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# Spatial Content Models and UIDLs for Mixed Reality Systems

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**Abstract**

In Mixed Reality (MR) interfaces spatial information plays a central role. The integrated consideration of dynamic, functional and spatial characteristics will be essential for the creation of UIDLs for MR interfaces and similar next-gen UIs.

**Keywords**

Mixed Reality, augmented reality, spatial information, content models, UIDL

**Introduction**

Our experience with the development of Mixed-Reality (MR) systems for a variety of domains (e.g. illustration, entertainment, museums and navigation [2,3,4]) shows that changing base-technologies make it hard to maintain MR systems in a working state and prevent reuse across applications. The description of MR interfaces in an application and technology independent model is a prerequisite for the development of generic tools for content creation and management, and key to the reuse of MR content across different hardware platforms. One central feature that MR systems share with many other types of novel interaction styles is the focus on spatial content – in MR systems a spatial model of both the virtual elements presented in the interface as well as the real-world surroundings is required. Similar requirements exist in tangible user interfaces, 3D interaction and virtual reality systems

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Forgotten Valley MR Game



AR Enigma Museum Guide



GeoScope MR System



MR Navigation System

**figure 1.** Exemplary MR applications using spatial contents

and spatial features are also a central characteristic of the context exp[5]. loited in context-aware interfaces. In recent work ([5]) we have examined the adaption of existing spatial data-models for MR applications and have identified a number of requirements for the description of spatial MR content. One aspect that is largely missing from current spatial data models is dynamic behavior which is the defining element of interactive user interfaces. UIDLs, on the other side, have addressed UI specification from a high-level functional perspective, focusing explicitly on the specification of dynamic behavior. Given the historic development of UIDLs from early UIMS for desktop environments spatial characteristics have only been considered to a limited extend, e.g. in the arrangement of UI elements by automated layout planners. In MR interfaces consideration of dynamic, functional and spatial characteristics will be essential for the creation of content models for future MR interfaces. For the workshop we aim to identify a set of common requirements for UIDLs that are relevant to a variety of next generation user interfaces and hope that our experience with MR and geoinformatics in general and spatial data-models in particular will provide an interesting supplement to current UIDL work.

### Motivation

Mixed-Reality (MR) integrate interactive computer graphics into real-world environments. In contrast to traditional computer graphics applications where the complete graphics representation is generated from an internal model, MR applications combine computer generated graphics, audio and other multimedia information with the information of the real-world surroundings of the user. While MR may seem like the ideal solution for many user interface problems the use

of mixed reality in real applications has been very limited so far. In the past technological limitations imposed by the available technologies (e.g. MR displays with adequate resolution or precise spatial positioning techniques) have been a major problem. However, with maturing base technologies the question arises: why are practical applications still largely missing?

One observation from our experience in MR projects is that constantly changing base technologies (e.g. graphics libraries, tracking systems and toolkits) make the maintenance of working applications problematic and prevent reuse of MR content. A central reason for this is the integration of MR content with the application implementation into a monolithic structure. While libraries and toolkits are available to support MR application developers there is currently no standardized way to create, exchange and maintain MR content. Maintaining the augmentation content in an internal application specific data-structure was effective and useful in early technology demonstrators, but it now prevents the reuse of existing content in other applications, requires reimplementing of MR applications to adapt to new hardware platforms and makes the creation of distributed multi-user applications and application independent tools difficult. As in other areas it would therefore be useful to separate MR content description from the application implementation. The description of MR content in an application and technology independent model would allow to create generic tools for content creation and management, enable the reuse of MR content across different hardware platforms or in different applications, and support the shared simultaneous use of an MR application by multiple users.

### Requirements of MR-UIs

All mixed reality applications require some model of the real physical surroundings (real world model) as well as an internal representation of the augmentation information (augmentation model). A common approach in many MR demonstrator applications is to represent the augmentation information by placing the corresponding geometry in the scene-graph datastructure of the underlying graphics system. The real world model is often implicitly defined in the MR program by tying information and actions to spatial positions provided by tracking sensors. Implicit models that combine real world models and augmentation model have been defined as part of MR toolkits such as DWARF [1], Studierstube [6] and I4D [3]. A problem with implicit models is that they do not allow explicit interaction with the model content, are often system specific, not documented in detail and can change between different versions of a system. The use of explicit models has many advantages and enables the creation of system independent authoring tools.

Static models alone are not sufficient to describe MR interfaces. Dynamic content and behavior are central to interactive applications and form a central part of MR interfaces. In MR systems these dynamics can be caused by changes in the environment as well as explicit user actions. Similar to static content the dynamic and interactive behavior of MR applications is currently often defined implicitly in the system. To enable effective creation of dynamic interactive MR systems with tool support the explicit modeling of dynamic system is required. UIDLs based approaches form the basis for such solutions in a number of domains. However, a direct transfer to MR interfaces is difficult because in many cases the interaction logic can

not be considered separately from the real world and augmentation models, e.g. in cases where the presence of specific physical objects or the spatial locations of the user are used to trigger actions in the system. We therefore see a central challenge in the tight coupling or direct integration of UIDL based dynamics specifications with spatial content models for MR systems. We believe that such an approach has applications not only in a wide variety of MR systems but that the integration of spatial aspects would also be useful in related areas like tangible user interfaces and context-aware interfaces.

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