Up in Smoke

New Mexico
Supercomputing Challenge
Final Report
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Executive Summary

Our project is over the flow and movement of second-hand smoke through the air in a room. As in, how second-hand smoke moves from a person or group of people with the smoke source (e.g. a cigarette) to a person or group of people who are non-smokers. We wanted to see particularly how smoke barriers in restaurants actually affect the movement of smoke, and whether or not they are effective in preventing smoke from passing between the two classic designated sections, smoking of non-smoking.

In our computer model we created a room that is divided in half by a barrier. The barrier's length can be changed as needed to show how it's size affects the smoke's movement. In the designated smoking section there are a group of smokers whose number can also be changed. Periodically the smokers exhale their smoke particles into the room. From there, the particles float randomly in something of a Brownian motion way. The smoke has chances of being absorbed or bouncing off the ceiling and walls. If it makes around the barrier into the non smoking section, it continues its random floating until it is absorbed by something, either a surface or a non-smoker. The non-smokers are spread randomly about in their section and if a smoke particle collides with a non-smoker, they 'count it' for our statistics.

After running this program multiple times our conclusions are simple. The smoke barriers do, in fact, prevent the biggest part of the smoke particles from crossing over to the other side. The non-smokers farthest from the gap in the barrier get the very least amount of smoke, almost none.

Introduction

There has been a great deal of controversy in our country, and specifically in our state, over laws that limit smoking in public locations. On March 13, 2007, Gov. Bill Richardson signed the Dee Johnson Indoor Air Act, which bans smoking in almost all indoor workplaces. The law took effect on June 15 of the same year and it also banned smoking around entrances, windows and ventilation systems. New Mexico also has laws restricting smoking in public places and government buildings.

So much news over second-hand smoke got us thinking about second-hand smoke quite a bit, and we wanted our Challenge project to somehow involve smoking. After much brainstorming, we decided our project would be over smoking in restaurants; less generally, how partitions between smoking and non-smoking sections help (or do not help) to keep the smoke particles in one place.

Description

To begin our project, we had to understand how air and air particles flow or diffuse through a room. We wanted to accurately represent how smoke particles move in a room. For our purposes, we do not have any moving air or ventilation systems, so the smoke particles have a random, Brownian motion movement.

To model our project, we used Starlogo TNG. We chose this program because it is within our ability to use as it is very simplistic and the code is easy to write when compared with other modeling programs. Also, because it is three dimensional, it demonstrates our projects particularly well and shows the exact movement of the smoke particles.

Our first step in creating the model was to make the walls of our restaurant. We used the X and Y coordinate grid to map out where the walls would be. They are on the edge of the available area on all sides so that the space is used economically. An agent builder creates the walls with each new set up and then creates a partition across the center of the room. The length of the partition is controlled by us by a slider numbered from one to a hundred so the partition's effectiveness can be shown at different lengths.

The next agent in our program is simply referred to as the smoker. Each time the program is restarted by pushing the setup button, the smokers are created and scattered randomly within their designated smoking area. Again, we used the X and Y coordinate grid to limit the space they could be created in. The smoker's main purpose is, of course, to create the second-hand smoke particles. At every tenth tick of the timer, the smokers have a chance to either exhale a particle or to not. The chance is random. If they are able to put out a particle, the particle then appears in front of them at the average height of a standing person, approximately six feet. This completes the agent smoker's duties.

Once a smoke particle is created, with each tick of the clock it moves somewhere. Because it moves according to a Brownian motion pattern, its direction and angle are completely random, but whatever way it chooses it only moves one unit. If the particle collides with a smoker or another smoke particle, nothing happens. If, however, it collides with a wall, the floor, or ceiling, it has a new task. The smoke can either be absorbed by the surface or it can 'bounce' back off of it. This, too, is a random chance.

If the smoke moves around the partition and enters the non-smoking section it will continue to follow the same rules as before until it collides with a non-smoker. The non-smoker agent is created with the same specifications as the non-smoker, as in they are scattered randomly within their area designated by the X and Y coordinate grid. Their task is simply to wait until a smoke particle collides with them. When this happens, they record it and absorb the particle which disappears.

The number of smoke particles inhaled by the non-smokers is recorded as a group and an average; all the non-smokers compile their numbers together.

Results

While we worked on our project, we learned much about the movement of air and air particles. We discovered Brownian motion, something neither of us had heard of previously. Below is a screen shot of part of our code and a screen shot of our model as it is running.

Conclusions

To come to an accurate conclusion, it was necessary to run our model multiple times. We recorded the data from each separate run and then averaged the data out. We came to the conclusion that the partition in between the smoking and non-smoking sections did prevent most of the smoke particles from reaching the non-smokers. As long as the length of the partition was ¾ of the total width of the room it served its purpose proficiently. The more smokers there were, the more quickly the smoke particles reached the non-smokers. The non-smokers furthest away from the partition and the gap in the partition received the least amount of smoke particles.

Recommendations

Though a year seems like a lot of time, our team as seen how quickly it goes by when you are trying to finish a project. We accomplished a lot but there is still more that might be done with this project and model. Currently, our smokers and non-smokers are stationary but if they were to move about in their areas, this might affect how many smoke particles were inhaled by each non-smoker. We also wanted to put in some sort of ventilation to create movement in the air besides only random motion. For instance, how might a fan prevent smoke from passing the partition? Or would a central air conditioning unit transport the smoke around the barrier through a vent? Given more time, we would have liked to find answers for these questions.

Acknowledgements

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