Interactive and Adaptive Data-Driven Crowd Simulation: User Study

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Abstract

We present an adaptive data-driven algorithm for interactive crowd simulation. Our approach combines realistic trajectory behaviors extracted from videos with synthetic multi-agent algorithms to generate plausible simulations. We use statistical techniques to compute the movement patterns and motion dynamics from noisy 2D trajectories extracted from crowd videos. These learned pedestrian dynamic characteristics are used to generate collision-free trajectories of virtual pedestrians in slightly different environments or situations. The overall approach is robust and can generate perceptually realistic crowd movements at interactive rates in dynamic environments. We also present results from preliminary user studies that evaluate the trajectory behaviors generated by our algorithm.

1 Introduction

Crowd simulation has received considerable attention in virtual reality (VR), games, computer-aided design, and robotics. Some of the driving applications include training of law enforcement officials or military personnel [6], virtual reality therapy for crowd phobias [5], investigation of pathological processes in mental disorders [2], pedestrian flow analysis of architectural models and urban layouts, etc. In these applications, one of the goals is to generate realistic crowd movements or emerging behaviors in the background, while the user is immersed in the scene and performing certain tasks.

Many researchers have advocated use of data-driven or example-based crowd simulation algorithms to generate realistic crowd behaviors. Their emergence grows out of the increasing availability of real-world examples of individual humans and crowds movements, driven in part by improvements in high-resolution cameras and motion-capture systems that can be used to generate large databases on real world crowd data [4, 3]. Moreover, advances in computer vision and tracking algorithms have made it possible to extract pedestrian trajectories at interactive rates and use them for data-driven crowd simulation [1]. However, current methods are limited to generating 2D trajectories and cannot handle any changes in the environment or simulate different trajectory behaviors from those observed in the videos.

Main Results: In this paper, we present a new crowd simulation approach that combines the realism of data-driven methods with the adaptation and interactivity of synthetic multi-agent techniques. We capture the motion characteristics of pedestrians by learning the movement patterns and motion dynamics from extracted 2D trajectories. These characteristics are represented as time-varying pedestrian dynamics and used to generate crowd movements in virtual environments that are similar to those observed in real-world videos. The overall approach is automatic, involves no user editing, and can be used for interactive crowd simulations in dynamic environments. We have implemented our approach and tested it on several indoor and outdoor scenarios with varying pedestrian movement patterns, using trajectory data from a variety of crowd videos. The original videos of these scenes have tens of real-world pedestrians, and we are able to generate adaptive data-driven simulations with tens or hundreds of pedestrians in slightly different environments or situations. We also evaluated the benefits of our approach for virtual environments by performing two user-studies. Our preliminary results indicate that use of data-driven pedestrian dynamics results in realistic crowd trajectory behaviors.

Figure 1: **Interactive Crowd Simulation:** Our adaptive data-driven algorithm can generate realistic crowd trajectory behaviors of a large number of agents at interactive rates. The pedestrian dynamics and movement characteristics are captured from real-world trajectory data. Our approach can adapt the simulation to a dynamic environment.

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