Proposal for: A Comparison of Crowd Simulation Techniques

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October 31, 2012

1 Introduction.

In my project I intend to briefly explain what crowd simulations are and why they matters. Crowd simulation is the act of recreating crowds of people in a digital environment. I propose to take several crowd simulation models and compare them, based on a number of simple factors. The models I hope to use come from and potentially influence a variety of different fields, including: architecture analysis, evacuation simulation, crowd control, movie and game making, teaching and training. The goal of this comparison is to determine what models are most suited to what applications, and then use those specific results to create more general conclusions about model *type* applicability.

There are two primary reasons why I wish to undertake this project. Firstly there does not appear to be a great deal of literature available that explains the pros and cons of using certain simulation techniques in different scenarios. I would like to contribute to this limited literature, hopefully saving people time and effort in the future. It should be noted that literature does exist on this topic, however, the majority of it elaborates on individual models rather than on several. The second reason for performing this comparison is that there are so many potential benefits, in so many fields, to be gained from appropriate use of crowd simulations. In addition to the benefits of correct use, there are also potential problems that one can create by using an inappropriate model; an extreme example of this could be using a low end cellular automaton to predict real-time venue safety.

I hope to avoid coding these models myself, as most of the algorithms and software are already available on the internet. However in the event that a particular model is unavailable I will attempt to create it myself, unless said model would be too large or complex for my timeline to allow. In the event of too many models being unavailable an alternative method for comparison will be devised, perhaps deriving scores based entirely on related literature.

2 Models to Compare.

According to [1] there are three basic crowd simulation models, none of which deal with high-density crowds well. These are: cellular automata, rule-based models such as those described by [2, 3], and social forces models such as Helbing's model [4]. According to [1] these basic models all have drawbacks of some kind, some more than others. For example cellular automata show the grid that they are stored on when densities become high (this phenomenon is known as boxing), while agents in rule-based models are prone to limb clipping issues. For this reason I will also attempt to include both comparisons of several fundamental models as well as more advanced software models.

At present there are three 'advanced' models that I wish to investigate: Massive by Massive Software, MassMotion by Oasys Software and the HiDAC model developed by [1]. Hopefully there will be no trouble obtaining a copy of the HiDAC model as it is more academic than commercial. Massive and MassMotion on the however are expensive, which may prove to be problematic. My proposed solution to this potential problem is to investigate the models during any kind of trial period offered, alternatively I will find a friend or colleague with a copy that I can briefly use, once again if none of these options are possible the models will be investigated using a more literature based approach

Some potential alternative implementations of the fundamental models to compare include: Quinn's social forces model[5], the OpenSteer rule-based library[6], the Floor Field Cellular automaton model by Burstedde et al.[7] and others.

3 Method of Comparison.

My original proposal for comparing models was to take footage of various real world crowd situations; these situations would include high and low density crowds as well as panicked, rushed, and calm scenarios. The environments in these videos would then be recreated as accurately as possible in each model to be compared. Each model would then be populated with autonomous agents and run several times to ensure reliability of results.

Depending on which model is being used agents may or may not have custom placement abilities. When the model permits for custom agent placement the agents would be placed in a similar fashion to the initial state of the footage being compared against. In theory the initial placement of agents should not have a profound impact on the outcome of each simulation.

Once each scenario has been simulated in each model, the outcome of each simulation would be compared to the footage. A simulation that accurately re-creates the video will get higher marks for accuracy than a model that gives only a vaguely correct outcome.

This video comparison method would only be possible if copies of each model could be obtained, the alternative method for comparing and scoring models is as follows: Each model is given a score for several comparison factors (including accuracy, real-time, 2D vs 3D, scalability, cost, hardware, graphics, usability and support), these same factors are given importance weights for each application and then a weighted average scoring system, based on the literature for each model, will be implemented in order to obtain a final score for each model.

If the project stopped here it would simply be a grading of the quality of each model (admittedly quite a detailed one). However as the goal of this project is to determine what model is most appropriate when, this is not sufficient. Here is an example to illustrate: assume that Massive Software gets full marks for everything, that tells us that it could be used to demonstrate crowd behaviour to psychology students; however it costs over R20, 000 and has a very steep learning curve, which makes it inappropriate for such a task.

In order to determine which models are most appropriate for what tasks I intend to create a list of applications that could potentially make use of crowd simulation technology. Each task would then be assigned a set of requirements, including: max budget, accuracy, scalability, environmental accuracy, degree of agent interaction, rendering quality and ease of use. These requirements would also be graded or ranked according to their importance for each task, for example: accuracy is more important than cost when using crowd simulation to determine if a sports venue would be safe during an evacuation. If a single model meets all of a tasks requirements it would immediately be deemed the most appropriate for that task. If no model met all the requirements, the one that met the most would 'win'.

In order to determine the requirements for each application, I may have to speak to people who have experience in the appropriate fields. If said experts are unavailable for whatever reason, I intend to research each task and grade it according to the literature that is available. In the unfortunate event that no expert or literature can be found I will attempt to use common sense in order to determine requirements.

For each model I *hope* to find at least one task where said model will be the most appropriate.

4 Proposed Timeline.

My first goal is to research all the potential models available and then select the ones I want to compare. If copies of the models can be obtained my next task is to learn how the selected models work; some may take 20 minutes while others could take days (Cellular Automata and Massive respectively). If copies of the models can be obtained getting high quality footage of various crowd situations would be next task. It is at this point that I will be able to begin running direct comparisons between video and model output, however I will not yet be able to compare models with one another. In the event of not being able to obtain the required software, the next step is instead to obtain as much literature as possible about each model and gain an in-depth understanding of each model from the associated literature. Before I can begin inter-model comparisons I will need to create the aforementioned list of applications that could make use of crowd simulation. The various application then need to have their requirements set out, which involves more research into each application. Finally I will be able to score each model for each task and determine which ones are most appropriate when.

5 Final Goal.

The final goal of this project is to have a list and/or table that clearly illustrates which models can be used for what tasks as well as which model is most appropriate, next this model-specific list would be extended to generalise what model types are appropriate for what applications. The final result will be a succinct paper that will allow future readers to choose the best crowd simulation model or model type for whatever task they need to accomplish.

References

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