Use of Hybrid Rendering Styles for Presentation

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ABSTRACT

This paper presents hybrid rendering that combines the use of photorealistic and non-photorealistic rendering styles in the same image. This allows to extend the set of expression dimensions available in a visualization environment. To provide general applicability, this use of hybrid rendering styles is controlled by an XML-based scene description. We discuss the according schema definition and present an architecture for implementing the presented methods as well as two exemplary applications.

Keywords

Hybrid Rendering, Presentation, Non-Photorealism, XML Schema.

1. INTRODUCTION

In the past, the main direction in computer graphics used to be photorealistic rendering—meaning the quest to get as close to photography or video as possible. However, photorealism usually only means to render using the Phong illumination model and either Gouraud or Phong shading, sometimes with additions or enhancements. A recent addition to computer graphics in approximately the last decade—non-photorealistic rendering (NPR)—is not as well defined. Typically, it is conceived as everything except photorealism. However, is not even clearly understood whether photorealistic rendering is a subset of non-photorealistic rendering or if both are disjoint. There are two major directions or goals within non-photorealistic rendering: to build tools for artists to create art on the one hand and to build tools for illustrators to enhance technical, scientific, or medical illustrations on the other. In typical non-photorealistic renderings, however, usually only one specific style is used such as pen-and-ink, watercolor, or oil paint. The combination of more than one style in the same image or even traditionally produced photorealistic images with non-photorealistic styles is not as common.

In this paper we present the use of hybrid rendering styles in order to extend the set of expression dimensions in a visual presentation system. For this purpose, we combine rendering styles for the creation of photorealistic images with styles for non-photorealistic images and control this composition on a temporal basis. Two exemplary applications show the potential use of this approach. One presents the utilization of an NPR style for highlighting correlating parts of an otherwise photorealistically rendered geometric model. The other outlines the expression potential of mixing different rendering styles for an information visualization task.

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The remaining parts of this paper are organized as follows: Section 2 presents a brief overview on related work done in the field of combining photorealistic and non-photorealistic rendering. A client/server based architecture for hybrid rendering is outlined in Section 3. Section 4 discusses the XML Schema component of this architecture. This is followed by the two distinct and exemplary application domains in Section 5 whereas Section 6 concludes this paper.

2. RELATED WORK

The question of how to communicate information more effectively is an important area of research. A visualization supporting this task was explicitly cited as one of the grand challenges for NPR by David Salesin's keynote at the 2nd NPAR symposium (Salesin, 2002). By using their early NPR system SKETCH RENDERER, Strothotte et al. (1994) express how non-photorealism can be used to guide the user's attention in a visual system. The use of the outlined expression potential of NPR for visualization tasks is further motivated by studies pertaining to the limited expression capability of classic presentation variables. Ware (2000) presents an overview of information visualization constraints that specifically concentrates on aspects of perception.

In their classic work on non-photorealistic rendering, Saito and Takahashi (1990) show how to compute silhouette renderings from three-dimensional models using an image space method. By combining the traditional rendering with non-photorealistic elements in form of silhouettes they achieve accentuation of the models especially in the domain of technical visualization. A similar technique is used by Preim and Ritter (2002). They apply silhouettes to medical 3D visualizations to enhance the ability for recognition of semi-transparent objects in an interactive application. Strothotte et al. (1999) also take a photorealistically rendered object and combine it with non-photorealistic elements. However, they place the whole rendition into a photography and use the combination of rendering styles to show the degree of trust in a virtual reconstruction. Different from just accentuating objects with non-photorealistic elements, Masuch and Strothotte (2001) show examples for combining a photorealistic environment with non-photorealistically rendered objects. Similar to the effect in the work mentioned before, the non-photorealistic style is used to convey the impression of uncertainty of the shown virtual reconstruction. A completely different and rather artistic approach is taken by movies in the style of “Roger Rabbit”. These combine traditionally filmed movies—the ultimate form of photorealism, so to speak—with cartoon characters. In recent years, the creation of these cartoon characters has become an increasingly computer-assisted task. Johnston (2002), for example, shows ways to apply the correct illumination of a shot scene to the cartoon character.

Gooch et al. (1998) present a non-photorealistic lighting model especially for the application in the area of technical illustration. In Gooch et al. (1999) this work is extended to allow for interactive illustration of technical models. Emphasis is placed on using non-photorealistic techniques for highlighting the shape of objects for better recognition rather than displaying them as they would appear when photographed. For a comprehensive survey of these and other non-photorealistic styles see Strothotte and Schlechtweg (2002). A system that allows for easy combination of photorealism as well as various non-photorealistic styles has been demonstrated by Halper et al. (2002). It is mainly intended for designers and makes the assembly of different rendering styles as easy as possible so that the designer does not have to know details about the technical background.

3. ARCHITECTURE

Figure 1 shows a client/server architecture to be used for the generation of presentations enriched by hybrid rendering styles. The client is used as the interface to the user. It is responsible for the implementation of individual presentation techniques. The server holds

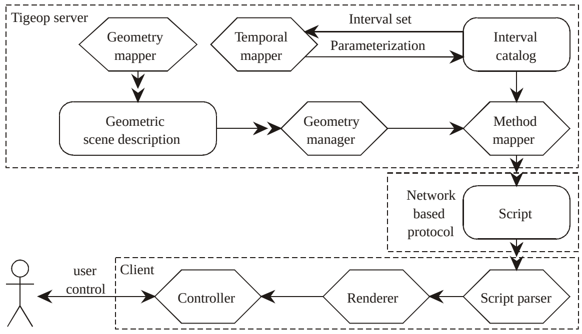

Figure 1. Overview of the TIGEOP-based client/ server architecture for hybrid presentation systems.

responsible for the mapping of geometry as well as the (semi-automatically) construction of an XML script controlling temporal operation of all rendering styles. Both client and server do not necessarily need to reside on the same physical computer. Communication is done by use of a TCP/IP-based protocol. In the figure, hexagons represent active architecture components whereas storing components (databases, scripts, or internal data structures) are represented by rounded boxes. The double-arrows indicate flow of physical data (files, scripts, database content) whereas single-arrows are used for flow of internal data.

The application-dependent server component is the geometry mapper. It is the source of geometry definition and therefore providing the overall scene context. The design of this component is formally based on the work presented by Kreuseler and Schumann (2002). Their model was developed in the context of Visual Data Mining. But its general nature allows for applications in other domains as well. In principle, the model is based on the definition of *information objects* IO_i that combine to an *information space* $\mathbf{IM} = \{IO_1, \ldots, IO_n\}$ with $IO_i = IO_j \Leftrightarrow i = j$ and $i, j, n \in N$. Each information object represents some real world data. In order to parameterize these objects according to their represented data characteristics, an attribute function *attr* is provided: $\mathbf{AM} = attr(\{IO_1, IO_2, \ldots, IO_n\}) = \{A_1, A_2, \ldots, A_k\}$ with $A_i = A_j \Leftrightarrow i = j$ and $i, j, k, n \in \mathrm{N}$. Thereby, **AM** is the *attribute set* of the respective information objects. For the purpose of defining relations between IO_i the *information structure* **IS** is introduced as $\mathbf{IS} \subseteq \mathbf{IM} \times \mathbf{IM}$.

Specific model instances for the mapper are to be constructed semi-automatically. The information space **IM** is either pre-modeled or generated by executing a user defined visualization pipeline. Creation of any possible IO_i as well as the setup and modification of attribute sets is based on a user controlled presentation description as outlined in the following two sections. Examples of specific instances of this model are presented in Section 5.

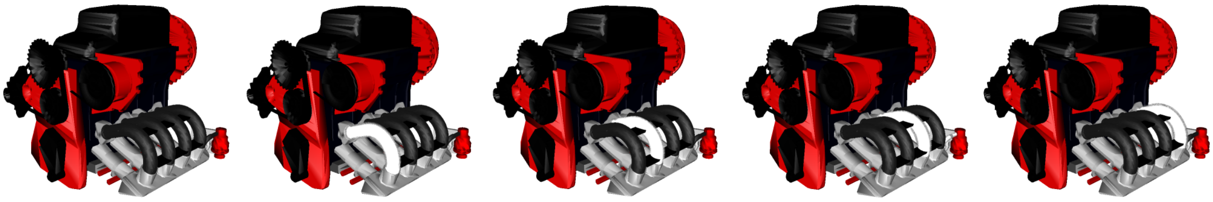

Figure 2. Emphasis of correlating parts of an engine model. The raw model is shown to the left whereas the remaining images show the appliance of NPR rendering style to the individual tubes of the engine.

4. SCHEMA

This section presents the definition of an XML Schema for modeling the presentation of any geometry using hybrid rendering styles. The schema is named TIGEOP which is short for *temporally influenced geometry presentation*. XML is used as it allows for streaming support, object orientation, and therefore generality in appliance for a maximum number of application domains. An example of a potential application besides the one presented in this work is a workbench for information fusion such as the one presented by Dunemann et al. (2002). The schema is presented in detail by Jesse (2003) and allows for easy reuse and verification of the model basis. As it exclusively uses the XML Schema facilities as defined by the W3C[1] its content structure follows a well defined standard and is of self-documenting nature. Individual types of the schema represent direct mappings of the formal notations presented in Section 3. A document consists of a set of presentation methods (rendering styles), the geometric scene data, and a sequence of object presentation definitions. A *string* type for the geometry definition is to be interpreted as containing a scene graph in Open Inventor format.

Presentation methods bridge between the attribute set **AM** of Kreuseler and Schumann's framework as outlined in the previous section and a set *M* representing all currently defined rendering styles (methods). Attributes for the individual methods are defined as *methodProperties*. Their content model is empty. Therefore, the *property* element for each *presentation method* conveys both the name and the value of a specific method attribute. Depending on the content of these attributes in a document instance, its resulting rendering is to be interpreted as producing either photorealistic or non-photorealistic image components.

The heart of a document in regard to temporal modeling of hybrid rendering styles is the definition of object presentations. These presentations represent the evaluation of individual rendering styles at defined time points for given durations. The temporal dependencies conform to the above algebra definition. Similar to the method properties mentioned above, the content model for an object's *present* description is empty which results in all parameters being specified as element attributes.

5. APPLICATIONS

For the purpose of showing the applicability of the presented methods, this section presents two distinct and exemplary application domains making use of hybrid rendering styles. The first deals with the presentation of a pre-modeled geometric object, the second is about a modified information mural for visualisation of climate data.

Highlighting parts of a geometric model

The interactive exploration of geometric models requires a set of highlighting techniques which is as rich as possible. Various emphasizing methods have already been developed (Ritter et al., 2001). The use of hybrid rendering styles adds another option to this list whereby specific model parts can be highlighted by presenting them in another rendering style as the remaining parts of the model. An example is the changing use of an NPR style for the tube parts of a geometric engine model. The highlighting is done consecutively for all tubes according to starting time stamps and durations as specified by a presentation description as outlined in the previous section. Snapshots of the presentation are shown in Figure 2.

Enhancing an information mural for climate data visualization

The use of an information mural (Jerding and Stasko, 1998) for visualization of climate data is documented by Jesse (2002). Therein, the geometry mapping framework presented in Section 3 is used as well. Creation of the information objects IO_i correlates directly to daily weather data as generated by ClimGen[2]. The initial attribute set **AM** is created automatically depending on data dimensions such as temperature and precipitation. Figure 3 shows snapshots of the mural based on a TIGEOP presentation description The left part of the figure shows the realistically raw information mural as it is initially generated by the geometry mapper. The use of a non-photorealistic rendering

[1] Information about XML Schema, tools, and documentation is available at http://www.w3.org/XML/Schema.

[2] More information about ClimGen, its availability, and a comparison compendium of ClimGen and other climate data generators is available at http://c100.bsyse.wsu.edu/climgen/. For information about why the program is used at all, see Jesse (2002).

style for the purpose of presenting the information objects possibly referring to data sets with the highest variation range of temperature and precipitation values is displayed in the right part of the figure. For the example presented, this is the day before the last.

6. CONCLUSION

The presented work shows that hybrid rendering styles can be used to extend the set of available presentation variables for visualization systems. The combination of photorealistic and non-photorealistic techniques has been shown. The presented XML Schema provides a formalism to express syntactic, structural, and value constraints to any document instances and, therefore, to the description of temporally enhanced geometry presentation. An architecture of a flexible framework for implementing presentations by use of hybrid rendering is introduced. This architecture is open to a wide range of potential application domains. Two exemplary applications show the presentation of pre-modeled geometry as well as for the presentation of the result of a geometry mapping process typical for information visualization tasks.

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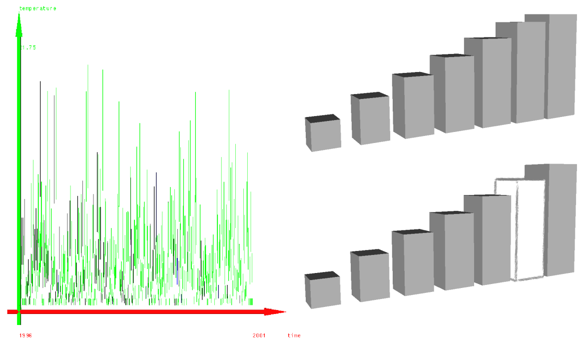

Figure 3. Enhancing an information mural presentation with NPR. The raw mural without special emphasis is shown left; the right side shows a zoomed in view on selected information objects.

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