University of Oxford Brookes

Final year project

Simulation of the pedestrian flow in the context of fire evacuation in buildings

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1 Introduction

Every year, fires in buildings are the cause of many deaths and injuries. In the United States, during the year of 2005, there have been 3,055 deaths and 13,825 injuries caused by fire in residential structures alone [1]. Even though it is impossible to foresee every accident, prevention plays a major role in saving lives.

There are numerous factors that can be influenced: training people to evacuate a site efficiently, building the constructions with less flammable materials, etc.

One parameter that is interesting to study is the pedestrian flow in the context of the evacuation of a building. The study of pedestrian flow is rather recent, so most building weren't studied as to achieve maximum evacuation in that respect.

Figure 1: Fire in New Orleans, 2005/ (photography credit to Direct-NIC.com)

This project will aim to provide a simulation tool that will allow to design a building and set initial parameters, run the simulation of a fire outbreak, and obtain statistics relevant to the evacuation. The focus will be put on the modelisation of the pedestrian flow, but also on the usability and relevance of the tool itself.

2 Rationale

When deciding upon a final year project, my main motivation was to work on a subject that had to do with Artificial Intelligence, as I wish to pursue my studies in this field.

However, AI is a very broad field, and can hardly be treated in itself. The two subfields that interest me the most are swarm intelligence and genetic programming. After talking with several teachers of the computer science department about my interests, it appeared that Dr. Zhu's work was heavily related to swarm intelligence and emergent behaviors.

Even though I was interested in these fields, I had to decide to work on a concrete application, as the purpose of this final year project is not to do any original research, but rather apply knowledge to build the solution to a problem.

Discussing with Dr. Zhu, we realized that safety is a growing concern in many aspects of our daily lives. Whether it is in automobiles, hospitals, offices, homes, the safety of the human beings involved is a top priority. In this era, our computational possibilites grow by the day, and it is most constructive to apply them to these needs.

To this extent, we came to the conclusion that artifical intelligence is a great mean to simulate real life situations in order to achieve this goal of maximum safety without any "trial and error" that would imply human lives.

Fire hazards are one of the most important safety preoccupations due to their destructive, costly and highly unpredictable nature. I thought it would be interesting to simulate the evacuation of a single building- and expanding on that I decided to buil a generic tool that woul allow the modelisation of a building with various corresponding parameters, and then a run the simulation of a fire outbreak.

3 Objectives

This project has multiple goals that cover different areas of computer science.

The agent simulation part is relative to the field of artificial intelligence and more specifically swarm behavior.

Swarm behavior, inspired by natural phenomenons such as the flocking of birds or the schooling of fish, is relevant to multi-agent simulation- its aim is to make use of a context in which the interactions between the agents is key to the resolution of the given problem, as opposed to single agent applications in which only one agent solves a given problem.

Our main goal is to provide a thorough and reasonably accurate modelisation of the pedestrian flow. For example, we could enable the user to have several different agent behaviors he can choose from, as well as specifiy their distribution in the overall simulation. This would allow a more precise simulation. For example, we could specify that some agents posess a knowledge of the environment (ie., the location of fire exits) and some do not- that would simulate, in a way, the effect of fire simulation trainings. To add realism, it is also interesting to include local variations on each agent's characteristics, which include: movement speed, field of vision and so forth.

Another important objective is to provide an intuitive and easy to use interface for the simulation, so that it can be used as a tool in real life auditing of buildings. Features offered by the simulator would include:

- Map editor to design the building layout- possibility to define walls, fire exits, doors, staircases with floors.
- Possibility to manually set the flamability of zones in the building- some areas would be unignitable (dry standpipes) while some others could be very flammable (book room, etc.)
- Real time visualization of the pedestrian flow, with the ability to

pause

- Detailed statistics (time at which first agent exited, time at which last agent exited, ratio of agents that exited, mean time of exit, etc.)

It would also be interesting to have a somewhat realistic simulation of the fire. As this project focuses on pedestrian flow, it seems unlikely that a detailed simulation of the fire (ie. collapsing structures, detailed smoke and heat propagation,...) can be implemented. However, some of the following seem relevant to the simulation:

- Propagation of the fire throughout the building
- Simulation of the intensity of the fire (ie. some places could burn out, allowing passage where it was previously impossible)
- Basic simulation of smoke limiting the evacuees' field of vision

These are the main three axis that will be taken into account for the development of the project. Other factors, such speed of execution, code portability and flexibility, quality of the graphics,... will be regarded but not be a priority.

4 Research

The main ressources for this project will be academic papers on pedestrian flow and the simulation of human crowds, more specifically in the context of building evacuation.

So far, I have been able to find a small set of relevant, recent papers (see [2] , [3] , [4] , [5] , [6]).

The aim of this research will be to be able to implement efficient, modern algorithms of crowd simulation.

5 Methodology

The application can be divided in 2 parts:

- First, the simulation environment itself, which includes the tools to design the layout of the building, the flammability of various areas, etc.
- The second part is the agent intelligence

For each part, a specification document will be written, after preliminary research. This document will be used as a model to follow when designing the application.

The whole project will be written using the Java language.

This decision is motivated by the object oriented nature of Java, as well as features of the language that make it superior, in my opinion, to a similar OO language such as C++. The most notable of these features is automated garbage collection.

Furthermore, the portability of Java will allow the tool to run on a variety of platforms, including inside an internet browser.

6 Ressources

The ressources needed are rather limited, besides the original research required as stated previously.

As far as technical skills go, I have a basic understanding of the Java language, but will need to document myself on graphical libraries that will allow a graphical rendering of the simulation. The main libraries I will use to this purpose will be:

- Swing, for the user interface and OS integration
- AWT, and more specifically its Java2D componenent, which allows rendering video surfaces in a graphical buffer, for the visualisation of the simulation in itself.

7 Schedule

The schedule presented here is a rough outline of how I plan to run the project, and its only purpose is to have an overview of the different work phases. During the conception phase, a more detailed schedule will be set up.

	Task Name	Duration	Start	Finish	Predecessors
	Environment conception and implementation	**47 days**	**Mon 10/26/09**	**Fri 12/11/09**	
1	Environment design document	9 days	Mon 10/26/09	Tue 11/3/09	
2	Environment implementation	23 days	Wed 11/4/09	Thu 11/26/09	1
3	Environment tests and debug	7 days	Sat 12/5/09	Fri 12/11/09	2
	Agent conception and implementation	**42days**	**Sat 12/12/09**	**Fri 1/22/10**	
4	Agent design document	10 days	Sat 12/12/09	Mon 12/21/09	
5	Agent implementation	23 days	Tue 12/22/09	Wed 1/13/10	4
6	Agent debug	9 days	Thu 1/14/10	Fri 1/22/10	5
7	Agent/Environment Integration	16 days	Sat 1/23/10	Sun 2/7/10	3,6
8	Complete application tests and debug	17 days	Mon 2/8/10	Wed 2/24/10	7
9	Interim Report	8 days	Fri 11/27/09	Fri 12/4/09	
10	Final Report - draft	16 days	Thu 2/25/10	Fri 3/12/10	8
11	Demo prep. and samples	6 days	Sat 3/13/10	Thu 3/18/10	
12	Final Report - Final modifications	8 days	Fri 3/19/10	Fri 3/26/10	
13	Poster	2 days	Sat 3/27/10	Sun 3/28/10	

Figure 2: List of high level tasks

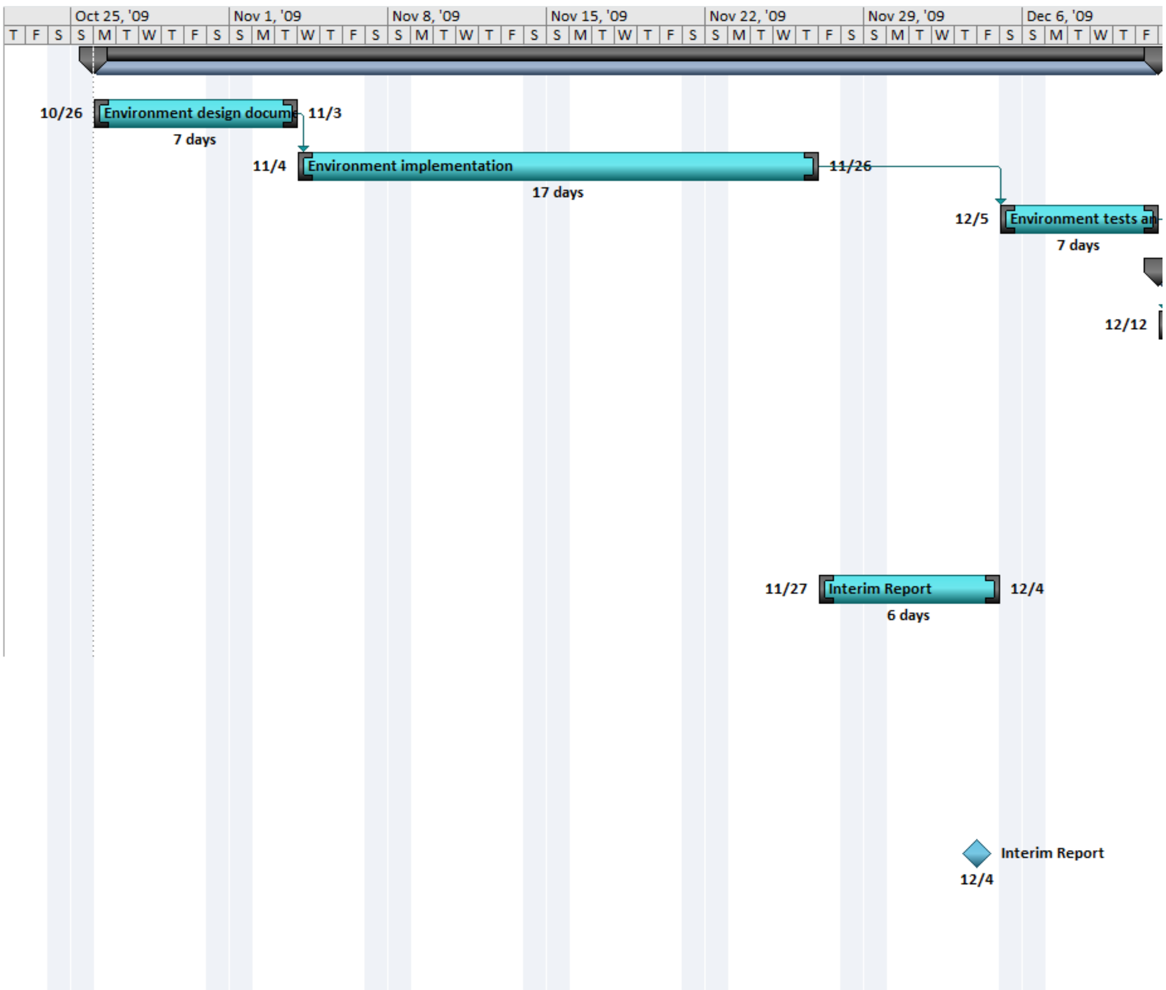

Figure 3: Gantt chart for the high level tasks (part 1/3)

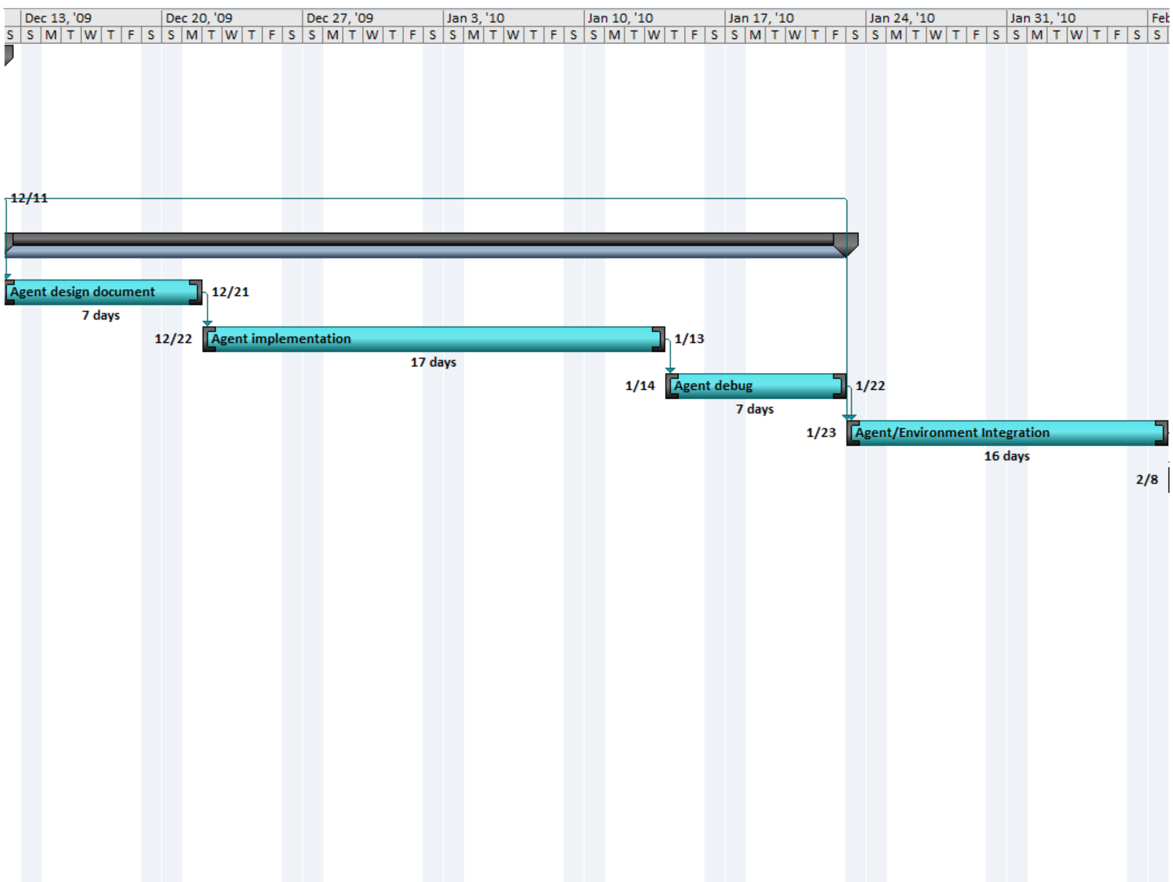

Figure 4: Gantt chart for the high level tasks (part 2/3)

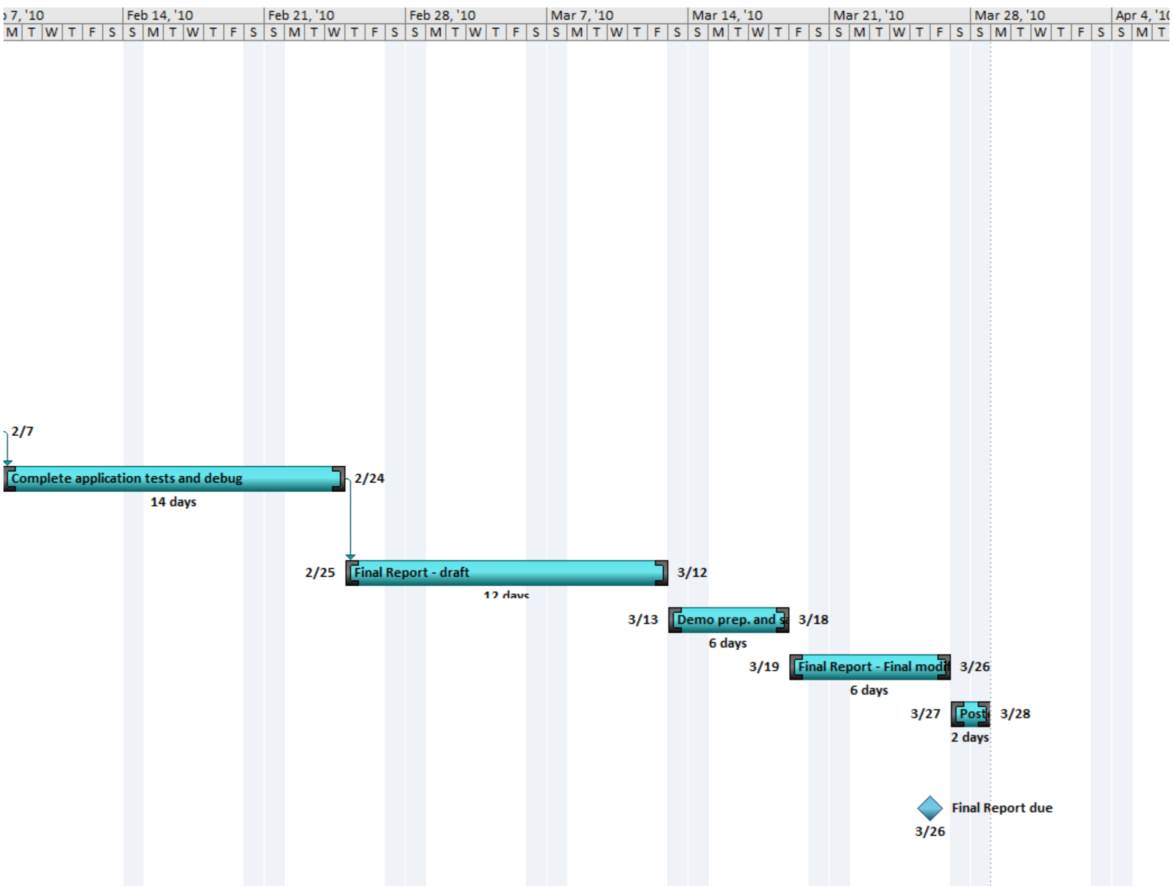

Figure 5: Gantt chart for the high level tasks (part 3/3)

8 References

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