OPTIMUM
3-D EVACUATION

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ABSTRACT:

Urbanization and population are rapidly increasing all over the world. People move into cities to seek economic opportunities. A major contributing factor known as "rural fight" leads rural families to move to cities to improve one's standard of living beyond basic sustenance as cities offer better jobs, education and health facilities. And due to large population density, many architectural developments are emerging where at a time thousands of people can stay or sit. Fire or any other emergency conditions in this type of places can lead to lots of deaths if proper evacuation is not done. Such incidents have clearly showed the need for reliable systems which can support rescue operations.

There have been various attempts for computing optimum evacuation techniques but this application promotes a different approach. This model can be easily used for evacuations in a multi-storied building. The application takes parameters such as dimensions of building (number of floors, breadth and width of floors), position of agents in each floor, number and position of doors, number and position of staircases as the input and then calculates the optimum evacuation time of evacuation of the building also showing the optimal path for each agent towards the exit.

INTRODUCTION:

Since the ‘birth’ of buildings, the damage from both natural and unnatural disasters never stops. The buildings being designed these days are higher and more complex than ever before, therefore the potential disasters are also various. Primary disasters such as: fire, power outage, terrorism (bombing incidents, bomb threat, taking of hostages, etc.), chemical releases (radioactive materials, toxic gases, etc.), earthquake, flood, hurricanes, etc. Secondary disasters for example, an earthquake could cause a structural fire, which may in turn burn out circuits resulting in a power failure.

All of the above disasters require people inside buildings to be evacuated as soon as possible. Considering the complexity of modern buildings and the great numbers of people that can be inside buildings, it is rather difficult to organise a quick evacuation. For e.g in Bangalore recently Nine people died and 60 others were injured, many of them seriously, after a major fire broke out on evening at the Carlton Towers.

In order to make minimal losses from these disasters, many evacuation strategies have been researched and some of them are widely accepted or even integrated into architecture design.

CURRENT EVACUATION STRATEGIES:

A lot of developments and research are aiming at providing more efficient means for alarming and guiding people. Good examples are fire alarming systems. Many buildings are currently equipped with modern fire detection systems and it is possible to alert people to a fire. However, this gives no clues as to how to escape. Directional Sound Evacuation (DSE) systems are also available and they can eventually give clear audible navigation to nearest exit (http://www.soundalert.com/dse_buildings.htm). These systems can be combined with sophisticated analogue addressable Fire Alarm Control Panels(FACP) (e.g. http://www.adt.co.uk/fire_panels.html). These are systems that can locate seats of fires and decide which are preferred evacuation routes. DSE can then be activated only along these routes. It is also possible to teach people what is the meaning of sounds. The problem is still that these kinds of systems react only on the seat of the fire and are ‘blind’ about situation after the fire alarm is triggered.

In principle, current alarming systems can be subdivided into three groups :

Automatic detection system involve a sensor network plus associated control and indicating equipment. Sensors may detect heat, smoke or radiation and it is usual for the control and indicating equipment to operate an alarm system. It may also perform other signaling or control functions,such as the operation of an automatic smoke control system.

Alarm system alert people at the early stages of a disaster and give them maximum escape time. Normally any of following devices needs to be incorporated in the building:

• Manually operated sounders;

• Simple manual call points combined with bell, battery and charger;

• Internal speed communication system (telephone, intercom, etc.) should be provided so that conversation is possible between every floor and the control centre.

Emergency lighting is designed to allow occupant to continue to occupy, although they may not operate as efficiently as under normal lighting.

Despite the variety of systems, current emergency alarming systems are only able to provide simple mostly constant evacuation instructions (evacuation plans, green lights, sounds, voice) which is not sufficient because evacuation plans are not flexible enough , lack intelligence, sometimes give insufficient information. More elaborated systems are needed that can offer intelligent, knowledge-based evacuation navigation. How such a system should react?

PROPOSED MODEL:

Our model takes into consideration no of floors in a building, no of doors and their respective positions, obstacles in each floor with their positions, and position of agents in each floor. The application gives optimum evacuation path for each agent, the total time needed to evacuate the building and also showing other information such as the no of agents evacuated from each door. By changing no of doors and position of doors we can get the positions which will lead to minimum evacuation time, hence this model is of great architectural help.

While making our model we kept various things in mind like:

1. Population density: There're always more people in certain areas and less in other areas. So it might happen for some agents that though some path is small, but due to population density evacuation through that path takes time. Our algorithm design takes this thing into consideration and so those agents are directed towards other path (which might be longer) but the overall evacuation time is reduced as minimum evacuation time is the first priority.

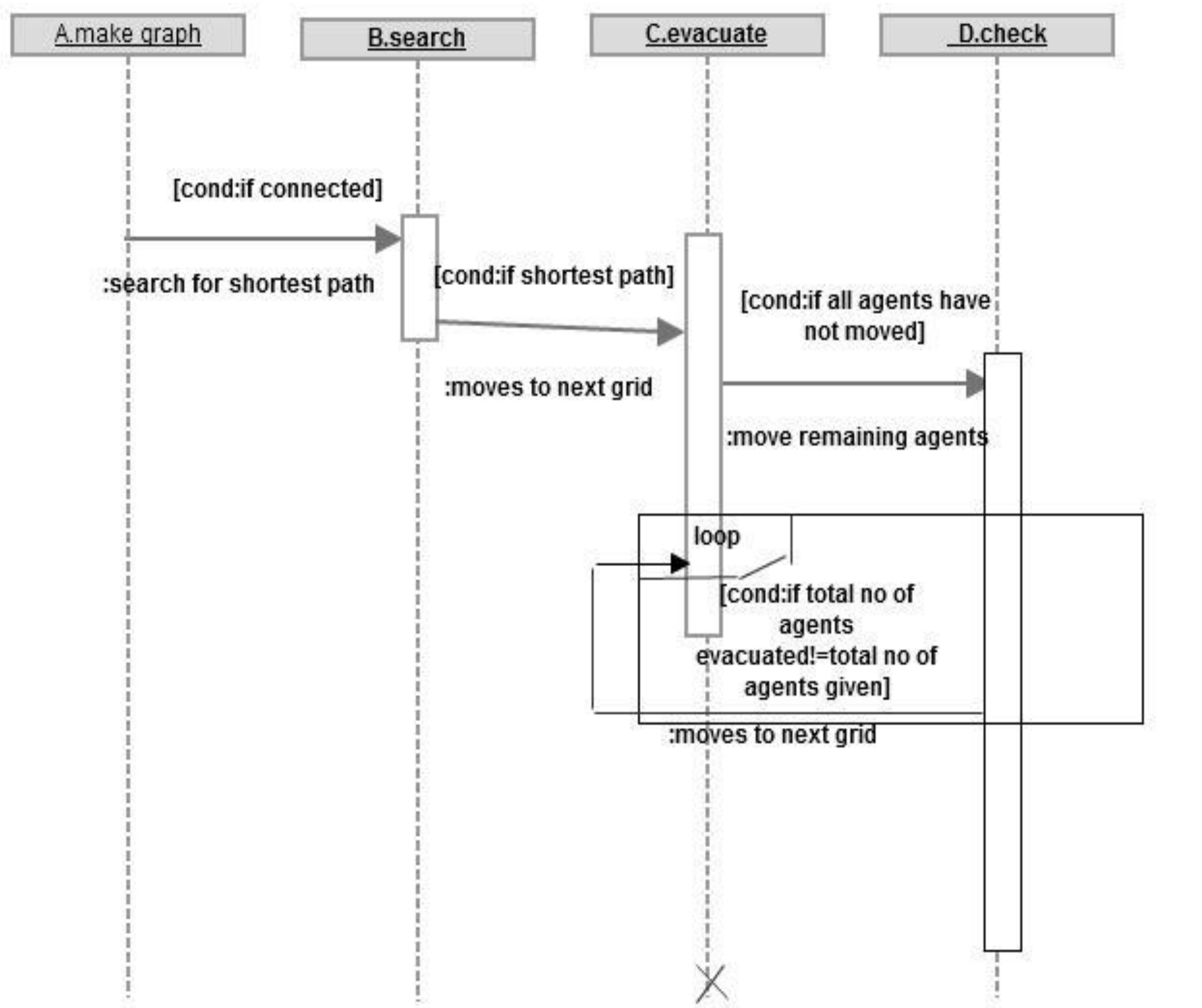
2. Damage status. Areas that are already damaged should be avoided in an evacuation route.

3. Capacity of the routes. If people are given an evacuation route that did not consider the capacities of routes, they would probably get stuck in some low-capacity parts. This is quite dangerous, and should be avoided with no doubt. Like while evacuating in stairs we need to consider capacity of each stair.

Algorithm:

The basic flow of our model goes like this:

Sequence Diagram

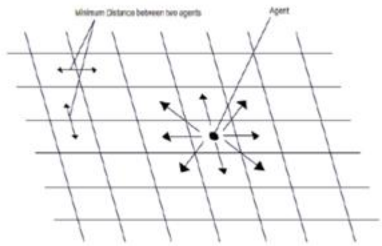


The make graph module takes dimensions of room (n length and m breadth) as input and makes graph of (n x m) x (n x m) adjacency matrix considering every grid as a node .The graph is made keeping in mind following things:

First the n x m room is divided into 1 x 1 grids

And each grid is considered as node.

1. Each node will have has maximum of 8 neighbours.



2. Whether a node will have a edge between it and its neighbour will depend if there’s a obstacle or not. If there is no obstacle a edge exist otherwise edge doesn’t exist.

   After the make graph module, the search module takes position of each agent and provide us with shortest path for each agent and it also stores the shortest path for each agent. This is done using breadth first search .Starting with node that represents agent we do breadth first search to search for a door and we store our path for the nearest door while also considering the density near each door. For every agent this algorithm is run and minimum path is stored.

   The evacuation module takes position of each agent and according to the shortest path given by search module shifts each agent’s position by one grid towards the evacuation path.

   Next is the check module which checks whether every agent has moved or not and also counts the total no of agents who have evacuated if it equals to the total no of agents given our program ends there otherwise whole process is repeated from the evacuation module.

   Some of our assumptions are:

   1. Each agent occupies only one grid.
   2. Agent moves with velocity equal to 1 grid / time unit.
   3. All agents move with same velocity.
   4. Depending upon where the agent is velocity do not change.

5. A grid can have only one of possible three states: either an agent is present or an obstracle is there or it is empty.

Now changing various parameters we can get minimum evacuation time for different cases. We can change following parameters:

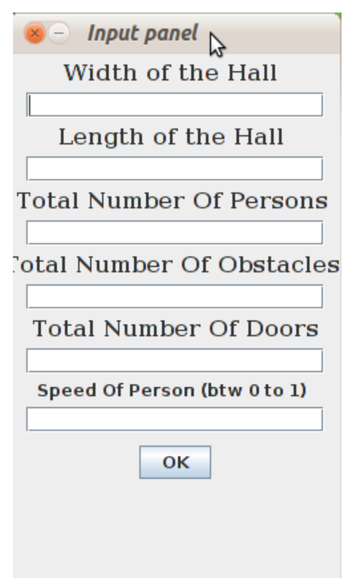
1. No and positions of doors and obstracles.
2. No of people and their positions.
3. No of floors and position of staircases.
4. Dimension of floor or staircase.

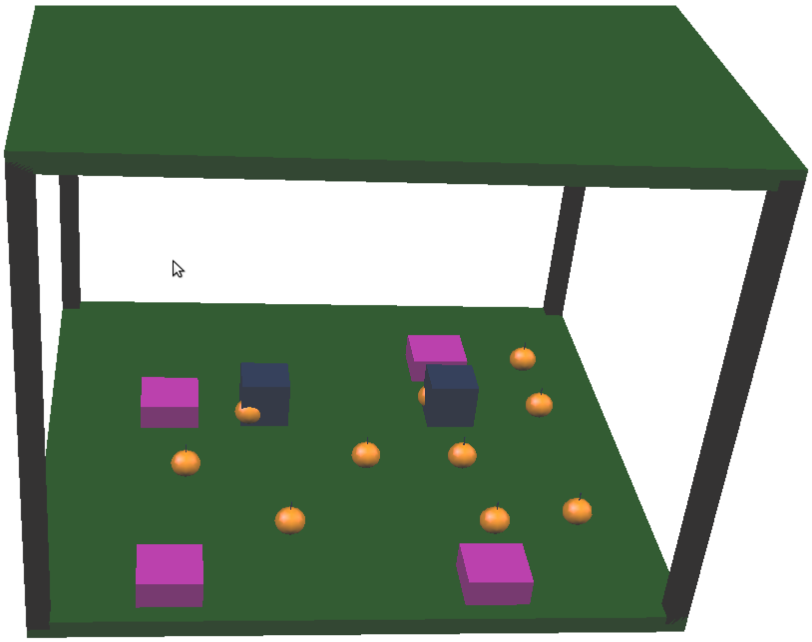
INPUT AND OUTPUT FROM THE MODEL:

The application can take input by two ways:

1. Giving the grid's state and the number and locations of doors in a file.
2. Specifying the grid dimensions, number of agents, obstracles, doors and theapplication will randomly place them in the grid. This type of provision for input is basically for testing purposes i.e one doesn't have to write the whole grid and just specifying some parameters will do.

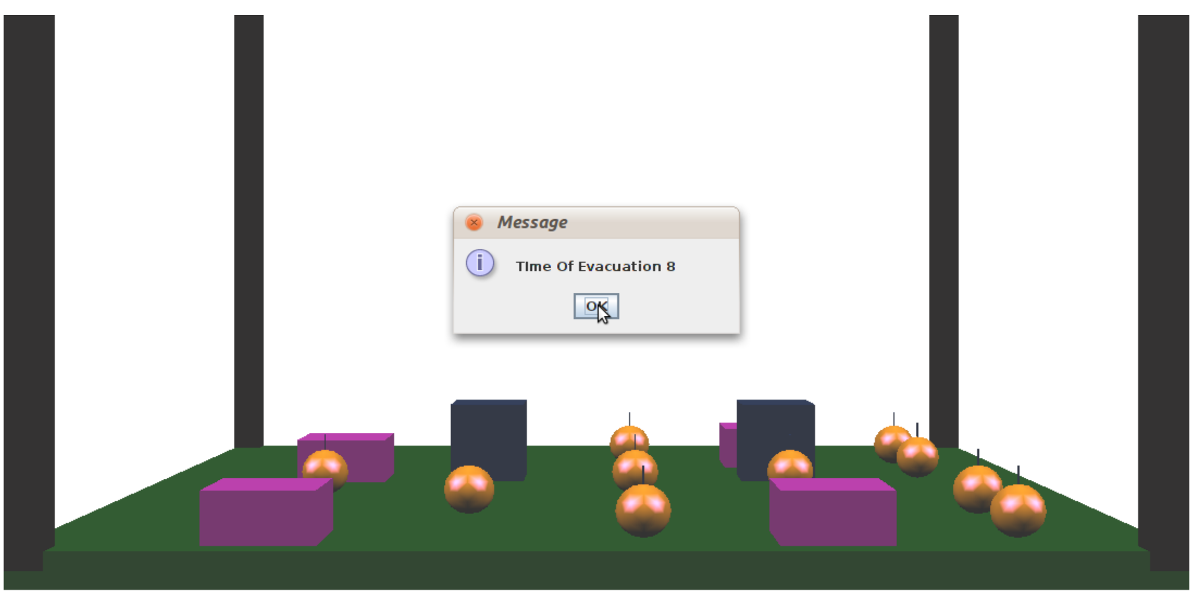
The application also gives an additional provision for manipulating the speed of the agents. It is a decimal between 0 and 1, 0 being the lowest.





The golden spheres shown in the image above are the agents that are being evacuated, pink blocks are the obstacles and blue blocks being the doors. It can be seen that agents are moving towards time optimally closest doors. The interface can be easily rotated upside down for easy visualisation and understanding. The application will output

1. The total time of evacuation
2. Number of agents evacuated from each door
3. The path of each agent towards its exit can be seen from the user interface of the application.



Dialog box showing the total evacuation time. State of grid for a particular floor.

CONCLUSION:

The model presented suggests a concept for proper evacuation while considering important factors such as density of a place. The evacuation algorithm is basically based on breadth first search. Sensors can be deployed on ground to get the locations of agents and obstacles and this can serve as input to our application. The application when properly applied can be of great help at the time of an emergency in a building. There is big scope for extending the model to public places like temples, stadiums or any other gathering places.

References:

1. Paper on Evacuation Route Calculation of Inner Buildings by Shi Pu and Sisi Zlatanova.

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