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RESEARCH PAPER

Traffic Incident Prediction on Intersections Based on HMM

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Abstract: The intersection is an area where many accidents occur. Reasons for accidents are due to complicated intersection designs and the congested travel conditions. For these reasons, traffic incident detection is more complicated. This paper uses the intersections of Huaihai South Road and Jiefang Road as an example. According to the vehicle operation and phase timing, the situations of two vehicle's relative movement on four phase intersections are summarized. The motion vectors of the conflicting vehicle are quantized on the basis of vehicle tracking. Then, the HMM is used to classify the traffic conflicts of the intersection. Finally, numerical experiments verify that the algorithm is able to classify the conflict when the traffic is normal. Furthermore, the algorithm can forecast the traffic accidents (such as bumping, tandem, and stop) which occurred in the intersection.

Key Words: intelligent transportation; incident detection; hidden Markov model; intersection; traffic conflict

1 Introduction

In recent years, the rate of urban road traffic accidents remains high, especially in urban intersections. Except for the complicated intersection designs, the other factor is that the travel condition is often congested. For example, vehicles always travel freely to different directions at multilane intersections, yet the driver may park their cars illegally in the middle of the road when an accident occurs. The car will need to be parked in a safe position in order to allow traffic to return to its normal status. Moreover, because of this, the ambulance and police have to work for a long time to deal with the accidents. These obstructions makes it difficult for the traffic incident detection of the intersection[1].

Until now, several research institutions abroad have investigated the simulation experiment of collision detection at intersections. They used data mining technology to find a traffic flow mode suitable for various intersections. They also contrasted the traffic flow conditions of the intersection to predict the incidents[2]. Cuchira *et al*.[3] utilized the traffic rules' inference to reflect a simple traffic condition on a one-way street. Jung *et al*.[4] adopted computer technology to track vehicles from a traffic image and to enhance the accuracy of traffic information detection. Oikawa *et al*.[5] identified traffic congestions based on the video sequence. In China, current research on intersection traffic conditions is in the design stage of traffic controllers. Moreover, building the detecting coil and predicting incidents via the direct usage of the highway traffic flow mode must still be designed. In view of the lack of intersection traffic incidents detection in China, this study designs a set of traffic conflict detection systems suitable for urban intersections.

2 Analysis of the relative motion between two vehicles with conflict at the intersection

Fig. 1 displays the intersection plan for Huaihai South Road and Jiefang Road in Huai'An city. The signal is controlled by four phases. According to the vehicle running and phase timing, this paper summarizes the relative motion condition between two conflicting vehicles at the intersection controlled by four phases, as shown in Fig. 2. Fig. 2(a) indicates north-south and east-west through vehicles; Fig. 2(b) indicates north-south and east-west left-turn vehicles; Fig. 2(c) indicates the traffic conflict between two adjacent direction's vehicles; one is the through vehicle, and the other is the right-turn vehicle; Fig. 2(d) indicates the traffic conflict between two vehicles of north-south or east-west direction; one is the left-turn vehicle, and the other is the right-turn vehicle, as shown in Fig.3.

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3 Feature extraction

3.1 Feature extraction about relative motion vectors

This paper designs an algorithm that was suitable for a variety of intersections with different factors, such as geometry of the intersection, angle of video camera and location of the accident. Here, the intersection controlled by four phases is used as an example. In this study, vehicles run in multiple directions and conflicts may occur in every image frame. Therefore, such geometric dependencies increase the amount of training data for HMM algorithm. Thus, in order to avoid this scenario, the algorithm tries to avoid using image intensity as the features, because it depends on the color of vehicles consequently, the processing image is gray. First, the algorithm extracts the motion vectors feature from vehicles[6-8]. The process is shown in Fig. 4 and Fig. 5.

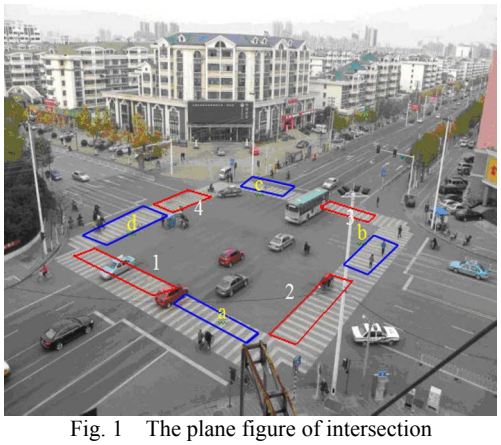

Fig. 1 The plane figure of intersection

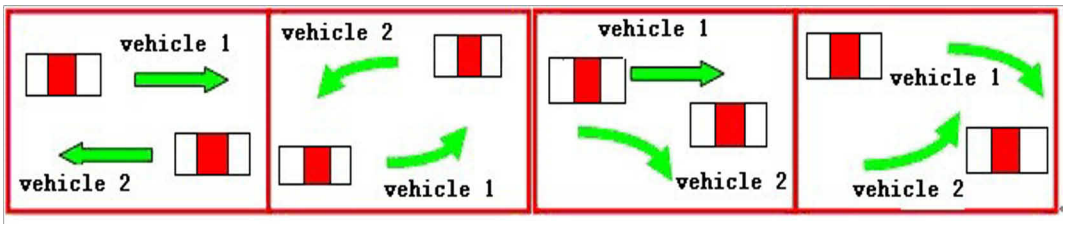

Fig. 2 The relative motion of two vehicle with conflict(supposing vehicle 2 is before vehicle 1)

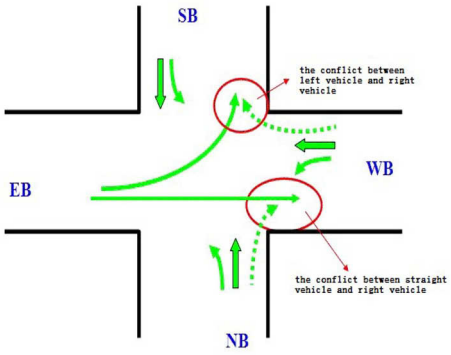

Fig. 3 The schematic diagram of conflict

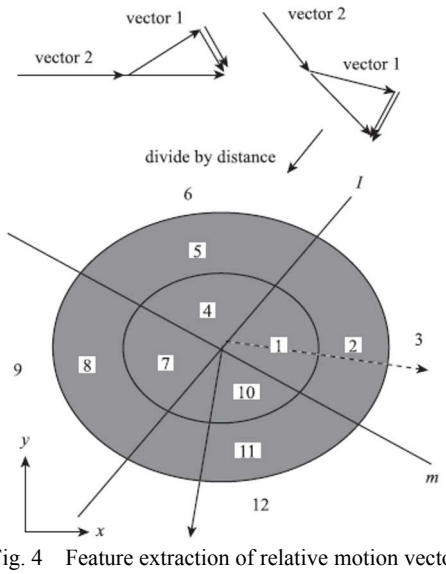

Fig. 4 Feature extraction of relative motion vector

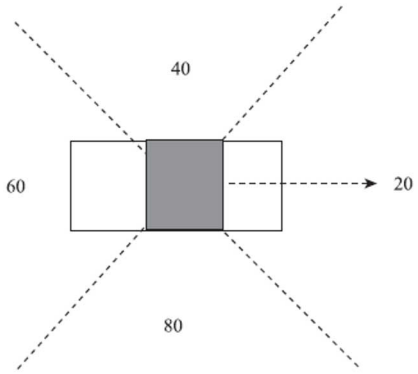

Fig. 5 Feature extraction of relative location

Deductive process for feature extraction of relative motion vector

(1) Estimate the difference of motion vectors between the two objects, which is the motion vector of Vehicle-1 minus the motion vector of Vehicle-2.

(2) Rotate the differential motion vectors to different locations, so that the differential motion vector $\vec{V}_d$ rotates along the dotted line pointer in Fig. 4, counterclockwise to the position of the solid line cursor. The differential motion vector $\vec{V}_d$ to $\vec{V}_r$ form a circular arc and distribute in four areas, which can then be divided by the geographic coordinates.

(3) Divide the rotated vector by the distance between the two objects. Here, the distance is measured by the nearest blocks between the two objects, because the nearest distance directly affects the collision time of the two objects. As shown in Fig. 4, the three circular arcs with different radius sizes are