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Empiric design evaluation in urban planning

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ABSTRACT

We propose a system to simulate, analyze and visualize occupant behavior in urban environments by combining parametric modeling and agent-based simulation. A procedurally generated 3D city model, with semantic information about the functions and behaviors of buildings, is automatically populated with artificial agents (i.e. pedestrians, cars, and public transport vehicles). In a simulation the built environment and the agents interact with each other. The system identifies empiric correlations between properties such as: functions of buildings and other urban elements, population density, utilization and capacity of the public transport network, and congestion effect on the street network. Practical applications include the assessment of a) bottlenecks, b) public transit efficiency, c) accessibility of amenities, d) quality of service of public transport and the traffic network, as well as e) the stress level and exhaustion of pedestrians. All these aspects ultimately relate to the quality of life within the given urban areas.

1. Introduction

The majority of the world population already lives and works in cities [30]. This influx of new residence puts a lot of pressure on the existing infrastructure, and on the planning of new and the upgrade of existing areas of cities. Cities, like Laos, cannot keep up with building the necessary infrastructure, with the consequence that the quality of life remains insufficient in general. This is partially confirmed by the level of stress experienced by citizens when compared to rural inhabitants. Even though inhabitants of cities are consuming less energy than rural dwellers [40], cities still consume too much energy, produce too much waste and emit too much CO_2 for a sustainable way of living. As a result, we are facing the unprecedented challenge of simultaneously improving the quality of life and sustainability of cities.

Sustainability and quality of life are both complex matters that depend on numerous other, sometimes conflicting, aspects. In the last century, urban planning patterns put emphasis on path and network optimization for motorized traffic and made drastic changes to the structure of the city. These changes not only impact traffic, they also change the allocation of amenities, land price etc. Adjusting one aspect of the city has an influence on different other equilibriums within the city. It has become clear that optimizing the urban layout for pedestrians has a positive effect on the sustainability of the urban environment and the quality of life of its citizens. A shift in the mindset has thus been taking place, with the human perspective shifting into the focus of attention. Taking the interests of pedestrians at heart, we present a robust and efficient method for simulating and visualizing the related performance of different urban environment alternatives. This method combines crowd simulation with procedural city modeling techniques, thereby enabling: a) assessment of the impact of a given built environment on pedestrians, and b) efficient iterative analysis of different built environments. Such tools empower planners with the means to efficiently investigate subtle ways to adjust the urban fabric. Our automated method also offers added value for the entertainment industry. It delivers high quality output imagery through standard production pipelines and decreases the workload to generate the urban layouts. These are simulated as realistic urban environments inhabited by virtual occupants. Traditionally, costs and time needed to produce populated digital urban sets for movies or games are enormous.

The rest of the paper is organized as follows. Section 2 reviews related work in the field of city modeling and urban simulation, Section 3 presents the proposed system for the simulation of pedestrians within a city environment. We also assess the impact of the built environment on pedestrians, and vice versa. We introduce our city model in Section 4 and the semantic data in Section 5. How the city model and the semantic data are affecting the agents is described in Section 6 and the in depth study of their agents is in Section 7. In Section 8 the performance of the proposed system is analyzed through three examples.

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