What is prediction?

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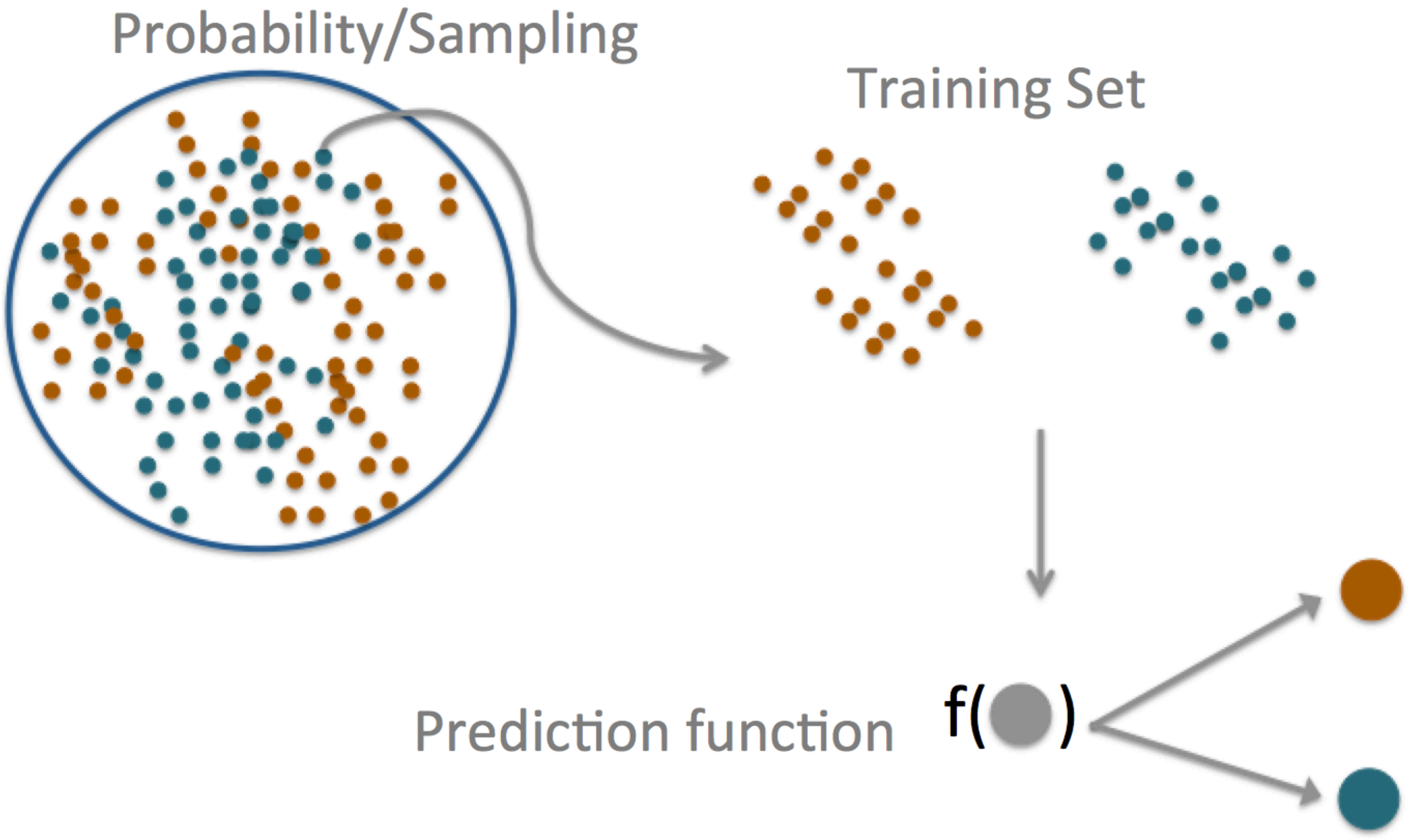
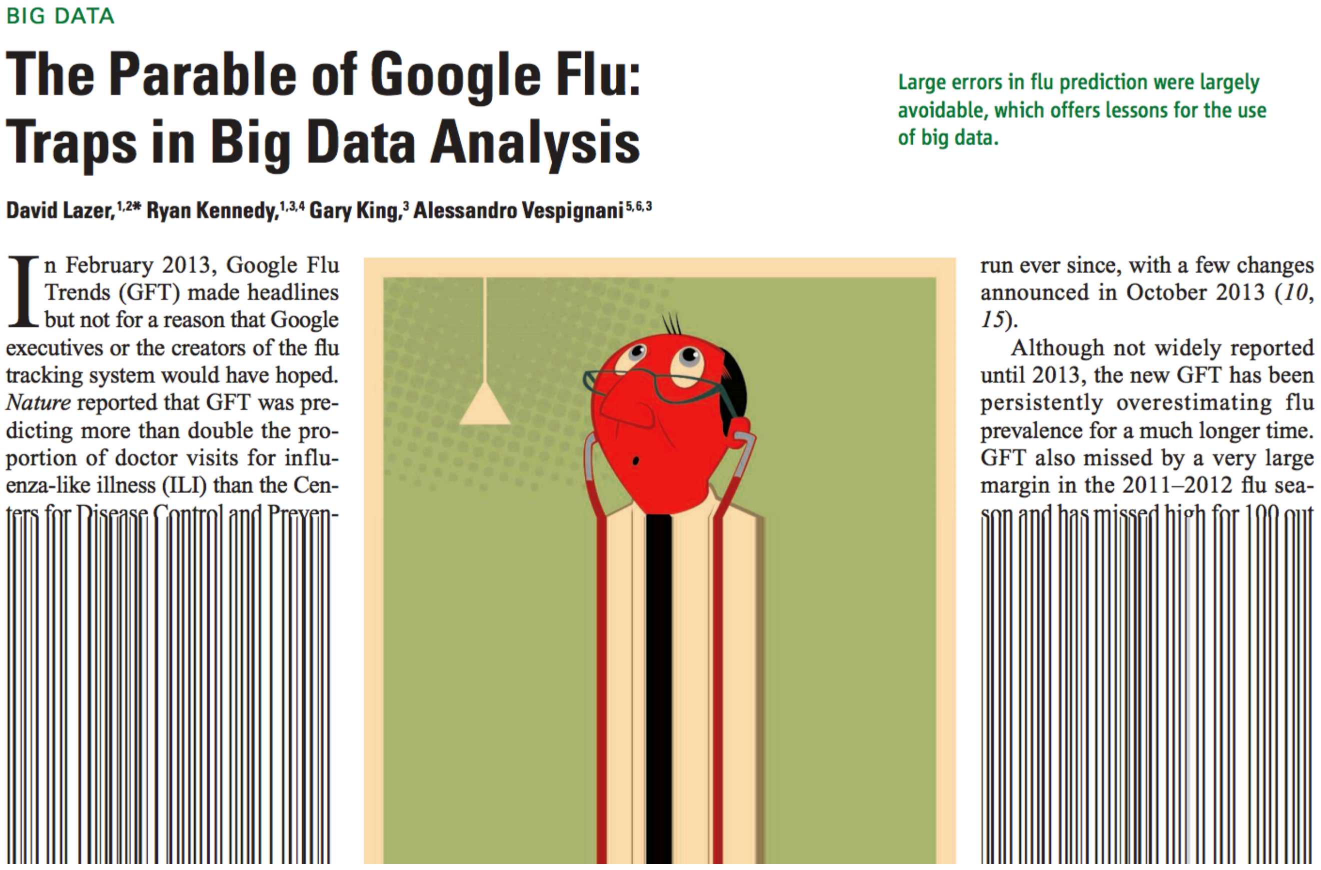
The central dogma of prediction



What can go wrong



BIG DATA

The Parable of Google Flu: Traps in Big Data Analysis

Large errors in flu prediction were largely avoidable, which offers lessons for the use of big data.

David Lazer,[1,2*] Ryan Kennedy,[1,3,4] Gary King,[3] Alessandro Vespignani[5,6,3]

In February 2013, Google Flu Trends (GFT) made headlines but not for a reason that Google executives or the creators of the flu tracking system would have hoped. *Nature* reported that GFT was predicting more than double the proportion of doctor visits for influenza-like illness (ILI) than the Centers for Disease Control and Preven-

run ever since, with a few changes announced in October 2013 (*10*, *15*).

Although not widely reported until 2013, the new GFT has been persistently overestimating flu prevalence for a much longer time. GFT also missed by a very large margin in the 2011–2012 flu season and has missed high for 100 out

http://www.sciencemag.org/content/343/6176/1203.full.pdf

Components of a predictor

question -> input data -> features -> algorithm -> parameters -> evaluation

SPAM Example

question -> input data -> features -> algorithm -> parameters -> evaluation

Start with a general question

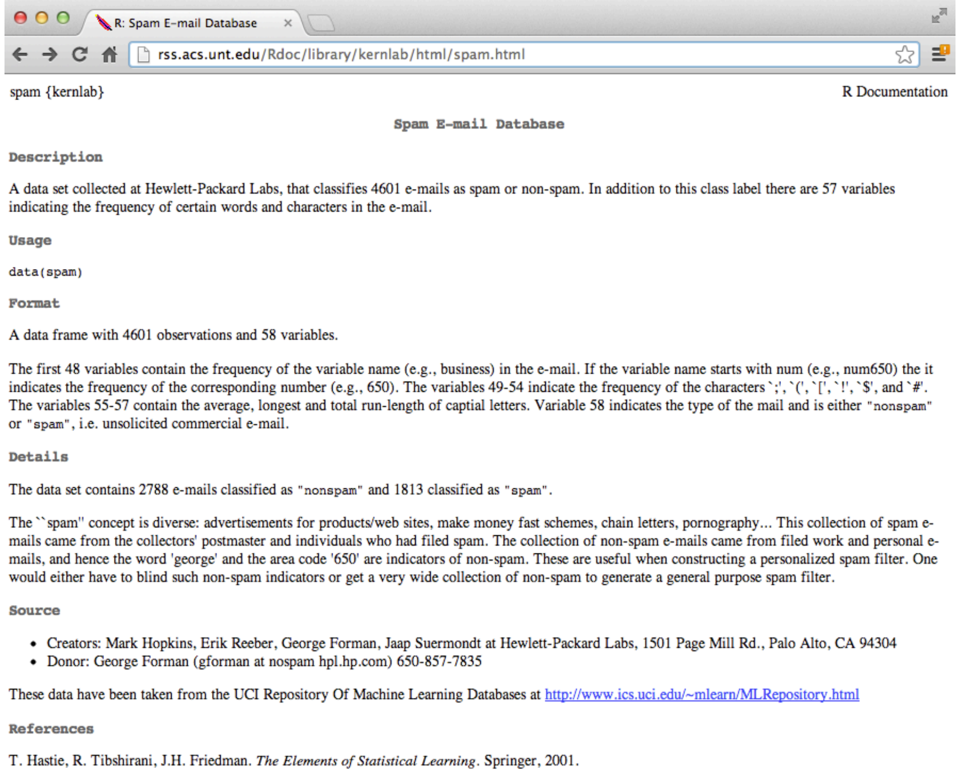
Can I automatically detect emails that are SPAM that are not?

Make it concrete

Can I use quantitative characteristics of the emails to classify them as SPAM/HAM?

SPAM Example

question -> input data -> features -> algorithm -> parameters -> evaluation



spam {kernlab} R Documentation

Spam E-mail Database

Description

A data set collected at Hewlett-Packard Labs, that classifies 4601 e-mails as spam or non-spam. In addition to this class label there are 57 variables indicating the frequency of certain words and characters in the e-mail.

Usage

```
data(spam)
```

Format

A data frame with 4601 observations and 58 variables.

The first 48 variables contain the frequency of the variable name (e.g., business) in the e-mail. If the variable name starts with num (e.g., num650) the it indicates the frequency of the corresponding number (e.g., 650). The variables 49-54 indicate the frequency of the characters `;', `(', `[', `!', `$', and `#'. The variables 55-57 contain the average, longest and total run-length of captial letters. Variable 58 indicates the type of the mail and is either "nonspam" or "spam", i.e. unsolicited commercial e-mail.

Details

The data set contains 2788 e-mails classified as "nonspam" and 1813 classified as "spam".

The ``spam'' concept is diverse: advertisements for products/web sites, make money fast schemes, chain letters, pornography... This collection of spam e-mails came from the collectors' postmaster and individuals who had filed spam. The collection of non-spam e-mails came from filed work and personal e-mails, and hence the word 'george' and the area code '650' are indicators of non-spam. These are useful when constructing a personalized spam filter. One would either have to blind such non-spam indicators or get a very wide collection of non-spam to generate a general purpose spam filter.

Source

- Creators: Mark Hopkins, Erik Reeber, George Forman, Jaap Suermondt at Hewlett-Packard Labs, 1501 Page Mill Rd., Palo Alto, CA 94304
- Donor: George Forman (gforman at nospam hpl.hp.com) 650-857-7835

These data have been taken from the UCI Repository Of Machine Learning Databases at http://www.ics.uci.edu/~mlearn/MLRepository.html

References

T. Hastie, R. Tibshirani, J.H. Friedman. *The Elements of Statistical Learning*. Springer, 2001.

http://rss.acs.unt.edu/Rdoc/library/kernlab/html/spam.html

SPAM Example

question -> input data -> features -> algorithm -> parameters -> evaluation

Dear Jeff,

Can you send me your address so I can send you the invitation?

Thanks,

Ben

SPAM Example

question -> input data -> features -> algorithm -> parameters -> evaluation

Dear Jeff,

Can you send me your address so I can send you the invitation?

Thanks,

Ben

Frequency of you $= 2/17 = 0.118$

SPAM Example

question -> input data -> features -> algorithm -> parameters -> evaluation

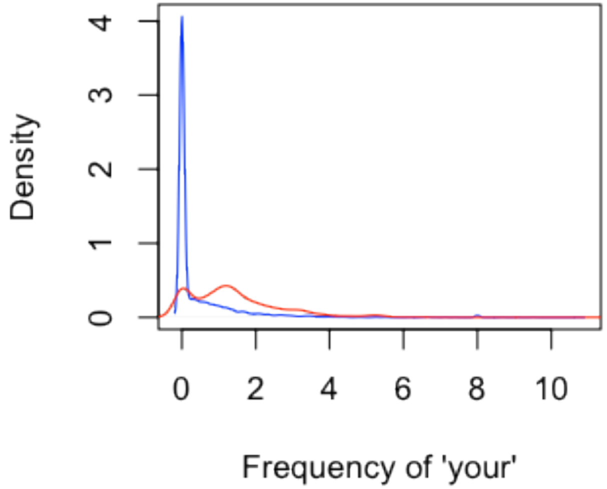
```r
library(kernlab)
data(spam)
head(spam)
```

```
  make address  all num3d  our over remove internet order mail receive will people report addresses
1 0.00    0.64 0.64     0 0.32 0.00   0.00     0.00  0.00 0.00    0.00 0.64   0.00   0.00      0.00
2 0.21    0.28 0.50     0 0.14 0.28   0.21     0.07  0.00 0.94    0.21 0.79   0.65   0.21      0.14
3 0.06    0.00 0.71     0 1.23 0.19   0.19     0.12  0.64 0.25    0.38 0.45   0.12   0.00      1.75
4 0.00    0.00 0.00     0 0.63 0.00   0.31     0.63  0.31 0.63    0.31 0.31   0.31   0.00      0.00
5 0.00    0.00 0.00     0 0.63 0.00   0.31     0.63  0.31 0.63    0.31 0.31   0.31   0.00      0.00
6 0.00    0.00 0.00     0 1.85 0.00   0.00     1.85  0.00 0.00    0.00 0.00   0.00   0.00      0.00
  free business email  you credit your font num000 money hp hpl george num650 lab labs telnet
1 0.32     0.00  1.29 1.93   0.00 0.96    0   0.00  0.00  0   0      0      0   0    0      0
2 0.14     0.07  0.28 3.47   0.00 1.59    0   0.43  0.43  0   0      0      0   0    0      0
3 0.06     0.06  1.03 1.36   0.32 0.51    0   1.16  0.06  0   0      0      0   0    0      0
4 0.31     0.00  0.00 3.18   0.00 0.31    0   0.00  0.00  0   0      0      0   0    0      0
```

SPAM Example

question -> input data -> features -> algorithm -> parameters -> evaluation

```
plot(density(spam$your[spam$type=="nonspam"]),
     col="blue",main="",xlab="Frequency of 'your'")
lines(density(spam$your[spam$type=="spam"]),col="red")
```



SPAM Example

question -> input data -> features -> algorithm -> parameters -> evaluation

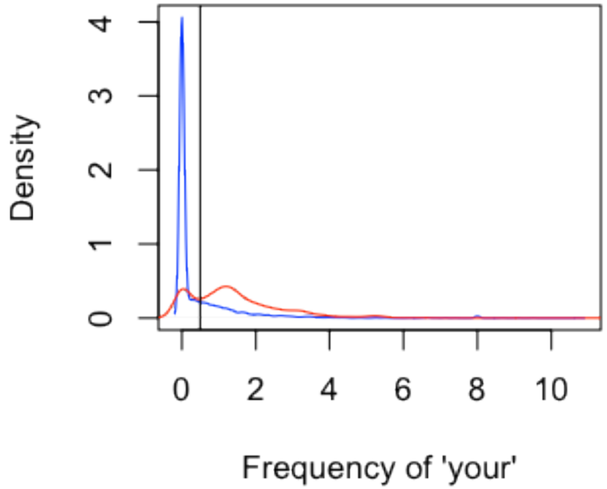
Our algorithm

- Find a value C.
- **frequency of 'your'** $>$ **C** predict "spam"

SPAM Example

question -> input data -> features -> algorithm -> parameters -> evaluation

```
plot(density(spam$your[spam$type=="nonspam"]),
     col="blue",main="",xlab="Frequency of 'your'")
lines(density(spam$your[spam$type=="spam"]),col="red")
abline(v=0.5,col="black")
```



SPAM Example

question -> input data -> features -> algorithm -> parameters -> evaluation

```r
prediction <- ifelse(spam$your > 0.5,"spam","nonspam")
table(prediction,spam$type)/length(spam$type)
```

```

prediction nonspam   spam
   nonspam  0.4590 0.1017
   spam     0.1469 0.2923
```

Accuracy$\approx 0.459 + 0.292 = 0.751$