Aircraft Evacuation Simulation using Fuzzy Logic

Authors :

Anup Rai 201201221

Kshitij Sharma 201201146

Device Property

Name:	GeForce GTX 680
Total global memory:	2147287040
Total shared memory per block:	49152
Total registers per block:	65536
Warp size:	32
Maximum memory pitch:	2147483647
Maximum threads per block:	1024
Maximum dimension 0 of grid:	2147483647
Clock rate:	1058500
Total constant memory:	65536
Concurrent copy and execution:	Yes
Number of multiprocessors:	8

Abstract of the Project

The potency of Aircraft Evacuation plays a vital role in the safety of the passengers on board. Our motive is to create a multi-agent simulator, which would enable the aircraft manufacturers to test the evacuation process of the aircraft. The model is based on a bi-dimensional grid, which acts as a basic structure of the aircraft and

multi-agents, which represents passengers who are supposed to be evacuated. Each agent is characterized by the properties of a human. An agent can have properties like motion, sex, response time, position and status. Each cell in the grid represents a capacity, which is occupied by the agent i.e. the passenger. The application of this model is at the time of emergency evacuation of the aircraft.

Introduction

With an increase in demand for air travel the responsibility of the aircraft manufacturers increases to ensure comfort as well as safety of the passengers. All newly manufactured aircrafts should satisfy the exit time limits. To approve the aircraft evacuation system design various demonstrations have been performed in the past, right from collecting information from the people who survived the crash to performing emergency evacuation mock drills. But with such advancement in technology numerical simulation tools are being developed to avoid the fundamental limitations of real demonstration. The main limitation of real demonstration was bias decisions taken by passengers. So to overcome this problem simulation tools such as Agent Based simulation, Fluid dynamics and cellular automata were used. All these simulation tools depict passenger movement inside a physical space, which moves according to its surroundings.

In this project we propose a cellular automata based simulation model. The main aim of the simulation is to help the aircraft manufacturers to check if their design follows the rules and regulations set by the Federal Aviation Administration (FAA). While designing an aircraft there are a few criteria that should be met, the prime one being evacuating people from the aircraft within ninety seconds with only fifty percent functional doors in case of an emergency. In order to test their design and see whether this primary criteria is being fulfilled these manufacturing companies hire people to perform evacuation drills. For example, between 1969 and 1993, more than 20 full-scale evacuation certification demonstrations were performed for aircraft designs involving over 7000 volunteers, with each trial costing approximately $2 million dollars. Numerous injuries, including a

permanent paralysis case, resulted from such trials [1]{Human Behavior Effects on Cabin Configuration Design
Using VacateAir}. This scheme not only provides a solution for the above problem but is also a lot more reliable because here the manufactures can try different strategies as well visualize scenarios in which each passenger has a different state of mind. This rather gives them a much refined result because in case of the mock drills, the performers are aware that a disaster is coming which somewhat gives the manufactures a rather biased result but in case of this scheme this bias can be dissolved. The scheme works in a manner that in case of an emergency the passenger will first try and locate the nearest functional exit then depending on his/her fear, number of passengers at an exit door and agility will decide which exit is feasible and then start its movement for evacuation.

The limitation of this cellular automata based model is that it does not consider group dynamics i.e. in case of a real life emergency it is sure that a child will not leave his/her parents and exit the aircraft alone, so such cases are not considered in this model.

Simulation Properties

The ability of passengers to evacuate an aircraft depends on two major factors, namely, neighboring passenger behavior and the aircraft design. The main focus of the aircraft companies is to design a structure, which enables the passengers to evacuate in minimal time with least number of casualties.

Many characteristics of the passengers’ behavior at the time of evacuation is psychological and even after people being educated about how to act in such situations, instinct is often responsible for the behavior of the crowd. Thus when any computation simulation is done, it is tried to model the crowd behavior as appropriate as possible.

Passenger Behavior

The behavior of the passenger depends on their instinct, the behavior of neighboring passengers and the group.

During the evacuation it the basic human nature of protecting themselves, so everyone would want to get out as quickly as possible which would create chaos. This chaos eventually is responsible for slowing down the evacuation process.
It is observed that people tend to move towards the door they have entered.
During this situation the problem that concerns an individual is selection of the door to exit from. In a non-evacuation situation a choice can be made wherein the person evaluates every possible exit and chooses what is best at that time, whereas during evacuation whether a person selects an exit rationally or by following his instincts depends on the scale of the danger sensed by him.

Interaction between the people during evacuation brings significant affect on the time taken to evacuate the aircraft. Interactions may not be only physical in nature, it is observed that people who lack in experience tend to look upon the behavior of other passengers and follow them. Also many times following the people towards the exit leads to more number of people at an exit than others, leading to increase in the time of evacuation. People who are panicked act on their instincts and thus do not follow the social norms. This in turn increases the physical interaction between the passengers, which often lead to stampede, and slows down the time of evacuation.

Passengers often travel in groups, and during evacuation group dynamics acts as a very important factor to be considered. Both individual in the group as well as outside it affects the movement of the group as a single entity. If the size of the group is large, the comfort level of individual decreases which often increases the risk of that individual loosing the group. Under these situations passengers tend to get wounded.

Aircraft Design

At the time of aircraft designing factors such as aisle width, exit door dimensions, location of the exit doors in the aircraft and the number of exit doors and also the type of doors to be used. According to the FAA rules and regulations, no passenger should be at a distance of more than 60 feet from an exit door. At the same time they also have to take care if their design is following the 90-second rule of evacuation.

Our Simulation Algorithm

We have taken an A 320 Aircraft which is created by Airbus and is the most selling Aircraft nowadays. We have tried to make the simulation as real as possible.

We have taken Passengers of the aircraft and we have taken 5 states that the passenger can be in

0 : is his seat aisle
1 : is in aisle
2 : in the exit aisle
3 : in the middle exit aisle
4 : out of the plane

Now each thread is represents a passenger. At each runtime the passenger can think about what are his options and according to that he takes a step. So at any given time the state of passenger can be represented by 3 state variables
x , y and status. Now at each time the passenger try to make a move and then we pause and store the current state in a file.

Passenger Decision

In our simulation the passenger try to find the nearest exit and try to move towards that exit. There are 6 exits in the plane and the passenger try to choose one of those exits. These exits might be open or closed in our simulation we have kept only 4 out of 8 exits open. So the passenger try to move towards that exit. If that exit is open then he pursues that exit else he waits in the queue.

Over all Simulation Work

The overall simulation work in such a way that for each time step Δt each of the thread moves according to their speed and other variables like closest exit and then each thread waits for all the thread to finish execution for that time step.

Case 0 : The passenger is in the seat aisle. In this case the passenger try to get to the central aisle or move to the next seat so as to get closer to the central aisle.

Case 1 : The passenger is in the central aisle. In this situation the passenger try to move to the closest exit and for that is first find the closest of all the open exits and when it does find the closest exit it move towards that exit according to his/her speed and depending on the place it is trying to occupy is open or close.

Case 2 : The passenger is in the middle aisle and in this case he try to move towards to 0 from 55 as the length of the side aisle is 55 inches.

Case 3 : The passenger is in the side aisle and in this case he try to move towards to 0 from 55 as the length of the side aisle is 55 inches.

Case 4 : In this case the passenger is successfully outside the airplane.

Comparison with single CPU System

In a single CPU system the way to implement this simulation is that each of the passenger will be given turn to move and then we will move to the next passenger. In this case the simulation will not be upto mark as the movement of the passenger will be non continuous and one by one.

We need parallelism for this simulation as each passenger has random movement time but all the passenger have the same time clock.

Optimization Technique

We need atomic operation for changing the position of the passenger as some other passenger can move to that location. So basically this can lead to situation where both the passenger might end up sharing the same position.

For this case we have tried to implement and algorithm in which one passenger try to see if the position is going to be occupied by some other passenger. So randomly he can give up the position for the other passenger or take it. In which case the other passenger will have to give the position up.

Theoretical Speedup

Speedup = time taken in Serial code / time taken by parallel code

Calculation of move by each passenger is parallel. And the only serial part is to setup the system of simulation i.e randomly setting the seats and providing random characteristics to the passengers. So theoretically the time for serial

Time taken by CPU serial implementation :

= Time taken for setup (ts)

+

Time for calculation of movement(tm) * number of passengers (npas)

Time taken by GPU parallel implementation

= Time taken for setup (ts)

+

Time taken to copy data from CPU to GPU (tcp1)

+

Time taken for calculation of movement(tm)

+

Time taken to copy data back from GPU to CPU(tc2)

So theoretical Speedup will be : (ts + tm*npas)/ (ts +tcp1+ tm + tcp2);

As the computation become more and more rigorous as the problem for calculation of movement is very complex so we can say that the time taken to copy data and the time taken for setup are negligible in front of time for computation.

tm >> tcp1 , tcp2 and tm >> ts

So basically our speedup will be = (tm *npas)/ tm;

or = npas (approx)

where npas represent the number of passenger aboard the plane.