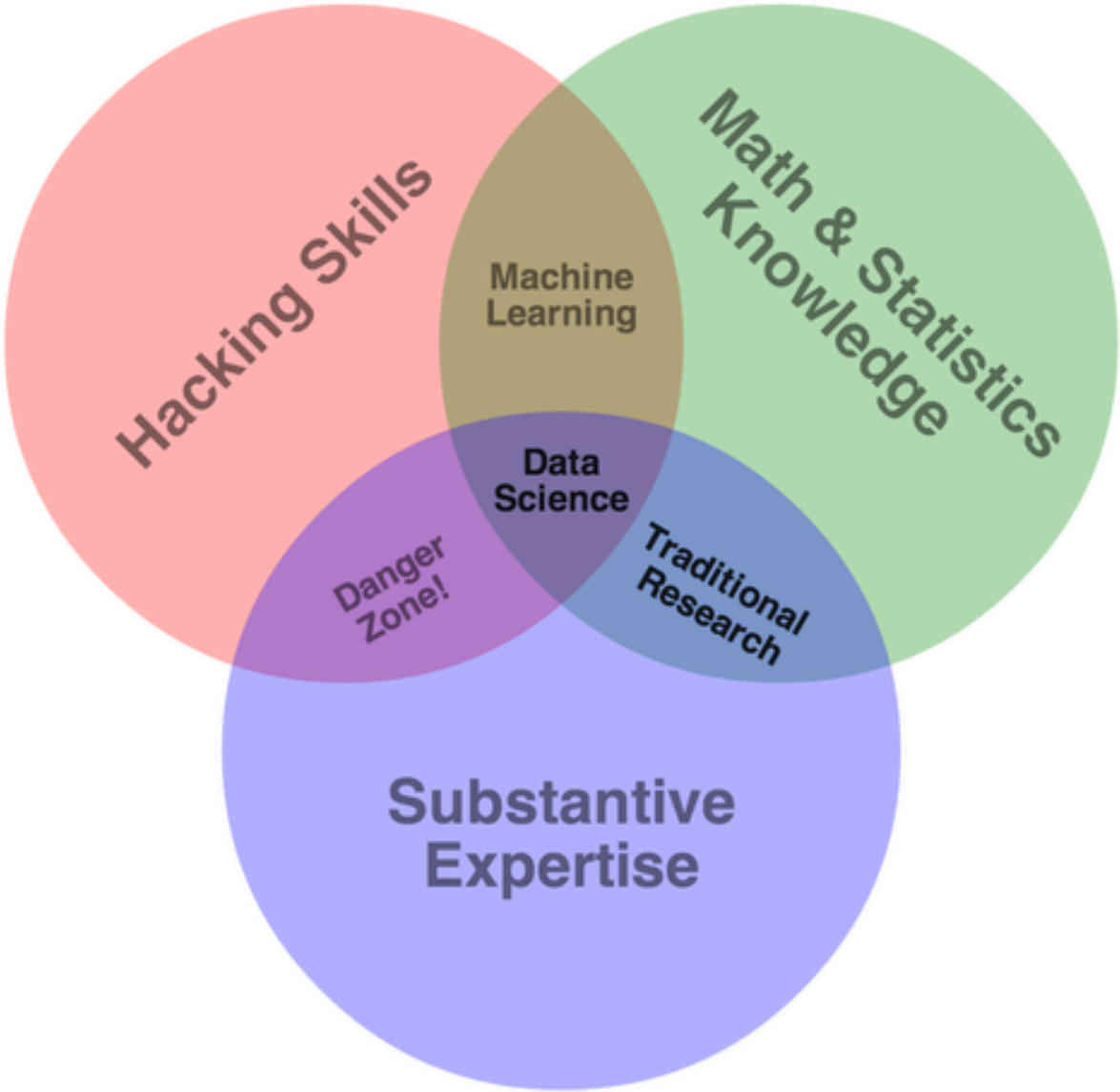
It looks like there is a clear decision boundary between the two classes. Now we need to implement logistic regression so we can train a model to predict the outcome. The equations implemented in the following code samples are detailed in "ex2.pdf" in the "exercises" folder.

Figure from http://nbviewer.jupyter.org/github/jdwittenauer/ipython-notebooks/blob/master/notebooks/ml/ML-Exercise2.ipynb

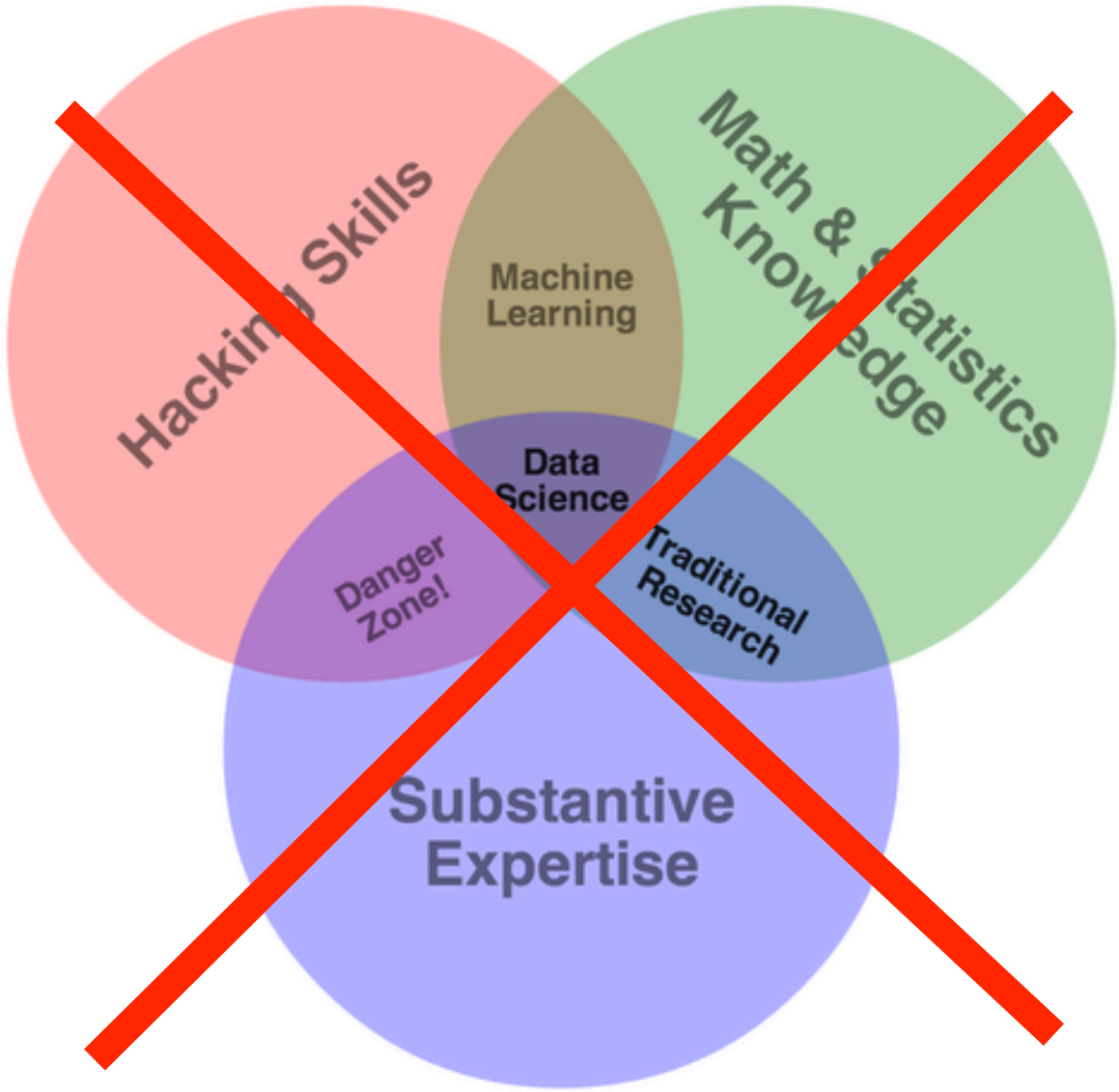
What is Data Science?

- Data science involves the full lifecycle of data: from messy unstructured data to predictions and decisions
- Data science is broader than just databases, statistics, ML, algorithms, but these are all critical components
- Key aspects of data science include
  - Domain knowledge and problem definition
  - Data preparation/organization/management
  - Understanding of uncertainty (statistics)
  - Computing, algorithms, fitting models, machine learning
  - Iterative exploration and experimentation
  - Human judgement and interpretation

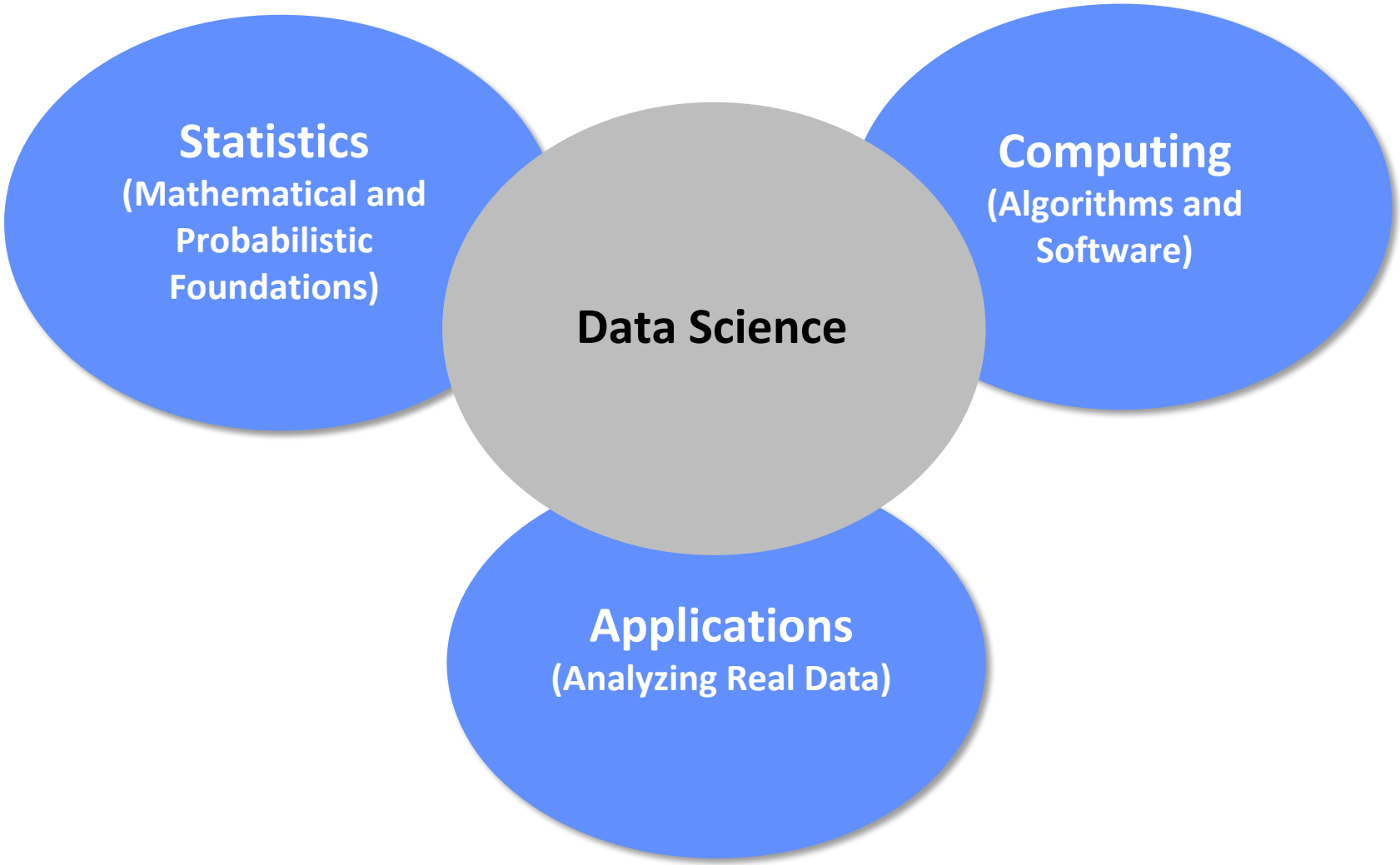
Components of Data Science



Components of Data Science



Components of Data Science

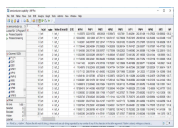


Data pipeline

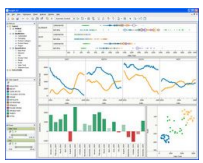
Unstructured Data

Extracted Data

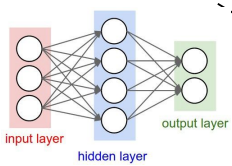
Transformed Data



Data for Modeling

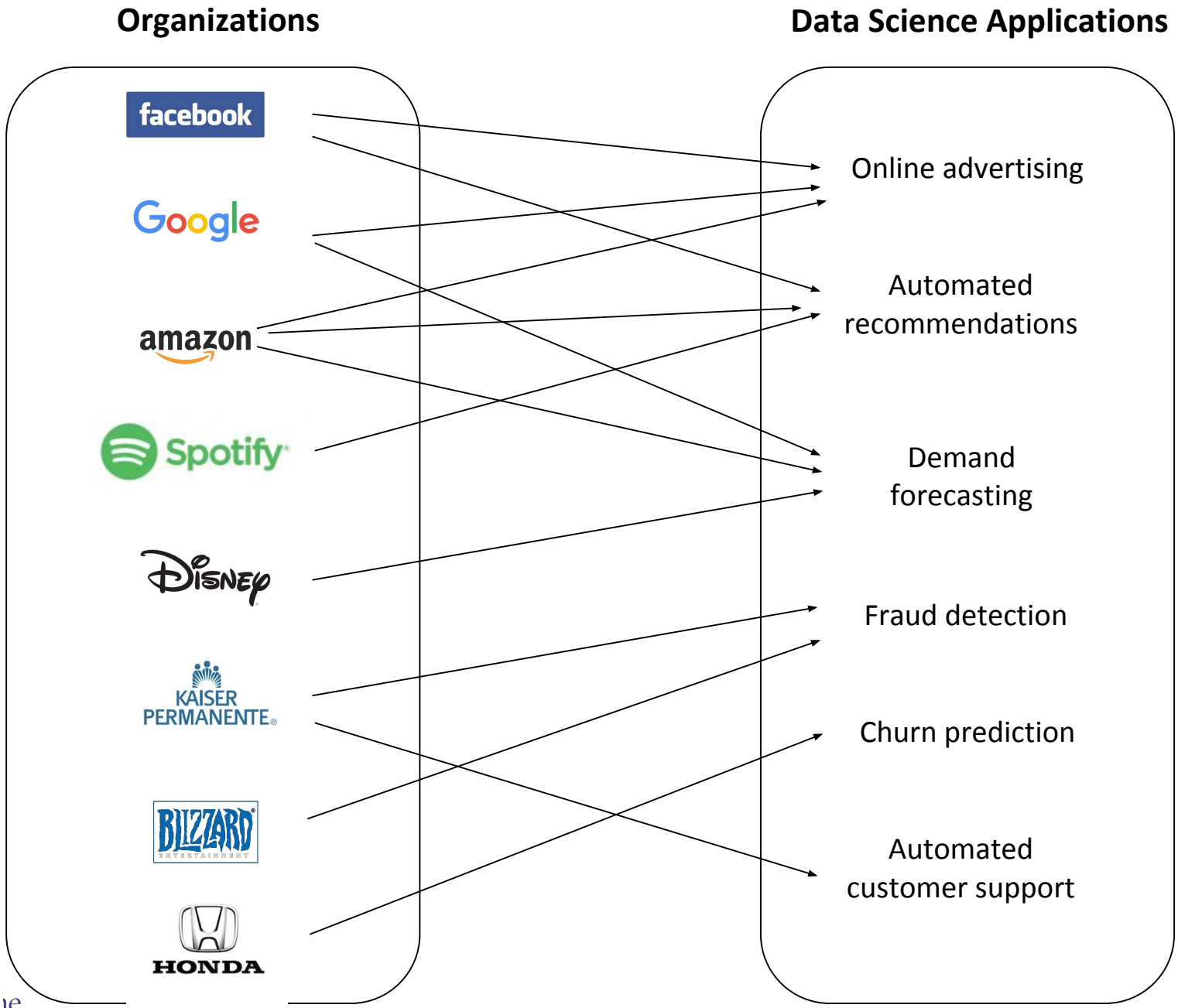


Predictive Model



Predictions/ Decisions

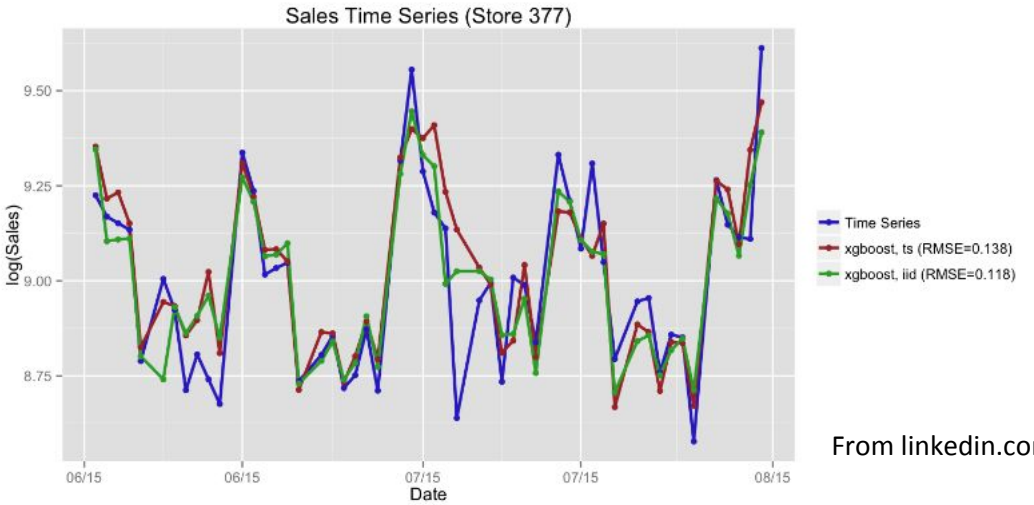
How is Data Science used in these Organizations?



How does Amazon forecast how many items for its warehouses?

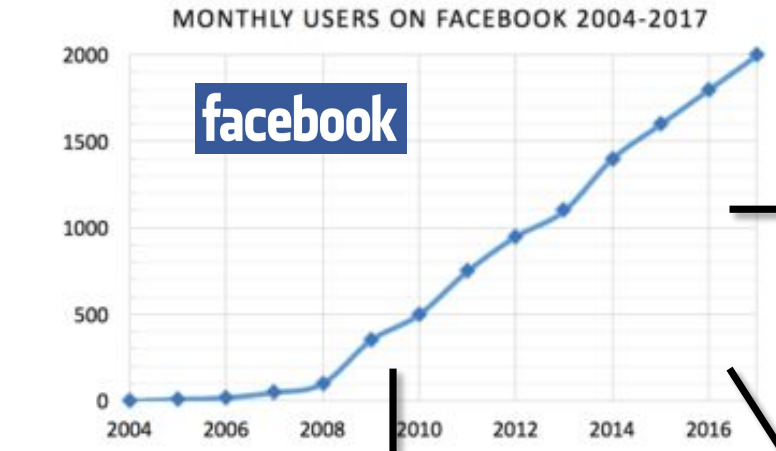
From dailymail.co.uk

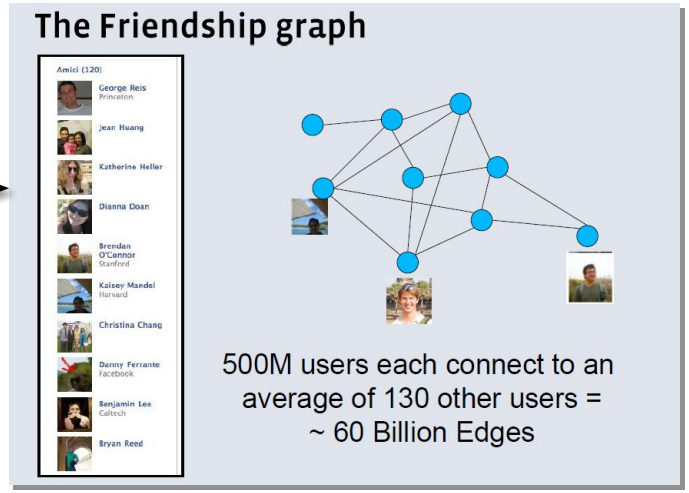
From www.formaspace.com

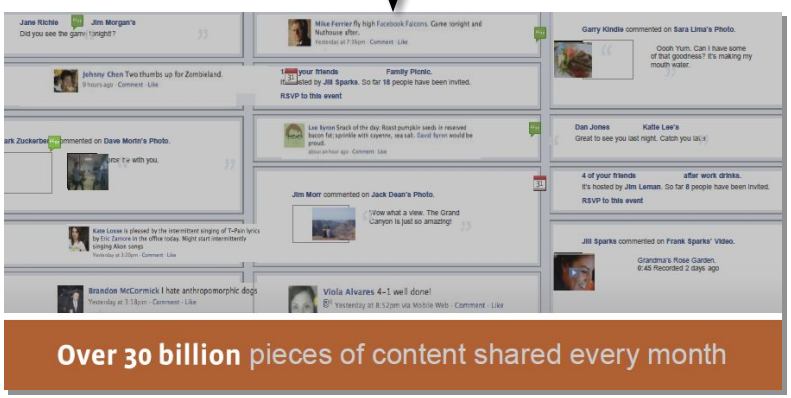


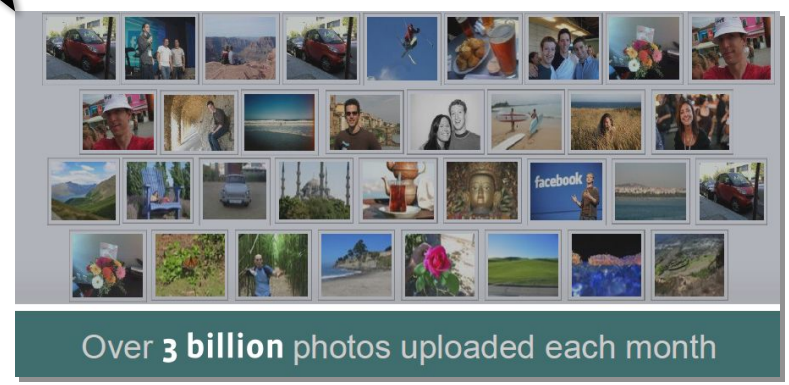
From linkedin.com

How does Facebook predict what content to show you?









Graphics from Lars Backstrom, ESWC 2011

How do companies decide what ads to show you?

?

?

?

U.S. INTERNATIONAL 中文网

The New York Times

Tuesday, March 4, 2014 | Today's Paper | Personalize Your Weather

WORLD U.S. NEW YORK BUSINESS OPINION SPORTS SCIENCE ARTS FASHION & STYLE VIDEO All Sections

TURMOIL IN UKRAINE

Putin, Flashing Disdain, Defends Action in Crimea

By STEVEN LEE MYERS
59 minutes ago

President Vladimir V. Putin's first public remarks on the political upheaval in Ukraine were aimed at both international and domestic audiences, defending Russia from the fury of global criticism and rallying support at home.

NEWS ANALYSIS

No Easy Way Out of Ukraine Crisis

By PETER BAKER 54 minutes ago

White House officials are weighing their options, knowing that reversing the occupation of Crimea would be difficult, if not impossible, in the short run.

Uriel Sinai for The New York Times

Ukrainian riot police officers stood guard at an anti-Russian rally in Donetsk on Tuesday.

Crimea's Pro-Russian Leader Says Region Is Secure

By DAVID M. HERSZENHORN 8:21 PM ET

The prime minister of the autonomous region offered the assurance on Tuesday even as armed standoffs continued.

RELATED COVERAGE

- **Kerry Takes Offer of Aid to Ukraine** 33 minutes ago
- **Cyberattacks Rise as Crisis Spills to Internet** 6:47 PM ET
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The Opinion Pages

OP-ED CONTRIBUTOR

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By JULIA ANGWIN

It takes a lot of money and time to avoid hackers and data miners.

- **Editorial: Frustration With Afghanistan**
- **Brooks: Putin Can't Stop**
- **Cohen: Russia's Crimean Crime**

DRAFT

My Character to Kill

By ALEX BERENSON

I'm not sure I can say goodbye to a man who has defined my creative life for so long — and who will pay the mortgage for at least one more contract.

- Op-Docs: **'Chinese, on the Inside'**

MARKETS » At 10:03 PM ET

JAPAN Nikkei	HangSeng	CHINA Shanghai
14,942.78	22,690.46	2,059.39
+221.30	+32.83	−12.09
+1.50%	+0.14%	−0.58%

Data delayed at least 15 minutes

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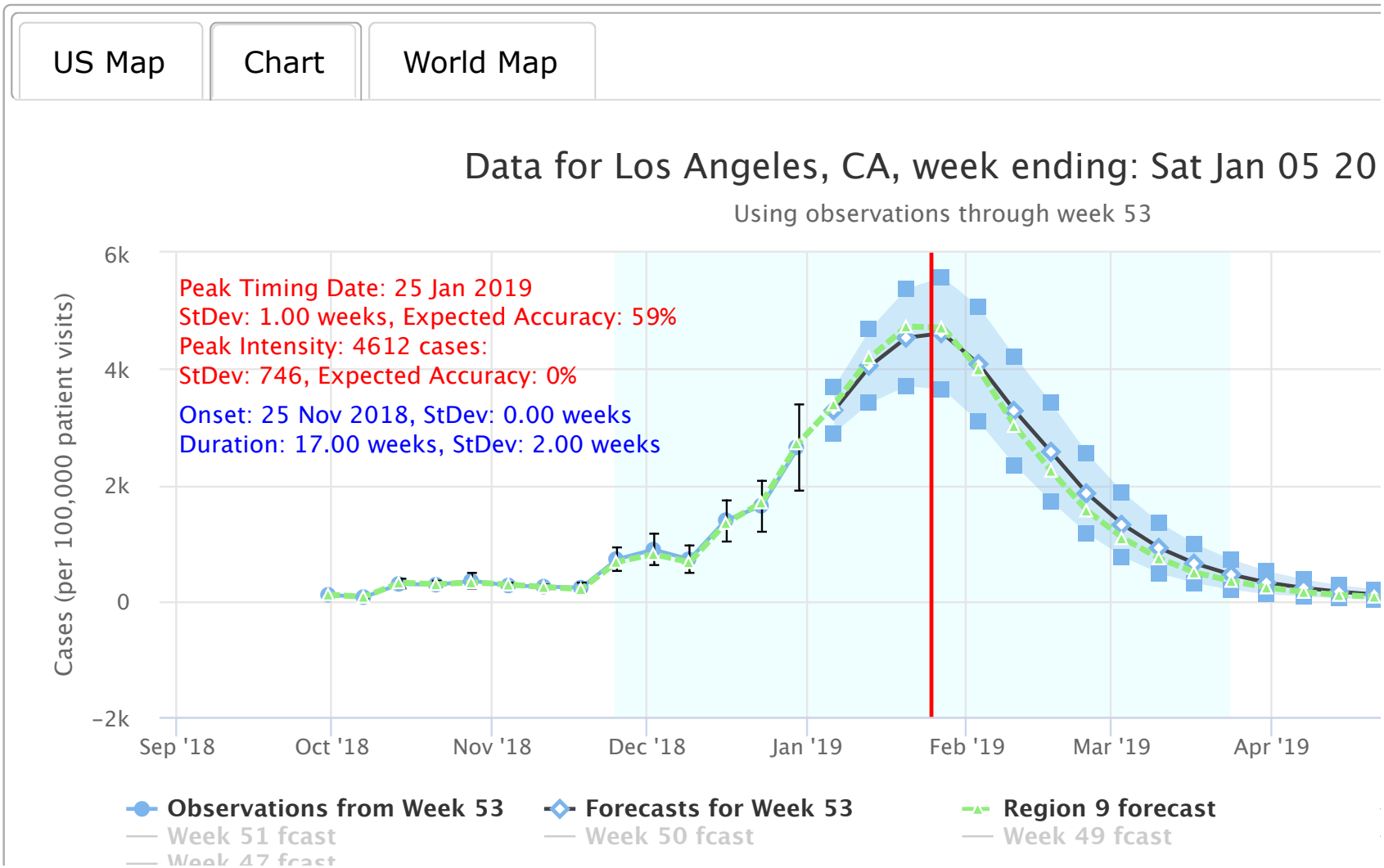
How do public health workers predict infectious disease outbreaks?

Influenza Observations and Forecast



https://cpid.iri.columbia.edu

Questions?