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Generating virtual environments of real world facilities: Discussing four different approaches

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ABSTRACT

There is an increasing need to generate detailed real-time virtual environments that closely mimic real world facilities. Approaches for the generation of virtual environments can be manual, automatic, or hybrid. Manual approaches are time consuming, inaccurate, and coarse whereas automatically generated data sets are less than optimal for practical use within real-time virtual environments because of the huge unstructured amount of data. Therefore, common approaches are most likely to have a balance between human and computer effort. Based on different projects, we discuss possible distributions of manual and automatic methods for the generation of 3D virtual environments. We present different facets of the pipeline from initial data gathering up to the final deliverable. The approaches employed in these projects vary from fully hand made up to semi-automatic reconstruction of the environments. The paper concludes with recommendations regarding the reconstruction methods.

1. Introduction

There is an increase in use of 3D virtual environments in architecture, engineering, and construction (AEC) industries. Applications like virtual training environments, virtual prototyping of designs, and joint virtual development of information systems require a valid representation of the real environment. Often, the real environments are industrial facilities such as oil rigs, container terminals, or manufacturing plants.

There is no single reason why 3D virtual environments are increasingly popular, but drivers stem from multiple backgrounds. Advantages of 3D virtual environments are found in improving communication [1], increasing insight [17,23], supporting collaboration [4], and supporting decision-making [13]. The divergence in applications requires different levels of fidelities of the 3D virtual environment. This can be illustrated by the different levels of fidelity required in the design process of a manufacturing plant. Designing the plant is mostly done in a 3D environment with high precision. The design drawings are complex, show different layers (e.g. mechanical, electrical, and plumbing), and therefore become hard to understand. On the contrary, for the presentation of the final result to stakeholders, a 3D visualization with a reduced level of complexity is preferred. The 3D visualization can be used as a platform for shared understanding to be used by every stakeholder involved in the design process. The different types of visualizations, both in 2D and 3D, achieve different types of fidelity for each specific goal.

1.1. Realism in 3D virtual environments

According to Webster's dictionary, “fidelity” means the accuracy in details. Fidelity is the general term for the way in which a model is a valid representation of a reference system; 3D modelers tend to use the term “realism,” as their reference system is the real world, i.e. the real industrial facility. Ferwerda [8] distinguishes three varieties of realism in computer graphics: physical realism, photorealism, and functional realism. For each type of realism, there is a criterion which needs to be met in order to achieve that type of realism.

Physical realism is achieved when computer graphics provide the same visual stimulation as reality. This type of realism means that “the image has to be an accurate point-by-point representation of the spectral irradiance values at a particular viewpoint in the scene.” It requires an accurate description of the scene, simulation of the spectral and intensive properties of light energy, and reproduction of those energies by the display device. Technically this type of realism is the hardest one to achieve. Although this aspect is often ignored for models that have to be visually appealing, it might become essential in 3D virtual environments for future uses. In this paper, physical realism is ignored.

Photorealism in a virtual scene provides the same visual response as the real scene. It aims at displaying an image indistinguishable from a photograph of the real scene. Although achieving photorealism has primarily been a task for off-line rendering algorithms (such as

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