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Situated Analytics: Demonstrating immersive analytical tools with Augmented Reality

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ABSTRACT

This paper introduces the use of Augmented Reality as an immersive analytical tool in the physical world. We present Situated Analytics, a novel combination of real-time interaction and visualization techniques that allows exploration and analysis of information about objects in the user's physical environment. Situated Analytics presents both situated and abstract summary and contextual information to a user. We conducted a user study to evaluate its use in three shopping analytics tasks, comparing the use of a Situated Analytics prototype with manual analysis. The results showed that users preferred the Situated Analytics prototype over the manual method, and that tasks were performed more quickly and accurately using the prototype.

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1. Introduction

In this paper, we present real-time interaction techniques, which we called Situated Analytics (SA) [1]. SA draws on two research domains—Visual Analytics (VA) and Augmented Reality (AR)—to provide analytical reasoning in the physical space [2]. VA is a multidisciplinary field covering analytical reasoning techniques while AR enriches the physical world view with contextual information in real-time [3,4]. SA combines VA analytical techniques with AR techniques for in situ projection of information onto the physical space.

We consider the question of how SA can be beneficial for data exploration and information comprehension. We believe SA can enhance decision making in three ways: clearer information presentation by directly associating information with the relevant physical objects, more natural interaction for information exploration by touching and manipulating physical objects, and more sophisticated information analysis providing contextual and overall information.

Fig. 1 demonstrates SA within the context of a shopping task. SA enables user exploration and interaction with information in novel ways. In Fig. 1a, a user explores a product's overall information, presented to them as a virtual annotation overlayed on the top of the physical box. Information of interest is highlighted—for example, if the user is searching for Australian-made products, the Australian logo can be highlighted. Fig. 1b shows a user interacting with the physical object to explore more information (Details-on-Demand). The user can explore information, such as the ingredients printed on the product's box, and the SA system will display detailed visual analytical information based on the product's ingredients (for example, the percentage of the user's daily recommended intake (RDI) for a nutritional category such as sugar or fat that the product contains). SA also allows a user to analyze and compare information between products (seen in Fig. 1c). As an example, when a user selects two products and places them side-by-side, the SA system presents a comparison of the two products to the user.

To create the SA system described in Fig. 1, a number of challenges need to be addressed in order to merge VA and AR techniques. Some of the open research questions include:

- How should the visual presentation of the information be linked to the objects in the physical space [5]?
- What are the best ways to represent the abstract data (categorical, rank, numeric, temporal, spatial etc.) associated with the physical objects [6]?
- How should abstract relationships, such as connectivity or ranking, between physical objects be shown to the user?

Within this investigation we developed and evaluated a shopping application that demonstrates how SA can support users in the manipulation of complex data mapped to physical artifacts

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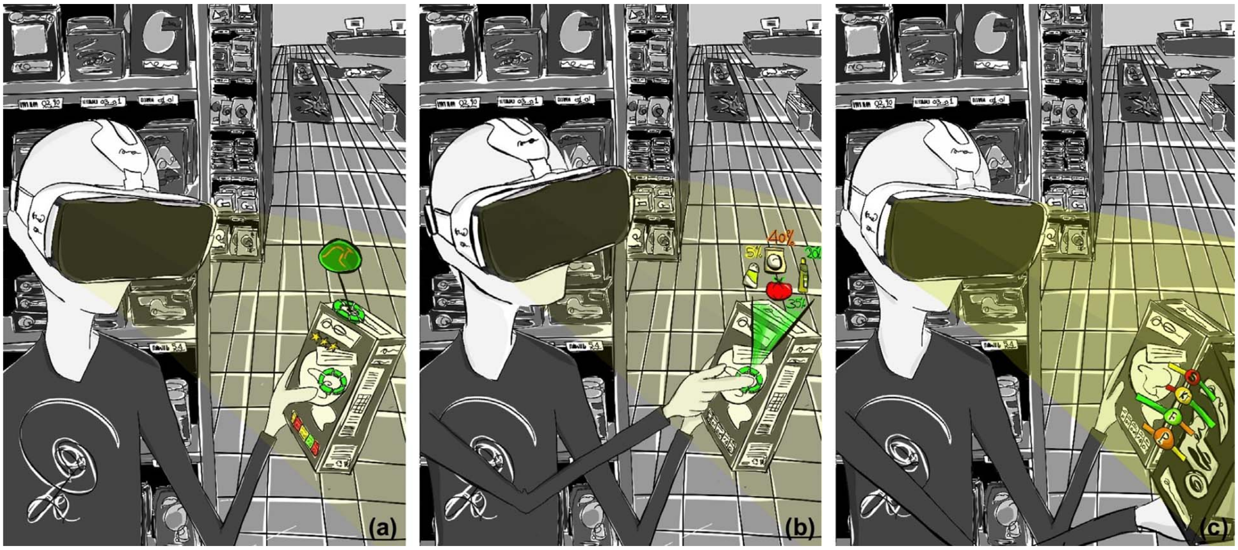

Fig. 1. Situated Analytics allows users to visually interact with information in Augmented Reality. (a) Users can view the attached information, (b) interact with physical objects to explore more information, (c) and view/compare the information associated multiple physical objects.

with AR. The evaluation of our prototype explores possible directions to address the mentioned challenges. When reasoning with location based multidimensional data, we believe SA is a method that fulfils the needs for enhancing its approachability, while also improving its speed.

We present SA, a novel method of interactive exploration for multidimensional data that is designed for use in AR enhanced applications. This work is built on White and Feiner's work for visualization in AR [6]. They presented different visual representations for multi-dimensional data. While the data in White and Feiner's SiteLens system are multi-dimensional, their visualizations do not support real time analytics and interactive manipulations of the analytics. They provided information based on the situation, but to apply situated analytics we need to present multi-level data with different data types (multidimensional, temporal, tree, etc.) [7]. We need to provide interaction tools that allow users to manipulate the data attached to the physical space.

We applied a number of techniques on a set of visual representations for displaying results from multi-dimensional data queries for product selection contexts (shopping tasks). These techniques are filter (see Fig. 2), find (see Fig. 3), and rank (see Fig. 4), of co-located physical objects.

In this paper we experimentally investigate the usefulness of SA and explore the trade-offs between it and manual information analysis. We are also interested in exploring real world tasks to support users in decision making through the use of AR-presented multi-dimensional data, and improving users' abilities to analyze information. We present the results of a user evaluation that focused on the visual representation and interaction aspects of the situated analytics system, where the users were asked to select, rank and filter grocery products based on their price, ingredients and nutritional benefits.

In the remainder of this paper discusses the related work of AR, Visualization, and VA. Section 3 details our SA approach, including our interaction and visual representations. Following this, our user evaluation, and results thereof, are presented. The paper finishes with set of concluding remarks.

Fig. 2. Example of Filtering visual representation, by highlighting the product of choice with a green enclosing rectangle while hiding the unwanted products with a semi-transparent black object with a red "x" overlay. (For interpretation of the references to color in this figure caption, the reader is referred to the web version of this paper.)

Fig. 3. Example of Finding visual representation, by highlighting the resulted product with a green frame, and the other products blocked with visual green navigation arrows to guide the user to the correct product. (For interpretation of the references to color in this figure caption, the reader is referred to the web version of this paper.)

2. Related work

AR overlays physical objects with computer generated information [8]. This information merged with the real scene gives AR the potential to be one of the main display spaces for supporting immersive analytics applications [1,9,10]. Providing a user with a spatial grouping of information AR can enhance user understanding of information; however, the grouping and

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