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Deep learning classification of land cover and crop types using remote sensing data

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Abstract : Hyperspectral imaging (HSI), measuring the reflectance over visible (VIS), near-infrared (NIR), and shortwave infrared wavelengths (SWIR), has empowered the task of classification and can be useful in a variety of application areas like agriculture, even at a minor level. Band selection (BS) refers to the process of selecting the most relevant bands from a hyperspectral image, which is a necessary and important step for classification in HSI. Though numerous successful methods are available for selecting informative bands, reflectance properties are not taken into account, which is crucial for application-specific BS. The present paper aims at crop mapping for agriculture, where physical properties of light and biological conditions of plants are considered for BS. Initially, bands were partitioned according to their wavelength boundaries in visible, near-infrared, and shortwave infrared regions. Then, bands were quantized and selected via metrics like entropy, Normalized Difference Vegetation Index (NDVI), and Modified Normalized Difference Water Index (MNDWI) from each region, respectively. A Convolutional Neural Network was designed with the finer generated sub-cube to map the selective crops. Experiments were conducted on two standard HSI datasets, Indian Pines and Salinas, to classify different types of crops from Corn, Soya, Fallow, and Romaine Lettuce classes. Quantitatively, overall accuracy between 95.97% and 99.35% was achieved for Corn and Soya classes from Indian Pines; between 94.53% and 100% was achieved for Fallow and Romaine Lettuce classes from Salinas. The effectiveness of the proposed band selection with Convolutional Neural Network (CNN) can be seen from the resulted classification maps and ablation study.

***IndexTerms* – Convolutional Neural Network, Hyper Spectral Imagining, Band Selection, Normalized Difference Vegetation Index, Modified Normalized Difference Water Index.**

I. INTRODUCTION

Accurate and timely grasp of the information about the agricultural resources is extremely important for agricultural development. Obtaining the area and spatial distribution of crops is an important way to obtain agricultural information [1,2]. Traditional methods obtain crop classification results through field measurement, investigation and statistics, which are time-consuming, labor-consuming and money-consuming [3,4]. Remote sensing technology advances by leaps and bounds, and the resolution and timeliness of remote sensing images have been improved, and hyperspectral remote sensing data have been widely used [5,6]. Specifically, hyperspectral data play a great role in agricultural surveys [7–10], and have been used for crop condition monitoring, agricultural yield estimation, pest monitoring and so on. In agricultural survey, the fine classification of the hyperspectral image provides the information of crops distribution [11–13]. Fine classification of crops requires images with high spatial and spectral resolution [14]. In recent years, airborne hyperspectral technology has developed rapidly; the application of airborne hyperspectral imagery can solve the above needs.

Due to advancements in remote sensing image acquisition mechanisms and the growing availability of rich spectral and spatial information by using a variety of sensors, hyperspectral imaging has gained importance. In particular, Hyperspectral Image (HSI) classification has become a prominent source for practical applications in fields like agriculture, environment, and forestry, mineral mapping, etc. [1–5]. The present paper focuses on analyzing and using HSI in the agriculture field. Accurate information about growing crops with different climate conditions and agricultural resources and with different timestamps (before, during, and after cultivation) is extremely important and useful for agricultural development. Traditional methods, like field surveys and other statistical-based analyses, are very time-consuming. Advanced remote sensing technology, including HSI, provides a suitable solution and can fill the gap [6–10] with solutions like crop classification. The problem of crop classification using hyperspectral images has been addressed by researchers with various methods [11,12]. A method based on regression analysis was used to classify the variety of sugarcane crops in Brazil. This HSI data was captured using the EO-1 satellite [13]. The method, proposed in [14], is a combination of Support Vector Machine (SVM) and linear spectral models and was used successfully on the data captured from the Hyperion satellite. This method was also used to classify litchi crops in Guangzhou. Crops in the Karnataka area were classified using the Spectral Angular Mapper (SAM) classifier method for the Hyperion data.

The major agricultural applications of remote sensing include vegetation and soil. Vegetation includs crop type classification, crop area classification, and crop monitoring and crop yield estimation. Farmers can receive field-based information including vegetation identification, crop region determination and crop condition monitoring. This kind of processing includes the work on different agricultural objects and products such as crop, flowers, fruits, leaves etc. In crop production estimation using remotely sensed data, it is essential to approximate the crop area and its yield. The two strategies were applied to rice crop area estimation. Crops are normally issued between the time of the plantation and the time of harvest. In research, I will use “satellite image” captured in-between the plantations or before and the time of the forecast. There are several image processing techniques available. Image processing techniques provide tentative data from satellite images. When working with images, there are many things to keep in mind such as loading an image, with the right format, saving the data as different data types, displaying images, conversion between different image formats, etc. Mainly these instructions require an Image processing techniques. Future data may be quantitative or qualitative. In this paper, our main focus is to develop a vegetation area classification model framework that can:
(1) Collect forecaster satellite data from multiple sources.
(2) Apply image processing techniques.
(3) Classify vegetation area.

II. RELATED WORKS

1. Sanjay D. Sawaitul et al., focuses the information about weather and are observed and stored. The recorded parameters are used to forecast weather. If there is a change in any one of the recorded parameters like wind speed, wind direction, temperature, rainfall, humidity, then the upcoming climatic condition can be predicted using artificial neural networks, back propagation techniques. The increase in signal range will work in large areas as well [1].
2. Somvanshi, V.K. et al., deliberate the modeling and prediction of rainfall using artificial neural networks and Box-Jenkins methodology. Other applications of artificial neural networks in hydrology are forecasting daily water hassle and flow forecasting [2].
3. K. Verheyen et al., Data Mining is the process of discovering meaningful patterns and trends by shifting through huge amount of data, using pattern detection technologies as well as statistical and mathematical techniques. Data Mining techniques are often used to studied soil characteristics. As an example, the K-Mean approach is used for classifying soils in combination with GPS based techniques [3].
4. Urtubia et al., The prediction of wine fermentation problems can be performed by using a k-means approach. Knowing in advance that the wine fermentation process could get jammed or be slow can help the enologist to correct it and ensure a good fermentation process [4].
5. I. Jagielska et al., describe applications to agricultural related areas. Such as Yield prediction is a very important agricultural problem. Any farmer might be interested in knowing how much yield is expected. In the past, yield prediction was achieved by considering farmer's experience on particular field, crop and climate condition. We have discussed additional information about data like probability in probability theory, grade of membership in fuzzy set theory [5].
6. Tellaeche et al., detecting weeds in precision agriculture. The paper summarize an automatic computer vision system for the detection and differential spraying of Avena sterilis, a toxic weed growing in cereal crops. With such purpose it have been designed a hybrid decision making system based on the Bayesian and Fuzzy k-Means classifiers, where the a priori probability required by the Bayes framework is supplied by the Fuzzy k-Means [6].
7. Veenadhari, S. Influence of climatic factors on major kharif and rabi crops production in Bhopal District of Madhya Pradesh State was considered. The findings of the study revealed that the decision tree analysis indicated that the productivity of soybean crop was mostly influenced by comparative humidity followed by temperature and rainfall. The decision tree analysis shows that the productivity of paddy crop was mostly inclined by Rainfall followed by comparative Evaporation and humidity. For Wheat crop, the analysis shows that the productivity is mostly influenced by Temperature followed by relative humidity and rainfall. The result of decision tree was confirmed from Bayesian classification. The rules formed from the decision tree are useful for identifying the conditions intended for high or low crop productivity [7].
8. Shalvi D and De Claris N Bayesian network is a powerful tool and broadly used in agriculture datasets. The model developed for agriculture application based on the Bayesian network learning method. The results show that Bayesian Networks are feasible and efficient. Bayesian approach improves hydro geological site characterization even when using low-resolution resistivity surveys [8].
9. Altannar Chinchulunn et al.,The k-nearest neighbor classification algorithmic rule may be divided into 2 phases: coaching section and testing section. Bermejo associated Cabestany urged a reconciling learning algorithmic rule to permit fewer information points to be utilized in coaching information set. Several different techniques are projected to scale back procedure burden of k-nearest neighbor algorithms [9].
10. B. Rajagopalan and U. Lal A number of studies have been carried out on the application of data mining techniques for agricultural data sets. For example, the K-Nearest Neighbor is applied for simulating daily precipitations and other weather variables [10].
11. According to Schupp et al. [11], imaging technology has the potential to cross multiple areas of tree fruit production, such as crop load assessment, including blossom or green fruit counts, yield estimation, determination of insect presence

or disease infection and associated eradication, soil moisture content determination for enhanced irrigation system design, estimation of fertilizer, pesticide, and herbicide application rates, and the development of assisted or automated pruning and harvesting strategies.

12. Schupp et al. state that different technological approaches such as satellite imagery, real-time laser images, and video imagery application will prove successful for fruit and nut crop SSCM.
13. Goel et al. [13] reported a strong correlation between the digital information, e.g., spectral data of the aerial image, and soybean crop physiological parameters such as chlorophyll fluorescence, leaf greenness, leaf area index (LAI), photosynthesis rate, and plant height. In another application, Goel et al. [30] used multi-spectral (24 wave band) airborne optical remote sensing for detecting weed infestation in sitespecific managed field crops. They used the multi-spectral band, with a range of 475.12 nm to 910.01 nm, and their results indicated that the wave band centered on 675.98 and 685.17 nm in the red region and 743.93 to 830.43 nm in the NIR region, had good potential for weed classification in a maize field. The Schiffes multiple range tests provided a pvalue that was less than 0.05 to support their findings.
14. Xia Zhang et.al. (2016) , introduced a new kind of crop treatments, including the construction itself, and object oriented nature of the vegetation type groups FBS. Model also accounts for 20 additional sensitive index specters of the features that distinguish the parameters of most vegetation. In order to reduce additional information, resolution of birth will improve the resolution of its kind between the pair. Algorithm is proposed, by the kind of crop has been improved with sufficient accuracy, chlorophyll, execute the office of, the texture of which is associated with the index, reducing the effect of the ends of the face of a better mind, apparitions, to the kind of sensitivity is very much a sign of anthocyanins, which indicates that you'd like. Therefore, insert the seeds of crops, in order to monitor invasive species is an effective approach to better use in agriculture.
15. Chlingaryan and Sukkarieh performed a review study on nitrogen status estimation using machine learning (Chlingaryan et al., 2018). The paper concludes that quick developments in sensing technologies and ML techniques will result in cost-effective solutions in the agricultural sector.
16. Elavarasan et al. performed a survey of publications on machine learning models associated with crop yield prediction based on climatic parameters. The paper advises looking broad to find more parameters that account for crop yield (Elavarasan et al., 2018).
17. Liakos et al. (2018) published a review paper on the application of machine learning in the agricultural sector. The analysis was performed with publications focusing on crop management, livestock management, water management, and soil management.
18. Li, Lecourt, and Bishop performed a review study on determining the ripeness of fruits to decide the optimal harvest time and yield prediction (Li et al., 2018).
19. Mayuri and Priya addressed the challenges and methodologies that are encountered in the field of image processing and machine learning in the agricultural sector and especially in the detection of diseases (Mayuri and Priya,).
20. Somvanshi and Mishra presented several machine learning approaches and their application in plant biology (Somvanshi and Mishra, 2015)
21. Gandhi and Armstrong published a review paper on the application of data mining in the agricultural sector in general, dealing with decision making. They concluded that further research needs to be done to see how the implementation of data mining into complex agricultural datasets could be realized (Gandhi and Armstrong, 2016a, Gandhi and Armstrong, 2016)
22. Beulah performed a survey on the various data mining techniques that are used for crop yield prediction and concluded that the crop yield prediction could be solved by employing data mining techniques (Beulah, 2019).

III. Proposed Methodology

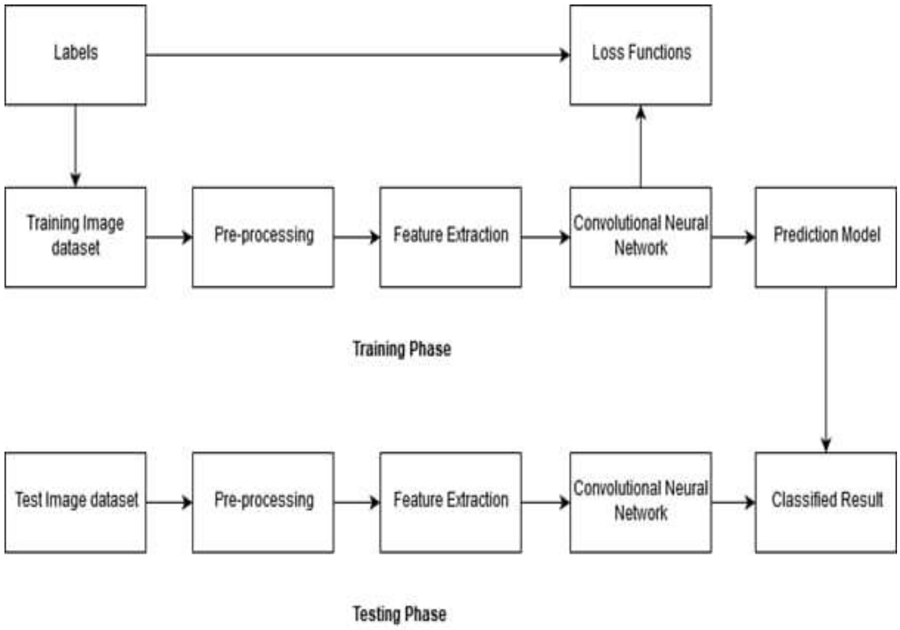

Figure 1.1: Block Diagram

In figure 1.1, the first step is to give training image dataset by using MATLAB software. In MATLAB software to read an image, use the imread command. The example reads one of the sample images included with the toolbox, pout.tif, and stores it in an array. Second step is Pre-Processing in that, to display a binary image, using either imshow or imtool, specify the image matrix as an argument. After the pre-processing third stage is feature extraction, in that convert RGB image into the HSV image. HSV is returned array whose three planes contain the hue, saturation, and value for the image. After extracting feature of the image, fourth step is to apply convolution neural network for that purpose median filtering technique is used. Median filtering is a nonlinear function frequently used in image processing to reduce noise. A median filter is more efficient when the aim is to concurrently reduce noise and preserve edges. Then adjust image intensity values. This maps the intensity values in grayscale image to new values, such that data is saturated at low and high intensities of image. Now apply area thresholding to reduce the intraclass variance of the black and white pixels. After this convert the gray scale image into a binary image. Sometimes if we want to process pixel values in the original grayscale image, then first segment grayscale image to acquire a binary image of objects. After examine the original grayscale pixel values corresponding to each object in the binary image. Last step is to predication model where the region of image measures.

IV. Conclusion

Satellite images perform as good source for classify or identify area related to crops monitoring & mapping in region. Image processing is having its precious significance in the agricultural applications. These applications contain the crop identification and classification, and crop disease identification, land identification and classification etc. I could say that whole vegetation with green is detected. Only green fields were detected even if the image has fields in different colors. Better outcome are obtained if the image contains nothing in shades of green other than vegetation. Any object, which is in green color, will be detected by the proposed system. These techniques are used to perform the classification or identification of vegetation area.

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