1 Introduction

Computer generated crowds can be found in films, commercials, computer games and other virtual environment applications. Usually, crowd simulation techniques, such as [Treuille et al. 2006; Lerner et al. 2007] focus on controlling the direction and speed of the simulated agents, aiming at generating realistic crowds at the trajectory level. In principle, if the simulated paths reflect paths taken by real people, then the agents would appear to behave correctly. However, the definition of behavior does not end at the trajectory level. It can be defined as the aggregate actions of a person to internal or external stimuli. Talking to nearby people, or glancing at something of interest are common actions performed by a person in a crowd. Actions such as these, which are often missing from simulated crowds, are vital for generating seemingly natural behaviors. Ideally, actions should be generated by the crowd simulation algorithm itself. However, in order to enrich existing simulations, one can examine its output, deduce the stimuli of each simulated agent in the scene and assign plausible actions that are compatible with their trajectory. In this sketch we describe a technique for adding behavior information to simulated crowds as can be seen in the accompanying video.

2 Behavior-Graph

A person decides to act in a certain manner as a response to internal and external stimuli. The internal stimulus can often be inferred from the actions that the person performed in the recent past along with his trajectory. The external stimulus emanates from the people and objects surrounding him. Certain actions, such as looking at an approaching person, require the presence of internal stimulus, while other actions, such as looking at ones feet, do not. Since most crowd simulation techniques do not provide, as part of their output, group information, we can use the surrounding configuration of people and objects to determine the existence, or lack of, external stimulus.

In a preprocessing stage, we extract information from a video of a crowd. The people in the video are tracked and their actions marked. In a typical crowd a person performs only a limited number of unique actions. From the markings in the video, we construct a Behavior-Graph. The graph encodes the observed actions as nodes and the transitions between actions as directed edges. When facing similar situations, people may act differently. We assume that for a given configuration of internal and external stimuli there exists a probability function over the actions that the person might perform. We associate each transition with a set of examples, representing the internal and external stimuli affecting the person in the video. The internal stimuli are represented by the agents history and the external by the surrounding configuration of people. Each example can be seen as a sample of the probability function for a certain stimuli configuration. Using the examples, we can approximate the probability function for any stimuli configuration.

During a simulation, each agent traverses the behavior-graph generating a plausible sequence of actions. The agent compares the configuration of its stimuli to that of the examples associated with the edges of its current behavior node. It approximates the probability function over the possible actions and randomly chooses an edge. The actions observed in the video do not cover the entire range of possible actions of a person in a crowd. Rather, they represent the behaviors of the people in the video. Therefore, it is possible to change the input video or add an additional video in order to generate different behaviors for the same simulated agents.

3 Preliminary Results

Given the continuous nature of the results we refer the reader to the accompanying video. We implemented the technique and used a five minute video of a sparse crowd for generating the behavior-graph. We used the crowd simulation of [Lerner et al. 2007], to generate trajectories over which we added the behavior information. As can be seen in the video, plausible behaviors are assigned to the simulated agents enriching the simulation. Actions, such as people speaking on the phone when they are standing or looking at other people while walking are common in the resulting simulation.

References
