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Evaluation of a safety map generated from a collection of difference of Individuals

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Abstract

In this paper, a method to generate traffic safety maps automatically from a collection of GPS logs of a drivers' smartphone. So far methods that residents can update their traffic environment better by their opinion are required for. The proposed method which uses a collection of individual summary not raw data achieves a consistent safety map while their privacy is protected moderately. In this paper, the summarization method is explained.

Keywords: Traffic Safety Map; Risk Estimation; Smartphone Sensing; Collective Intelligence; Reality mining;

1. Introduction

In this paper, we propose a method for generating traffic safety maps based on differences in individual recognition of the road environment by using smartphone data from various users.

Safety map is a kind of risk analysis result of traffic environment. There are some works related to risk analysis. For example, Google Live Traffic is a service that utilizes GPS data from Android smartphones to estimate traffic jams based on average GPS speed. Honda initiated a project for traffic safety map in 2013 using data recorded by their Internavi in-vehicle unit, along with police reports and user contributions to their safety map website[1]. The locations where sudden brake occurs as risky spots are plotted automatically in the map.

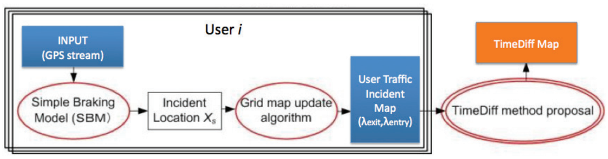

Fig.1. Process for generating traffic safety map

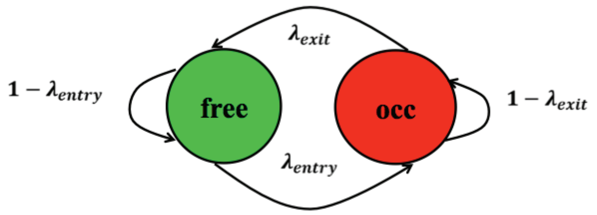

Fig.2. IMAC: it supposes that each grid forms a two state Markov chain with two states of being: free and occupied.

In this paper, we propose a method for integrating a collection of hazard locations based on differences in drivers' recognition of the road environment. The method is inspired by STEP technique of risk analysis in traffic safety field. We suppose that if every drivers have the same recognition of a crossroad, the level of danger will depend on one's driving skill. By contrast, where one driver recognizes a crossroad as passable and where other drivers recognize it as impassable, accidents are more likely to occur.

2. The Proposed Method

The process for generating the proposed traffic safety maps is depicted in Fig.1. We refer to the proposed traffic safety map as a TimeDiff map. The map integrates a collection of traffic-incident maps that are generated from users' smartphone log data (proposed in [2][3]). In this section, we explain the method for constructing a user's traffic-incident map which is the left side of Fig.1. Finally, we describe the proposed summarization method for integrating these incident maps into a global hazard map which is shown by the right of Fig.1.

2.1. *Simple Braking Model(SBM)*

We explain a method for generating a traffic incident map that can be used to interpret how a driver recognizes the road environment. The Simple Braking Model (SBM) is used for estimation of location of a hazard spot from a log stream of a smartphone.

We assume that whenever a vehicle encounters an incident, it always decreases its speed to avoid an accident. The relation between the current speed and the moving distance is described in the following equation:

$$\frac{dx}{dt} = v_0\left(1-\frac{x}{Xs}\right)^n \qquad (1)$$

where X_s is the initial distance to the incident, x is current distance to the incident (x=0 when the vehicle begins to slow down), n>0, and v_0 is the initial speed. By fitting by eq(1), it can tell the distance X_s to an incident.

2.2. *Generating a traffic-incident map with IMAC*

We explain the method for generating a user's traffic-incident map [2]. Saarinen et al. proposed IMAC[4], a model for describing dynamic environments with an occupancy grid map, and this model is utilized to represent traffic incidents. With the IMAC model, an environment is evenly divided into grids. Each grid is modeled as a two-state Markov chain with two states of being: free and occupied (see Fig.2). The IMAC model is suitable for representing dynamic objects, such as traffic signals or traffic incidents, with a grid map. Furthermore, IMAC is used to estimate the transition-probability parameters (λ_{exit} , λ_{entry}) by observe) by observing the occurrence of the state occupied or free and the transitions between them.

To estimate the grid states from the observed events, Saarinen proposed a method for observing two processes in each grid in a dynamic environment with Eq. (2):

$$\hat{\lambda}_{exit} = \frac{\#occupied\,to\,free+1}{\#occupied}, \hat{\lambda}_{entry} = \frac{\#\,freetooccupied+1}{\#\,free} \qquad (2)$$

Fig. 3. Input: a log stream of smartphone

Fig. 4. Output; the user's traffic-incident map

Fig.3 shows an example of a GPS log of a vehicle which is the input to generate a traffic incident map. Fig.4 and 5 illustrate the traffic incident map, Fig.4 shows the IMAC map of λ_{exit} and Fig.5 depicts the map of λ_{entry}. Small circles indicate incidents of this driver. As these figures show the proposed method can detect incidents at each corner adequately. In the next section we explain a method to merge multiple users' traffic incident maps.

2.3. *TimeDiff method[3]*

This section proposes an integration method for generating a global map from a collection of IMAC users' grid maps for ($\lambda_{exit}, \lambda_{entry}$). This method is based on the average time that users hold a different recognition of the same road environment. We call this the TimeDiff method. The global map (i.e., the TimeDiff map) shows the total time for road-recognition differences between users in a given area.

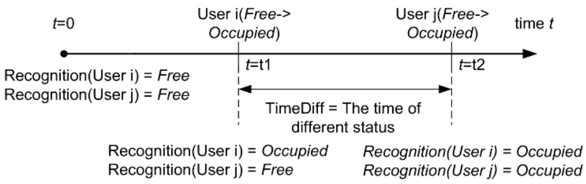

Fig. 5. Time differences in the judgment of a road environment

Consider a scenario where two vehicles are driving along a road. At this time, the road upon which the vehicles are traveling is recognized as *Free* (see Fig. 5). As the two vehicles approach a red traffic signal, they encounter an incident, and the road at this location is recognized as *Occupied*. Consequently, both vehicles come to a stop. At this time, both vehicles must change their recognition of the road environment from *Free* to *Occupied*. TimeDiff method focuses on the time that each vehicle changes its status. It is clear that the occurrence of an accident depends on the recognition of both drivers. If two vehicles change their status at the same time, they both have the same recognition of road environment. Thus, an accident will not occur unless a driver makes a mistake in controlling the vehicle. By contrast, the more difference in time between when the recognition changes - that is, between when one vehicle recognizes the road as *Free* and other recognizes it as *Occupied* - the higher the likelihood of a collision. Thus, the global TimeDiff map is based on the road-recognition level of the users.

Let D be the set of users. We assume that all users generate their own traffic incident map ($\lambda_{exit}, \lambda_{entry}$) by using the update method in Eq. (2). We define the hazard level of each grid g in the global map with Eq. (3). Suppose two users, i and j in D, initially report an *Occupied* status. Suppose further that user i changes this status to *Free* before user j does. Alternatively, suppose that i and j initially report a *Free* status, and that the status from user i switches to *Occupied* before that of user j. The total difference in time between such status changes (whether *Occupied* or *Free*) from all pairs of users i and j in D is calculated as follows:

$$TimeDiff_g = \sum_{i \in D} \sum_{j \neq i \in D} c_{ij} \left(E(P_{dif}^{f}(i,j)) + E(P_{dif}^{o}(i,j)) \right) \quad (3)$$

where $E(P_{dif}^{f}(i,j))$ is the difference in time between switches when each pair of users initially reports a *Free* status, and $E(P_{dif}^{o}(i,j))$ is the difference in time between switches when each pair of users initially reports an *Occupied* status. c_{ij} is a probability that user i and j meet.

$$E(P_{dif}^{f}(i,j)) = \int_0^{B_f} t \cdot \Pr ob[X_i = occ \leq t](1 - \Pr ob[X_j = occ > t])dt \quad (4)$$

$$E(P_{dif}^{o}(i,j)) = \int_0^{B_o} t \cdot \Pr ob[X_i = free \leq t](1 - \Pr ob[X_j = free > t])dt \quad (5)$$

We suppose that this follows a Poisson process so that these 2 terms can be calculated briefly. For example, when $\lambda_{i,exit}$ =0.01, $\lambda_{j,exit}$ =0.1, Bo=10, c_{ij} =1, then $E(P_{dif}^{o}(i,j))$=1.5505.

3. Experiment

The global hazard map (i.e., the proposed TimeDiff map) is shown in Fig.8. This map is generated by the personal incident map of a vehicle shown by Fig.6 and the incident map of a motor cycle rider in Fig.7. In the Fig.8 the spots where accidents occurred in the last 5 years are also illustrated. This proposed map agrees with the accident data.

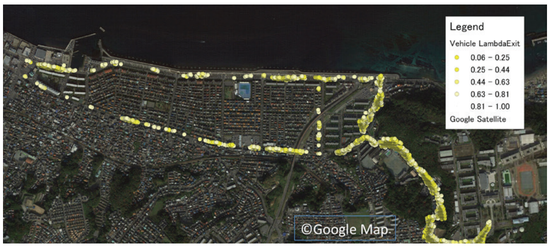

Fig. 6. The Incident map of λ exit of the car driver.

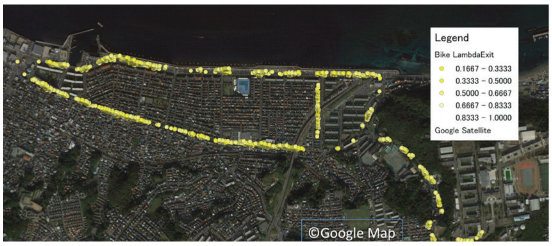

Fig. 7. The Incident map of λ exit of the motor cycle rider.

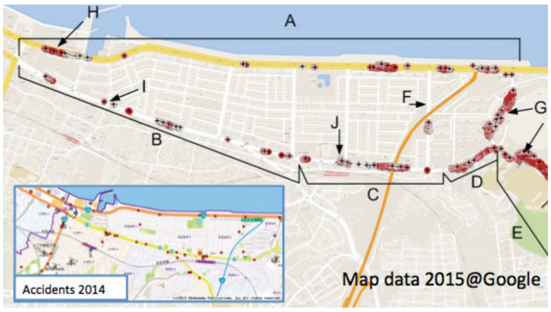

Fig. 8. Process for generating traffic safety map

Also spots where a field survey is conducted are shown in Fig.7 For example spot J has many pedestrians because it is in front of a gate of a train station. Spot H is an ext of a parking area of restaurants. Fig.9 shows spot F. Spot F is on a straight road, but some accidents have been occurring. As shown by Fig.9 spot F is along a park and has a zebra crossing. The proposed safety map can detect a zebra crossing without a signal.

Fig. 9. Spot F

4. Conclusion

In this paper, a method for generating traffic safety maps based on differences in individual recognition of the road environment by using smartphone data from various users is proposed.

References

1. http://www.honda.co.jp/safetymap/
2. V. C. Dang, M. Kubo, H. Sato, T. Shirakawa, A. Namatame,Anomaly Stop Detection by Smartphone, Journal of Robotics, Networking and Artificial Life, Vol. 1, No. 1 (June 2014), 2-6.
3. V. C. Dang, H. Sato, M. Kubo and A. Namatame, Building Safety Road Maps Based on Difference of Judgment of Road Users by their Smartphone, International Journal of Advanced Computer Science and Applications(IJACSA), 6(9)(2015) 15-23.
4. J. Saarinen, A. Henrik, and J. L. Achim, Independent Markov chain occupancy grid maps for representation of dynamic environment., in Proceedings of IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)(2012)3489-3495.