A General Graphical Selection Model

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Abstract

Interactive selection is a ubiquitous requirement for modern exploratory visualization environments. We propose a general framework for modeling complex linked and brushed selection interaction tasks on a level of abstraction above the underlying data model. We demonstrate the generality of our solution by discussing use cases for the following data models: generic data tables, the entity-relationship (ER) model, the Universal Data Cube (UDC) model, and subspace clustering results.

1 Introduction

Selecting objects is a common operation present in many contexts, such as operating system GUIs, information visualization systems, and geographic information systems (GISs). In all these contexts, objects may be represented multiple times in different views (for example, two views of the same file system may contain two different representations of a directory). Also, selection of an object may impicitly cause other related objects to be selected as well (for example, selection of a directory may imply selection of its children).

We concern ourselves with selection operations within information visualization systems with linked views. In this domain, objects in the data space are visually represented. Selection in this context refers to the definition of a subset of data objects for further operations, such as highlighting, probing, or filtering.

Visual representations may be interacted with directly to cause selection of the corresponding object(s) in the data space, which in turn may cause other visual representations of the same object(s) to change their appearance. Lets consider an example in which there are two linked views, a scatter plot

and a parallel coordinates view, and selection causes visual representations to be highlighted. The data objects represented by points in the scatter plot may be selected with a selection polygon (rectangle or lassoo), or the points may be clicked on individually. When an object is selected, its corresponding visual representation in both the scatter plot and parallel coordinates view is highlighted.

Refinement of selections is also an essential operation. For example, selecting a group of files in an operating system GUI may include several steps in which a coarse selection is made, then additional selections are removed or added to it to reach the desired set of files. Thus union, intersection, and relative compliment operations must be available on selections.

When the underlying data model contains relationships between data objects, it may be reasonable to require that selection of one object may propagate to others. For example, in a geographic visualization of countries and their, selection of a country may cause its states to be selected as well. We call this *selection propagation*

Our framework addresses the issues of selection creation, refinement, and propagation in a data-model-agnostic way, providing the basis for defining operations on selections such as highlighting, probing, and filtering.

2 Related Work

Fua et. al. introduced a method of navigating hierarchies with brushes [1].

Wills introduced a taxonomy of selection operations [2].

3 Approach

We define a selection model based on the notion of *visualization primitives* and *selectable objects*. A visualization primitive is a graphical representation of a selectable object. For example, a single circle in a scatterplot is a visualization primitive. A selectable object represents a selectable manifestation of an object in the underlying data model. For example, a row in a data table may be represented by a selectable object. There is a one to many relationship between selectable objects and visualization primitives.

Selection of one selectable object may cause the selection of another. This is called *selection propagation relation*. The set of all selection propagation

relations induces the *selection propagation graph*, which is a directed acyclic graph defining how selections will be propagated.

4 Implementation

Each visualization primitive can be spatially indexed for improved performance.

For the highlighting operation, highlighted visualization primitives can be drawn on a layer separate from that of the underlying visualization. This will improve performance, as the underlying visualization does not need to be redrawn when the selection changes.

5 Application Scenarios

Terms: Visualization Primitive/Selectable Graphic - Each visualization has their own instance of these, they point to (represent) Selectable elements Selectable elements/objects/entities - These are able to be selected, one is represented by many different visualization primitives - Selection of a selectable element makes all of the visualization primitives which represent it appear as selected Selection propagation link - a directed edge/link/relation between two selectable elements - When element A is selected, it causes B to be selected, etc (may be many hops, i.e. through many levels of a record hierarchy)

Ideas:

All these (below) data models can potentially be visualized with selection interaction. Selection interaction is a general problem which deals with any type of selectable element, and propagation of selection through related selectable elements.

A graphics/selection layer on top of potentially different data models, i.e. the UDC model and Subspace clustering results.

Summary of entity relationship model (relational database) selectable elements: - Table rows selection propagation - May propagate through relations

Summary of UDC model and selectable elements selectable elements: - Records selection propagation - Down through a record hierarchy

Summary of subspace clustering model and selectable elements selectable elements: - Subspace clusters - Dimensions (columns) - Elements (rows)

selection propagation - for Subspace clusters: - Select all Dimensions and Elements within the cluster - for Dimensions - Select all clusters which contain that dimension - for Elements - Select all clusters which contain that element

A graphics/selection layer on top of potentially different data models, i.e. the UDC model and Subspace clustering results. Structures within the graphics/selection layer: - Directed acyclic graph of "selectable objects" which could be anything - Nodes represent selectable elements in the underlying data model - Edges represent selection propagation

Graphics/Visualization Primitives

Selectable elements

Selection propagation

References

[1] Y.H. Fua, M.O. Ward, and E.A. Rundensteiner. Navigating hierarchies with structure-based brushes. In *infovis*, page 58. Published by the IEEE Computer Society, 1999.

[2] GJ Wills. Selection: 524,288 ways to say. In *infovis*, page 54. Published by the IEEE Computer Society, 1996.