7Q-04

Collision Detection and Responsibility Assignment in Traffic Accidents Using Object Detection, Knowledge System, and Open Data

Helton Agbewonou YAWOVI† Masato KIKUCHI† Tadachika OZONO†

Department of Computer Science, Graduate School of Engineering – Nagoya Institute of Technology†

1. Introduction

Vehicle collisions are recurrent events that occur every day [1] for various reasons [2]. Quick assessments of actors' responsibilities after traffic accidents help victims obtain faster compensation. However, many types of information are required to determine responsibilities, and collecting such information takes time and effort. In our previous study [3], we developed a system that assess responsibilities from driving recorders' videos on traffic accidents using image detection and a rule-based knowledge. The system was limited only to crashes with traffic lights.

Toward realizing a general responsibility evaluation system, we examined the possibility of using open data to complement the lack of information. This paper describes our improved crash and traffic light recognition models and how we use OpenStreetMap API as an available open data source and a complementary tool. This paper demonstrates that the combination of our updated image recognition models (crash and traffic light recognition models) and OpenStreetMap API enables the system to handle more crash scenarios and improves the performance of responsibilities evaluation mainly during nighttime with traffic lights, 55% successful evaluation against 46%-53% obtained in the previous system.

2. Implementation

To solve the limitation of a previously implemented system [3], we changed the architecture and working flow of the system and associated the usage of open data from OpenStreetMap API to get roads and traffic signs data independently of the weather, visibility, and time. Additionally, we retrained, updated, and used a previously created custom crash and traffic light detection models. With such changes and improvements, the system can handle more accident cases such as accidents without traffic lights, can perform better even during night. The new system's architecture is based on a mobile application and a server. The mobile app streams in real-time the recorded video to the server which saves it as a sequence of data-tagged images (containing data about the speed, the GPS location, and the orientation of the vehicle). When the user sends a request for responsibilities evaluation through the mobile app, the server first uses its crash detection model to detect the crash time in the saved data-tagged images. It then uses its traffic light detection model to detect all traffic lights within the data-tagged images. After decoding the data-tagged images and getting back the data of the vehicle, it uses the GPS location to retrieve road information from OpenStreetMap API such as road width, and the presence of other traffic signs (such as stop signs, and speed limit signs). Finally, it uses a rule-based knowledge system of road rules and the vehicle's speed and orientation to deduct each party's probable responsibility.

To evaluate responsibilities, the system uses the logic of degree of negligence. For example, let's consider two crossroad head-on crashes involving two vehicles (Vehicle A and Vehicle B) at an intersection. According to Japanese traffic rules, we have basic degrees of negligence for each vehicle depending on the situation:

- **Situation 1 (with traffic lights)**: "*In case the traffic light is green for A and red for B, the degree of negligence for Vehicle A is 0, and the one of Vehicle B is 100.*"
- **Situation 2 (without traffic lights):** "*If Vehicle B was going straight on a priority road and A was coming from a small road, the degree of negligence for Vehicle A is 90, and the one for B is 10.*"

In Situation 1, we only need **the status of the traffic light (green/yellow/red)** making it easy to easily handle thanks to the traffic light detection model. However, in Situation 2, we need: **the type of the road (priority road) and its width (small road)**. In such a situation, computer vision cannot be of any help. Therefore, the current system uses an additional layout and algorithm based on open data from OpenStreetMap API. Situation 2 is just one of the multiple crash scenarios where road information is needed, and for each of them, the system fetches any necessary additional data (such as stop signs, road width, road type, and speed limits) from OpenStreetMap API. Table 1 summarizes the type of information needed and shows their availability and accessibility in our current system in comparison with the previous one.

3. Experiments

To evaluate the system, we performed some experiments with 80 head-on crash videos within the context of crossroad accidents with and without traffic lights during daytime and nighttime. We simulated the crash by playing the crash videos with a video player on a computer and recording them using the mobile app. Table 2 shows the results of the successfully evaluated responsibilities within the videos over the total number of videos tested for the specific environmental condition.

As shown in the results, during the daytime the system performs well in evaluating actors' responsibilities when the crash occurs either with traffic lights or without traffic lights. During nighttime the system performs relatively well without traffic lights. The lowest accuracy is reached when the environment condition is night with bad visibility.

Table 1. List of information needed for responsibility evaluation and their accessibility/availability in our current and previous system

Information needed for head-on crashes	Accessibility & Availability	
	Previous system	*Current system**
Situations with traffic lights		
Traffic lights presence	Yes ✓	Yes ✓
Traffic lights status	Yes ✓	Yes ✓
Situations without traffic lights		
Road width	No ✗	Yes ✓
Road type	No ✗	Yes ✓
Direction	No ✗	Yes ✓
Stop signs presence	No ✗	Yes ✓
Speed limit signs presence	No ✗	Yes ✓

Table 2. Results of the current system in evaluating responsibilities within crashes with/without traffic lights in comparison with the previous one

Type of crash & Responsibility assessment	Environment Conditions	
	Day	*Night*
Accuracy: Previous system		
With traffic lights	53-66%	46-53%
Without traffic lights	Not available	Not available
Accuracy: Current system (with open data)		
With traffic lights	90%	55%
Without traffic lights	100%	80%

4. Discussion

Within crashes with traffic lights, the system uses its traffic light detection model to detect the state of existing traffic lights (green/yellow/red). On the other hand, within crashes without traffic lights, the system gets the location of the device at the moment of the crash and uses open data to get information about the road before assessing the responsibilities. As a comparison with results obtained from the evaluation of our previous system, we see a significant accuracy improvement for crashes with traffic lights either during daytime or nighttime (thanks to the updated crash and traffic light recognition models) as well as the support of crashes without traffic lights (thanks to the usage of open data) and the good performance of the system in such situations.

Moreover, crashes at intersections are a common type of road collision. According to the National Cooperative Highway Research Program in the U.S.[1], intersection-related crashes constitute more than 50% of all collisions in urban areas and over 30% in rural areas. Additionally, in 2021, according to the U.S. Department of Transportation, National Highway Traffic Safety Administration[2], among collisions involving moving motor vehicles, angle collisions and head-on collisions are the most frequent, accounting for 45.46% and 27.18%, respectively. This is in comparison to rear-end collisions (18.66%), sideswipe collisions (7.5%), and other/unknown incidents (1.2%). Currently, the system fully supports head-on (front impact) collisions and angle collisions (left and right-side impacts), highlighting the importance and relevance of the proposed system in real world applications. However, the support of angle collisions is limited to the condition that the impact with the other vehicle is shown in the crash video. This is due to the fact that driving recorders can only capture limited angles, therefore angle collisions can only be handled if the crash video (of either Vehicle A or Vehicle B) that is input in the system shows the impact with the other vehicle.

5. Conclusion

This paper introduced a system that can recognize a crash within images generated from video streaming of a mobile app, detect traffic signs, and finally assess the responsibilities of actors within the crash by using the vehicle's speed, its GPS location, and its orientation as well as OpenStreetMap API to get information about the road. Experiments showed good results in assessing responsibilities when crashes with/without traffic lights occur, and discussions showed the relevance of the system in real world applications.

Acknowledgement

This work was supported in part by JSPS KAKENHI Grant Number JP16K00420, 19K12097, 19K12266.

References

[1] World Health Organization: Global status report on road safety 2018. Tech. rep., World Health Organization (2018)
[2] Bucsuhazy, K., Matuchova, E., Zuvala, R., Moravcova, P., Kostikova, M., Mikulec, R.: Human factors contributing to the road traffic accident occurrence. Transportation Research Procedia 45, 555–561 (2020)
[3] Yawovi, H.A., Kikuchi, M., Ozono, T.: Who was wrong? an object detection based responsibility assessment system for crossroad vehicle collisions. AI 3, 844–862 (2022)

[1] https://web.archive.org/web/20061003032951/http://safety.transportation.org/doc/1P%20Unsignalized%20Intersection%20Crashes.pdf
[2] https://www.iii.org/table-archive/21904