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Construction of Spectral Library according to Various Factors in River Space

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ABSTRACT : *Recently, remote sensing technology has been used as a method to measure the factors of wide river environments. In particular, comprehensive spatial technologies such as RS techniques using satellite and aerial image data and Geographic Information Systems are being applied to collect and apply information for wide areas. Therefore, the purpose of this study is to establish a spectral radiation library by measuring the spectral reflectance for various factors in rivers. The target factors were divided into vegetation, riverbed materials, and water depth and we compared the reflectance of each factor. As a result of the analysis, each material showed unique characteristics of reflectance in the visible and near-infrared areas. These observations are expected to be used as basic research data to evaluate river environments in the future.*

KEYWORDS *-Remote sensing, Hypers pectral image, Spectral information, Bed material, Bathymetry*

I. INTRODUCTION

Since the evaluation of river environments change over time and space, the accuracy of the evaluation increases according to the number of survey points. However, the economic loss also increases due to an increase in equipment, manpower, time, and cost. On the other hand, the accuracy of data to identify the environmental distribution of the entire river space is reduced if there are fewer survey points. In order to resolve these issues, methods using Remote Sensing (RS) technology have been proposed to measure factors in wide river environments as shown in Fig. 1.

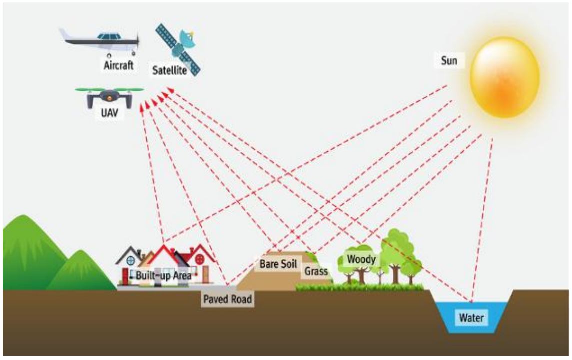


Figure 1. Principle of remote sensing(RS)

Recently, comprehensive spatial technologies such as RS using satellite and aerial image data and Geographic Information System (GIS) have been applied to collect and apply information for wide areas. We can now easily identify and provide information on the spatial distribution of hydrological factors and variables that can observe the hydraulic and hydrological state or variation, in addition to extracting the patterns of change in time and space of suspended solids, surface temperature, land coverage, and vegetation.

Jeong [1] analyzed the wavelengths of the spectral reflectance characteristics of each specimen using measuring instruments to predict soil carbon and nitrogen in mountainous areas. Cho et al. [2] evaluated the possibility of measuring the organic matter content in soils using near-infrared spectroscopic analysis as a basic study to rapidly measure organic matters. In addition, a system to continuously measure the raw material content of waste cooking oil using spectroscopy was developed. Research was also performed on the preparatory work for observing celestial bodies in the solar system and methods for calculating the observational order were developed [3, 4]. In particular, Jang et al. [5] performed a study on reflectance in conjunction with satellite data to classify sediments. Park and Ryu[6] analyzed the monthly fluctuation characteristics of the spectral reflectance data of rice by performing research on rice fields around the city in order to continuously identify the spectral reflectance data and vegetation index of crops at each stage of growth.

Although the application of RS technology is increasing, there is a lack of research that reflects field conditions. Therefore, as the purpose of this study is to develop a spectral library by measuring the spectral reflectance of various factors in rivers, we established a spectral radiation library using hyper spectral sensors.

II. THEORY AND STUDY METHOD

2.1 SPECTRAL ENERGY THEORY

In general, solar energy incident on a water body is reflected, absorbed, or transmitted by water. The interaction of energy in a water body can be expressed as follows by using the law of energy conservation.

$$E_I(\lambda) = E_R(\lambda) + E_A(\lambda) + E_T(\lambda)$$

λ : wavelength, E_I:incident energy, E_R:reflected energy, E_A:absorbed energy, E_T: transmitted energy.

At this point, all energy elements are values generated for a specific wavelength λ, and the energy incident on the surface and the electromagnetic energy recorded on the earth observation satellite sensor are different because of the atmospheric action between the sensor and the target object. In addition, sunlight is also absorbed and scattered by substances in the atmosphere until reaching the surface, and the atmosphere acts as a reflector. In this way, scattered path radiance is incident on the earth observation satellite sensor, in addition to the light that is reflected and scattered from the target object. The mathematical expression of this atmospheric effect is as follows [7].

$$L_{tot} = \frac{\rho ET}{\pi} + L_p$$

L_{tot} : total spectral radiation measured by the satellite sensor,ρ: reflectance of the target object, E: radiation incident on the target object (incident energy), T: atmospheric transmittance, L_p : path radiance generated in the atmosphere.

However, when measuring the reflectance of a target object using hyperspectral sensors in the field as in this study, there is no need to consider the influence of the atmosphere because the path radiance from the atmosphere or the electromagnetic energy reflected from the target object is hardly affected by the atmosphere.

2.2 STUDY METHOD

The purpose of this study was to develop a spectral library by measuring the spectral reflectance of environmental factors of rivers. The target factors were set as 3 cases (vegetation, riverbed material, water depth) and each case was divided into 3 materials for measurement. The study was performed at the River Experiment Center of the Korea Institute of Civil Engineering and Building Technology in order to measure the reflectance of the vegetation, structures, and water depth in the river space as shown in Fig. 2. Moreover, we used a hyperspectral sensor to receive the electromagnetic energy reflected from the target object and a portable spectral radiometer to acquire the data. The wavelength range of the spectrometer was 350 nm-2500 nm and the number of channels was 768.

Figure 2. Measurement section (REC of KICT)

In addition, the transmitted electromagnetic energy values were separated by wavelength ranges by the spectral radiometer and stored in text format. Since the electromagnetic wave energy values change according to the change of solar radiation energy by season and time, we introduced the concept of reflectance to minimize the errors [8]. The reflectance $R(\lambda)$ was calculated as the ratio of the electromagnetic wave energy reflected from a standard white plate with a reflective characteristic of 99% to the electromagnetic wave energy reflected from the target object.

$$R(\lambda) = \frac{I_O(\lambda)}{I_T(\lambda)} + 100(\%)$$

λ : wavelength, $R(\lambda)$: reflectance,$I_O(\lambda)$: electromagnetic energy reflected from the target material, $I_T(\lambda)$:

electromagnetic energy reflected from a standard white plate.

III. Research Contents and Results

3.1 Research Contents

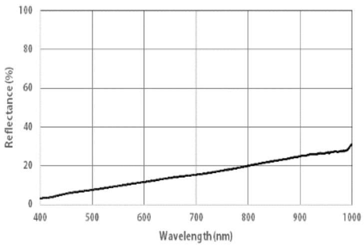
The purpose of this study was to develop a spectral library for the factors (vegetation, structure, water depth) of rivers. The target factors were divided into vegetation factors including grass, reed, and willow; structures (riverbed materials) such as road, sand, and granite; and water depth (0.3 m, 1.0 m, 1.5 m) for measurement in Fig. 3.

Figure 3. Spectral reflectance measurement

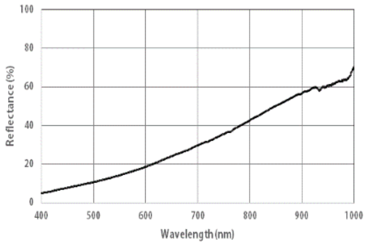
3.2Results

The results are shown as a reflectance graph for wavelengths as shown in Fig.4. Case 1 is a spectral library for vegetation factors, in which the reflectance increased as the wavelength increased, and the highest reflectance was shown in the reed area. In case 2 (riverbed materials), road and granite showed similar reflectance according to the wavelength, while the reflectance of sand was found to increase to a certain wavelength (near-infrared area). Case 3 showed a different reflectance according to the water depth. At a depth of 0.3 m and 1.0 m, the reflectance is similar for each wavelength. However, distinguishing riverbed materials at 1.5 m becomes difficult because of the increased water depth.

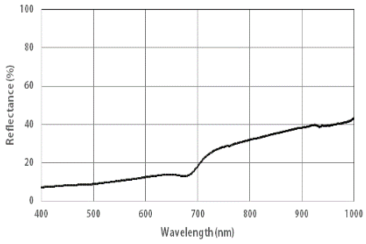
(a) Grass



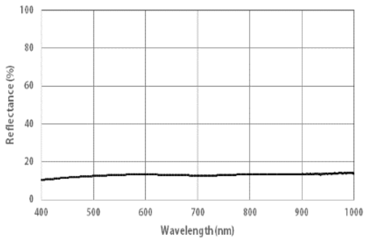
(b) Reed



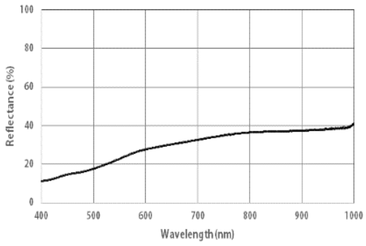
(c) Willow



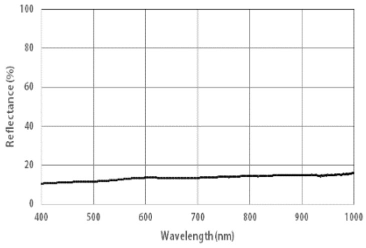
(d) Road



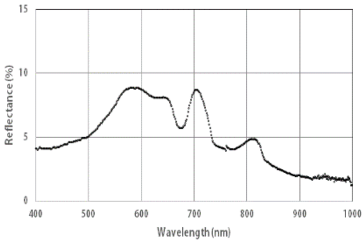
(e) Sand



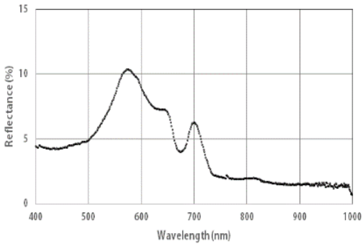
(f) Granite



(g) Water depth (0.3 m)



(h) Water depth (1.0 m)



(i) Water depth (1.5 m)

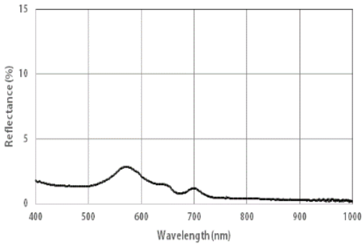


Figure 4. The reflectance for the wavelength of each target

IV. CONCLUSION

The purpose of this study was to establish a spectral library for various materials in rivers, and we performed measurements on vegetation, riverbed materials, and water depth by using hyperspectral sensors. The 3 target factors were vegetation, riverbed materials, and water depth, and they were subdivided into 3 materials for each case. The research was carried out at the River Experiment Center of the Korea Institute of Civil Engineering and Building Technology, where we can measure the reflectance of vegetation, structures, and water depth. As a result of comparing the reflectance in the visible light and near-infrared areas for each material, there was a difference in reflectance depending on the materials. In particular, there was a large difference in reflectance according to the water depth. The spectral radiation library developed by this study is expected to be used as basic research data applicable to unmanned aerial vehicles (UAV) and hyperspectral images (HSI) as shown in Fig. 5. Further research will be required on the reflectance according to the water depth.

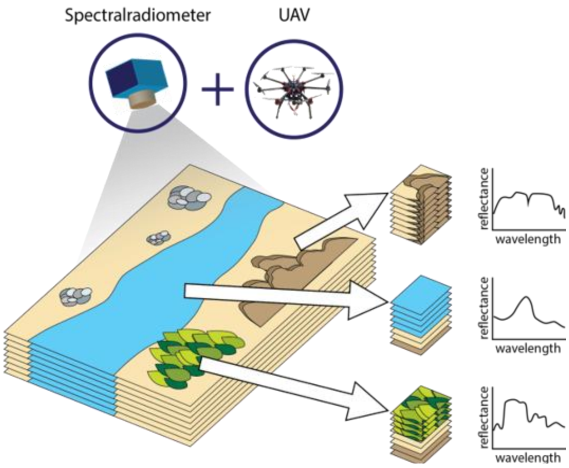


Figure 5. Remote sensing with spectral radiometer using UAV

V. Acknowledgements

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