

Applicability Study on the Optical Remote Sensing Techniques in a River

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ABSTRACT : Since the recent development of UAVs(Unmanned Aerial Vehicles) and digital sensors technology has enabled the acquisition of high-resolution image data, it is considered that the image data of riverside can be analysed. Therefore, this study analyses the applicability of remote sensing techniques through image analysis in river systems and habitats. The target stream in this study was the Cheongmi stream and the applicability of the river environmental evaluation technique was analysed through image analysis. The satellite images used for the analysis of river topography and environments were compared with the aerial images taken by a micro UAV), and the river environmental evaluation was carried out with the field research at the same time. The data acquisition range and application limit by river environmental evaluation technique proposed previously were evaluated, and as a result, it was found that it was possible to draw various evaluation parameters using a drone that could take an image at a low altitude in comparison to satellite images.

KEYWORDS :GIS, image, optical remotesensing techniques, river, UAV

I. INTRODUCTION

River environmental management encompasses various activities to optimize the environmental function of the river, such as flood control and water conservation of rivers, nature conservation and restoration, and creation of waterfront spaces, and to preserve or create natural and social environmental functions by minimizing the adverse effects. According to a recent global environmental outlook, biodiversity and renewable natural resources are in a serious or critical condition due to climate change and urbanization [1-2].

The OECD Environmental Outlook to 2030 designates climate change, biodiversity loss, water scarcity, environmental pollution and hazardous chemicals as priority environmental issues. In other words, it is time to take measures to deal with the shortage of environmental ecological flow caused by sophisticated land use, the expansion of cities, reduction of the maintenance of the river and the flood plain, the reduced restoration elasticity of protected lowlands, obstacles to the continuity of rivers such as dams, overuse of water resources in the basin, change of the water circulation system, and deterioration of river floating matter.

Major developed countries including the U.S., the European countries, Australia and Japan have been intensively developing and utilizing river ecosystem conservation and restoration policies to

cope with climate change, increase biodiversity and restore species, promoting the accumulation and development of scientific knowledge related to the river environment as a sustainable mid-term and long term task. In Korea, active investment and efforts are needed to investigate and manage the river environment scientifically in terms of physics, chemistry, and biology in order to improve the river environment in each basin unitso that the diversity of river ecosystems can be secured. To address these diverse issues that are happening today, field research has been conducted. But the research that can be conducted by humans in the field has its limitations. For this reason, it is necessary to apply various techniques such as optical remote sensing technology, which is being rapidly developed to the river environment field [3-6].

Optical remote sensing has been applied in various fields for a number of years, and has grown in particular since satellite data started to be analysed. It mainly provides information on land, and various studies have been conducted on changes in land coverage and land use, applying various techniques such as classification and mapping of data. In the forest sector, research on deforestation analysis, damage assessment, disaster monitoring, urban expansion and planning, and land management has been conducted. In addition,

analysis of spatial phenomena that could not have been attempted through temporal analysis and existing mapping techniques in connection with GIS has been performed, providing the advantages of a faster and more accurate analysis at a lower cost [7].

In the maritime sector, remote sensing has been carried out in various parts of the world in relation to analysis of changes in the coastal zone and depth measurement. Much more progress has been made in coastal and hydroponic environments, where the benefits of remote sensing compared to field measurements are more pronounced [8-10]. However, research that extends the remote sensing technology to the river analysis to understand the water depth and temperament characteristics of the coastal environment has not been actively pursued.

This is because in general, optical remote sensing, satellite images and aerial images of rivers, which are relatively narrow areas, have low resolution. Since the recent development of UAV technology has enabled the acquisition of high-resolution image data, it is considered that the image data of riverside can be analysed. Therefore, this study analyses the applicability of remote sensing techniques through image analysis in river systems and habitats.

II. CONTENTS OF STUDY

2.1 Theoretical background

The ecological functionality parameter of river developed by LAWA (Laenderarbeitsgemeinschaft Wasser) which was the most frequently used river environmental evaluation technique in Korea. This parameter that enabled the evaluation of ecological functions shown in the physical structure of river was developed in 2000 in Germany and this parameter integrated 6 components of riverbed, riverbank and riverside zones.

LAWA technique classifies the river into planform, longitudinal profile, riverbed structure, cross-section, riverbank structure and floodplain corridor and it consists of 26 parameters that evaluate the physical structure of each component. This technique can evaluate the ecological quality of river structure shown by dynamic process through the evaluation of physical structure of river. And it is uptaken in river plans and management such as the verification of effect of river conservation and restoration works carried out previously.

2.2 Target stream for application

The Cheongmi stream rises from the Wonsammyeon in Yongin, Gyeonggi do and joins with the Han river and it is managed as a local stream from the source of stream to the channel junction with the Eung stream and as a national stream from the channel junction with the Eung stream to the channel junction with the Han river. The target range of this study is the section from the downstream of the channel junction with the Eung stream to the channel junction with the Han river, which is surrounded by relatively high mountainous region. As a direct branch stream of the Namhanriver, relatively wide sedimentary plain has been developed in its basin, but the section from the Hyeonsuri in Jeomdongmyeon, Yeosu to the channel junction of the Namhan river meanders significantly and joins the Namhan river through the mountainous valley. The target stream has the basin area of 595.1 km² and the river length of 60.7 km, and the target range for study is a 25.46 km section where the river restoration project was carried out (Fig. 1).



Figure1. Target area for application

2.3 Remote sensing data

Aerial images with longitudinal of 60% and lateral of 30% were acquired at a height of an approximately 20 m using UAV Inspire (Pixel: 12.4 M) from the Cheongmi stream the target section for longitudinal and lateral and the section of 25.46 km from channel junction with the Eung stream to the channel junction with the Han river. The river environmental evaluation was carried out for the target section using the DMS data displayed through the coordination of the acquired images. The satellite images from Google Earth that could be acquired in Korea and two portal sites providing satellite images and geographic information were examined, and the satellite photogrammetry performance of Naver(Representative search site s

in Korea) which was most similar with the official digital terrain information of Korean government was used.

III. RESULT OF STUDY

Three representative positions were selected by priority from the target section, and the river environmental evaluation technique was applied to a 200 m section in the upper stream and downstream based on each position using the LAWA technique.

3.1 Comparative analysis of investigation results

The application limit of satellite images and UAV images was summarized as shown in Table 1.

Table 1. Comparison to application limit for the remote sensing

Satellite	Reduced Scale	Reading limit of specific height	Time of acquire data
Satellite image	-	50 cm	2016
Field survey image	1:10,000	25 cm	2016.9
UAV image	1:6,000	5 cm	2017.8

The river environmental evaluation using the LAWA technique is carried out in the way to give points for 26 detailed physical parameters of planform, longitudinal profile, riverbed structure, cross-section, bank, structure and floodplain corridor according to the evaluator's subjective criteria. Table 2 shows the result of river environmental evaluation at the channel junction with the Han river using the LAWA technique. As a result of comparative analysis for the selected position, it was confirmed that the number of river environmental evaluation parameters that could be drawn through the satellite images and UAV images among the 26 parameters was 11 parameters and 23 parameters respectively.

Table 2. Result of river environmental evaluation using the LAWA technique

Taxonomy	Index of evaluation	Satellite image		UAV image		field survey	
		Evaluation	Characteristic	Evaluation	Characteristic	Evaluation	Characteristic
Planform	Sinuosity	6	>10% straight line type	6	>10% straight line type	6	>10% straight line type
	Longitudinal bars	2	several (>3)	2	several (>3)	2	several (>3)
	Erosion at bends	2	weak feeble	2	weak feeble	2	weak feeble
	Special channel features	2	several (>3)	2	several (>3)	2	several (>3)
	Cross section depth	-	not verifiable	-	not verifiable	-	2.62 m
Longitudinal section	Artificial barriers	-	not verifiable	3	two	3	two
	Variability wave	-	not verifiable	5	small	5	small
	Depth variability	4	normal	4	normal	4	normal
	Transverse structure	0	none	0	none	0	none
	Covered rivers	-	not verifiable	0	none	0	none
	Box	-	not verifiable	0	none	0	none
	Stagnate	-	not verifiable	0	none	0	none
Riverbed structure	Riverbed substrate	-	not verifiable	7	sand / gravel	7	sand
	Substrate diversity	-	not verifiable	5	small	5	small
	Special riverbed features	-	not verifiable	4	stagnant section	4	stagnant section
	Riverbed protection	-	not verifiable	3	river-bed maintenance structure	5	pitching
Cross section	Cross-section depth	-	not verifiable	-	not verifiable	4	general deep
	Bank erosion	-	not verifiable	1	none	1	none
	Width variability	-	not verifiable	2	large	2	large
	Cross-profile type	-	not verifiable	3	erosion cross diversity	3	erosion cross diversity
Riverbank structure	Riverbank vegetation	4/2	some trees / group of trees	4/2	some trees / group of trees	4/2	some trees / group of trees
	Bank protection	2	several (>3)	2	several (>3)	2	several (>3)
Floodplain corridor	Special riverbank features	-	not verifiable	-	not verifiable	5/5	pitching
	Land use	1/1	natural biotop forestrootedness	1/1	natural biotop forestrootedness	1/1	natural biotop /forest rootedness
	Riparian buffer strip	5/1	riverbank greenbelt / forest transition	5/1	riverbank greenbelt / forest transition	5/1	riverbank greenbelt/ forest transition
	Harmful surrounding environment	0/0	none	0/0	none	0/0	none
total		27		56		71	

3.2 Analysis result

The scores presented for each parameter according to the visual judgment were selected and evaluated. Sinuosity is classified into 5 levels according to the meandering level and this parameter evaluates the meandering level from the plan, and the longitudinal bars are the parameter evaluated according to the type and number of bars shown. The score of satellite images and UAV images evaluated according to the presented field book by subjective criteria is 27 points and 56 points respectively (Table 3).

The field investigation was carried out additionally in order to verify the confirmation result from the images and the index of the LAWA is referred to. The result of 24 out of 26 parameters were confirmed visually and 71 points were drawn. The satellite images were 1D images and it was unable to confirm the riverbank structure and cross-section at all, and longitudinal profile could not be confirmed partially. UAV images were other photo so that it was possible to confirm the characteristics of cross-section.

Table 3. Comparison whether or not to utilize the remote sensing technique

	Evaluation index		Score	
	Amount	Availability	Sum	Applicability
Satellite	11	0.4231	27	0.3803
UAV	23	0.8846	56	0.7887
Field survey	24	0.9231	71	1.0000

The visual analysis result varies according to the photography technique or resolution, and this result is significantly influenced by the characteristics of target basin for river investigation. The result of the Cheongmi stream which was a large urban stream and the applicability of remote sensing data acquired from the Namdae stream screen which was a small mountainous stream studied previously were summarized in Table 4. O for a parameter that could be utilized, Δ for a parameter that could be utilized conditionally or partially and x for a parameter that could not be utilized were marked respectively. In case of satellite images, it was possible to confirm the riverbed protection, riverbank system and riparian buffer strip in an urban stream that were unavailable from a mountainous stream, and in case of UAV image, the status of 2 parameters of longitudinal profile were drawn additionally.

Table 4. Analysis of availability and applicability by parameter

Taxonomy	Function Taxonomy	Index of evaluation	Large scale urban stream			Small scale mountain stream			
			Satel lite	UAV	Field survey	Satel lite	UAV	Field survey	
Vertical characteris tic	Meandering	Vertical meandering	o	o	o	o	o	o	
		Longitudinal bars	o	o	o	o	o	o	
		Erosion at bends	o	o	o	o	o	o	
	Degree of movement	Special channel features	x	o	o	x	o	o	
		Cross section depth	x	x	o	x	x	o	
		Artificial barriers	x	o	o	x	o	o	
Longitudinal section	Natural Longitudinal section structure	Variability wave	x	o	o	x	o	o	
		Depth variability	Δ	o	o	Δ	o	o	
		Transverse structure	o	o	o	o	o	o	
	Artificial cross track interception	Covered rivers	x	Δ	o	x	Δ	o	
		Box	x	Δ	o	x	Δ	o	
		Staggate	x	Δ	o	x	Δ	o	
Riverbed structure	Substrate diversity	Riverbed substrate	x	o	o	x	o	o	
		Substrate diversity	x	Δ	o	x	Δ	o	
		Special riverbed features	x	Δ	o	x	Δ	o	
Cross section	Riverbed protection	Riverbed protection	Δ	o	o	Δ	o	o	
		Cross-section depth	x	x	o	x	x	o	
	Cross section	Bank erosion	x	o	o	x	o	o	
		Width variability	x	o	o	x	o	o	
	Traverse type	Cross-profile type	Traverse type	x	o	o	x	o	o
			Cross-profile type	x	o	o	x	o	o
Riverbank structure	Natural landscape	Riverbank vegetation	o	o	o	o	o	o	
	Natural riverbank vegetation	Riverbank peculiar structure	o	o	o	o	o	o	
	Riverbank features maintenance	Special riverbank features	Δ	Δ	o	Δ	Δ	o	
Floodpla in corridor	Riverbank forest belt	Land use	Δ	o	o	Δ	o	o	
	Flood plane	Riparian buffer strip	o	o	o	o	o	o	

The produced data showed the overall accuracy within 15 cm although there was a difference by target area. The allowable limit of error for the coordinates of boundary point provided in the Act on the Establishment, Management, Etc. of Spatial Data is within 10 cm based on the target area, so it is judged that it is possible to acquire image data for river environmental evaluation using such images. Fig. 2 shows an data of the blue rice stream obtained using an optical remote sensing technique.



Figure2. Data of optical remote sensing techniques from Cheongmi stream

IV. CONCLUSION

The satellite images used for the analysis of river topography and environments were compared with the aerial images taken by a micro unmanned aerial vehicle, and the river environmental

evaluation was carried out with the field research at the same time. Through this evaluation, the data acquisition range and application limit of each river environmental evaluation technique proposed previously were identified. As a result of comparison, it was found that various evaluation parameters could be drawn from UAV images enabling the acquisition of relatively higher precision images in comparison to satellite images. It is judged that remote sensing image data could be provided as a useful tool for monitoring and evaluating the environment of a river through the integration of GPS and GIS technologies.

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