DATA ABSTRACTION

Bùi Tiến Lên

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Contents

The Big Picture

Data Types

Data Types

The five basic **data types**:

1. An **item** is an individual entity that is discrete, such as a row in a simple table or a node in a network
2. An **attribute** is some specific property that can be measured, observed, or logged
3. A **link** is a relationship between items, typically within a network
4. A **position** is spatial data, providing a location in two-dimensional (2D) or three-dimensional (3D) space
5. A **grid** specifies the strategy for sampling continuous data in terms of both geometric and topological relationships between its cells

➔ **Data Types**

➔ Items ➔ Attributes ➔ Links ➔ Positions ➔ Grids

Dataset Types

- Tables
- Networks and Trees
- Fields
- Geometry
- Other Combinations
- Dataset Availability

Dataset Types

Concept 1

A **dataset** is any collection of information that is the target of analysis. Data sets are made up of data objects.

- These basic **dataset types** arise from combinations of the data types of items, attributes, links, positions, and grids.

Data and Dataset Types

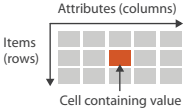
Tables	Networks & Trees	Fields	Geometry	Clusters, Sets, Lists
Items	Items (nodes)	Grids	Items	Items
Attributes	Links	Positions	Positions	
	Attributes	Attributes		

Dataset Types (cont.)

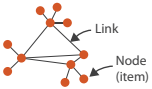
- The detailed structure of the four basic dataset types

Dataset Types

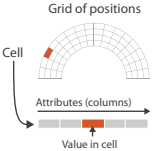
Tables



Networks

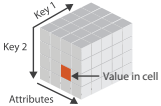


Fields (Continuous)



Geometry (Spatial)

Multidimensional Table



Trees

Tables

- Many datasets come in the form of **tables** that are made up of rows and columns, a familiar form to anybody who has used a spreadsheet
- For a simple **flat table**
  - Each row represents an **item** of data, and each column is an **attribute** of the dataset
  - Each **cell** in the table is fully specified by the combination of a row and a column—an item and an attribute—and contains a value for that pair
- A **multidimensional table** has a more complex structure for indexing into a cell, with multiple keys

Tables (cont.)

A	B	C	S	T	U
Order ID	Order Date	Order Priority	Product Container	Product Base Margin	Ship Date
3	10/14/06	5-Low	Large Box	0.8	10/21/06
6	2/21/08	4-Not Specified	Small Pack	0.55	2/22/08
32	7/16/07	2-High	Small Pack	0.79	7/17/07
32	7/16/07	2-High	Jumbo Box	[illegible]	7/17/07
32	7/16/07	2-High	Medium Box	[illegible]	7/18/07
32	7/16/07	2-High	Medium Box	[illegible]	7/18/07
35	10/23/07	4-Not Specified	Wrap Bag	0.52	10/24/07
35	10/23/07	4-Not Specified	Small Box	0.58	10/25/07
36	11/3/07	1-Urgent	Small Box	0.55	11/3/07
65	3/18/07	1-Urgent	Small Pack	0.49	3/19/07
66	[illegible]	5-Low	Wrap Bag	0.56	1/20/05
69	[illegible]	4-Not Specified	Small Pack	0.44	6/6/05
69	[illegible]	4-Not Specified	Wrap Bag	0.6	6/6/05
70	12/18/06	5-Low	Small Box	0.59	12/23/06
70	12/18/06	5-Low	Wrap Bag	0.82	12/23/06
96	4/17/05	2-High	Small Box	0.55	4/19/05
97	1/29/06	3-Medium	Small Box	0.38	1/30/06
129	11/19/08	5-Low	Small Box	0.37	11/28/08
130	5/8/08	2-High	Small Box	0.37	5/9/08
130	5/8/08	2-High	Medium Box	0.38	5/10/08
130	5/8/08	2-High	Small Box	0.6	5/11/08
132	6/11/06	3-Medium	Medium Box	0.6	6/12/06
132	6/11/06	3-Medium	Jumbo Box	0.69	6/14/06
134	5/1/08	4-Not Specified	Large Box	0.82	5/3/08
135	10/21/07	4-Not Specified	Small Pack	0.64	10/23/07
166	9/12/07	2-High	Small Box	0.55	9/14/07
193	8/8/06	1-Urgent	Medium Box	0.57	8/10/06
194	4/5/08	3-Medium	Wrap Bag	0.42	4/7/08

attribute

item

cell

Networks

The dataset type of **networks** is well suited for specifying that there is some kind of relationship between two or more items.

- An item in a network is often called a **node**.
- A **link** is a relation between two items.

Trees

- Networks with hierarchical structure are more specifically called **trees**.
- In contrast to a general network, trees do not have cycles: each child node has only one parent node pointing to it

Fields

- The **field** dataset type also contains attribute values associated with cells
- Each cell in a field contains measurements or calculations from a **continuous** domain
- Continuous data requires careful treatment that takes into account the mathematical questions of **sampling** and **interpolation**
- In contrast, the table and network datatypes discussed above are an example of **discrete** data where a finite number of individual items exist, and interpolation between them is not a meaningful concept.

Spatial Fields

- Continuous data is often found in the form of a spatial field, where the cell structure of the field is based on sampling at spatial positions

Grid Types

- When a field contains data created by sampling at completely regular intervals, the cells form a **uniform grid**
- There is no need to explicitly store the **grid geometry** in terms of its location in space, or the **grid topology** in terms of how each cell connects with its neighboring cells

Geometry

- The **geometry** dataset type specifies information about the shape of items with explicit spatial positions.
- The items could be points, or one-dimensional lines or curves, or 2D surfaces or regions, or 3D volumes.
- Geometry datasets are intrinsically spatial. Spatial data often includes hierarchical structure at multiple scales.

Other Combinations

There are many ways to group multiple items together, including sets, lists, and clusters

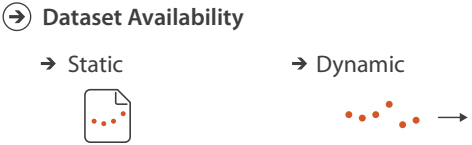
- A **set** is simply an unordered group of items
- A group of items with a specified ordering could be called a **list**
- A **cluster** is a grouping based on attribute similarity

There are also more complex structures built on top of the basic network type

- A **path** through a network is an ordered set of segments formed by links connecting nodes
- A **compound network** is a network with an associated tree

Dataset Availability

- The default approach to vis assumes that the entire dataset is available all at once, as a **static file**
- Some datasets are **dynamic streams**, where the dataset information trickles in over the course of the vis session



Attribute Types

Attribute types

Concept 2

An attribute (also called dimension, feature, variable) is a data field, representing a characteristic or feature of a data object.

- At the top level,
  - we can differentiate **qualitative** (or **categorical**) and **quantitative** (or **numerical**) attribute.
- At a second level,
  - we can categorize qualitative data into **nominal** and **ordinal** attribute,
  - and quantitative data into **discrete** and **continuous** attribute.

Level of measurement

- Describe the nature of information within the values assigned to variables

Type	Measure property	Mathematical operators	Advanced operations	Central tendency	Variability
Nominal	Classification, membership	$=, \neq$	Grouping	Mode	Qualitative variation
Ordinal	Comparison, level	$>, <$	Sorting	Median	Range, interquartile range
Interval	Difference, affinity	$+, -$	Comparison to a standard	Arithmetic mean	Deviation
Ratio	Magnitude, amount	$*, /$	Ratio	Geometric mean, harmonic mean	Coefficient of variation, studentized range

Nominal Attribute

Concept 3

Nominal attribute represents *things*

- His *name* is Brent Spiner.
- By *profession* he is an actor.
- He played the *character* Data in the TV show *Star Trek: The Next Generation*.

Ordinal Attribute

Concept 4

Ordinal attribute is similar to categorical data, except it has a clear order

- Brent Spiner's *date of birth* is Wednesday, February 2, 1949.
- He appeared in all seven *seasons* of *Star Trek: The Next Generation*.
- Data's *rank* was lieutenant commander.

Discrete Attribute

Concept 5

Discrete data are numeric data whose domain can be equated to the set of whole numbers $\mathbb{Z}$

An example of discrete data would be *the number of people* visiting a doctor.

Continuous Attribute

Concept 6

Continuous data are numeric data whose domain can be equated to the set of real numbers $\mathbb{R}$.

An example of continuous data would be *temperature values* as measured hourly by a weather station.

Sequential, Diverging and Cyclic

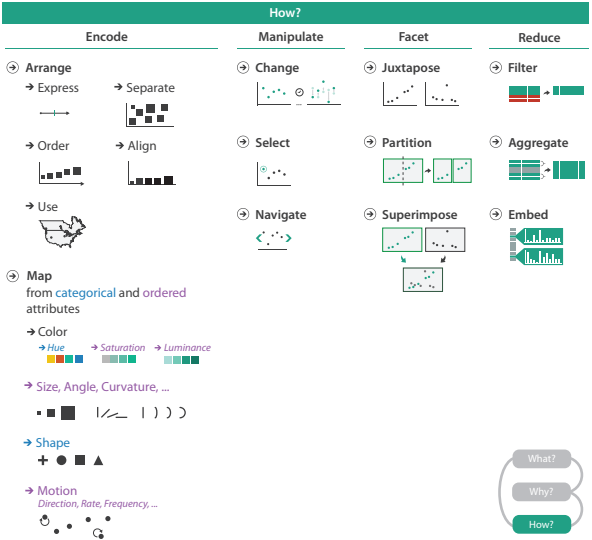
Ordered data can be

- **sequential**, where there is a homogeneous range from a minimum to a maximum value,
- **diverging**, which can be deconstructed into two sequences pointing in opposite directions that meet at a common zero point
- **cyclic**, where the values wrap around back to a starting point rather than continuing to increase indefinitely.

Hierarchical Attributes

- There may be hierarchical structure within an attribute or between multiple attributes.

The Big Picture



Data Processing

Dataset

ID	Name	Age	Shirt Size	Favorite Fruit
1	Amy	8	S	Apple
2	Basil	7	S	Pear
3	Clara	9	M	Durian
4	Desmond	13	L	Elderberry
5	Ernest	12	L	Peach
6	Fanny	10	S	Lychee
7	George	9	M	Orange
8	Hector	8	L	Loquat
9	Ida	10	M	Pear
10	Amy	12	M	Orange

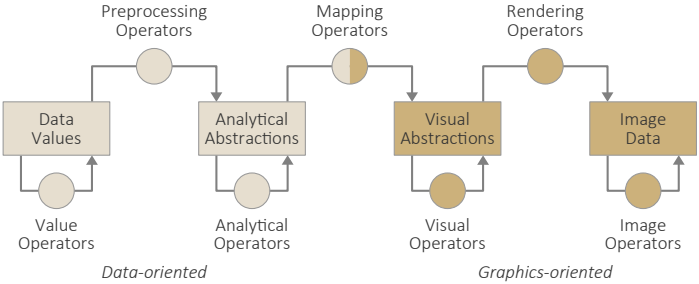
Functional dependency

$$f : (D_1 \times D_2 \times \cdots \times D_n) \rightarrow (A_1 \times A_2 \times \cdots \times A_m) \tag{1}$$

where D_i denote the *dimensions* (*independent variables*) and A_i the *attributes* (*dependent variables*)

D_1	D_2	$\cdots$	D_n	A_1	A_2	$\cdots$	A_m
$d_{1,1}$	$d_{1,2}$	$\cdots$	$d_{1,n}$	$a_{1,1}$	$a_{1,2}$	$\cdots$	$a_{1,m}$
$\vdots$							$\vdots$
$d_{k,1}$	$d_{k,2}$	$\cdots$	$d_{k,n}$	$a_{k,1}$	$a_{k,2}$	$\cdots$	$a_{k,m}$

Data Transformation



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