

**“Technical Research and Development for Road Policy Quality Improvement”  
Study Summary**

No.	Title	Principal Researcher
No.30 - 2	Detection and Risk Evaluation of Unusual Events by AI Learning with Traffic Theory	Tohoku Univ. Prof. Masao Kuwahara

This study proposed methods that detect and evaluate risks of unusual events under disasters by the AI learning together with traffic theory. The developed methods were embedded in the R-Alert system which visualizes traffic / weather conditions as well as alerts risks of unusual events in real-time so as to support road administrators.

### 1. Backgrounds and Objects

This study proposes methods that detect and evaluate risks of unusual events under disasters in real-time by the AI learning together with traffic theory. Unusual events we mainly focus are road damages due to a natural disaster, traffic standstills on snowy roads, and flooded streets by heavy rain. The several subsystems on the detection and evaluation of unusual event risks are embedded in the R-Alert system which visualizes traffic / weather conditions as well as alerts risks of unusual events in real-time so as to support road administrators.

### 2. Activities in Research Period

The whole study is divided into three categories of (1) detection, (2) risk evaluation, and (3) the R-Alert system; and our specialists on traffic, meteorology, image processing, computation, GIS, and probe data collectors are assigned among the three groups.

On (1) detection, a method that detects unusual events locally based on extraordinary vehicle motions such as U-turns and drastic speed/direction changes was proposed. Also, another method that finds area-wide abnormality based on MFD (Macroscopic Fundamental Diagram) was proposed. Furthermore, video images from driving recorders were analyzed to detect falling objects on roads, road flooding and accidents.

On (2) risk evaluation, standstill risks on winter roads were evaluated using probe vehicle and weather data; and we proposed two methods: one applicable to entire Japan considering regional characteristics and another for local but detailed risk evaluation based on SSM (State Space Model). Also, a method for the landslide risk evaluation was proposed based on the amount of rainfall and the terrain.

The above individual methods were then embedded in (3) the R-Alert system which visualizes traffic / weather conditions as well as alerts risks of unusual events in real-time so as to support road administrators.

### 3. Study Results

For (1) detection, a method that detects unusual events based on U-turn vehicle motions was proposed and validated by applying to the Hokkaido-Iburi earthquake (Fig.1). Another method based on vehicle motions of drastic speed/direction changes was developed mainly for urban areas and validated by applying to the Kumamoto earthquake. Another method that finds area-wide abnormality based on MFD was developed and validated using data in the central district of Sendai. Traffic monitoring system on a 2-dimensional network was also proposed using SSM and the application experiment was carried out.

Furthermore, video images from driving recorders were analyzed. A semi-automatic labelling was developed for the efficient preparation of training images and detections of road flooding as well as accidents from the images were examined. A method that detects falling objects on roads was proposed by the machine learning on extracted vehicle edges (Fig.2).



Fig.1 Detected U-turns



Fig.2 Detection of Falling Objects

For (2) risk evaluation, standstill risks on winter roads were evaluated using probe vehicle and weather data. A method applicable to several regions with different snow characteristics was developed based on the decision tree and risk thresholds were determined. And, another method for local but detailed risk evaluation was proposed based on SSM and validated using 61 standstill data (Fig.3). Also, a method for the landslide risk evaluation was proposed based on the amount of rainfall and the terrain (Fig.4).

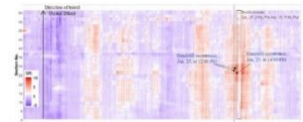


Fig.3 Risk Evaluation of Local Standstills

For (3) the R-Alert system, above individual methods were embedded in the R-Alert system which visualizes traffic / weather conditions as well as alerts risks of unusual events in real-time so as to support road administrators (Fig.5). The R-Several times, the alert system has been experimentally used by road administrators so as to improve the system for the practical use.



Fig.4 Landslide Evaluation



Fig.5 R-Alert System

#### 4. Papers for Presentation

1. Shogo Umeda, Yosuke. Kawasaki, **Masao Kuwahara**, Akira Iihoshi, Risk evaluation of traffic standstills on winter roads using a state space model, Transportation Research Part C, 125, 2021.
2. Yosuke Kawasaki, Yusuke Hara, **Masao Kuwahara**, Traffic state estimation on a two-dimensional network by a state-space model, Transportation Research Part C, 113, 2020.
3. Le Trung Nghia, Akihiro Sugimoto, Shintaro Ono, Hiroshi Kawasaki, Attention R-CNN for Accident Detection, 2020 IEEE Intelligent Vehicles Symposium (IV2020), 2020.
4. Yuji Morimoto, Toshio Yoshij, Takahiro Tsubota, Perdition on Traffic Breakdown on a Network by Artificial Intelligence, the 61<sup>st</sup> Annual Meeting of Infrastructure Planning and Management, 2020.
5. Kazuhiro Tanji, **Masao Kuwahara**, Shogo Umeda, Ryota Horiguchi, Akira Iihoshi, DOMINGO project and the Realtime Monitoring/Alert System – Detection of Road Failure under Heavy Snow, Journal of Snow Engineering, July, 2020.

#### 5. Study Development and Future Issues

1. Continuous Validation of Developed Technologies  
Although we have attempted validations of the developed methods as possible as we can, the further validations would be needed for various disaster types, time of day and places. The continuous validations and their records would not only improve our developed methods but also contribute to R&D on disaster mitigation in the future.
2. Continuous Data Accumulation  
Unusual events due to natural disasters may have a wide variety depending on disaster types, time of day and places, and so on. Since unusual events are in general rare events compared with daily usual events and therefore the continuous data gathering and accumulation have to be systematically carried out for the technology development for the disaster mitigation.
3. Transition from R&D to Practice  
Considering the objective of the CART project, we have tried to propose systems that could be used in practice. However, the further public assistance is requested so that the system could be truly utilized in daily work of road administrators, since several additional issues such as the customization based on user needs, the system failure response, the budget acquisition, etc. must be solved.

#### 6. Contribution to Road Policy Quality Improvement

1. The quick detection and risk evaluation of unusual events under disasters would contribute to safe and efficient evacuation, effective traffic regulations, road recoveries, emergency medical cares, good supply, etc. Especially, we have been recently experiencing long time road closures due to standstills under snowy condition. The proposed risk evaluation of standstills would help decision makings on the in-advance road closure, snow removal timings, amount of de-icer on roads, etc.
2. Throughout the CART project, we have several times contacted with road administrators to understand their needs under unusual events and to improved our system based on their advices. Therefore, our proposed methods would stay relatively closer to the practical use.

## 7. References, Websites, etc.

R-Alert System <<https://trafficscope.info/test2020snow/>>