学 位 論 文 内 容 の 要 旨

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学 位 論 文 題 名

A New Interactive Visualization Framework for Defining Both Standard Charts and Nonstandard Charts Based on Two Tree-structured Schemata

（二種類の木構造スキーマを用いて、標準チャートと非標準チャートを定義可能な新しいインタラクティブ情報可視化フレームワークに関する研究）

Information visualization is an important and widely-used technology for composing charts using a set of graphical objects, which represent data by their visual properties. Comparing to the abstract data, users can more easily read and understand visualization charts. A well-designed chart can even reveal information which is difficult to obtain from the original data used to define this chart. For example, users can more easily read the change trend of data from a line chart than from the original data. In recent years, because of the rapid development of data measuring technologies and data gathering technologies, the data sets used to store the gathered data become more and more complex, and their sizes become larger and larger. In order to define charts to represent such complex data sets, many new designs of charts are proposed. One of the most important research topics on information visualization is how to automatically create various charts using computers.

In the last decades, many researchers worked on developing visualization frameworks and systems for supporting users to define their desired visualization charts. Now, how to automatically construct standard charts from their declarative definitions is well studied. In this paper, I define a standard chart as either a basic standard chart, which is composed using four types of basic graphical objects, i.e., “Point”, “Line”, “Area” and “Interval”, or a chart composed with more than one standard chart by geometrically arranging them or embedding some of them into another in a nested way.

The next research challenge of information visualization is how to declaratively define nonstandard charts for their automatic constructions. Nonstandard charts are those that cannot be simply composed with standard charts. One typical example of nonstandard charts is the chart of Napoleon’s Russia Campaign of 1812. As to the challenge of the automatic construction of such nonstandard charts, I may classify conventional visualization frameworks into two categories. The first category requires users to procedurally defined nonstandard charts by programming. The second category requires users to declaratively define nonstandard charts with their logical specification using a given library of graphical objects.

In this thesis, I proposed a new visualization framework in the second category for automatically constructing nonstandard charts from their logical specifications to represent data both from local databases and from Semantic Web. Such a specification is described by one or more pairs of Data View Schemata (DVSs) and Chart View Schemata (CVSs). Each DVS is used for describing how to manipulate the data stored in either a local database or Semantic Web. Each CVS is used for defining the rendered appearances of the different chart components. Using this framework, users can easily create such complex nonstandard charts by simply defining the DVSs and CVSs as their logical specifications. This framework also provides a template composition method for supporting users to define a complex graphical template using primitive graphical objects in the library of graphical objects. Then users can use such newly-defined graphical templates to define charts. The charts

defined by this framework are interactive. By using the operations provided by this framework, users can indirectly modify its DVS and CVS though directly manipulating the visual objects in this chart.
Chapter 1 gives the background of this research. I outline the current research of information visualization, and the problems of the research on information visualization. I also explain the important terminologies in this paper. Then I briefly introduce the contributions of this paper.
In Chapter 2, I propose a new visualization framework. I first show the outline of this framework and introduce the process of how to use this framework to define a chart. Then, I explain the DVS, the CVS, and how to define linkages between them in details. In order to demonstrate the power of this framework, I recreate and extend the chart of Napoleon's Russian campaign by using this framework. Next, I explain the template composition method of this framework, which supports users to define a new visualization template by combining more than one primitive graphical object together and defining their geometric relationship. This method aims to solve the problem of insufficiently registered graphical objects in the library of this framework. Last, I discuss how to apply this framework to support users to define GeoVisualization charts. This framework provides four special functions, which can simplify the process of defining GeoVisualization Charts.
In Chapter 3, I explain how users interact with the charts generated by this framework. Beside the common chart manipulating operations, such as zoom in/out, brushing and linking, this framework also provides five special operations. Users can use these five operations to manipulate the visual object in a chart, for indirectly modifying the DVS and the CVS of this chart. By manipulating a chart by the interactions in this framework, users can easily obtain more information than directly observing a chart, and furthermore modify a chart without directly manipulating the DVS and the CVS.
In Chapter 4, I introduce how to use this framework to visualize the data retrieved from Semantic Web. Semantic Web develops rapidly in recent years. It provides a generic framework to describe the data on the web. Its rapid development makes Semantic Web become an important open data source. Users can use the data retrieved from Semantic Web as a complement of the data retrieved from local databases. This framework enables users to access Semantic Web, and search it through a Semantic Web search framework developed by Bin Piao. This framework supports to represent the data retrieved from Semantic Web by a DVS, and supports users to manipulate this DVS using the operations introduced in Chapter 2 and Chapter 3. Then users can visualize the retrieved data just like visualizing a data set retrieved from a local database.
In Chapter 5, I explain how to implement this framework, and the enabling technologies used to implement this framework.
In Chapter 6, I compare this framework with six successful visualization systems in eight functional aspects. I also compare the process of creating the chart of Napoleon's Russia Campaign by using this framework to the process of creating the same chart by using Mathematica. From the result of the first comparison, I know that this framework provides all the necessary functions which help users to define both standard and nonstandard charts in a unified method, while each of the other systems only partly supports these functions. From the result of the second comparison, I know that the process of defining the Napoleon's chart in this framework is easier than the process of defining the same chart in Mathematica.
In Chapter 7, I make some concluding marks.