Crowd Simulation

based on emergent behaviours

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Contents

Abstract

Abstract is the last thing you write, it should be concise. Spend time to write it correctly, it has to be perfect. Google how to write an abstract, it is not just summary!

Acknowledgements

To my parents, who paid the bills.

Chapter 1

Introduction

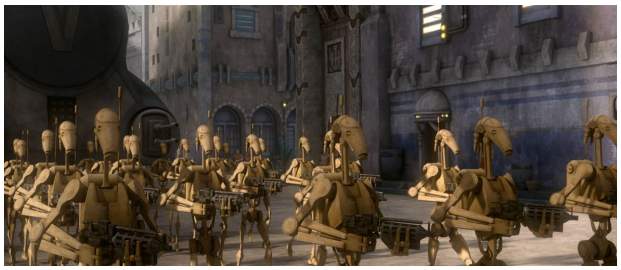
Currently, the presence of crowds in visual pieces, let they be films or video games, has acquired a lot of relevance. Scenes with a crowded train station, big streets full of pedestrians, tons of animals in a flock, troops of robots, hordes of zombies or armies of warriors can be found very often in modern films and games.

In the past, not many films could afford to employ this kind of resources in their scenes, since the only way of having more characters was actually including more characters in the cast. The use of extras highly increases the cost of a production, besides the requirement of a strict coordination and proper training in some situations. One of the reasons of the boom of big masses in films was the arrival of new technologies in computer graphics and artificial intelligence. Alongside with this, the generation and simulation of virtual crowds became a reality, saving money and time and making the use of crowds affordable to big and small studios.

Other of the reasons of the popularity of big groups of individuals is the strength they give to a shot. It is not only the matter of fact that crowds are visually stunning and their magnificence captures the attention of the audience, but also they are powerful tools to tell and enrich a story. At this point of time, it could be hard if not impossible imagine the saga of the Lord of the Rings without those epic battles of tens of thousands of warriors, or imagine the breathtaking apocalyptic scenes without those milliards of zombies wandering around.

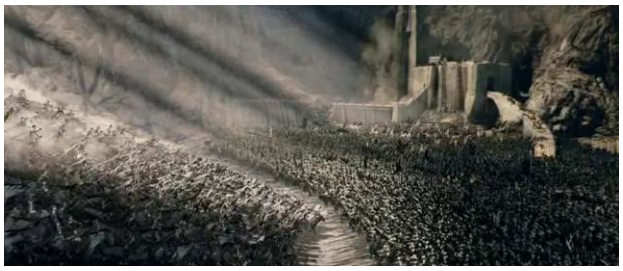
Closely tied to the idea of crowd simulation, the concept of behaviour appears. This is what gives live to the crowd and make the spectator perceive the group nature of it. No matter the shape of the individuals, an army of brave warriors in a battlefield will find enemies and will show aggressive movements; on the other hand, on a ballroom gentlemen and ladies will dance graciously.

(a) *Crowd in a train station*



(b) *Troops of droids (Star Wars)*

(c) *Horde of zombies (World War Z)*



(d) *A Battlefield (Lord of the Rings))*

(e) *A Ballroom*

(f) *One vs Many (Matrix)*

Figure 1.1: *Crowd scenes*

The aim of this project is to propose an approach which gives the flexibility to simulate any sort of crowd needed for a scene. Taking base on how the real world works, this method is based on the principle than the group behaviour is determined by the specific behaviours of every individual. And here is where one of the main

ideas for this project appear: Emergent behaviour.

Leonard Kleinrock, professor of computer science in UCLA, states that emergent behaviour is unanticipated behaviour shown by a system (Kleinrock, 2011). Once a system is designed and defined by certain rules or mathematical equations, it may configure itself in a way that could not be anticipated. The interaction of a large number of simple individual things is very hard to predict; the complexity does not reside in the individuals, but on the way they are interconnected and they interact to each other. Professor Kleinrock proposes this example: we might know how a bunch of children behave when they are alone, but once you put them together in a group, you will observe behaviours that will surprise you.

Subsequently, how a real crowd behaves is something hard to predict, and how realistic it is depends directly on how realistic each individual is.

This thesis is structured as follows:

- **Chapter 2: Related Work.** It explains the previous approaches in this field, the similarities and differences to the proposed method, as well as the advantages and drawbacks they present.
- **Chapter 3: Technical Background.** Mathematical and physical concepts, algorithms and optimized routines, and object orientation features for the build of the crowd engine or how scripting may enhance the flexibility and scalability of the system.
- **Chapter 4: Agent Based Model.** This is where the current approach is explained into details. The main aims of the method are discussed, how all of this was faced, designed, implemented and tested, and a pipeline where this methodology might fit in a real production situation is presented.
- **Chapter 5: Crowd Engine.**
- **Chapter 6: Applications and results.** Some results of different tests will be shown in this chapter. A set of individual behaviours will be presented and the emergent behaviour observed will be explained and discussed.

- **Chapter 7: Application design and implementation.**
- **Chapter 8: Conclusion.** A final concluding chapter will summarize the whole approach, mentioning the main advantages and drawbacks, as well as presenting possible lines for future work.

Chapter 2

Related work

Include your literature review here. Be critical: find pros and cons of the different methods, explore the applications etc...

Chapter 3

Killing chickens

Rename the file and the chapter/label and fill it. Remember to use figures and tables. Aim at clarity! Equations are easier to read than english!

Chapter 4

Cooking chickens

This is your next chapter.

4.1 Section title

4.1.1 Sub Section title

sub sub Section title

As if you ever need sub sub section

Paragraph title But if subsubsection isnt enough, you can use paragraph

All those commands have the "star" equivalent to get rid of numbering.

Chapter 5

Applications and results

There is ALWAYS a chapter for applications and results. Here we want to see scenarios, images, comparisons, graphs. If your project is about speed, show graphs of speed improvements compared to other techniques. If you're doing rendering, you need to put plenty of renders, from your renderer and compare against others. This is where you show off!

Chapter 6

Conclusion

Your conclusion should be structured like this. An introductory sentence then:

6.1 Summary

A summary of what has been achieved.

- Bullet points are good to clarify
- Bullet points are fun
- I ran out of ideas

6.2 Known bugs and issues

This is optional, some people put it in future work, I think it is better to have a separate section for it. Issues and bugs are different. Bugs are unexpected behaviour in the program, something not running as it should. Issues are more due to algorithm limitations. If the algorithm only works for meshes of less than 100k polygons, it is a limitation, not a bug. A program crashing if you move around in a particular

order is a bug. A render becoming ugly just on that particular spot in space, is a bug too.

6.3 Future work

What should be done in the future, what you would like to do.

- Become an astronaut
- Go out
- Make it work for real

Bibliography

L. Kleinrock (2011). 'What is emergent behaviour?'. Available from: http://curiosity.discovery.com/question/emergent-behavior [Accessed 10.08.2013].

You can have different appendices (A. B. etc...) and sub sections too.