



**VS.**



**Weiwei Cheng**

University of Marburg / Deutsche Bank

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**Deutsche Bank**



# Outline

- Cases that the human  $>$  computer  
Application: **Human computation**
- Cases that the computer  $>$  human  
Application: **Text classification**



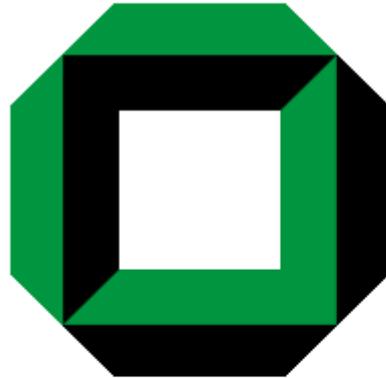
# Round 1

Human kicks computer's ass



The *best* computer science in Germany is at...

(Please click one)



The information is reliable only if there is no **SPAM!**

Yahoo! Registration - Microsoft Internet Explorer

File Edit View Favorites Tools Help

Back Forward Stop Refresh Home Search Favorites Home Mail Print Word Pad Go Links

Address [http://edit.yahoo.com/config/eval\\_register?.intl=us&new=1&.done=http%3A//mail.yahoo.com&.src=](http://edit.yahoo.com/config/eval_register?.intl=us&new=1&.done=http%3A//mail.yahoo.com&.src=) Go

### Verify Your Registration

\* Enter the code shown:  [More info](#)

This helps Yahoo! prevent automated registrations.



### Terms of Service

Please review the following terms and indicate your agreement. [Printable Version](#)

1. ACCEPTANCE OF TERMS  
Yahoo! Inc. ("Yahoo!") welcomes you. Yahoo! provides its service to you, subject to the following Terms of Service ("TOS"), which you agree to accept.

By clicking "I Agree" you agree and consent to (a) the Yahoo! Terms of Service and [Privacy Policy](#), and (b) receive required notices from Yahoo! Inc.

Code verification technology developed in collaboration with the [Captcha Project](#) at [http://www.captcha-project.com/](#)

**"CAPTCHA"**

# CAPTCHA

A program that can generate and grade tests that:

- Most humans can pass
- Current computer programs cannot pass



Prof. Luis von Ahn  
from CMU

*“Help! I’ve been waiting for 20 minutes, and nothing happens.”*

Yahoo! Registration - Windows Internet Explorer

https://edit.yahoo.com/config/eval\_register?.intl=us&new=1&.don

Google

Yahoo! Registration

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Verification technology developed in collaboration with [Carnegie Mellon University](#)

Internet | Protected Mode: Off 100%

Yahoo! Registration - Windows Internet Explorer

https://edit.yahoo.com/config/eval\_register?.intl=us&new=1&.don

Google

Yahoo! Registration

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I Agree  I Do Not Agree

Verification technology developed in collaboration with [Carnegie Mellon University](#)

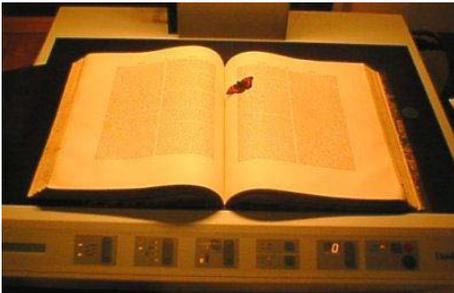
Internet | Protected Mode: Off 100%

Roughly 200 million CAPTCHAs are typed every day  
10s of human time per CAPTCHA  
That is: **500,000** hours every day!

Can we use this human  
effort for good?

CAPTCHA™

# Digitizing Books

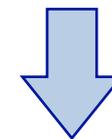


→  
Scan

DENMARK.

COPENHAGEN, Dec. 17—Noon.

The royal palace at Friedericheberg took fire last night. The King himself directed the operations for extinguishing the fire. The whole structure was, however, destroyed.



OCR optical character recognition

DE xi li ARli..

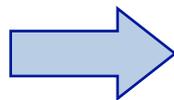
COPBCtrAGE\, DeC. 11 1 QON.

The royal palace at Frieclericheberg took fire last night. The li.ing himself directed the operations fns extinguishing the lire. The whole structure

□□□,□□□□□□□□□□,□□□□□ed.

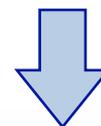


scanned book



**between**

word that OCR can't read

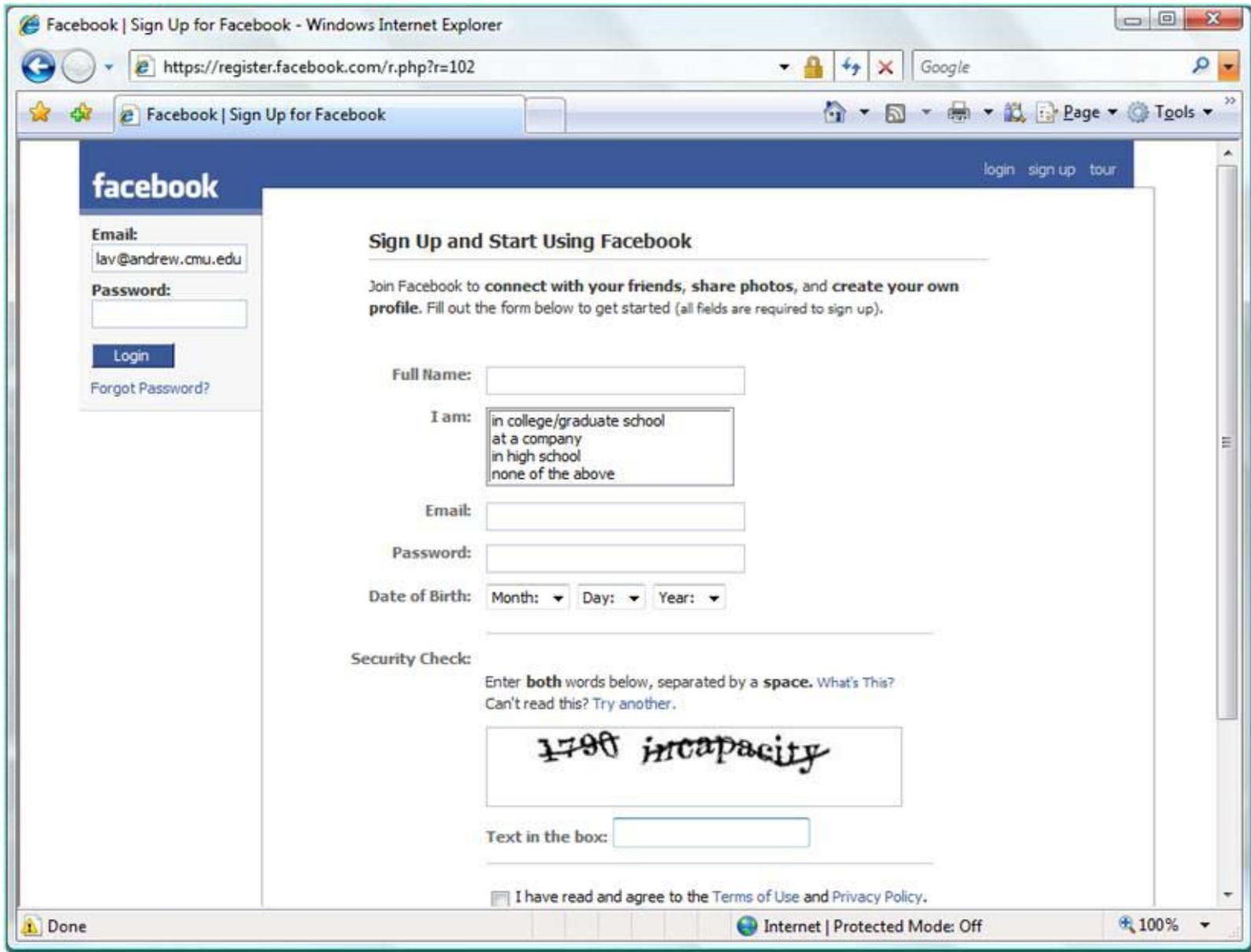


**between**

randomly distorted  
image of word



Type the two words:



facebook

login sign up tour

Email:

lav@andrew.cmu.edu

Password:

Login

Forgot Password?

### Sign Up and Start Using Facebook

Join Facebook to **connect with your friends, share photos, and create your own profile.** Fill out the form below to get started (all fields are required to sign up).

Full Name:

I am:

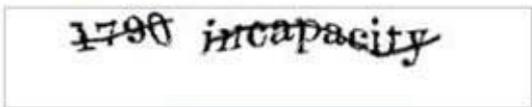
Email:

Password:

Date of Birth: Month:  Day:  Year:

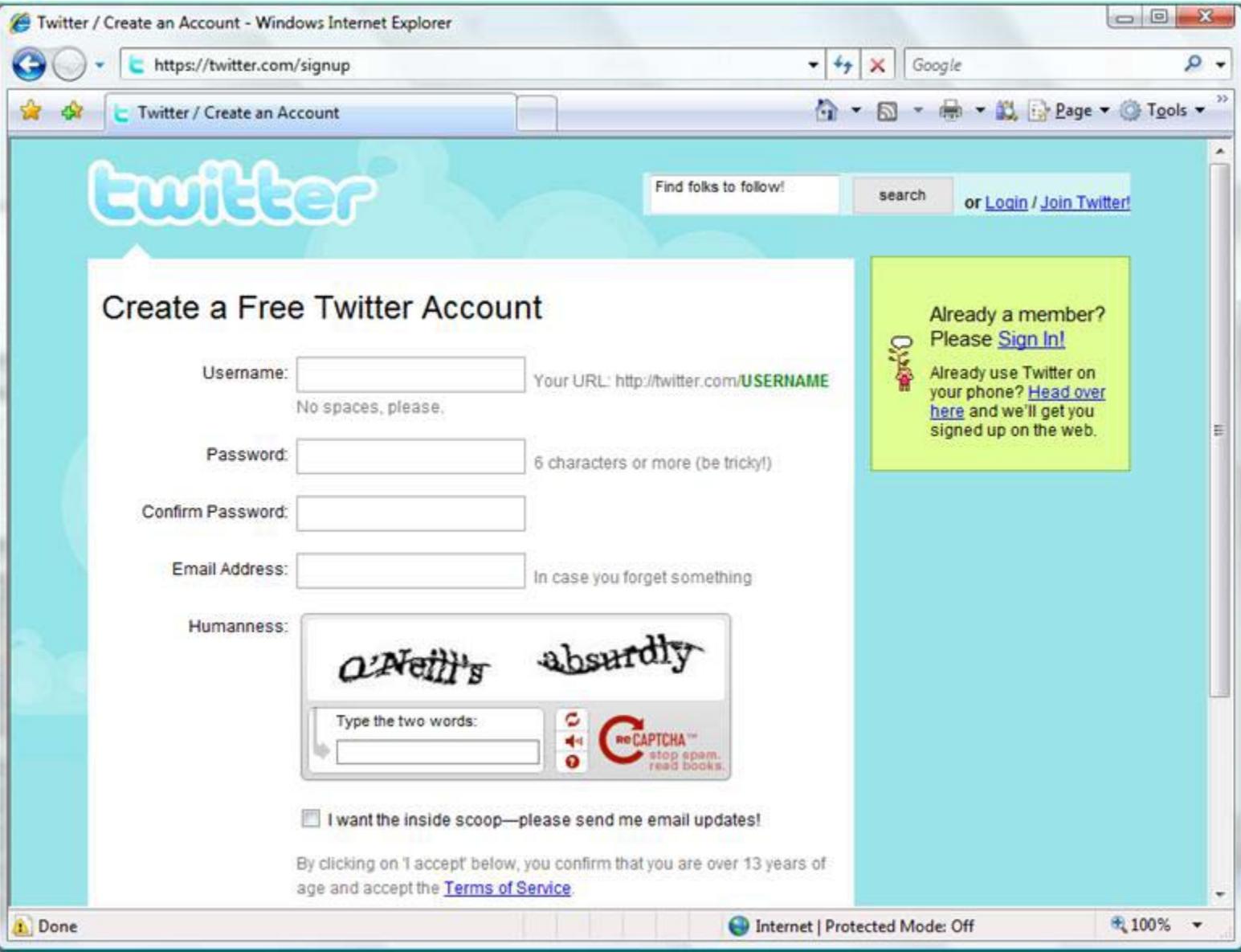
#### Security Check:

Enter **both** words below, separated by a **space**. What's This? Can't read this? Try another.



Text in the box:

I have read and agree to the [Terms of Use](#) and [Privacy Policy](#).



twitter

Find folks to follow! search or [Login / Join Twitter!](#)

## Create a Free Twitter Account

Username:  Your URL: <http://twitter.com/USERNAME>  
No spaces, please.

Password:  6 characters or more (be tricky!)

Confirm Password:

Email Address:  In case you forget something

Humanness:

*O'Neill's* *absurdly*

Type the two words:

 **reCAPTCHA™**  
stop spam. read books.

I want the inside scoop—please send me email updates!

By clicking on 'I accept' below, you confirm that you are over 13 years of age and accept the [Terms of Service](#).

Already a member?  
Please [Sign In!](#)

Already use Twitter on your phone? [Head over here](#) and we'll get you signed up on the web.

Done

Internet | Protected Mode: Off

100%

## Security Check

Type both words separated by a space below

excellent yes

Type both words:

 [Get a new word](#)

 [Vision Impaired](#)

 [Help](#)

The Security Check allows us to:

### Ensure Fair Access to Tickets

Automated programs known as "Bots" cannot read distorted text as well as humans. The Security Check helps prevent automated programs from blocking other customers from getting tickets.

### Digitize Books One Word at a Time

By entering the words in the box, you are also helping to digitize books from the Internet Archive and preserve literature that was written before the computer age.

### Provide an Audio Option for Visually Impaired Customers

An audio option allows visually impaired customers to hear a set of 8 digits that can be entered instead of the word challenge.

You do not have permission to access this website if you are using an automated program.

[Continue](#)

Security Check provided by [reCAPTCHA](#). © Carnegie Mellon University, all rights reserved.

# The New York Times

Years 1851-1980 is completed in 11 months.

400,000,000

(6% of the world's population)

# Lesson learned from Round 1

- The concept of human-computational
- CAPTCHA fights with internet spam
- reCAPTCHA fights with spam & helps digitizing books

**Human wins!**



**Think differently!!**



## Round 2

Computer kicks human's ass



You might think

If we have *enough* brains,  
we can solve *all* problems!

**Wrong!**

It is not all about **capacity**.

Human **perception** is fuzzy.

Human **intuition** is (more than often) wrong.

Human **reasoning** is not robust against illusion.

*You like watching magic, don't you?*

# Examples

# Lesson learned from Round 2

- By nature, human cannot cope with...
- We need computers, not only for our *difficult* work.

Computer  
wins!



We now talk about one “intelligent” work done  
by the computer (with *machine learning*):

**text classification**

- Top Stories
- World
- U.S.
- Business
- Sci/Tech
- Entertainment
- Sports
- Health
- Spotlight
- Most Popular

## World »

### [Iraqi Shoe Thrower Says He Was Tortured in Jail](#)

New York Times - [Marc Santora](#) - 17 minutes ago

BAGHDAD - Hours after his release from prison, the Iraqi journalist who hurled his shoes at former President George W. Bush said that he had been tortured while in jail, and his family said that he would flee Iraq, fearing for his life.

[Video: Iraqi shoe-throwing journalist released from prison](#) ITN  

[Bush 'shoe thrower' claims he was tortured in prison](#) CNN International

[Christian Science Monitor](#) - [Los Angeles Times](#) - [guardian.co.uk](#) - [BBC News](#)

[all 1,894 news articles »](#) [Email this story](#)



Telegraph.co.uk

### [US may have killed al Qaeda target in Somalia, officials say](#)

CNN International - [Barbara Starr](#) - 38 minutes ago

(CNN) -- US special operations forces raid in Somalia on Monday may have killed a wanted al Qaeda terrorist, US officials said. The FBI has this photo of Saleh al Saleh Nabhan on its Web site.

[Video: US forces have "killed" leading Al Qaeda suspect](#) ITN  

[Somalia raid likely wins intel haul, stirs tension](#) Reuters

[The Associated Press](#) - [guardian.co.uk](#) - [Bloomberg](#) - [Wikipedia: Saleh Ali Saleh Nabhan](#)

[all 721 news articles »](#) [Email this story](#)



Financial Times

### [Only Decisive Force Can Prevail in Afghanistan](#)

Wall Street Journal - [Lindsey Graham](#) - 43 minutes ago

Growing numbers of Americans are starting to doubt whether we should have troops in Afghanistan and whether the war there is even winnable.

[SCENARIOS: Obama's options in Afghan war](#) Reuters

[Joint Chiefs Chairman Mullen says more troops likely needed in ...](#) Los Angeles Times

[Bloomberg](#) - [The Associated Press](#) - [AFP](#) - [United Press International](#)

[all 809 news articles »](#) [Email this story](#)



WA today

## Business »

### [Business Inventories in US Decline in July](#)

Bloomberg - [Timothy B. Homan](#) - 1 hour ago

Sept. 15 (Bloomberg) -- Inventories in the U.S. fell in July, the first decline in 12 months as a gain in sales helped...

[Car Sales Lead Increase in US Retail Sales](#)

[NRF: Retail sales up in Aug. for first time in 10 months](#)

[Retail Sales in August](#)

[Retail Sales in August](#)

## U.S. »

### [Police: Roseville home broken into, cat killed](#)

Chicago Tribune - 27 minutes ago

AP ROSEVILLE, Mich. - Police in Roseville say at least one burglar broke into a home in th suburb and killed the family cat by putting it in the washing machine.

[Burglar killed cat in washing machine](#) The Detroit News

[burglars ransack home, kill cat](#) Detroit Free Press

[WDIV](#) - [WLNS](#) - [MLive.com](#)

[all 8 news articles »](#) [Email this story](#)

### [Report: Student stabbed to death at Florida high school](#)

CNN - 46 minutes ago

MIAMI, Florida (CNN) -- Police said Tuesday they are investigating a death at a high school in Coral Gables, Florida. Miami-Dade County police told CNN the death occurred at Coral Gables Senior High School but would not provide further information.

[Student killed at Coral Gables High School](#) MiamiHerald.com

[Student stabbed at Fla. school; 1 in custody](#) The Associated Press

[WESH.com](#) - [NBC2 News](#) - [KMBC.com](#) - [Miami New Times](#)

[all 391 news articles »](#) [Email this story](#)

### [FBI warns police depts after NYC terror raid](#)

The Associated Press - [Tom Hays](#), [Devlin Barrett](#) - 29 minutes ago

NEW YORK - Counterterrorism officials are warning police departments around the country to be on the lookout for evidence of homemade bombs following raids on several New York City apartments in a hunt for explosives and possible links to al-Qaida ...

[NY Police: Terror Task Force Conducts Raids in Queens](#) Voice of America

[NY Homes Raided in Terror Probe](#) Washington Post

[New York Times](#) - [Christian Science Monitor](#) - [Los Angeles Times](#) - [CBS News](#)

[all 1,232 news articles »](#) [Email this story](#)

## Sci/Tech »

### [Zune HD: No ipod Killer](#)

PC World - [Daniel Ionescu](#) - 38 minutes ago

Really think it can outdo Apple and its fleet of iPods with the Zune HD? Get on with a flaky refresh of the iPod touch last week, the Zune HD still doesn't that well against Apple's popular army of music-playing ...

[Under the hood](#) CNET News

[Zune HD: No iPod Killer](#) News of today DailyTech





Search

[Advanced Search](#)

## Advanced Search

Use this form to automatically construct your query. (Alternatively, you can type [search operators](#) directly into the search box.)

Find tweets based on...

Search

Words

All of these words

Attitudes

With positive attitude :)

With negative attitude :(

Asking a question ?



[bergcross121189](#): oh! how i wish I'm in **Germany**!!! :) Such a Nice Place to live..... :)  
35 minutes ago from web · [Reply](#) · [View Tweet](#)



[Susi1984](#): Good Morning from **Germany**. It's 08:18 am and I need a cup of coffee! :)  
about 1 hour ago from web · [Reply](#) · [View Tweet](#)



[denigab](#): Good Morning **Germany**. :) Today is a hard day, too...uff...[@Chaosqueen79](#) okay, honey, that's a deal :D  
about 1 hour ago from web · [Reply](#) · [View Tweet](#)



try it at <http://search.twitter.com/advanced>

# Other examples

Classify email as *Spam, Not Spam*.

Classify email to tech staff as *Mac, Windows, Hardware, .....*

Classify movie reviews as *Favorable, Unfavorable, Neutral*.

Classify technical papers as *Interesting, Uninteresting*.

Classify jokes as *Funny, Not Funny*.

**Can you come up with any other possible application?**

# Formally...

## Training (or learning):

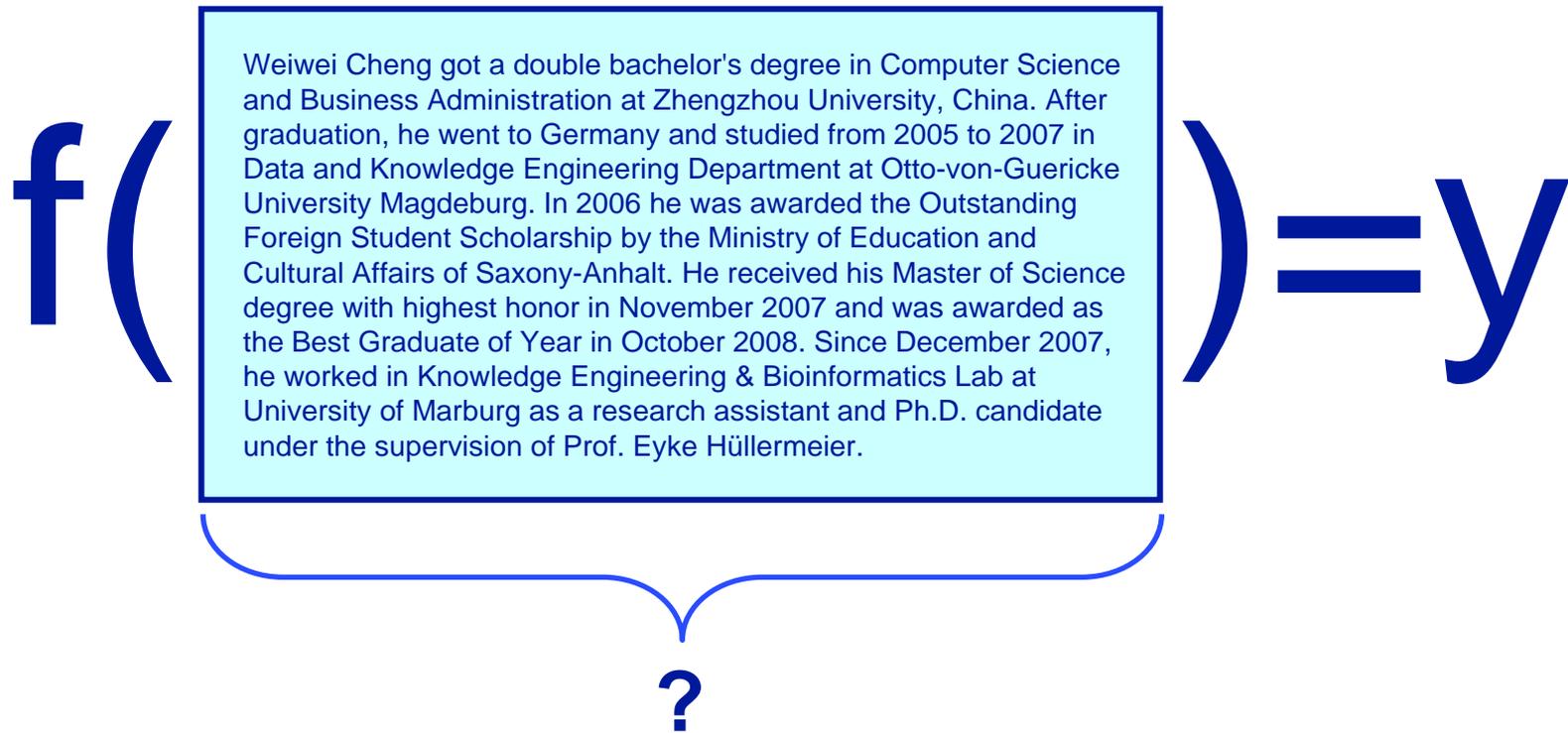
Input: a set of  $m$  labeled documents  $(x_1, y_1), \dots, (x_m, y_m)$

Output: a learned classifier  $f: x \rightarrow y$

## Testing (or predicting):

Input: a document  $x$

Output: a class  $y$  from some fixed set of labels  $y_1, \dots, y_K$



*Question:*

What is the ~~best~~ representation for the document?

**simplest useful**

# Two useful pre-processing steps

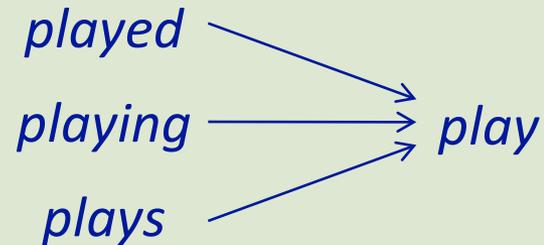
## Stop word removal

Kick out the words e.g.

*"a",  
"able",  
"about",  
"according",  
"the", ...*

## Stemming

Group the words with the same logical meaning



# Representing document with bag-of-words

**x** → [ A lady was picking through the frozen turkeys at the supermarket, but couldn't find one big enough for her family. She asked a stock boy, "Do these turkeys get any bigger?" The stock boy replied, "No madam, they're dead." ]

→ [ ladi pick frozen turkei supermarket find big her famili she ask stock boi turkei big stock boi repli madam dead ]

→ [ 166 193 78 ... .. 210 188 60 ]

Word	Index
a	1
:	:
frozen	78
:	:
repli	210
:	:

... ignores the ordering of the words.

Ready for the meat!

Now we have the representation scheme.

How do we do the classification?

What will you do? Any idea?

# Multinomial Naïve Bayes classifier

- A probabilistic learning method;
- Based on Bayes' theorem;
- State-of-the-art;
- Simple, in terms of implementation and use.

*Great and simple idea  
with fancy name*

# Some basic probability

Notation	Example
$P(A)$	$P(\textit{someone studies in MD})$
$P(B)$	$P(\textit{someone is smart})$
$P(A\&B)$	$P(\textit{someone studies in MD and she/he is smart})$
$P(A\cup B)$	$P(\textit{someone studies in MD or she/he is smart})$
$P(A B)$	$P(\textit{someone studies in MD given she/he is smart})$

$$P(A\&B) = P(B)P(A|B)$$

If A and B are **independent**, e.g.,

A: *I wear yellow shoes today,*

B: *Today it rains,*

then  $P(A\&B) = P(B)P(A)$ .

# Bayes' theorem

The chance that a smart guy studies in MD

The chance that a guy in MD is smart.

The chance someone studies in MD.

$$P(A|B) = \frac{P(B|A)P(A)}{P(B)}$$

The chance someone is smart.

A: *someone studies in MD*

B: *someone is smart*

## Quiz - *drug test*

There is a drug test. It will correctly identify a drug user as testing positive **99%** of the time, and will correctly identify a non-user as testing negative **99%** of the time. Let's assume Deutsche Bank decides to test its employees for drug use, and it is known that **0.5%** of the population actually use the drug. What is the probability that, given a positive drug test, an employee is actually a drug user?

$$\begin{aligned}P(D|+) &= \frac{P(+|D)P(D)}{P(+)} \\ &= \frac{P(+|D)P(D)}{P(+|D)P(D) + P(+|N)P(N)} && \sim 33\% \\ &= \frac{0.99 \times 0.005}{0.99 \times 0.005 + 0.01 \times 0.995} \\ &= 0.3322.\end{aligned}$$

$\mathbf{x}$ : the document (e.g. *an email message*)  
 $y$ : the class (e.g. *spam* or *not spam*)

We want to know which class can lead to the highest

$$P(y|\mathbf{x}) .$$

The probability of the email's *class* (spam/not spam) given its *text*.

By **Bayes' theorem**

$$P(y|\mathbf{x}) = \frac{P(\mathbf{x}|y)P(y)}{P(\mathbf{x})} \propto P(\mathbf{x}|y)P(y)$$

With the **bag-of-words** representation

$$P(y) P(\mathbf{x}|y) = P(y) P(x_1|y) P(x_2|y) \dots P(x_n|y)$$

To choose a *class* that maximize this.

The probability of class  $y$ , e.g., the chance an email being spam.

The probability of word  $x_2$  found in class  $y$ , e.g., the chance of word "pharmacy" seen in a spam email.

# Avoid numerical problems

We talked about computing

$$P(y|\mathbf{x}) \propto P(\mathbf{x}|y)P(y) = P(y) P(x_1|y) P(x_2|y) \dots P(x_n|y) \quad \textcircled{1}$$

Can you sense the problem?

**It goes very fast to ZERO.**

**Solution – use logarithm.**

- $\log(ab) = \log(a) + \log(b)$
- If  $a > b > 0$  then  $\log(a) > \log(b)$

The formula becomes

$$\log P(y) + \log P(x_1|y) + \log P(x_2|y) + \dots + \log P(x_n|y) \quad \textcircled{2}$$

The class  $y$  that maximizes  $\textcircled{2}$  also maximizes  $\textcircled{1}$ .

## In summary

Given a document containing  $n$  words  $x_1, x_2, \dots, x_n$ , we choose the class  $y$  that maximize

$$\log P(y) + \log P(x_1 | y) + \log P(x_2 | y) + \dots + \log P(x_n | y)$$

Weight, indicates the relative frequency of class  $y$ , e.g.,  $\log P(\text{spam})$  is smaller than  $\log P(\text{not spam})$

Weight, indicates how good an indicator  $x_2$  is for class  $y$ , e.g.,  $\log P(\text{lottery} | \text{spam})$  is large,  $\log P(\text{weiwei} | \text{spam})$  is small.

# Take-away message

Text classification finds the patterns in documents, reduces the human effort.

How do we represent the text in the computer?

*bag-of-words*

Any pre-processing?

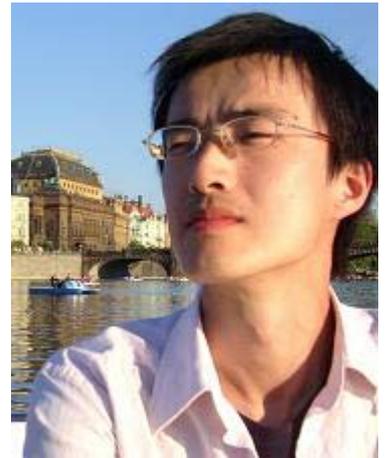
*Stop word removal & stemming*

Which classifier?

*Naive Bayes.* Key idea: *Bayes' theorem*

That is all from my side 😊  
Thank you all for being here!

Time for discussion!



程蔚蔚

[www.chengweiwei.com](http://www.chengweiwei.com)