



UNIVERSITY OF
KELANIYA

Faculty of
Computing & Technology



9th International Conference on Advances in Technology and Computing

Deep Learning for Soil Moisture Content Estimation via Reflectance Multispectral Imaging

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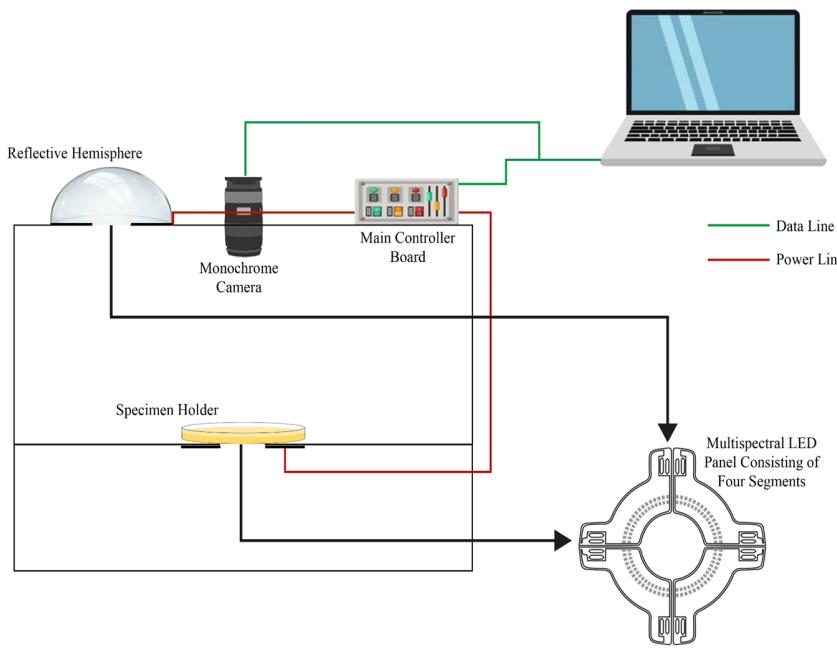
Objectives

- Provide an accurate technique to measure the Soil Moisture Content while being cost-effective, fast, and simple.
- Identify the variation of multispectral data with Soil Moisture.
- Develop a regression model to map captured spectral information to Soil Moisture Content.

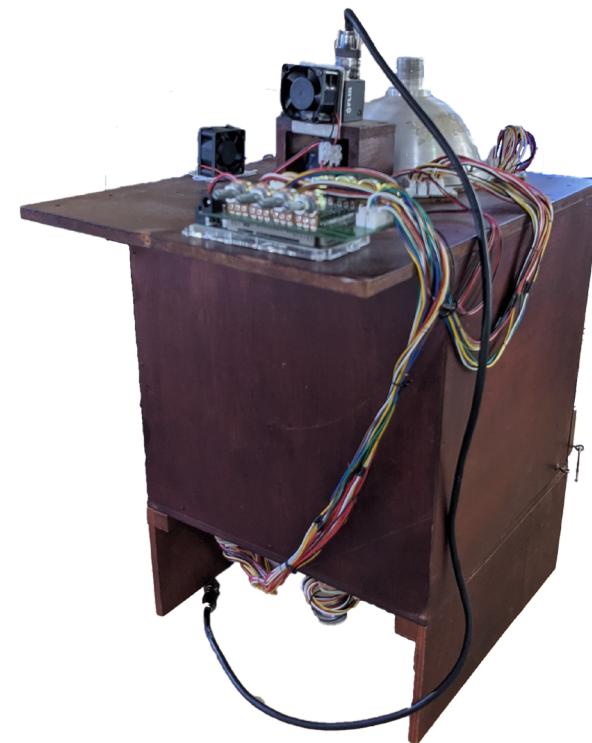
Background

- An essential factor that needs to be thoroughly assessed prior to commencing any construction is the site's soil characteristics.
- One such crucial parameter is the content of water stored in the soil, known as Soil Moisture Content.
- There are two main approaches for estimating SMC, namely indirect methods and direct methods.
- Recently multispectral or hyperspectral imaging has emerged as an excellent analysis method due to its non-destructive and non-invasive capabilities.
- In multispectral imaging, a wide range of color channels are utilized, spanning from near-infrared to near-ultraviolet across the electromagnetic spectrum.
- Multispectral imaging is applied in diverse fields such as medicine, agriculture, and industry.

Multispectral Imaging System



Cross section of the Multispectral Imaging System



Multispectral Imaging System

Preparation of Soil Samples

Yellow-orange silty soil was excavated from a building site

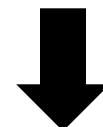


Removed leaves, roots, gravel, and similar large particles and then passed through a 2mm sieve

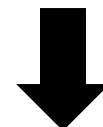


Yellow-orange silty soil

Water was added to the soil till saturation

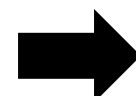


Soil was placed in moisture tins



Soil Moisture Content(SMC) Measurement

Soil specimens were oven-dried at 105 °C at a 5-minute time interval



Measure SMC at each stage using the following equation

$$SMC(\%) = \frac{m_w - m_d}{m_d - m_t} \times 100$$

m_w - Wet mass of the specimen at each drying stage

m_d - Completely dried mass of the specimen

m_t - Empty mass of moisture tin

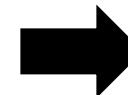


Soil specimens

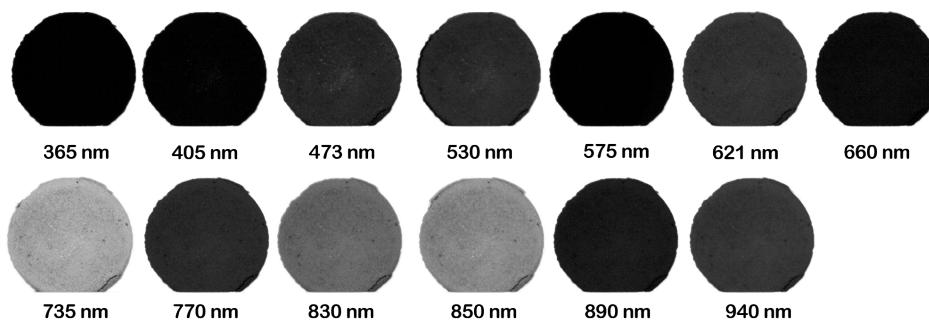
Completely dried mass of the soil specimen was obtained after continuously drying the specimen for 24 hours at 105 °C

Multispectral Imaging and Preprocessing

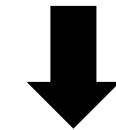
Obtaining multispectral images of samples using the MSI device at each drying stage



The images that were acquired were preprocessed by applying, dark current subtraction



MSI images of a soil specimen

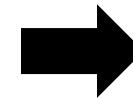


Images were cropped to 100×100 pixels and a histogram equalization algorithm was added

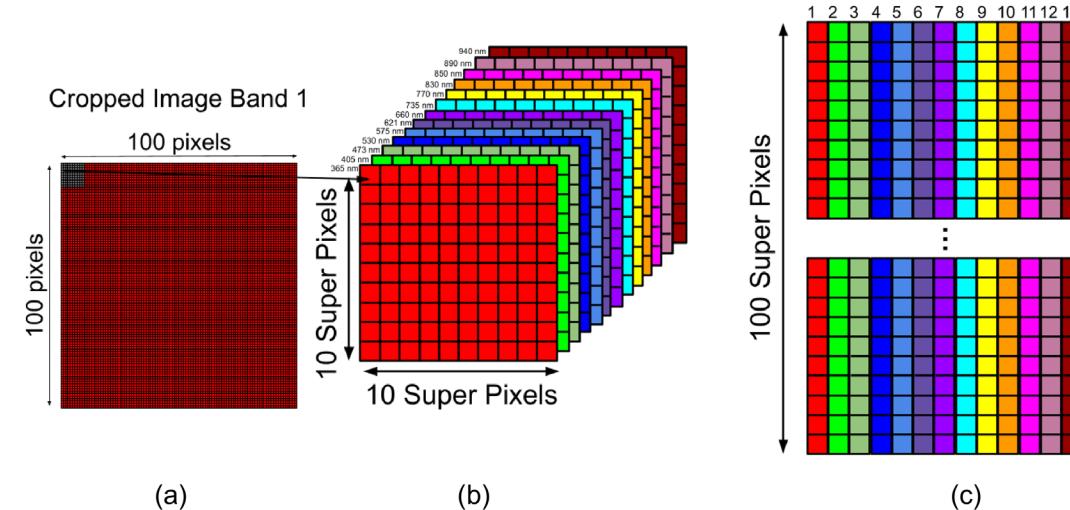
$$I_{correct} = \left(avg - \frac{std}{2} \right) + std \cdot \frac{\tanh(0.04 \cdot (I_{crop} - avg) + 1)}{2}$$

Dataset preparation

Preprocessed 100×100 pixels were further divided into 10×10 pixels

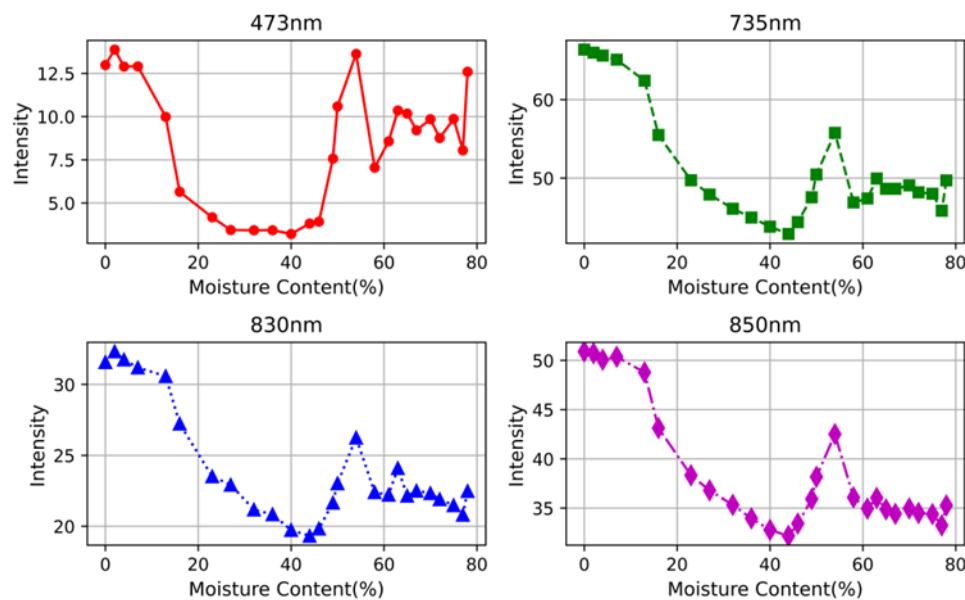


Created the 100×13 matrix and doing for all images the full dataset was made

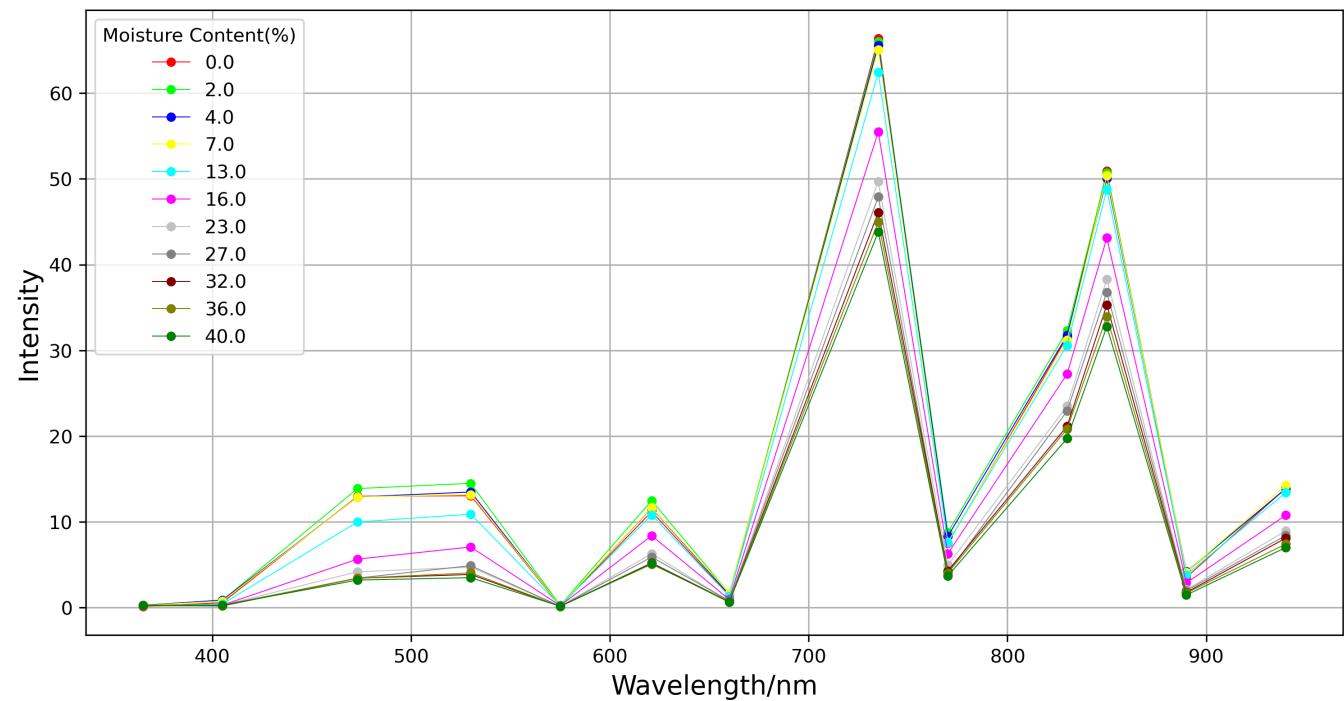


Development of data matrix for a SMC level of a soil specimen

Spectral Signature



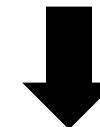
Variation of intensities with SMC at wavelengths 473 nm, 735 nm, 830 nm, and 850 nm



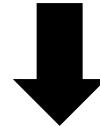
Spectral signatures for Moisture contents

Regression Analysis

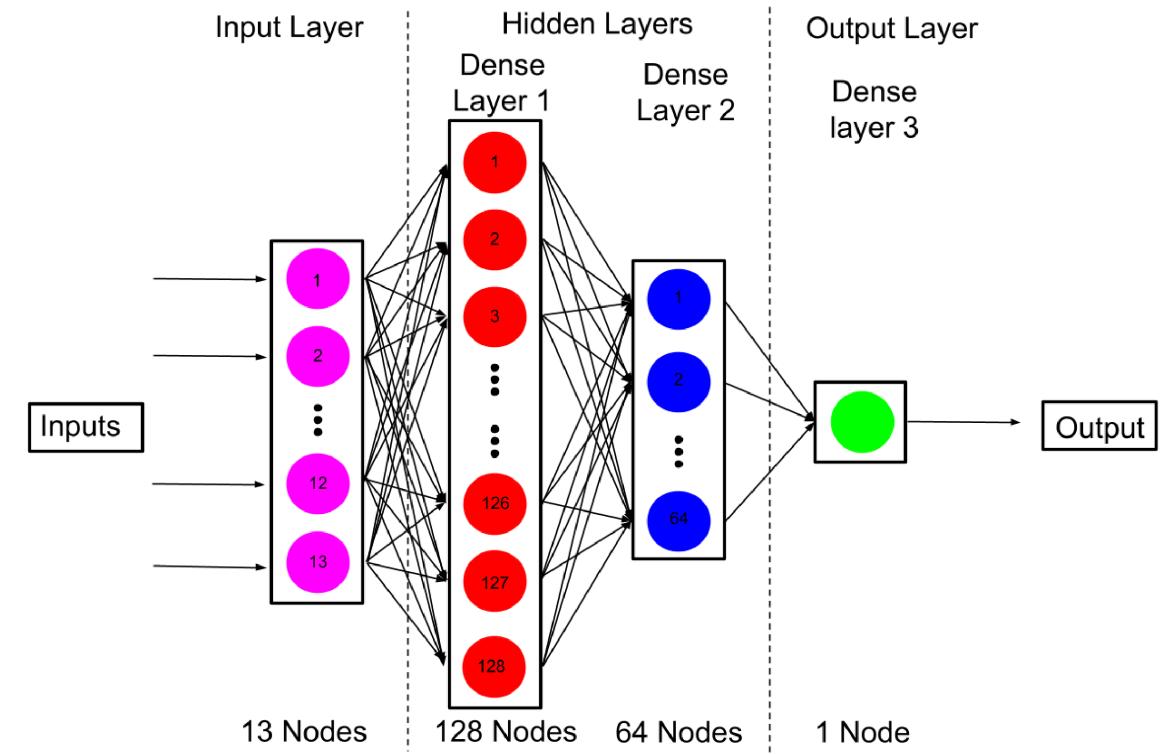
A four-layer fully connected feed forward neural network is utilized for regression analysis.



80/20 train-test split applied to normalized final dataset and predicted the moisture content for testing data from trained neural network.



Neural network is validated using the validation dataset.

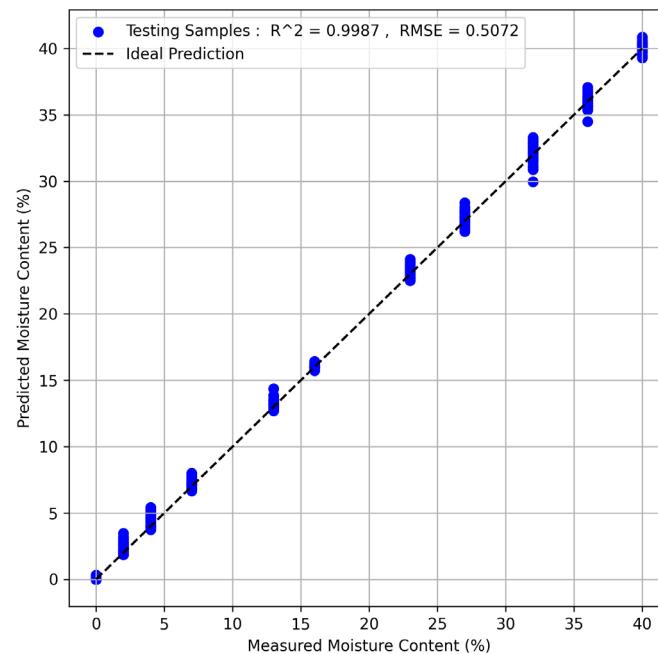


Structure of the Regression neural network

Predicted outputs from Regression model

R^2 value = 0.9987

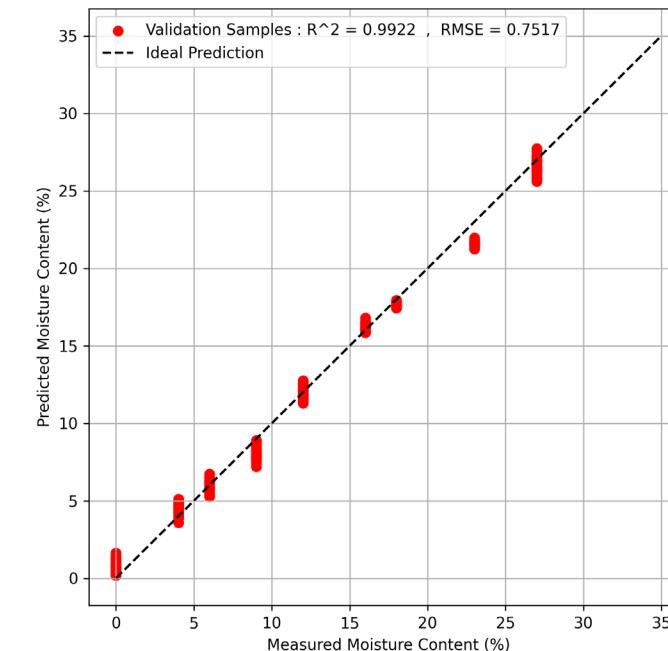
RMSE = 0.5072



Predicted outputs for testing samples

R^2 value = 0.9922

RMSE = 0.7517



Predicted outputs for validation samples

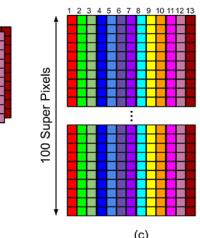
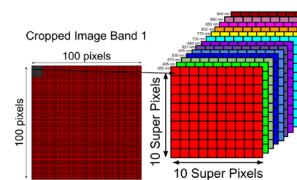
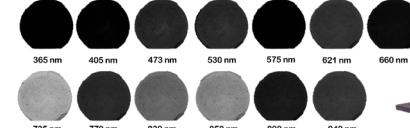
Conclusion

Prepare soil samples and measure SMC

$$SMC(\%) = \frac{m_w - m_d}{m_d - m_t} \times 100$$

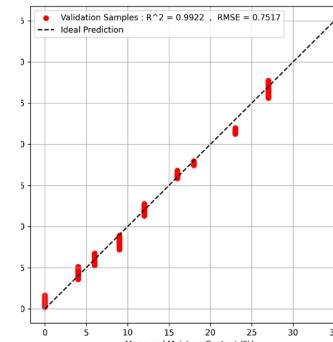
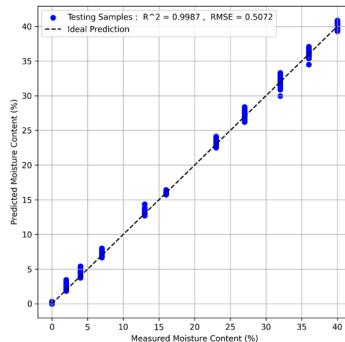
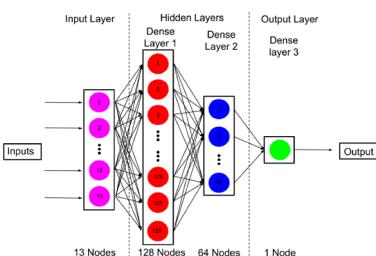


Capture and Preprocess MSI Images

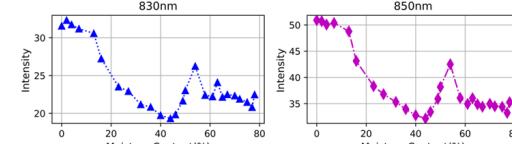
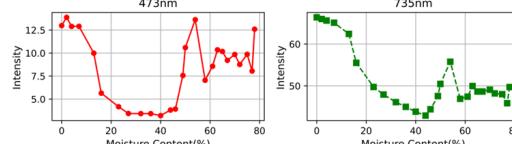
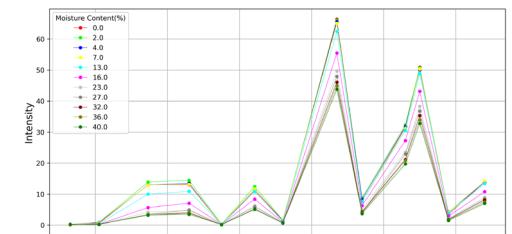


Dataset Preparation

Regression Analysis



Spectral Signature





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Thank You!

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