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# COMPOSITION OF DISPLAY SYSTEM FOR PREDICTING OF ROAD SURFACE TEMPERATURE

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## ABSTRACT
The severity of accident is tend to be fatal when the traffic accident occurrence caused by skid resistance.Since the road surface temperature is down in winter, road surface freezing causes especially the occurrence of traffic accident. To prevent the occurrence of traffic accident caused by road freezing, the studies and technologiesare needed to predict road surface temperature and provide the driver. Therefore, this study conducts to develop the road surface temperature forecasting system using prediction model developed in the previous year. The system proposed in this study is expected to contribute the research in regards to prevent traffic accidents due to freezing of the road surface.

**Keywords:** *Road Surface Temperature, Display System, Prediction Model, Traffic accident*

## I. INTRODUCTION
The analysis results on traffic accidents resulted from road slipperiness reported that the fatality rate of traffic accidents in rainy days during the typhoon-affected season amounts 3.7 persons per 100 traffic accidents. In particular, traffic accidents in rainy days occur more in nighttime (62%) around 10 pm to next 4 am than in daytime (38%). Furthermore, 13,217 traffic accidents have occurred during the last three years, resulting in 351 deaths and 21,519 injuries. Moreover, the fatality rate (2.7 person) of traffic accidents in rainy days during the rainy season in Korea was 1.2 times higher than that of other causes during the same period (2.2 person), which is presented in Table 1.

***Table 1. The Traffic Accident Rate by Climate***

| Category | Fatality rate | Number of Accidents | Proportion | Number of Fatality | Proportion |
|---|---|---|---|---|---|
| Rainy day | 2.7 | 13,217 | 19% | 351 | 22% |
| Others | 2.2 | 55,135 | 81% | 1,234 | 78% |
| Total | 2.3 | 68,352 | 100% | 1,585 | 100% |

In winter, traffic accidents resulted from road slipperinessdue to frozen road surface are likely to occur. When a road surface temperature is dropped in winter, road freezing causes traffic accidents. A study in overseas on comparison results of various data between winter and non-winter seasons also indicated that traffic accidents in winter have increased by 19% and the number of casualties has also increased by 13% more than that in non-winter seasons (Black and Mote 2015). The reason for traffic accidents resulted from road slipperiness is due to external factors such as frictional coefficient of tire and road surface and defective pavements causing skid road surface. However, external factors such as poor road surface conditions or weather deterioration are difficult to be controlled realistically. Thus, this study aims to cope with road surface freezing when weather conditions are deteriorated in winter. For more detail, if appropriate monitoring on road surface temperatures is taken, and if road management and traffic operation strategies are established properly, human casualties and property damage due to skid-related accidents in winter can be reduced considerably.

In particular, this study investigated a system to display a road surface temperature in the road surface temperature predictionmodel, which was developed previously. It is highly important to prevent sliding traffic accidents by providing drivers with well-displayed predicted temperature. Thus, this study proposed a method that configured a system with mobile app and web interface to provide information about road surface temperature to drivers. Particularly, this study provided a basis that can not only establish the model that estimated a road surface temperature through the development of the proposed system but also implement and manage a vast amount of road surface temperature data. When the implementation and management of the road surface temperature data developed in this study are expanded to provide information to a large number of drivers, it can provide road safety-related information more accurately and preemptively than before.

## II. LITERATURE REVIEW

In this chapter, researches and practical services were reviewedin relation to methods of providing risk information to users.

In relation to display of road surface temperature and weather conditions, a prediction model of black ice occurrence was developed in the USA.The data collected road weather information systems and National Weather Servicewere used to predict regions of black ice occurrence and provide dangerous road section information (Bukkapatnam et al., 2014). Furthermore, a technology that distinguishes dryness, wetness, and frozen condition in road surfaces is currently commercialized utilizing imaging equipment such as stereo cameras or remote sensing technologies (Jonsson, 2011; Omer and Liping, 2010). The skid resistance occurs at a contact surface between road surface and tire when vehicle tires move on the road with a series of actions. If a larger force than a force occurred at the contact area with the road surface is generated, a vehicle slides, and the resistance at this state is called skid resistance. If skid resistance is low, vehicles slide frequently thereby increasing risk of accidents. Thus, an appropriate frictional force is required on the road surface.Hankook Tire (2000) reported that when hydroplaning occurred, tires in the axes where a driving force was not transmitted had a deceleration of rotational speed due to the resistance with water and the driving axle was in idling state, resulting in vehicle driving with only inertial force and a loss of breaking function as well as motion function of tires, which led to a loss of vehicle control via handle. The company suggested that the minimum depth of water was 2.5mm–10.0 mm although it varied according to tire speed, a level of wear, and roughness of the road surface. It is necessary to consider a wavelength and amplitude of road surface profile according to a driving speed when micro-texture of the surface is investigated to increase skid resistance of the pavement. The following table presents a range of wavelengths and limits of profile amplitude that affect driving safety and comfort. Table 2.presents a range of wavelengths that affect the safety and comfort.

***Table 2. Range of Wavelengths on Driving Speed***

| Driving speed (km/h) | Range of wavelength (m) | |
|---|---|---|
| | Safety Impact | Comfort Impact |
| 40–60 | 0.60–1.6 | 3.7–16.6 |
| 90 | 1.25–2.5 | 8.3–25.0 |
| 130 | 1.80–3.5 | 12.0–25.0 |

It is necessary to investigate internal communications in vehicles to predict a road surface temperature effectively. In vehicles, the standard on-board diagnostics tool and Controller Area Network communication is used, which will be explained in the next. The standard on-board diagnostics tool refers to a self-diagnostic and reporting device used in vehicles. The diagnosis items are catalytic converter, O2 sensor diagnosis, misfire, fuel control system, evaporative gas prevention system, Positive Crankcase Ventilation system, Exhaust Gas Recirculation, secondary air system, and other system diagnosis. It is a kind of information path that can open and view information in various control systems including an Electronic Control Unit. It can acquire the standard OBD information, information for vehicle scanner, and unique information of vehicle manufacturer. It can also see various fault codes via the standardized maintenance interface through a 16-pin diagnosis connector. The CAN communication mode is used in information exchange among engine management system, transmission control, and dashboard in the automobile industry, as well as on-board ECU, which is an embedded system in a vehicle. Theoretically, up to 2,032 devices can be connected to a single CAN bus in a single network, but only 110 nodes are allowed in a single network due to the practical limitation of hardware. The CAN provides data communication up to 1 Mbit/sec, and facilitates real-time control. The advantage of the CAN is to provide an economical and stable network by which a number of CAN devices can communicate. Since the ECU owns a single CAN interface only rather than having analog and digital inputs for each device in the system, it can reduce overall cost and weight of vehicle. Each device over the network owns a CAN controller chip, which is highly intelligent, and all devices over the network can check transferred messages. Each device determines filtering whether a message is related or not. All messages have their own priority. Thus, if two nodes send messages simultaneously, a high priority message is sent first, and a transmission of low priority message is delayed. Information exchange between ECUs can be processed according to their priority by connecting a number of ECUs in parallel using two lines.

## III. TEST SECTION AND DATA COLLECTION

A continuous flow section was selected for analysis in this study. It was a 34km long two-way section from SungDong IC to Isanpo IC. The data of outdoor air and road surface temperatures were collected five times during October in 2015 for the first time. The same types of data were collected four times at the same section in October this year. This year, ambient temperature and humidity data were collected in addition to outdoor air temperature. Table 3.presents the data collection section and collection schedule. Weather condition in the table refers to a weather condition at the time of data collection, which was divided into A to C. A, B, and C refer to sunny and windless condition, cloudy and a little windy condition, and cloudy, humid, and windy conditions, respectively. For data collection, a thermal mapping system was utilized that can collect road surface temperature, ambient temperature, and humidity complexly.

*Table 3. Range of Wavelengths on Driving Speed*

| Data | Origin | Destination | Weather Condition | Data | Origin | Destination | Weather Condition |
|---|---|---|---|---|---|---|---|
| 15.10.16 | SungDong IC | Isanpo IC | B | 15.10.28 | SungDong IC | Isanpo IC | A |
| 15.10.23 | Isanpo IC | SungDong IC | B | 16.10.12 | Isanpo IC | SungDong IC | B |
| 15.10.23 | SungDong IC | Isanpo IC | B | 16.10.25 | Isanpo IC | SungDong IC | B |
| 15.10.26 | Isanpo IC | SungDong IC | C | 16.10.26. | Isanpo IC | SungDong IC | B |

## IV. DESIGN AND IMPLEMENTATION OF DISPLAY SYSTEM OF ROAD SURFACE TEMPERATURE

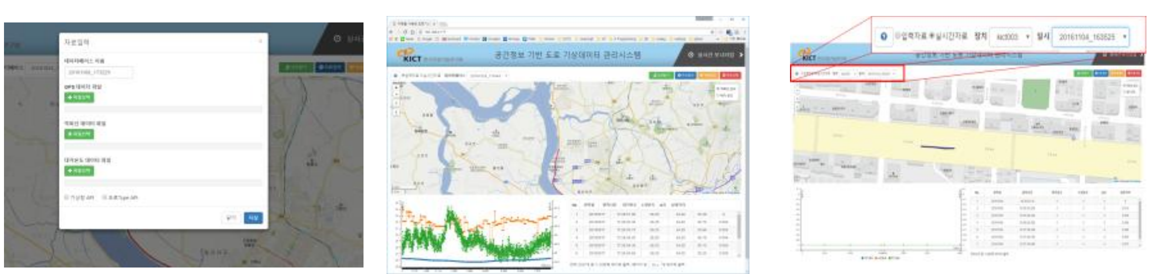
The data acquisition system, which is under development in this study, consists of data acquisition and storage module, real-time communication module, and data display module. The data acquisition and storage module consists of request of vehicle information and reception through the standard On-Board Diagnostics tool and CAN, application of API to OBD-II/CAN equipment, vehicle information acquisition through the standard on-board diagnostics tool and CAN, acquisition, analysis and storage of location information through the GPS mounted in the mobile terminal. The real-time communication module consists of data transmission and service request using the REST Application Programming Interface, transmission of vehicle and location information acquired through the Internet to the server, and request of estimation on road surface temperature from the server by the Internet. The data display module selects information system among vehicle information acquired in real time, and sets a display format thereby displaying the information using visual graph and gauge and visualizing estimate road surface temperatures.

The architecture of the data management system consists of real-time data reception/storage, estimation services module of road surface temperature, and real-time visualization module. The estimation service of road surface temperature is providedby the REST API format, and an estimation process of changes in pattern of road surface temperature is presented. The data reception/storage module receives and analyzes data transferred from the "data acquisition system" as well as performs data loading through the time-series database REST API, and responds to the "data acquisition system" upon normal or error occurrence. The estimation service module of road surface temperature replies with estimation results of road surface temperature through location information and [estimation road surface temperature model] included in the request parameter upon the information providing request. Furthermore, the real-time visualization module consists of a system that displays monitoring results of real-time data acquisition status. Figure 1.shows implementation details in the acquisition system of road data and data acquisition process.

*(a) Execution of the application* *(b) Vehicle communication (CAN → BLUETOOTH)* *(c) Check the GPS and outdoor air temperature information* *(d) TRACKING execution*

***Figure 1. Example of the display and data acquisition process***

The data management (upload and monitoring) acquired in the acquisition system of road data is performedby the following method. GPS data, infrared data, ambient temperature data files are uploaded using the [data input] button in the upper right side in the data management screen, and once data from the Korea Meteorological Administration (KMA) and road type API are selected, corresponding data upload can be done. Once the upload of the file is complete, location information of the data and sensor information can be checked. Furthermore, the selected real-time storage data can be checked through the real-time data check function.The condition of the device can be classified into READY (state that the device is connected), RUNNING (state that the device is tracking), and DISCONNECT (state that the device is disconnected). A system that stored data in the database was implemented while RUNNING operation state. Figure 2.shows the real-time monitoring function and screen of road weather data based on spatial information.



*(a)Data upload* *(b)Data display* *(c)Check the detailed information*

***Figure 2. Composition of road surface temperature display using the web***

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## V. CONCLUSION

The number of sliding traffic accidents is occurreddue to external factors such as frictional coefficient of tire and road surface and defective pavements causing skid road surface. Particularly, sliding traffic accidents occur often in rainy days during winter because water in a road surface is likely to become ice upon the wet condition of roads in winter. The control of external factors such as weather deterioration can be effective to prevent traffic accidents due to road skid. However, it is difficult to control them realistically. Thus, this study aimed to cope with frozen road surface when weather is deteriorated in winter. In particular, this study conducted the development of system that can display information about circumstances where frozen roads are likely to occur. The road surface temperature display was achieved by a system consisting of mobile app and the web, which was presented in this study. Nonetheless, the following research is needed to advance the study result further. First, the display system developed in this study consisted of data input and output and display functions. The system should be developed by taking user's convenience into consideration in the future for advanced system. Second, this study verified the system using data in a single section. However, more through verification is needed in the future by collecting data from various sections and displaying them.

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