Development of Road Surface Investigation Method for Night-time Visibility Assessment Solution Using a Mobile Technology

1Chunjoo Yoon, 2Young Rok Kim*, 3Minho Park
1Researcher, Korea Institute of Civil Engineering and Building Technology, Korea
2Ph.D. Student, Department of Transportation Engineering, University of Seoul, Korea
3Senior Researcher, Korea Institute of Civil Engineering and Building Technology, Korea (* Corresponding Author)

1cjyoon@kict.re.kr, 2busbay@kict.re.kr, 3minhopark@kict.re.kr

ABSTRACT

Currently, although the number of traffic accidents and deaths are on the decrease, the number of traffic accidents at night-time is unchanged. To enhance the night-time safety on the road, it is the time to start a comprehensive study, to analyze and evaluate the visibility environment which affects driving during night-time. For this purpose, this study suggests a mobile-based nighttime road surface visibility investigation system, consisting of the data acquisition system utilizing low-price mobile devices and the web-based data management system utilizing the document database. The system is developed to acquire and manage data based on spatial information. A comprehensive nighttime road visibility evaluation technology is planned to be developed based on the proposed system with additional facilities affecting the vision of the drivers.

Keywords: Road, visibility, investigation system, mobile-based system, GIS

1. INTRODUCTION

In Korea, the number of traffic accidents and the number of deaths are on the decrease, while the number of nighttime traffic accidents is remained unchanged. In 2013, there were 215,354 traffic accidents in Korea, and among which 53.4% were in the daytime, and 46.6% were in the nighttime [1]. Although the rate is lower, the death rate, which represents the number of the dead in 100 accidents, is higher in the nighttime accident than the daytime by about 1.3 times. Considering that nighttime traffic is about 30% of the daytime traffic, the risk of traffic accident felt by drivers is about 3 times in the nighttime.

The research conducted so far in Korea to secure safety of road in the nighttime focused mainly on improvement of visibility of individual facilities, such as road lightings, pavement markings and delineators. The safety of the nighttime road is more influenced by the drivers’ identification and recognition of road state than by the performance of individual facilities. Therefore, a comprehensive study is required to research, analyze and evaluate effectively the nighttime visibility environment.

The purpose of this study is to develop the technology of acquiring and analyzing the nighttime visibility environment information of the road surface to comprehensively evaluate visibility of road surface in the nighttime. For this purpose, this study suggests a mobile-based nighttime road surface visibility investigation system developed with the low-power-consuming computing technology, the digital image technology such as image processing, the GPU-based image processing acceleration technology and the document-based database technology.

In order to conduct a spatial evaluation of the quantitative nighttime road visibility environment, an acquisition program is developed to save the nighttime road surface image, the luminance value of the target area and the relevant information.

Also, in order to utilize the data in evaluation of spatial nighttime road visibility, a data management program is developed to systematically manage the site research data collected, and to express and analyze the data with GIS.

2. LITERATURE REVIEW

2.1 Road Visibility-Related Research in Korea

Researches have been conducted on the performance of retro-reflection of road marking and the quality of lane materials to improve visibility on the nighttime road [2, 3], on the installation criteria and performance of individual facilities in terms of visibility [4, 5], on improvement of visibility for old-aged drivers with deteriorated vision when compared with young drivers [6, 7], and on measurement of luminance of lighting with digital image devices (CCD and DSLR) with enhanced point luminance meters to evaluate the performance of lighting which has the largest effect on the nighttime road visibility environment [8, 9].

2.1 Trend of Video Processing Technology Using the Mobile System

With the development of mobile terminal technology, research is under way in various fields on real-time image processing on the mobile system [10, 11]. Various research are being conducted in relation with the link between the mobile system and the vision system technology for safety of nighttime drivers [12, 13, and 14].

3. DESIGN FOR MOBILE-BASED ROAD SURFACE INVESTIGATION SYSTEM

3.1 System Architecture Design

In this study, a data acquisition program utilizing Android-based OpenCV (Open Computer Vision) and a data management program are developed to support evaluating of
night time road visibility in consideration of trend of research and technology (Figure 1).

Android is the Linux-based open source mobile operating system applied to Open Handset Alliance (OHA) led by Google. Android supports Java as the default development language, and the native code through Java Native Interface (JNI). In order that the system should process and acquire image without omission in a running survey vehicle, NVIDIA Tegra Note 7 (with 72 built-in graphic cores) is selected as the survey device to apply high-speed image processing algorithm using the graphic core.

Figure 1: System architecture

In consideration of future expansion of the acquisition data, the meta-data is created with JSON (JavaScript Standard Object Notation) for easy transfer of data to the data.

Figure 2: Data processing flow

 RGB image and YUV image are saved together for Night-time Visibility Evaluation, and the program is designed to convert RGB image to YUV image by using the formula as Equation.

3.2 Road Surface Visibility Data Process Design

Figure 2 depicts the data acquisition and processing. Acquisition and processing of image data are designed to utilize the OpenCV library. Major function of the data acquisition and processing include saving and conversion of image, and detection of target area through road geometry in acquisition image.

3.3 Data Structure Design

The data acquisition program is designed to save meta-data on attitude and position of the camera, as well as the image data. Figure 3 depicts the data structure for meta-data. The saving meta-data consists of eight parts such as Camera, GPS, Attitude, Tracking, Luminance, Target Area and Center-Line.

Figure 3: Meta-data structure design

The image data are designed to save the file directory in Camera, Luminance and Tracking (Figure4).
4. DEVELOPMENT OF MOBILE-BASED ROAD SURFACE INVESTIGATION SYSTEM

4.1 Data Acquisition Program

Figure 5 shows the data acquisition program. The program provides the tracking function to detect the target area, the image data saving function, the environment data saving function (for example, location information), and other survey device setting functions.

Figure 6 shows the view of the data acquisition program in RGB mode. The target area is up to 100m in the front. The tracking function is designed to track the area of interest in 3 levels in consideration of road geometry. The program connects the center lines in the tracked area, keeps tracking the area of interest, and save the average illumination, image data, attitude data, position data.

Figure 7 shows the data acquisition program view of the YUV mode. This program is developed to extract illumination (Y value) with Equation (1) and to express the converted image. YUV image is expressed according to the red-blue color codes. The red code indicates the dark area, and the blue code indicates the bright area. The YUV mode is developed to provide intuitive visual information for nighttime road visibility evaluation.

Figure 8: Main view of data management program
4.2 Data Management Program

The data management program is developed to systematically manage the data acquired with the data acquisition program (Figure 8). The left pane of the screen provides the database search function. If you select the searched data, the map of the investigated location, image data and other data are provided on the right pane.

5. CONCLUSIONS AND FURTHER WORK

This study suggests a nighttime road surface visibility investigation system to evaluate visibility of road at the nighttime. The suggested system consists of the data acquisition system utilizing Android-based mobile devices and the web-based data management system. In order to enhance usability and field applicability, the system is developed with the low-price mobile devices and the web-based management program utilizing the document database. The system is designed to acquire and manage data based on the spatial information, and to spatially express and analyze the nighttime road visibility investigation data. The system is expected to provide various analytic data when it is linked with various road-related data.

For comprehensive nighttime road visibility evaluation in the future, the system is planned to include additional facilities that affect the driver’s visibility environment, and to provide the function to acquire and manage data in consideration of characteristics of individual facilities.

REFERENCES


ACKNOWLEDGEMENTS

This research was supported by a grant from a Strategy Research Project (Development of Enhancement and Evaluation Technologies for Driver’s Visibility on Nighttime – 3rd research field: Development of Enhancement and Evaluation Technologies for Driver’s Visibility on Nighttime) funded by the Korea Institute of Civil Engineering and Building Technology.

AUTHOR PROFILES

Chunjoo Yoon received his master’s degree in geo-informatics engineering at the Inha University in Korea. Currently, he is a researcher at the Korea Institute of Civil Engineering and Building Technology as well as a PhD student in transportation engineering at the University of Seoul in Korea. Young Rok Kim have completed PhD degree in the University of Seoul in Korea. Currently, he is working as a senior researcher at the Korea Institute of Civil Engineering and...
Building Technology as well as a professor at the University of Science & Technology. Minho Park have completed PhD degree at the Pennsylvania State University in the U.S. Currently, she is working as a senior researcher at the Korea Institute of Civil Engineering and Building Technology.