Crowd Simulation

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(Daniel)
To my beloved wife Nadia and beloved daughters Melanie, Vanessa, and Sabrina

(Soraia)
To my daughter Marina, parents Iara (in loving memory) and Eduardo, who made me understand how simple things can be.

Preface

This book surveys algorithms and techniques of crowd simulation, and is intended for graduate students, researchers, and professionals. In particular, computer animation researchers, developers, designers, and urban planners will greatly benefit from this book.

In 1996, when the authors started researching into crowd simulation, there was very little material available on crowd simulation in the Computer Science literature. Daniel Thalmann supervised Soraia Raupp Musse PhD thesis in 1997 and since then they have jointly published more than 40 papers in the domain. There has since been significant research in this area and many techniques have been developed, with the entertainment industry in particular realising the potential of crowd animation. As a result, many other research groups have also started working in the area. As early pioneers in this research, the authors organized the first workshop on Crowd Simulation (V-Crowds) in 2005 in Lausanne. But why is this subject so fascinating?

Aggregated motion is both *beautiful* and *complex* to contemplate. *Beautiful* due to the synchronisation, homogeneity and unity described in this type of motion, and *complex* because there are many parameters to be handled in order to provide these characteristics. History shows that there has always been interest in understanding and controlling the motion and behaviour of crowds of people. Psychologists and sociologists have studied the behaviours of groups of people for several years, primarily to study the effects that occur when people with the same goal become one entity – a crowd or a mass. When this happens, people can lose their individuality and adopt the behaviour of the crowd entity, behaving in a different way than if they were alone.

Certain problems arise only when studying crowds. For instance, collision avoidance problems related to a large number of individuals in the same place require different strategies in comparison with the methods used to avoid collision between individuals. Also, motion planning used in a group that walks together requires more information than that needed to implement individual motion planning. The trajectories computed for agents who are part of the same group and walk together with similar speeds have to be different even when they share the same environment and goals.

Moreover, a crowd is not only a large group of individuals, but can also be formed by groups which in turn are related to individuals. In addition other levels of behaviour can exist when treating crowds in this hierarchical structure. The group behaviours can be used to specify the way a group moves, behaves and acts in order to fit different group structures (flocking, following, repulsion, attraction, etc). Individual abilities can also be required in order to improve the autonomy and intelligence of crowds, for instance perception, emotional status, memory, communication, etc. However, when we consider thousands of individuals, these complex behaviours cannot be provided individually due to the hardware constraints and to computational time rates. A further problem relates to how to improve the intelligence and provide autonomy to scalable crowds, in real-time systems.

The simulation of large crowds in real time requires many instances of similar characters. We need algorithms to allow for each individual in the crowd to be unique. In this book we explain two methods: first, a simple and efficient way of attaching accessories to individuals in order to modify their look; and secondly, a new and generic technique based on segmentation maps to add detailed color variety and patterns to human meshes as well as to accessories. Both methods are scalable to suit all human levels of detail exploited in crowd simulations.

Depending on the application of crowds, other requirements may be needed. For instance real time simulations can be required in order to populate virtual environments in virtual reality systems. In order to provide a tool to simulate behavioural aspects of a crowd, social conventions of interrelationships are needed. Yet, accurate validations should be provided to simulate safety systems.

Some crowd requirements along with strategies and techniques that can be adopted to deal with these, are described in this book. Some of the topics presented are related to population modelling, virtual human animation, computer vision techniques focusing on crowd control and crowd rendering, and some applications are analysed.

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