Data Analytics (CS61061)

Lecture #2

Data Categorization

Dr. Debasis Samanta

Professor

Department of Computer Science & Engineering

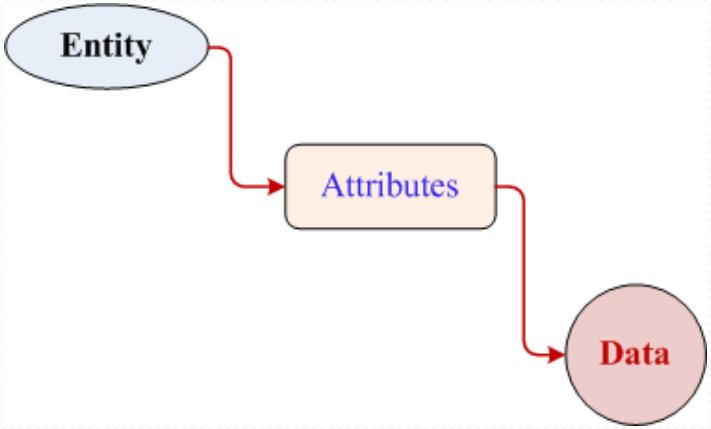
Quote of the day..

- The simple things are also the most extraordinary things, and only the wise can see them.
  - Be minute to everything around you. The world is a great teacher!
    - PAULO COELHO Brazillian author.

We are going to learn…

- Data in data analytics
- NOIR topology
- Nominal scale of measurement
- Ordinal scale of measurent
- Interval scale of measurement
- Ratio scale of measurement
- Data model for high-dimensional data

Data in Data Analytics



NAME	AGE	GENDER	SALARY	EMPLOYER
:				
:				
ABCD	34	F	40000	XYZ
:				
:				

- **Entity:** A particular thing is called entity or object.
- **Attribute.** An attribute is a measurable or observable property of an entity.
- **Data.** A measurement of an attribute is called data.
- Note
  - Data defines an **entity**.
  - Computer can manage all type of data (e.g., text, numeric, image, audio, video, etc.).

Data representation

- How a document (e.g., text) can be represented?

THE SILVER CHAIR

by C.S. Lewis

CHAPTER ONE
BEHIND THE GYM

IT was a dull autumn day and Jill Pole was crying behind the gym.

She was crying because they had been bullying her. This is not going to be a school story, so I shall say as little as possible about Jill's school, which is not a pleasant subject. It was "Co-educational," a school for both boys and girls, which used to be called a "mixed" school; some said it was not nearly as mixed as the minds of the people who ran it. Those people had the idea that boys and girls should be allowed to do what they liked. And unfortunately what six or seven of the biggest boys and girls liked best was bullying the others. All sorts of things, horrid things, went on which at an ordinary school would have been found out and stopped in half a term, but at this school they weren't. Or even if they were, the people who did them were not expelled or punished. The Head said they were interesting psychological cases and sent for them and talked to them for hours. And if you know the right sort of things to say to the Head the main result was that you became rather a favourite than otherwise.

That was why Jill Pole was crying on that dull autumn day on the damp little path which runs between the back of the gym and the shrubbery. And she hadn't nearly finished her cry when a boy came round the corner of the gym whistling, with his hands in his pockets. He nearly ran into her.

"Can't you look where you're going?" said Jill Pole.

"All right," said the boy, "you needn't start –" and then he noticed her face. "I say, Pole," he said, "what's up?"

Jill only made faces; she isn't one to make what you're trying to say something but find that if you speak you'll start crying again.

"It's Thom, I suppose – as usual," said the boy grimly, digging his hands further into his pockets.

Jill nodded. There was no need for her to say anything, even if she could have said it. They both knew.

"Now, look here," said the boy, "there's no good in all –"

He meant well, but he did talk rather like someone beginning a lecture. Jill suddenly flew into a temper (which is quite a likely thing to happen if you have been interrupted in a cry).

Data representation

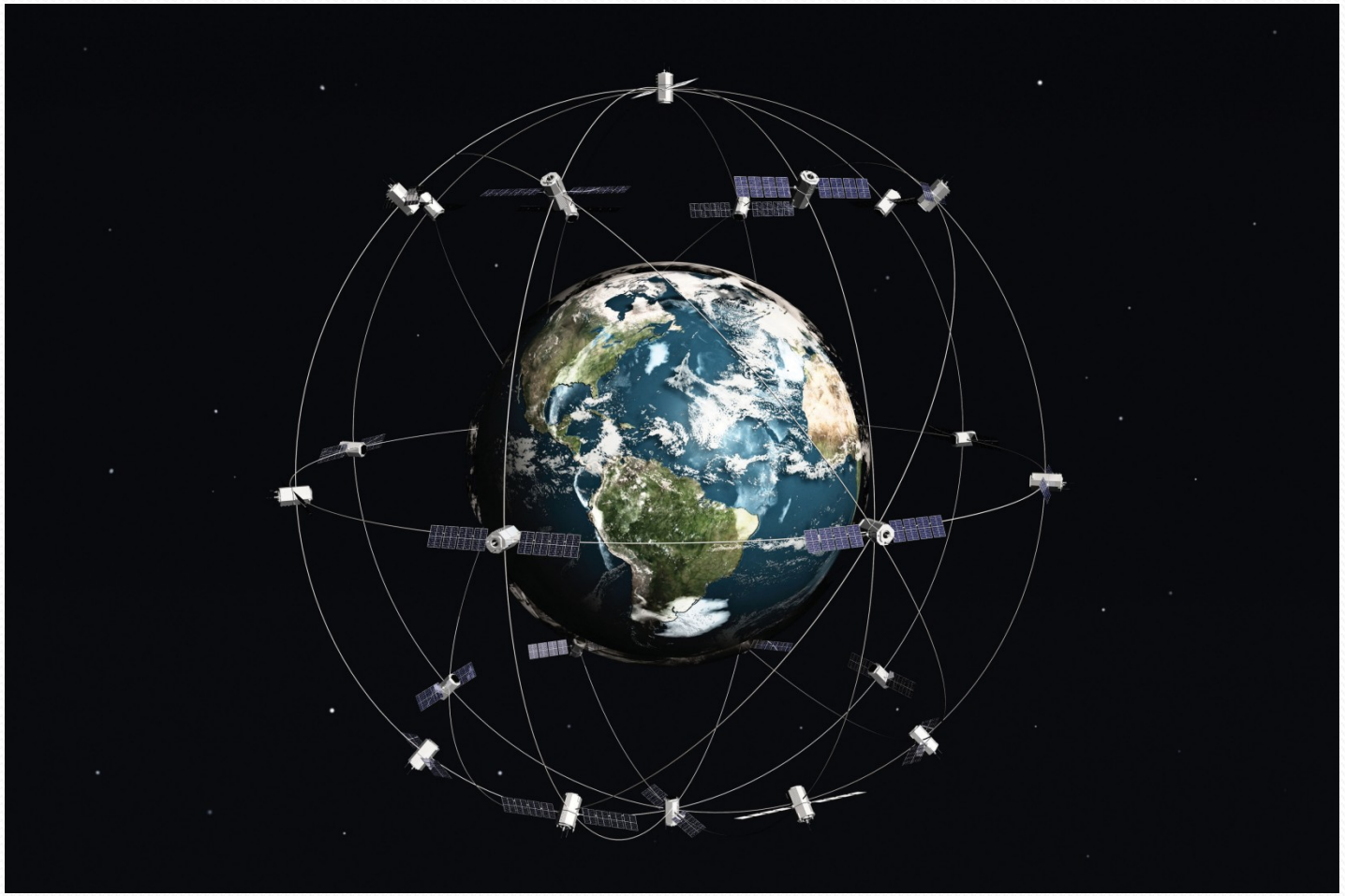
- How an image can be represented?

Data representation

- How a video can be represented?

Data representation

- How the streaming data from an artificial earth satellite can be represented?



Data in Data Analytics

- In general, there are many types of data that can be used to measure the properties of an entity.
- A good understanding of data **scales** (also called scales of measurement) is important.
- Depending the scales of measurement, different techniques are followed to derive hitherto unknown knowledge in the form of
  - patterns, associations, anomalies or similarities from a volume of data.

NOIR

Classification of scales of Measurement

NOIR classification

- The mostly recommended scales of measurement are

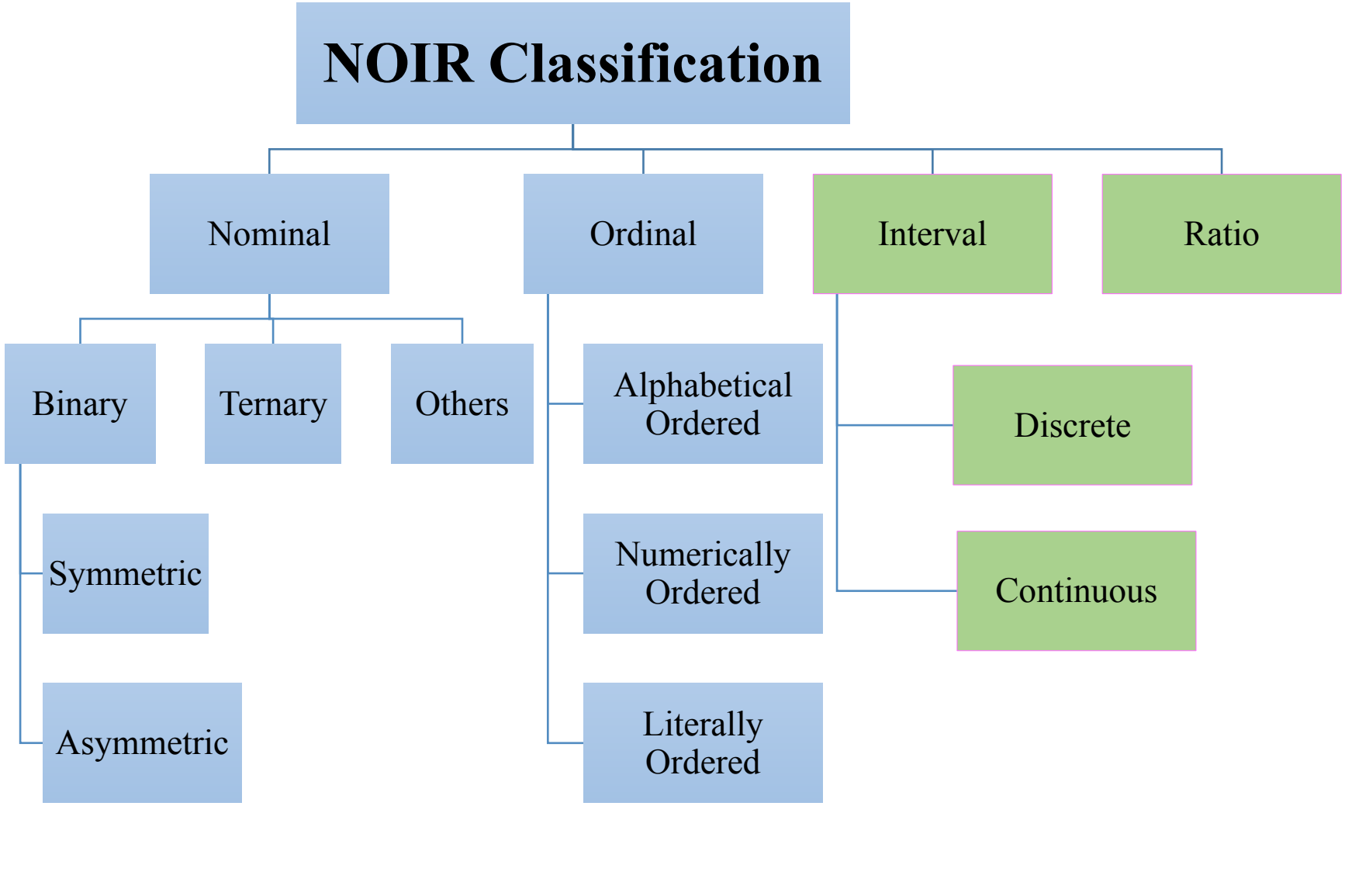
N: **N**ominal

O: **O**rdinal

I: **I**nterval

R: **R**atio

The NOIR scale is the fundamental building block on which the **extended data types** are built.


NOIR Classification
Nominal
Ordinal
Interval
Ratio
Binary
Ternary
Others
Alphabetical Ordered
Discrete
Symmetric
Numerically Ordered
Continuous
Asymmetric
Literally Ordered
Categorical (Qualitative)
Numeric (Quantitative)

Nominal scale

- **Definition**

A variable that takes a value among a set of mutually exclusive codes that have no logical order is known as a nominal variable.

- **Examples**

Gender Used letters or numbers
{ M, F} **or** { 1, 0 }

Blood groups Used string
{A , B , AB , O }

Rhesus (Rh) factors Used symbols
{+ , - }

Country code ??
????

Nominal scale: Properties

Note

- The nominal scale is used to label data categorization using a consistent naming convention.
- The labels can be numbers, letters, strings, enumerated constants or other keyboard symbols.
- Nominal data thus makes "category" of a set of data.
- The number of categories should be two (binary) or more (ternary, etc.), but countably finite.

Nominal scale: Properties

Note

- A nominal data may be numerical in form, but the numerical values have no mathematical interpretation.
  - For example, 10 prisoners are 100, 101, … 110, but; 100 + 110 = 210 is meaningless. They are simply labels.
- Two labels may be identical (=) or dissimilar (≠).
- These labels do not have any ordering among themselves.
  - For example, we cannot say blood group B is better or worse than group A.
- Labels (from two different attributes) can be combined to give another nominal variable.
  - For example, blood group with Rh factor (A+ , A- , AB+, etc.)

Binary scale of nominal data

- **Definition**

A nominal variable with exactly two mutually exclusive categories that have no logical order is known as binary variable

- **Examples**

Switch: {ON, OFF}

Attendance: {True, False}

Entry: {Yes, No}

etc.

Note

- A Binary variable is a special case of a nominal variable that takes only two possible values.

Symmetric and Asymmetric Binary Scale

- Different binary variables may have unequal importance.
- If two choices of a binary variable have equal importance, then it is called symmetric binary variable.
  - Example: Gender = {male, female}
    // usually of equal probability.
- If the two choices of a binary variable have unequal importance, it is called asymmetric binary variable.
  - Example: Food preference = {V, NV}

Operations on Nominal variables

- Summary statistics applicable to nominal data is mode.
- Arithmetic (+,-,*and/) and logical operations (<,>,≠, etc.) are not permitted.
- The allowed operations are : accessing (read, check, etc.) and re-coding (into another non-overlapping symbol set, that is, one-to-one mapping), etc.
- Nominal data can be visualized using line charts, bar charts or pie charts, etc.
- Two or more nominal variables can be combined to generate other nominal variable.
  - Example: Gender (M,F) × Marital status (S, M, D, W)

Ordinal scale

- **Definition**

Ordered nominal data are known as ordinal data and the variable that generates it is called ordinal variable.

- Example:

Shirt size = { S, M, L, XL, XXL}

Note

The values assumed by an ordinal variable can be ordered among themselves as each pair of values can be compared literally or using relational operators (< , ≤ , > , ≥).

Operation on Ordinal data

- Usually relational operators can be used on ordinal data.
- Summary measures mode and median can be used on ordinal data.
- Ordinal data can be ranked (numerically, alphabetically, etc.) Hence, we can find any of the percentiles measures of ordinal data.
- Calculations based on order are permitted (such as count, min, max, etc.).
- Spearman's R can be used as a measure of the strength of association between two sets of ordinal data.
- Numerical variable can be transformed into ordinal variable, but with a loss of information.
  - For example, Age [1, … 100] = [young, middle-aged, old]

Interval scale

- **Definition**

It allows to measure the interval between two measures.

Interval scale data are like ordinal data, in that they can be placed in a meaningful order. In addition, they have meaningful intervals between them.

Example 1:

S, M, L, being in ordinal scale, we cannot say that interval between S and M is same as that of between M and L , etc. Whereas, on the Celsius scale (which is an interval scale of measurement), the difference between 100°C and 90°C is the same as the difference between 50°C and 40°C.

Note that in interval scale of measurement, a zero-value does not mean that there is nothing!

Interval scale: Properties

- **Examples**

  Latitude, longitude, temperature (in Celsius/Fahrenheit scale), calendar dates, etc.

Properties

- Interval data are with well-defined interval.
- Interval data are measured on a numeric scale (with +ve, 0 (zero), and –ve values).
- Interval data may have a zero point on origin. However, the origin does not imply a true absence of the measured characteristics.
  - For example, the temperature outside is 0°C. Here, 0°C does not indicate a complete absence of heat; it is a value of a temperature.

Operations on Interval data

An interval scale, however, has a zero point with an arbitrary presence. This means that the value of zero has no real meaning.

- We can add to or from interval data.
  - For example: date1 + x-days = date2
- Subtraction can also be performed.
  - For example: current date – date of birth = age
- Negation (changing the sign) and multiplication by a constant are permitted.
- All operations on ordinal data defined are also valid here.
- Linear (e.g. cx + d) or Affine transformations are permissible.
- Other one-to-one non-linear transformation (e.g., log, exp, sin, etc.) can also be applied.

Operation on Interval data

Note

- Interval data can be transformed to nominal or ordinal scale, but with a loss of information.
- Interval data can be graphed using histogram, frequency polygon, etc.
- The statistical estimation like mean, median, and mode can be calculated.

Ratio scale

- **Definition**

  Interval data with a clear definition of “zero” are called ratio data.

  - Examples:

    Temperature in Kelvin scale, intensity of earth-quake on Richter scale, sound intensity in Decibel, cost of an article in Rupees, population of a country, weight of a body, age of a tree, height of a building, etc.

Note

- The data with ratio scale of measurement are the mostly used data in data science.
- In ratio scale, both differences between data values and ratios (of non-zero) data pairs are meaningful.
- $100^{o}C$ is not twice as hot as $50^{o}C$. On the other hand, 100 Kg is twice heavy as 50 Kg.
- Temperature in Kelvin scale is a ratio scale of measurement. Here, $0^{o}K$ means an absolute temperature and also we can say that $20^{o}K$ is as twice as $10^{o}K$.

Ratio scale: Properties

Because of the existence of true zero value, the ratio scale doesn't have negative values.
on a ratio scale there can be no negative number.

- **Properties**

- All ratio data are interval data but the reverse is not true.
- Ratio scale, as mentioned earlier has an absolute zero characteristic. It has orders and equally distanced value between units. The zero point characteristic makes it relevant or meaningful to say, "one object has twice the length of the other" or "is twice as long".
- Ratio scale doesn't have a negative number, unlike interval scale because of the absolute zero or zero point characteristic.

To measure any object on a this scale, researchers must first see if the object meets all the criteria for interval scale plus has an absolute zero characteristic.

Operation on Ratio data

- All arithmetic operations on interval data are applicable to ratio data.
- In addition, multiplication, division, etc. are allowed.
- Mean, median and mode are the permissible statistical operations.
- Any linear transformation of the form (ax + b)/c are known.

Properties of data

- Following FOUR properties (operations) of data are pertinent.

#	Property	Operation	Type
1.	Distinctiveness	= and ≠	Categorical (Qualitative)
2.	Order	< , ≤ , > , ≥	
3.	Addition	+ and -	Numerical (Quantitative)
4.	Multiplication	* and /	

NOIR summary

- ✓ Nominal (with distinctiveness property only)
- ✓ Ordinal (with distinctive and order property only)
- ✓ Interval (with additive property + property of Ordinal data)
- ✓ Ratio (with multiplicative property + property of Interval data)

- Further, nominal and ordinal are collectively referred to as categorical or qualitative data. Whereas, interval and ratio data are collectively referred to as quantitative or numeric data.

Data Cube

Multidimensional Data Modeling

Concept of data cube

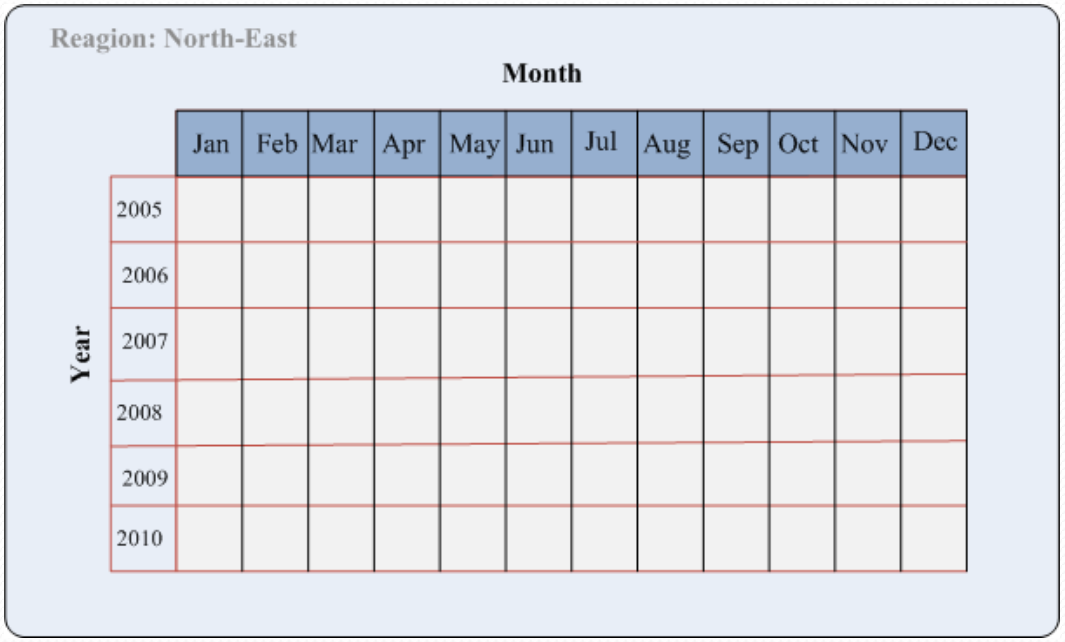
- A multidimensional data model views data in the form of a cube.

- A data cube is characterized with two things
  - **Dimension:** the perspective or entities with respect to which an organization wants to keep record.
  - **Fact:** The actual values in the record

Example.

- Rainfall data of Metrological Department
  - Time (Year, Season, Month, Week, Day, etc.)
  - Location (Country, Region, State, etc.)

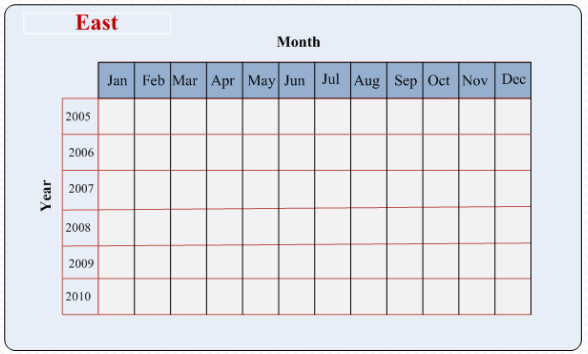
2-D view of rainfall data

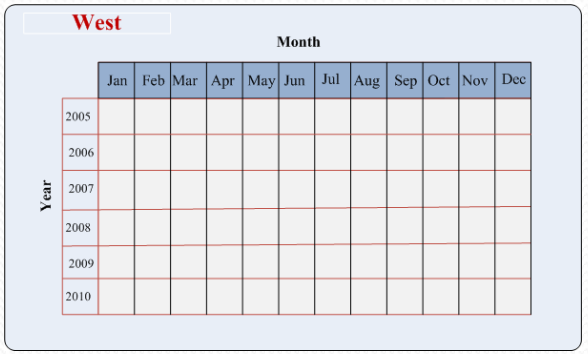


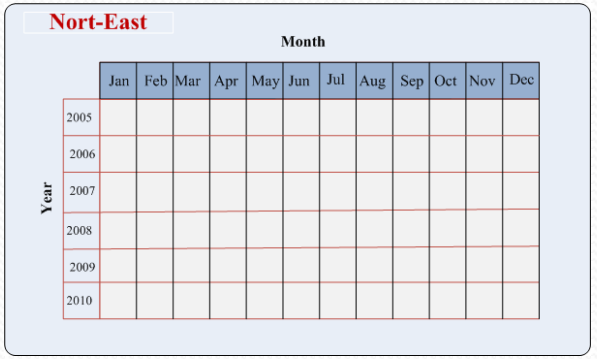
- In this 2-D representation, the rainfall for "North-East" region are shown with respect to different months for a period of years

3-D view of rainfall data

- Suppose, we want to represent data according to times (Year, Month) as well as regions of a country say East, West, North, North-East, etc.

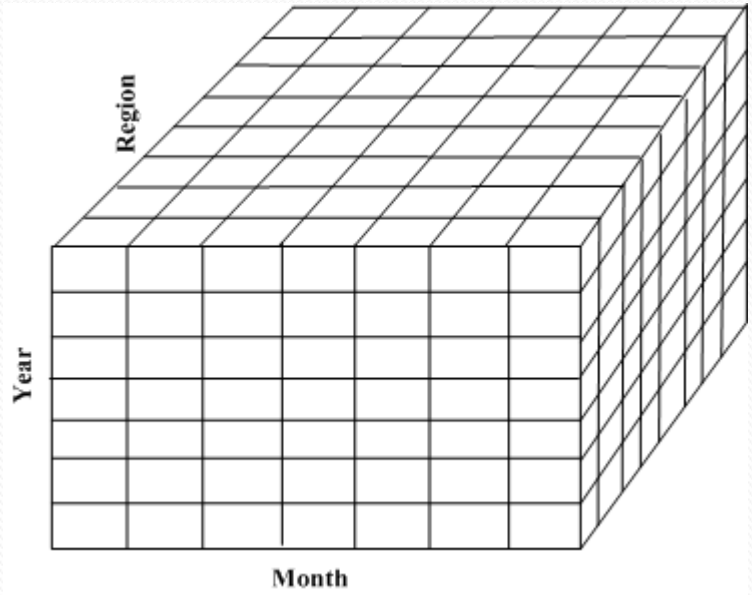






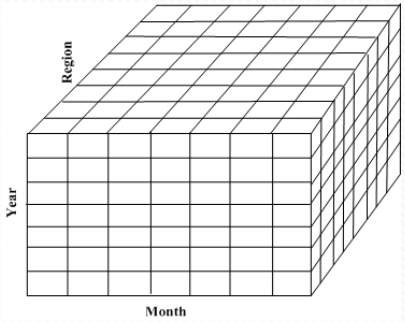
- A 2-D view of 3-D rainfall data

3-D view of rainfall data

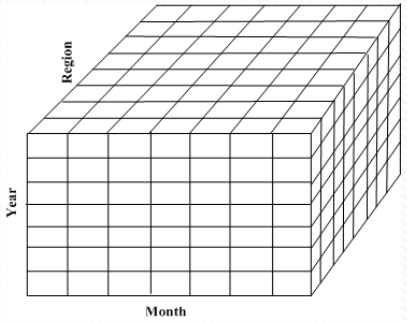


- Data cube: This enables us a 3-D view of the rainfall data

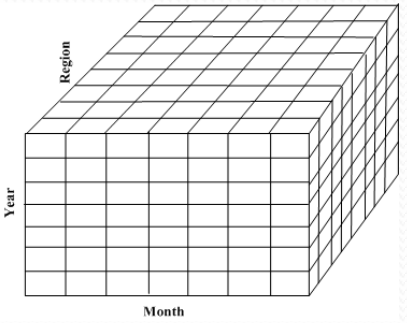
3-D view of rainfall data



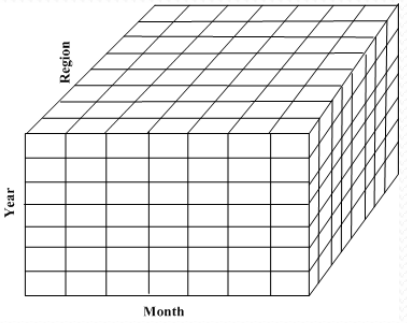
India



China



Russia



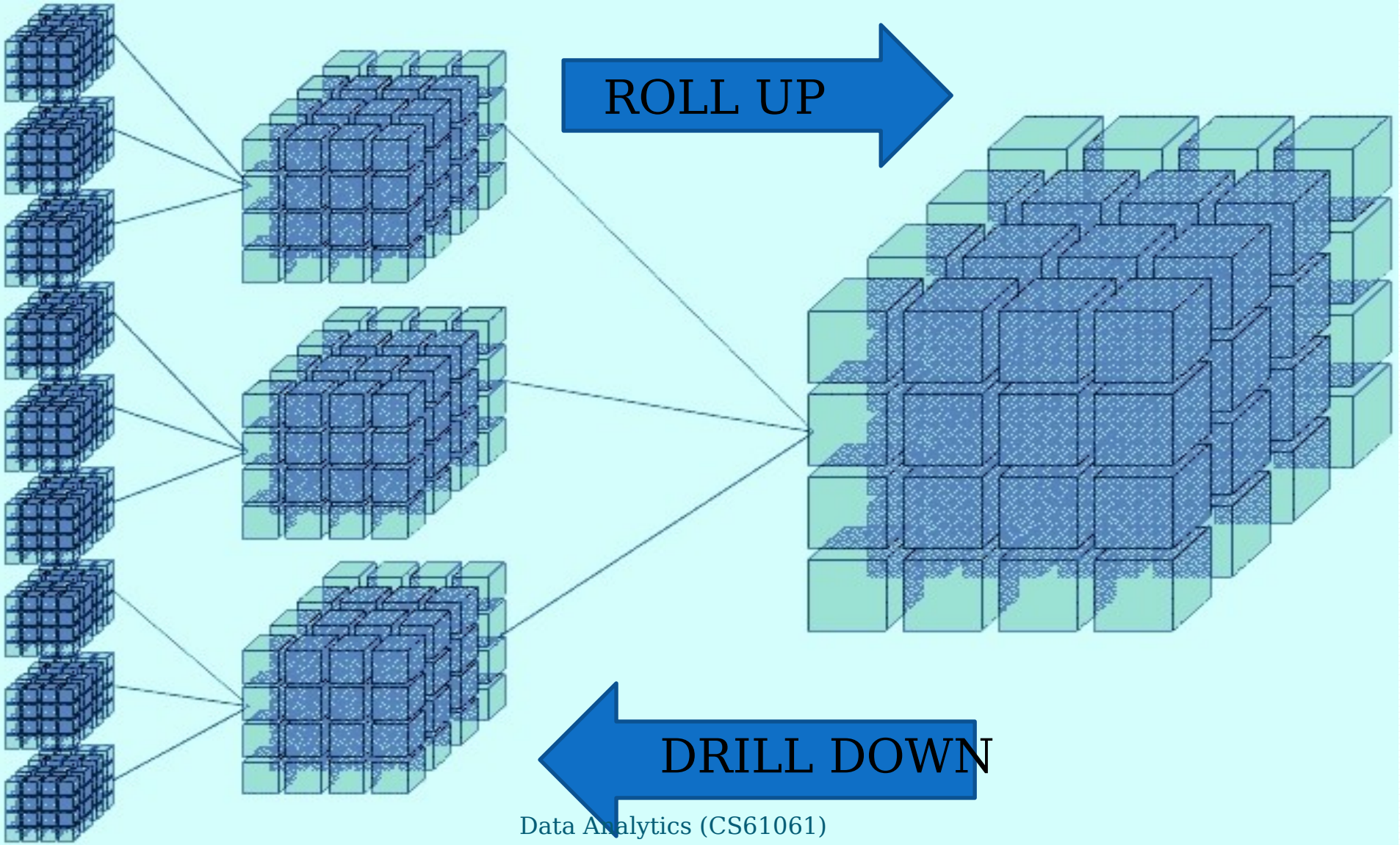
Pakistan

- Data cube: This enables us a 3-D view of the rainfall data for a continent say?

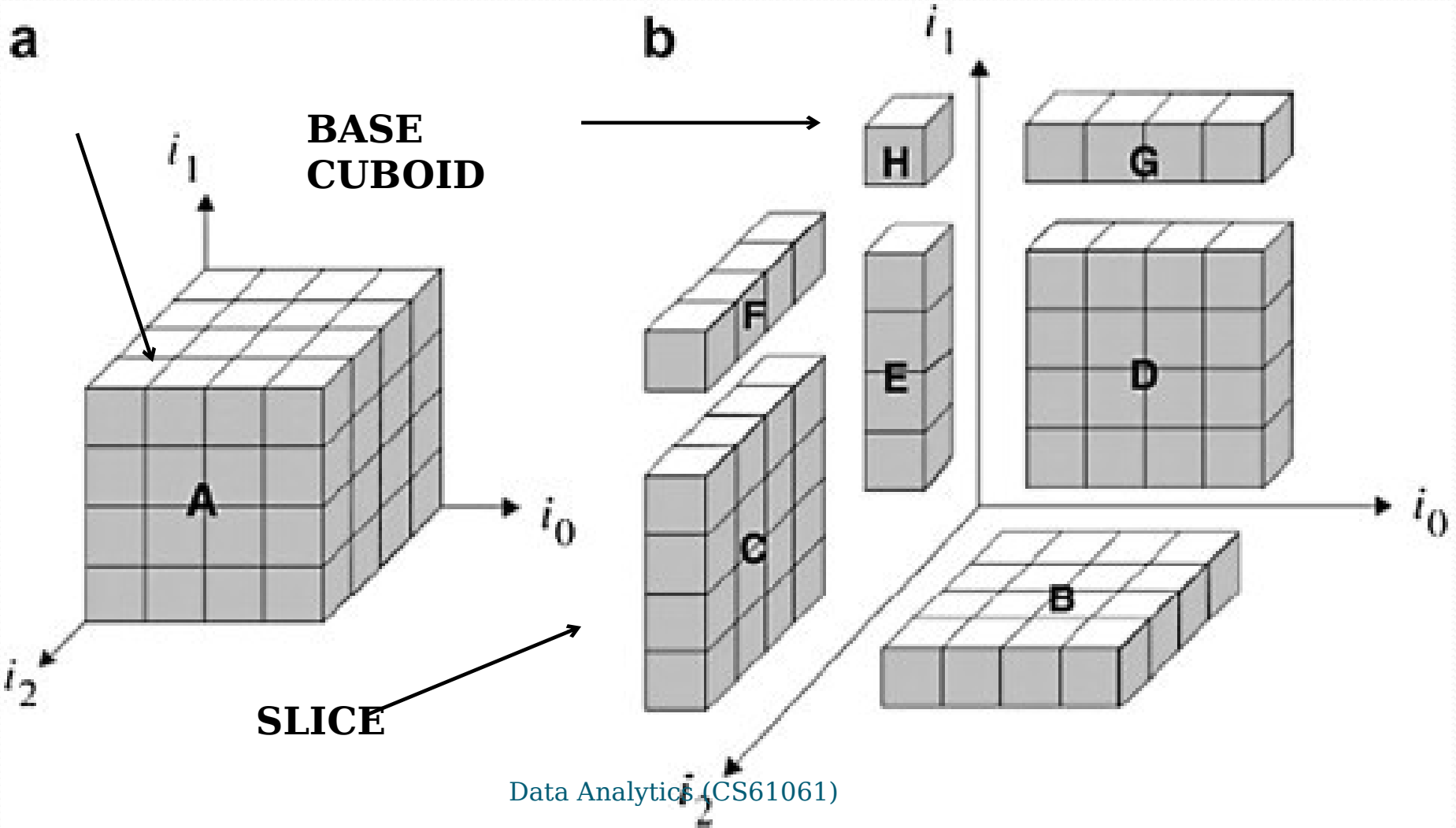
3-D view of rainfall data

- What is the data cube representation of rainfall data of the entire world?

Data cube aggregation



Data cube segregation



Reference

- The detail material related to this lecture can be found in

  Data Mining: Concepts and Techniques (3rd Edn.) by Jiawei Han, Michelline Kamber and Jian Pei, Morgan Kaufmann (2014).

Any question?

Questions of the day…

1. Consider an image as an entity.
   - What are the attributes you should think to represent an image?
   - Categorize each attribute according to the NOIR data classification.
   - Suppose, two images are given. Give an idea to check if two images are identical or not.

2. How you can convert a data of interval type to ordinal type? Give an example. What are the issues of such transformation? Whether the reverse is possible or not? Justify you answer.

Questions of the day…

3. What are the different properties used to categorize the data according to NOIR data categorization?

4. Given an entity say “STUDENT” with the following attributes. Identify the NOIR

Scholarship amount	Name	RollNo	DoB	Aaadhar No.	Gender	Mobiloe No.	Email Id

Questions of the day…

5. Give the concept of data cube to represent hyper-dimensional data? Also, explain with suitable diagrams the following.
   - Roll up
   - Drill down
   - Slice
6. Using the concept of data cube, how YouTube can archive videos of all type?
7. Give FOUR differences between data of types “interval” and “ratio-scale”

Questions of the day…

8. What are the different types of data you can think to judiciously represent an entity like the following?