TOWARDS A FLEXIBLE USER-CENTRED VISUAL PRESENTATION APPROACH

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Abstract

Leveraging the power of flexible visual presentations has become an effective way to aid information interpretation, decision making and problem solving. It is indispensable to address the high complexities with visualization problems and relieve the impact from the intrinsic limitations of human cognitive capacity. Addressing these problems raises demanding requirements for information presentation flexibility. However, many existing visualization systems tend to provide weak support for such flexibility due to the issue of closely coupled information representation and presentation in system designs. This issue limits their support for rich presentation options, flexible presentation integration and reusability, and vivid storytelling of data. To help with addressing these problems, issues and requirements, this paper generalizes typical presentation models to provide paradigm level support for achieving presentation flexibility, and identifies key requirements for presentation development to accomplish the flexibility at a system level. With articulating the requirements at both paradigm and system levels, the paper proposes a user-centred process to realize presentation flexibility by meeting both functional and cognitive requirements for information presentation. The proposed theory is validated against a real-world business case and applied to guide the development of a prototypical system, which is demonstrated through a sequence of scenario-driven illustrations.

Keywords: Presentation Flexibility, Information Presentation, Visualization, Model, Process, Implementation.

1 INTRODUCTION

With the advances achieved in the field of information visualization, a variety of visualization techniques and tools have been widely adopted under many application domains or contexts such as visual decision support, knowledge management, social media, and mobile applications. When visualizations are appropriately deployed for their intended purpose, users can often obtain illuminating, useful, relevant and actionable information from the visualizations with less effort and time. This, in turn, helps to inform, shape, change and/or reinforce mental models and behaviours of the users. An ultimate goal of leveraging the power of visualization is to amplify the cognitive capacities of human beings. However, this goal is rather challenging to achieve due to difficulties originated from two aspects: users and visualization problems.

The cognitive capacity of an individual is largely dependent on the ability of processing information in his memory systems. Such information processing involves cognitive processes and activities that one performs to acquire, encode, transform, integrate, retain, retrieve and apply information (Wickens et al. 2004). It also compromises rational-analytical and experiential-intuitive cognitive styles (Epstein et al. 1996), both of which work together in a harmonious fashion and are closely coupled with human memory systems to foster the cognitive capacity of the human brain.

Much research has been conducted in the field of psychology to study how information is processed in human memory systems. For instance, Atkinson and Shiffrin (1968) proposed a multi-store model based on three essential memory stores: sensory memory, short-term memory and long-term memory. The multi-store model has become one of the most influential models of human information processing nowadays. Due to the critique of the multi-store model oversimplifying the processes and complexities involved in human memory systems, Baddeley and Hitch (1974) developed a model with a particular focus on the depth of information processing. Unlike the multi-store model, the levels of processing model does not differentiate short term memory and long term memory. It argues that how well information is remembered in human memory depends on the way of how it is encoded, and how easily the information can be recalled is determined by how deep it is processed.

Miller (1956) purports that human cognitive capacity is limited due to the fact that the short-term memory capacity of an average individual is delimited to seven plus or minus two elements. This has caused short-term memory to become the biggest bottleneck in human information processing (Adnan et al. 2003). Nonetheless short-term memory is able to handle more elements when they are coded into patterns already familiarized by the individual (Carroll & Zeller 2012). It implies that visualizations with overloaded information or high data ink may dramatically limit human information processing.

Apart from the intrinsic limitations of human cognitive capacity and information processing ability, visualization problems nowadays become rather challenging to address due to the complexities caused by (1) extensive data volumes, (2) multiple paradigms, domains and data types, (3) requirements for visualization integration, quality and aesthetics, and (4) high demand for domain knowledge to interpret visual outputs (Bai et al. 2009). For instance, in the field of spatial decision making, typical problems to deal with are locating sustainable places, planning infrastructure development, optimizing emergency responses, and resource logistics (Andrienko et al. 2007). Such problems often involve data with spatial, temporal and multi-dimensional features and particularly need the support from information visualization.

The above user and visualization problem related challenges are intimately linked with three fundamental issues pertaining to information visualization, that is, generating the data required to address user problems (information generation), visually encoding the data in such a way that users' perception and cognitive activities can be augmented (information representation), and presenting the encoded data with appropriate interaction mechanism in order to amplify human cognition with less effort and time (information presentation). How well these issues can be addressed determines how effectively the information conveyed via a visualization can attract and be memorized by its intended users (Wood & Wood 2002). Moreover, how well the way to encode and present the information can fit in the cognitive characteristics of a user significantly affects the effectiveness of visualizations and the performance of visualization systems.

Our research has a particular focus on supporting information presentation. Relieving the above problems and issues, from this angle, imposes demanding requirements on the presentation flexibility of visualizations. An effective presentation technique or mechanism should facilitate users to tell a story of their data. Storytelling is a natural way for people to present, interpret and share information and knowledge. Applying storytelling to the field of visualization has emerged as a promising way to achieve better information presentation (Hullman et al. 2013; Kosara & Mackinlay 2013; Ma et al. 2012; Hullman & Diakopoulos 2011; Segel & Heer 2010; Scheidegger et al. 2007).

In this paper, we further elaborate on the necessity of flexible information presentation by reviewing the support from existing visualization systems, and highlight the common problems in section 2. We then proceed to discuss how to address such flexibility at a paradigm level by exploring typical information presentation models in section 3. This, in turn, helps us to identify essential system requirements that are indispensable to the achievement of presentation flexibility in section 4. With the understanding of requirements at both paradigm and system levels, we propose a user-centred process towards the realization of flexible information presentation in section 5. This process can be used to guide the design and development of visualization systems to achieve high presentation flexibility. To validate the process, we apply it to implement a prototypical system for supporting the presentation requirements of a real-world business case. The system implementation is demonstrated through a sequence of scenario-driven illustrations in section 6.

2 INFORMATION PRESENTATION SUPPORT IN VISUALIZATION SYSTEMS

The field of information presentation has attracted interests from many researchers. By examining a large number of visualization techniques and systems, Spence (2007) identified a series of representative presentation techniques, for example, scrolling information, separating overall and detailed views of information, distortion to highlight the interested information, suppression to balance details and relevant contexts, zoom and pan, semantic zoom, and so on. A common objective of these techniques is to conquer the limitations of available visual space and time. Chuah and Roth (1996), with a specific interest of the user interaction perspective of presentation, proposed a taxonomy to outline typical interaction tasks in regard to graphical, set and data operations. Additionally, to support visual information seeking, Shneiderman (1996) introduced a presentation mechanism - “overview first, zoom and filter, then details-on-demand”, which provides design guidelines particularly useful for dealing with information exploration and retrieval. This mechanism has been widely adopted in the implementations of standalone visualization systems and visualization subsystems embedded in other systems like business intelligence and reporting systems, knowledge management systems, and ubiquitous systems. From the perspective of storytelling, Segal and Heer (2010) examined visualizations from a variety of sources (such as digital journalism, online blogs, videos, and the extant research in the field of data visualization summarized) and synthesized them into seven visual narrative forms: magazine style, annotated chart, partitioned poster, flow chat, comic strip, slide show, and animation.

Though the existing information presentation techniques and applications tend to provide some support for relieving the user intrinsic limitations and visualization problem related challenges, they are still weak when it comes to fulfilling the requirement for flexible presentations. A common problem with implementations of information presentation in many visualization systems is that information presentation is tightly coupled with, even embedded within information representation. By conducting an extensive review of typical visualization systems, we realise that this weakness is closely associated with, but not limited to, the following common problems:

- Lack of presentation options
- Lack of support for presentation transformation
- Lack of support for presentation integration at both model and instance levels

- Lack of support for reusable presentation models
- Lack of support for turning visual contents into a vivid story to communicate with and influence stakeholders.

To remedy the gap between the need of flexible information presentation and the support from existing visualization systems, we are obliged to explore typical visual presentation models and find out a generic approach towards the realization of high presentation flexibility.

3 ESSENTIAL INFORMATION PRESENTATION MODELS FOR EFFECTIVE STORYTELLING

An information presentation model defines the way of how the represented visual structures of data are organized and transformed into views that users can display, manipulate, interact with and leverage. Typical visual structures are spatial substrate, marks (including points, lines, areas and volumes), connections, enclosure, retinal properties and temporal encoding (Card et al. 1999). It is through the views that the useful and effective information embedded within the data is eventually conveyed to the users and assist with their decision making and problem solving. Based on our literature review on implementations of information presentation, we identified five popular presentation models, that is, landscape, semantic layering, nested spaces, sequential scenes, and integrated presentations. Among them, the landscape model is the only single layer presentation paradigm while all others are multi-layer multi-dimension paradigms. Figure 1 compares these models in terms of the overall complexities involved and development efforts expected. It deserves to be noted that these models fulfil many common presentation requirements, but may not support every individual requirement for presentation.

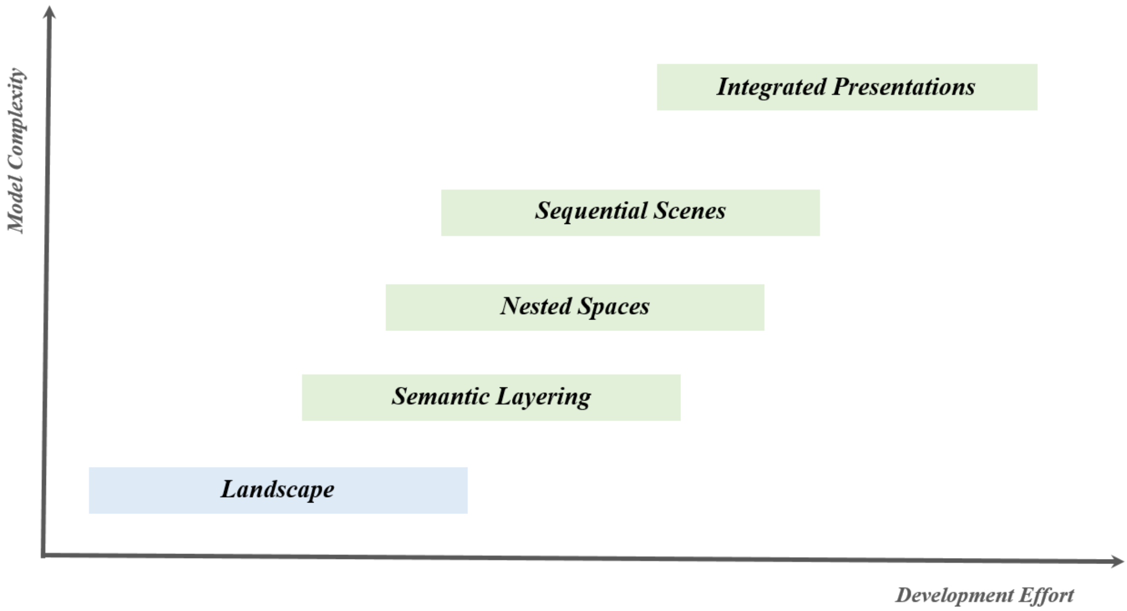

Figure 1. Essential presentation models

This section briefly discusses the key features of each presentation model while the applications of them will be illustrated through a real-world case of demand forecasting in section 6.

Landscape

A landscape (also namely single layer landscape) is essentially a two-dimensional or three-dimensional display canvas on which users can present various visual representations of their interested data and navigate through the representations by scrolling, zooming, panning and/or rotating. Applications of this model fall into two types: bounded and unbounded landscapes. The key difference between them is the number of visual representations the landscape is able to incorporate. As its name suggests, a bounded landscape has a clear boundary of the available display canvas and hence allows to present a limited number of visual representations. Typical data analytics and reporting systems with bounded landscapes are Microsoft Excel, SQL Server Reporting Services, and SAP Crystal Reports. Bounded landscape is also popularly deployed in most mobile-based applications. In comparison, an unbounded landscape is a never ending visual space, which allows an unlimited number of visual representations.

Semantic Layering

A semantic layering model comprises a serious of landscapes, each of which is used to reflect different levels of details and/or features of the underlying data. With semantic layering, users may navigate through the landscapes to show details on demand by zooming in and out. Typical applications of this model are Microsoft Bing Maps, Google Maps, bifocal display (Schaffer et al. 1996), hyperbolic display (Keahey & Robertson 1997) and pliable surfaces (Carpendale & Cowperthwaite 1995). Depending on whether the landscapes are of the same type (bounded or unbounded), this model may be further instantiated into two forms: symmetric and asymmetric semantic layering. If the model employs both bounded and unbounded landscapes, it is then an asymmetric semantic layering model. Otherwise, it is in the symmetric form.

Nested Spaces

A nested spaces model defines a virtual space that contains multiple nested and/or parallel landscapes with each one (either bounded or unbounded) presenting an independent visual world. Users may navigate through the landscapes by zooming, panning and/or rotating. It is often applied to present high-dimensional spaces. Example applications of this model are n-dimensional worlds (Feiner & Beshers 1990) and Microsoft's deep zoom image viewer (Deep Zoom 2015).

Sequential Scenes

The sequential scenes model organises and presents visual representations via a list of landscapes, which can be displayed in chronological order or by subject or in any other logical sequence. When it deploys a chronological axis, it can use any time scale, such as linear scale or logarithmic scale, depending on user requirements for grouping the visual representations. It can also use a single unit of time or mix up multiple time units. An example visualization presented based on the logarithmic scale is the Sparks' Histomap (Sparks 1931). Typical applications deploying this model with a linear scale are Tableau and Gapminder. Moreover, the landscapes may also be displayed in an animated fashion. For example, the animated sequential scenes model is used in ArcGIS to create an animation of a series of map frames.

Integrated Presentation

An integrated presentation model combines a set of preselected presentation models by defining the communication and cooperation among them. Compared to previous models, it is normally employed to support more sophisticated presentation requirements. Typical applications of this model are often seen in systems offering effortless layout transformation, for example, CA Xtraction and Microsoft SharePoint.

Depending upon complexities and requirements of a visualization problem, users may adopt one or more of the above models to aid in information presentation. The effectiveness of each selected model is determined by how well it fits to presentation requirements of the problem and the cognitive characteristics and preferences of the users. Exploring generic information presentation models facilitates us to discover the system requirements for accomplishing flexible presentation, which will be explicated in the following section.

4 SYSTEM REQUIREMENTS FOR FLEXIBLE VISUAL PRESENTATION

We argue that the key to realize flexible presentation in visualization systems is to decouple information representation and presentation. Separating presentation from representation has long been advocated due to its benefits to (1) understanding and assessing features of visualizations, (2) comparing across visualizations of a similar type, and (3) identifying opportunities to create new visualizations by trying different combinations of representations and presentations (Chi & Riedl 1998; Chi 2000; Carpendale & Montagnese 2001; Spence 2007). It is also a recommended design pattern of visualization systems due to the improved flexibility, reusability and extensibility (Heer & Agrawala 2006). With regard to information presentation in particular, we identify the following fundamental requirements to support presentation flexibility and to guide visualization system design and development.

Presentation Creation and Customization

With a visualization system offering good presentation flexibility, users should be able to create a new presentation from scratch or by reusing and modifying existing presentations. Moreover the system should allow users to modify, customize and enhance presentations. This is often accompanied by relevant representation level customizations, and is quite helpful to accommodate different user preferences against the same presentation.

Presentation Integration

Presentation integration is concerned with flexibly combining the visual representations to achieve a rich view of the underlying data. Visualization techniques nowadays usually have their particular strengths in dealing with certain data types and revealing certain features of data (Chi et al. 1997). No single visualization technique is effective to address all data types and visualization requirements. This, in turn, raises the requirement for integrating the visual representations generated by various visualization techniques so that users can explore more features of the underlying data (Hibbard 1999). It is worth to note that seamless presentation integration often requires the support from the integration at data and representation levels.

Presentation Transformation

To match the cognitive styles and preferences of different users, visualization systems should enable visual presentations to be transformed from one type to another in a flexible, seamless and efficient manner. This is particularly helpful for users to highlight different features or perspectives of the underlying data. Similar to presentation integration, presentation transformation also needs the support from related representation transformation.

Visualization Context Adaptation

The visualization contexts of a presentation involve the problem context within which the presentation is deployed and the situational context of its users (Bai et al. 2013). They may comprise relevant problem situations, time, space, social context, and technological context (including hardware and software), and encompass the visualization profiles of users such as their cognitive styles, personal characteristics and preferences, pre-knowledge, age and gender. When the contexts are changed, visual presentations should be adaptive or adaptable to the context change. To achieve context adaptation, visualization systems should support modelling different contexts and defining the adaptation rules for presentations to follow under context changes. This is particularly useful to implement role based data security.

The above requirements for presentation customization, integration, transformation and context adaptation are indispensable to achieve high presentation flexibility. Fulfilling these requirements often require corresponding support at information representation level. The ultimate goal of implementing these requirements is to ensure the effectiveness of visualizations for users under changing and varied contexts. With the understanding of supporting presentation flexibility at both paradigm and system levels, we create a user-centred process to guide the development of flexible visual presentations.

5 A USER-CENTRED PROCESS FOR ACHIEVING FLEXIBLE PRESENTATION

In this section we propose a process that takes user functional and cognitive requirements of information presentation as a key driver to underpin the design and development of visualization systems and the achievement of presentation flexibility. Consistent with our research focus mentioned in the introduction section, this process has a clear emphasis on developing flexible information presentations but does not outline other equally importantly processes required by visualization system development, for example, information generation and representation processes. That is, it can be used a specialized process on information presentation to complement the overall visualization system development approach adopted by researchers and practitioners.

This user-centred process is composed of six essential steps as illustrated in Figure 2. The top three steps assist with understanding user problems, users and their functional and cognitive requirements for information presentation. In comparison, the bottom three steps facilitate the development of flexible visual presentations within visualization systems to meet the requirements.

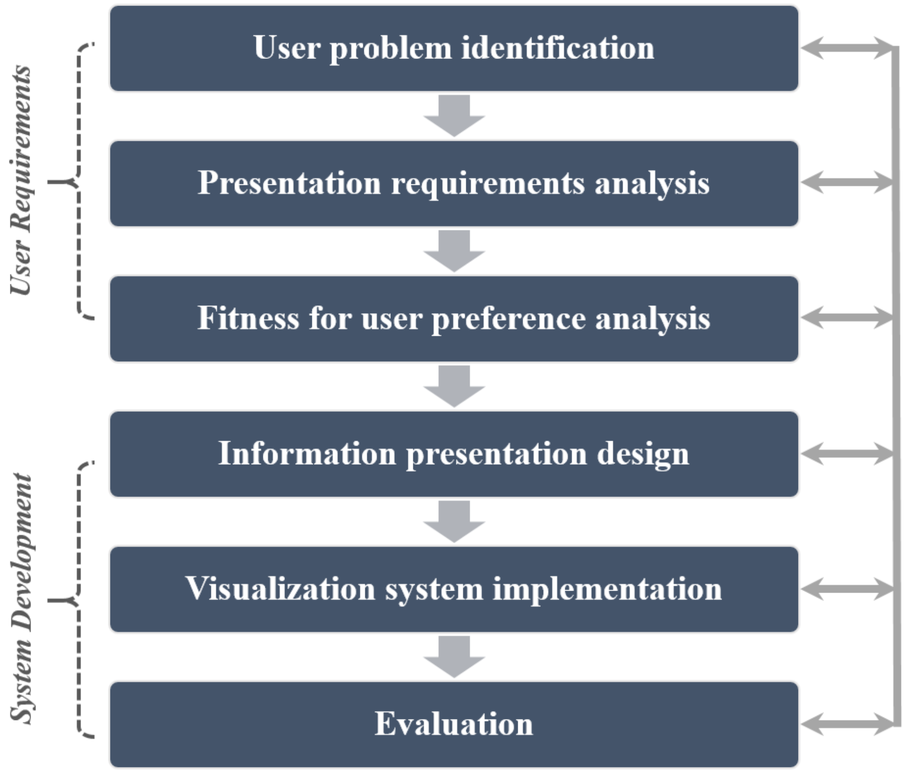

Figure 2. A user-centred process for developing flexible information presentation

More specifically, the whole process starts with understanding the visualization problem that users attempt to resolve. A clear definition of the problem ensures users to formulate a unified understanding of the problem situation, which, in turn, aids in the communication of the problem. For example, a problem definition may cover a description of the problem situation, problem boundary, time duration and/or available resources. Based on the problem definition, the second step is to identify and formulate the functional requirements for addressing the user problem. An important output of this step is a set of evaluation criteria against presentation effectiveness and flexibility, which will be applied to assess the implemented presentations at the later evaluation step. Apart from this, articulating user requirements should also directly consider the cognitive features and preferences of users. The third step of the process is introduced particularly to adjust presentation requirements to ensure the users' cognitive needs are satisfied. Similar to the second step, assessment criteria against how well the cognitive requirements are fulfilled needs to be defined as a basis for later evaluation.

Driven by the identified functional and cognitive requirements, the process proceeds to information presentation design. At this step, the generic information presentation models discussed in section 3 may serve as a starting point and contribute relevant design ideas. The visual presentation designs are then passed on to the subsequent step to constitute a part of the implementation of the visualization system adopting the presentations. Once the implementation is complete, the presentation models and visual output will be examined against the predefined evaluation criteria. During the evaluation, new problems or user requirements may be identified and trigger a new iteration of the whole process or go back to some earlier step.

To validate the proposed process, we apply it to fulfil the presentation requirements for a case about electricity demand forecasting in the following section.

6 DEMONSTRATION

To demonstrate the support of our proposed process and generic presentation models, we apply them to guide the design and development of flexible visual presentations required by a real-world case of demand forecasting from the electric utility industry in New Zealand. Electricity demand forecasting is concerned with analysing and discovering patterns and trends of historical load variations and estimating future load growth in short, medium and long terms. It is particularly useful for electric utility businesses to support their decision making in energy trading and generation, system operations and maintenance, transmission/distribution planning, demand side management and financial planning. Accurate load forecasts effectively help them minimize engineering and financial risk and optimize operational efficiency and reliability. Due to the critical role demand forecasting plays, many electric utility operators develop in-house solutions to generate load forecasts.

Although existing demand forecasting methods, algorithms and systems tend to provide reasonable support for generating demand forecasts, it is still challenging for them to fulfil varied user-specific presentation requirements and eventually meet business expectations on flexible information presentation. This area caught up our attention because of complexities associated with the involved users, data, models and processes. More specifically, demand forecasting involves multiple users from different business units with different backgrounds, requirements and purposes. Producing forecasts for them requires to select and apply appropriate forecasting models/processes to deal with (1) large volumes of complex historical load data with spatial, temporal and multi-dimensional features and (2) forecast adjustment factors like weather, economic and demographic trends, customer profiles, and end technology trends at the forecasted area. Dealing with such complexities necessitates flexible information presentation for supporting users with different interests, purposes and presentation requirements.

This section organises the demonstration into two parts. The first part focuses on understanding user problem and personation requirements (i.e. the top three steps of the proposed process), while the second part demonstrates the support for presentation design and implementation (i.e. the bottom three steps).

6.1 User Problem and Requirements Understanding

To obtain a good understanding of user problems and presentation requirements, we have conducted a large number of interviews with relevant users from network control, maintenance and planning teams at a local utility company in past three years. We have also performed regular field observations to study how the users prefer to work with their demand forecasts. As an important output of this process, we have identified a list of functional and cognitive requirements for their preferred visual presentations.

For the demonstration in this paper, we select a common user problem of understanding and quantifying the impact of different sets of influential forecasting factors on the forecasts. This problem raises a list of requirements for information presentation and some examples are provided as follows:

- Presenting future ten years' forecasts to highlight the future trend of electricity demand
- Presenting the comparisons among different forecast trials
- Interacting with the visualizations to present forecasts at yearly, seasonally and monthly levels
- Presenting forecast variations across years in an animated fashion

As different users apply the forecasts for different work purposes, the relevance and importance of the presentation requirements are not same for all users. Therefore, we collected both role-level and individual-level evaluation criteria from the users in order to assess the overall presentation effectiveness and flexibility. Understanding the user requirements has went through many iterations of the proposed process due to the learning curve of users. Our experiences with collecting and understanding user requirements for presentation have reinforced the necessity of following an iterative user-centred approach to ensure user satisfaction on presentations.

Based on the collected user requirements for information presentation, we designed a series of reusable presentation models and implemented them within a visualization system, which is discussed in detail in the section below.

6.2 Presentation Design, Implementation and Evaluation

Though the impact analysis of influential forecast factors requires a series of presentation designs, this section, for the purpose of the demonstration, highlights one of its presentation requirements (i.e. comparing results from multiple forecast trials) and focuses on demonstrating (1) the presentation flexibility and (2) the implementation of key system requirements. For this requirement, we created four presentation models by reviewing and instantiating from the generic information presentation models, i.e. landscape, nested spaces, semantic layering, and sequential scenes. Such presentation designs are realized through implementing a prototypical visualization system based on a multi-tier object oriented system architecture that is built upon the "Context Adaptive Visualization Framework" (Bai et al. 2013). The prototype leverages a set of Microsoft technologies, that is, Bing map, windows presentation foundation (WPF), ADO.NET entity framework, and SQL Server. However, a similar system could be developed by utilizing equivalent technologies from other vendors such as Oracle and IBM. Apart from the major implementation technologies, the prototype also employs several third-party controls to support the development of presentation models. For example, an open-source WPF control, namely timeline viewer (Silverlight & WPF Timeline Control 2015), has been integrated into the prototype to implement the sequential scenes.

The demonstration of the presentation models is conducted by applying the prototype to display and compare different versions of demand forecasts. To facilitate the demonstration, we introduce three forecast trials with each adopting different sets of forecast factors. For users who prefer to compare the overall differences among the trials, the landscape model may be considered to form a view including forecasts of all three trials. An example of this is demonstrated in Figure 3, which presents all trial forecasts for 2016. Each coloured polygon of a map indicates a feeder area. The darker the colour, the higher forecast the feeder is assigned. For those who need to focus on a single forecast trial at a time, the semantic layering model can be particularly helpful (Figure 4). If the users want to display the forecasts of each trial by year/season/month, they may consider the sequential scenes model (Figure 5). In addition, the users may seek to create a story with regard to a certain subject matter and then suppress its involved complexities when it is embedded within a bigger story. Under such circumstances, using the nested spaces model would be convenient. Figure 6 provides an example of nested spaces and the visual contents of the embedded story can be popped up when users want to view them (Figure 7). All the implemented presentation models allow users to navigate through the visual contents by zooming, panning, scrolling and rotating.

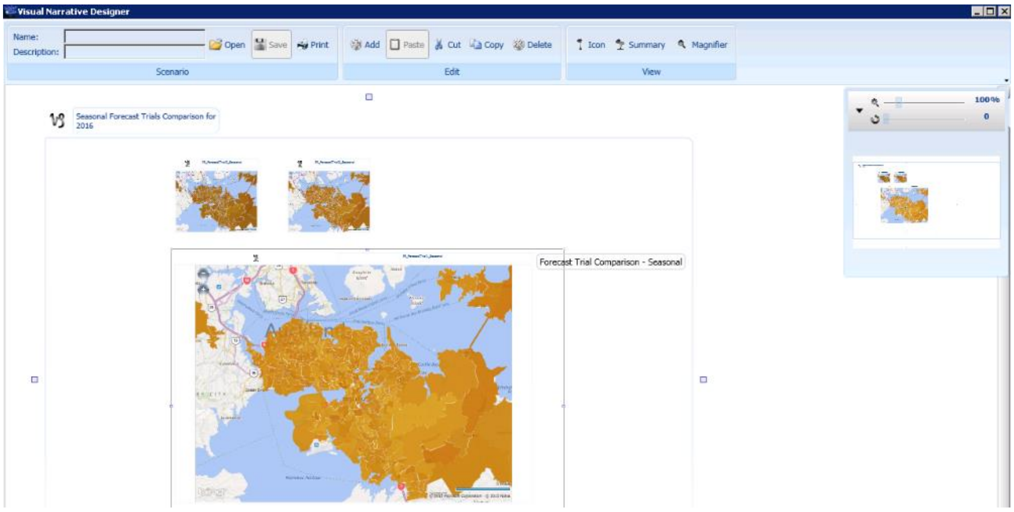

Figure 3. *An example of the landscape model comparing three forecast trials*

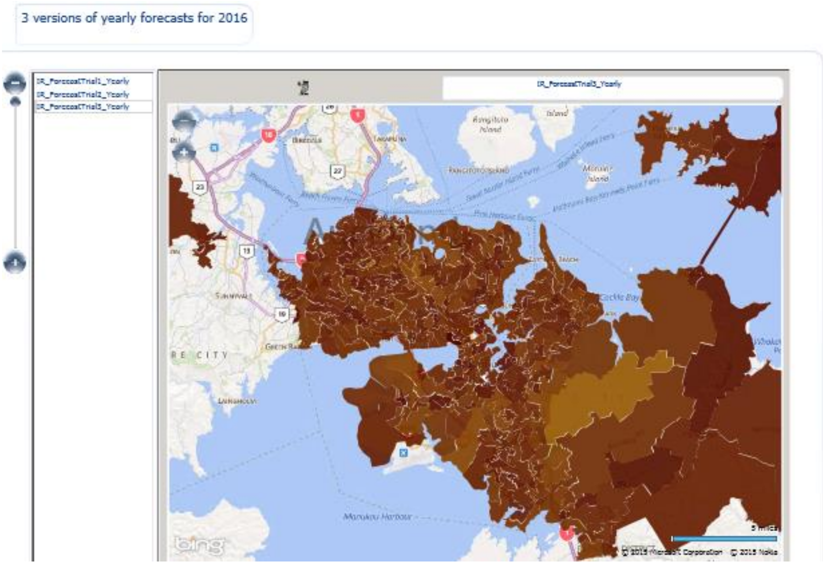

Figure 4. *An example of the semantic layering model highlighting each forecast trial at a time*

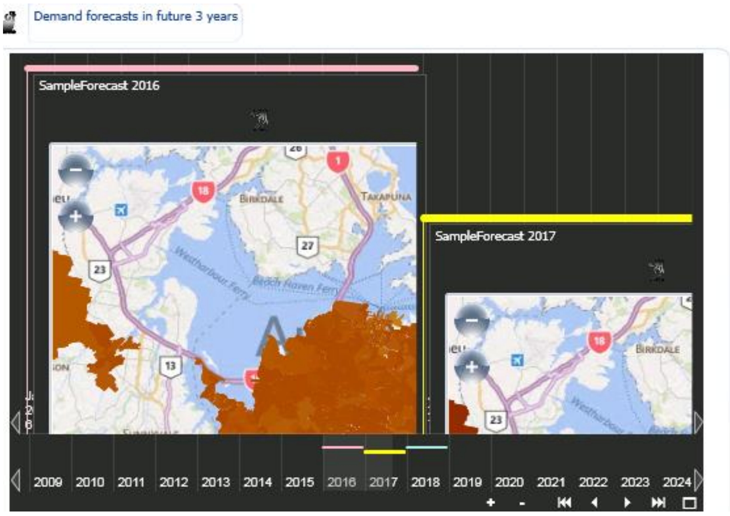

Figure 5. *An example of the sequential scenes model*

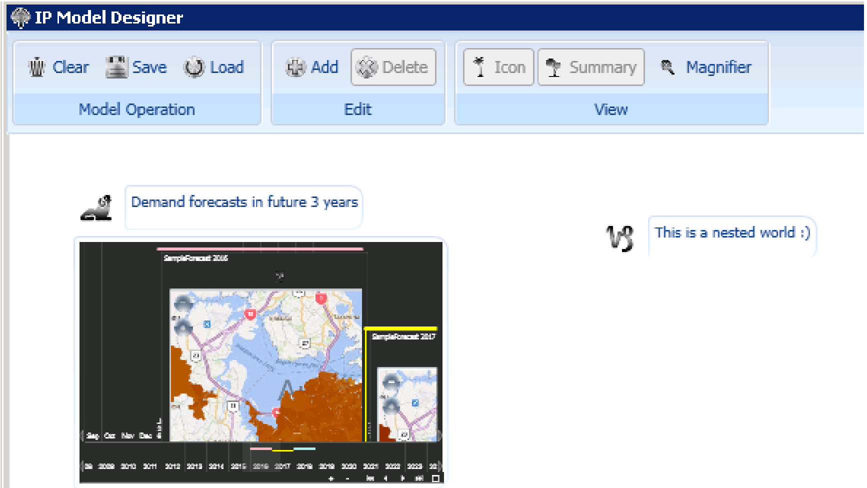

Figure 6. An example of the nested spaces model

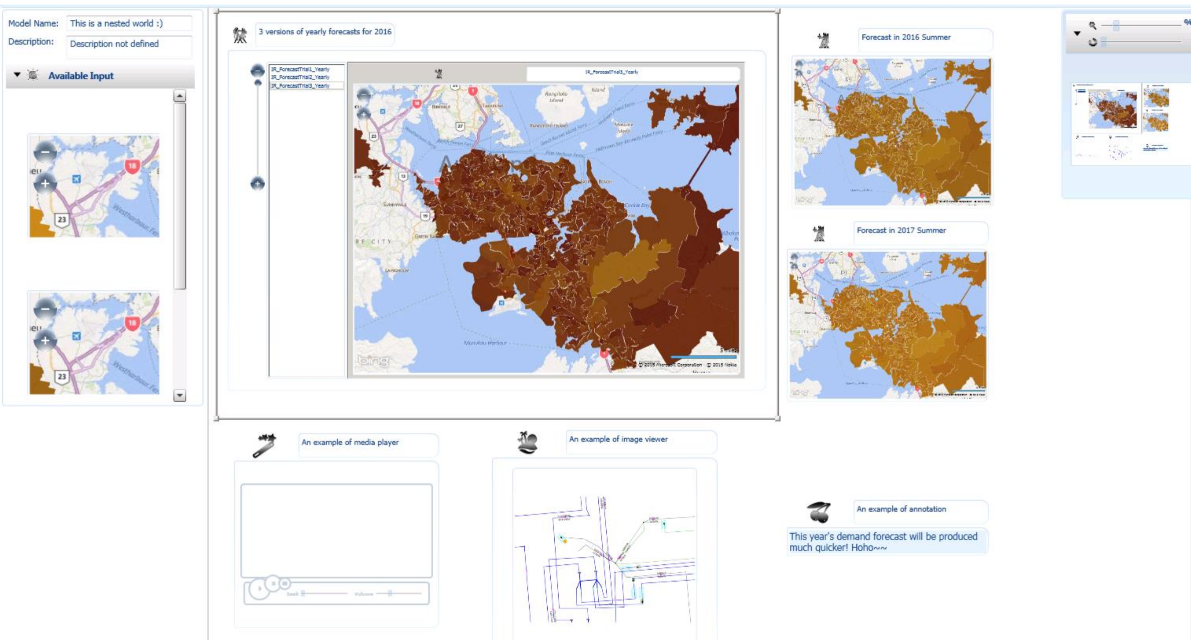

Figure 7. An example of a nested space

To assist users with developing flexible visual presentations, this prototype implementation supports presentation customization, integration, transformation and context adaptation. More specifically, it allows to create new presentations from scratch or existing presentations. With this prototype, a presentation model instantiated with appropriated data and solver can be saved to a reusable xml-based definition file. Such definition file stores model configurations and can serve as a directly input to model customization and context adaptation. For instance, Figure 8 shows the settings window of an instantiated sequential scenes model, at which users may customize and enhance the representations and adapt it to different visualization contexts in accordance with their requirements. Moreover, the prototype allows to display the same set of visual representations in various presentation fashions and transform the presentation from one type to another by switching presentation models and adjusting the model configurations. Furthermore, the prototype enables to integrate presentations to support more sophisticated user requirements. For example, Figure 9 illustrates how a sequential scenes model integrates another presentation model of the same kind and a semantic layering model.

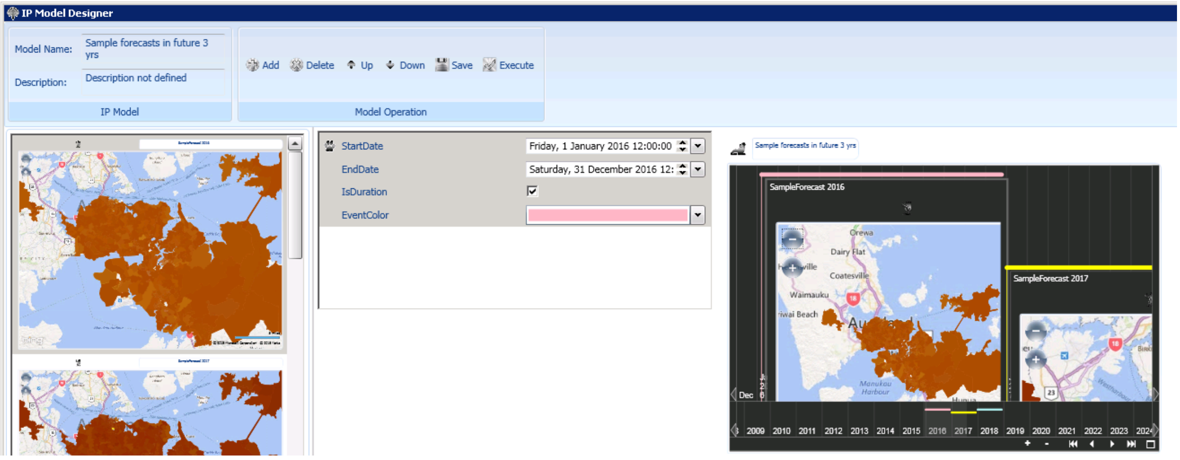

Figure 8. *Customization of a sequential scenes model*

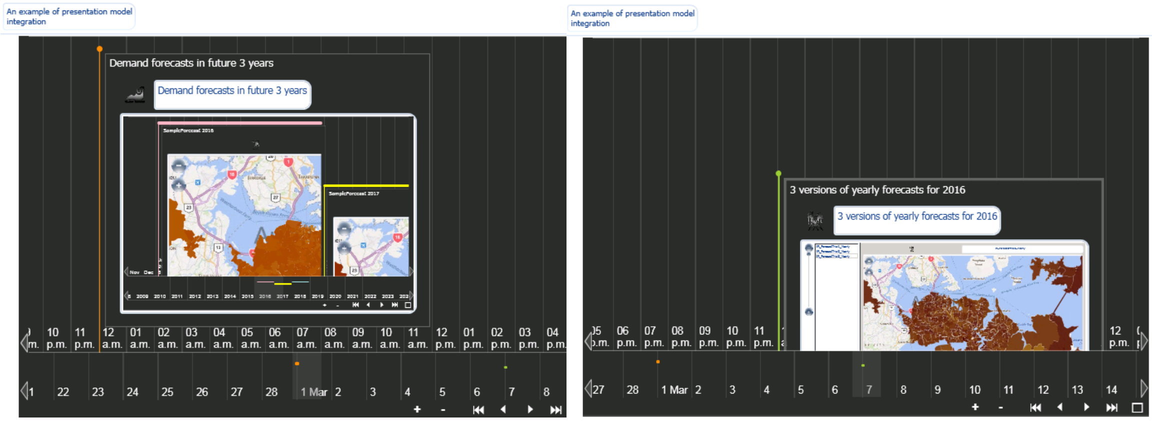

Figure 9. *Examples of presentation model integration*

7 CONCLUSION

Information visualization has long been recommended as a powerful way to support people with various tasks in information discovery and interpretation, decision making, and problem solving. It is particularly relevant nowadays because of (1) increasingly high complexities associated with visualization problems and (2) the intrinsic limitations of human cognitive capacity and information processing ability. Such challenges are closely related to information presentation, which transforms visual representations of data into proper views and conveys the useful information embedded in data to users. The ultimate goal of information presentation is to help users tell stories of their data and eventually amplify their cognition. Such problems and issues have raised demanding requirements for presentation flexibility. However, the support from existing visualization systems tend to be inadequate due to the issue of closely coupled information representation and presentation, which, in turn, limits their support for presentation options, presentation integration and reusability, and vivid storytelling of data. To relieve these problems, issues and requirements, we generalize five typical visualization presentation models to provide paradigm level support for achieving presentation flexibility. We also propose key requirements for information presentation development to accomplish the flexibility at a system level. To provide more guidance on how to achieve the flexibility, we introduce a user-centred process with a particular focus on meeting both functional and cognitive requirements for information presentation. To validate the proposed models and process, we apply them to a real-world case of electricity demand forecasting and demonstrate the improved presentation flexibility through scenarios created in a prototypical system. It deserves to be pointed out that the prototype has only been tested within a limited number of application domains. The application of the proposed models, process and implementation in a variety of scenarios ranging from business to art to history to engineering to science will be accomplished in our future research.

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