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Evaluation of Filed Application for the Night-time Visibility Assessment System for Road

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Abstract: *In the case of night-time accidents with high mortality rate during a traffic accident, there is a high probability that it will occur in a section where the visibility is degraded. Therefore, KICT developed the NVASo (Nighttime Visibility Assessment System for Road) in order to easily evaluate the poor visibility of the road. NVASo is a system that converts the RGB values on image pixels to YUV and evaluates the visibility of night roads with the Y value indicating brightness. It is necessary to verify the functionality and usability in order to utilize them in actual field. The evaluation was conducted by internal researchers and external experts, and the items were set with reference to the road safety diagnosis item in Korea. As a result of the evaluation, 78 out of 115 points were satisfied with 67.8% satisfaction. In the future, we will improve the function to be able to evaluate in various road geometry conditions and various lighting conditions, and we will perform the basic research on monitoring for comparative analysis before and after using the NVASo to reduce traffic accidents, And economic feasibility study.*

Keywords: *application, field, road, visibility, nighttime*

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I. Introduction

1.1. Background and Objective of Study

In the case of night-time accidents with high mortality rate during a traffic accident, there is a high probability that it will occur in a section where the visibility is degraded. At present, nighttime road visibility evaluation of Korea is performed based on luminance, and it is not easy to evaluate the visibility of night roads because the luminance of the relevant section should be collected in a situation where the traffic of the automobile is controlled at night.

Therefore, the Korea Institute of Civil and Building Technology (KICT) developed the NVASo (Nighttime Visibility Analysis System for Road), which can investigate and evaluate the visibility of nighttime roads [1, 2, 3, 4]. NVASo is a system that converts the RGB values on image pixels to YUV and evaluates the visibility of night roads with the Y value indicating brightness among them.

However, since this system was developed as Prototype, it is necessary to verify its suitability in terms of functionality and usability in order to use NVASo in actual field.

Therefore, in this study, we evaluated the system in various aspects in order to examine the applicability of NVASo in the field(Table 1).

Table 1. Research Activities

Contents	Descriptions
Quality conformity assessment of NVASo	- Conformity Assessment for Field Survey - Evaluation of conformity and image quality of presentation information of survey data
Conducted field survey using NVASo	- Field investigation of the selected section considering the nighttime accident accident spot of t he city area (Seoul city), the sudden curve section, and the section that provides many road traffic information at the same time - conduct on-site surveys to evaluate the acquisition process of survey data
Evaluating the effectiveness and usability of NVASo	- Comparison analysis between NVASo survey results and actual driver visibility - Future utilization plan of night road visibility evaluation system

II. Methodology

2.1 Evaluation Item Settings

NVASo's evaluation items are divided into system (hardware and software), solution provision, and usability. In order to set the evaluation items, we refer to the inspection items of Road Safety Audit in Korea[6]. Table 2 shows the hardware performance, reliability, economics, and maintenance of the hardware, analysis time, verifiability, scalability, and convenience for the software.

Each evaluation item was scored in 5 steps (5 points of satisfaction, 4 points of satisfaction, 3 points of average, 2 points of deficiency, 1 point of insufficiency) depending on the situation so that internal researchers could judge according to the result of the inspection.

Table 2. Effect evaluation method Evaluation item composition

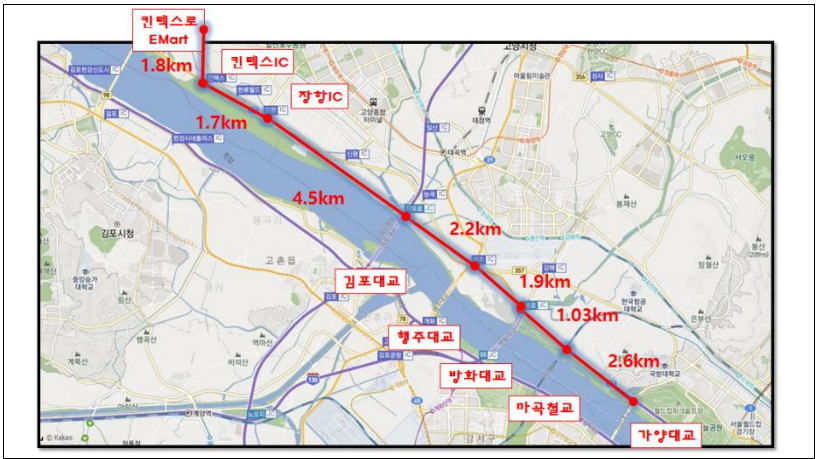
1stCategory		2ndCategory	Evaluation items
system	H/W	Portability	· Is it easy to detach and move the survey equipment?
			· Is there a problem with carrying and storing?
		stability	· Is it possible to conduct continuous surveys without extra power supply?
			· Is the attached survey equipment stable to impact during vehicle operation?
		Economics /Maintenance	· Is it economical compared to similar commercial products?
			· Is equipment easy to maintain?
	S/W	Analysis time	· Is the data captured in real time on the main screen without errors?
			· Is the collected data processing speed adequate?
		Verifiability	· Has it been developed to be suitable for night driving environment such as no lighting section?
			· Can we quantify the suitability of the night driving environment (Fair, Good, Poor etc.)?
			· Is the error range of the actual vehicle trajectory and GPS position coordinates appropriate?
		Extensibility	· Is it possible to share measured results on the Web?
			· Does it have extensibility in connection with other systems in the future?
		convenience	· Is the user having a convenient S / W UI environment?
			· Is there a good basis for interpretation and interpretation of the displayed value?
Solution		compatibility	· Is it appropriate to set the range of the evaluation scale (Y-Value) for the visibility measurement?
			· Is it possible to investigate according to road characteristics (up/downhill, left/right curve, etc.)?
		Repeatability /accuracy	· Is the quantitative value constant (repeatable) in the same condition (same environment)?
			· Is it equally applicable to linear guidance facilities?
Usability		manual	· Is there a manual that anyone can easily use with NVASo?
			· Is the picture explained so that it is easy to understand?
		Applicability	· Can it be used for traffic safety related business (night traffic accident area analysis)?
			· Is pre-training necessary?

2.2 Field Survey

In order to evaluate the effect of NVASo, the survey was conducted on actual roads. The field survey was conducted by separating the continuous road and the interrupted road, and the road lighting was divided into different types (Fig.1).

The target roads and sections selected by the effectiveness evaluation field survey are as follows and round trip survey was conducted.

- Uninterrupted road: Riverside north road Gayang Bridge - Kintex IC
- Interrupted road: Within Seoul (Gwanghwa gate intersection - Jongno 4 intersection)



[Uninterrupted Road] Gayang Bridge~KINTEX IC

[Interrupted Road] Gwanghwa-gate intersection ~ Jongno 4thintersection

FIg.1.Field survey road

III. Evaluation Of NVASO

3.1 Hardware

3.1.1 Portability

It has been found that the detachment and mobility of the survey equipment is very easy and a separate calibration procedure is required depending on the type of vehicle before the survey (Fig.2). However, in the case of carrying and storing, it was found that the product which was under development(the prototype) was not accompanied by a separate case manufacturing, and it was found that some connection between the sensors was necessary (Fig.3).

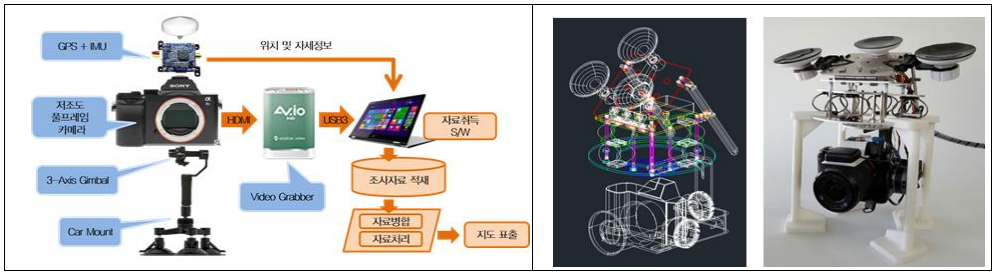


FIg.2.NVASo Equipment

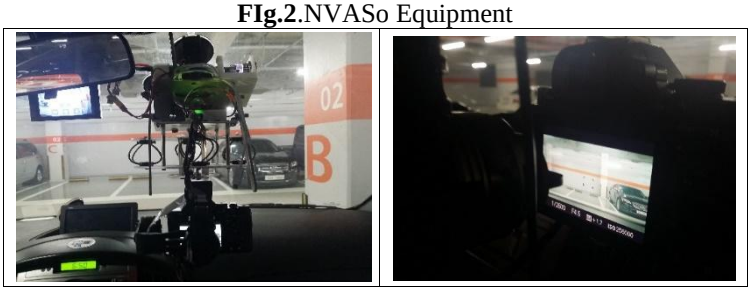


FIg.3.Attachment and Calibration Apparatus

3.1.2 Stability

Since the camera, camera gimbal, and image acquisition system are operated by separate batteries, the developed system can be continuously surveyed without power supply. In addition, the system can be operated for at least 2 hours. The image acquisition system composed of notebooks can be continuously operated through the power supply of the vehicle. In case of the camera, it is necessary to consider external battery or external power supply respectively.

Among the evaluation items, whether or not the stability of the attached inspection equipment is secured during the operation of the vehicle is fixed by three adsorption plates on the front glass of the vehicle, it is made lightweight by being made of solid aluminum parts, and the wire type damper and the biaxial gimbals system stabilized and operated (Fig.4).

FIg.4. Acquisition system attachment structure and vibration reduction device

In addition, while adopting a lightweight structure and applying a vibration reduction structure, the camera lens part is comparatively heavy because it has a relatively heavy weight. However, it needs to be replaced or improved in the future.

3.1.3 Economy and maintenance

The presently developed system is not a finished product in the form of a prototype, but rather a prototype of the research outcome. It is difficult to directly compare similar functions of commercial products and price competitiveness. In the future, it is necessary to find and compare products developed based on images in terms of night visibility.In addition, consideration and preparation in terms of maintenance will be needed more actively.

3.2 Software

3.2.1 Analysis time

When the calibration was completed and the system was operated on the actual road, the data was acquired in real time without any abnormality, and the processing speed was also determined as appropriate (Fig.6).

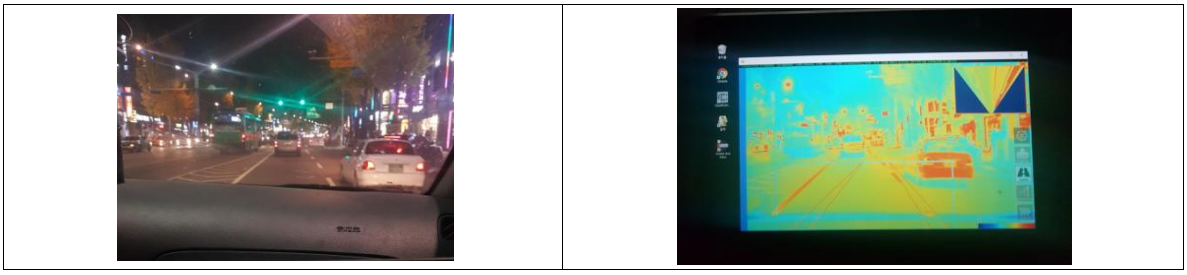


FIg.6. Example of data acquisition by various modules

3.2.2 Verifiability

Among the evaluation items, in the case of judging whether the error range of the actual vehicle locus and the GPS position coordinate is appropriate, the GPS receiver only shows the positional performance within a few meters of the road alignment because there are many open places in the non-illuminated area.In the case of a tunnel or a high-rise building, there is a phenomenon in which the position error increases rapidly (Fig.7). However, it is expected to be verified through continuous experimentation using a sensor that fuses MEMS-based IMU and GPS.

FIg.7. Field survey result position error

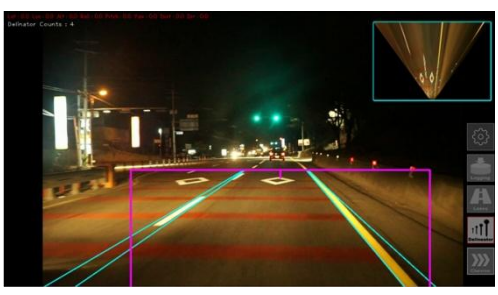
3.2.3 Extensibility

In the case of "whether the survey result can be shared on the web", the web-based evaluation system is implemented separately for the field data, and the survey data is managed and displayed in the form of standard spatial information in PostGIS as well as the map service using GeoServer is.

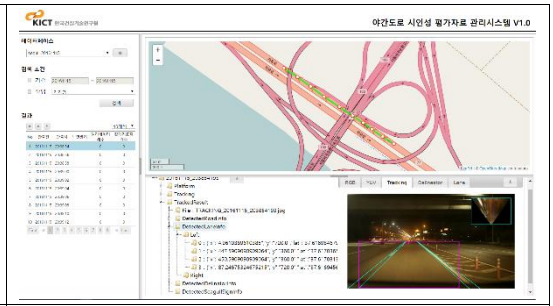
It is possible to check not only the road section information but also the individual image, the brightness image, the extracted image, etc. through the web, and the possibility of sharing the visibility target area at night through the web is very high. However, In addition, in case of securing expandability with other systems in the future, it is acquired not only as an open JSON type file unit but also as a document DB called CouchDB, and the space information is loaded and managed using PostGIS, It was judged to be secured.

3.2.4 Convenience

Considering that the use of a mouse or keyboard is limited in the acquisition system, the user interface for the screen touch is provided during operation, and the main function is also easily created by clicking the icon. In the case of the evaluation system, the inquiry screen is easy to confirm the survey list, the map display, the metadata and the individual image, but it is necessary to improve the editing environment such as adjusting the area necessary for the analysis (Fig.8).



Data acquisition system



Evaluation system

FIg.8. User interface

3.3 Solution

3.3.1 Compatibility

In the case of the suitability of the selected Y-value to measure the brightness, the brightness is selected as the evaluation scale in the case of the existing road lighting and it is installed and operated as follows(Table 3).

Table 3. Brightness criterion of road lighting for driver

Rating of Lighting	Average road surface luminance(Minimum allowable value), L_{avg}(cd/㎡)	Brightness uniformity (minimum allowable value)		TI(%) (Maximum allowable value)
		Total uniformity (U_o) L_{min}/L_{avg}	Total uniformity (U_l) L_{min}/L_{max}	
M1	2.0	0.4	0.7	10
M2	1.5	0.4	0.7	10
M3	1.0	0.4	0.5	10
M4	0.75	0.4	-	15

M5	0.5	0.4	-	15

※ Highway, Motorway: M1 ~ M3, Main/Secondary Highway: M1 ~ M3, collecting and country road: M4 ~ M5

These standards are based on the "Guidelines for the Installation and Management of Road Safety Facilities - Lighting Facilities, 2014, Ministry of Land, Transport and Maritime Affairs", and measures the brightness of road lighting installation standards(0.5 ~ 2.0cd/㎡)[5]. The measurement range of the Y value through the measurement of the luminance value with respect to the Y value is as follows, and it is analyzed that the range of 0.5 to 2.0 cd/㎡(Table 4.)

Table 4. Comparison of luminance and Y value

luminance(cd/㎡)	Y value	Rating of Lighting	luminance(cd/㎡)	Y value	Rating of Lighting
0.02	3.27	-	1.07	58.99	M3
0.07	5.27	-	1.51	75.44	M2
0.26	16.48	-	2	93.22	M1
0.36	23.71	-	3.69	137.34	-
0.5	30.99	M5	7.94	193.24	-
0.71	45.01	M4	13.42	225.67	-
0.79	46.76	-	-	-	-

Such a luminance is distributed in a wide range of range from dark night to bright day, which is not only difficult to process, but also limits the investigation.In this system, Y value which can be easily collected through image is utilized, and it is not only advantageous that it can be easily converted by general conversion formula, but also it is possible to utilize visibility of night road as the most important standard for driver's feeling.

However, according to the road geometry, the reference setting is still insufficient. In the case of the straight line, the lane recognition is accurately reflected, while the curved line and the uphill and downhill are low.In the case of "driver's sight test on road surface and linear induction system" which is simulated for the development of this system, it is judged that the experiment to divide road geometry into straight line and curved line is appropriate, It is analyzed that there are more various situations and the driver's satisfaction using night roads will be changed accordingly.If future work or research can be pursued, it will be necessary to experiment with the driver's feeling in various scenarios (uphill / downhill - left-curved road / right-curved road combination). It was judged necessary.

In addition, it is unfortunate that this system does not reflect diverse geometric structures, but it is a good result to construct a model that can evaluate the visibility in the straight line and the curve section.

3.3.2 Repeatability/Accuracy

The developed system was developed to be suitable for the non-illuminated section, and it was concluded that the quantitative values in the same section are not repeatedly measured in the illumination section. This is an important issue to be solved in terms of solution delivery, and it is necessary to present the results of the repeatability test (Fig.9).

FIg.9. Repeatability and accuracy test appearance(example)

In addition, since this technology evaluates the rough visibility of the entire road section, examines the section estimated as a bad section, and the section estimated as a bad section is a preprocessing review process

for performing a precise inspection by luminance measurement, there seems to be a lack of preparation for accuracy.

In addition, it has been shown that there is a limitation in applying to all linear induction facilities because the characteristics of the system developed for the non-lighting section may cause other reflectors (glass reflections, distant street lighting, etc.). There was also a case of recognition as a linear induction facility. However, it is analyzed that it is easy to grasp the linear induction facilities in a non-lighting section or in a place where the brightness of the lighting is low.

3.4 Usability

3.4.1 Manual

Manuals are not available, but based on the results of the research, the contents of the report are explained in detail along with the description of the photographs (Fig.10).

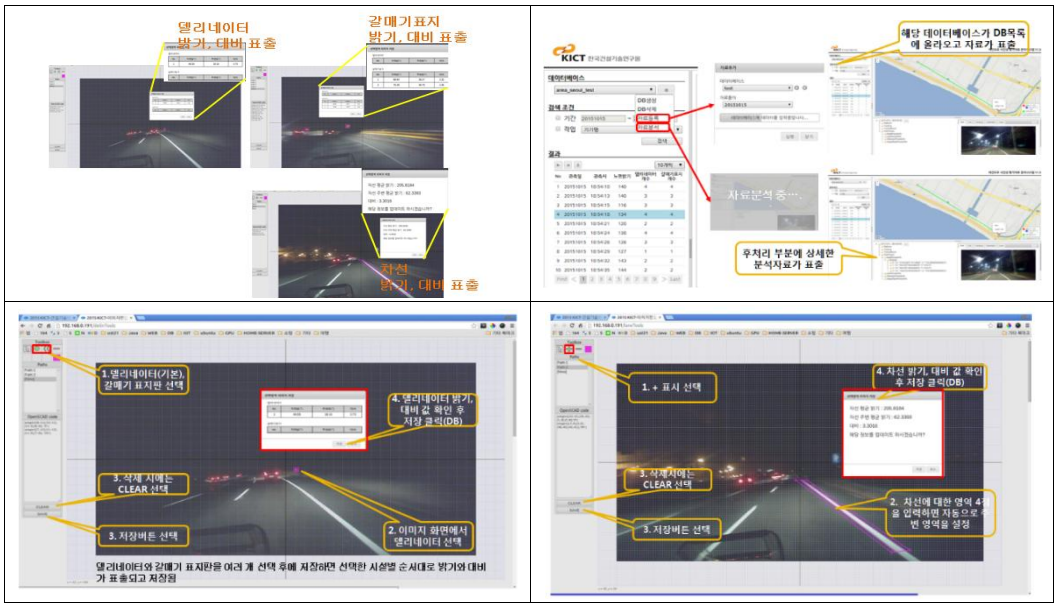


FIg.10.NVASo manual

3.4.2 Applicability

The presently developed system is expected to have some meaningful results in measuring and evaluating the brightness of the straight lane of the non-illuminated section, and it could be applied to the road traffic safety diagnosis and special survey of the Republic of Korea. Especially, it was considered that it would be a more efficient investigation method for the inspection and grasp of the road in operation at the point where many night traffic accidents occur.However, it is necessary to precede more various geometrical conditions and the repeatability test according to the brightness of illumination, and it is necessary that the further research is continuously carried out and should be supplemented. It is also necessary to cope with the prior education so that the user can use it easily.

3.5 Results of evaluation of effectiveness

3.5.1. Hardware

The currently developed system is used for measuring and evaluating the brightness of the straight lane of the non-illuminated section. Hardware measurement equipment and analysis The results of the evaluation of the effectiveness were analyzed to be more satisfactory than those of the portability and stability part.However, the comparison of economic efficiency with other products and the easiness of maintenance are not enough for the development of the prototype type.

3.5.2 Software

The analytical time showed satisfactory and satisfactory results. In the case of verifiability, the quantification in the operating environment other than the non-illuminated period was still at the normal level In addition, it has a strength in terms of connection scalability, but the convenience of user S / W UI (User Interface) environment in terms of convenience is still at a moderate level.

3.5.3 Rating scale

In order to measure the brightness in terms of conformity, the evaluation scale Y selected satisfies the level to some extent, but it was found that the standardization according to the geometry was at a normal level.
Also, it was found that the experiment for the constant numerical measurement in the same environment was somewhat insufficient, and it was found that the repeatability and the accuracy test were insufficient.

3.5.4 Usability

It is obvious that the description of the developed equipment and the purpose of development are clear, but the lack of manual or manual has not been provided. In addition, it seems to be able to be used in some causes of nighttime road accidents.

IV. Discussion And Conclusions

The effectiveness evaluation was divided into three categories and the system aspect, solution provision aspect, and other utilization methods were performed. A total of 23 evaluation items and check items (check list) were set to 115 points, were evaluated.The evaluation was based on the opinions of internal researchers and external experts. The evaluation was carried out while driving on actual roads based on field surveys and experiments (some software were evaluated in indoor environment). As a result of the evaluation, 47.8% (11 out of 23 items) of the total were satisfied with satisfaction (including very satisfied), and 34.8% (8 out of 23) were usually found.
There was no very insufficient items, and insufficient items were analyzed in 17.3% of the total (4 out of 23), and among the total 115 points, 78 points showed about 67.8% performance (Table 5). In addition, it was necessary to proceed to future research based on the following items.

- Development of system reflecting various road geometry conditions
- A study on night visibility in various lighting conditions except non-lighting section
- Basic monitoring for comparative analysis of road traffic accidents using system
- Comparative analysis with domestic and overseas similar systems and economic evaluation including effect evaluation

Table 5. Evaluation Results of Field Application for NVASo

1stCategory		2ndCategory	Evaluation items	Rate				
				5	4	3	2	1
system	H/W	Portability	· Is it easy to detach and move the survey equipment?		O			
			· Is there a problem with carrying and storing?			O		
		stability	· Is it possible to conduct continuous surveys without extra power supply?		O			
			· Is the attached survey equipment stable to impact during vehicle operation?		O			
		Economics /Maintenance	· Is it economical compared to similar commercial products?			O		
			· Is equipment easy to maintain?				O	
	S/W	Analysis time	· Is the data captured in real time on the main screen without errors?	O				
			· Is the collected data processing speed adequate?		O			
		Verifiability	· Has it been developed to be suitable for night driving environment such as no lighting section?		O			
			· Can we quantify the suitability of the night driving environment (over, suitability, insufficiency, etc.)?			O		
			· Is the error range of the actual vehicle movement trajectory and GPS position coordinates appropriate?		O			
		Extensibility	· Is it possible to share measured results on the Web?	O				
			· Does it have extensibility in connection with other systems in the future?		O			
		convenience	· Is the user having a convenient S / W UI environment?			O		
			· Is there a good basis for interpretation and interpretation of the displayed value?			O		
Solution		compatibility	· Is it appropriate to set the range of the evaluation scale (Y-Value) for the visibility measurement?		O			

		· Is it possible to investigate according to road characteristics (uphill, downhill, left-leaning, right-leaning, etc.)?			O		
	Repeatability /accuracy	· Is the quantitative value constant (repeatable) in the same condition (same environment)?				O	
		· Is it equally applicable to linear guidance facilities?				O	
Usability	manual	· Is there a manual that anyone can easily use with NVASo?			O		
		· Is the picture explained so that it is easy to understand?		O			
	Applicability	· Can it be used for traffic safety related business (night traffic accident area analysis)?			O		
		· Is pre-training necessary?				O	
-		Number	2	9	8	4	0
		Point	10	36	24	8	0
		Total	78/115≒67.8%				

Acknowledgements

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