

Chapter DM:I (continued)

I. Introduction

- Data Mining Overview
- On Data

On Data [Tan et al. 2005]

- ❑ An object $o \in O$ is described by a set of attributes.
An object is also known as record, point, case, sample, entity, or instance.
- ❑ An attribute A is a property of an object.
An attribute is also known as variable, field, characteristic, or feature.
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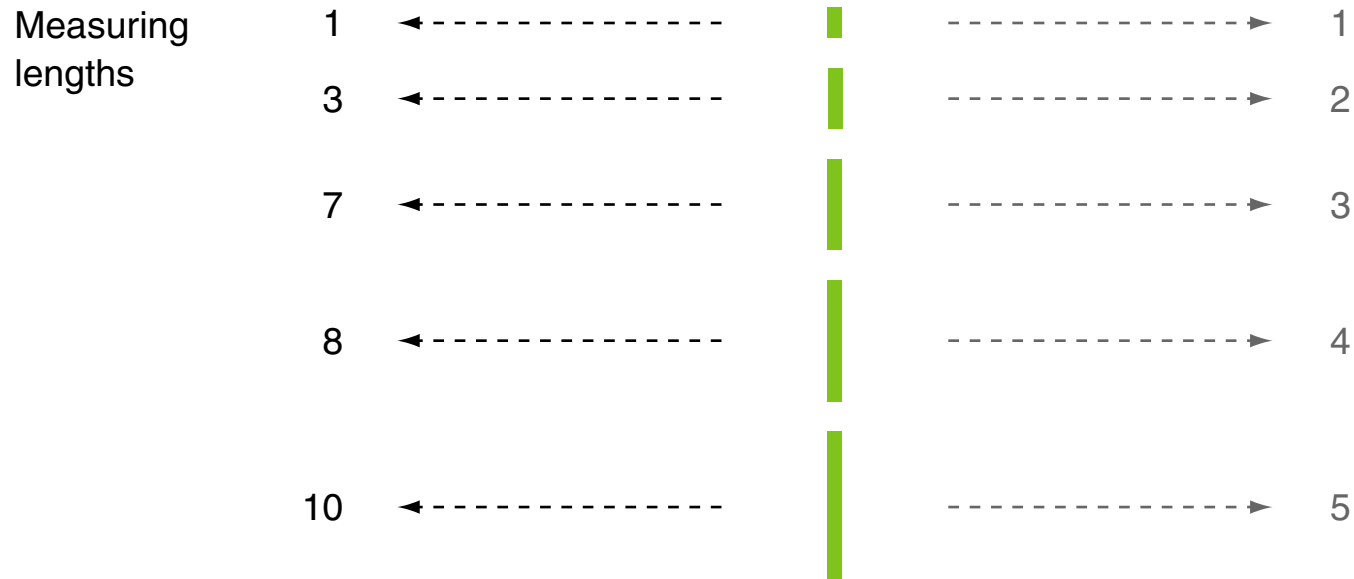
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- ❑ Attribute values may vary from one object to another or one time to another.
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The way an attribute is measured may not match the attribute's properties:



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Type		Comparison	Statistics	Examples
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	ratio	differences and ratios are meaningful * /	geometric mean, harmonic mean, percent variation	temperature in Kelvin, monetary quantities, counts, age, length, electrical current

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	ratio	$x \mapsto a \cdot x$, where a is a constant	Length can be measured in meters or feet.

Remarks:

- ❑ Identifying, considering, and measuring an attribute A of an object O is the heart of model formation and always goes along with a sort of abstraction. Formally, this abstraction is operationalized by a model formation function $\alpha : O \rightarrow X$. [\[ML Introduction\]](#)
- ❑ The terms “attribute” and “feature” can be used synonymously. However, a slight distinction is the following: attributes are often associated with objects, O , while features usually designate the dimensions of the feature space, X .
- ❑ The type of an attribute is also referred to as the type of a *measurement scale* or *level of measurement*.
- ❑ We call a transformation of an attribute *permissible* if its meaning is unchanged after the transformation.
- ❑ Distinguish between *discrete* attributes and *continuous* attributes. The former can only take a finite or countably infinite set of values, the latter can be measured in infinitely small units. Be careful when deriving from this distinction an attribute’s type.
- ❑ We will encode attributes of interval type or ratio type by real numbers. Note that attributes of nominal type and ordinal type can also be encoded by real numbers.
- ❑ Particular learning methods require particular attribute types.

Types of Data Sets

Data sets may not be a homogeneous collection of objects but come along with differently intricate characteristics:

1. Inhomogeneity of *attributes*:
2. Inhomogeneity of *objects*:
3. Inhomogeneity of *distributions*:
4. Resolution:
5. Curse of dimensionality:

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1. Inhomogeneity of *attributes*:

Consider the combination of different attribute types within a single object.

2. Inhomogeneity of *objects*:

Consider the combination of different objects in a single data set.

3. Inhomogeneity of *distributions*:

The correlation between attributes varies in the sample space.

4. Resolution:

The attributes may be given at different resolutions.

5. Curse of dimensionality:

Attribute number and object density stand in exponential relation.

Types of Data Sets: Record Data

Collection of records, each of which consists of a fixed set of attributes:

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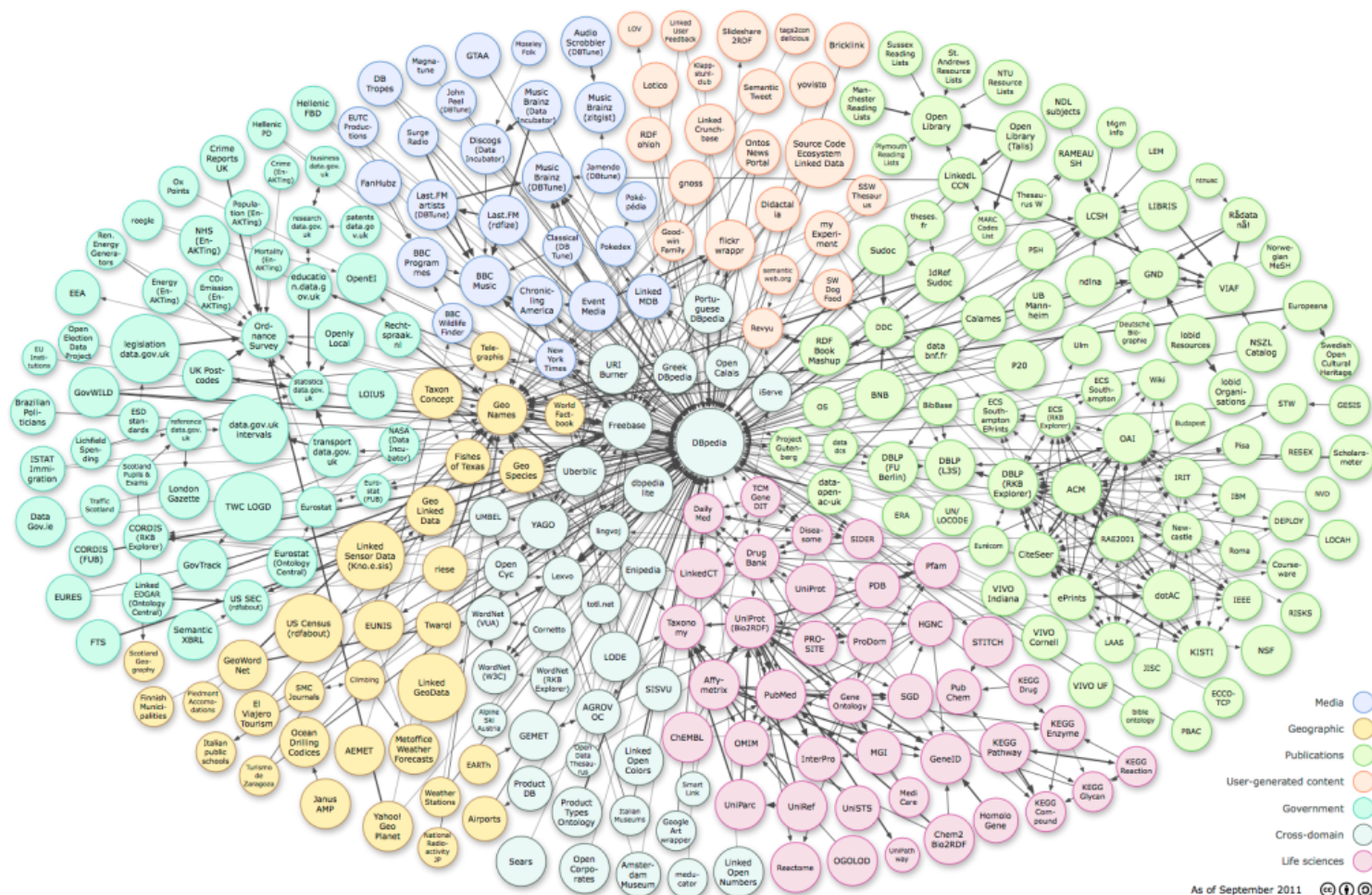
- ❑ If all elements in a data set have the same fixed set of numeric attributes, they can be thought of as points in a multi-dimensional space.
- ❑ Such data can be represented by a matrix, where each row stores an object and each column stores an attribute.

Example: term-document matrices in information retrieval.

On Data [Tan et al. 2005]

Types of Data Sets: Graph Data

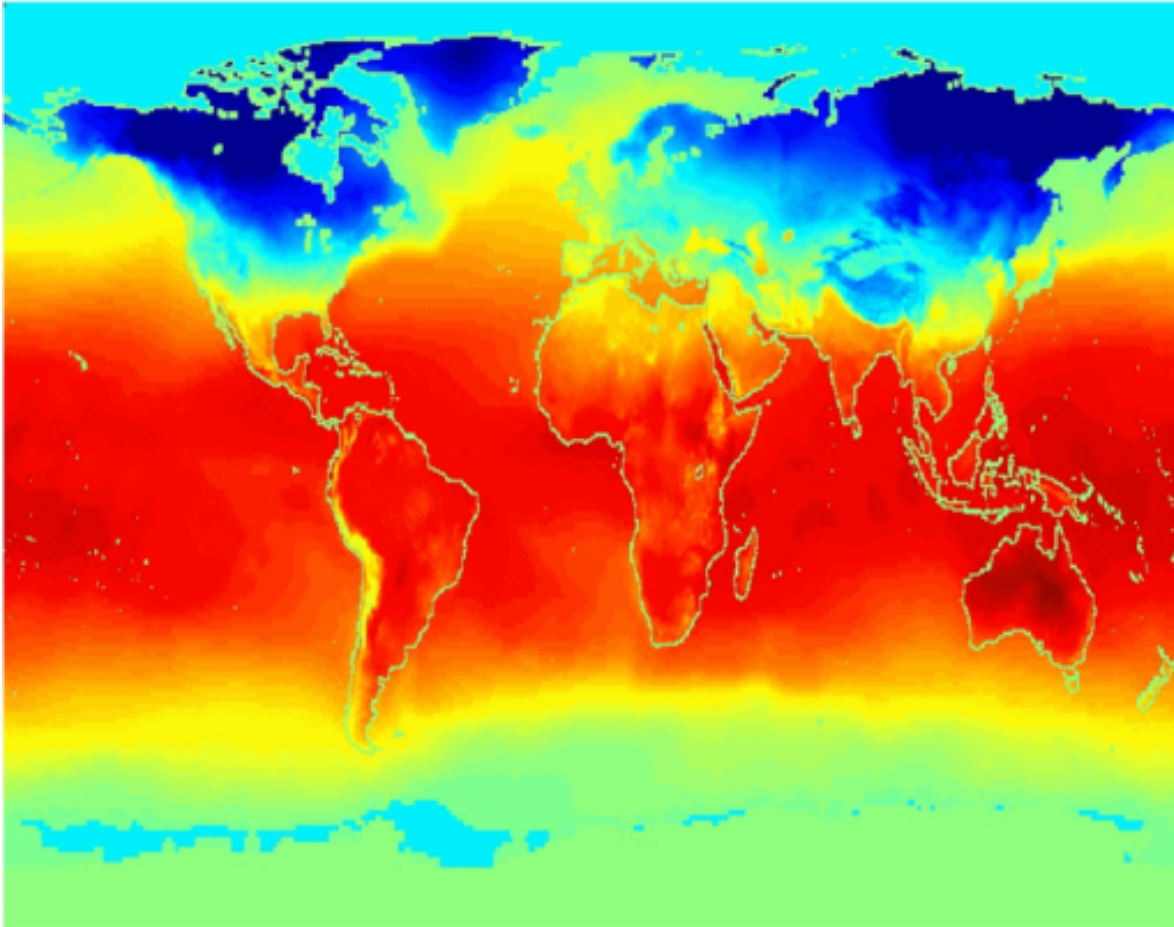
Graph of the Linked Open Data cloud [lod-cloud.net] :



On Data [Tan et al. 2005]

Types of Data Sets: Ordered Data

Average monthly temperature of land and ocean (= spatio-temporal data) :



When repeating measurements of a quantity, measurement errors and data collection errors may occur during the measurement process. Questions:

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Definition 1 (Precision, Bias, Accuracy)

Given a set of repeated measurements of the same quantity. Then, the closeness of the measurements to one another is called *precision*, a possible systematic variation is called *bias*, and the closeness to the true value is called *accuracy*.

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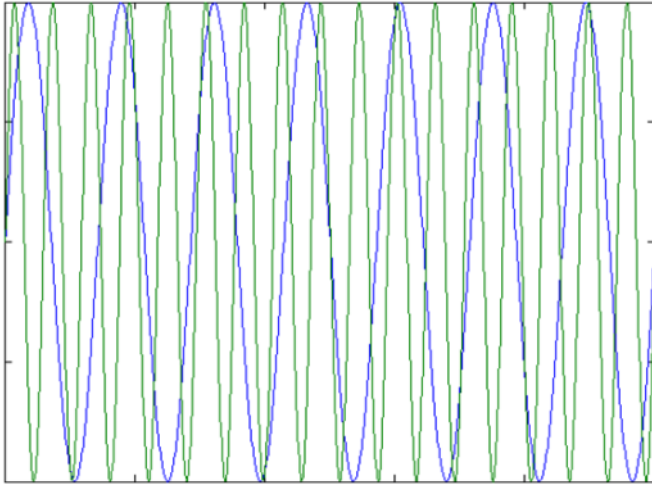
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Examples for data quality problems:

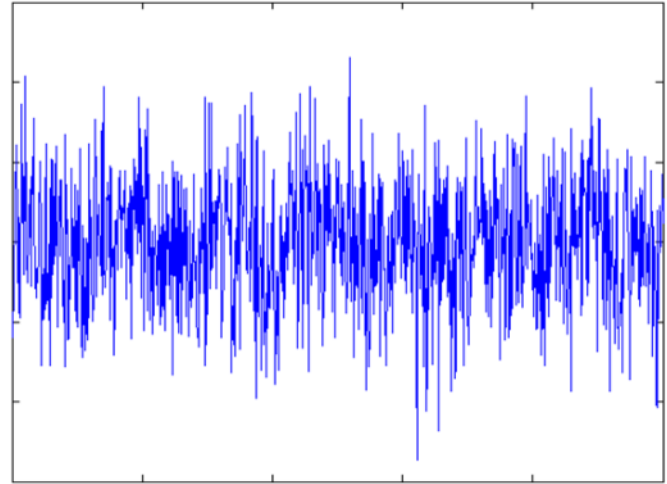
- ❑ noise, artifacts, outliers
- ❑ missing values
- ❑ duplicate data

Data Quality: Noise

Noise refers to random modifications of attributes that often have a spatial or temporal characteristics:



sine waves



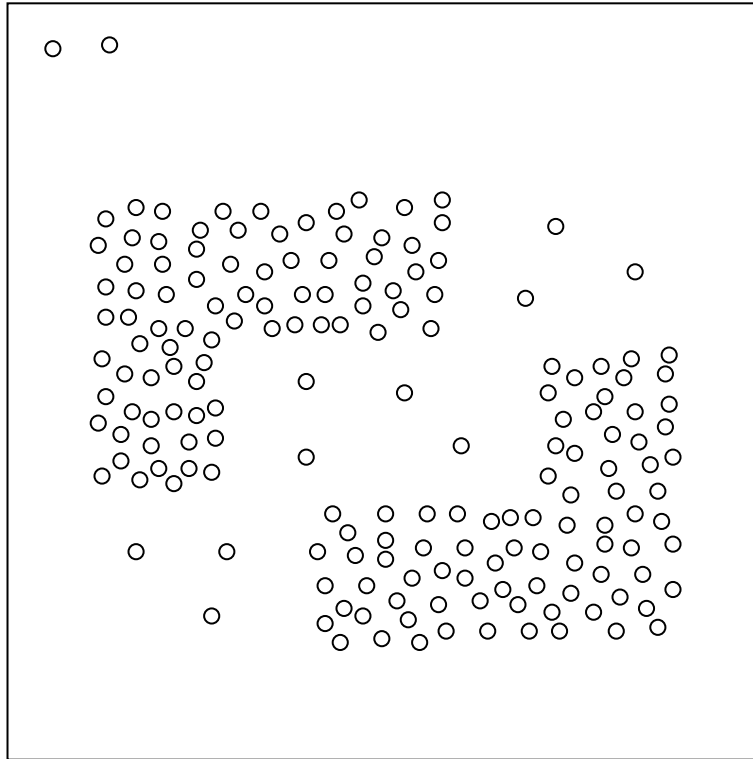
sine waves with noise

Noise represents the intrinsic variability of data. [Bishop 2006, p.47]

Artifacts refer to deterministic distortions of a measurement process.

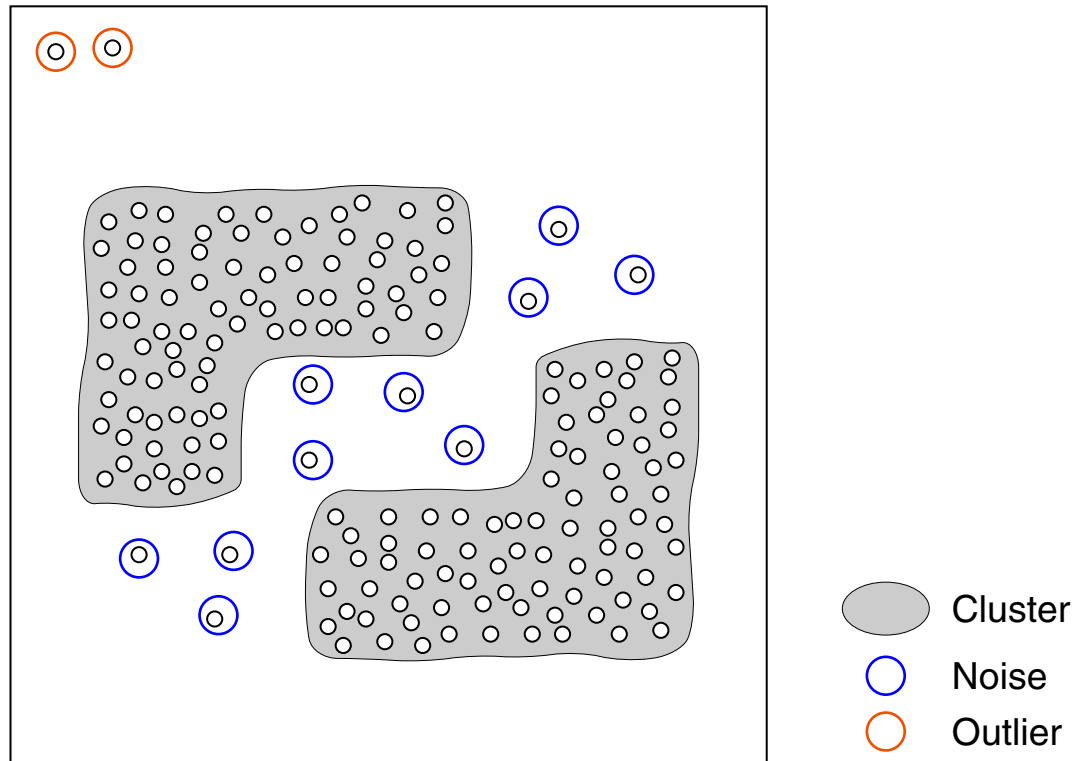
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Data Quality: Missing Values

Main reasons for missing values:

1. Information is not collected.
Example: people decline to give their age or weight.
2. Attributes may not be applicable to all elements in O .
Example: annual income is not applicable to children.
3. Information is not trustworthy.
Example: profile data on Facebook is intentionally misleading.

Strategies for handling missing values:

- ❑ eliminate members of the data
- ❑ estimate missing values
- ❑ ignore the missing value during analysis
- ❑ replace with all possible values weighted by their probabilities

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Data Preprocessing

- ❑ sampling of object set O
- ❑ modeling of objects, $\alpha : O \rightarrow X$
- ❑ sampling of feature space X [\[ML Introduction\]](#)
- ❑ selection of attributes (features) [\[attributes versus features\]](#)
- ❑ transformation of attributes (features)
- ❑ discretization and binarization of attributes (features)
- ❑ dimensionality reduction of feature space X