Lightweight Physics-Informed Convolutional Neural Network

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Industry Challenge

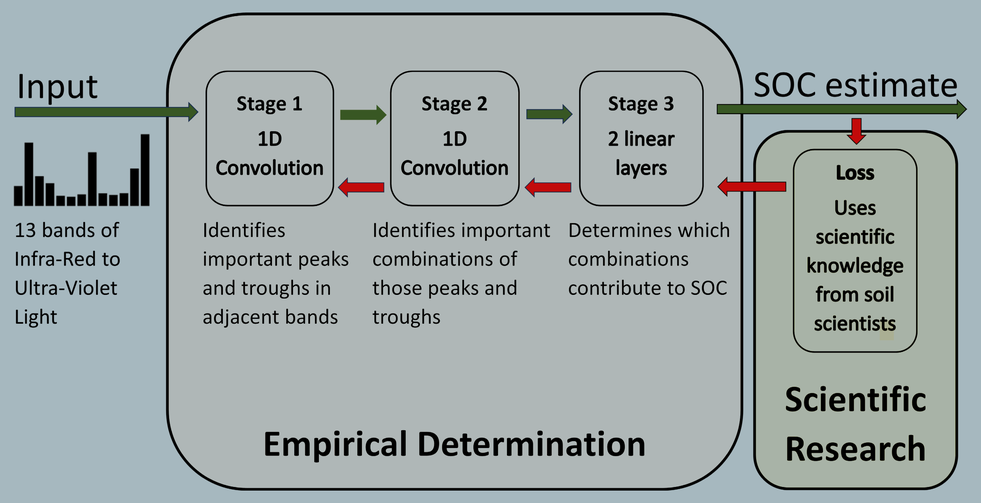
- Soil organic carbon (SOC) is important for those **who** produce food, farm carbon, generate domestic and export income
- Measuring SOC is slow (days or weeks) and expensive (about $500 per sample)
- Thus, an inexpensive, fast and transparent method is needed to estimate SOC

Motivation

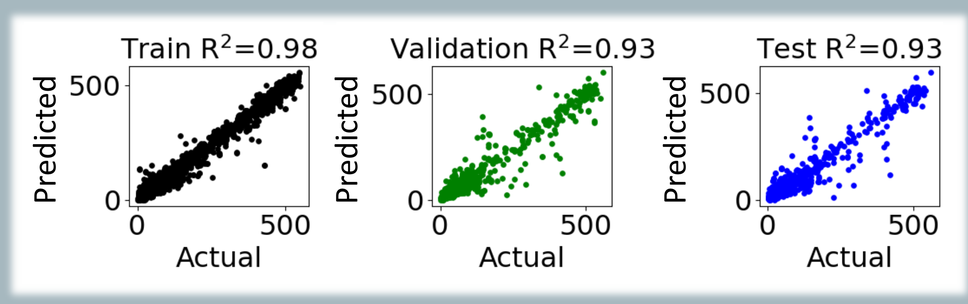
A personal desire to go beyond identifying patterns in data to include scientific research on **why** SOC can be estimated from light using Infra-Red to Ultraviolet frequencies

Our research combines the power of neural networks with science associated with soils

Model Architecture



Model Performance



→ Explains 98% of variation in the data - almost a perfect fit!

Physics-Informed Loss Function

$$Loss = \sum_{i=1}^{N} \left(accuracy_i \times \left(SOC_{CNN\ Model2_i} - SOC_{Index\ Estimate_i} \right) \right)^2$$

- This is **how** we include science knowledge in our SOC estimation model
- Active until model achieves accuracy estimated by Linear Regression of selected index and Soil Organic Carbon
- Inputs not associated with index replaced with randomised data
- Influence of SOC estimates from model de-rated by their accuracy as compared with estimate from scientifically informed index

Potential Applications

- Estimate SOC from satellite images where farming practices result in bare soil
- Estimate SOC from proximal sensor images where no-till precludes bare soil satellite images
- Web-based tool provided for farmers by NRM organisations
- Could be extended to estimate SOC at different depths by using proximal sensors and controlled light in the field
- Could be expanded to look at other soil properties such as Nitrogen, Phosphorus and Potassium

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