Simulation of Pedestrian Behavior in Intermodal Facilities

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ABSTRACT

Planning pedestrian environments requires that designers understand how pedestrians interact with their environment and one another. With improved knowledge, the design and planning of pedestrian areas can provide improvements in safety, throughput, and utility. This paper provides an overview of the Intermodal Simulator for the Analysis of Pedestrian Traffic (ISAPT). It focuses on the methodologies used in simulation of the pedestrian traffic, including route planning and navigation. Several illustrations of the system’s ability to reproduce observed crowd behavior are provided.

Keywords: Activity Scheduling, Intermodal Simulator for the Analysis of Pedestrian Traffic (ISAPT), Pedestrian Navigation Behavior, Pedestrian Traffic Simulation, Route Choice

1. INTRODUCTION

Capturing realistic pedestrian behavior in simulation is useful for evaluation and planning in building design (Daamen et al., 2001), urban design (Jiang, 1999), design of the area around an outside memorial (Monteleone et al., 2008), land use (Parker et al., 2003), marketing (Borgers & Timmermans, 1986), facility operational assessment (Daamen et al., 2009) and city wide regional planning (Raney et al., 2002).

The goal of our research is to develop a system that can be used as an aid for designers and planners in the evaluation and operation of intermodal facilities. The design of these facilities is often based on “rules of thumb” gained over the years from experience in the observation of operations within similar facilities. It is believed that the availability of a simulation system that can realistically model the behavior of pedestrians and crowds will permit the exploration and discovery of new guidelines for design and operations planning, while providing a scientific basis to support existing rules recognized as valid over the years.

When planning pedestrian environments it is necessary that designers take into consideration how pedestrians will respond to their environment as they navigate in order to complete their individual and sometimes joint missions. This poses unique challenges, given the crowd of persons simultaneously navigat-
ing towards specific destinations for various purposes. Some may be in a hurry to get to a particular location, while others are visiting intermediate points primarily to occupy time prior to reaching their intended goal. As crowd density increases, the path a person takes to reach their destination becomes convoluted as they may be required to make numerous divergences in their journey while navigating the crowds. In general, the environment is one that is highly dynamic.

Route planning and navigation are somewhat instinctive abilities for humans, but simulating this capability in a virtual environment is no easy task; it has likewise been of interest to researchers for nearly a decade. This paper provides an overview of the Intermodal Simulator for the Analysis of Pedestrian Traffic (ISAPT). The ISAPT system functions as a simulation tool to evaluate the influence of the architectural design and layout of new and existing intermodal facilities on pedestrian traffic within large-scale structures. The system models each pedestrian’s behavior individually, while the collective behavior of the crowd is allowed to emerge from the interactions that take place between individuals. In the sections that follow, the operation of the ISAPT system is discussed, providing some background on the functionality and methodologies employed by its pedestrian simulation model.

2. ISAPT SYSTEM

Broadly speaking, ISAPT is designed to simulate pedestrian traffic within a facility taking into account the diversity one might find in such a facility in terms of pedestrian characteristics, along with their specific trip plans. The system can generate variable pedestrian populations exhibiting specific traits at multiple entry points within that facility. Each pedestrian enters the system with a set of objectives in mind (e.g., reach departure gate by 1:30 pm) and a tentative plan (agenda) to meet them being provided with the means to utilize one or more of multiple resources located throughout the facility (e.g., ticketing, restaurants, restrooms, etc.). While in transit a pedestrian is able to dynamically re-plan, altering their route based on the environmental conditions that exist (e.g., long queues at the restaurant). When the pedestrian reaches their final departure point they may proceed to exit the system. As pedestrians move about the facility carrying out their agendas, individual statistics are collected with respect to their utilization of resources and the paths they follow.

3. PEDESTRIAN DEFINITION

In order to enable planning, routing, and navigation capabilities, ISAPT represents pedestrians within the system as individual agents, each of which is defined in terms of their agenda, individual attributes, navigation capabilities and preferences, current state(s), and simulation event history (see Figure 1). Their individual attributes include physical characteristics such as gender, age, size, and mobility, as well as navigation capabilities and preferences that affect their behavior, defining preferred and maximum speeds as well as navigation space and lead time preferences. The system allows the user to either directly generate attribute values for each pedestrian according to a stated distribution, or to rely on a predefined function that assigns values based on the pedestrian’s gender, age, size and so on. Both the personal space preference (comfort zone) and reaction lead time of a pedestrian, for example, influence collision detection and avoidance response. A pedestrian’s situational awareness can affect movement choices based on environmental factors, crowd dynamics, the individual’s preference, and whether they are in a hurry or not. A specified lead time affects their look-ahead distance based on the pedestrian’s current speed, adding to the distance upcoming obstacles will be scanned for. Although these
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