MODELING COLLATERAL DAMAGE

New Mexico
Supercomputing Challenge
Final Report
April 2, 2008

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Executive Summary

Explosives used for things such as weapons or demolition always have the risk of collateral damage. Being able to predict the area affected by the blast of a bomb or charge would allow for proper evacuation and containment to take place, minimizing the collateral damage to buildings, people, and other surroundings.

In our project, we aimed to create a model that can predict the area affected by a bomb or other explosive device. This will hopefully allow a greater measure of control over explosives and reduce the amount of unwanted damages. Unfortunately, many different kinds of explosives exist thus resulting in variations of power, velocity, and damage radius. Each of the properties stated was integrated into the model as well.

The program used was Star Logo: The Next Generation. We used agents to model a blast wave. To do so, the user would input an x y coordinate location of the bomb within a model city, and run the program. Depending on the type of explosive chosen, the computer would then model an explosion taking place at the chosen point. The computer would account for the characteristics of each explosive, as well as the materials of the surrounding buildings. These include concrete, wood, brick, etc. Then, the model would display the outer limit of the blast and show any damage effects on the affected buildings. By running each simulation multiple times, we were able to gather an average effect radius for each blast.

The algorithm to set up and run a blast at any given point has been modeled to real life data, as well as a model of the city in which the tests will be run. When the model is run, agents spread out from the detonation point and spread out in a circle, along a 2D plane. Each agent is given an energy level that fluctuates slightly. This helps model any possible irregularities in the blast power. As the agent moves, the energy slowly bleeds off. Each building is given a material property. Different materials affect the blast in differing amounts. As the agents collide with the different walls, the walls will drain a variable amount of energy from the blast. After a certain threshold of energy is reached, either the blast will be halted and channeled elsewhere, or the wall will be destroyed and subsequently be marked as such. The test will be run multiple times to allow for variations due to the energy fluctuations and to provide the calculations of an average blast.

Thus this project is to show the potential destruction radius of a given explosion, as well as the possible damage caused by several types of explosives on differing types of buildings and the surrounding areas.

Introduction

In a world full of wars being fought with more and more advanced weapons and tactics, construction and demolition, and cutting charges, collateral damage is always a risk. Nowhere is this truer than in the case of a city scenario. When a bomb or other explosive detonates, a large area around it is subjected to the blast. Being able to predict the area affected would allow proper evacuation and containment of the area to take place.

The goal of this project is to help predict possible damage and area affected by modeling the explosion of such a device. We hope that this will allow better control of explosives and reduce the amount of collateral damage caused by their use. We did this by modeling the blast radius and intensity of an explosive based on the amount of explosive and the structural materials around the explosion. This was done by incorporating real life data into the programs equations.

Problems

- Effectively modeling a blast wave from an explosion
- Modeling the effect of an explosion on different structural buildings in an urban area
- Trying to find the conditions under which the least amount of collateral damage

Description/ Method

We decided that Starlogo: TNG was the best visual program we could use to effectively model a blast wave. The first step in our program would be to input an x y coordinate location on the spaceland map. We then created many model buildings which then created a city block. These buildings were created out of specific types of materials with different structural strengths. The user can then set the power of the explosion and depending on the type of explosive chosen, the computer would then model an explosion taking place at the chosen point.
This is done by interpreting the blast power into energy for movement in each agent. When the model is run, agents spread out from the detonation point and spread out in a circle, along a 2D plane. For every forward movement taken each agent loses a set amount of energy, although beginning energy is slightly randomized. The computer would account for the characteristics and the materials of the surrounding buildings. This is done by setting each material to reduce a certain amount of energy from each agent when they pass through the material. That set amount of reducing energy is in proportion to real life data, which is in proportion to the materials compression strength (measured in MPa's). Structural materials include concrete, wood, brick, etc. As the agents collide with the different walls, the walls will drain a variable amount of energy from the blast. After a certain threshold of energy is reached, either the blast will be halted and channeled elsewhere, or the wall will be destroyed and subsequently be marked as such. Then, the model would display the outer limit of the blast and show any damage effects on the affected buildings. By running each simulation multiple times, we were able to gather an average effect of the blast on the set structural materials. The test will be run multiple times to allow for variations due to the energy fluctuations and to provide the calculations of an average blast.

We know that different materials affect the blast in differing amounts, but one thing we wanted to see was the effect of the explosion on composite walls made of one or more structural material. So in the program we made double layered walls each made of a different combination of structural material. We then incorporated these buildings into our city block and ran the test to see how the blast radius was changed. Any test that was setup was run multiple times to allow for variations due to the energy fluctuations and to provide the calculations of an average blast.

Results

The results taken from this project weren't as conclusive as we hoped they would be, but we did learn some very useful information. After running the simulation many times we found three very important things. The first thing our simulation showed was that thicker walls mean less collateral, and that the collateral damage is reduced more as these composite buildings get closer to the center of the explosion. The second result is as explosion power goes up or the strength of the structural materials goes down, the overall result is more collateral damage. If explosion power goes up or the compression strength of the structural materials goes up then overall collateral damage goes down (we felt we knew that this result wasn't very significant). The third major result is that we learned is that brick is the worst structural material in an explosion (with only the resistance of 11 MPa), but is more useful for the absorption of a blast than any other material. Although we did not get very many results, we were able to make a few fascinating conclusions from this information.

Conclusions

The first conclusion we made from our results is that more isn't necessarily better when it came to structural materials. For instance, three layers of brick are less efficient than one layer of concrete, or about two layers wood. Another fascinating thing we found was that three thin layers of a material is more subjective to collateral damage than one thick layer. In other words, three thin walled brick buildings in a series from the blast would take more overall damage than one thick walled brick building in front of the explosion. One thing further noticed was the effect of the positioning of high strength buildings on collateral damage. Collateral damage will be greatly reduced if more high strength buildings are placed closer to the explosion rather than farther away. An additional thing that should be mentioned is the fact that it takes a lot of blast power to blow through one building, you must remember the blast has to go through two walls(the blast has to enter and exit the building.

Most Significant Original Achievement

Our most significant original achievement was figuring out a way to model a blast using starlogo. It was very difficult to program agents to behave like a blast wave and interact with the buildings.

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Acknowledgements

We would like to acknowledge our computer science teacher, Bala Settu, for getting us into the supercomputing challenge. We really learned a lot from this experience. We would also like to thank professor Hamdy Soliman for helping us with the starlogo program because this program was very new to us. We would also like to thank Socorro high school for supporting us with new computers and the funds necessary to make the trips and accommodations. Overall this has been a fun learning experience, THANK YOU!