"*StatProb*" and "Your Life"

Why you should care about it ?

CSGE602013 – Statistika dan Probabilitas

Fakultas Ilmu Komputer Universitas Indonesia

Credits

The content was based on previous semester's course slides created by **all previous lecturers.**

References

- Introduction to Probability and Statistics for Engineers & Scientists, 4th ed.,
  - Sheldon M. Ross, Elsevier, 2009.
- Probability and Statistics for Engineers & Scientists, 3rd Edition
  - Anthony J. Hayter, Thomson Higher Education

Statistics

Art of learning from data, dealing with

- the **collection** of data,
- its **description** (presentation),
- and its **analysis**,

which can be used to draw **conclusions** (reasonable interpretations).

[Ross, 2009]

Probability

Branch of mathematics that has been developed to deal with uncertainty (random events).

[Hayter, 2007]

Random event: we don't know the outcome without observing it.

Way of expressing **how likely it is (belief) that an event occurs**

Probability & Statistics for Computer Science

“StatProb” and **“CS”** loves each other since long time ago ☺

- Machine Learning
- Data Mining
- Text Mining
- Natural Language Processing
- Simulation
- Cryptography
- Robotics & AI

- Algorithms
- Image Processing
- Computer Graphics
- Computer Vision
- Software Testing

ALAN TURING

While we develop a system for determining how much intelligence to act on. Which attacks to stop, which to let through. Statistical analysis. The minimum number of actions it'll take to win the war, but the maximum number we're able to take before the Germans get suspicious.

STEWART MENZIES

You're going to trust this all to statistics?

To maths?

ALAN TURING

Correct.

Dialog Script of the film "The Imitation Game"
In http://stats.stackexchange.com/

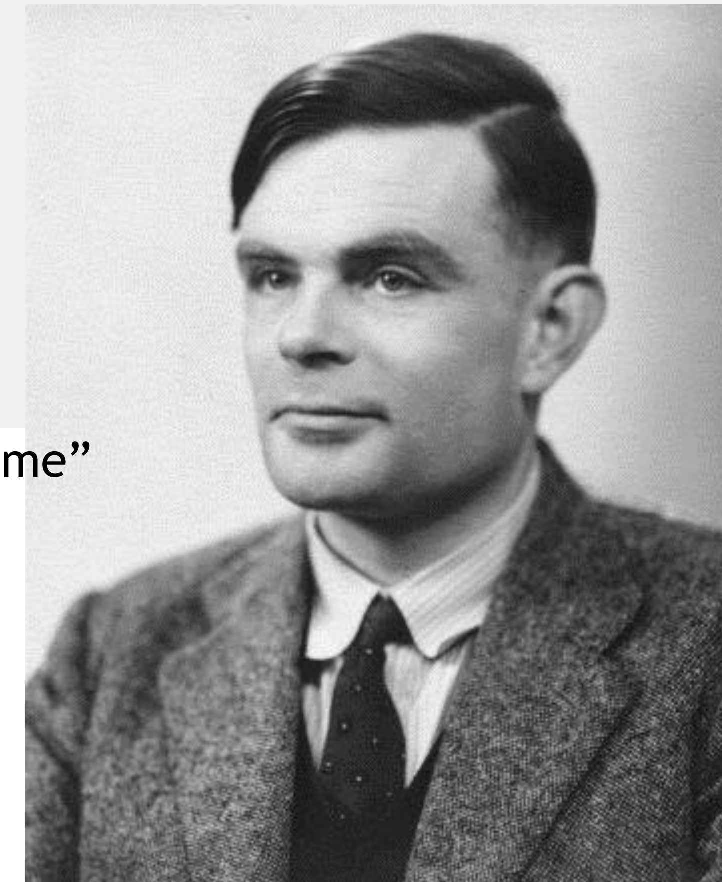


Photo: http://en.wikipedia.org/wiki/Alan_Turing

Probability & Statistics for Information Systems

Modern Information Systems are associated with **huge amounts of data !**

Probability and statistics provide strong theories and tools to all aspects of **data analysis** in the wide discipline of information systems.

- Risk Management
- Requirements Engineering
- Information Systems Security
- Information Systems Project Simulation
- ...

and…Business Intelligence !

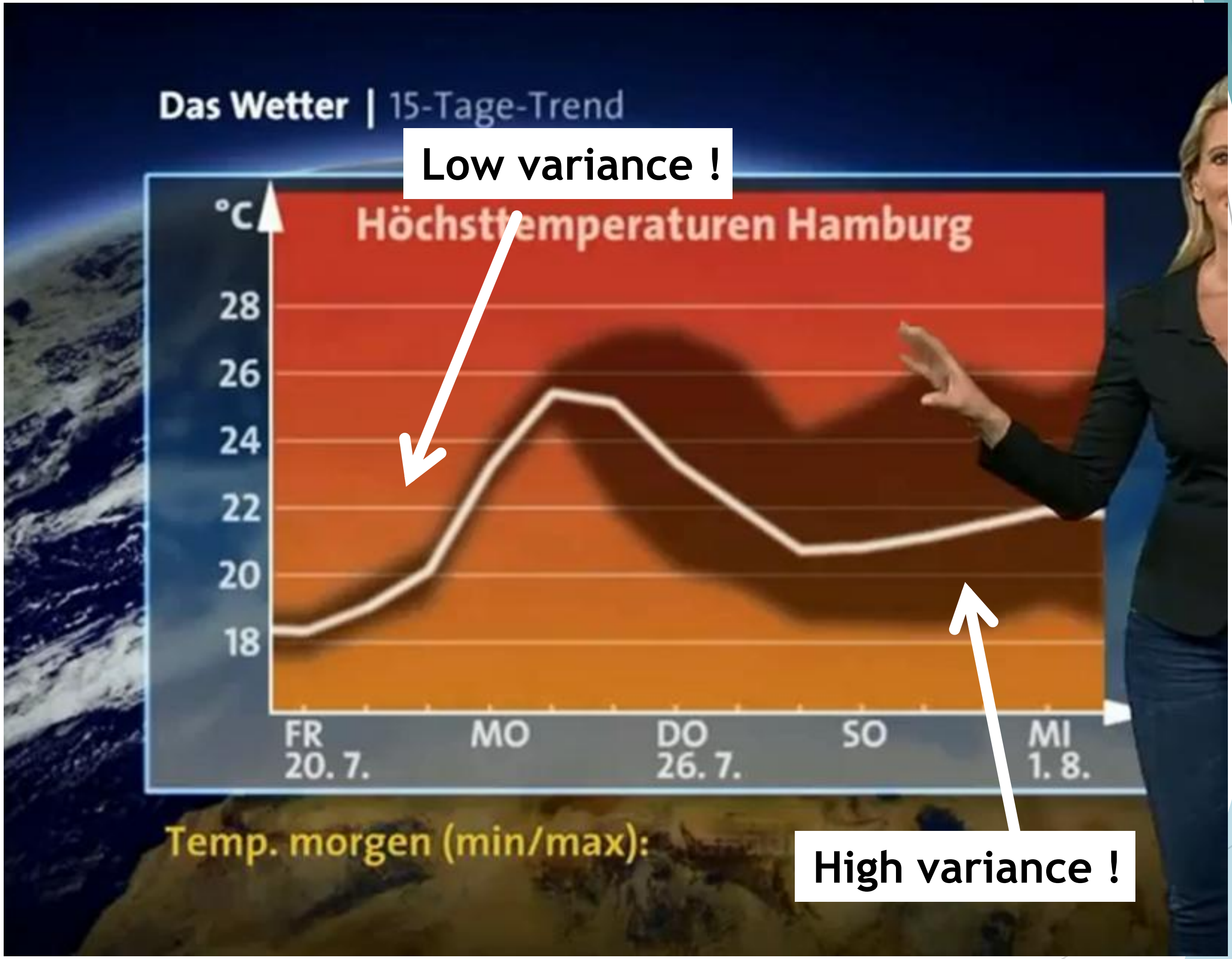
Probability & Statistics for Electrical Engineering

- Signal Processing
- Telecommunications
- Digital Communications
- Electronics Testing
- Instrumentation
- Sensors
- Automatic Control Theory
- Information Theory

Probability & Statistics for human being !

- Gambling (**DON'T TRY THIS !**)
- Stock Market Analysis
- Economics & Financial World
- Disaster: Flooding
- Politics
- Sports
- Demographics
- Law
  - Assess the truth of a statement
- Medicine
  - Test new drugs

Weather Forecast for the **next 15 days** !



http://dwjunkie.wordpress.com/2013/07/24/data-sciencewhats-the-big-deal-about-it/

Math equation could help find missing Malaysian plane

Bayes' Theorem helped researchers locate Air France Flight 447's black box in 2011

March 12, 2014 1:37PM ET

by **Ehab Zahriyeh** - @EhabZ

http://america.aljazeera.com/articles/2014/3/12/mathematical-equationcouldhelpfindmissingmalaysianplane.html

Machine Learning

Machine learning provides mechanisms to learn from data.

- There exists underlying **statistical model** on our data
- We estimate the parameter of our model based on **observable data**
- We use that to make decisions

Example of application:

- Classification (SPAM filtering, Handwriting Recognition)
- Prediction (Elections, Market analysis)
- Natural Language Processing
- …

Machine Learning (an Example)

Misal, Anda punya data berikut yang diperoleh dari pengalaman sebelumnya.

J. Kelamin	Cuaca Hari ini	IPK	Warna Baju	Makan Siang
Pria	Hujan	4	Merah	Bakso
Pria	Cerah	4	Biru	Mie Ayam
Wanita	Hujan	3	Hitam	Sate Kambing
Wanita	Hujan	4	Biru	Bakso

Buatlah **Algoritma** yang menerima input **tabel tersebut** dan menghasilkan sebuah fungsi prediksi **F**.

Fungsi prediksi tersebut digunakan untuk mejawab pertanyaan berikut:
Jika hari ini **hujan** dan ada seorang **pria** dengan baju **hitam** dan memiliki **IPK = 4**, apa jenis **makan siang yang tepat** untuk orang itu ?

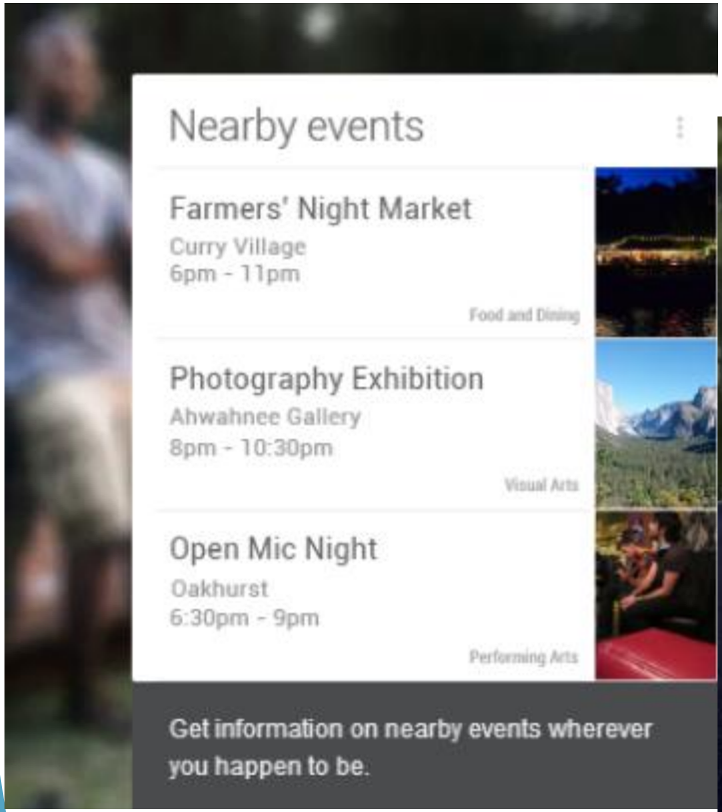
Application: Face Detection

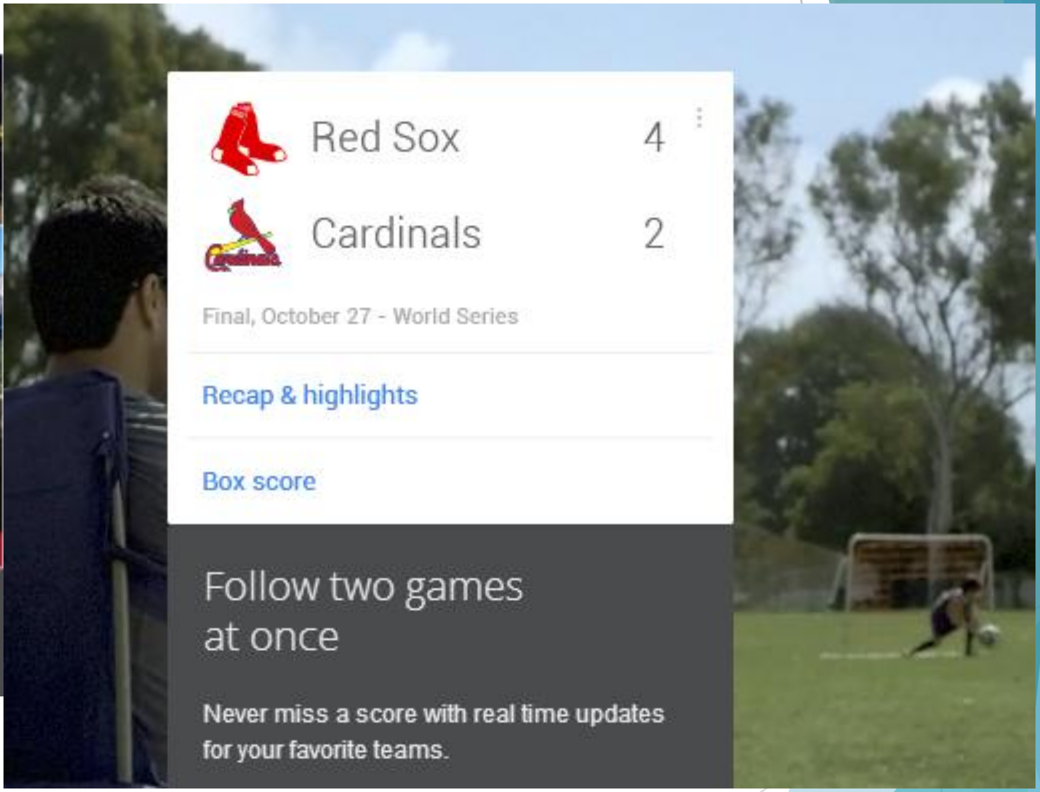
http://www.briancbecker.com/blog/projects/facebook-face-recognition/

B. C. Becker, E. G. Ortiz. "*Evaluation of Face Recognition Techniques for Application to Facebook*". IEEE International Conference on Automatic Face and Gesture Recognition 2008.

Google Now

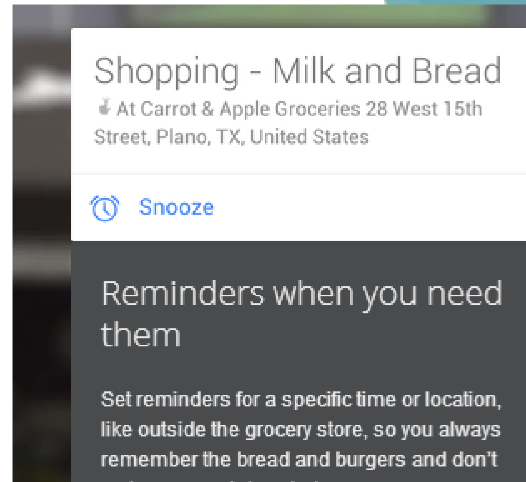
http://www.google.com/landing/now/





personalized assistant that can **predict your needs, wants, and deep desires !**

Google Now



How to do that ?

Google uses your **private data**

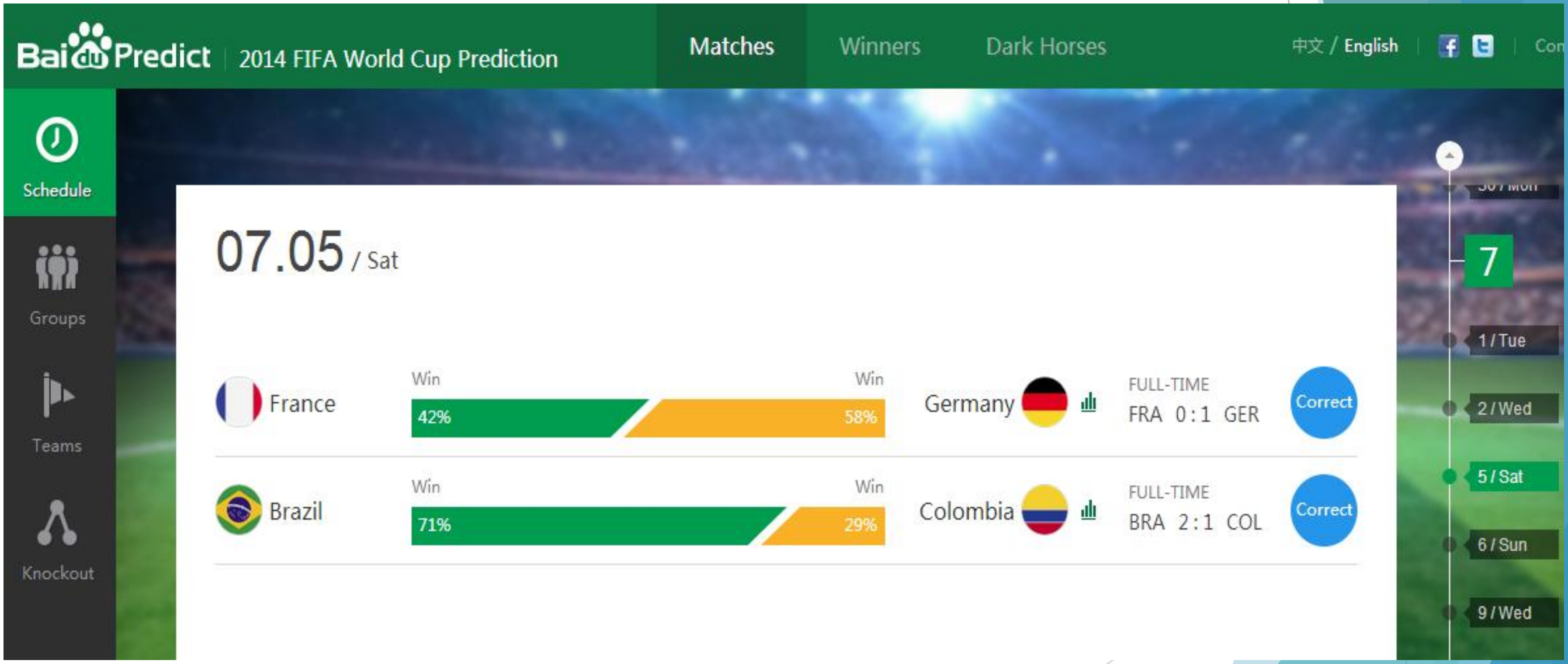
- people you know, documents, images, hangouts
- accessing your location, e-mail, daily calendar, and other info

in order to keep tabs on things like search preferences, appointments, flight reservations, payments and hotel bookings.

We need **statistics & math** to do that !

Deep Learning

Baidu big winner in World Cup !

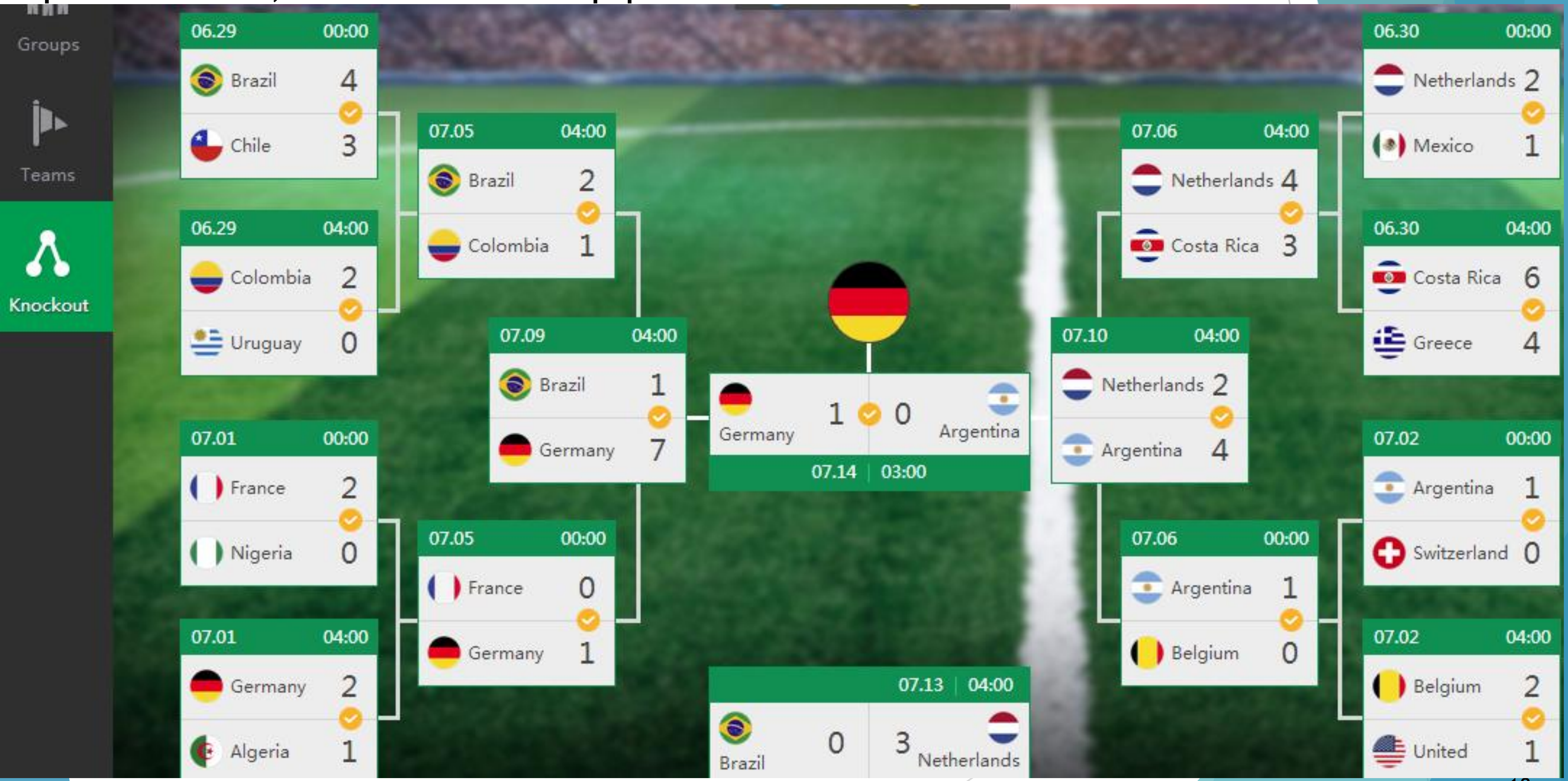


http://europe.chinadaily.com.cn/business/2014-07/14/content_17763137.htm

Deep Learning

Baidu said that its World Cup prediction model is based on data from as many as 37,000 matches played by 987 teams over the past five years.

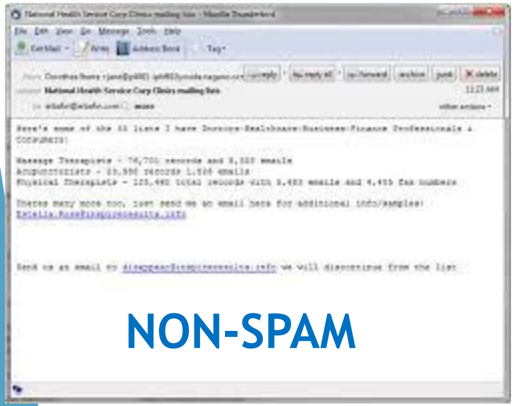
five factors: the teams' strength, home advantage, recent game performance, overall World Cup performance.



Application: SPAM Filtering

Training data (sample)

SPAM EMAIL



NON-SPAM

We want to check whether or not this email is SPAM ?

Statistical Model

P(SPAM | that email) = 0.8
P(NON-SPAM | that email) = 0.2

We can say, that email is SPAM ☺

Simple case is based on *Naive Bayes Classifier*

Application: Statistical Machine Translation

Parallel Corpus

Saya suka makan sup I like to eat soup
Dia pergi ke depok She goes to depok
Saya cinta dia I love him
Aku suka berbelanja I love shopping
Mereka suka makan They love eating
Saya pergi berbelanja di hari libur I go shopping on holiday

→

I love him INPUT

↓

i	saya	3
	aku	1
like	suka	1
love	suka	2
	cinta	1
she	dia	1
...		

Statistical Translation Model

↓

Saya suka dia OUTPUT

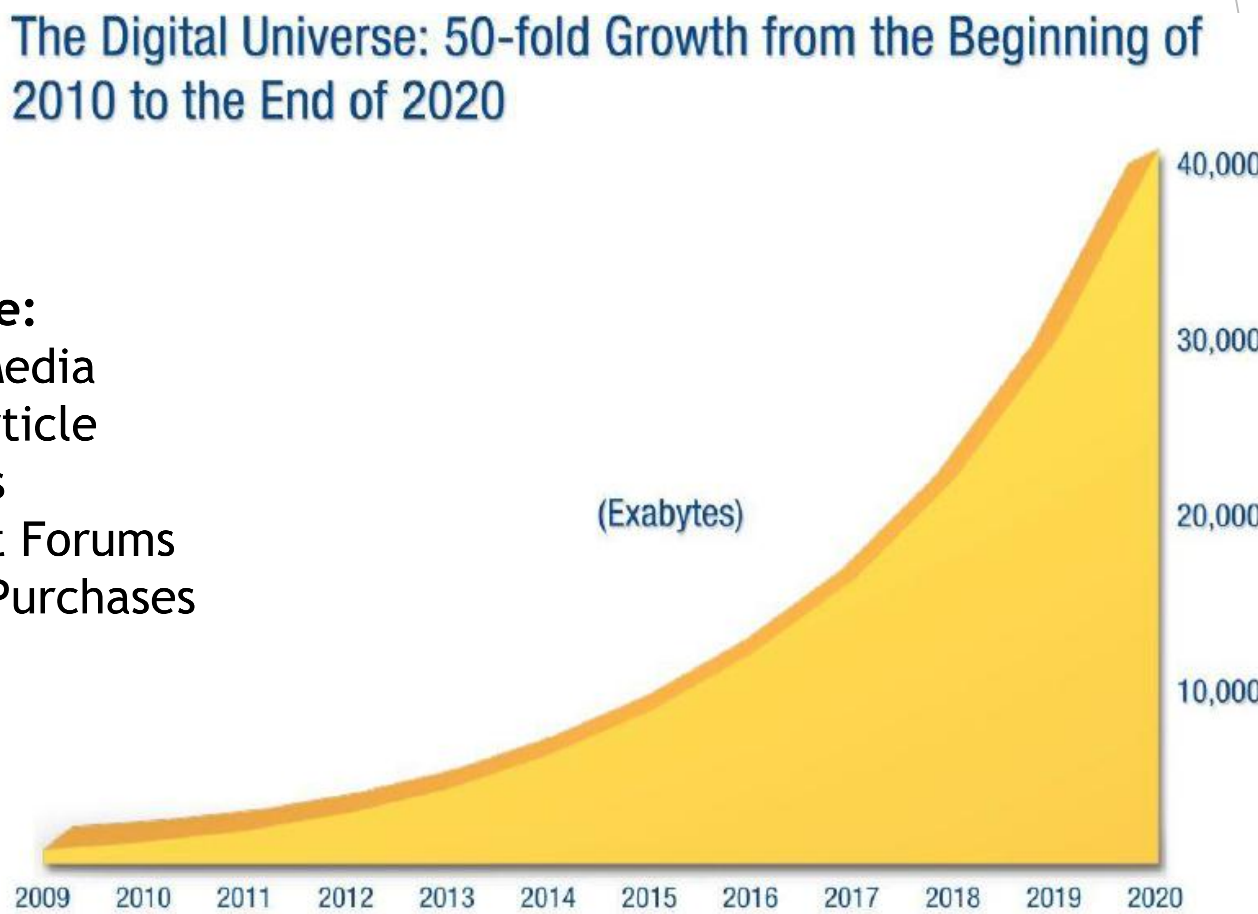
This is the simple case of SMT ☺

Data Scientist

"The **SEXIEST** Job of The 21st Century",
Thomas H. Davenport

Image: http://dwjunkie.wordpress.com/2013/07/24/data-sciencewhats-the-big-deal-about-it/

Digital Universe

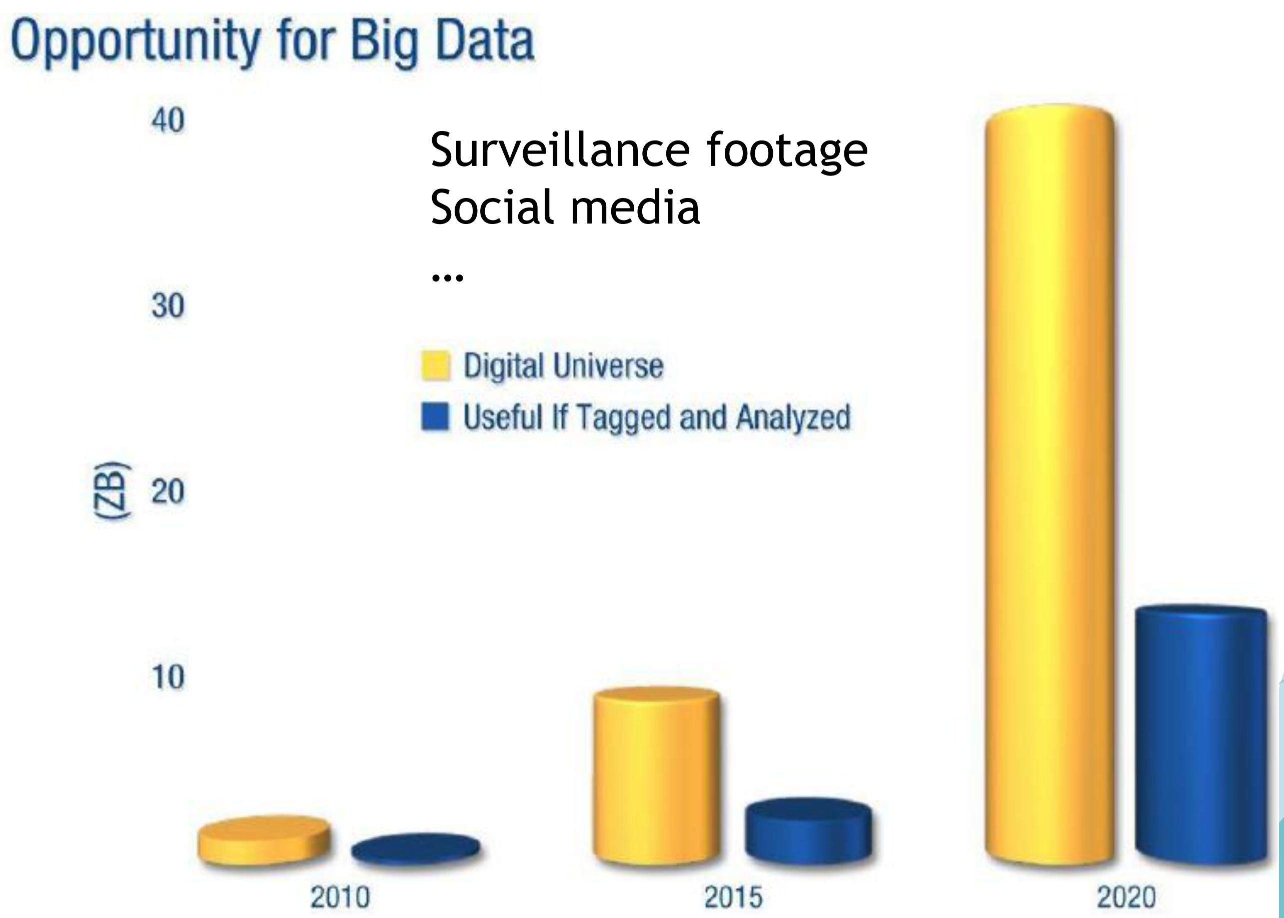


Example:
Social Media
News Article
Weblogs
Internet Forums
Online Purchases
...

Source: IDC’s Digital Universe Study, sponsored by EMC, December 2012

Big Data

Big Data is part of digital universe. If it is tagged and analyzed, **it will provide useful knowledge** !

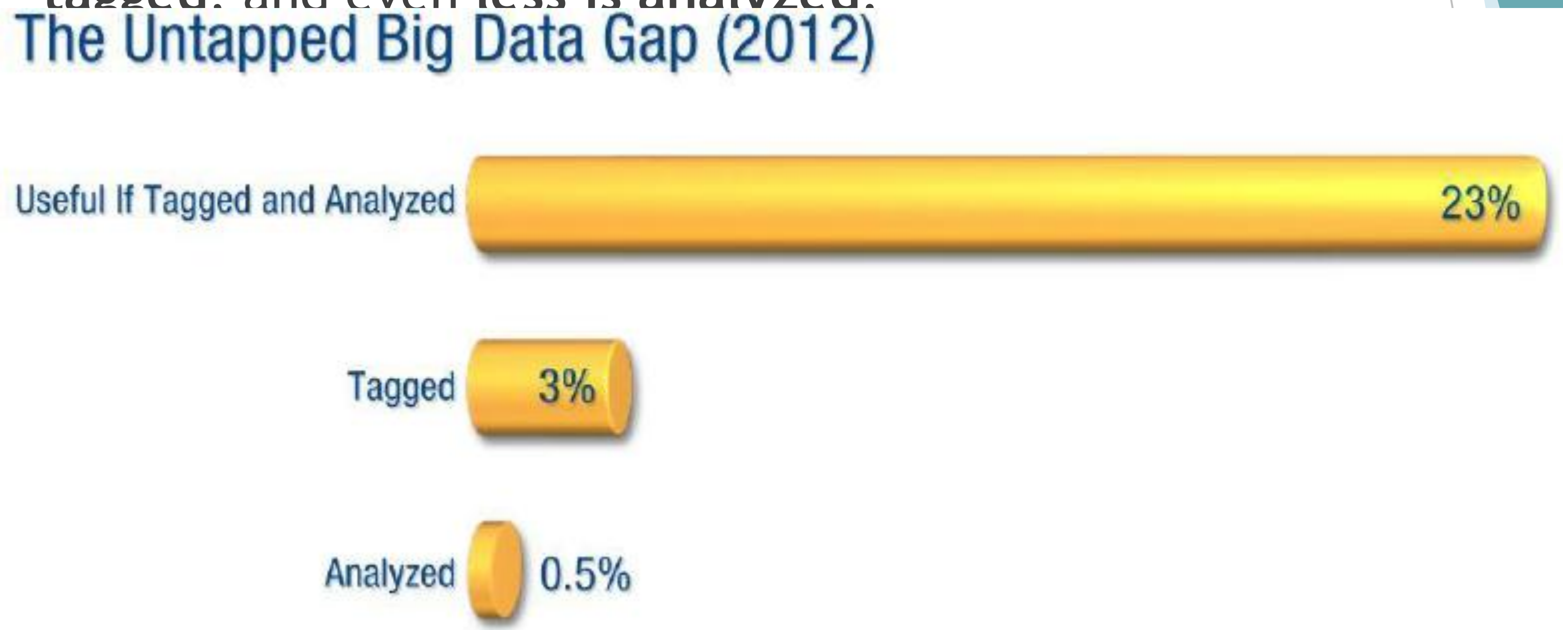


Surveillance footage
Social media
…

Source: IDC’s Digital Universe Study, sponsored by EMC, December 2012

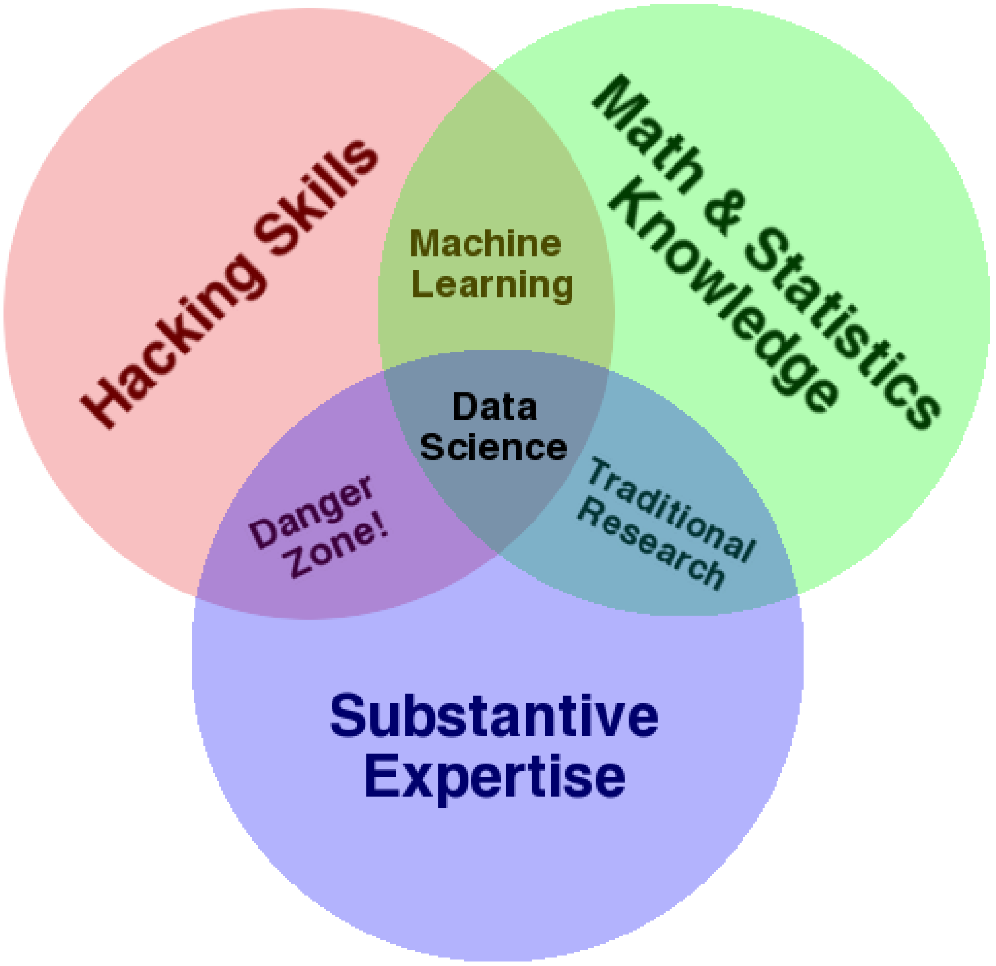
Big Data Gap

in practice, **only 3%** of the potentially useful data is **tagged**, and even **less is analyzed**.



Source: IDC’s Digital Universe Study, sponsored by EMC, December 2012

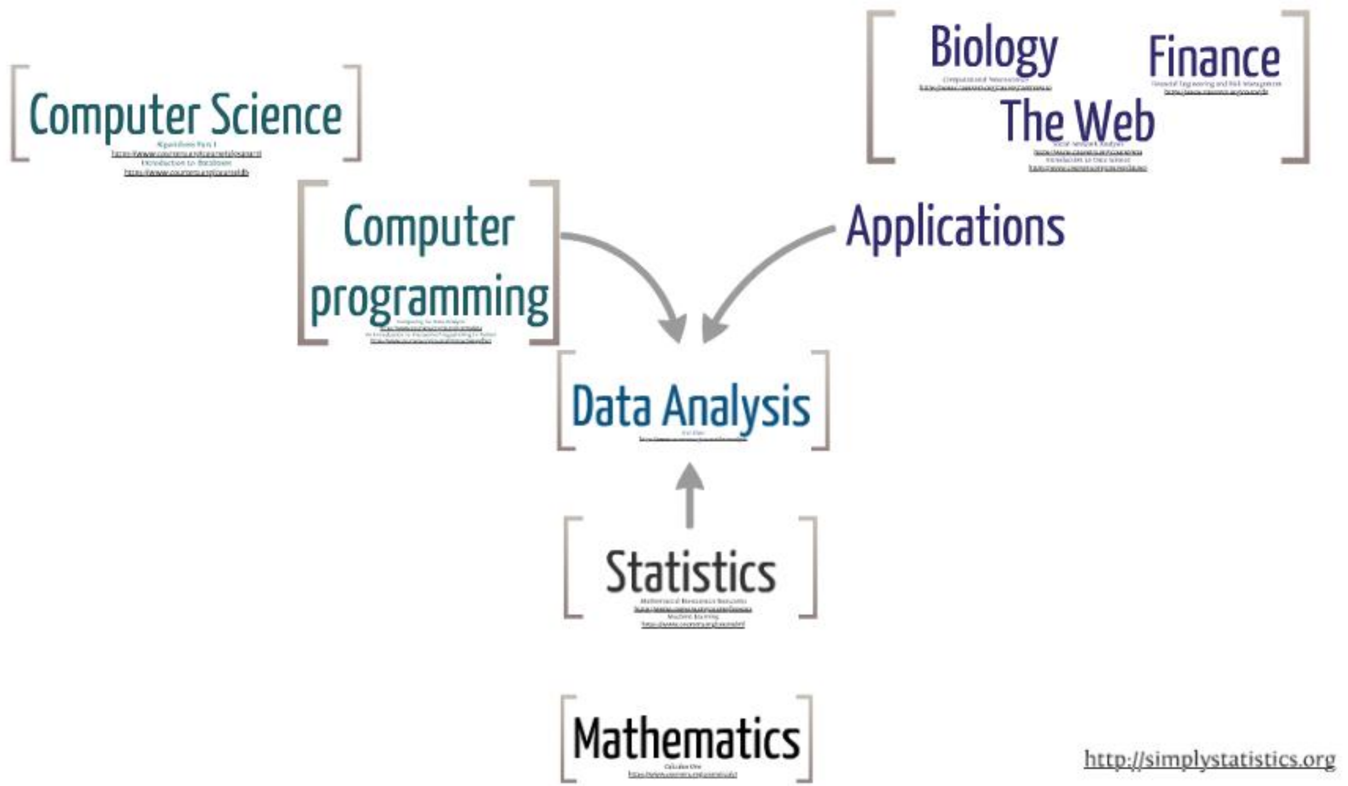
Data Science Venn Diagram



By **Drew Conway** Data Consulting, LLC. 2013

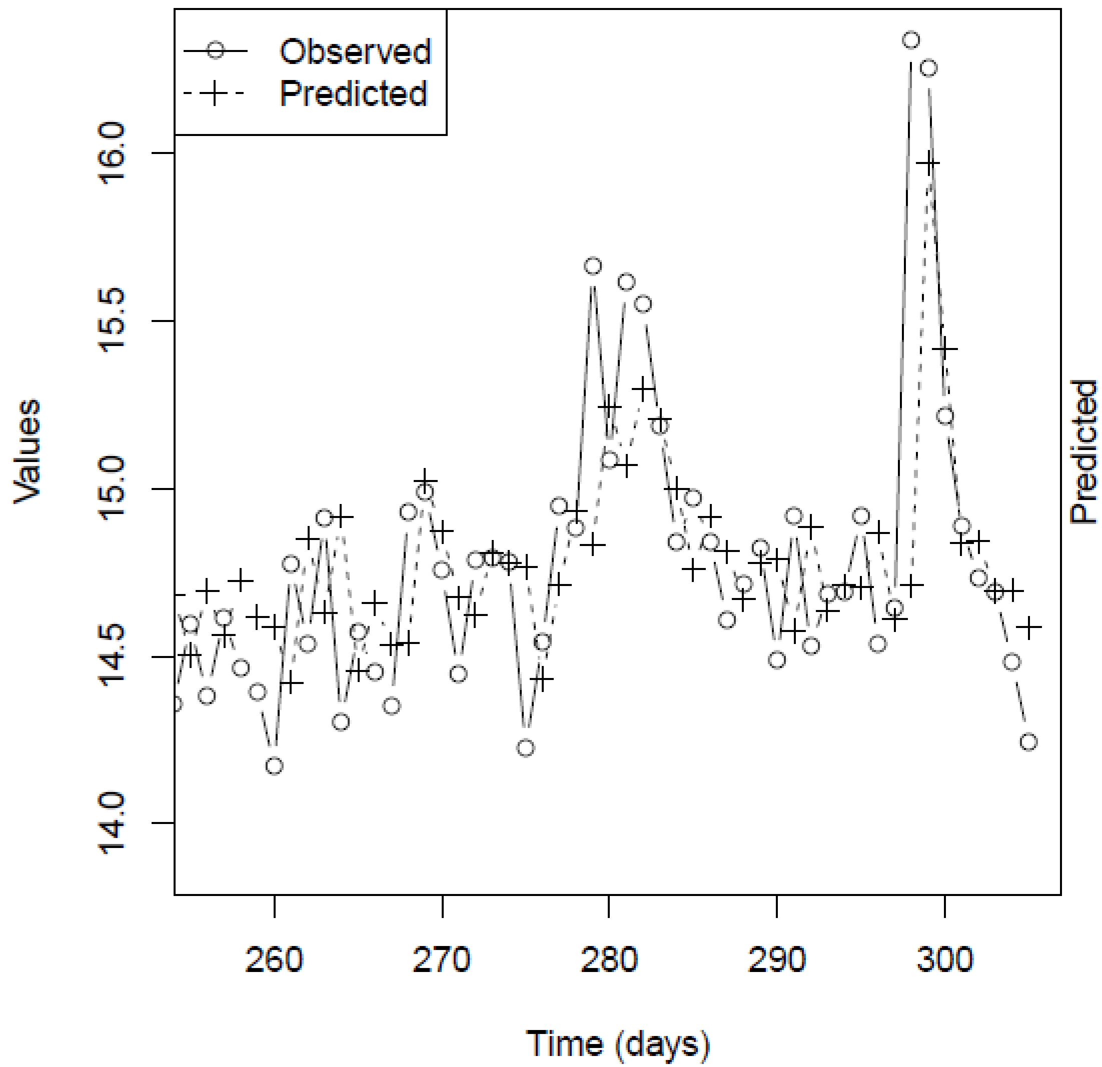
http://drewconway.com/zia/2013/3/26/the-data-science-venn-diagram

Simple Data Analysis



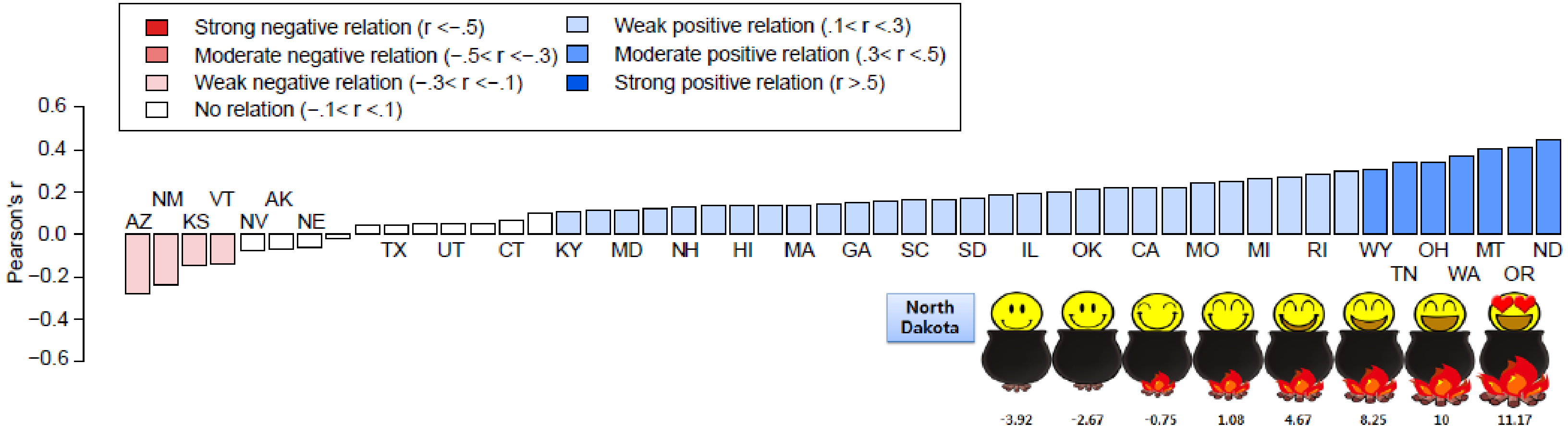
http://digitheadslabnotebook.blogspot.com/2013/02/data-analysis-class.html

Tweets for predicting stock market

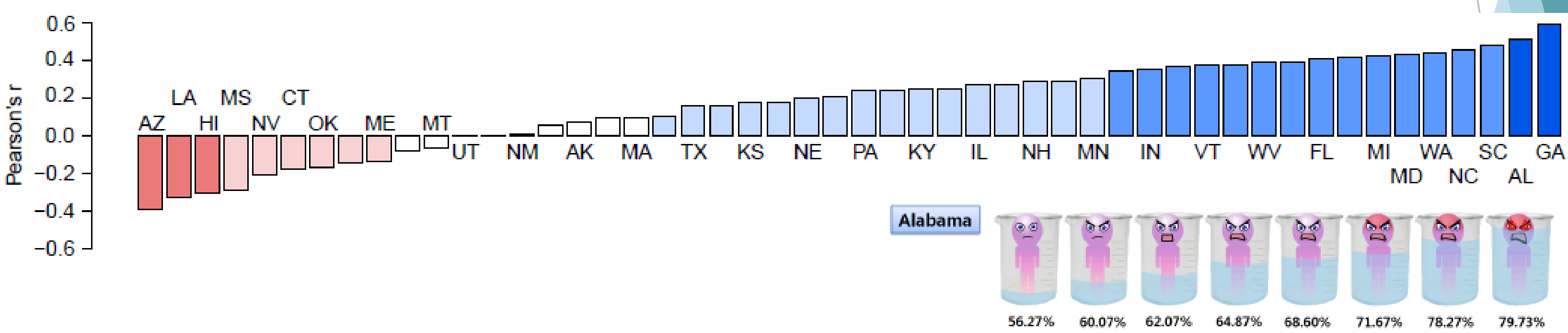


Nuno Oliveira, Paulo Cortez, Nelson Areal: **On the Predictability of Stock Market Behavior Using StockTwits Sentiment and Posting Volume.** EPIA 2013: 355-365

Mood & Weather



(a) Correlation between temperature and positive affect



(b) Correlation between humidity and negative affect

Park et al., Mood and Weather: Feeling the Heat ?, ICWSM 2013 (poster paper).

Twitter Can Predict Election ?

Table 4: Share of tweets and election results

Party	All mentions		Election	
	Number of tweets	Share of Twitter traffic	Election result*	Prediction error
CDU	30,886	30.1%	29.0%	1.0%
CSU	5,748	5.6%	6.9%	1.3%
SPD	27,356	26.6%	24.5%	2.2%
FDP	17,737	17.3%	15.5%	1.7%
LINKE	12,689	12.4%	12.7%	0.3%
Grüne	8,250	8.0%	11.4%	3.3%
			MAE:	1.65%

** Adjusted to reflect only the 6 main parties in our sample*

Mean Average Error

6 Parties in German election 2009

Tumasjan et al., Predicting Elections with Twitter: What 140 Characters Reveal about Political Statements, ICWSM 2010.

Jakarta: the most active *twitter* city

Table 1: Top 20 cities by percent of Twitter Decahose georeferenced tweets 23 October 2012 to 30 November 2012.	
City	**Percentage georeferenced tweets**
Jakarta	2.86
New York City	2.65
São Paulo	2.62
Kuala Lumpur	2.10
Paris	2.03
Istanbul	1.60
London	1.57
Rio de Janeiro	1.39
Chicago	1.28
Madrid	1.17
Los Angeles	1.14
Singapore	1.05
Houston	1.04
Mexico City	1.03
Philadelphia	0.99
Dallas	0.91
Manila	0.90
Brussels	0.88
Tokyo	0.85
Moscow	0.77

http://firstmonday.org/article/view/4366/3654

Social Media as early indicator of an unemployment spike

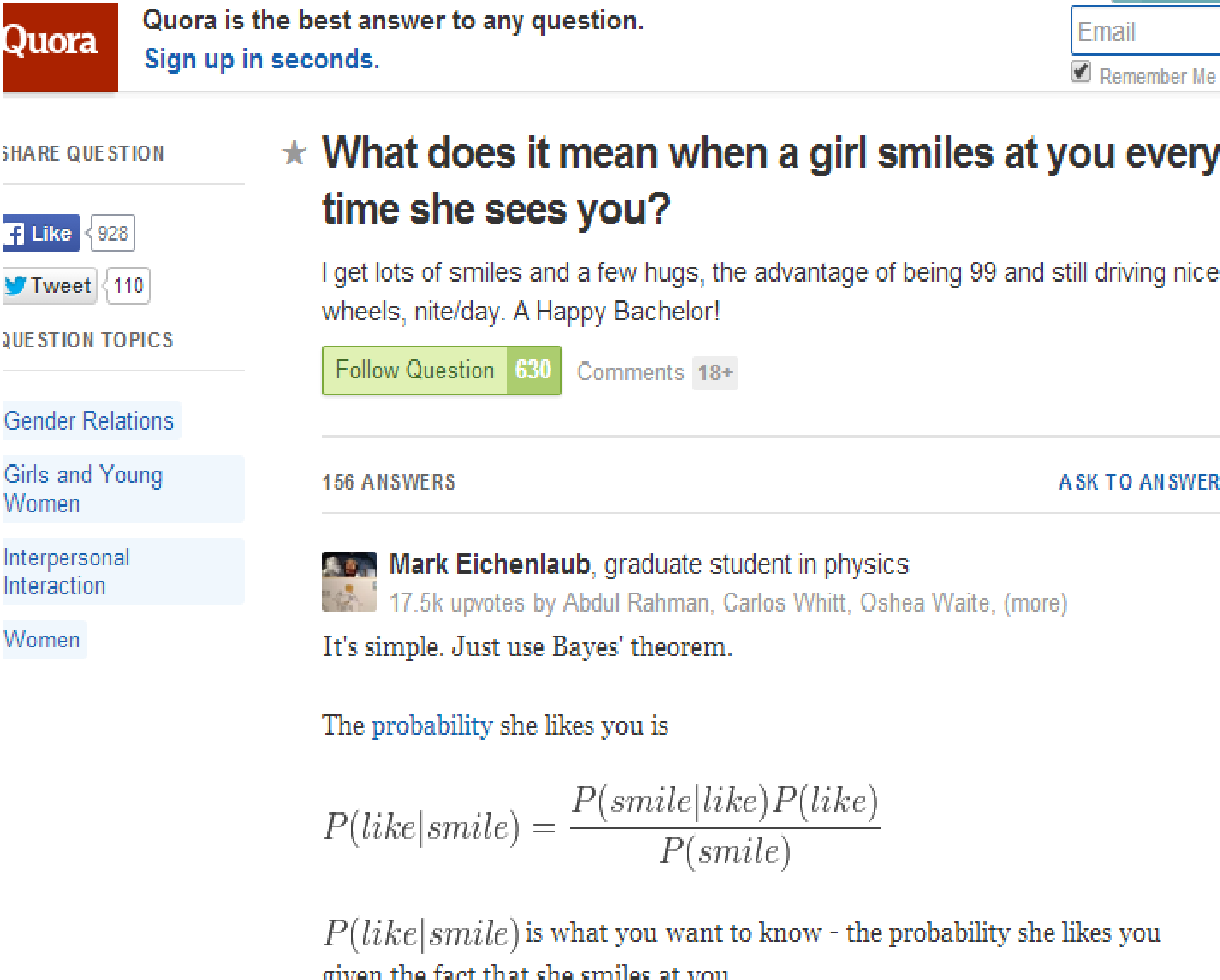
Challenge

Can social media add depth to unemployment statistics ?

Solution

1. Collect digital data (social media, blogs, forums, news articles) related to unemployment.
2. Perform sentiment analysis to categorize the mood of these online conversations.
3. Correlate volume of mood-related conversation to official unemployment statistics.

Source: IQ (Intelligence Quarterly), Journal of Advanced Analytics, 4Q 2013



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Like 928
Tweet 110

QUESTION TOPICS

Gender Relations
Girls and Young Women
Interpersonal Interaction
Women

What does it mean when a girl smiles at you every time she sees you?

I get lots of smiles and a few hugs, the advantage of being 99 and still driving nice wheels, nite/day. A Happy Bachelor!

Follow Question 630 Comments 18+

156 ANSWERS ASK TO ANSWER

Mark Eichenlaub, graduate student in physics
17.5k upvotes by Abdul Rahman, Carlos Whitt, Oshea Waite, (more)

It's simple. Just use Bayes' theorem.

The probability she likes you is

$$P(like|smile) = \frac{P(smile|like)P(like)}{P(smile)}$$

$P(like|smile)$ is what you want to know - the probability she likes you given the fact that she smiles at you.

Just a Joke ! ☺

Thanks to Raja Oktovin

Introduction to statistics

Two parts of statistics

Descriptive Statistics

- Gives **description (presentation) of data**
  - Output: **tables** or **graphs**.
- Gives **summarization of data**
  - Output: numerical quantity from data (mean, median, variance, mode, etc.)

Inferential Statistics

- Involves techniques for
  - drawing conclusions
  - making inferences about a **population** from the **samples.**

Some definitions

- Data & Data Set
- Population & Sample
- Parameters & Statistics
- Variables
- Scale of measurement
- Distribution
- Sample space & Events
- Probability
- Probability Distribution

Data & Data Set

Data (plural)

Measurements or observations

Data Set

A collection of measurements or observations

Datum (singular)

A Single measurement or observation and is commonly called as **score** or **raw score**.

Population & Sample

Population

- A **total** collection of elements being studied
- A group from which data (sample) is to be collected
- Complete set of individuals, objects, or scores of interest

Sample

- Population is often too large to examine.
- Sample is subset of a population.
- Sample is a group of subjects selected from a population
- The sample must be informative about the total population (representative of that population).
  - Usually drawn in a totally **Random** fashion

Parameters & Statistics

Parameters

- Descriptive measures of a **population**
- Quantities that describe a population characteristics.
- Usually unknown, why ? ☺
- Ex: The **mean** of **all** UI students' GPA.

It is impractical to ask All UI students ! so, we just ask **some** UI Students (sample).

Statistics

- Descriptive measures of a **sample**
- Ex: The **mean** of **100** UI students' GPA.

"Mean" statistic is then used to make statistical inferences about the **parameter**, i.e., **population's mean**.

Scale of Measurement (1)

The data collected on variables are the result of measurement.

Measurement is a process of assigning numbers to characteristics according to a defined rule.

Not all measurement is the same:

- Precise: the person is **six feet, five inches.**
- Less-precise: the person is **tall.**

Precision of measurement of a variable is important **in determining what statistical method** should be used to analyze the data in a study.

Scale of Measurement (2)

Measurement scales of variables are classified in a hierarchy based on their **degree of precision.**

More precise !

1. Nominal scale
2. Ordinal scale
3. Interval scale
4. Ratio scale

Scale of Measurement (3)

Nominal Scale

- Data categories are mutually exclusive; that is, an object can belong to only one category.
- Data categories have no logical order.
- Least precise measurement scale.
- Example:
  - Gender
  - Color of eyes
  - Blood types

Scale of Measurement (4)

Ordinal Scale

- Data categories are mutually exclusive
- Data categories have some logical order.
- Data categories are scaled according to the amount of the particular charateristics they possess.
- Differences in the amount of the measured characteristic are discernible.
- Example: **Your Grade ! A, B, C, D, E**.
  - We cannot infer: difference between A and B = difference between D and E ?

Scale of Measurement (5)

Interval Scale

- Data categories are mutually exclusive.
- Data categories have logical order.
- Data categories are scaled according to the amount of the particular charateristics they possess.
- Equal differences are represented by equal differences in the numbers assigned to the categories.
- Point 0 is just another point on the scale.

- Example: **Temperature**
  - Difference between 23’C and 20’C is the same with difference between 100’C and 97’C, i.e., **3’C**.

Scale of Measurement (6)

Ratio Scale (the most precise)

- Data categories are mutually exclusive.
- Data categories have logical order.
- Data categories are scaled according to the amount of the particular charateristics they possess.
- Equal differences are represented by equal differences in the numbers assigned to the categories.
- **Point 0 reflects an absence of the characteristics**.
- Example: **Weight, Height**
  - We **cannot** say 50'C is **twice as warm as** 25'C.
  - But, 50 KG really **weights twice as much as** 25 KG

Variable

Feature characteristic or attribute that **can take on different values** for different members of a group being studied.

Types of variable 1:

- Quantitative variable
- Qualitative variable

Types of variable 2:

- Discrete variable
- Continous variable

Qualitative & Quantitative Var.

Qualitative (Nomial) Variable

- A variable measured on the **nominal** or **ordinal scale**
- Measurement consists of unordered or ordered discrete categories.
- Example: blood group, color

Quantitative Variable

- A variable measured on the **interval** or **ratio scale**
- Described by a number
- Example: weight & height of people, time till cure

Discrete & Continous Var.

Discrete Variable

- Variable can only take one of a finite or countable number of values
- Example: a Count

Continuous Variable

- A measurement which can take any value in an interval of the real line
- Example: Weight, Height, etc.

Distribution

Distribution is a summary of the frequency of individual values or ranges of values for a variable.

Bar chart, frequency table, etc. can be used for presenting the distribution.

Distribution (of a variable) tells us ..

- What values the variable takes, and
- How often it takes these values

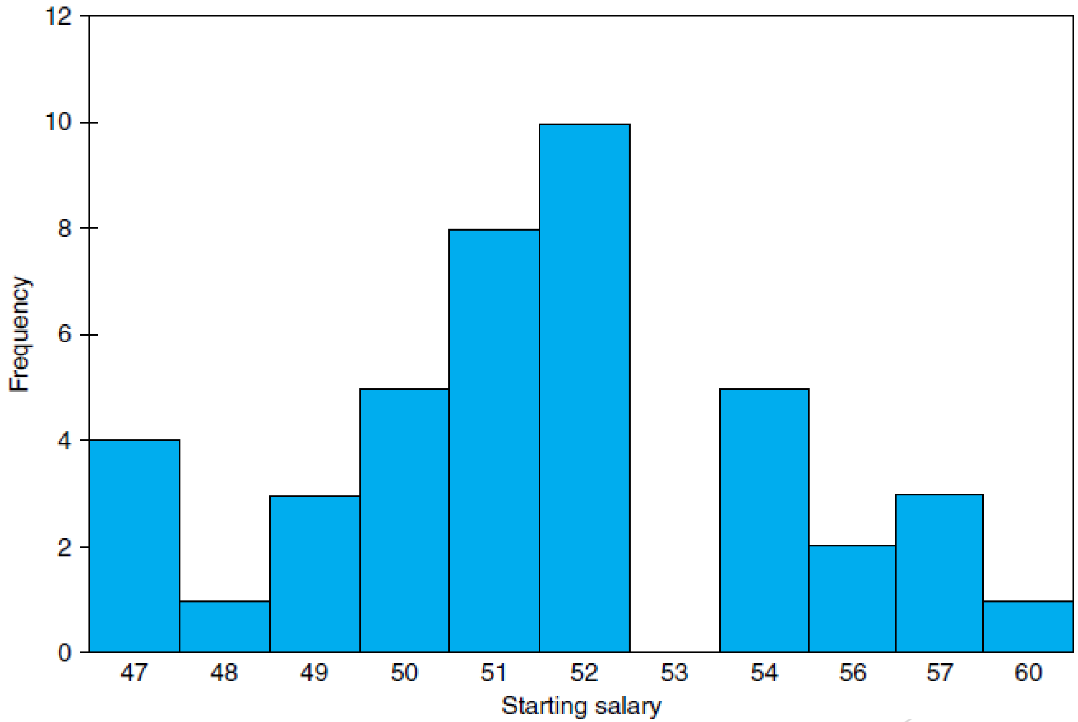
Simple distribution would be

- A list of every value of a variable
- + number of times each values occurs

Distribution

Example: distribution of a sample (discrete variable)

Consider a data set of **starting salary** of **42** recently graduate students. Frequency distribution of variable **"starting salary"** can be presented as follows:



Sample space & Events

Consider an experiment whose outcome is **unpredictable** or **random**. Ex: Rolling a Die, Tossing a Coin.

Sample space (*S*): set of all possible outcomes of an experiment.

Experiment: Rolling a Die, **S = {1, 2, 3, 4, 5, 6}**

Event (*E*) : subsets of the sample space.

If outcome of the experiment is contained in ***E***, we say that ***E*** **has occured**.

E = {all outcomes in **S** which is even number}

Probability Theory

Way of expressing **how likely it is (belief) that an event occurs.**

To do this, we need to **assign a probability to each event.**

For each event ***E*** of an experiment having a sample space ***S***, there is a number, ***P*(*E*)**

$$0 \leq P(E) \leq 1$$

*there will be more explanations in the next class