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AI In the Game Development

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ABSTRACT: *A focus of pedestrian's behavior in 3d games and simulations are increased. This paper presents model for efficient collision avoidance algorithm that can be used in simulation of crowd behavior in 3d games and simulation project. . Our model is based on a representation of the situation in a (x,y,t) space, which makes it possible to consider both detouring and speed modifications in the avoidance patterns.*

Keywords: *AI for games, Steer behavior, Path finding in 3d games and simulation*.

I. INTRODUCTION

For a more efficient and safer design of public facilities, it is important to be able to estimate the behaviour of the crowd, to predict heavily used routes or peak flows. For example, a computer simulation of crowd movement can be used to elaborate emergency evacuation plans.

The model available to describe the behavior of the crowd usually deals with microscopic variables like the average speed or the flow.

Our purpose is to design an individual-based model of the crowd, hoping that a more refined simulation might be obtained by considering each pedestrian's behaviour.

II. CROWD MODELS

a. Macroscopic approach

In this approach, the crowd is described with fluid-like properties. Usually, some measures are made to find an expression of the speed according to the density(of course, he higher the density is, the more frequent the contacts are, and the lower the speed is). Individually, there are many variations according to one's sex, age, physical shape, motivations… but his model only deals with averages.

1. Macroscopic description Variables

- Average walking speed U(in meter per minute)
- Density of pedestrians d(in pedestrians per square meter)
- Flow Q (in pedestrians per minute per meter width), with Q = U.d

Linear approximation U = A-B.d

2. Factors defining the quality of the flow

- Freedom to choose one's desired speed and to overtake
- Ability to cross a stream
- Ability to walk in the direction opposing the major flow.

In simulations using the macroscopic approach:

- The environment is modeled by a graph, each edge being a transit place (sidewalk, passageway, stairway, escalator…) with its own capacity (estimated from surveys).
- The pedestrian concentration is propagated across this graph.

This pedestrian concentration is propagated across this graph.

These simulations are successfully used for large-scale estimations, such as the study of the effect of a modification in the design of a facility (adding a new entrance a new exit..) or the estimation of the evacuation time of a building.

However, they do not take into consideration behavioral elements, and thus cannot be used at a more precise scale, to study how pedestrians really act.

b. Microscopic Approach

I. <u>Individual description</u>

Yielding is the action to change one's own trajectory to allow another pedestrian to pass. It is hard to measure exactly the distance at which one starts yielding. Observations made showed that the yielding distance decreases as the density increases, from 2.1m at low density, to 1.5m in congested situation:

When the density is low enough (unimplemented situation), at about 15~30m from the obstacle.

At high density, when a simple detour is not possible, the " step-and-slide" movement occurs, starting at a distance of about 1.5 m. It consists in slight angling of the body, the turning of the shoulders and a side step.
While the people coming ahead are usually briefly glanced at, and then discarded, when a collision is likely to happen, a kind of communication occurs, involving:
The emission of signs to allow the other to discover one's purpose
An establishment point, when both parties acknowledge
Of course, misunderstanding is possible in this communication, both parties proposing to take the same option at the same time.
They enter in what was called a " reciprocal dance", which can require a couple of occurrences to break.

II. Boids

The famous model of group movements can simulate flocks of birds, herds of horsed, schools of fish.. These bird-like agent are called boids.
The model is based on a very simple formulation of local rules that any agent in the group must enforce. Resulting in a surprisingly harmonious result.

- Separation: avoid collision with nearby flock mates
- Alignment : match velocity with nearby flock mates
- Cohesion: attempt to go towards the center of the flock.

When avoiding collisions, a bold only considers the center of the flock. When avoiding collisions, a boid only considers the positions of its flock mates, and it chooses its speed relying only on its 'neighbors' speed. Therefore, collision –free navigation appears as a side effect. Boids are cooperative and all share the same goal and preoccupation in a human crowd, everyone tries to avoid collisions, but the result is very different from a school of fish. This is probably because few pedestrians have the same objectives, and because everyone tends to act in rather selfish way, not enforcing the rules of alignment and cohesion. The difference shall be evident at low densities, when everyone is free to choose his speed.

iii. Particle systems

Particle systems are usually used in computer animation for the modeling and the visualization of clouds, water, gases, fires… They consist in some clouds of elementary primitives (particles) with physical attributes (which obey physical laws). One can make the analogy with actual particles in electro-magnetic fields

This method was used for simulation of crowd movement involving up to 50,000 persons, especially to test emergency Evacuation plans. The model is robust enough to allow such large-scale simulations, and can be used to study the apparition of **congestion points** or the spreading of **panic Phenomena**

III. AN ALGORITHM FOR COLLISION AVOIDANCE

a. Outline

We adopted the following specifications for our model.

- Each agent is able to plan a safe trajectory from the current position. Using information on the position and speed of the obstacles to forecast their trajectories.
- Both detouring and speed variations are possible in the avoidance scheme.
- (x,y,t) space is used to represent the collision avoidance problem.

b. (x,y,t) space

The future position of all visible obstacles is predicted and represented in a three dimensional (x,y,t) space. In such a space, all objects are static, and the problem becomes one of path planning(box 3, top)
By introducing the disk of admissible displacements, we simplified the search of a path in three-dimensional space to a search of a point in a limited two-dimensional domain(box 3, bottom).
Our goal is to select a good point in the disk for the next movement, "good" meaning collision-free and optimal in relation to speed variation and detouring.
To characterize a point P in the disk, we consider the trajectory Tp obtained by adopting the speed corresponding to P (therefore TP is a straight line). We showed that points corresponding to a collision are on a segment AZ (box 4, top)

Then, taking a point P not on AZ, we calculated the minimal horizontal distance dmin between TP and the line to avoid (the velocity of the obstacle is supposed to be constant). If the pedestrian discards all movements that correspond to a dmin inferior to a fixed limit, it creates a triangular shaped forbidden area having Z for vertex (see box 4, bottom).

c. *(x,y,t)* space

When avoiding a collision point in *(x,y,t)* space :

- Passing under it means passing earlier, thus accelerating
- Passing above it means passing later, thus Decelerating

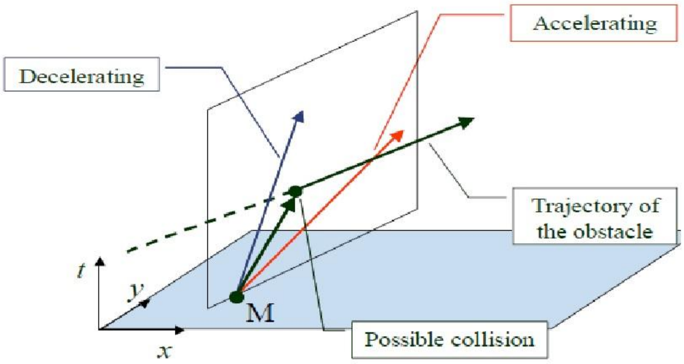

Figure 1. (x,y,t) space

Admissible displacements

The main constraint on the trajectory is that time is not reversible. Since *z=VZ.t*, where *VZ* is an arbitrarily fixed constant, all admissible displacement vector for the time interval, *t* must have *VZ. t* for third coordinates.

Hence, the points that can be reached after *t* are on a disk *VZ, t* above the current position, which radius is *VM t*, *VM* being the maximum speed for the pedestrian.

IV. GEOMETRICAL PROPERTIES

Property 1: If the trajectory to avoid is a line in *(x,y,t)* space, then the set of points that would lead to a collision is a segment *AZ* in the disk of admissible displacements

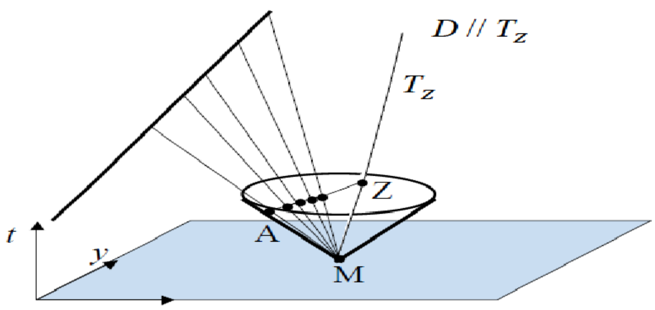

Figure 2. Geometrical properties

Property 2: The points on a same line from *Z* correspond to a same *dmin*. Intuitively, it means that the closer *P* is to *Z*, the further the collision point is, and the less deviation is required.

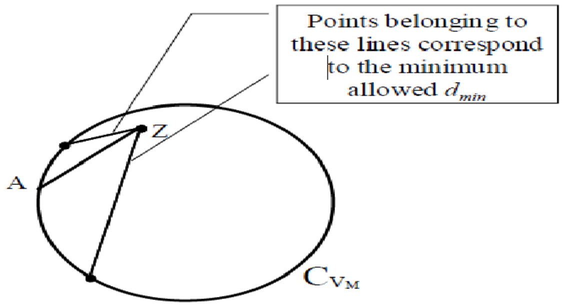

Figure 3

c. Finding the best movement

To choose among the points outside the forbidden area, we defined a **cost function** over the disk. In box 5, the forbidden zone created by three obstacles is represented. Points *V* represent the pedestrian's current speed, and the point leading to the goal at his favorite speed is *G*.

d. Planning and following the trajectory

By iterating *n* times the process, a n-step trajectory can be planned from the current position, as shown in the following chart:

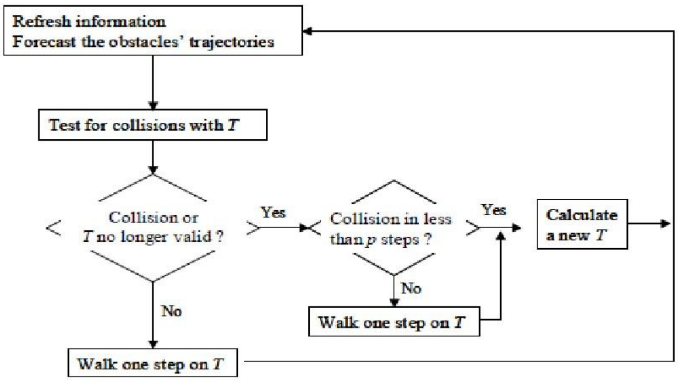

Figure 4. chart

4. Evaluation

a. Real data

Experimental data was obtained by filming outdoor scenes with a video camera, but we faced two problems. First, **the coordinates of the pedestrians must be pointed at manually**. It would have been interesting to make the whole process automatic, however, useful scenes involve many pedestrians. In such cases, it is difficult to apply object tracking methods since the environment is complex and many occlusions occur.

Next, **the behavior of the pedestrians is difficult to analyze**. We were able to obtain trajectories and velocity profiles; and we observed some variation according to the age (elder people walk more slowly) and the motivation (people in a hurry often rush when crossing the street). From these observations, we found that an average value for *vfav* can be 1.5 m/s.

b. Test situations

***i.* Frontal avoidance**

In this situation, the two agents walk from opposite directions and must deviate to avoid a collision. The amount of deviations depends on the value of dmin, and the value of the K parameters does not influence the movement (the points on the limit of the forbidden area have the lowest cost). The trajectories of the pedestrians for different values of dmin are represented in box 7 (top).

ii. Lateral avoidance

In this situation, the pedestrians come from orthogonal directions. Collision avoidance is possible both by changing speed and by detouring. This choice depends on the values of the K parameters.

- In the first case, the cost of deceleration is lower than the cost of acceleration for pedestrian 0 (in green)
- In the second case, the cost of acceleration is higher
- In the third case, the attraction to the goal is stronger, so that he does not

Avoidance with 12 agents Influence of *dmin*

- Too small (*dmin*<0.8m): the resulting trajectories are
- no longer collision-free. Too large: unnecessary detours are made.

Influence of *n*

- Too small (*n*<4): the agents constantly re-plan their trajectory, so that it becomes difficult to accurately forecast their behavior, resulting in unstable situations.
- Too large: the last part of the planned trajectory corresponds to unrealistic forecasting.

V. CONCLUSION AND POSSIBLE ENHANCEMENTS

We presented an efficient collision avoidance algorithm that was used in a simulation of crowd behavior, involving up to 12 pedestrians with conflicting goals. Our model is based on a representation of the situation in a *(x,y,t)* space, which makes it possible to consider both detouring and speed modifications in the avoidance patterns.

Among the enhancements that are to be implemented before our model can realistically describe crowd behavior:

- In the description of the environment: implement sources and sinks of pedestrians (doorways in reality) to generate large numbers of agents.
- In the description of the agents: improve the mechanical model (limited acceleration and rate of turn), implement specific behaviors (step-and-slide movement, group behavior), and improve the method used to forecast the trajectories to be avoided.

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