Five Features for Modeling Augmented Reality

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Abstract. Augmented reality is growing rapidly and supports people in different fields such as education, design, navigation and medicine. However, there is limited discussion about the characteristic features of augmented reality and what is meant by the term. This paper presents five different features: changeability, synchronicity and instant, antecedent, partial one to one and hidden reality. The explanation of each of these features is given follow a consistent structure. The benefits of generating features and future work are described.

Keywords: augmented reality, features, technology.

1　Introduction

Augmented reality (AR) technology combines virtual information with the real environment in real-time performance [1]. Due to the development of the mobile devices, AR is growing rapidly and is becoming popular through in a variety of areas [2]. However, because of the broad meaning for this term, it is not exactly clear what is meant or intended when people use AR. Some of the sources use a very general meaning for it, whereas others mean something very specific and narrow [3]. Section two will explicitly outline the existing research concerning the features of augmented reality. Section three presents five different features and briefly summaries the meanings of them using a lightweight diagrammatic notation. The benefits of developing our understanding through such features are then described in term of how they will be used in future work.

2　Related Work

There is relatively little literature examining the nature of augmented reality, what the term means and how it should be used. The term of AR was coined by Caudell and Mizell [4] as an enabling technology used to 'augment' the visual field of the user with information necessary in the performance of the current task. Azuma [5] defined AR as a system that has the following three characteristics: combines real and virtual, interactive in real time, registered in 3D. However, AR is not limited to our sense of sight, and it could potentially apply to any of the senses, including hearing, touch and

smell. We can speculate further as to whether tools such as, memory aids represent augmentations to other human capabilities (like cognition). Establishing meanings and identifying boundaries to concepts is a common and important activity much research and AR should benefit from the same.

3   Features

This paper introduces the five features of augmented reality, followed by an explanation of each to initiate establishing the characteristics of the concept. The features have been arrived at from reviewing existing AR research and critical reflection by the authors. The format of explaining the AR features is based upon Borcher's approach [6], which describes a formal model of pattern languages to reduce ambiguity. The structure of this model is simplified in this paper. The explanation of features consists of the following items:

- Title: a short and memorable phrase.
- Problem: the major issue that the feature addresses.
- Definition: a brief summary of the meaning of features.
- Description: a detailed explanation of AR features including examples.
- Diagram: a diagram summarizing the main idea in a graphical way.

3.1   Changeability

Problem: How should virtual information be generated?

Definition: Virtual information born of the real-world information can be changed during an AR event.

Description: With respect to an augmented reality system, virtual information is superimposed on a view of the real world [3]. A key aspect of augmented reality is that the virtual information can be changed dynamically, while the real-world information does not. For example, Wikipedia World is an AR application providing users with the locations of stations, hotels and more [7]. When users use the app and move around, the virtual information bubble will pop up automatically. An icon visually indicating, say, a real-world station, can be clicked more Wikipedia information will be about the station will be presented. This additional information replaces the previous virtual bubble. The content of virtual information has been changed easily and completely. As opposed to the virtual information, the real station has not changed. The feature of changeability is captured by the following diagram (see Fig. 1).

Diagram
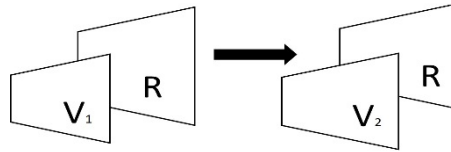
Fig. 1. Feature of Changeability

Letter R represents the real-world information and V the virtual information overlaid on the real-world content. The arrow expresses that the V_1-R augmented reality system is transferred to V_2-R because of an effect of changeability.
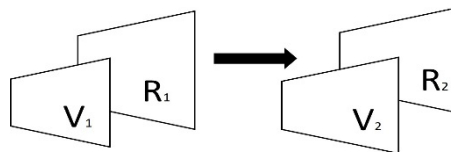
3.2 Synchronicity and Instant

Problem: How should the virtual and real content be connected?

Definition: Changing the real content will result in the synchronic and instantaneous transformation of the virtual counterpart.

Description: Due to the changes of the real-world content, an AR virtual counterpart has to be updated synchronously and instantaneously. For example, Word lens [8] is an AR translation application that scans and foreign text and displays the test translated in real time. Once the user changes his or her point of view to another word, the displayed translation on the device changes rapidly in the same time. If the process of generating virtual information is delayed for a long time, viewers are unable to obtain the useful information. However, the time lags can exist because of the inherent information processing. Synchronicity and instant is captured by the following diagram (see Fig. 2).

Diagram

Fig. 2. Synchronicity and instant

V_1-R_1 augmented reality system presents that the virtual content V_1 is the overlay of real-world content R_1. If changing the real-world content from R_1 to R_2, the virtual content has to be transformed from V_1 to V_2 in this process. This corresponding transformation is synchronous and instantaneous.

3.3   Antecedent

Problem: How should information about the real world be generated?

Definition: The real-world content in an AR system is existing or happening before the virtual counterpart.

Description: In respect of the AR system, there is no restriction on what the real-world content is, which might be visual (e.g. photo, object, building and etc.), auditory or even tactile information. However, the process of augmenting them follows a particular order. Going back to the Wikipedia World example [7], the virtual station bubble displayed on the device is based on the fact that there is a real station nearby the users. In other words, the prerequisite of creating the bubble is that the real-world content, the railway station, exists in the physical world first. If the virtual content is created before the real-world content, the virtual element is meaningless because it has no real world interpretation (see Fig. 3).
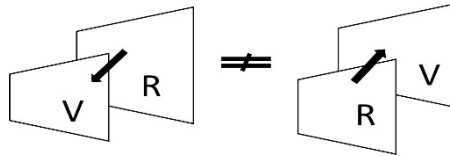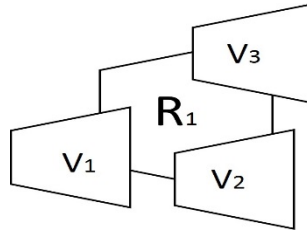
Diagram

Fig. 3. Feature of Antecedent

The left diagram shows the V-R augmented reality system that the real-world information is antecedent and the virtual content is overlaid. The right diagram illustrates the "R-V" system, which is not an AR system because the virtual information exists at first.

3.4   Partial One to One

Problem: How should the virtual and real content be matched?

Definition: There is one and only one real-world content to correspond with the virtual content. However, there might be one or more than one piece of virtual information to correspond with the real-world content.

Description: A key aspect to augmented reality is that the relationship between virtual and real-world content is one-to-one. Word lens [8] translator could display a translated word '¡Hola!' in Spanish when the AR device scanned the real word 'Hello!' in English. The meaning of one-to-one relationship is that the virtual content '¡Hola!' should only present the real content 'Hello!' and not another physical word. However, AR translator could also render the English word 'Hello!' into different foreign language, such as '你好!' in Chinese, 'Bonjour!' in French and so on. That means the real content can be augmented to lots of virtual content. The term 'Partial one to one' describes this AR feature (see Fig. 4).
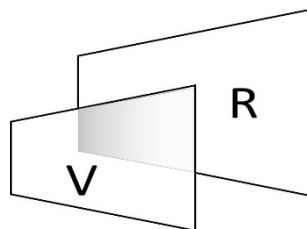
Diagram

Fig. 4. Partial one to one

The left diagram $V_1V_2V_3$ - R_1 augmented reality system summarizes the real-world content R_1 could match the different virtual content V_1, V_2, V_3.   However, it is not AR if more than one real-world contents correspond with the virtual content V_1.

3.5   Hidden Reality

Problem: How is the real content hidden by virtual content?

Definition: In an AR system, generating the virtual information will often result in the obstruction of real-world information.

Description: While users look through the virtual content, the real content will be more or less hidden. For example, Word lens [8] AR translator generates the virtually translated words, which replace the real-world words. Users have to remove the AR device if they need to see the original words. They cannot see both the virtual and real content simultaneously. While in such cases it is possible to try alternatives, such as whether the virtual content could be overlaid on the less important information. It still depends on the specific conditions to judge the difference between important and unimportant information, and intrinsic risk of AR is that the virtual occludes some of reality (see Fig. 5).

Diagram

Fig. 5. Hidden Reality

In this diagram, the virtual information V partially obstructs the real-world information R. The shadow presents the hidden real-world content because of the generating virtual content.

4   Conclusion and Future Work

This paper presented five features of augmented reality based upon a simplified model of pattern language. Specifically, these features are: changeability, synchronicity, antecedent, partial one to one and hidden Reality. These features of augmented reality might bring benefits to AR developers and research by providing a more explicit basis on which to articulate AR requirements, issues and technologies. For example, according to the feature of hidden reality, designers could begin to consider the appropriate position to display the virtual content. Partial one to one might bring the potential clues for developers to create different kinds of virtual content corresponding with one piece of real-world information. Understanding the meaning of AR is still the foundation of ongoing PhD research. Our hope is that this paper serves as to innovate, refine and prototype potential solutions using AR for enhancing older population's experience in the future.

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