Vr-UCAM2.0: A Unified Context-aware Application Model for Virtual Environments*

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ABSTRACT

With the rapid development of hardware and software, virtual reality technologies are applied to various areas, such as virtual heritage systems, entertainments, games, educations, etc. However, most virtual reality systems only offer limited interactions, i.e., it simply responds to explicit commands inputted by users. In this paper, we propose vr-UCAM2.0 (A Unified Context-aware Application Model for Virtual Environments) as a framework for designing reactive virtual environments. It makes virtual objects show active responses to context in real and virtual environment. It consists of vrSensor detecting any changes in virtual environments, vrSCM supporting seamless context sharing between real and virtual environments, and vrService showing different responses to contexts. The proposed vr-UCAM2.0 seamlessly shares context between real and virtual environments by exploiting a unified context. Additionally, it makes virtual objects react to the context according to its personality. Moreover, it ensures adaptation by changing degrees of the object's personality and abilities through learning. Consequently, we expect that the vr-UCAM2.0 can be a framework for designing intelligent interactions between users and virtual environments.

***Keywords*:** Context-aware Application Model, Framework for Designing Reactive Cyber Space, Seamless Interactions between real and virtual environment

1. INTRODUCTION

With rapid development of hardware and software, virtual reality technologies are applied to various areas, such as entertainments, games, educations and so on. However, most virtual reality systems simply respond to explicit commands inputted by users. Therefore, it only offers limited interactions to users and reduces realities of virtual environment.

In order to overcome the limitations, many researchers have combined artificial intelligence techniques with applications in virtual environment [1]. They especially have built several frameworks for designing the intelligent virtual objects. In the Oz project, Bate develops a broad agent architecture called *Tok*, which creates emotional characters in artificial world [2][3]. Yoon et.al. introduce *Creature Kernel* for building interactive synthetic characters[4]. Moreover, in the Virtual Theater project, they propose a social-psychological model for synthetic actors that interact with users according to themselves emotion, mood, etc [5]. However, they do not consider user's situation or context [6] in real environment. That is, they are only focused on virtual environment itself. It makes users perceive gaps between real and virtual environment, and then diminishes immersion in the environment.

In this paper, we propose vr-UCAM2.0 (A Unified Context-aware Application Model for Virtual Environments) as a framework for designing reactive virtual environments. . It makes virtual objects show active responses to context in real and virtual environment. In addition, the objects react according to their personality. In order to achieve this goal, the proposed vr-UCAM2.0 consists of three components; vrSensor, vrSCM and vrService. vrSensor detects any changes in virtual environment. vrSCM supports the seamless context sharing between real and virtual environment [7][8]. In addition, vrService is aware of context and makes virtual objects react actively according to the context.

The proposed vr-UCAM2.0 has following advantages. It seamlessly shares contexts between real and virtual environments by exploiting a unified context [9]. Additionally, it offers foundations for virtual objects to actively respond to the context according to its motivation. Moreover, it lets the objects to adaptively change its personality and abilities through learning. Consequently, the vr-UCAM2.0 can be foundations for designing reactive virtual environments which show active reactions to user and environmental context.

This paper is organized as follows. In chapter 2, we briefly show characteristics of the proposed vr-UCAM2.0. Then, in

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chapter 3, we describe components of the vr-UCAM2.0 in detail. In chapter 4, we explain how to exploit the proposed framework. Finally, we discuss conclusions and future works, in chapter 5.

2. VR-UCAM2.0

Vr-UCAM2.0 is a unified context-aware application model for virtual environments, as a part of UCAM [10]. It aims at designing reactive virtual objects which differently response to context through their personalities. Moreover since it offers life-like illusions, it increases immersions in the virtual environment. Therefore, the proposed model has following characteristics.

- **Context-awareness**: the vr-UCAM2.0 makes virtual objects show the personalized responses according to user or user's situation. Therefore, it arouses users' interest by exhibiting different reactions according to users. In addition, each object analyzes any explicit inputs or changes through user-centric view, and then is aware of user-centric context.

- **Unification:** the proposed model provides users with seamless interactions in real and virtual environments. It has an identical architecture with ubi-UCAM existing in real environment [11]. Additionally, it exploits a unified context as 5W1H (Who, What, Where, When, Why and How) [9]. Therefore it makes virtual objects naturally response to context generated from the two realms; real and virtual environments.

- **Believability:** the vr-UCAM2.0 aims at providing users with life-like impression about virtual objects. Therefore, the virtual object makes different reactions to same context according to its personality. Additionally, instead of simply response to any change, it actively reacts to arouse users' interests. Furthermore, the object shows adaptations to unpredictable situations by adjusting the degrees of its personality and abilities.

3. VR-UCAM2.0 COMPONENTS

As shown in Figure 1, vr-UCAM2.0 consists of vrSensor, vrSCM and vrSensor. vrSensor perceives any changes in virtual environment. vrSCM supports seamless context sharing between real and virtual environments. vrService is aware of context, and makes virtual object actively react to the context.

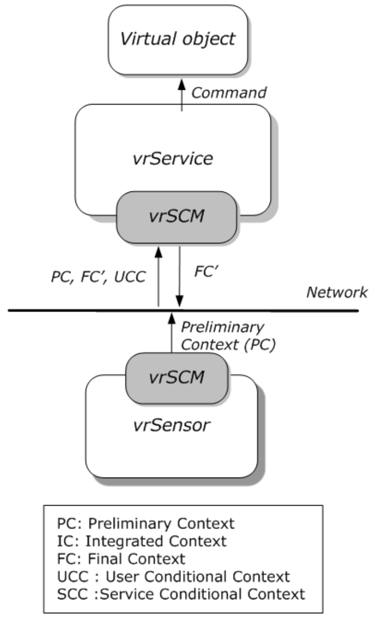

Figure 1: vr-UCAM2.0.

3.1 vrSensor

vrSensor detects changes in virtual environment by imitating human's five senses, i.e., a sense of sight, hearing, smell, touch, taste. Since each vrSensor has limited abilities, it only detects the limited changes in the virtual environment. And then generates preliminary contexts containing incomplete elements among 5W1H. As shown in Figure 2, it has two components; Feature Extractor and Preliminary Context (PC) Generator.

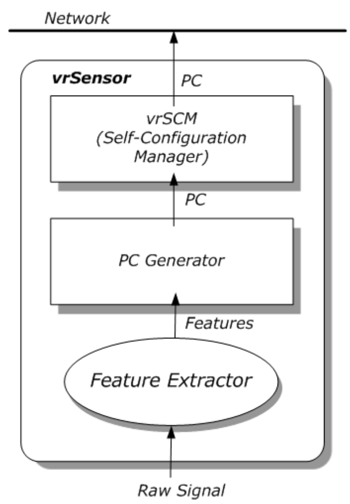

Figure 2: vrSensor.

Feature Extractor analyzes raw signals acquired by sensor, and extracts useful features from the signals. Then, Preliminary Context(PC) Generator forms meaningful preliminary context by mapping extracted features to suitable elements among 5W1H. Finally, the generated preliminary context is forwarded to vrSCM (Self-Configuration Manager) for sharing with other sensors or services in real and virtual environment.

3.2 vrSCM

vrSCM supports seamless connection between sensors or services in real and virtual environment [8] by utilizing a publisher-subscriber mechanism. It is embedded to each vrSensor or vrService and dynamically generates multicasting group by vrSensor or vrService itself. Figure 3 shows three components of vrSCM, i.e., ConfigurationManager, ContextPublisher and ContextSubscriber.

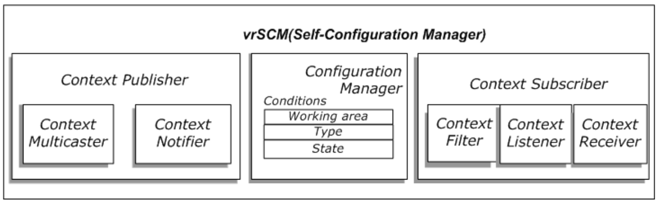

Figure 3: vrSCM Components.

ConfigurationManager extracts suitable configuration conditions from generated contexts in embedded vrSensor or vrService, and then manages the conditions for generating a multicasting group. The conditions contain properties, e.g., active area, the kind of embedded vrSensor or vrService, etc, and state information.

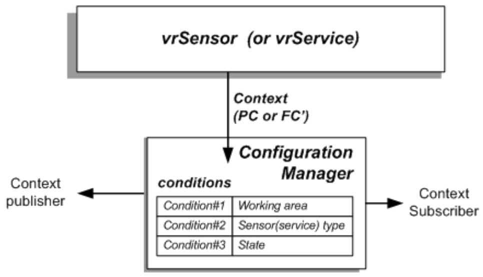

Figure 4: Configuration Manager.

ContextPublisher dynamically generates a multicasting group and then shares context whenever the context is generated. As shown in Figure 5, it broadcasts announcements, which describe context generations, to other sensors or services existing in real and virtual environment. Then, it dynamically forms a multicasting group which is composed of sensors and services responding to the announcements. And it transmits the generated context to members in the same group. Therefore, it makes each vrSensor or vrService share the context without other management components. That is, ContextPublisher has a suitable mechanism for distributed computing environments.

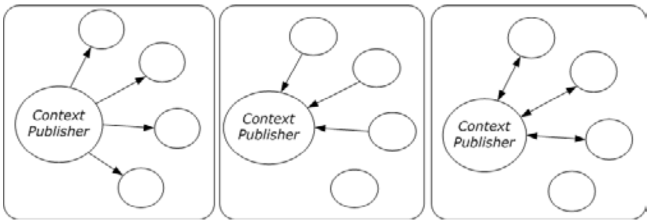

Figure 5: Multicasting group generation.

ContextSubscriber receives the necessary context among several contexts generated from others. It discriminates the necessities of broadcasted announcements by exploiting configuration conditions of ConfigurationManager. If the generated context is needed, ContextSubscriber transmits a response message to sender, and then joins the multicasting group. Finally it actually receives the generated context. Therefore, it supports efficient context sharing by receiving only necessary context.

3.3 VrService

vrService provides users with the personalized responses according to contexts in real and virtual environment. It analyzes contexts inputted from several sensors and services. It also interprets user's individual information generated from WPS [12]. In addition, it creates final decisions according to virtual object's personality. Then it applies the decision to the object's actual reaction. As shown in Figure 6, it consists of vrContextIntegrator, vrInterpreter, vrContextManager and vrServiceProvider.

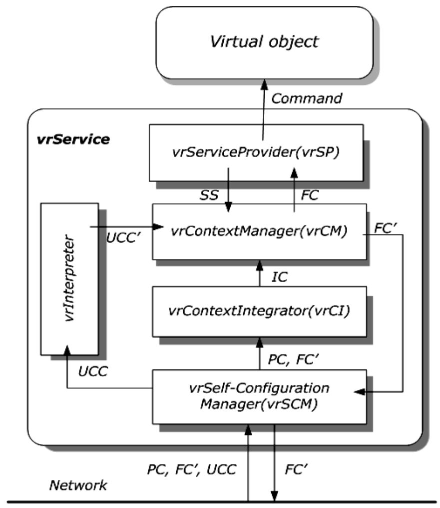

Figure 6: vrService components.

vrContextIntegrator performs user centric context fusions by exploiting several contexts generated from other sensors or services in real and virtual environments [11]. As shown in Figure 7, it integrates Who elements, and then fuses other four elements, i.e., What, Where, When, How, by utilizing voting methods according to its conditions. Moreover, it infers user's intention as Why element by using context history. Finally, it generates the Integrated Context containing integrated 5W1H elements. Therefore, the virtual object can perceive its faced situation through this integration.

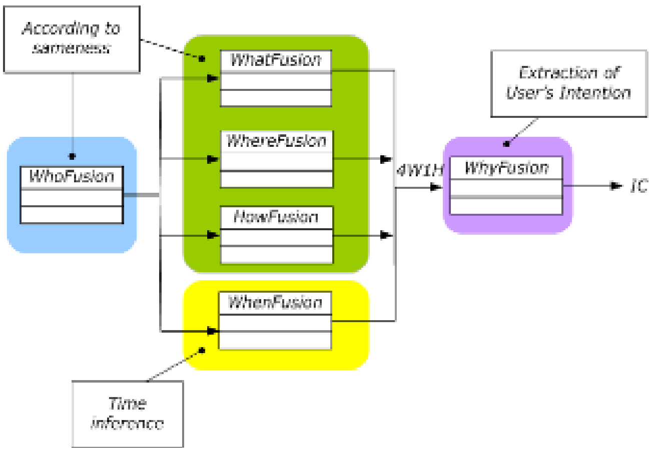

Figure 7: Integrated Context(IC) Generation.

vrInterpreter applies user's preferences to virtual object reactions. It manages User Conditional Context (UCC), which contains the user's preferences and is generated from wear-UCAM [12], according to users. Then, it transforms the UCC to understandable forms for the virtual object. Therefore, it can offer personalized interactions between the object and the user by making the object show suitable responses for user's preferences.

vrContextManager generates final contexts suitable for the situation according to the virtual object's personality. As shown in Figure 8, it analyzes contexts according to history in profile engine, and then adjusts the degrees of affect and drive of the object. Moreover, it forms the Motivation-driven Conditional Context (MCC) which reflects the motivation of the object, such as emotional state and drive, etc. Finally, it forms final context, which reflects final behavior decisions, by comparing three kinds of conditional context: User Conditional Context (UCC), Motivation-driven Conditional Context (MCC) and Service Conditional Context (SCC). Furthermore, it changes degrees of its personality through feedback of Service State (SS) as the result of final decisions. Therefore, it intensifies the object's adaptations to unpredictable situations.

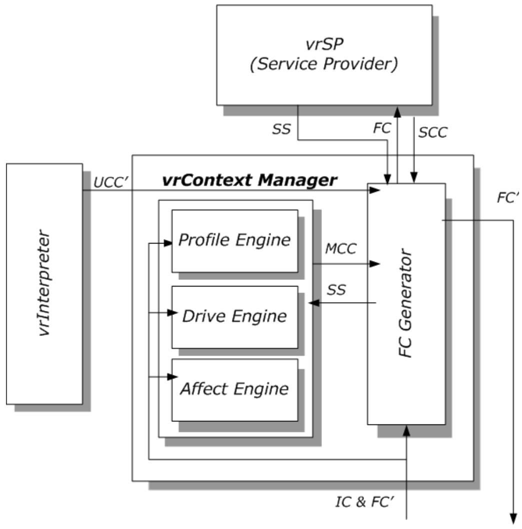

Figure 8: vrContextManager (vrCM).

vrServiceProvider generates commands for executing suitable behavior patterns according to final context. At first, it offers interfaces which developers can link their virtual object to vrService. Thus, the developer can register the set of basic behaviors and Service Conditional Context (SCC) through the interface. In addition, it finds behavior sets proper for the state of object itself and conditions of virtual environment. Finally, it creates commands to execute actual behaviors. Moreover, it manages state of the object according to command executions.

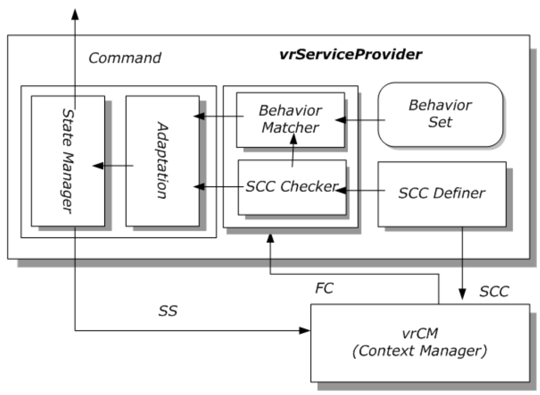

Figure 9: vrServiceProvider (vrSP).

4. IMPLEMENTATIONS

In this paper, we implemented the vr-UCAM2.0 as libraries. It allows developers to easily implement intelligent virtual object or vrSensor. As shown in Figure 10, the libraries of vr-UCAM2.0 consist of *context, vrscm, vrsensor* and *vrservice*.

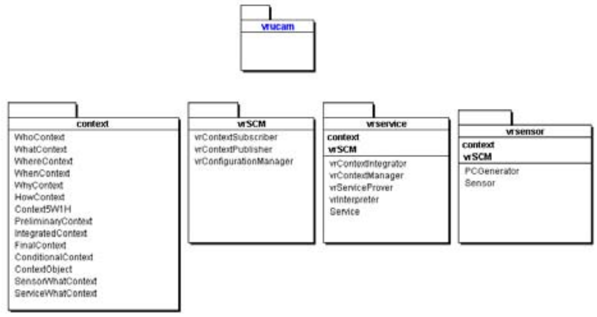

Figure 10: Components of vr-UCAM2.0 libraries.

The vr-UCAM2.0 offers templates for representing any situation as 5W1H (Who, What, Where, When, Why and How) forms with *Context*. As shown in Figure 11, since it shows hierarchical structures between several contexts, it offers flexibilities for describing the specific situation. Moreover, the proposed model exploits the unified context for supporting mutual context sharing with ubi-UCAM [11] and wear-UCAM [12].

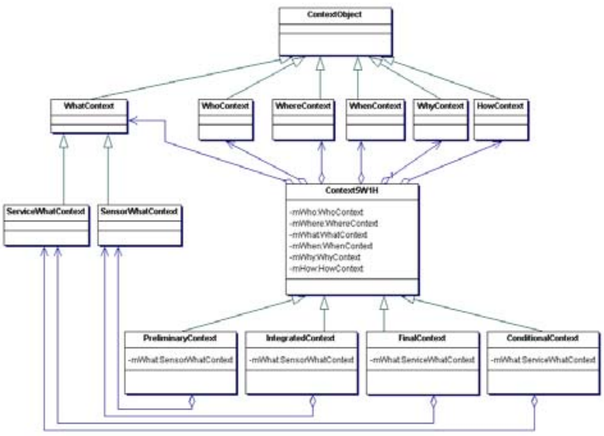

Figure 11: Context representation

It also has developers easily build its virtual sensor through *vrsensor*. That is, it offers *Sensor* class, which transforms features to preliminary context as 5W1H forms. Thus, developers merely inherit the class and override specific methods suitable for their implementations. For example, as shown in Figure 12, if we want to implement a *ProximitySensor*, we just inherit the *Sensor* class and redefine the method for mapping extracted features to preliminary contexts. In addition, the developer must set configuration conditions for sharing generated contexts with other sensors and services. Therefore, it automatically transforms the generated features to preliminary contexts, and seamlessly shares the preliminary contexts with others. As a result, we help developers to easily implement their own sensors.

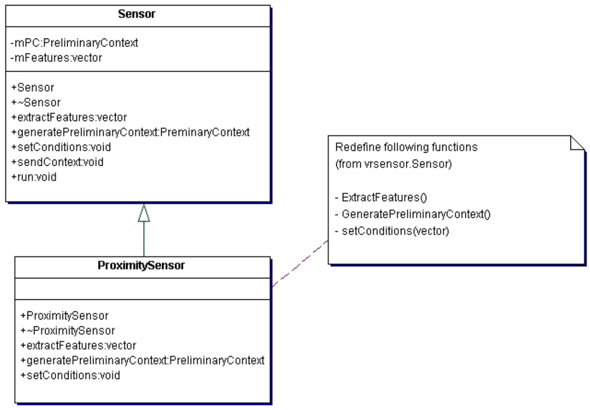

Figure 12: Implementation of *ProximitySensor* by using *vesensor.*

It also lets developers to readily implement context-aware virtual object by using *ServiceProvider* and *Service* classes in *vrservice*. It offers interfaces for the developers to link their own functions to specific situations. Accordingly, it makes them to couple their own implementations to our *vrservice*. Figure 13 shows *VirtualPlant* implementation as an example. That is, they simply create *VirtualPlantService* and *VirtualPlantServiceProvider* suitable for their implementations by inheriting *ServiceProvider* and *Service* classes. Therefore, even though actual implementation is diverse, it allows the developers to easily build context-aware intelligent virtual object through abstract processes.

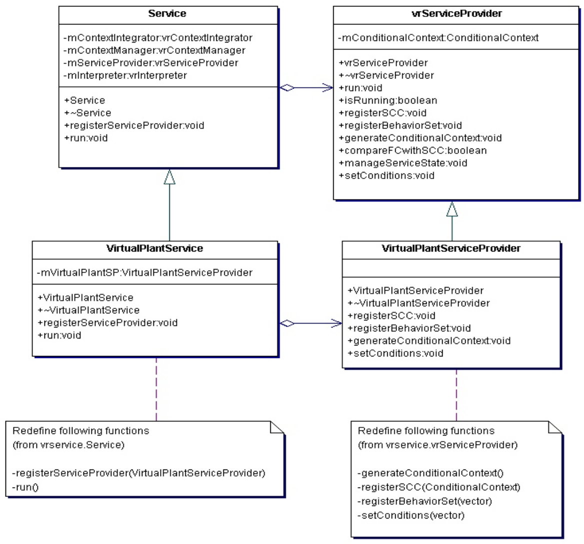

Figure 13: Implementation of *VirtualPlant* by using *vrService.*

5. CONCLUSION

In this paper, we proposed vr-UCAM2.0 (A Unified Context-aware Application Model for Virtual Environments) as a framework for designing reactive virtual environments. The proposed model seamlessly shares contexts between real and virtual environment by exploiting a unified context. It also offers foundations for virtual object to actively respond to the context according to its personality. Moreover, it shows adaptation to unpredictable situation by changing degrees of the object's personality and abilities through learning abilities. In this paper, we also introduced detail descriptions and implementations about the proposed vr-UCAM2.0. For the future works, we have a plan to apply the proposed model to virtual heritage system. In addition, we plan to perform further qualitative and quantitative analyses of the model.

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