Deep Learning for Multi Crop Classification of Hyperspectral Data

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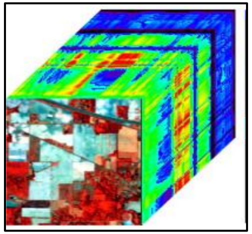
Overview

- Review of Literature
- Objectives
- Deep Learning Framework
- Results and Discussion of Basic Deep Learning Model
- Conclusion

Features of the Hyperspectral Data

- Hyperspectral data has a large set spectral information in the frequency range of its sensor, and the spatial information captured airborne or spaceborne is also of high resolution.
- This large set of information can help us analyse and get important features from the remote sensing data , and derive robust applications through these studies. The data is optical data and not time-series.



Review in Literature

Deep Learning

(Yushi Chen, 2015) introduces Deep Learning-Based Classification of Hyperspectral Data by building up an architecture from stacked autoencoders and mathematical functions.

(Henrik Petersson , IEEE 2016) illustrates how deep learning an appealing approach for analysing hyperspectral data.

Hyperspectral Image Analysis using Deep Learning - a Review

Henrik Petersson, David Gustafsson and David Bergström
Swedish Defence Research Agency (FOI)
Division of C4ISR

Review in Literature

CNN in HSI

(Yushi Chen, 2017) Deep Feature Extraction and Classification of Hyperspectral Images Based on Convolutional Neural Networks showed how Unsupervised CNN can be used for classification of Hyperspectral data effectively.

(Amina Ben Hamida et al 2018) 3-D Deep Learning Approach for Remote Sensing Image Classification shows how 3D architecture is best suited for Hyperspectral Data.

(Xiaofei et al , 2018) showed importance of Convolutional networks as Deep Learning Models for HSI classification , exploiting spatial aspect of HSI data.

Hyperspectral Image Classification With Deep Learning Models

Xiaofei Yang, Yunming Ye, Xutao Li, Raymond Y. K. Lau, *Senior Member, IEEE*, Xiaofeng Zhang, and Xiaohui Huang

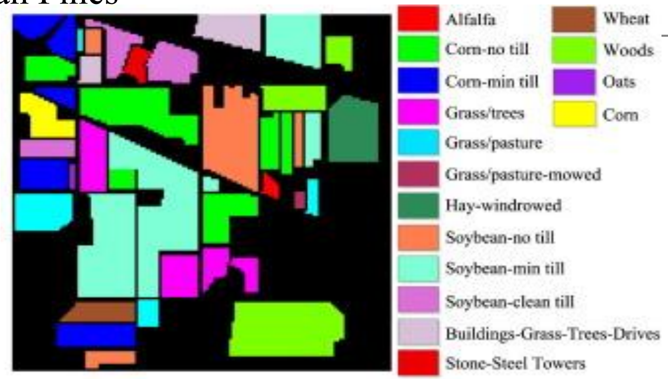
Objectives

- To develop a Deep Learning (DL) Framework for multi crops classification.
- Comparison of Deep Feature Extraction with Image Processing Feature Extraction Techniques using crop HSI data.

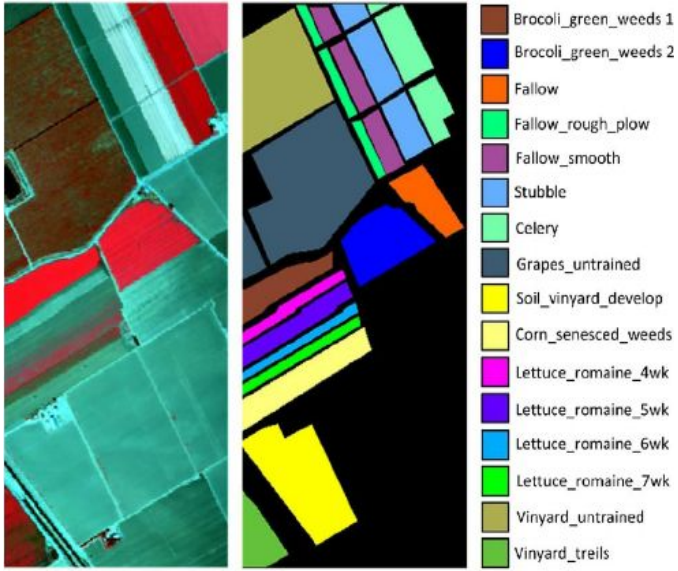
Ref: (Yushi Chen, 2016) - "Deep Feature Extraction and Classification of Hyperspectral Images Based on Convolutional Neural Networks"

Hyperspectral Datasets

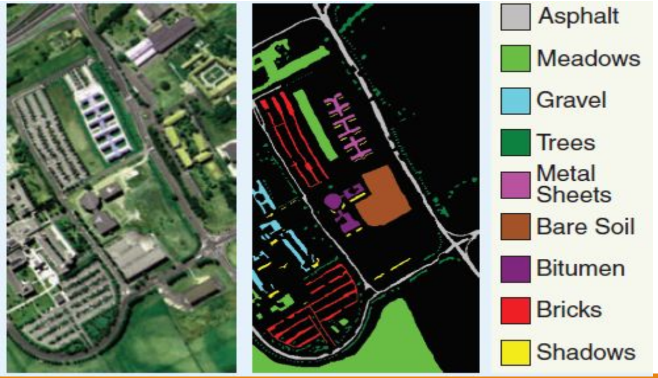
Indian Pines



Salinas Dataset



Pavia Dataset



Comparison of the datasets

Table: Datasets comparison

Information	Indian Pines	Pavia	Salinas	Anand Site
Sensor	AVIRIS	ROSIS	AVIRIS	AVIRIS-NG
Number of Classes	16	9	16	19
Number of Bands	220	103	200	372
Frequency range	0.4 to 2.5 um	0.43 to 0.86 um	0.43 to 2.5 um	0.4 to 2.5 um
Spectral Resolution	9.5 nm	4.1 nm	9.2 nm	5 nm
Size of site	145x145	610x610	512x217	2033x653
Spatial Resolution	20 m	1.3 m	3.7 m	10 m
Classes with min. sample	Oats(20)	Shadows(476)	Lettuce romaine(916)	Crop patch(30)

Why AVIRIS-NG dataset is challenging to make a Deep Learning model on?

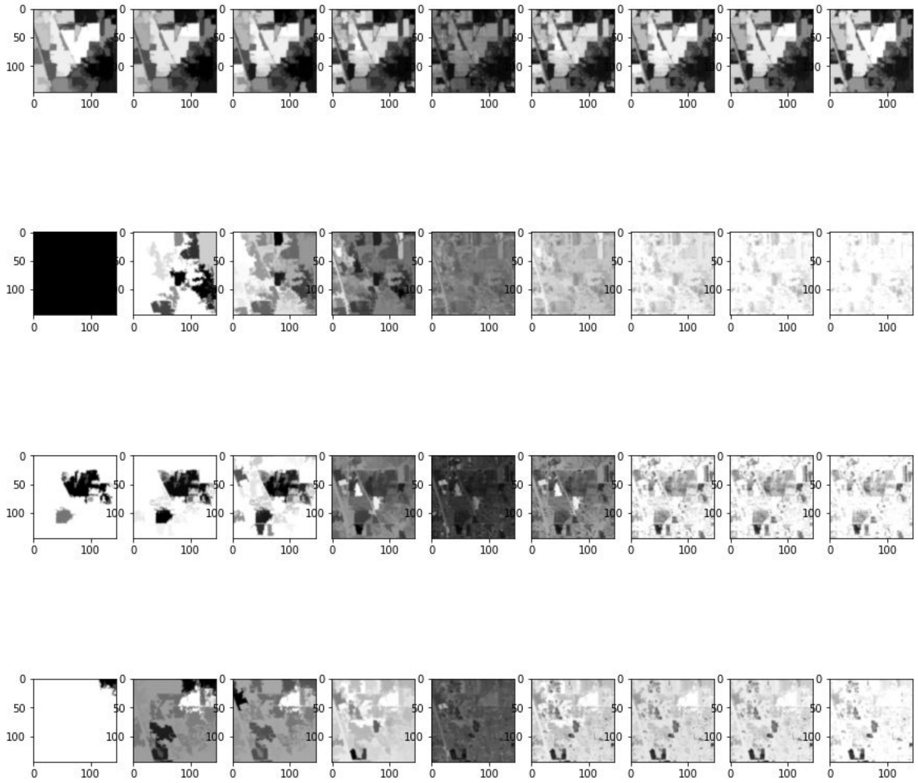
- AVIRIS-NG stands for Airborne Visible Infrared Imaging Spectrometer - New Generation.
- This data is challenging to classify due to small patches and less rare ground truth information. Standard models like Spectral Angle Mapper are not adequate, so Deep Learning Models are chosen for classifying areas with small farm strips.
- There is the issue of mixed pixels and high dimensions in the data which require careful pre-processing to resolve before feeding to the Neural Network.

Attribute Profiles ,Morphological Profiles and Extinction Profiles for Feature Extraction

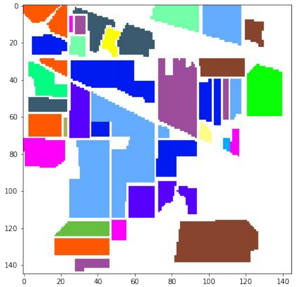
Attribute profiles (APs) are constructed by the sequential application of attribute thinning and thickening 2 with a set of progressively stricter threshold values.

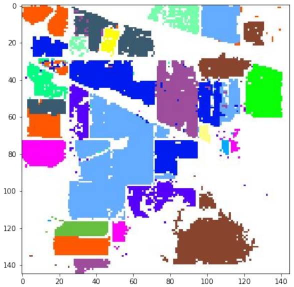
MPs, APs, and EPs produce several additional features from a single gray scale image (i.e.,the input image). It is possible to apply such profiles to all the bands of the hyperspectral data individually and concatenate them.

Extended Morphological Profile on Indian Pines Dataset



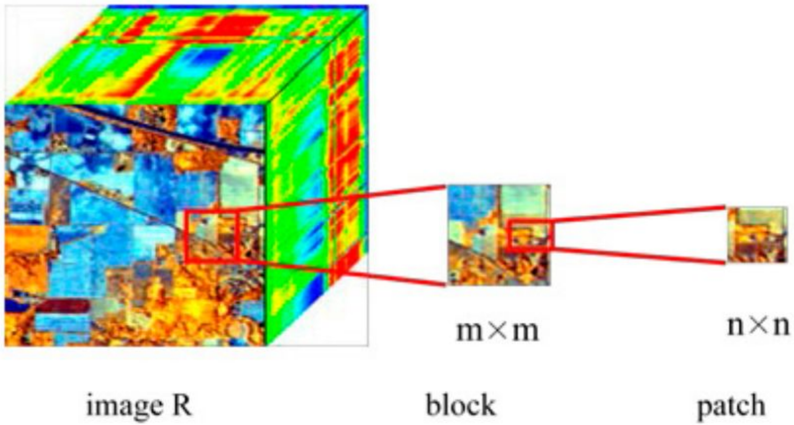
EMP+SVM: OA= 88%





Ground truth

Deep Learning Framework



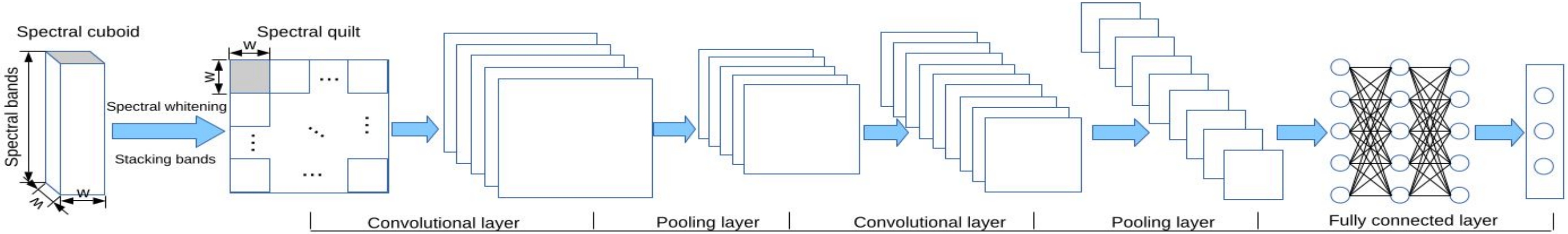
Motivation to use CNN approach:

- In deep learning, the convolutional neural networks (CNN) play a dominant role for processing image-related problems.

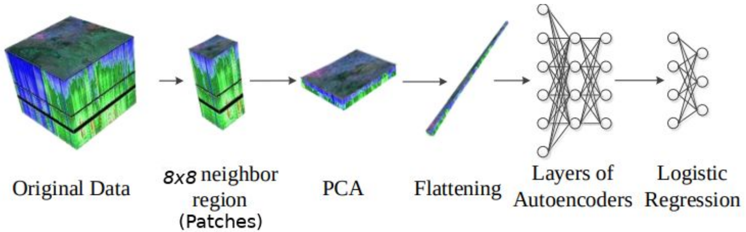
- In HSI classification, the nearby pixels or the land patch's features must be extracted for constructing effective decision functions.

Diagram credit : (Chen Ding, 2017) Convolutional Neural Networks Based Hyperspectral Image Classification Method with Adaptive Kernels

Block Diagram (Deep Learning)



Block Diagram of Autoencoder (Patch making and Spectral reduction by convolutional and pooling layers)



Input pipeline and pre-processing done before feeding HSI data to input layer of DL Model.

Credits: “Hyperspectral Image Classification With Stacking Spectral Patches and Convolutional Neural Networks” , Lei Shu

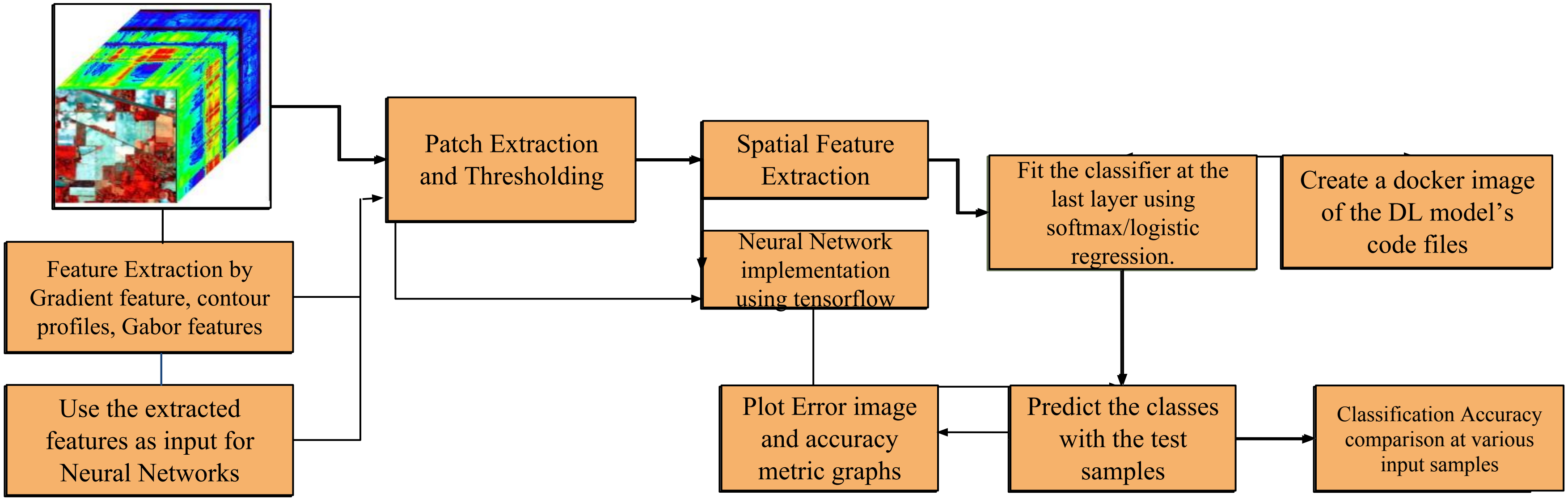
Flow Diagram on improving the CNN architecture

- SVM (linear, RBF and poly kernels with grid search)
- SGD (linear SVM using stochastic gradient descent for fast optimization)
- Baseline neural network (4 fully connected layers with dropout)
- 1D CNN (Deep Convolutional Neural Networks for Hyperspectral Image Classification, Hu et al., Journal of Sensors 2015)
- 2D CNN (Hyperspectral CNN for Image Classification & Band Selection, with Application to Face Recognition, Sharma et al, technical report 2018)
- 3D CNN (3-D Deep Learning Approach for Remote Sensing Image Classification, Hamida et al., TGRS 2018)
- 3D CNN (Deep Feature Extraction and Classification of Hyperspectral Images Based on Convolutional Neural Networks, Chen et al., TGRS 2016)
- 3D CNN (Spectral–Spatial Classification of Hyperspectral Imagery with 3D Convolutional Neural Network, Li et al., Remote Sensing 2017)
- 3D CNN (HSI-CNN: A Novel Convolution Neural Network for Hyperspectral Image, Luo et al, ICPR 2018)
- Multi-scale 3D CNN (Multi-scale 3D Deep Convolutional Neural Network for Hyperspectral Image Classification, He et al, ICIP 2017)

Code Ref: https://github.com/nshaud/DeepHyperX

Deep Learning Framework in TensorFlow

Data Flow Diagram for Deep Learning Framework



Ref: (Yushi Chen, 2016) - "Deep Feature Extraction and Classification of Hyperspectral Images Based on Convolutional Neural Networks"

Future Tasks

- To use both spatial and spectral components and build a Neural Network that can have hyperparameters which can extract maximum features from spatial and spectral side ,or better Spatial-Spectral integration.

- To implement Deep Learning Framework and one-shot Learning ML method (Training with Limited Samples).

- To perform further analysis on separability of classes, Mixture Augmentation in Hyperspectral agricultural datasets.

Timeline and Future Work

2018	November	Ensemble Methods and Kernel Learning Methods combining classical pixel based classifiers
2018	December	Attribute Profiles ,Morphological Profiles and Extinction Profiles for Feature Extraction
2019	January	Literature Review for CNN and Feature Extraction
2019	February	Develop spatial based CNN architecture in tensorflow
2019	March	Compare spatio-spectral CNN with other methods.
2019	April	Review paper, Tool Development. Refine the model for mixed pixels and radiometric augmentation.

Papers Publishing Pipeline

- Paper on using Hyperspectral Crop Classification algorithms for abundant Multispectral Datasets.

- Review Paper Deep Learning Algorithms on Hyperspectral Crop Classification

Extra Information

Results and Discussions

Conclusions

Future Approaches

- Deriving from the study since the past 6 months, the representation of the samples and the spectra is very important in any HSI dataset , so for 19 class Anand site, excluding the under-represented classes and developing a DL model can be one approach.

- Oversampling weak classes and/or undersampling major classes can be done to handle the issue of class imbalance.

Key References

Yushi Chen, 2016 - “Deep Feature Extraction and Classification of Hyperspectral Images Based on Convolutional Neural Networks”

“Hyperspectral Image Classification With Stacking Spectral Patches and Convolutional Neural Networks” , Lei Shu