ABSTRACT

MODELING REALISTIC HIGH DENSITY AUTONOMOUS AGENT CROWD MOVEMENT: SOCIAL FORCES, COMMUNICATION, ROLES AND PSYCHOLOGICAL INFLUENCES

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The simulation of realistic, large, dense crowds of autonomous agents is still a challenge for the computer graphics community. Typical approaches either look like particle simulations (where agents 'vibrate' back and forth) or are conservative in the range of motion possible (agents aren't allowed to 'push' each other). Our HiDAC system (High Density Autonomous Crowds) focuses on the problem of simulating the local motion behaviors of crowds moving in a natural manner within dynamically changing virtual environments. This is achieved by applying a combination of psychological and geometrical rules layered on top of a social forces model. The results show: elimination of agent 'shaking' behavior, fast perception, and a wide variety of emergent behaviors including: bi-directional flows, overtaking, emergent queuing with different line widths, agents being 'pushed' and 'falling', and panic propagation. These behaviors emerge based on the current situation, agent personality and perceived density of the crowd.

To accurately simulate crowds in large, complex environments, it is not enough to only model local motion; agents must also have the ability to navigate the unknown virtual environment. We therefore address the problems that arise during crowd navigation where not all individuals have complete knowledge of the building's internal structure. In addition, we simulate the effects of communication on the behavior of autonomous agents while exploring the building. We have developed a system called MACES (Multi-Agent Communication for Evacuation Simulation) which combines local motion with wayfinding using inter-agent communication and

different roles. Together they automatically augment an agent's mental map of the environment to produce empirically better maze evacuation performance.

We study the emergent behavior during building evacuation under different conditions such as agents using communication to share their knowledge of the building routes and hazards, psychological factors driving different navigation skills, and agents taking different roles such as trained personnel, leaders and followers. The experimental results show significant improvements in evacuation rates with inter-agent communication and demonstrate that only a relatively small percentage of trained leaders yield evacuation rates comparable to the case where all are trained.

The framework presented in this dissertation combines decision making, including communication and roles (MACES), with local motion (HiDAC). The two systems interact in real-time while being driven by a set of psychological and physiological parameters that allow the user to have control over the final behavior exhibited by the crowd.