Using Augmented Reality to Support Situated Analytics

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Abstract

We draw from the domains of Visual Analytics and Augmented Reality to support a new form of in-situ interactive visual analysis. We present a Situated Analytics model, a novel interaction, and a visualization concept for reasoning support. Situated Analytics has four primary elements: situated information, abstract information, augmented reality interaction, and analytical interaction.

Index Terms: H.5.1 [Multimedia Information Systems]: Artificial, Augmented, and Virtual Realities—Life Cycle

1 Introduction

We present a conceptual model that combines Visual Analytics (VA) and Augmented Reality (AR) to provide real-time, in-situ information visualization of multi-dimensional data. Building on scientific and information visualization, VA is a multidisciplinary field covering analytical reasoning techniques; visual representations and interaction techniques; data representations and transformations; and techniques to support production, presentation, and dissemination of analytical results [2]. The second research area, AR, enriches the physical world view with in-situ registered computer-generated information and can provide the user with contextual information in real-time [6]. We consider the question of how to support VA's analytical reasoning by embedding the visual representations and interaction of the resulting data in the physical environment using AR. We define this as *Situated Analytics* (SA), a new area of research at the intersection of VA and AR.

The need to understand and analyze complex and often large data sets is an ongoing research challenge. The results of VA are tied to a physical location or a particular object, such as presentation of geological information for mining in the field, medical data for emergency services, and the selection of products given a requirements list. AR brings a new dimension to the information presentation by allowing the visualizations to be enhanced with physical objects that provide contextual information and form part of the reasoning used during interactions. We believe SA is a technique that can be developed to fulfil the need of improved accessibility and speed when reasoning with location-based, multi-dimensional data.

A critical issue in SA is the model for interactive data exploration. Traditional information visualization has been modified by Keim [2] for VA to be: "Analyze first, Show the important, Zoom, Filter and analyze further, Details on demand". In our view, a different model is required for SA. In SA the objects in the physical environment provide the immediate and primary focus. This focus on particular objects in the environment suggests that for SA, the interactive data visualization model should almost be the reverse of Keim's. Rather than starting with an overview or the results of a global data analysis, the user should first be provided with *details* concerning the visible objects. Subsequent *interactive analytics* is focussed on these objects and the query results are displayed in-situ. Global and *contextual information* is only provided on demand. Our SA mantra is: Details first, Analysis, then Context-on-Demand.

This model is a first step towards exploring solutions to this new research space, SA. To our knowledge this is the first investigation into the application of AR technology to VA. Using SA can enhance information understanding in different domains, such as shopping, where the informed grocery shopper has a wealth of information directly and indirectly available about products on the shelf: price, ingredients and nutritional information, use-by-date, information about the manufacturer, origins of ingredients, sustainability of the manufacturing processes, and comments about the product in social media. However, how do you make relevant information available to the in-store shopper and how can such an application provide customized advice that takes account of the shoppers requirements and desires? We believe SA can be applied to different domains such as traffic, public transportation, planning trips based on user profile, and social network visualization.

2 Related Work

In the previous AR visualization work, researchers applied three main methods: complexity reduction, layout optimization, and interaction techniques. Complexity reduction techniques use data filtering to reduce the displayed information such as location, user profiles, point of interest, or tasks. Layout optimization techniques are used to map the display information. Bell et al. [1] used filtering methods to reduce the data presented based on the user's view. Bell et al.'s investigation identified a potential solution for large information visualization by combining data filtering and layout optimization tools. Tatzgern et al. [3] proposed a technique for view management in AR to solve cluttering by mapping the annotations into 3D space instead of 2D space. The interaction approaches reflected a potential solution for multidimensional information in AR. White et al. [5] presented one of the earlier approaches to visualize multidimensional information in AR. Their approach allows users to inspect a static database; queries were performed by computer vision techniques to recognize physical objects. Their approach employed tangible interactions to explore the data and compare solutions. However, working with abstract information requires a more generalized visual representation than that presented in White's approach. Walsh and Thomas [4] also developed wearable AR visualization system focused on the visualization of real-time data from wireless sensors monitoring large structures. These approaches allow large dataset visualization but do not support multi-dimensional analysis.

In summary, the existing solutions for the large multi-dimensional information visualization for AR lead to masking data, which made them incompatible for complex decision-making purposes. Moreover, the existing visualization interaction tools for AR employ static data relationships to navigate through them, for example: location, time, or type. These tools provide the users with

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only a limited number of predefined analytical perspectives for the presented data. Previous investigations have applied analytic techniques to enhance the layout management and content exploration, however in our approach we applied the analytics to the user interactions, which allow users to view the information from their own perspective.

3 Situated Analytic Conceptual Model

The main goal of Situated Analytics is to provide users the ability to visualize the result of complex queries in context with a physical object. The main difference between AR visualization and SA is that situated analytics allow users to continuously analyze, interact, and visualize data in-situ. The user can interact with a system to alter the analytics'parameters, which directly reflect the results. Figure 1 depicts an artistic concept of the interaction and visual representations for the SA model. There are four main UI elements: situated information, abstract information, AR interactions, and analytical interactions.

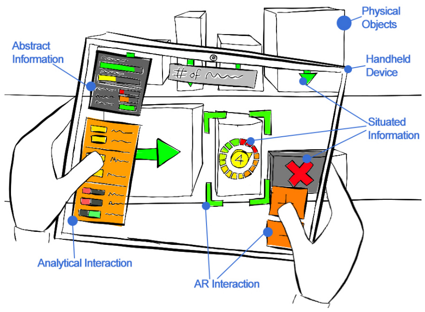

Figure 1: SA system interaction and visual representation

Situated information is registered on the physical objects. The location and appearance of this information dynamically changes based on the tracking information, and the representation is altered based on users'queries by using the AR and analytical interactions. This information can represent the comparisons between physical objects and the proximity of their relationships. The situated information can be represented by diminished reality, transparency filters, visual highlighting, perceptual cues, and subliminal cues. The main goal is to apply visualizations that are informative, easy to understand and intuitive. Figure 1 showed a potential example that can be use for situated information. The object of interest can be highlighted with a green enclosing rectangle and the unwanted physical objects are hidden with a semi-transparent black rectangle (a diminished reality technique) and overlaid with a red X. Situated color-coding can be used for clustering, and the visualization's size and color can be changed based on the output values. Moreover, textures, labels, and health bars can be used to provide additional information.

Abstract information supports the presentation of high level representations of the results, although they vary greatly across domains. Abstract information provides a summary and overview of the analysis at any point in the task, and as with VA, the analytic techniques are specific to the domain. The abstract information is critical to the completion of reasoning tasks, and the use of abstract information is an ongoing process to build understanding during the interactions. The information analysis builds on aggregates and selections from situated information.Abstract information may include elements such as the percentage of task completion, the results of an analysis, and the presentation of results in an easy to understand format. Figure 1 depicted an example of the abstract information panel. We can use salient cues, size, color, text, and texture to present the overview information. We can use health bars with dynamic size and color. A bar's size and color changes based on the users'status and queries. All these visualizations are affected by both the analytical interaction, and the AR interaction.

Augmented Reality interaction allows users to interact with the physical objects in context with the queries, such as selecting and deselecting an object, which allows users to filter the information. Moreover, these interactions can allow users zoom and explore Details on Demand by simply picking up objects and moving them closer or further from the camera. The main goal of AR interaction is that that it allows users to view query results based on their context and based on manipulating the pose of the physical objects. This form of interaction allows results filtering by selecting offscreen physical objects. Figure 1 depicted an additional interaction performed on a touch display by selecting a physical object; the user highlights the physical object and presses the "+" button. To deselect a physical object, the user highlights the object and presses the button "-". This works by using a ray-casting technique between the handheld's camera and the physical object to select the object.

Analytical interaction allows the user to control the analytics, where users can modify the type and form of analysis applied to the data registered to the physical objects. A naive approach would be to present the formulas of the analysis to the user and ask them to modify elements such as constants and variables. Our model concept is to bind the analytical interaction controls to high-level constructs that define a range of dimensions in the information space. Examples of the different input controls that can be applied to analytical interaction are as follows: touch controls, toggle buttons, radio buttons, and sliders. Toggle buttons allows the user to construct queries that encode a series of binary options. When only one option from several can be made, as in the case of orthogonal relationships, radio buttons are employed. Sliders are employed to allow users to specify a ratio between two extremes. The use of SA is application specific, therefore, each binding of analytical interactions will be unique to each application.

4 Conclusions And Future Work

We presented *Situated Analytics*, a new interactive in-situ decision making concept model that combines VA with AR. SA is more than just combining VA with AR. Our model changes the existing VA mantra to become "Details First, Analysis, then Context-on-Demand". We presented an interactive visual representation solution for multi-dimensional information in AR, which reflects the potential for enhancing the understanding of information.

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