Combining Activity Scheduling and Path Planning to Populate Virtual Cities

(Extended Abstract)

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ABSTRACT

When navigating in a city, the organisation of daily activities is strongly interrelated with the choice of a path between the places where these activities can be performed. Most of existing crowd simulation models relies either on scripted behaviours or on decision models in which path planning and activity scheduling are computed separately. In this paper, we propose a model combining path planning and task scheduling into a single process. This process takes spatial and temporal constraints into account, as well as agents' personal preferences. It produces a path in the city, associated with a time-constrained arrangement of tasks to perform. This model allows us to credibly populate virtual cities with agents performing consistent individual activities.

Categories and Subject Descriptors

I.6.8 [**Simulation and Modelling**]: Types of Simulation : Animation

General Terms

Algorithms

Keywords

Agent-based simulations::Simulation techniques, tools and environments
Virtual Agents::Virtual character modelling and animation in games, education, training, and virtual environments

1. INTRODUCTION

Flows of people in cities are complex phenomena: densities and directions are strongly dependent on the place, day and time. As pointed out in [5], these flows emerge from the combination of individual paths. At a microscopic level, these paths depend on the tasks each individual performs in the city. The organization of these tasks over the day relies on a complex process taking into account the environment topology, the nature of navigation zones and buildings as well as personal preferences. This makes path planning and activity modelling strongly interrelated processes. However, in most existing crowd simulation models, these processes are not directly linked. Indeed, macroscopic approaches tend to model crowds as global systems in which individual activities are not accounted for [1, 2]. Most of microscopic approaches rely on a scripted reactive behaviour [7]. Although some approaches focused on activity-driven navigation, they either rely on high-level information on the environment [6] or do not handle long-term planning [5]. In this article, we propose a model relying on a multi-criteria planning algorithm that combines path planning and activity scheduling. In this model, each pedestrian is given time and space constrained tasks to perform as well as personal preferences. Based on this information and on an informed environment, our planning algorithm produces a path and an arrangement of tasks that each pedestrian should perform at the computed time and place. In the next section, we give a quick overview of this model and the associated planning algorithm and present the obtained results.

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2. MODEL OVERVIEW

Flows of pedestrians in cities are the sum of individual paths. For a given individual, this path is highly dependent on the city topology, on the tasks he has to perform and on his personal preferences. In order to produce consistent individual paths, it is essential to model these properties which are the inputs of the proposed planning algorithm.

2.1 The agent and his environment

In order to represent the environment topology and nature, as well as the task that can be performed in it, we use an informed environment [8]. We extract a planning graph from a Delaunay triangulation of the environment's 3D model [4, 3]. In this graph, nodes represent crossroads and places of interest (shops, homes, schools. . .) while transitions represent path between these places. This graph is labelled with the nature of navigation zones (road, pedestrian area, zebra. . .). For each task that can be performed at a given place, a loop edge is added to the corresponding node in the graph, labelled with the task identifier, as seen in Fig. 1.b. Each of these tasks is also informed with duration and cost functions, as well as time constraints (shops open hours. . .). The navigation behaviour of an individual is driven by his activity in the city. In order to represent different tasks arrangements (with partial orders and variations), the activity is modelled with an acyclic oriented graph (see

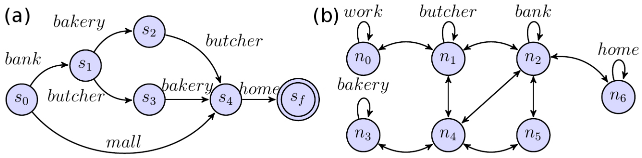

Figure 1: (a) Activity graph (b) Planning graph

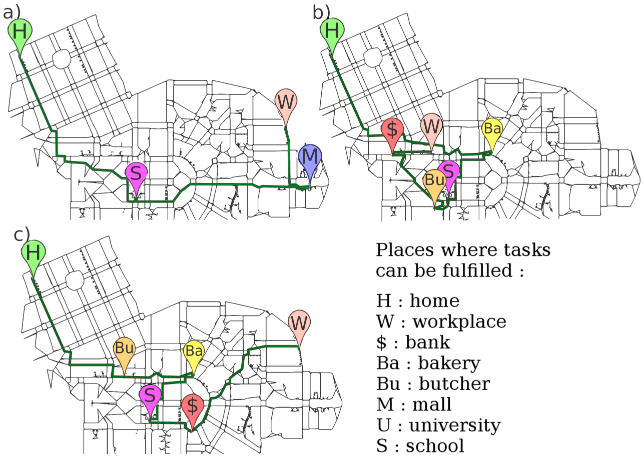

Figure 2: (a) Reference path (b) With different workplace (c) With different work leaving time

Fig. 1.a). Nodes represent the different situations in which the agent can be (having money but no bread...). Transitions represent the tasks allowing situation changes. A path inside this graph describes a suitable task arrangement realizing the associated activity. Some tasks have to be performed in specific places (one does not go to any workplace, but to the one where he works) or at specific times (appointments). To model this, spatial and temporal constraints can be added to the tasks. Variability between planned paths is very important for credibility. To ensure this variability, each agent is embedded with some personal parameters: an activity graph constrained with specific times and places, a set of possible paces and preference factors, personal preferences on navigation areas, places and tasks.

2.2 Combined planning process

Our planning process explores a 4 dimensions planning space. These dimensions are the positions in the planning graph, the situations in the activity graph, the time and the pace of the agent. We use an altered A* algorithm to plan a path that fulfils spatial and temporal constraints while optimizing personal preferences. The computed path is labelled with paces, and contains a valid arrangement of tasks that must be performed at the given place and time.

2.3 Results

In order to test our model, we planned multiple paths in a virtual city using slightly different parameters. Fig. 2.a shows a path planned for a pedestrian leaving work at 4.10 pm, having to buy food (see Fig. 1.a) and pick up his child at school at a 4.30 pm before getting back home. Other paths are planned with same parameters but on Figure 2.b, a different workplace was assigned to the agent and on Figure 2.c, the agent was set up to leave work at 4.20 pm. In both cases, not only different path were planned, but the chosen arrangement of tasks was also different. This demonstrates how our model combines activity scheduling and path planning in order to produce consistent paths in the city. We used this model to populate a virtual city with 5000 virtual pedestrians embedded with 6 different activities and randomly generated personal parameters. The result is a crowd in which each individual follows a consistent path. Credible flows and densities can be observed and automatically emerge from our model (see Fig. 3).

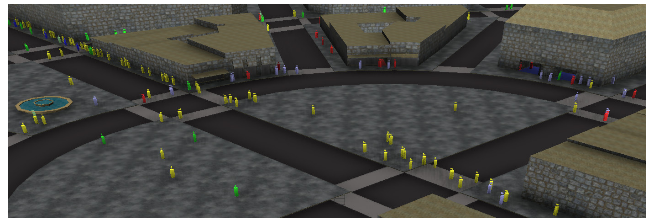

Figure 3: Example of a generated population.

3. CONCLUSION

We proposed an original approach to credibly populate virtual environments. This approach is based on a planner that combines path planning and activity scheduling, while automatically selecting the best locations where activities can be performed. It also handles spatial and temporal constraints as well as agent personal preferences relating to navigation zones, tasks and paces. Based on those properties, credible emergent phenomenon such as variations in crowd density and distribution during a day can be observed.

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