

Integrating Peripheral Interaction into Augmented Reality Applications

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ABSTRACT

We address in this paper software architecture design to enable peripheral interactions in Augmented Reality applications. To this end, we rely on SAPIENS, a recently introduced software architecture for engineering peripheral interactions in smart environments, which we reuse to our purpose. Our approach can be readily tested using the online simulator available from the SAPIENS home page.

Index Terms: Human-centered computing—Human computer interaction—Interaction paradigms—Mixed / augmented reality.

1 INTRODUCTION

Since only one task can run efficiently in the user's center of attention, the consequence of presenting multiple, concurrent stimuli and requiring users to handle several tasks at once is an increase in cognitive load [7]. However, tasks running at the periphery of attention can share users' attentional resources without inducing the feeling of sensory or cognitive overwhelming [2, 12]. In this context, the concept of "calm technology" [13, 14] was introduced to design interactions between users and computers that address both the *center* and the *periphery of users' attention*.

Augmented Reality (AR) applications can deliver a wide range of useful services and content to users in various modalities, mostly visually. However, extreme forms of AR can be cognitively demanding, as in the case of the "Hyper-Reality" kaleidoscopic, media saturated dystopia imagined by Keiichi Matsuda [8]. AR systems rely on three requirements: mixing the physical and the virtual, real-time interactivity, and 3-D registration [1]. Also, there are several ways in which users can interact with AR content, such as via 3-D user interfaces, tangibles, or by means of gesture, voice, and multimodal input as part of natural user interfaces [6]. Regarding the latter, these interfaces connect well to two key requirements of a peripheral interaction system [2]: (i) the existence of perceptual and action routines and (ii) interactions that shift between the center and the periphery of the user's attention. Moreover, peripheral interaction is mostly driven by automatic behaviors instead of conscious goals [2]. In this context, most of previous research on peripheral interaction has focused on visual stimuli delivered at the periphery of users' visual field [4, 11], whereas signals to shift tasks between the center and the periphery of attention were either visual or aural [4, 5].

In this work, we explore the idea of integrating peripheral interactions into AR applications. To this end, we employ SAPIENS [10], a recently introduced software architecture for engineering peripheral interactions for smart environments specialized in handling notifications according to their priorities and to the output modalities available in the smart environment. We propose a straightforward extension of SAPIENS to include AR-capable output devices, and discuss how the proposed change reflects in the informational data

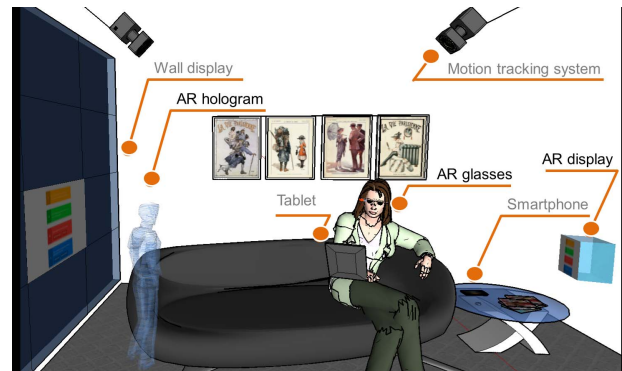


Figure 1: An illustrative scenario, adapted from Bakker [2] and expanded from Schipor *et al.* [10], for integrating peripheral interactions into AR. In this scenario, the user Sandra receives notifications from ambient systems (e.g., the wall display), her personal devices (smartphone and e-book), but also an AR-capable wearable (smartglasses); see Schipor *et al.* [10] for a detailed description of this scenario.

flow of the SAPIENS architecture. To exemplify our approach, we start from the classical scenario for peripheral interaction illustrated by Bakker [2] and adopted for SAPIENS [10] as well, to which we add an AR-capable output device (a pair of smartglasses) for displaying virtual content superimposed on the physical surrounding; see Figure 1. In this scenario, notifications can be delivered to the user Sandra not just by means of output devices from the smart environment (e.g., the wall display), but by AR devices as well. The AR content can be dynamically positioned with respect to Sandra to match any particular area of the interaction-attention continuum [3].

2 AN OVERVIEW OF SAPIENS

SAPIENS [10] is a software architecture specifically designed for engineering peripheral interactions that rests on the core engine of EUPHORIA [9], a generic, event-based architecture design for implementing interactions across heterogeneous I/O devices in smart environments. SAPIENS inherits all the design requirements of EUPHORIA (i.e., event-driven, asynchronicity, adaptability, modularity, flexibility, interoperability, web-based, JavaScript-based, open-source, and smart-space orientation) and introduces four attentional-related properties for implementing peripheral interactions (i.e., multimodal orientation, priority inference, probabilistic response, and proactivity). SAPIENS includes modules specific to engineering peripheral interactions, such as Attention Detection (for estimating the user's focus of attention), Priority Management (responsible with prioritization mechanisms for notifications), Interruptibility Prediction (handling all the tasks, devices, and events that request the user's focus of attention), and Context Awareness (for modeling the physical context in which the user's actions take place). These modules are instantiated and implemented according to the needs of a particular smart environment and application [10]. Moreover, SAPIENS can prioritize concurrent notifications by targeting various output modalities, e.g., visual or aural, and devices, e.g., wall display or e-book; see Figure 1 and Schipor *et al.* [10] for technical details.

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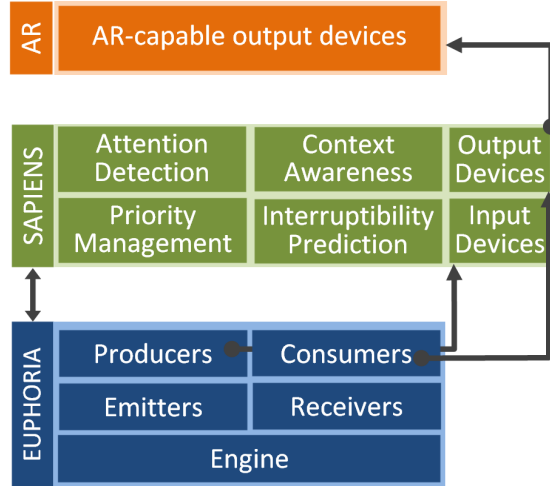


Figure 2: A proposal for using the SAPIENS software architecture [10] for peripheral interactions in AR applications.

```

message{2} ▾
  header{3} ▸ entityName   :SAPIENS
               entityIP    :192.168.0.8
               eventName   :Notification
               timestamp    :1561628410560
  body {2} ▸ content      : "Rate your last ..."
             modality     :VISUAL
             priority      :LOW

```

Figure 3: An example of a JSON message employed in SAPIENS.

3 SAPIENS FOR AR APPLICATIONS

Figure 2 illustrates the SAPIENS original architecture [10] and the connection to AR applications represented by a new layer including AR-capable output devices. The input devices handled by SAPIENS are abstracted as PRODUCERS (a generic term used in EUPHORIA [9] and adopted by SAPIENS [10] as well), which generate messages for the other components of the architecture. AR content is delivered by AR-capable output devices, such as smartphones, tablets, head-mounted displays, and smartglasses that are abstracted as CONSUMERS, according to the same formalism from [9, 10]. Since AR content is dynamically generated, it needs to be in sync with the physical surroundings and the user's field of view. The world sensing component of any AR application can be decomposed into hardware and software modules that can be dynamically linked to form a flexible processing chain. This flexibility is possible due to the decoupled way in which SAPIENS modules exchange information [10]. All messages exchanged by SAPIENS have a standard structure with a header specifying the entity and the event type; see Figure 3 for an example. In order for a component to receive a specific message, a consumer needs to be implemented and subscribed to the EUPHORIA engine [9, 10]; see Figure 4. During the registration process, the component specifies the types of messages to receive. The message exchange process within the architecture can be visualized in a simulation that is available at the SAPIENS home page: <http://www.eed.usv.ro/mintviz/projects/SAPIENS>.

4 CONCLUSION AND FUTURE WORK

We addressed in this work-in-progress paper peripheral interactions for AR applications from the practical perspective of engineering such interactions using the SAPIENS [10] software architecture. Our extension of SAPIENS consists in employing AR-capable output devices for delivering content and notifications to the users of AR

```

1 class Smartglasses {
2   constructor(outputURL, deviceName, deviceIP, events) {
3     this.consumer=new EuphoriaConsumer(outputURL, events,
4       this.onMessageRead.bind(this));
5     this.onMessageWrite=this.onMessageWrite.bind(this);
6   }
7   onMessageRead(message) {
8     if(message.header.eventName === "onNotification")
9       this.showNotification(message.body.content, message.
10        body.modality, message.body.priority);
11   }
12   showNotification(modality, content, priority) {
13     // call of device specific API
14   }
15   start() { this.consumer.start(); }
16   stop() { this.consumer.stop(); }
17   pause() { this.consumer.pause(); }
18   resume() { this.consumer.resume(); }
19 }

```

Figure 4: SAPIENS compatible code for a smartglasses device.

applications. A simulation is available on the SAPIENS home page. More work is envisaged in the future to evaluate SAPIENS for specific AR-capable devices, contexts of use, and application scenarios.

5 ACKNOWLEDGMENTS

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