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We are delighted to introduce this book *Simulating Heterogeneous Crowds with Interactive Behaviors*. This book project started after a Eurographics Tutorial, which the editors organized in 2014. The original tutorial was extended by inviting renowned researchers in the crowd simulation field to contribute their latest work to the book.

Although many of the topics covered in this book already appear in published papers, they are spread over many different journals and conferences. This volume consolidates in one place many of those fundamental topics and approaches that are important when trying to simulate crowds that demonstrate a certain level of heterogeneity.

This book is divided into four major sections: navigation and steering, editing and realism, evaluation, and applications.

The chapters on navigation and steering introduce a variety of methods that have been used over the past decade to move groups of virtual people toward individual goals while avoiding collisions between agents and with the environment. Some of the methods described in the first chapter include a variety of parameters that can help introduce heterogeneity in the crowd. In order to have agents navigating complex or large spaces, steering alone is not enough; the second chapter gives an overview of methods that can create abstract representations of the environments to perform higher-level tasks such as path finding. Finally, in order to enhance heterogeneity, the third chapter introduces methods for data-driven simulation that exploit heterogeneity in behaviors extracted from examples in the real world.

In the second section, editing and realism play a role in providing some control over the final look of the simulation. For example, we may want to observe certain formations among agent groups, or have specific densities or flows in different parts of the environment. In order to achieve heterogeneity, it is important to explore effective methods for editing and authoring in order to allow the user to orchestrate overall crowd movement. For example, crowds may have a global “personality,” which is evident in their collective behavioral choices. The inclusion of models of personality and emotion to drive the simulation can also greatly enhance realism and heterogeneity. For realism and rendering speed, one chapter provides an overview of graphics display techniques, focusing on two methods that are based on graphical impostors per body part. These techniques enhance the overall realism of the crowd by adding variety in appearance.

One of the most important issues when doing research in crowd simulation is addressed in the third section on evaluation. Here, we cover a number of methods for performing quantitative evaluation of crowds in terms of measurable features such as densities or flows. Evaluation may also compare simulations with agent decisions based on available real data.

Finally, the fourth section of this volume documents some examples of applications where crowd simulation is required. The first chapter in this section provides a very entertaining view of how this field has evolved in the animation industry from a Pixar point of view. The second chapter covers a completely different industrial and societally important application in safety and evacuation dynamics.

The editors of this book have made notable contributions to and have a comprehensive history in the crowd simulation research field. Norman Badler became interested in computational modeling of humans and their movements in the mid-1970s as he was completing
his PhD dissertation at the University of Toronto. After taking an academic position at the University of Pennsylvania, he worked with a variety of geometric and animation methods for human modeling. Eventually, he and his students developed an interactive human software system for ergonomic applications: “Jack.” After successfully spinning this software to a start-up, he began to look into animating groups of virtual human models. The primary drivers of these investigations were Jan Allbeck and Nuria Pelechano. Allbeck was particularly interested in agent heterogeneity, action variety, scheduling, and reactive behaviors. Pelechano examined agent communication, high-density crowds, and geometric extensions to social forces models. Their achievements were documented in the 2008 book Virtual Crowds: Methods, Simulation, and Control. Subsequently, Mubbasir Kapadia became a postdoctoral researcher for 2 years in Badler’s Center for Human Modeling and Simulation at Penn and produced considerable new approaches to various issues in human crowd simulation ranging from steering behaviors to story-telling planning systems.

Nuria Pelechano continued her work with Allbeck and Badler during her postdoc to explore the field of presence for the evaluation of crowd simulation methods, as an alternative to the quantitative approaches presented in this book. They also investigated the inclusion of psychological models to add heterogeneity into the overall simulation. In 2007, Pelechano joined the Universitat Politècnica de Catalunya, and since then she has been working on developing rendering techniques that can handle a variety of animations for crowds in real time. Part of her recent work in collaboration with Kapadia and Badler has focused on animation techniques to accurately following footstep trajectories and simulation of groups of agents with different granularities.

Jan Allbeck’s interest since joining George Mason University has focused on developing purposeful agents. Allbeck and her students have looked at ways to increase virtual human’s understanding of their environment, including attention and memory models and most recently automated generation of action and object semantics.

After his postdoctorate, Mubbasir Kapadia joined the animation group at Disney Research, Zurich. Since 2015, Kapadia is an assistant professor at Rutgers University where he conducts research in humanoid character animation, crowd simulation, and digital storytelling.

It is the editors’ collective hope that this volume will continue to motivate research and applications in heterogeneous crowd simulation. Realistic spatial environments supporting real-life situations and populated by multiple individuals have been an inspiration to us. We hope you will find them just as fascinating.
Editors

Nuria Pelechano is an associate professor at the Universitat Politècnica de Catalunya. She earned a BS in computer science engineering at the Universitat de València in 2001, an MSc at the University College London in 2002, and a PhD at the University of Pennsylvania (UPenn) in 2006 as a Fulbright Scholar, under the supervision of Professor Norman I. Badler. During her postdoc, she worked at the Architecture Department at UPenn in technology transfer projects on crowd evacuation. She is a coauthor of two books on virtual crowds with Morgan & Claypool Publishers (2008 and 2015). She has over 35 publications in journals and international conferences on computer graphics and animation, and she has also been a reviewer for many conferences and journals. She has participated in projects funded by the EU, the Spanish government, and U.S. institutions. Her research interests include simulation, animation, and rendering of crowds, generation of navigation meshes, real-time 3D graphics, and human–avatar interaction in virtual environments.

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