Using Unmanned Aerial Vehicle to Obtain Digital Images and Estimating In-Situ Soil Water Content

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Motivation & Purpose

The many applications of remote sensing have become a very popular method for analyzing the soil water content (SWC) in-situ due to the benefits they provide, including the distant observation, large data collection in short time, and limited manpower and resource usage.

Despites the advantages, inaccurate or false data owing to the anomalies in geomorphological and meteorological conditions may affect the research results.

This research evaluates the efficiency of the gray level (GL) remote sensing technique for estimating the SWC under such conditions.

Location

The sampling location, that is a rice field is in Jhuweizih, Douliu City, Yunlin County, Taiwan (R.O.C.)
For this experiment, a setup of 25 m × 25 m sampling range was selected. It was divided in grids of 5 m × 5 m (25 grids in total).

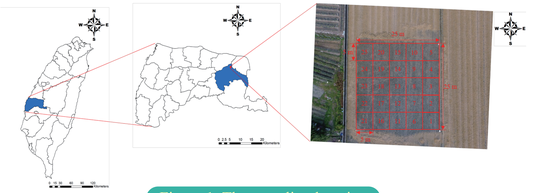

Figure 1. The sampling location

Flow chart

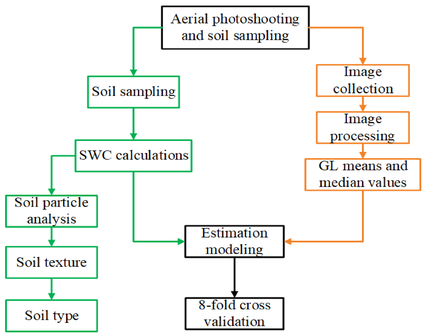

Figure 2. Flow chart of this study

Materials and methods- Soil analysis

Soil sampling method:

The ASTM D4959-00(2000) was used as a reference for soil sampling estimations. Specifically:
1. The sampling range was determined and divided in 25 grids. In every grid 500g of soil were sampled.
2. A sampling ring (8cm diameter) was used for the soil sampling.
3. The soil samples were packaged in sealed plastic bag. Then, they were taken to the lab for further analysis.

Soil water content:

Gravimetric method (ASTM D4959-00, 2000.).

$$\theta_m = \frac{W_{water}}{W_{dry\ soil}} \quad [1]$$

for

θ_m is soil water contain (w/w)
W_{water} is weight of water in soil column(w)
$W_{dry\ soil}$ is weight of dry soil in soil column(w)

Soil particle size analysis:

For this experiment, the ASTM D422-63, (2007) was used as a reference.

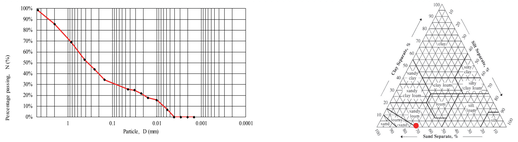

Figure 3. The result of soil particle size analysis. (Sand: 70%, Silt: 30%)

Materials and methods- Image analysis

Aerial Photoshooting:

For this experiment, the DJI phantom 4 pro drone was used for a duration of 8 days. The drone was flying 30 m above the sampling location and it was operating 4 times per day; at 9 h, 11 h, 13 h, and 15 h, respectively.

Image process:

When all 4 photoshooting operations were completed in a day, the produced images were modified in the Adobe Photoshop Lightroom 5 program in order to match with the analysis rate (25 m × 25 m).

GL analysis:

After modifying the images, they were imported in the Matlab so to be divided in 25 grids. Next, the mean and median of the GL were investigated.

Materials and methods- 8 fold cross validation

In 8 fold cross validation, the data is divided into 8 subsets. Now the holdout method is repeated 8 times, such that each time, one of the 8 subsets is used as the validation set and the other 7 subsets are put together to form a regression set.

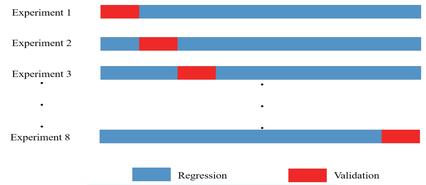

Figure 4. The 8 fold cross validation.

Materials and methods- Regression

In this experiment, 8 GL-SWC estimation models were deduced using the inverse relationship between GL-squared and SWC (Zhu, et, al. 2010).[a]

$$\theta = aGL^2 + b \quad [2]$$

where a, b : Regression coefficient
GL : Gray level, range：0-255
θ : Estimating soil water content

Figure 5. GL-SWC estimation model

Results- 8 fold cross validation

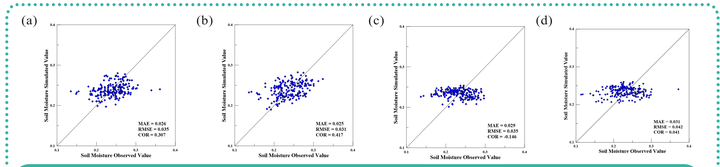

Figure 6. The results of 8 fold cross validation in median GL value. (a) 9h, (b) 11h, (c) 13h and (d) 15h

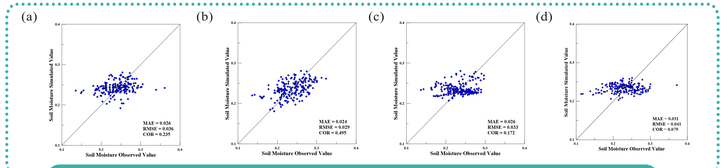

Figure 7. The results of 8 fold cross validation in mean GL value. (a) 9h, (b) 11h, (c) 13h and (d) 15h

Conclusion and suggestions

1. According to the validation results, the before noon's data are better than afternoon's data. Also, the mean result is the most preferable.

2. According to the verification results, this experiment is lacking high and low SWC data. Therefore, it is suggested more soil samples to be obtained when the weather conditions are drier or more humid in order to increase the SWC range.

3. According to the correlation results, the GL value is not the most appropriate for estimating the SWC. Therefore, another resolution of image processing (i.e. RGB) should be investigated for SWC estimations.

Acknowledgements

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[a]Zhu, Y., Wang, Y., Shao, M., & Horton, R. (2011). Estimating soil water content from surface digital image gray level measurements under visible spectrum. *Canadian Journal of Soil Science*, *91*(1), 69-76.