Visual Analytics in Augmented Reality

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Figure 1: (a) Our vision is to enable the user to interactively explore products in a supermarket by overlays in the Head Worn Display (HWD) (b-d). First, an understanding of which products can make a healthy meal that complements the milk the user holds (b); glyphs illustrate the result. Next, the user wants to learn about the ingredients of the cheese (c). After selecting the cheese, links with percentages show the breakdown of ingredients. Note that water is an off-screen object that is represented through a screen-stabilized proxy object. Finally, the user is interested which products contain only little salt (d).

ABSTRACT

In the last decade, Augmented Reality has become more mature and is widely adopted on mobile devices. Exploring the available information of a user’s environment is one of the key applications. However, current mobile Augmented Reality interfaces are very limited compared to the recently emerging big data exploration tools for desktop computers. Our vision is to bring powerful Visual Analytics tools to mobile Augmented Reality.

Challenges for this approach include: limited input capabilities of mobile platforms, limited display capabilities (resolution, field of view), and the dynamically changing environment the user is in. To solve these problems, we propose to create mobile Augmented Reality visualization techniques based on Visual Analytics tools. We will demonstrate these techniques in a food shopping assistant. The assistant can show the containment relations of ingredients between different products.

We are currently working on the visualization design; next, we will implement a prototype and evaluate different alternative visualizations. Our research will impact the Augmented Reality community, as well as the Visual Analytics community.

Keywords: mixed reality, context-based, visualisation

Index Terms: H.5.1. [Information Interfaces and Presentation]: Multimedia Information Systems—[Artificial, augmented and virtual realities] H.5.2. [Information Interfaces and Presentation]: User Interfaces—[Haptic I/O ] H.1.2. [Information Systems]: Models and Principles—[Human factors]
1 Motivation

Augmented Reality (AR) adds computer-generated information to the user’s surroundings. During the last decade the interest in location-based and context-based applications increased [16, 11, 6, 2, 3, 5, 18, 7, 15]. The context-based visualization research area experienced a huge interest due to the rapid growth of the amount of information. Visual Analytics (VA) is one of the main tools used to solve the information overload problem. Our vision is to create mobile AR visualization techniques based on VA tools to increase the effectiveness of the presented information.

AR applications are used to enhance the real scene with computer generated information. Visualization is one of the main parts of AR applications for the visual interaction with user. According to [8] visualization research areas can be classified into three main-types: data integration, scene manipulation, and context driven visualization. Data integration is the process of integrating properly virtual objects into real scenes. Scene manipulation works on ways for increasing the virtual information content. Context driven visualization focuses on merging the virtual information according to the physical context. Mobile AR context driven visualization expands the interaction features, which triggered extra challenges on this specific type (such as limited input capabilities, limited display capabilities, and the dynamic change in the user’s surrounding environment). In this research we propose an approach to solve these mentioned problems.

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Figure 2: Visual analytics integrates scientific disciplines to improve the division of labor between human and machine [10].

VA is the way of combining automated analysis techniques with interactive visualizations to extend the information analysis role to the machine, rather than the human [9]. The difference between VA and the regular visualization is the information analysis stage that occurs prior to visualization. Different research disciplines work together to achieve the VA outcome. VA research field integrates multiple science and technology disciplines to improve the interaction between human and machine (see Fig.2) [10, 19]. These disciplines are visualization, data management, data analysis, perception, cognition, human interaction, infrastructure, and evaluation. This research considers the discipline of visualization. Working in the visualization discipline VA divided into two main fields [10], scientific and information visualization. Scientific visualization concerns with presenting the information in 3D geometries (that can be understood as scalar, vectorial, or tensorial fields with explicit references to time and space). Information visualization concerns in presenting plots and glyph of abstract data. In our approach we will work with information visualization.

Our goal is to create mobile AR visualization techniques based on VA tools, to increase the effectiveness of communication between human and computer. Working with mobile AR visualization triggers extra challenges such as: limited input capabilities, limited display capabilities, and the dynamically changing user’s surrounding environment. However, the main parts of VA are the information analysis and the visualization tools. Therefore, developing mobile AR visualization based on VA analysis part can reduce the mobile AR display challenges. Moreover, using VA visualization tools can increase the impact of the presented information and the effectiveness of communication between human and computer. This approach will work properly in the dynamically changing environment of AR applications. We will demonstrate the proposed techniques in a food shopping assistant (see Figure 1). Figure 3 shows the delineation of our research against related research areas.

1.1 Research Situation

One of the main AR visualization system limitations, is that it has to deal with vast amount of information in reality [20]. In the literature review [20] they mentioned that one of the future directions for AR is to filter the information, retain useful information, discard useless data and display the remaining in a convenient way. One of the main challenges of the AR visualization is that real objects are connected to multi-dimensional virtual information. Representing multi-dimension data, with internal dependency relations between them, is a main challenge for both VA and AR fields. In recent years AR visualization has become a point of interest in the research field.

Researchers at Michigan State University [21] worked on an in-store e-commerce context-based system. They used AR on a handheld tablet PC to provide the user with a better shopping experience. They developed an AR assistant. In this approach the data is arranged in layers and presented to the user with Details-on-Demand (DOD). In this research the dependencies between the real objects are based on pre-defined clustering, which limits the query options for this system. Moreover, this approach did not provide a solution for data cluttering raised from multiple identical objects on the same shelf.

Visualize information with an internal dependency relation became a point of interest not only for assistant application, but also for location-based applications. Researchers at Columbia University [11, 18, 4] worked on visualization techniques for situated hypermedia in AR. They presented techniques that enable mobile users to visualize and navigate complex hypermedia structures embedded in the real world. The user visualizes the data based on location-based filtering. However the only connections between the nodes are navigation paths. Moreover, working with single data-filtering attributes for filtering leads to the increase in the information needed to be displayed. They solved this problem by using the special interaction techniques of tilting, lifting and shifting.

Visual analytics is the integration of interactive visualisation with automated analysis techniques. One of the main challenges that faced the previous work was the way of representing and interacting with the information. Augmenting the information in 3D
real space triggers extra challenges to be considered in the visualizations, such as ergonomic constraints, materiality, and robustness [14]. Our goal is to develop AR visualization techniques based on VA standards (Analyse First - Show the Important - Zoom, Filter and Analyse Further - Details on Demand) [17].

2 Gap & Research Question

The gap we identified in AR visualization is that most of the approaches minimized the readability problems by using arranging and mapping techniques, such as aesthetic rules, minimize crossing, and optimised designs (through colour and scheme). Other approaches worked on filtering the data based on context. However, minimizing the representation’s challenges on mobile AR based on VA standards has not been achieved yet.

The research question we want to investigate through my research is: How AR with VR can increase the information impact under the limited display of the mobile platform (resolution, field of view)?

3 Research Method

To enhance the visualization impact for the AR mobile application, we will develop visualization techniques and evaluate their impact based on the aesthetic criteria: readability, representation’s area, and overlap [14]. The system will be developed by the iterative and incremental process [13] and validated through user evaluation using the shopping application. The proposed system will give the user the ability to specify real-time queries.

![Figure 4: System Components Decomposition](image)

Figure 4 shows the components of the proposed approach. It contains three main parts: the identification part, the analysis part, and the display mapping part.

- The identification: is responsible for multi-objects (nodes) identification and the calculation of the dependencies between them. This part contains two main stages; nodes Identification stage and nodes dependencies stage. Nodes identification stage is responsible for multi-objects identification process. Nodes dependencies stage is responsible for nodes’ relations calculation.

- The analysis: is responsible for analyzing the information, based on location, context, and user’s interest. This part contains three main stages; query-based filtering stage, context-based filtering stage, and similarity removal stage. Query-based filtering is responsible for filtering the nodes’ relevant virtual information based on user query. Context-based filtering is responsible for filtering the nodes’ relevant virtual information based on user’s profile. Similarity removal is responsible for removing similar information (resulted from similar nodes in the sight view) to avoid cluttering.

- The display mapping: is responsible for mapping the information to visual representation. This stage is also responsible for generating the display layout. The layout structure (color, size, and arrangement) is dynamically changing according to the query’s results. The information will be displayed based on information analysis and nodes’ pose and avoid overlapping and cluttering.

![Figure 5: Illustration for the result of “expire date” query. The colored overlay regions represent a color coding for the products expiration dates. The red regions mean that these products will be expired in less than a week. Yellow regions mean that they will be expired within a month. The green regions show that these products will not be expired from 1-6 months.](image)

![Figure 6: Illustration to identity exploring after similarity removal. The labels for the similar objects are placed once in the centre.](image)

Figure 5, 6, 7 illustrate some simple cases of information representation when using prior information analysis stage. Figure 5 shows a way to explore the products’ expire date using color coding technique. This representation is more readable than augmenting the expire date labels on each object. Figure 6 illustrates another solution to decrease cluttering using similarity removal technique. This technique clusters the similar neighbor nodes to decrease the amount of information needed to be presented. So if multiple neighbor nodes are connected to the same virtual information, the information will be augmented once in their cluster physical 3D space.
be evaluated based on: embodiment, metaphoric distance, multi-modality, interaction, affordable, and physicality factors [14].

4 Expected Contributions

This thesis will make a research contribution by developing a Mobile AR visualisation approach. The proposed approach will provide a novel information representation under the space limitation of AR display. This approach can be used for information-based applications to enhance its visualization. Moreover this thesis will show measurable benefits of using the VA in AR.

5 Current Situation

We are currently in the process of designing the runtime environment. A critical part of the design is to choose the appropriate VA techniques that can achieve our proposed goal. Furthermore, the proper visualization techniques need to be investigated in more detail. These techniques are needed to present the VA Engine’s results. We have designed the prototype application scenario that we are endeavoring to develop it on mobile phones, and Google Glasses.

REFERENCES


