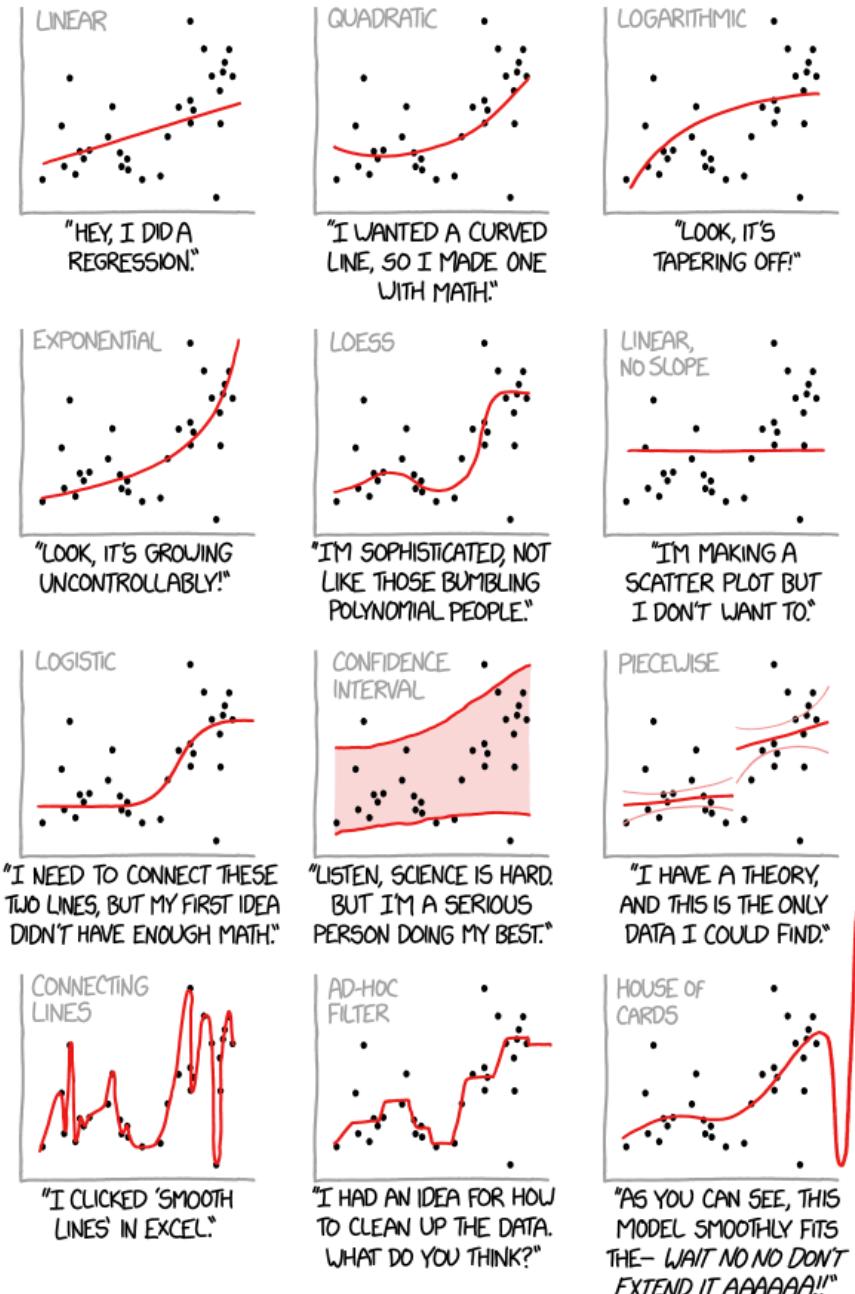


# Introduction to *Urban Data* Science

Data Engineering  
(EPA1316)  
Lecture 4

Trivik Verma

## CURVE-FITTING METHODS AND THE MESSAGES THEY SEND

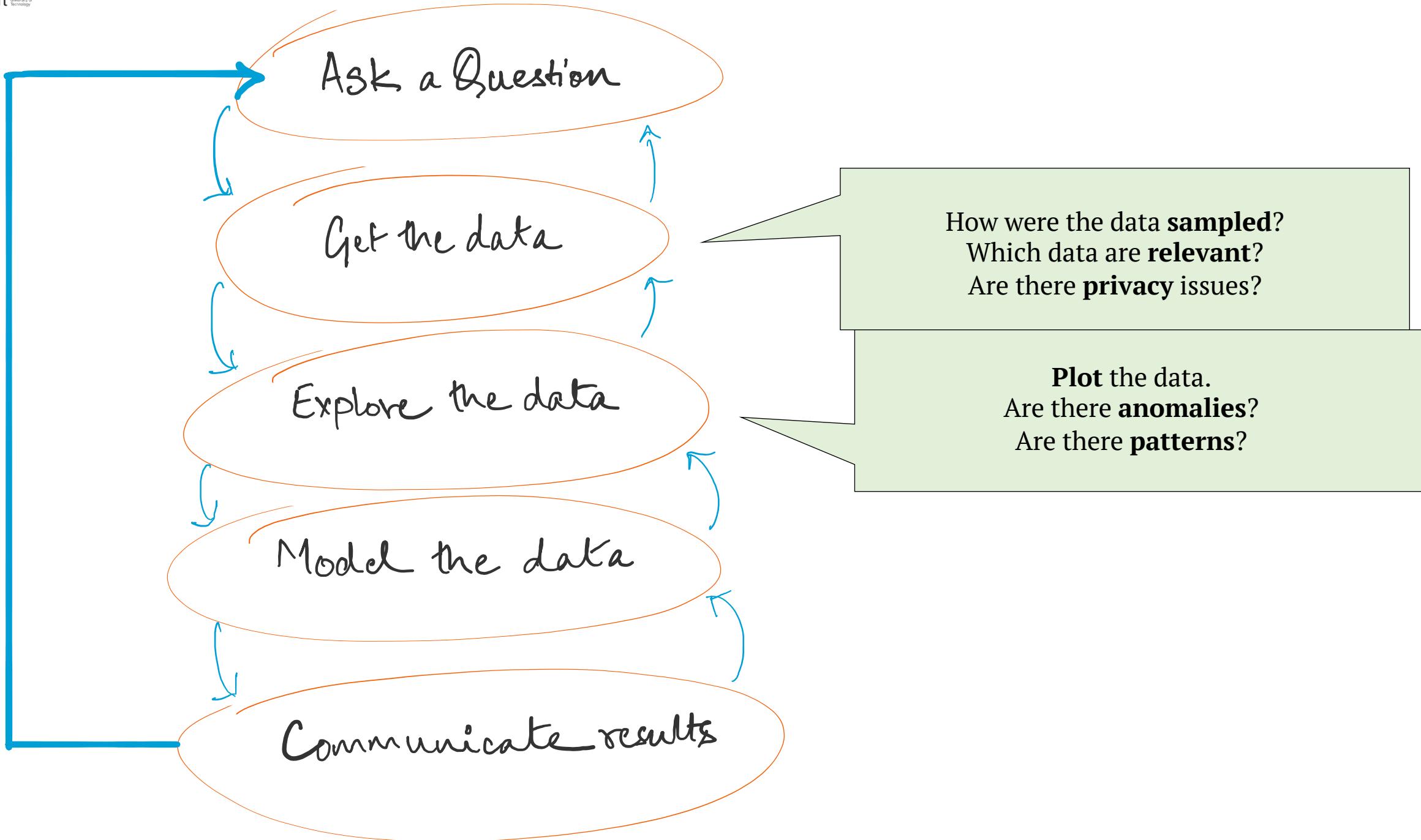


# Last Time

- Types of Data
- Grammar
- EDA without Pandas
- EDA with Pandas
- Data Concerns

# Today

- Descriptive Statistics
- Data Transformations



# Descriptive Statistics

# Basics of Sampling

Population versus sample:

- A **population** is the entire set of objects or events under study. Population can be hypothetical “all students” or all students in this class.
- A **sample** is a “representative” subset of the objects or events under study. Needed because it’s impossible or intractable to obtain or compute with population data.

Biases in samples:

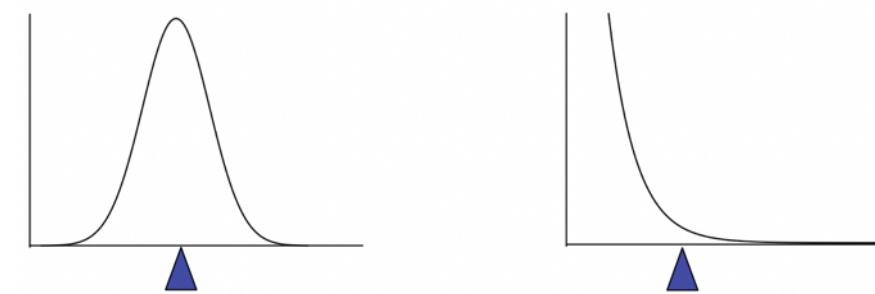
- **Selection bias:** some subjects or records are more likely to be selected
- **Volunteer/nonresponse bias:** subjects or records who are not easily available are not represented

Examples?

# Sample mean

- The **mean** of a set of  $n$  observations of a variable is denoted  $\bar{x}$  and is defined as:

$$\bar{x} = \frac{x_1 + x_2 + \cdots + x_n}{n} = \frac{1}{n} \sum_{i=1}^n x_i$$



- The mean describes what a “typical” sample value looks like, or where is the “center” of the distribution of the data.
- Important :** there is always uncertainty involved when calculating a sample mean to estimate a population mean.

# Sample median

- The **median** of a set of  $n$  number of observations in a sample, ordered by value, of a variable is defined by

$$\text{Median} = \begin{cases} x_{(n+1)/2} & \text{if } n \text{ is odd} \\ \frac{x_{n/2} + x_{(n+1)/2}}{2} & \text{if } n \text{ is even} \end{cases}$$

- Example (already in order):

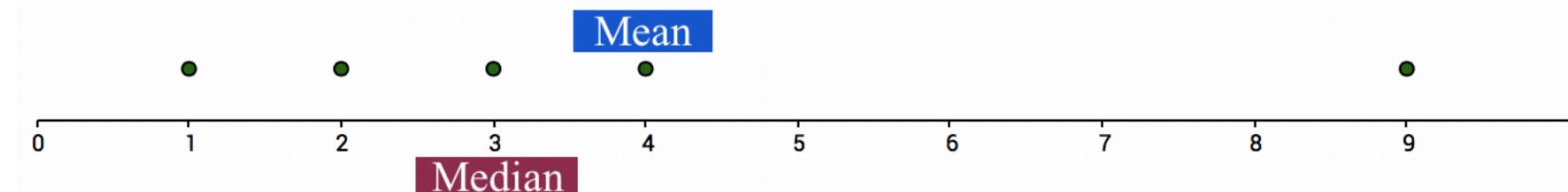
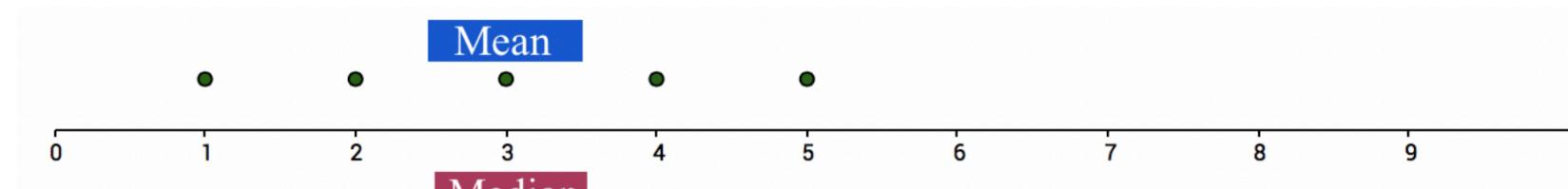
Ages: 17, 19, 21, 22, 23, 23, 23, 38

$$\text{Median} = (22+23)/2 = 22.5$$

- The median also describes what a typical observation looks like, or where is the center of the distribution of the sample of observations.

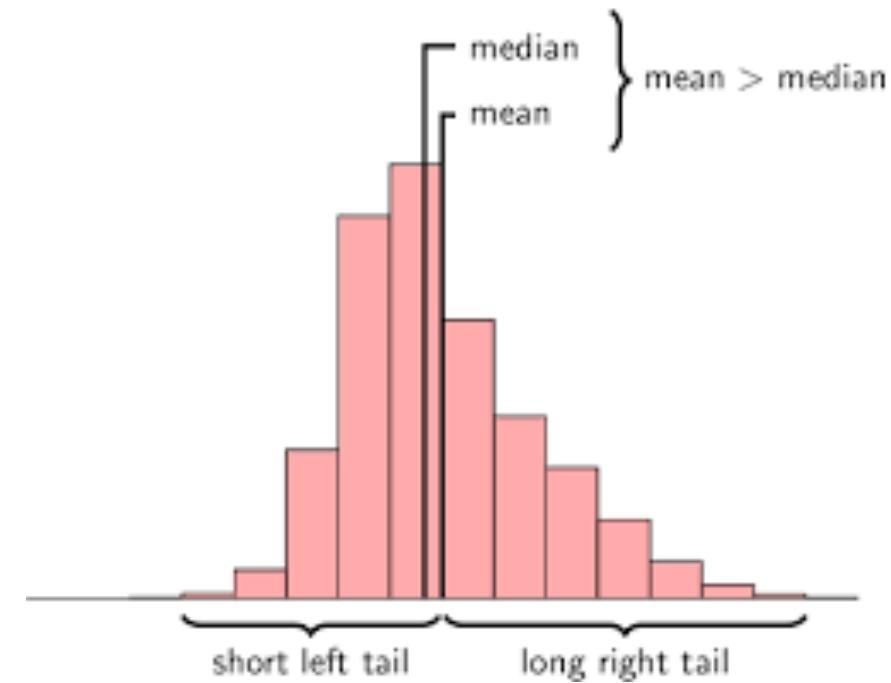
# Mean vs Median

The mean is sensitive to extreme values (**outliers**)



# Mean, median, and skewness

The mean is sensitive to outliers:

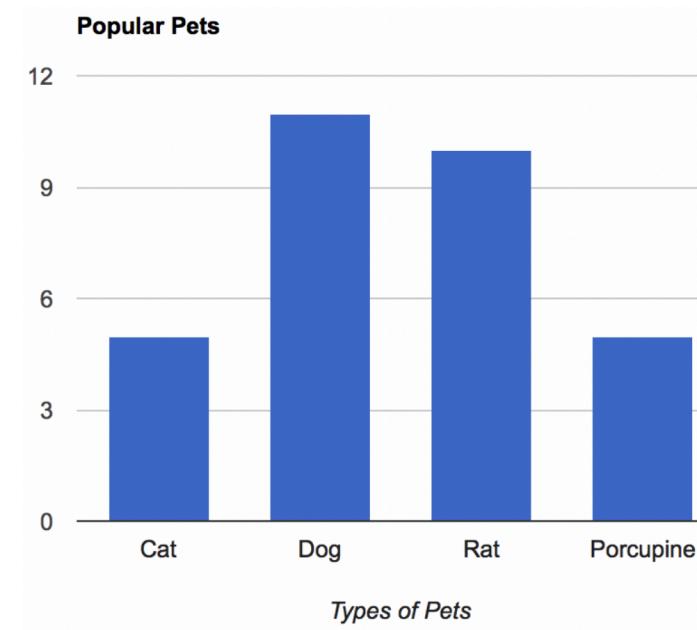


The above distribution is called **right-skewed** since the mean is greater than the median.

**Note:** skewness often “follows the longer tail”.

# Regarding Categorical Variables...

For categorical variables, neither mean or median make sense. Why?



The mode might be a better way to find the most “representative” value.

# Measures of Spread: Range

The spread of a sample of observations measures how well the mean or median describes the sample.

One way to measure spread of a sample of observations is via the **range**.

$$\text{Range (R)} = (\text{Max})\text{imum Value} - (\text{Min})\text{imum Value}$$

# Measures of Spread: Variance

- The (sample) **variance**, denoted  $s^2$ , measures how much on average the sample values deviate from the mean:

$$s^2 = \frac{1}{n-1} \sum_{i=1}^n |x_i - \bar{x}|^2$$

- Note: the term  $|x_i - \bar{x}|$  measures the amount by which each  $x_i$  deviates from the mean  $\bar{x}$ . Squaring these deviations means that  $s^2$  is sensitive to extreme values (outliers).
- **Note:**  $s^2$  doesn't have the same units as the  $x_i$  :(
- What does a variance of 1,008 mean? Or 0.0001?

# Measures of Spread: Standard Deviation

The (sample) **standard deviation**, denoted  $s$  (or  $\sigma$ ), is the square root of the variance

$$s = \sqrt{s^2} = \sqrt{\frac{1}{n-1} \sum_{i=1}^n |x_i - \bar{x}|^2}$$

**Note:**  $s$  does have the same units as the  $x_i$ . Phew!

# Break



WATER



WALK



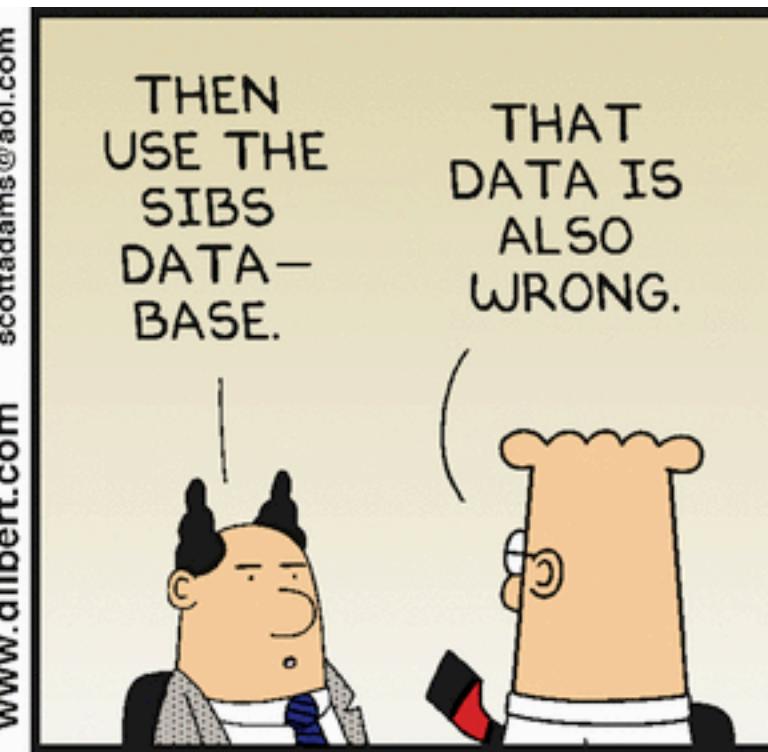
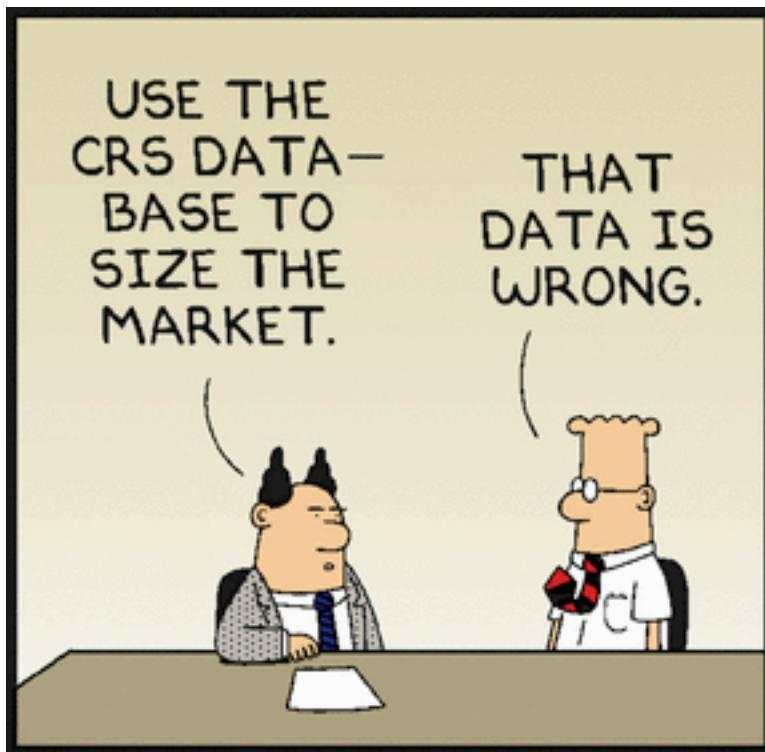
COFFEE OR TEA



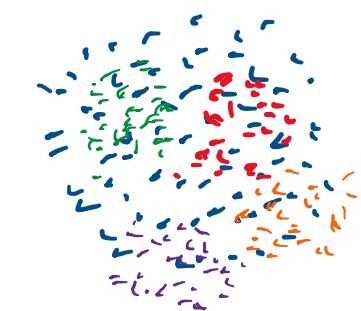
MAKE FRIENDS

# Data Transformations

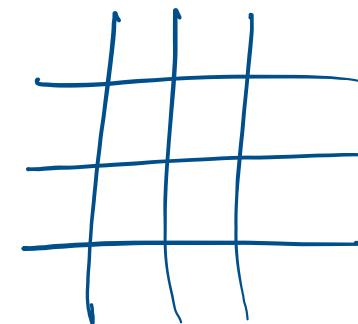
# Why Transform Data



# feature engineering



RAW



TABULAR



objects

	features		
	$f_1$	$f_2$	$\dots$
01			
02			
:			

Based upon  
Domain knowledge

## SMART-CARD

Eg. CHECK-IN LOGS



\*

Users

ID	F1			
001				
002				
003				
:				

Features (measurable)

F1 → trips / month

F2 → class

F3 → Avg. time of trip

F4 → total price

:

\* Alternative: trips / station

# Scale Data

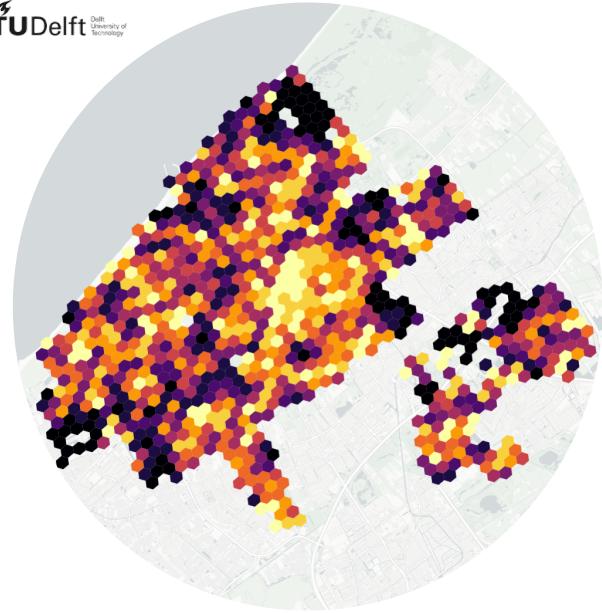
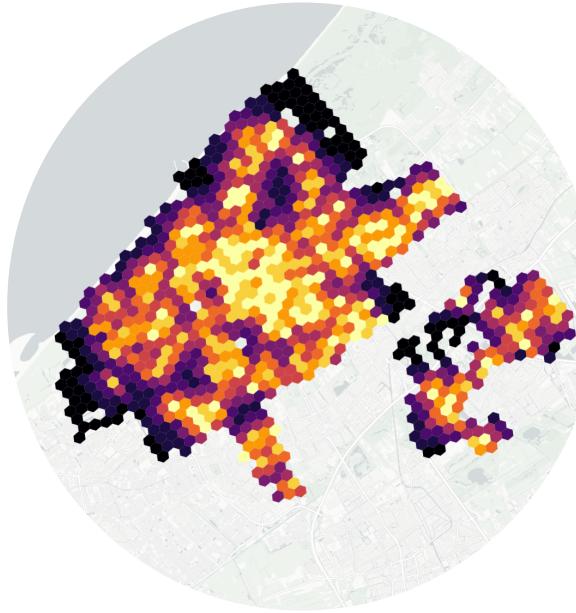
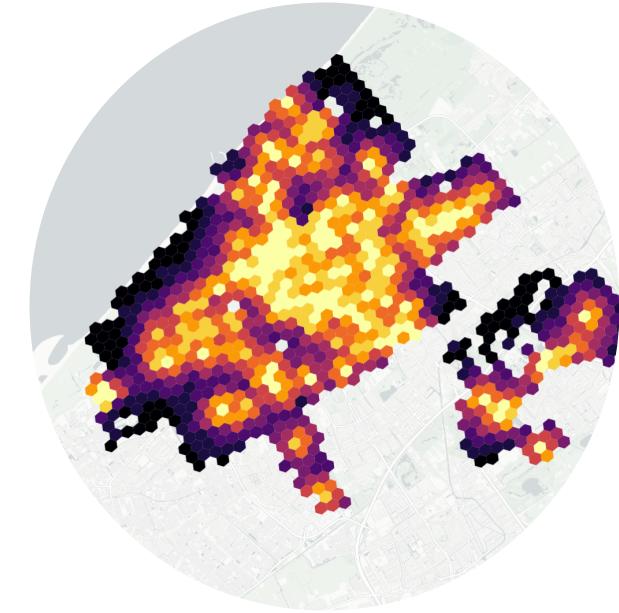
F1	F2	F3	F4
Dimensions			
1-500 trips/month	200-2000	CHF/month	



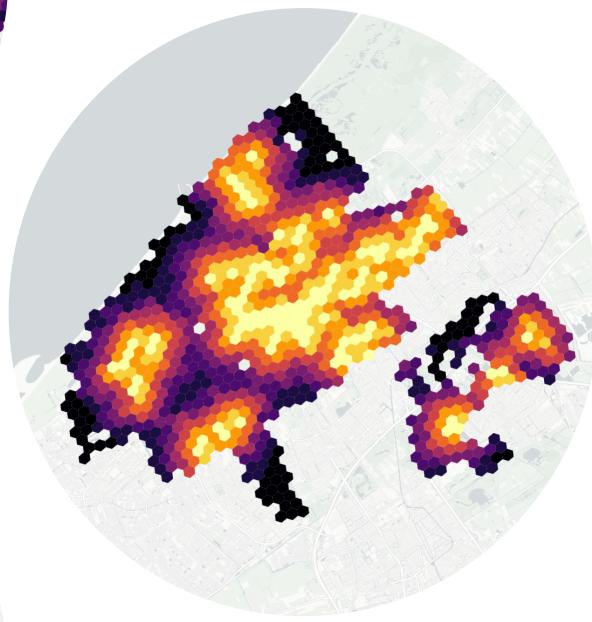
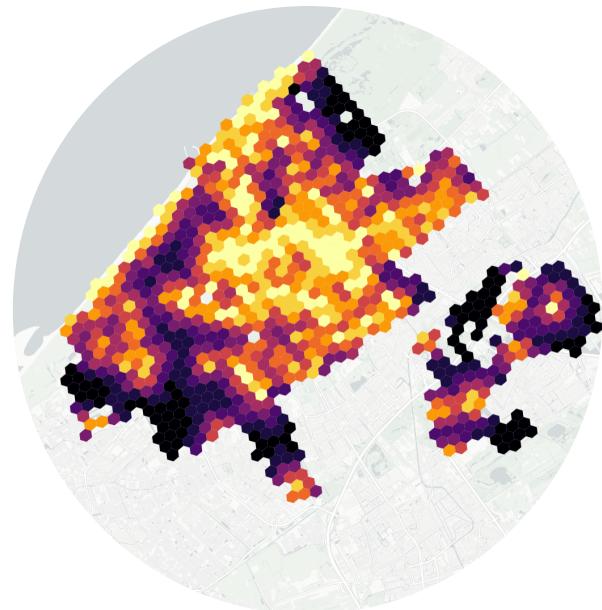
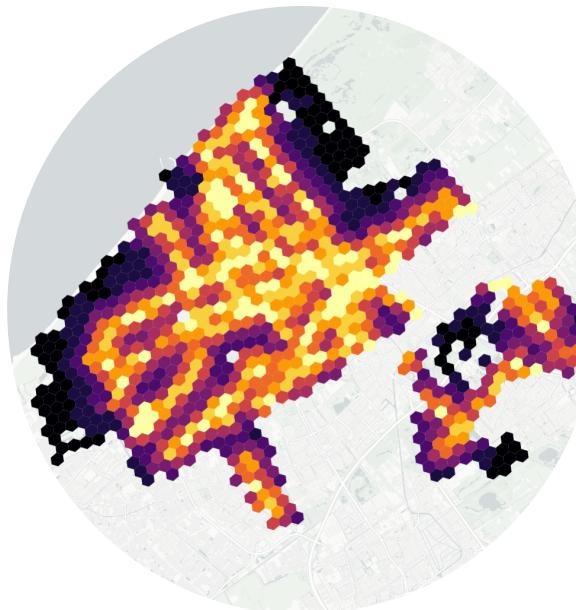
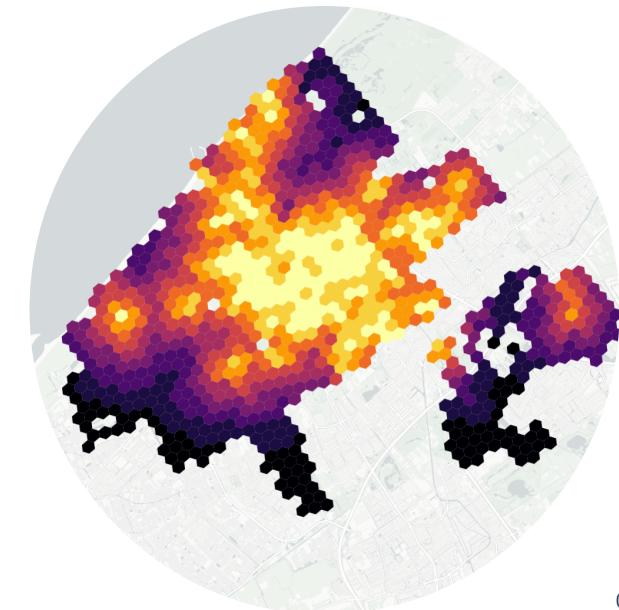
# Why Scaling

- Comparison of groups of Object
- Example:** Access to infrastructure in Cities
- ML algorithms use Euclidean distance  
(higher magnitude will weigh more) –  
**advanced** topics will be explored in week 6



**Active Living****Education****Health and Well Being**

Measure of Access

**Nightlife****Food Choices****Mobility****Community Space**

# Dealing with Missing Data

- If your data is big, sacrifice examples with missing features
- Data Imputation techniques
  - Use average of the feature for replacing a missing value
  - **Advanced**: regression modelling to estimate missing values

$$x_i^o \leftarrow \bar{x}$$

# Normalisation

- Transformation of data to a different range [a - b]
- Normally [0-1]
- Create new variables from the transformations.

$$x'_i = \frac{x_i - \min(x)}{\max(x) - \min(x)} \times [b - a] + a$$

Rescaled value      Original value  
Min value in feature      New range



# Standardisation

or, Z-score normalisation

- Transformation of data to a different range that is normally distributed with mean 0 and standard deviation 1.

$$\mathcal{N}(\mu=0, \sigma=1)$$

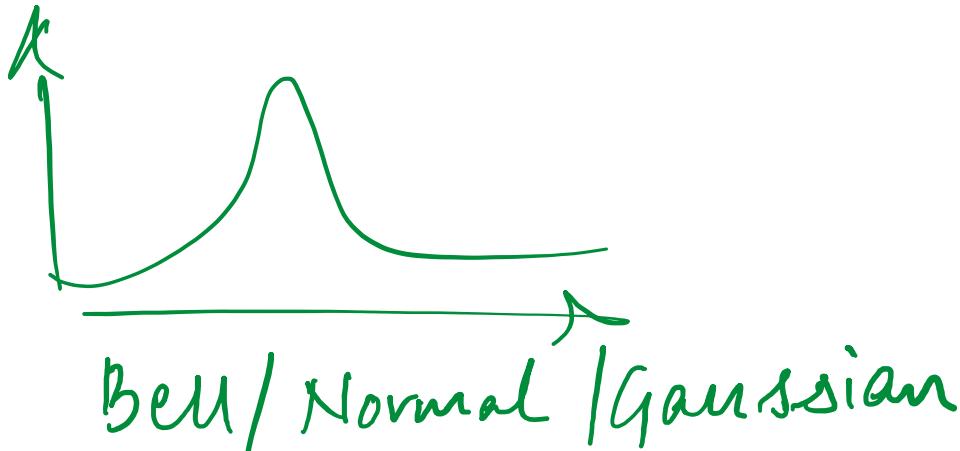
Rescaled value

$$x_i' = \frac{x_i - \mu_i}{\sigma_i}$$



# Use S (All others N)

- Features are normally distributed (**not normalisation**)



- Many outliers (normalization squashes them in a limited range)
- All unsupervised learning algorithms, like clustering or dimensionality reduction



# For next class..



**Finish** Lab 03 to practice programming



**Submit** Homework 03 for peer review on Peer



**Submit** Assignment 1 – due in **Week 3** on Friday at **2330**



**See** “To do before class” for every lecture (~ 1 hour of self study)



**Read** paper for **Discussion** session before every Friday



**Post** questions on the **Discussion** forum on Brightspace (especially on **Pandas** and **Data Features**)