Statistical Data Mining

ORIE 4740
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INTRODUCE TAS

Outline

Data Mining

"[Data mining is] the process of discovering meaningful correlations, patterns, and trends by sifting through large amounts of data...[it] employs pattern recognition technologies, as well as statistical and mathematical techniques."

- the Gartner Group

Data mining

- Finding hidden, meaningful, and often unsuspected information in data
- Data mining often involves large data sets with many records (e.g. customers) and many variables (attributes). Desirable approaches are both meaningful and computationally tractable on these large data sets.
- Desirable approaches have few assumptions or are robust to the violation of those assumptions.
  - Contrast w/ intro stats class: assume normal distribution, linear relationship, etc.

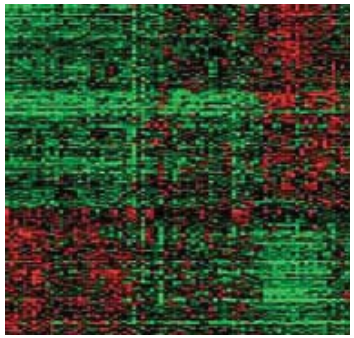
Business Applications

- Market segmentation
  - Finding groups of customers with similar purchasing habits
- Evaluating risk of credit card applicants
- Targeted marketing
  - Identifying likely purchasers
- Home valuation

Aircraft Identification

Estimating the type of aircraft based on its location at a series of time points.

Identification of Cancer Genes



Finding genes that show very high or low expression in individuals with a particular cancer

Information Tech. Applications

- Search engine technology
- Identifying spam
- Handwriting and voice recognition
- Smart web browsers that identify ads on web pages

Course goals

Course Goals:
To be able to:

- Take a large data set, decide on a set of data mining techniques to address the question of interest, apply and compare those techniques, and draw conclusions.
- handle large data sets
  - lack of knowledge about the relationships between the variables.
  - computational complexity
  - numerical issues
- modify or extend an existing implementation of a data mining technique.

Syllabus

- Review syllabus.

Syllabus

Are you well-versed in R, S-PLUS, Matlab, C or Java?

A. Yes
B. No

Syllabus

Have you had a course that included multiple linear regression and logistic regression?

A. Yes

B. No

Syllabus

Reading & Assignment for 1st week: Chap. 1 & 2 in SPB. Read & complete tutorial in Sections 1.7-3.4 of “Introduction to R”

- Questions welcomed in class!
- Class participation is part of grade

Software

- R statistical software (open-source).
- Has a proprietary relative, S-PLUS, frequently used for statistical analysis and graphics in industry and government
- Everything we will do also works in S-PLUS.

Supervised Learning

Supervised Learning:

- Learn a rule for predicting the value of an outcome variable based on the value of some set of predictor variables.
  - e.g. predicting house sale price using square footage, number of BRs, etc.
- Have a set of "training" samples for which the predictors and outcome values are known.
  - <fill in>
- Example: classification
  - Outcome variable is a class (category).
  - E.g., predicting whether or not a Skype account is fraudulent based on the number of contact requests issued, number of contact requests accepted, and number of contact requests received.
  - Learn a good "classification rule" from the training data
  - Apply it to new data to predict the class.

Supervised Learning: Evaluating Accuracy

- How would you evaluate the predictive accuracy of a classification rule on new (test) data?

Unsupervised Learning

Unsupervised Learning:

- Sometimes the outcome variable is unknown for the training data
- E.g., Categorizing customers into groups with similar purchasing habits
  - The training data is the purchasing data of a set of customers
  - Learn a decision rule for categorizing new customers
- How might one evaluate accuracy for this type of decision rule?

Supervised or Unsupervised?

Say we want to estimate the amount of $ an individual spends annually on fabric softener, based on their demographics (age, income, location of residence, etc.). The training data consist of measurements of the demographic variables and self-reported amount of $ spent annually on fabric softener, for 6,000 individuals.

Choose one:

A. Supervised learning

B. Unsupervised learning

Supervised or Unsupervised?

We want to reduce the dimension of our data, while preserving as much information as possible. E.g., want to create a single numeric summary of financial status, based on the variables: income, savings, potential future earnings, and credit rating (reduces dimension from 4 to 1). The training data consist of these 4 financial measurements for 200,000 customers.

Choose one:

A. Supervised learning

B. Unsupervised learning

Supervised or Unsupervised?

We want to group power generation facilities into groups of similar facilities, using a set of operational variables:

- power output per year
- generation capacity
- % time fully utilized
- type of fuel.

The training data consist of these operational measurements, for 1,700 facilities.

Choose one:

A. Supervised learning

B. Unsupervised learning

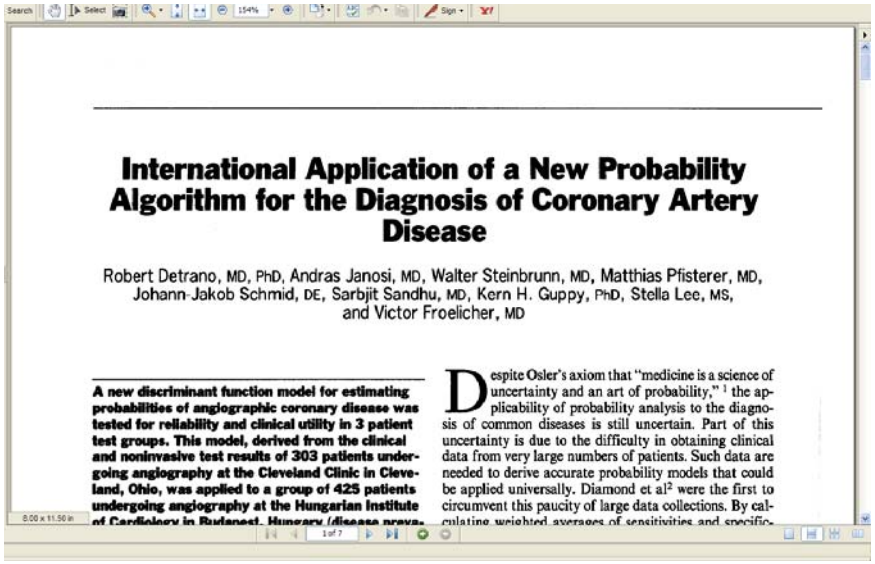
Model-based vs. Heuristic Approaches

- Heuristic approaches to learning
  - employ decision rules that have been observed to often work well in practice
  - Are not based on an explicit model and may not have other formal justification
- Model-based approaches
  - use an explicit model of the system
  - use the data to learn the parameters of that model
  - predict in an optimal manner based on the model
- What would be the advantages of each?

Heart Disease Detection

- Can patients be effectively screened for the presence of heart disease (CAD) without the use of angiography?
- Angiography is an invasive and expensive procedure where a tube is inserted into the artery of concern.
- Rather than using angiography on all patients to detect CAD, it is better to use it on high-risk patients.

Heart Disease Detection



International Application of a New Probability Algorithm for the Diagnosis of Coronary Artery Disease

Robert Detrano, MD, PhD, Andras Janosi, MD, Walter Steinbrunn, MD, Matthias Pfisterer, MD, Johann-Jakob Schmid, DE, Sarbjit Sandhu, MD, Kern H. Guppy, PhD, Stella Lee, MS, and Victor Froelicher, MD

A new discriminant function model for estimating probabilities of angiographic coronary disease was tested for reliability and clinical utility in 3 patient test groups. This model, derived from the clinical and noninvasive test results of 303 patients undergoing angiography at the Cleveland Clinic in Cleveland, Ohio, was applied to a group of 425 patients undergoing angiography at the Hungarian Institute of Cardiology in Budapest, Hungary (disease preva-

Despite Osler's axiom that "medicine is a science of uncertainty and an art of probability," [1] the applicability of probability analysis to the diagnosis of common diseases is still uncertain. Part of this uncertainty is due to the difficulty in obtaining clinical data from very large numbers of patients. Such data are needed to derive accurate probability models that could be applied universally. Diamond et al[2] were the first to circumvent this paucity of large data collections. By calculating weighted averages of sensitivities and specific-

Heart Disease Detection

- The authors use data from the Cleveland Clinic. The data has non-invasive clinical test results as well as angiography results (CAD / no CAD) for 303 patients.
- They learn a classification rule for predicting CAD based on the non-invasive test results.
- This classification rule uses a model-based approach (logistic regression).
- They check the predictive accuracy of their classification rule on data from patients in Hungary (74%) and California (77%).

Heart Disease Detection

- What are the training data here?
- What are the test data?
- Is the test data set a good choice or not?

Heart Disease Detection

What type of learning is this?

A. Supervised

B. Unsupervised

Heart Disease Detection

The Cleveland data:

```
70.0 1.0 4.0 130.0 322.0 0.0 2.0 109.0 0.0 2.4 2.0 3.0 3.0 2
67.0 0.0 3.0 115.0 564.0 0.0 2.0 160.0 0.0 1.6 2.0 0.0 7.0 1
57.0 1.0 2.0 124.0 261.0 0.0 0.0 141.0 0.0 0.3 1.0 0.0 7.0 2
64.0 1.0 4.0 128.0 263.0 0.0 0.0 105.0 1.0 0.2 2.0 1.0 7.0 1
74.0 0.0 2.0 120.0 269.0 0.0 2.0 121.0 1.0 0.2 1.0 1.0 3.0 1
65.0 1.0 4.0 120.0 177.0 0.0 0.0 140.0 0.0 0.4 1.0 0.0 7.0 1
56.0 1.0 3.0 130.0 256.0 1.0 2.0 142.0 1.0 0.6 2.0 1.0 6.0 2
59.0 1.0 4.0 110.0 239.0 0.0 2.0 142.0 1.0 1.2 2.0 1.0 7.0 2
60.0 1.0 4.0 140.0 293.0 0.0 2.0 170.0 0.0 1.2 2.0 2.0 7.0 2
63.0 0.0 4.0 150.0 407.0 0.0 2.0 154.0 0.0 4.0 2.0 3.0 7.0 2
59.0 1.0 4.0 135.0 234.0 0.0 0.0 161.0 0.0 0.5 2.0 0.0 7.0 1
53.0 1.0 4.0 142.0 226.0 0.0 2.0 111.0 1.0 0.0 1.0 0.0 7.0 1
44.0 1.0 3.0 140.0 235.0 0.0 2.0 180.0 0.0 0.0 1.0 0.0 3.0 1
61.0 1.0 1.0 134.0 234.0 0.0 0.0 145.0 0.0 2.6 2.0 2.0 3.0 2
57.0 0.0 4.0 128.0 303.0 0.0 2.0 159.0 0.0 0.0 1.0 1.0 3.0 1
71.0 0.0 4.0 112.0 149.0 0.0 0.0 125.0 0.0 1.6 2.0 0.0 3.0 1
46.0 1.0 4.0 140.0 311.0 0.0 0.0 120.0 1.0 1.8 2.0 2.0 7.0 2
53.0 1.0 4.0 140.0 203.0 1.0 2.0 155.0 1.0 3.1 3.0 0.0 7.0 2
64.0 1.0 1.0 110.0 211.0 0.0 2.0 144.0 1.0 1.8 2.0 0.0 3.0 1
40.0 1.0 1.0 140.0 199.0 0.0 0.0 178.0 1.0 1.4 1.0 0.0 7.0 1
```


Heart Disease Detection

The meta-data:

```
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      -- 1. age
      -- 2. sex
      -- 3. chest pain type  (4 values)
      -- 4. resting blood pressure
      -- 5. serum cholestoral in mg/dl
      -- 6. fasting blood sugar > 120 mg/dl
      -- 7. resting electrocardiographic results  (values 0,1,2)
      -- 8. maximum heart rate achieved
      -- 9. exercise induced angina
      -- 10. oldpeak = ST depression induced by exercise relative to res
      -- 11. the slope of the peak exercise ST segment
      -- 12. number of major vessels (0-3) colored by flourosopy
      -- 13.  thal: 3 = normal; 6 = fixed defect; 7 = reversable defect

Attributes types
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Real: 1,4,5,8,10,12
Ordered:11,
Binary: 2,6,9
Nominal:7,3,13
```
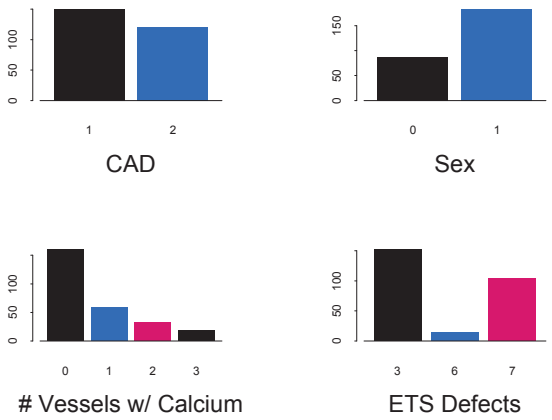


Heart Disease Detection

Frequencies of Variables:



Heart Disease Detection

- The goal is to learn a good classification rule to predict the presence / absence of CAD from the 13 predictors in the data set:
  - age
  - sex
  - chest pain type
  - blood pressure
  - Number of vessels showing calcium on fluoroscopy
  - exercise thallium scintigraphic defects (fixed, reversible, none)
  - electrocardiogram results
  - exercise-induced angina (presence / absence)
  - etc.

Heart Disease Detection

- We'll come up with our own classification rule for this problem

Heart Disease Detection

We'll use a classification tree: