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An Application of the Mesh-wised Traffic Information System using Floating Car Data for Nationwide Road Network

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Abstract

This study describes an application of the real time mesh-wised traffic information “Traffic Scope” for nationwide road network. Traffic Scope calculates mainly two indicators of the fluidity and the singularity of road traffic based on Macroscopic Fundamental Diagram using floating car data. The on-line demonstration of Traffic Scope for the area of 23 wards of Tokyo has been operated for several years. For the next step, we are developing the new system to provide Traffic Scope of nationwide road network in Japan. However, some technical issues to be tackled for large scale area are found from the analysis of floating car data. In this paper, we introduce the concept of Traffic Scope and describe the issues to apply nationwide floating car data to Traffic Scope, showing some examples of anomaly detecting in road traffic such as the analysis result on the day of heavy snow and the day of several events.

Keywords: Traffic Information, Floating Car Data, Macroscopic Fundamental Diagram

Introduction

The purpose of this paper is to introduce the application examples of the real time mesh-wised traffic information “Traffic Scope” for a large area and describe the issues to be tackled for the development of the nationwide service of Traffic Scope. We first explain the model concept of Traffic Scope, and show the system structure and the data process of Traffic Scope system. After the explanation, we show the example of Traffic Scope for wide area and consider the applicability and the issues before the discussion for further steps in the conclusion.

In recent years, the huge amount of floating car data is collected as one of the type of big data by car navigation, smartphone and other devices to collect vehicle information. On the other hand, the services and the technologies using floating car data have been rapidly because the several potentials of floating car data are recognized. In addition, it is said that the target areas

for the services about road traffic information can be expanded with the increasing of floating car data. In our study, we have come to the conclusion that “Traffic Scope” has a potential to expand to nationwide using floating car data in Japan. The two major purposes of Traffic Scope are to provide the current traffic situation at first glance and to encourage the users to consider their behaviours in transportation. Traffic Scope is one of the new traffic information services to assist the movement of people to avoid congestion and some troubles in daily traffic.

Model Concept

Traffic Scope is the mesh-wised traffic information with two indicators of the fluidity and the singularity of road traffic which are calculated in real time. This methodology which is developed by Horiguchi et al.[1][2][3][4] is used the idea of Macroscopic Fundamental Diagram (MFD). MFD is formulated by Daganzo[5]. In recent years, many researches using MFD to understand the traffic situations or to use for traffic management can be found by several approaches such as Geroliminis[6]. Basically, MFD is a statistical approach for area-wide traffic which is calculated using floating cat data or detector data. Traffic Scope employs the idea of integration of real time data and statistical analysis to understand the difference between usual traffic situation and unusual traffic situation. On the other hand, it is also important that the visualisation of traffic situation should be designed to provide as the easy-to-understand traffic information. Traffic Scope is designed to understand the fluidity and the singularity of road traffic at first glance for broadcasting system such as TV.

Figure1 shows the concept of Traffic Scope. The input data is basically floating car data with time and GPS position. The point on MFD can be calculated by the product of average flow and network length (Q) and the product of density and network length (K). Thus Traffic Scope can also calculate by aggregated data such as traffic volume and average travel time for each link. The procedure of the indicators of Traffic Scope is below.

i. Analyse the statistical QK pattern on MFD using the floating car data in the last 1 month (maximum 3 months). Now the time resolution of aggregating QK point is 15 minutes.
ii. Estimate the approximate curve from the QK pattern on MFD. The curve is the basic line that expresses the normal traffic situation.
iii. Calculate the present point of QK on MFD from real time floating car data and analyse the difference between the present situation and the approximate curve.
iv. Make the indicators (the fluidity and the singularity) of Traffic Scope from the analysis result (the present QK point and the difference from the normal situation).

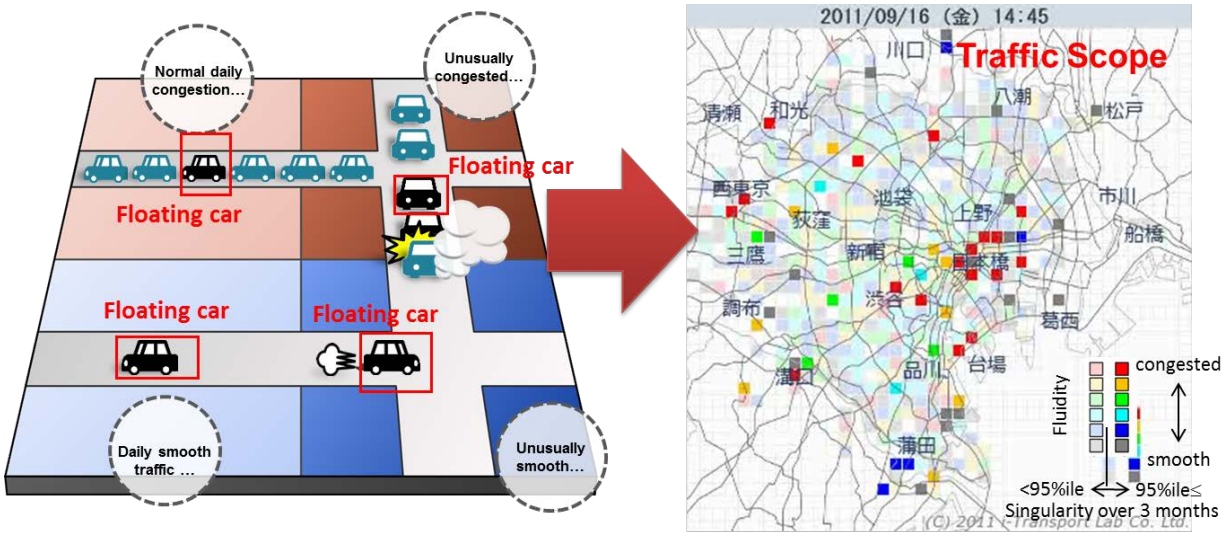

Figure1 – Concept of Traffic Scope

System structure of Traffic Scope

Figure 2 shows the system image of Traffic Scope System. Traffic Scope Server is receives the aggregated floating car data with link travel time and sample number. And Traffic Scope Server analyse floating car data and calculate the Traffic Scope data (the fluidity index and the singularity index). Traffic Information Server receives the Traffic Scope data and makes the image data to deliver some services. When the aggregated data with link information is used, the network data (link id, link length, etc.) should be shared between Floating car data server and Traffic Scope Server.

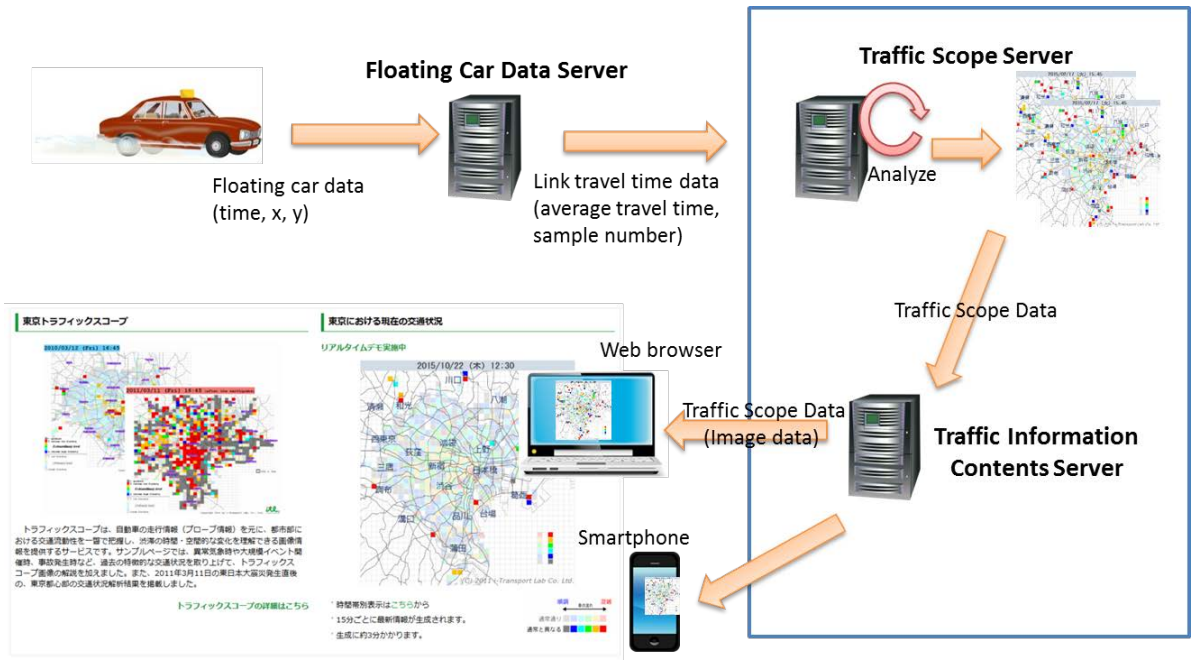

Figure2 – System image of Traffic Scope system

Figure 3 shows the data process in Traffic Scope Server. Traffic Scope Server consists of 4 processes. The data collection process is the front-end process to collect floating car data and to divide the collected data into target mesh-areas every 15min. or 5min. QK data making process calculates the QK plot on MFD and dispose floating car data for the data security policy. The statistical process is the important process to estimate the normal traffic situation (the basic QK pattern) from QK pattern for each mesh area and decide the parameter of the basic QK pattern curve. The Traffic Scope information making process calculate the fluidity index and the singularity index based on the current QK plot and the basic QK pattern on MFD for each mesh area. The calculated results are accumulated the Traffic Scope Database for the several service.

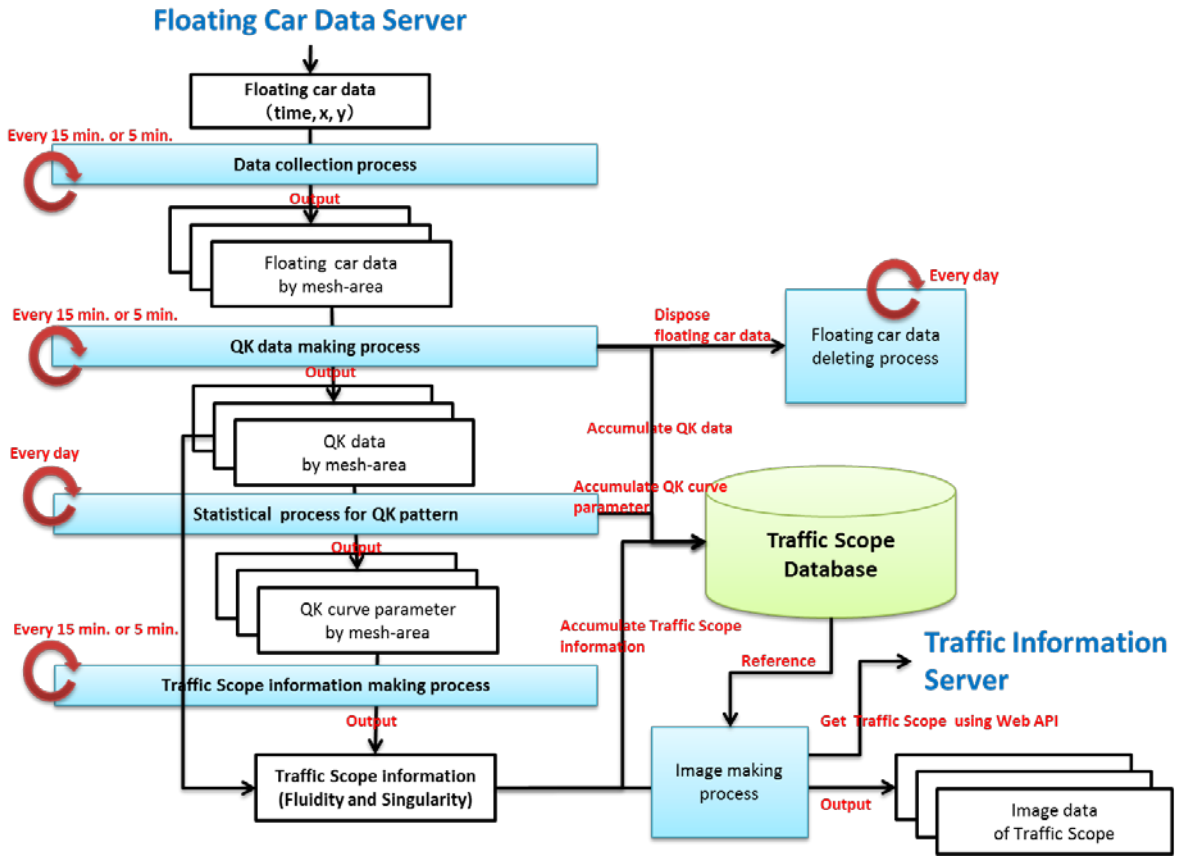

Figure3 – Data process in Traffic Scope Server

Tokyo Traffic Scope

Traffic Scope system is operating for the area of Tokyo 23 wards called “Tokyo Traffic Scope”. Figure 2 shows the online demonstration website of Tokyo Traffic Scope [7]. This system uses the floating car data from SPATIOWL[8] data base in Japan. The target area is only Tokyo 23 wards area but the collection rate of floating car data is reliable and stable. We have been operated Tokyo Traffic Scope as a real time demonstration for several years and the transition of gridlock of road traffic was detected in the day of the Great East Japan

Earthquake. Tokyo Traffic Scope is updated each 15 minutes. The process time is approximately 3minuts from the collection process to the delivery of the image data of Tokyo Traffic Scope.

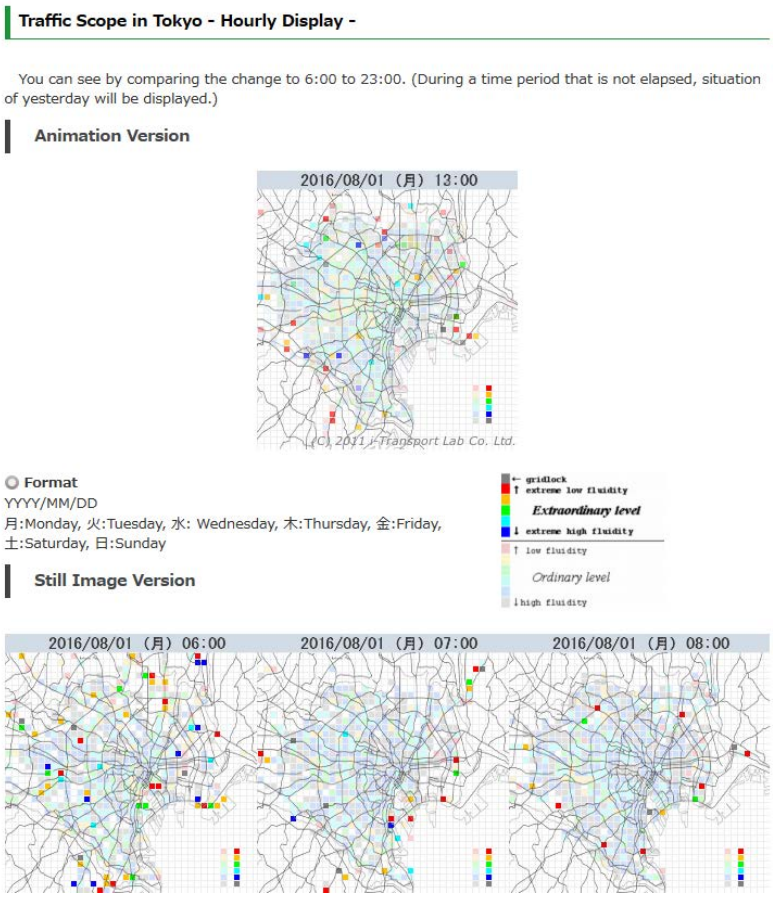

Figure4 – Online demo of Tokyo Traffic Scope

Applications for large area

For the application to nationwide area, we made the prototype of Traffic Scope system updated some functions to process nationwide floating car data in real time. The prototype was implemented the new data processes by parallel computing techniques based on the framework in Figure 2 and Figure 3. By using the new prototype, all meshed areas in Japan can be calculated by the new Traffic Scope System.

Figure 4 and Figure 5 show the analysis results of the singularity index and the speed difference in the day of heavy snow. The floating car data we use basically covers all areas in Japan, and is aggregated into the format consisting of traffic volume (number of samples) and average travel time for each link. The red mesh area in Figure 4 shows the unusual situation highlighted by the singularity index. And the red mesh areas in Figure 5 are the highlighted areas which the speed is rapidly declined. We can be fairly certain that Traffic Scope can detect unusual traffic situations and indicate the areas for large area.

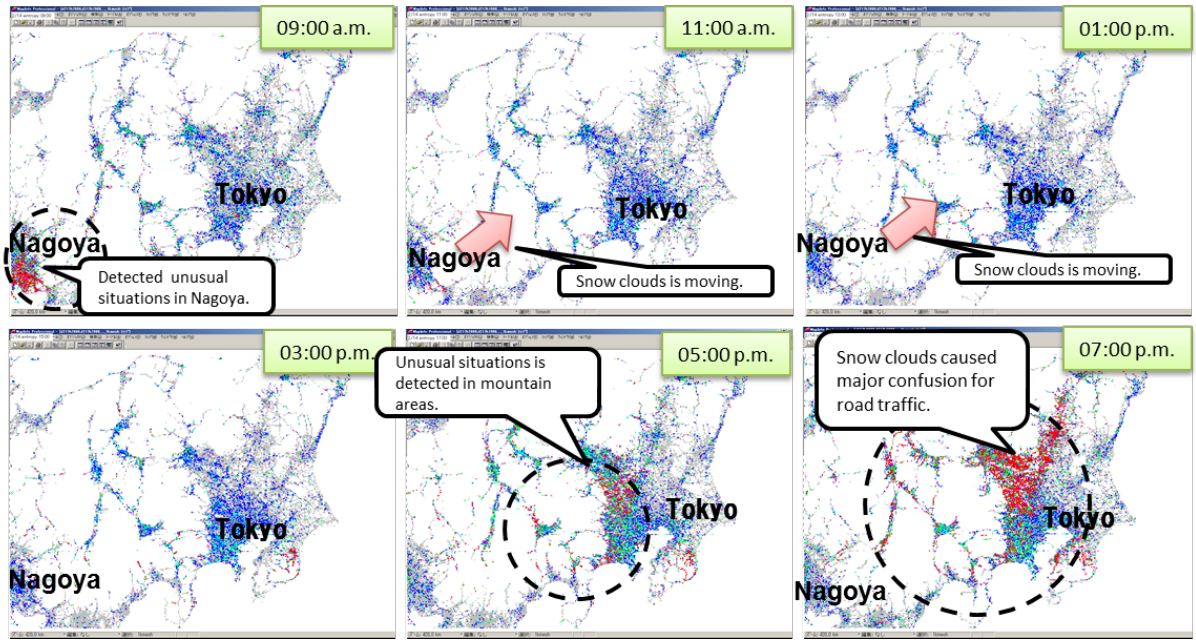

Figure4 – Singularity of Traffic Scope on the heavy snow day

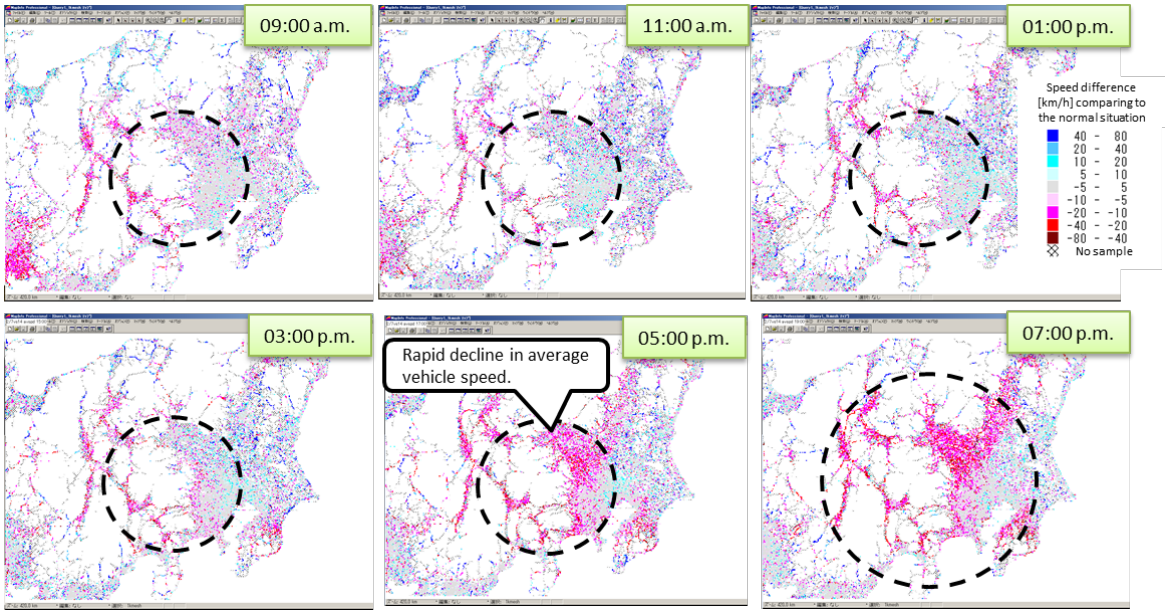

Figure5 –Speed difference of Traffic Scope on the heavy snow day

Figure 6 shows the enlarged area of the result in Figure5. The unusual traffic situation on this day was detected especially on mountain corridors. It is likely that the stopped vehicles or the troubled vehicles by the snow-filled road existed in this area. In addition, some mesh shows the cross mark areas which had no data or very few data. These areas express that the roads in the area might be closed by some reasons such as heavy snow. Thus the cross mark area should be focused and the system may alert as the area to take precautions for the rescue or the road regulation. On the other hand, the singularity index and the difference speed in Tokyo

area have relatively less impacts. One of the reasons is said that the many people in Tokyo and the around areas are no need to use vehicles and they have many choices of transportations to their destination such as train and bus. The other reason is also said that the snow depth in Tokyo is low related to the mountain areas.

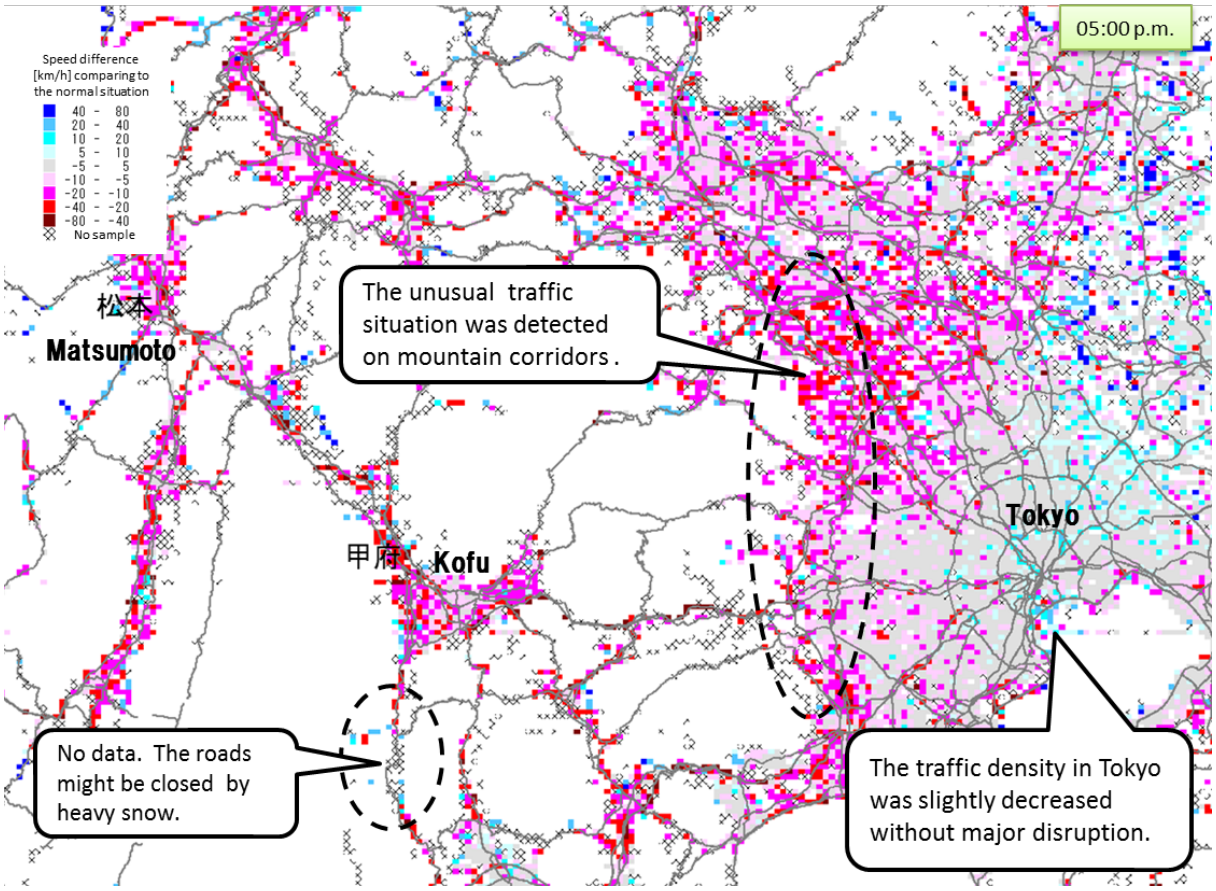

Figure6 – Traffic Scope near Tokyo area on the heavy snow day (February 14, 2014)

We also estimated a Traffic Scope example on another day which some events were held. See Figure 7 for the Traffic Scope on the day of firework festivals in three areas. These festivals began after 6:00 p.m. and finished at 8:30 p.m. Generally, fireworks viewers might go home all together and the around area could be congested by the people by walk and vehicles. Traffic Scope shows the unusual congested area in three areas at the finish time of the festivals. Therefore, this example turned out that the singularity index and fluidity index of Traffic Scope can detect unusual situation area not only weather but also special event for large area.

On the other hand, some issues to apply to nationwide area are described through the calculation examples. One is the process when a mesh area does not have enough floating car data for the calculation of Traffic Scope. Basically the floating car data is collected in the past 1 hour to calculate Traffic Scope for a time slot (15 minutes). The current system of Traffic Scope and the prototype cannot adjust the calculation in response to the amount of floating

car data. Thus the result of Traffic Scope could be misunderstood with small amount of data in 1 hour, especially in suburbs. It is said that the function of parameter adjustment of should be developed. And the other one is the believability of Traffic Scope. Traffic Scope can detect the unusual situation but there is no supplement to know the reason of the situation. Open data related to public transport and social networking service is one of the solutions to estimate the believability. It is the important issue to overlay with several types of data on Traffic Scope and develop the framework to know the traffic situation from various perspectives.

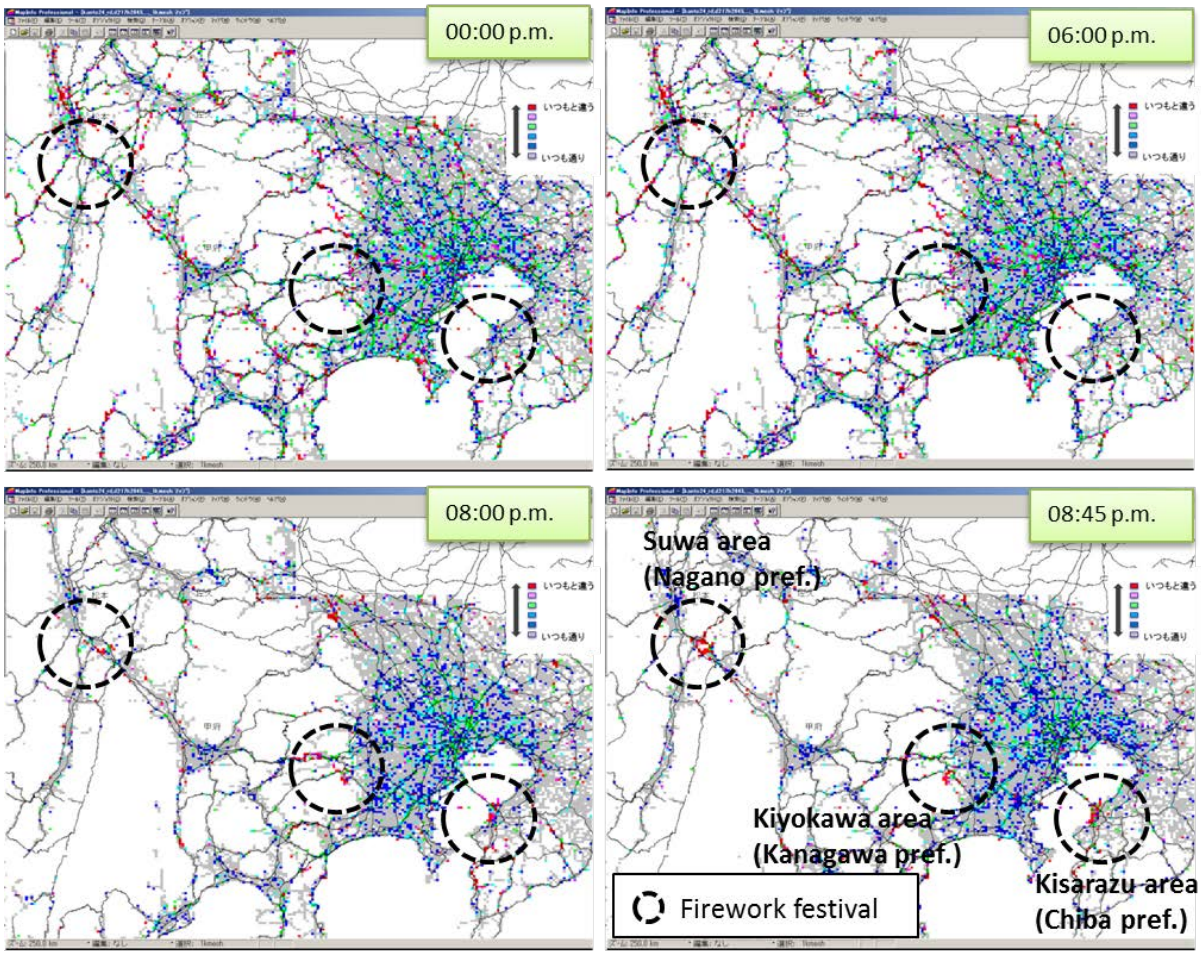

Figure7 – Traffic Scope on the day of firework festivals

Conclusions and Future works

In this paper, we describe the system structure and the data process of Traffic Scope, and the application result for large area. The following results from our activities were obtained:

- The Traffic Scope system was extended to process the nationwide data of floating car.
- Traffic Scope can detect the unusual situation for large area in the heavy snow day and in the day with several events.
- However, it is said that the calculation of QK analysis in an area with small amount of data is needed to adjust the statistical process for real time.

- On the other hand, there is room for further consideration of the believability of the detected unusual situation by Traffic Scope comparing to other traffic information sources.

Judging from the above, much can be said on the following tasks for the application to the nationwide service of Traffic Scope.

- Develop an approach of Traffic Scope to solve the issue of the QK analysis with small amount of data.
- Combine Traffic Scope with several types of data such as weather information.
- Find and visualize the reason of the detected area in unusual situation, analysing the data from social networking services.
- Develop the risk index of unusual traffic congestion to avoid an additional disruption of traffic in advance.

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