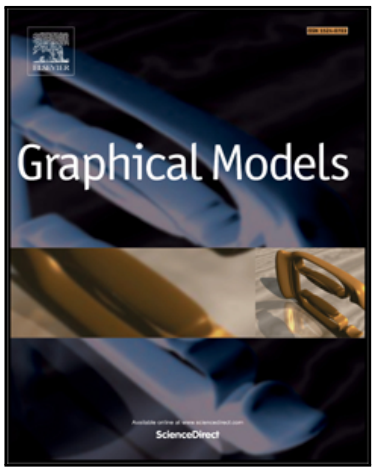

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Large-Scale Distributed Semantic Augmented Reality Services – A Performance Evaluation

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Abstract

This paper presents an architecture for large-scale distributed AR services and an experimental evaluation of the main component – *Semantic Augmented Reality Middleware*. The architecture is based on a client-server design, which supports semantic modeling and building contextual AR presentations for a large number of users. The architecture is based on the Service Oriented Architecture (SOA) paradigm that enables building distributed systems that provide application functionality as services to either end user applications or other services. The proposed architecture consists of two client-side components and multiple server-side distributed service applications – semantic middleware and AR service providers. The presented findings are promising and demonstrate that an application of semantic web techniques can be a useful solution to implement large-scale contextual distributed AR environments.

Keywords: augmented reality, AR, semantic web, architecture for AR services, CARE, middleware, quantitative evaluation

1. Introduction

Augmented reality (AR) techniques enable superimposing computer-generated content, such as interactive 2D and 3D multimedia objects, in real time, on a view of real-world objects [1]. Widespread use of AR has been enabled in the recent years by remarkable progress in consumer-level hardware performance, in particular, in the computational and graphical performance of computing hardware and quickly growing bandwidth of mobile networks. The progress is particularly visible in the domain of mobile devices, such as smartphones, tablets, and wearables. These devices are nowadays equipped with multi-core processors, large amounts of memory, high-quality displays and multimodal interaction interfaces with a variety of sensors, such as accelerometers, gyroscopes, cameras, microphones, and GPS receivers. Mobile devices became general-purpose computing platforms well suited for deployment of various kinds of multimedia applications. Last but not least, technical progress is accompanied by dynamic development of economic activity in this field. According to [2], companies developing AR and VR technologies, during the 12 months until the end of the first quarter of 2018, have collected record-breaking 3.6 billion dollars in financing.

Augmented reality, with its potential to blend real and virtual objects, creates new opportunities for building interactive and engaging applications in multiple application domains. Education [3, 4, 5], entertainment [6, 7, 8], medicine [9, 10, 11], and cultural heritage [12, 13, 14] are examples of application areas, in which the use of AR technology offers considerable benefits.

Currently available AR application design tools include, on the one hand, advanced libraries and development platforms that require designers to have advanced technical skills [15, 16, 17, 18, 19, 20, 21, 22, 23], and on the other hand, easy-to-use visual programs [24, 25, 26, 27, 28, 20, 29, 30], by which people without programming skills are able to create simple AR presentations. However, in both classes of tools, AR presentations are designed manually – by programming or visual design. To facilitate the use of AR in various application domains and for information visualization in general, new models and new methods are required to automatically create AR presentations based on the available data sources.

In this paper, an architecture for distributed augmented reality services and evaluation of semantic middleware are presented. The architecture is a basis for the implementation of Contextual Augmented Reality Environment (CARE), which enables composition of interactive AR presentations based on multiple distributed semantically described data sources depending on the user's context. Particular components of the architecture are described, together with the communication protocol that enables modeling and exploring dynamically generated ubiquitous AR presentations. Results of performance analysis of the semantic discovery and matching process are also provided.

The remainder of this paper is organized as follows. Section 2 presents state of the art concerning augmented reality, semantic web, and a combination of these technologies in practical applications. In Section 3, the concept of Contextual Augmented Reality Environments (CARE) is introduced. Then, Section 4 presents the distributed CARE architecture, together with its main components and data flow between them. Next, Section 5 describes CARE back-end services, in particular, *Semantic Augmented Reality Middleware* and AR Services Providers.