

# The Data Mining Process

## Mining Massive Datasets

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**I'M A DATA SCIENTIST**

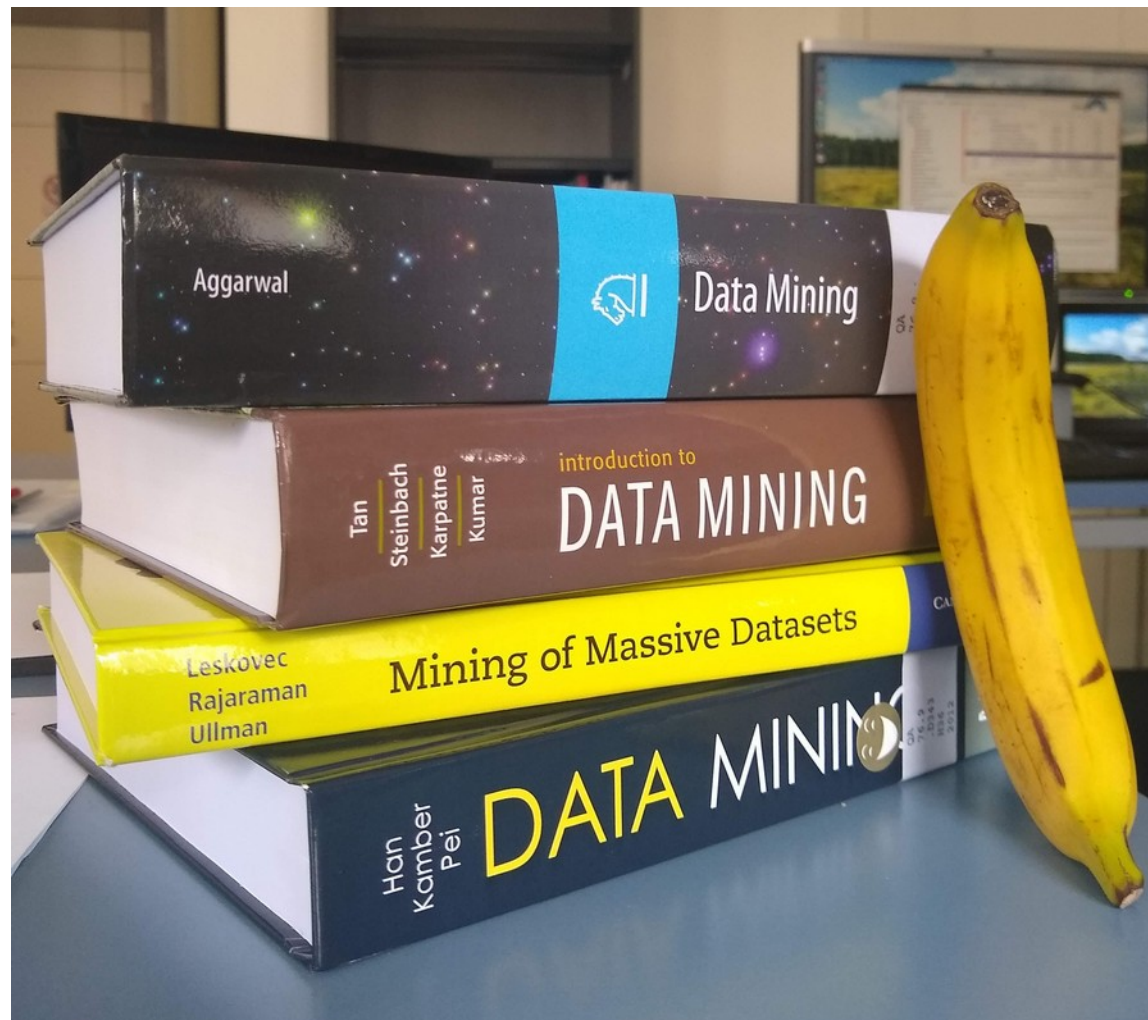
**AND I HAVE A VERY PARTICULAR SET OF  
SKILLS I HAVE ACQUIRED OVER A VERY LONG CAREER**

imgflip.com

*Taken (2008)*

# Main Sources

- Data Mining, The Textbook (2015) by Charu Aggarwal (Chapter 1) + [slides by Lijun Zhang](#)
- Mining of Massive Datasets, 2<sup>nd</sup> edition (2014) by Leskovec et al. ([Chapter 1](#))
- Data Mining Concepts and Techniques, 3<sup>rd</sup> edition (2011) by Han et al. (Chapters 1-2)



(Banana for scale)

## Scientists



## Programmers



# Data Mining



# What do these have in common?



Stone



Clay



Papyrus



Paper



Wax cylinder



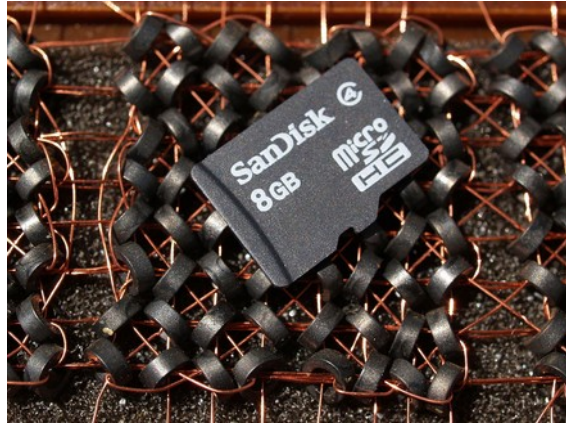
Tape



Vinyl

<https://en.wikipedia.org/wiki/Writing>

# What do these have in common?



8GB (front) vs 8B (back)



Floppy disks (8", 5 1/4", 3 1/2")



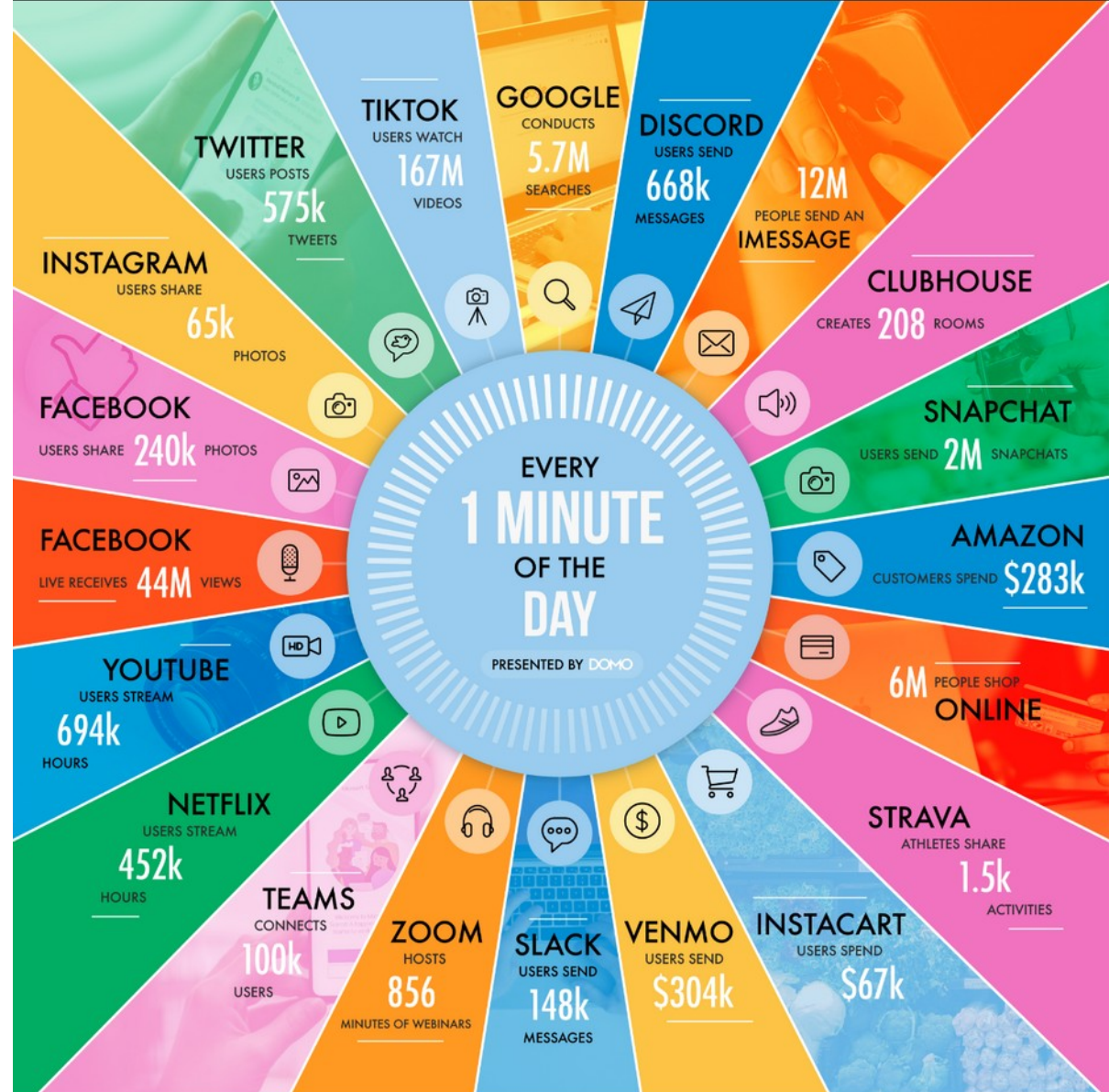
Compact disk



# The age of “Big Data”

The co-evolution of  
**storage** capacity,  
**transmission** capacity, and  
**processing** capacity

Visualcapitalist.com (2021)



# Wikipedia definition

- **Data mining** is the process of
  - discovering patterns in
  - large data sets
  - involving methods at the intersection of
    - machine learning,
    - statistics, and
    - database systems.

# Informal definition

Given **lots of data**, discover **patterns** and **models** that are:

- **Valid** hold on new data with some certainty
- **Useful** should be possible to act on them
- **Unexpected or novel** non-obvious
- **Understandable** interpretable
- **Complete** contain most of the interesting information

# Example : 300 numbers

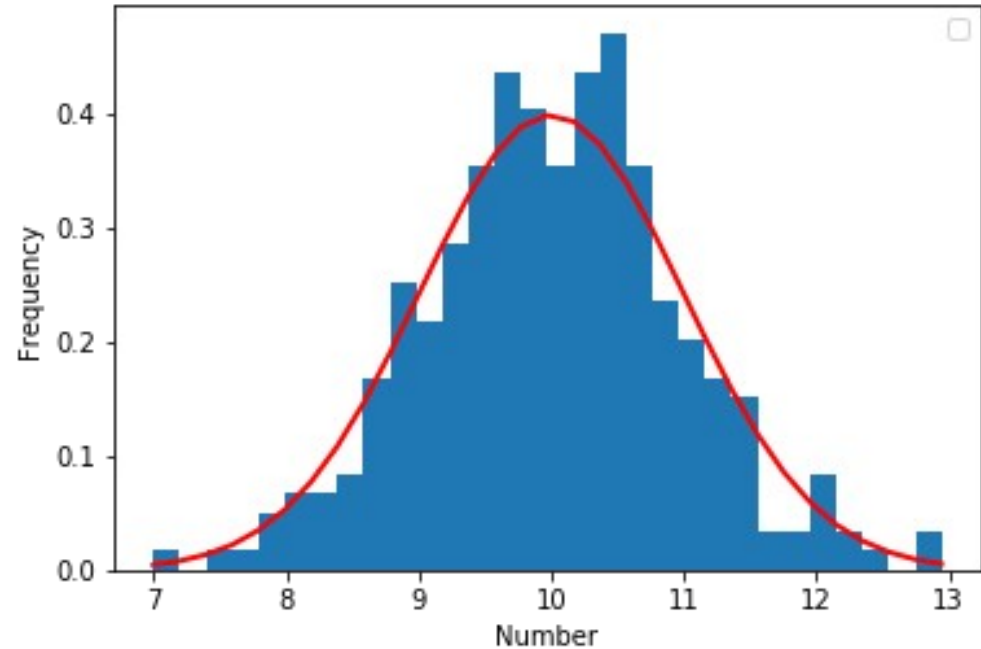
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9.6545295	10.83958189	12.20970744	10.41521275	10.15902266	9.86904675	10.17021837	10.58768438	12.07341981	8.45713965
9.62152893	11.2494364	9.30073426	10.12753479	11.06429886	9.80406205	9.74418407	11.15815923	10.87659275	10.39190038
10.52911904	10.84125322	11.98925384	10.63545001	9.07420116	10.48011257	11.32273164	9.4831463	10.67973822	10.87064128
9.35940084	9.51149749	11.13211644	9.23292561	8.4767592	9.64339604	9.91374069	9.84184184	9.85576594	9.18523161
10.27107348	8.7511958	8.70297841	10.50609814	11.1908866	10.59484161	10.60027882	9.06375121	10.48534475	9.34253203
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10.29787802	9.87946998	8.3799398	10.21263966	9.93826568	9.17325487	10.22256677	10.04892038	11.01233696	9.6145273
9.9495437	10.51474851	9.19288505	7.87728009	9.987364	10.94639021	10.01814962	9.40505023	8.87242546	10.23686131
8.90710325	10.31678617	10.4571519	9.04315227	9.85321707	11.89885306	6.99926999	10.71534924	10.29215034	10.59516732
9.8807174	9.01321711	8.45289144	9.1739316	7.90909364	9.42165081	10.37087284	9.57754821	9.60350044	10.75691005
8.24594836	10.33419146	9.7779209	9.51609087	10.25712725	12.1256587	9.53397549	9.44765209	9.53901558	9.8006768
9.633075	11.17692346	11.00022919	8.38767624	8.63908897	8.10049333	10.66422258	10.70986552	10.82945121	10.45206684
9.21578565	10.21230495	10.28984339	9.4130091	10.54597988	10.8042254	10.52795479	10.76288124	11.3554357	11.484667
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9.25613292	11.59370587	8.62517536	10.29703335	9.11065832	10.68766309	9.86507094	10.58314944	10.65232968	8.13400366
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11.47090441	8.92472486	10.04585273	10.41149437	9.90118185	9.02229964	8.66708035	11.53976046	11.40609367	9.73014878
8.94607876	11.562354	9.58552216	9.74172847	9.64220948	9.69459042	9.58460199	11.14917832	9.49543794	9.46369271
10.16544667	9.92277128	9.61975057	11.11679747	9.42894032	9.25751891	11.44948256	8.16601628	10.11500258	9.42431821

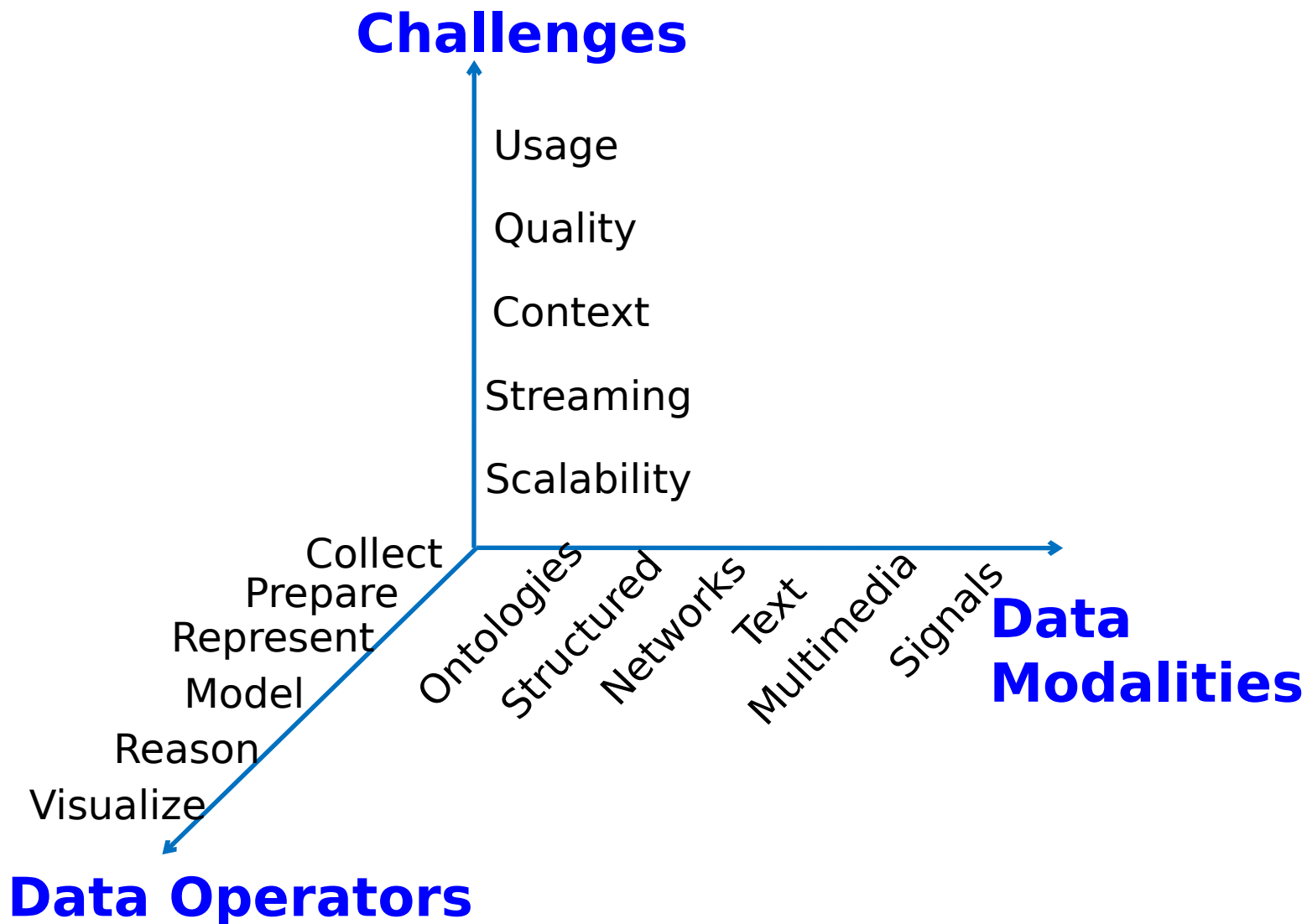
What are these numbers?

# Example: 300 numbers (cont.)

Through *statistical modeling* we can find the data comes from a Normal distribution with mean 10 and standard deviation 1

- **Normal( $\mu=10, \sigma=1$ )** is a *model* for the data







# Describing vs Predicting

## Descriptive methods

- Find human-interpretable patterns that describe the data
- Example: Clustering

## Predictive methods

- Use some variables to predict unknown or future values of other variables
- Example: recommender systems

# Characterizing vs Distinguishing

## Data characterization methods

- A summary of the general characteristics or features of a target class of data

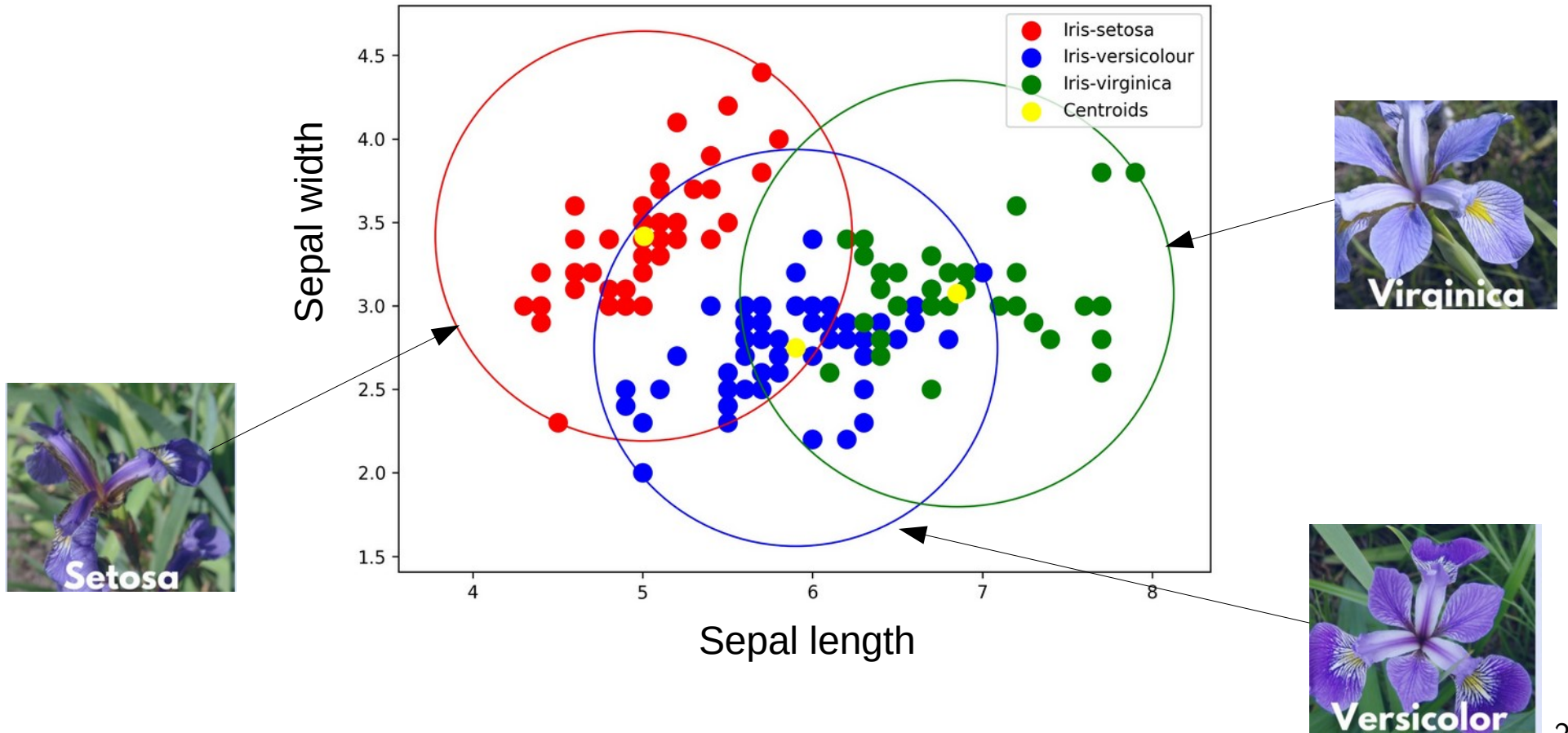
## Data discrimination methods

- A comparison of the general features of the target class data objects against the general features of objects from one or multiple **contrasting** classes

# Data mining has several goals

- To produce a **model**
  - E.g., a regression model for a numerical variable, or a classification model for a categorical variable
- To create a **summary**
- To extract **prominent features**

# Example summary: clustering

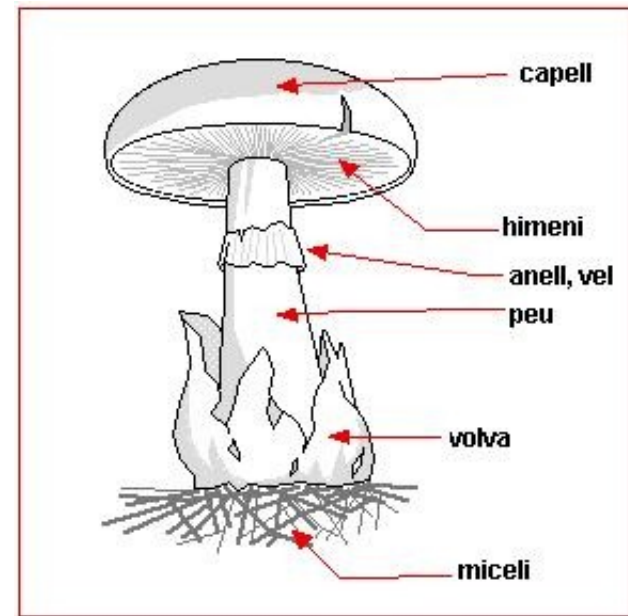
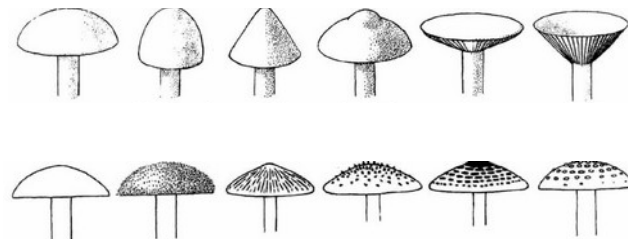


# Picking the right features

- Representing these flowers by their *petal length* and *sepal length* was key
  - These are good features for this task
- Other features such as color or number of leaves may not be so good
- Feature selection is key!

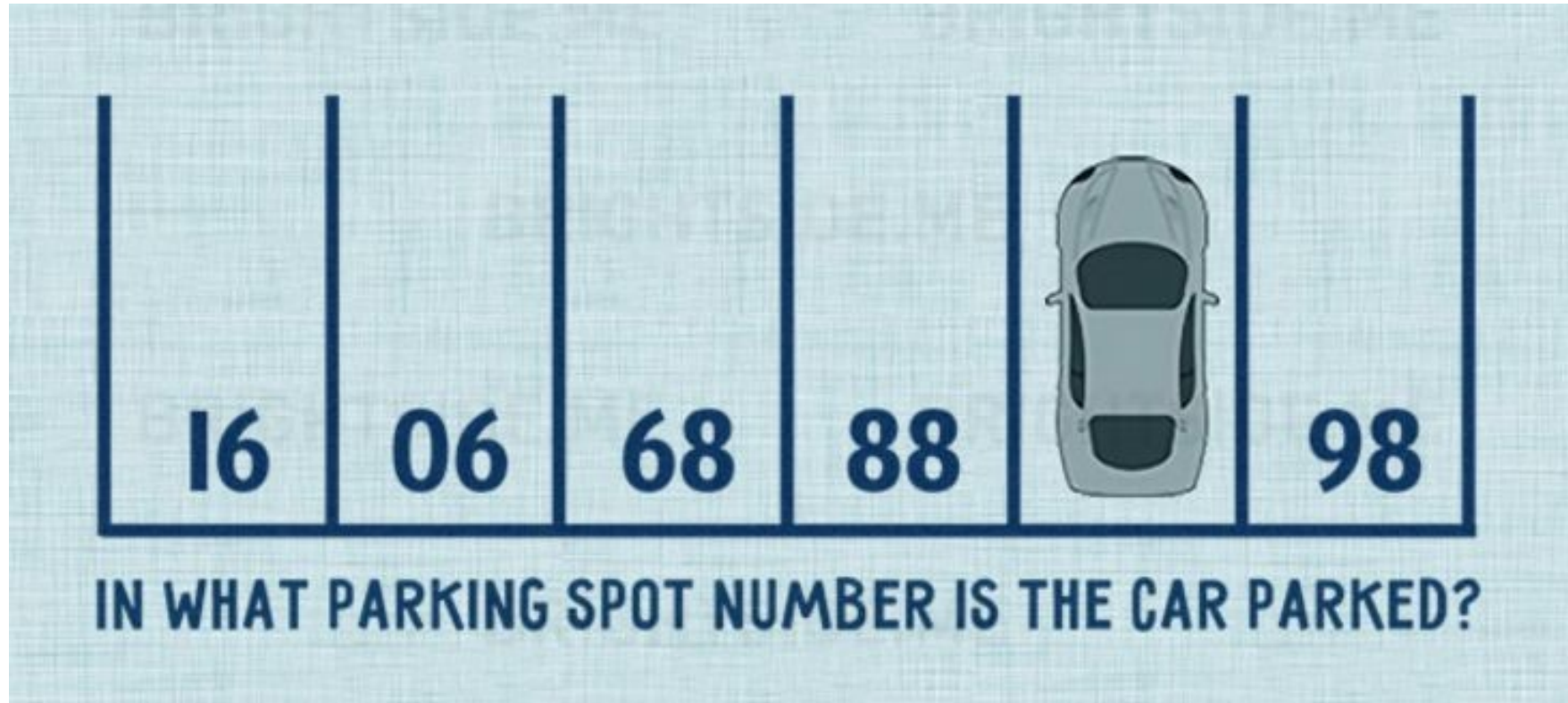


# Features: a matter of life or death





# Another pattern-finding example



# Example: complex features

- Given shopping baskets of previous customers, determine:
  - **Frequent itemsets**  
(bought together)
  - **Similar items**  
(e.g., for recommendations)



# Risk #1: Spurious patterns

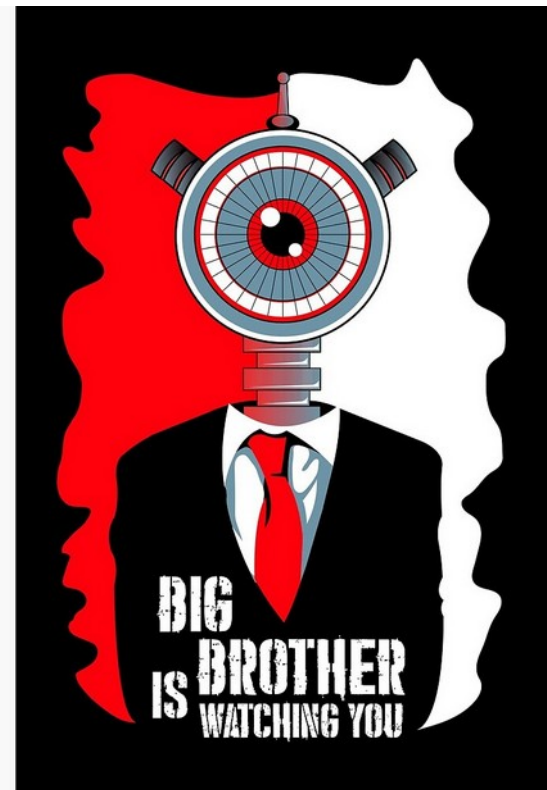
- A risk with “Data mining” is that an analyst can “discover” patterns that are **meaningless**
- *If you look in more places for interesting patterns than your amount of data will support, you are bound to find something (~Bonferroni principle)*

If you interrogate data  
**hard enough** it will tell you  
what you want to hear



# Risk #2: Surveillance state

- Attention-grabbing evil actions are also very rare, with consequences:
  - Suppose 1 in a million is a suicide bomber
  - Catching one suicide bomber a year on average means examining 999.999 innocent people
- A system with 1% false positive rate will flag ~10K people as potential suicide bombers



# Data mining (DM) vs other disciplines

- For a database person, DM means analytic processing
- For a machine learning person, DM means modeling
- For an algorithms person, DM means ensuring scalability

Our focus will be on **scalable algorithms**

# Data rich but information poor

- Fast-paced data streams become **data archives** that become **data tombs**
- Decisions could be better made by using **data that already exists** but is hard to “mine”





# Knowledge **Discovery** from Data

- KDD, a popular acronym
  - “Discovery” is Data Mining
- Other names: knowledge mining from data, knowledge extraction, data/pattern analysis



# Typical stages of KDD

- 1) Data Cleaning
- 2) Data Integration
- 3) Data Selection
- 4) Data Transformation
- 5) Data Mining ← application of a DM algorithm
- 6) Pattern Evaluation
- 7) Knowledge Presentation

# Typical stages of KDD

1)Data Cleaning

2)Data Integration

3)Data Selection

4)Data Transformation

5)Data Mining

6)Pattern Evaluation

7)Knowledge Presentation

Pre-processing  
phase

Analytical  
phase

# Summary

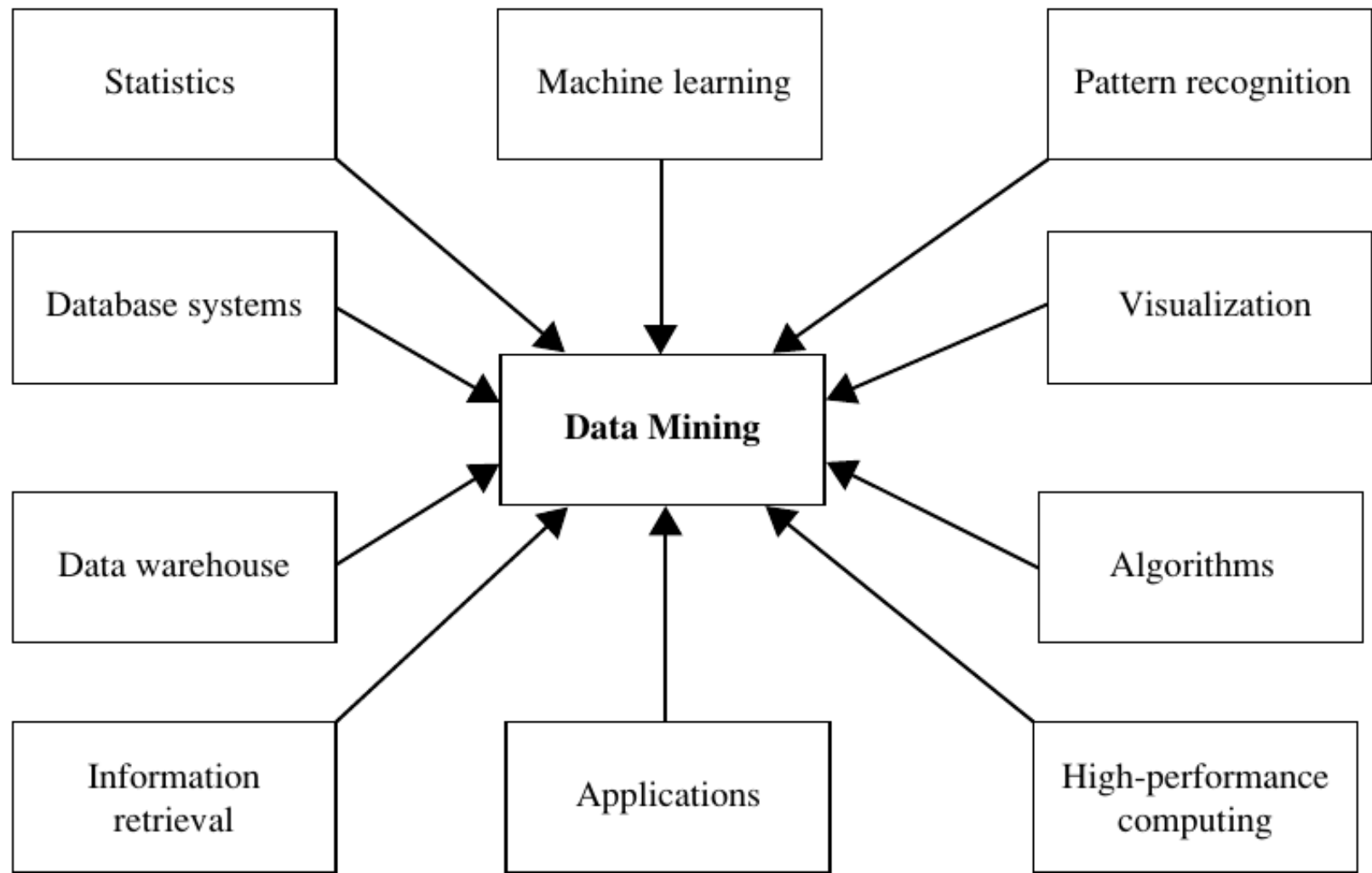
# Things to remember

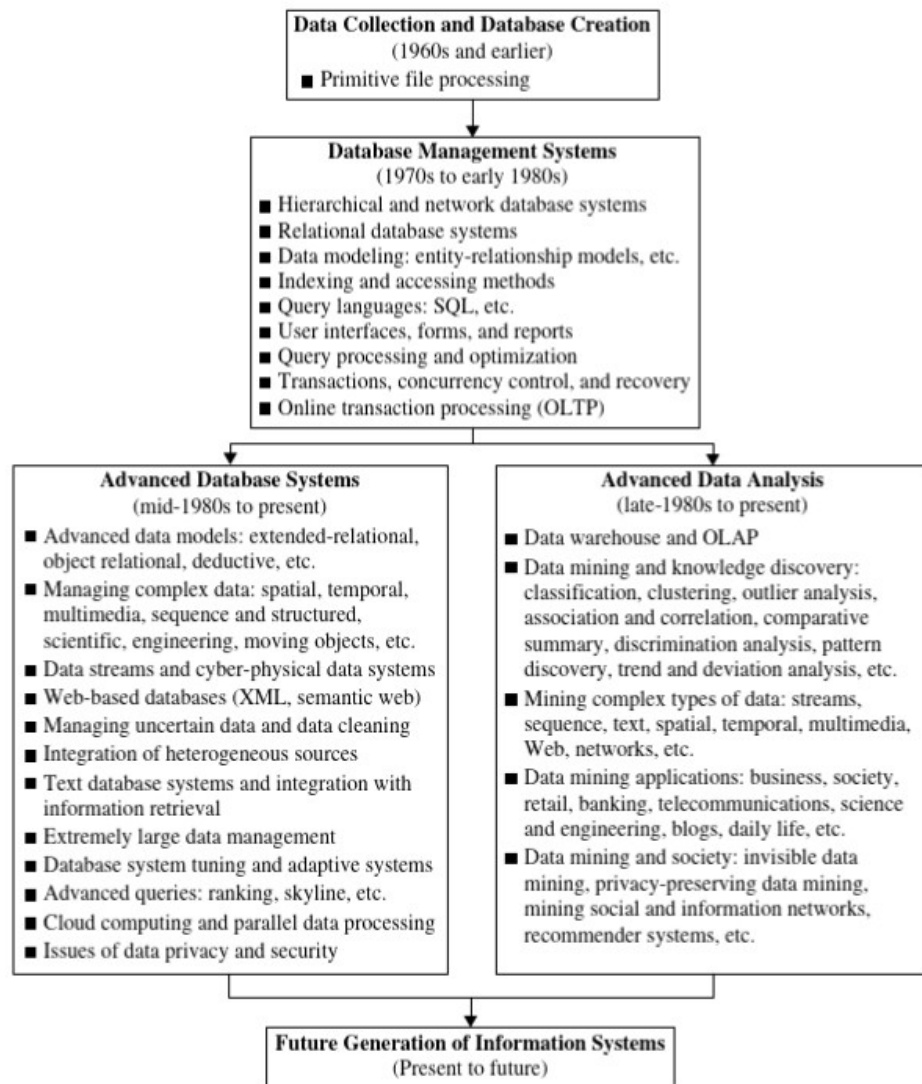
- Define and contrast:
  - Describing vs Predicting
  - Characterizing vs Discriminating
- Describe the stages of the KDD process

**Additional contents**  
**(not included in exams)**

**EXTRA**







Data mining is a  
descendant of methods for  
Online Analytical  
Processing (OLAP) done  
over Data Warehouses