

Security Analytics Course Overview

Purdue University

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Based on slides by Prof. Jenifer Neville
and Chris Clifton

Relationship to Other Security Courses

- 526 Information Security
- 555 Cryptography
- 626 Advanced Information Security
- 655 Advanced Cryptography
- 527 Software Security
- 528 Network Security
- 529(?) Social Econ Legal Asp Of Sec
- This course: Security Analytics
- In Spring: Data Security and Privacy

Relationship to Other Courses

- CS 573 Data Mining
- CS 578 Statistical Machine Learning
- If you have taken (or plan to take) any of the above, you should not be taking this course.
- If you are interested in security, consider taking Data Security and Privacy in Spring.

My Plan for the Course



- Applied data mining and machine learning techniques, using security problems as examples

Topics

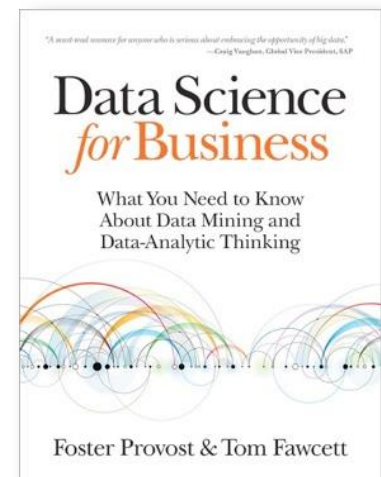
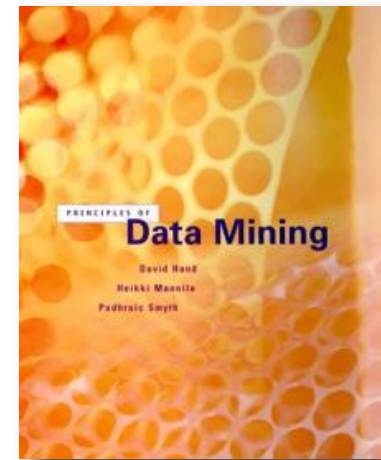
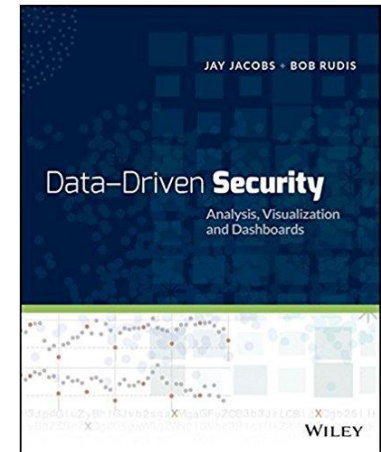
- Intro to data mining and machine learning
- Predictive modeling
- Descriptive modeling
- Pattern mining
- Neural networks
- Big data techniques
- Security applications

Logistics

- Time and location: TTh 3:00-4:15pm, HAAS G066
- Instructor: **Ninghui Li** <ninghui@purdue.edu>,
 - LWSN 2142K, office hours: After lecture and appointment by email
- Teaching assistants: **Wuwei Zhang** <zhan1015@purdue.edu>
 - LWSN 2161, office hours, Wednesday 1pm to 2pm and appointment by email
- Webpage:
<http://www.cs.purdue.edu/~ninghui/courses/Fall17>
- Piazza signup: piazza.com/purdue/fall2017/cs590

Readings

- No required text, readings will be announced/distributed on course webpage.
- Recommended texts
 - Data-Driven Security: Analysis, Visualization and Dashboards by Jay Jacobs, Bob Rudis
 - *Principles of Data Mining*, Hand, Mannila, and Smyth, MIT Press, 2001.
Available as e-book through Purdue library:
<http://ieeexplore.ieee.org/xpl/bkabstractplus.jsp?bkn=6267275>
 - *Data Science for Business*, F. Provost and T. Fawcett, O'Reilly Media, 2013.
<http://data-science-for-biz.com>



Workload

- Homeworks
 - About 6 assignments, which will be either written assignments, or small projects that require programming
 - Late policy: Five extension days to be used at your discretion
 - Must be stated explicitly in header of work being turned in
 - No fractional days
 - May not be used to extend submission past last day of class.
- Exams
 - 4 (in-class) quizzes during the semester
 - Final exam

Data mining

The process of identifying valid, novel, potentially useful, and ultimately understandable patterns in data

(Fayyad, Piatetsky-Shapiro & Smith 1996)



Machine learning: How can we build computer systems that automatically improve with experience? *(Mitchell 2006)*

- Data mining is the analysis of (often large) observational data sets to find **unsuspected** relationships and to summarize the data in **novel** ways that are both understandable and useful to the data owner.
- The relationships and summaries derived through a data mining exercise are often referred to as *models* or *patterns*. Examples include linear equations, rules, clusters, graphs, tree structures, and recurrent patterns in time series.
- While novelty is an important property of the relationships we seek, it is not sufficient to qualify a relationship as being worth finding. In particular, the relationships must also be **understandable**.

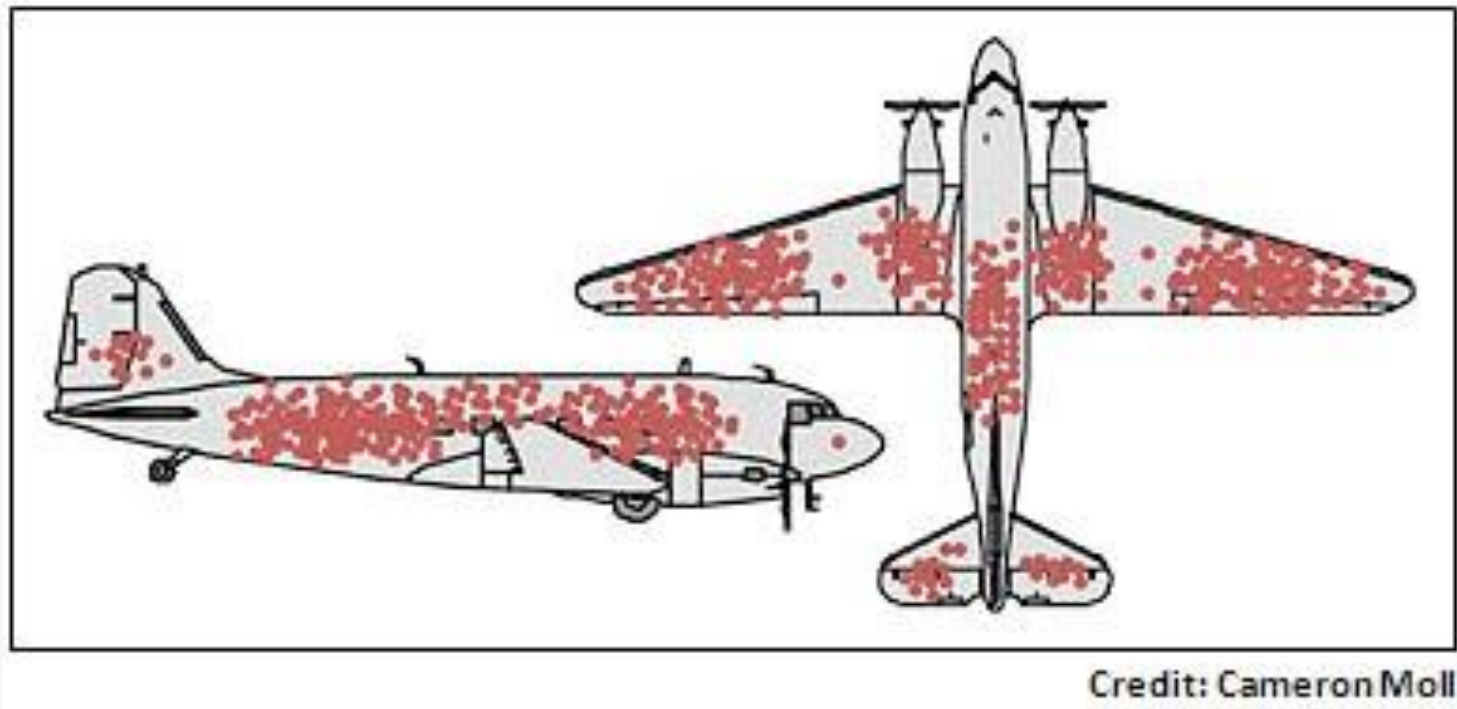
Example: John Snow's London Cholera Outbreak Map



- London's 1854 cholera outbreak claimed 14,000 lives
- Two competing theories: Air pollution (Dr. William Farr) and Water Contamination by "special animal poison" (Dr. John Snow)
- Farr uses data with 8 explanatory variables showed relationship between elevation and deaths.
- Snow produced a graph with 13 wells and death tolls, showing concentration of death near one well

Full map: https://www1.udel.edu/johnmack/frec682/cholera/snow_map.png
<https://www.theguardian.com/news/datablog/2013/mar/15/john-snow-cholera-map>

Example: Abraham Wald's Analysis of Planes



During WWII, statistician Abraham Wald was asked to help decide where to add armor to their planes

<https://medium.com/@penguinpress/an-excerpt-from-how-not-to-be-wrong-by-jordan-ellenberg-664e708cfc3d>

The data revolution

The last several decades of research in ML/DM has resulted in wide spread adoption of predictive analytics to automate and improve decision making.

As “big data” efforts increase the collection of data... so will the need for new data science methodology. Data today have more volume, velocity, variety, etc.

Machine learning research develops statistical tools, models & algorithms that address these complexities.

Data mining research focuses on how to scale to massive data and how to incorporate feedback to improve accuracy while minimizing effort.



Bringing **big data** to the **enterprise**

#ibmbigdata

What is big data?

Every day, we create 2.5 quintillion bytes of data — so much that 90% of the data in the world today has been created in the last two years alone. This data comes from everywhere: sensors used to gather climate information, posts to social media sites, digital pictures and videos, purchase transaction records, and cell phone GPS signals to name a few. This data is **big data**.

How Companies Learn Your Secrets



And among life events, none are more important than the arrival of a baby. At that moment, new parents' habits are more flexible than at almost any other time in their adult lives. If companies can identify pregnant shoppers, they can earn millions.

As Pole's computers crawled through the data, he was able to identify about 25 products that, when analyzed together, allowed him to assign each shopper a "pregnancy prediction" score. More important, he could also estimate her due date to within a small window, so Target could send coupons timed to very specific stages of her pregnancy.

Soon after the new ad campaign began, Target's Mom and Baby sales exploded. The company doesn't break out figures for specific divisions, but between 2002 — when Pole was hired — and 2010, Target's revenues grew from \$44 billion to \$67 billion. In 2005, the company's president, Gregg Steinhafel, boasted to a room of investors about the company's "heightened focus on items and categories that appeal to specific guest segments such as mom and baby."

Antonio Bolfo/Reportage for The New York Times

By CHARLES DUHIGG

Published: February 16, 2012 |  570 Comments

Skills for a Data Scientist/Analyst

- Domain expertise
- Data management
- Programming
- Statistics
- Visualization

Where are Security Analytics Used by Enterprises?

- Assessing risk
- Identifying malicious behavior
- Meeting compliance mandates

Table 1. Systems, Services and Applications Used for Data Collection Today

Systems, Services and Applications	Response
Application information (event logs, audit logs)	86.3%
Network-based firewalls/IPS/IDS/UTM devices	82.5%
Vulnerability management tools (scanners, configuration and patch management, etc.)	77.6%
Endpoint protection (MDM, NAC, log collectors)	72.0%
Host-based anti-malware	70.6%
Dedicated log management platform	65.0%
Whois/DNS/Dig and other Internet lookup tools	62.4%
Security intelligence feeds from third-party services	60.9%
Network packet-based detection	60.3%
SIEM technologies and systems	59.8%
Intelligence from your security vendors	58.6%
Host-based IPS/IDS	57.1%
Relational database management systems (transactions, event logs, audit logs)	53.4%
ID/IAM (identity and access management) systems	50.1%
User behavior monitoring	41.7%
Network-based malware sandbox platforms	41.4%
Cloud activity/Security data	36.2%
Management systems for unstructured data sources (NoSQL, Hadoop)	24.8%
Other	4.7%

What are Concrete Security Applications for Data Analytics?

- Intrusion detection
 - Network-based, host-based
 - Insider threats
- Malicious entity identification
 - Spam/phishing emails
 - Phishing websites/websites delivering malwares
 - Malwares
 - IP addresses controlled by malicious parties
- Enhance security technology (such as authentication)
- Situation awareness
- Identifying vulnerabilities in code, systems, etc.
- ...

Security Analytics

- In Which Ways is Analytics in Security Different from Data Mining/Machine Learning
 - Against intelligent adversaries

Readings

- Readings
 - Chapter 1 of *Principles of Data Mining*
 - Chapter 1 of Data-Driven Security
- Upcoming
 - KNN
 - Probability and Statistics background