A Visual Simulation of a Car-Traffic Flow by Customizing Boid Model

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Abstract: A visual simulation of a car-traffic flow is proposed, which is based on the boid model. In order to apply the model to a car-traffic flow, the behaviors of the model are adjusted and two behaviors are newly defined for a signal and an intersection. The proposed method can visualize more realistic motion of cars on a road, namely a turn at an intersection.

1. Introduction

Studies on geographic information systems (GIS)[1] have been actively developed in recent years. Visualization technologies such as computer graphics (CG) become more useful and more important for GIS in response to larger amount of complicated information. Usually still images related to maps are used for visualization of static information, and motion images (animations) are used for visualization of dynamic information. Among the dynamic information, traffic flow information of cars and pedestrians in an urban space is one example of the dynamic information and its reconstruction is impossible due to its properties such as dynamism, hugeness, and complexity. Therefore its visual simulation is meaningful for users to understand and analyze it easily. Furthermore, a certain immersive visualization system such as the CAVE is desirable for their clearer and easier understanding.

We have proposed a visual simulation of a car traffic flow[2], which is based on a cell automaton. Although this method can represent the flow at a low computational cost, movement of cars is restricted by size and shape of a cell. In this paper, we propose a visual simulation of a car-traffic flow, which is based on the boid ("bird-droid") model[3]. In this model crowd motion such as a flock of bird can be represented by three simple steering behaviors: separation, cohesion and alignment. It is not appropriate to apply this model to our problem directly, since it has been developed to represent "random" motion of a boid, whereas a car moves on a traffic-lane in order.

Therefore, we adjust the above behaviors to a car following a car in front on the same lane. In addition to this adjustment, we define two behaviors at a signal and an intersection. The proposed method can visualize motion of cars on a road, namely a turn at an intersection, more realistically.

2. A Customized Boid Model for a Car-Traffic Flow

The boid model[3] consists of three steering behaviors which describe how a boid maneuvers itself through a crowd based on its position and velocity:

Separation: steer to avoid crowding local boids

Cohesion: steer to move toward the average position of local boids

Alignment: steer towards the average heading of local boids

Although each boid can access global geometric information and positions and velocities of other boids, its motion in a crowd is determined in local area where the boid exists. The model can easily represent smooth motion of a crowd. However, it is inapplicable directly to a car-traffic flow, because a car moves on a traffic-lane in order.

In order to apply the boid model to a car-traffic flow in consideration of signals and intersections, we firstly group cars by lane of a road. Each group contains a lane and cars on the lane (see Figure 1). Motion of cars such as a change of lanes and a turn at an intersection is recognized as a shift into another lane group. Each car has a driving route and can access information on current situation (driving road, coming to a signal, or turning/going at an intersection) and other cars' groups, positions and velocities. Namely a car can easily access information on a car in front in the same group.

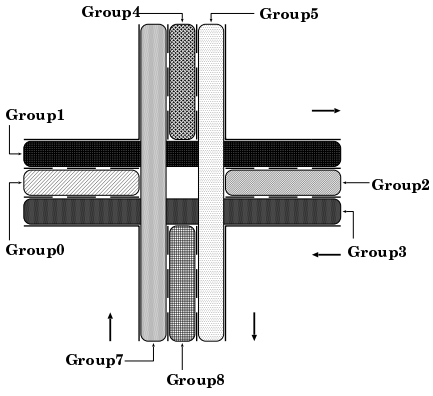

Figure 1: Grouping cars

Secondly we regard a car as a boid and set two distances for a boid: d_1 as a warning distance in which a car reacts the others, and d_2 as a danger distance in which a car is too close to other cars.

Thirdly, we adjust the three original boid behaviors and add two new behaviors to cars' motion as the followings:

Deceleration: (former Separation) steer to avoid collision with a forward car. A car is forced to slow

down if another car exists within d_1 ahead, and to stop if it exists within d_2.

Acceleration: (former Cohesion) steer to catch up a forward car in the same group. A car is forced to speed up or to keep maximum velocity if no car exist within d_1 ahead.

Follow: (former Alignment) steer towards the heading of the group at an average velocity.

Signal: steer not to enter an intersection when a signal is not green. A coming car to a signal is forced to slow down if the signal is yellow, and to stop if the signal is red.

Turn: steer to reduce velocity enough to turn safely at an intersection. A car making a turn at an intersection is forced to slow down before coming to the intersection and keep its (safe) velocity.

In order to visualize a car-traffic flow according to the above model, we execute the following steps:

Step 1: Set static and dynamic geographic information on roads and traffic (position of intersections and signals, number of lanes, traffic density of cars, cycles of signals). Also define a steptime to be calculated.

Step 2: Define initial information on cars (positions, velocities and routes).

Step 3: Determine next positions and velocities of cars at next time according to the proposed five behaviors on the given geographic information. If a car arrives at its destination, it is eliminated.

Step 4: Visualize the situation.

Step 5: Return to Step 3 as time proceeds to the next.

3. Simulation

For example, we consider a crossroad which consists of a signal, crosswalks and right turn lanes on two-way left-hand traffic. Figure 2 shows an image of bird's-eye view and Figure 3 is a plane figure zoomed in the intersection. Since it takes 0.01 second on average to calculate cars' situation and rendering by OpenGL, we can easily view a series of generated images as an animation. Smooth motion of cars (going/turning) can be observed in the animation.

4. Conclusion

In this paper, we proposed a visual simulation of a car-traffic flow, which is based on the boid model. In order to apply the model to a car-traffic flow, we adjust the behaviors of the model and add two behaviors for a signal and an intersection. The proposed method can visualize motion of cars on a road, namely a turn at an intersection, more realistically. The proposed model is in process of an installation on the CAVE for clearer and easier understanding in larger urban space. Stronger combination with geographic information is to be discussed in future papers.

Acknowledgement

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References

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Figure 2: A bird's-eye view at an intersection

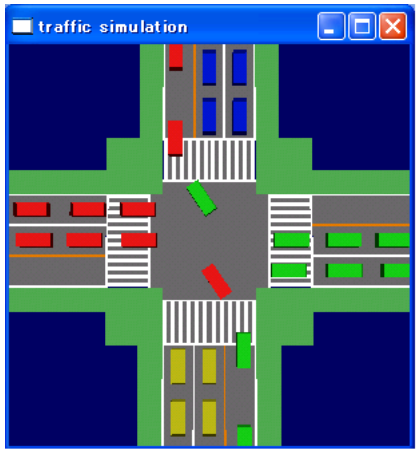

Figure 3: A plane figure at zoomed intersection