Managing Multi Robotic Agents to Avoid Congestion and Stampedes

(Extended Abstract)

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ABSTRACT

Crowd management is a complex, challenging and crucial task. Lack of appropriate management of crowd has, in past, led to many unfortunate stampedes with significant loss of life. To increase the crowd management efficiency, we deploy automated real time detection of stampede prone areas. Further, we use robotic agents for aiding the crowd management police in controlling the crowd in these stampede prone areas. Lastly, we simulate a multi agent system based on our model and use it to illustrate the utility and viability of robotic agents for detecting and reducing congestion.

Categories and Subject Descriptors

I.2.11 [**Distributed Artificial Intelligence**]: Multi-agent Systems; I.6 [**Simulation and Modeling**]

General Terms

Design, Management, Performance

Keywords

Crowd Management, Stampede, Congestion

1. INTRODUCTION

Managing large crowds is a difficult task. Ineffective execution of this task can potentially lead to stampedes. History suggests that crowd management police, appointed to prevent such incidents from happening, have not been very successful [2, 1]. Crowd management is a team task, it requires strategic communication to figure out where to lead the crowd. Due to perennial availability of agents, communication between agents is more reliable, and it is much faster. If programmed with efficient strategies, agents can, in real time, monitor and analyze the crowd to detect potential congestion [4]. This motivated us to propose a multi agent based solution to facilitate the police officers in crowd management.

In this paper, we consider a large crowd, moving in a two dimensional space, in an omnidirectional way. Given such a scenario, we developed an automated strategy to detect congested areas and a semi-automated strategy for congestion reduction.

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2. CROWD MANAGEMENT

We have two kinds of agents for crowd management: Congestion Detecting Agents (CDAs) and Congestion Controlling Agents (CCAs). Congestion detecting agents inspect parts of the field and report presence or absence of congestion. Congestion controlling agents take pro-active measures to reduce congestion in a congested area.

CDAs are computing machines present off-site. They receive location coordinates of humans present inside the field and use it to check for congestion. CCAs on the other hand are flying robots. They have a spotlight and a speaker attached to them to allow them to illuminate the areas below them and to announce instructions.

2.1 Congestion Detection

For computational ease and efficiency, we divide our field into smaller rectangular areas (henceforth called grids). The division allows multiple CDAs to inspect grids in parallel. We propose a macro micro strategy for congestion detection which takes as input the coordinates of humans present in the field. We use the spatio-temporal change in coordinates to determine their direction of movement. We also make use of the fact that humans tend to visit places in groups of families or friends. In a particular group, all the humans tend to be close to each other and move in the same direction [5]. Their inherent tendency to avoid collisions also affects their direction of movement.

We divide the humans into groups where a group is defined as a connected group of humans moving in the same direction. The congestion detection procedure is as follows:

(i) At the macro or inter-group level, we count the number of groups that are moving towards each other. We report presence of congestion if this number is greater than or equal to three. (Our simulations show that when the number of conflicting directions is two, the human tendency to avoid collisions ensures hassle free movement.)

(ii) At the micro or intra-group level, we further divide the groups into connected sub-groups of humans moving with similar speeds. We report presence of congestion if speed of a sub-group is more than the speed of the sub-group moving in front along the direction of movement of the group.

(iii) If both the conditions stated above do not hold, we report absence of congestion.

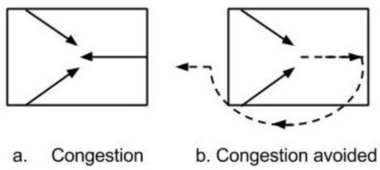

Figure 1: When there is no space in front of any of the groups, one of the group is led through a semi circular path around the congested area while the other groups wait.

2.2 Congestion Control

When a CDA finds congestion, it calls a CCA and then they work together to achieve congestion control. One of the following scenarios arises:

(i) There are no conflicting directions among moving groups but the speed of a sub-group is greater than the speed of the sub-group moving in front. The CCA moves above the faster sub-group while shining its spotlight on the sub-group and playing a pre-recorded message requesting the humans to slow down.

(ii) There are conflicting directions but at least one of the group has space in front to proceed. The CCA then positions itself above that group and leads the group in its target direction while requesting the other groups to wait for it to return. The group being led is required to follow the spotlight and maintain the speed of the spotlight. After the group is led out of the congested area, the new scenario could conform to case (ii) or case (iii) and is handled accordingly recursively till congestion is resolved.

(iii) There are conflicting directions and none of the groups have space in front to proceed (see Figure 1). Using the pre-recorded messages and the spotlight, the CCA leads one of the group through a semi circular path around the congested area while requesting the other groups to wait for it to return. The center of the semi circular path is given by equations (1) and (2) and the radius is given by equation (3). After the group is led out of the congested area, the new scenario could conform to case (ii) or case (iii) and is handled accordingly recursively till congestion is resolved.

$$\begin{aligned} center_x = \{(a_x + b_x)/2 | dist(a,b) \geq dist(i,j) \\ \forall i,j \in humansInCongestedArea\} \end{aligned} \tag{1}$$

$$\begin{aligned} center_y = \{(a_y + b_y)/2 | dist(a,b) \geq dist(i,j) \\ \forall i,j \in humansInCongestedArea\} \end{aligned} \tag{2}$$

$$\begin{aligned} radius = \{dist(a,b)/2 | dist(a,b) \geq dist(i,j) \\ \forall i,j \in humansInCongestedArea\} \end{aligned} \tag{3}$$

Notice in Figure 1 that the groups finally end up moving in the direction they originally intended to.

The outcome of the congestion control strategy would depend on the obedience of the crowd. Therefore, the CDA keeps recalculating humans' speeds and directions to calculate the percentage of disobedience. A human is disobedient if he/she does not have the speed or direction he/she is being instructed to have. If the percentage of disobedience is high, the CDA requests the police in charge to help in managing the crowd.

Figure 2: Situation before(a) and after(b) congestion control. Red dots represent humans experiencing congestion.

3. RESULTS

We use Helbing and Molnar's social force model [3] for crowd simulation. The motion of each human is governed by the summation of all the forces exerted on and by the human. The following forces help us in modeling group behavior. (i) *Intent*: A human exerts force in the direction he wants to move in. (ii) *Cohesion*: A human exerts force to remain close to his group. (iii) *Coherency*: A human exerts force to walk in the same direction as his group. (iv) *Momentum*: Inertial force. (v) *Avoidance*: A human exerts force to avoid colliding with other humans and obstacles.

We simulate humans on a central park background and test our congestion detection and congestion control strategies. The results are presented in Figure 2.

Remember that we are not making the humans move in a direction they did not intend to (see Figure 1). Therefore, we cannot assure complete absence of congestion. Direction conflicts will inevitably arise unless we force the humans to move in a direction they do not want to move in (see Figure 2(b)). Nevertheless, our congestion control strategy resolves congestion as soon as it is detected and keeps on doing so to ensure hassle free movement of the crowd.

4. CONCLUSION

In this paper, we presented a multi agent based solution to crowd management. Our results show that the agents are able to detect the presence of congestion as well as take remedial actions. Thus the robotic agents help the police force in ensuring a congestion free movement of the crowd.

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