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Relationship Exploration Of Different Machine Learning Methods For HSI Classification

Anmol Kundlia

Teaching Associate, Department of Computer Science, Graphic Era Hill University, Dehradun, Uttarakhand India 248002

ABSTRACT

Hyperspectral imaging (HSI) captures spectral data across several electromagnetic radiation bands, making it popular. Agriculture, environmental monitoring, mining exploitation, and military surveillance use HSI. Hyperspectral imaging (HSI) data is complex and high-dimensional, making analysis and interpretation difficult. Machine learning (ML) techniques for HSI categorization analyse and analyse large amounts of data, revealing relevant patterns and characteristics. This study compares hyperspectral images classification machine learning methods. This article summarises HSI classification studies using SVM, RF, CNN, and DBN. The research evaluates HSI categorization methods. PCA and ICA are used to assess HSI categorization accuracy. Feature extraction reduces data dimensionality and improves machine learning model discrimination.

HSI classification research suggests more study. The work emphasises the need for robust and flexible machine learning methods to handle hyperspectral imaging data's complexity. Machine learning and feature extraction are suggested to improve hyperspectral picture categorization.

I. INTRODUCTION

The classification of pixels in a Hyperspectral image (HSI) involves the categorization of said pixels within an HSI data cube into distinct land cover or land use classes, utilising their spectral signatures. The classification of hyperspectral imagery (HSI) is a critical component of HSI data analysis and interpretation, and has found extensive use in a variety of domains, including but not limited to environmental monitoring, agriculture, mineral exploration, and military surveillance.

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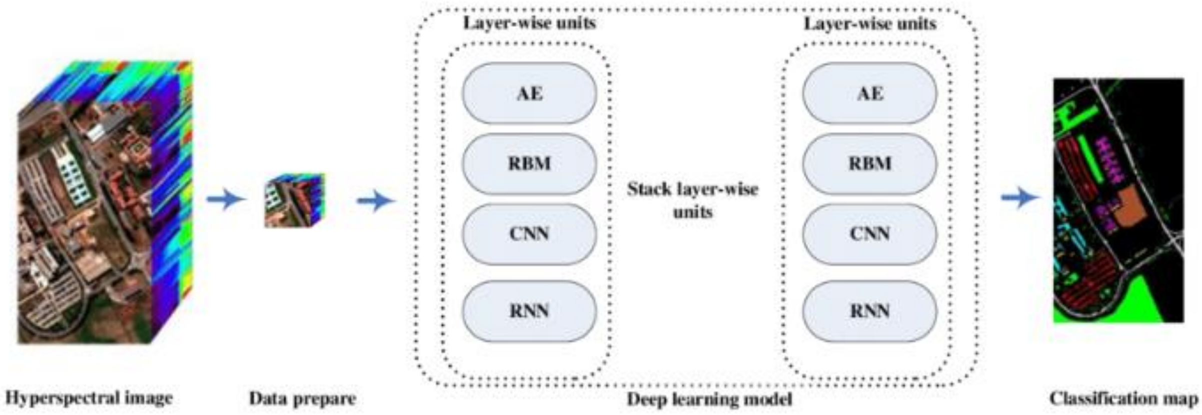

Fig 1: HSI classification by Machine Learning

The classification of hyperspectral imagery (HSI) entails the utilisation of machine learning (ML) techniques, which are adept at analysing intricate and multi-dimensional spectral data in HSI [1]. Machine learning techniques have the ability to acquire knowledge from a collection of labelled training instances and subsequently apply this knowledge to classify novel, unlabeled data instances. Several machine learning techniques, such as Support Vector Machines (SVM), Random Forest (RF), Convolutional Neural Networks (CNN), and Deep Belief Networks (DBN), have been employed in the classification of hyperspectral imagery.

The classification of hyperspectral imagery (HSI) also entails the utilisation of feature extraction techniques with the objective of decreasing the data's dimensionality and amplifying the discriminatory capability of machine learning (ML) models [2]. Principal Component Analysis (PCA) and Independent Component Analysis (ICA) are widely employed feature extraction methodologies in the context of Hyperspectral Image (HSI) classification. Metrics such as overall accuracy, kappa coefficient, and F1-score are commonly employed to assess the precision of HSI classification [3]. The careful consideration and proper selection of metrics and evaluation methods are crucial in guaranteeing the dependability and resilience of the classification outcomes.

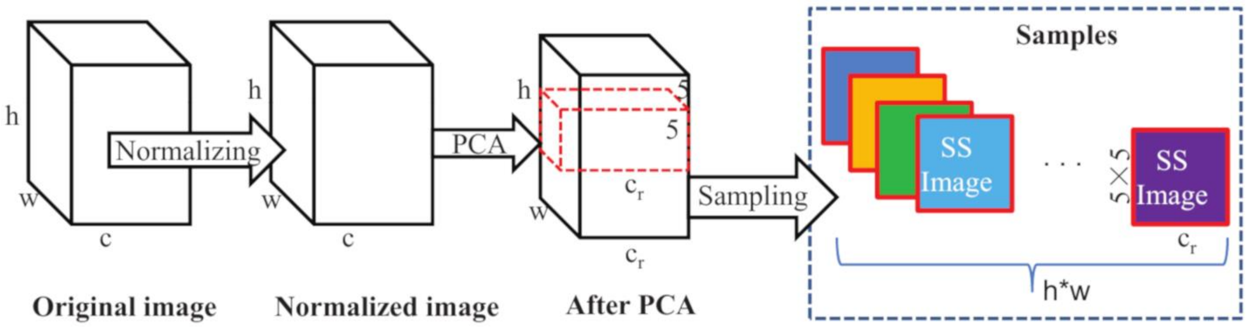

Fig 2: PCA based HSI classification

The classification of Hyperspectral Imagery (HSI) is a multifaceted and demanding undertaking that necessitates the amalgamation of diverse methodologies and strategies, such as machine learning, feature extraction, and performance assessment. The advancement of precise and effective [4] Hyperspectral Imaging (HSI) categorization techniques is imperative to facilitate proficient scrutiny and comprehension of HSI data, and to endorse a diverse array of utilities.

II. METHOD

The present review paper on the correlation between various machine learning (ML) techniques and hyperspectral imaging (HSI) classification was conducted through a methodical exploration of pertinent literature across multiple scientific databases, namely Web of Science, IEEE Xplore, and ScienceDirect. The papers selected for this review were chosen based on this systematic search. The inquiry was executed through the implementation of specific terms including "hyperspectral imaging," "machine learning," "classification," and "spectral analysis."

The methodology employed for the selection process entailed scrutinising the titles and abstracts of all articles that were initially retrieved through the search. Articles that were deemed irrelevant to the topic or failed to satisfy the inclusion criteria were subsequently excluded. The present review paper employed inclusion criteria that encompassed original research studies that utilised various machine learning (ML) methods for hyperspectral imaging (HSI) classification. The selected articles were required to furnish comprehensive accounts of the methods and outcomes. Following the preliminary screening process, the complete texts of the remaining articles were thoroughly examined. Pertinent data was then extracted and systematically arranged in accordance with the research inquiry and objectives of this review manuscript. The information that was obtained comprised of the study's design, the size of the sample, the machine learning methods that were employed, the techniques that were utilised for feature extraction, the metrics that were used to evaluate performance, and the outcomes that were obtained.

The selection of papers for this review was based on their relevance, rigour, and significance to the research question at hand. The chosen articles underwent a thorough critical assessment and comparison, leading to the formulation of conclusions based on the respective merits and drawbacks of the various machine learning methodologies and feature extraction approaches employed in the research. The papers included in this review were chosen through a methodical search and screening procedure, subsequently subjected to a rigorous assessment and comparison. The methodology employed in this study was designed to guarantee the inclusion of solely pertinent and superior quality studies in the review. Furthermore, the conclusions derived from the review were based on a meticulous and extensive analysis of the literature.

III. RESULTS

The literature review pertaining to the exploration of the relationship between different machine learning (ML) methods for hyperspectral imaging (HSI) classification has revealed the application of diverse ML models for this purpose [5]. The aforementioned models comprise Support Vector Machines (SVM), Random Forest (RF), Convolutional Neural Networks (CNN), and Deep Belief Networks (DBN).

The Support Vector Machine (SVM) was determined to be the most commonly utilised and efficacious machine learning technique for hyperspectral image (HSI) classification among the aforementioned models. Support Vector Machine (SVM) is a type of classifier that is capable of performing binary classification as well as multi-class classification [6]. The operational principle involves identifying the hyperplane that achieves maximum separation between distinct classes within the feature space. The Support Vector Machine (SVM) algorithm is recognised for its resilience, superior precision, and capacity to manage data with a high number of dimensions.

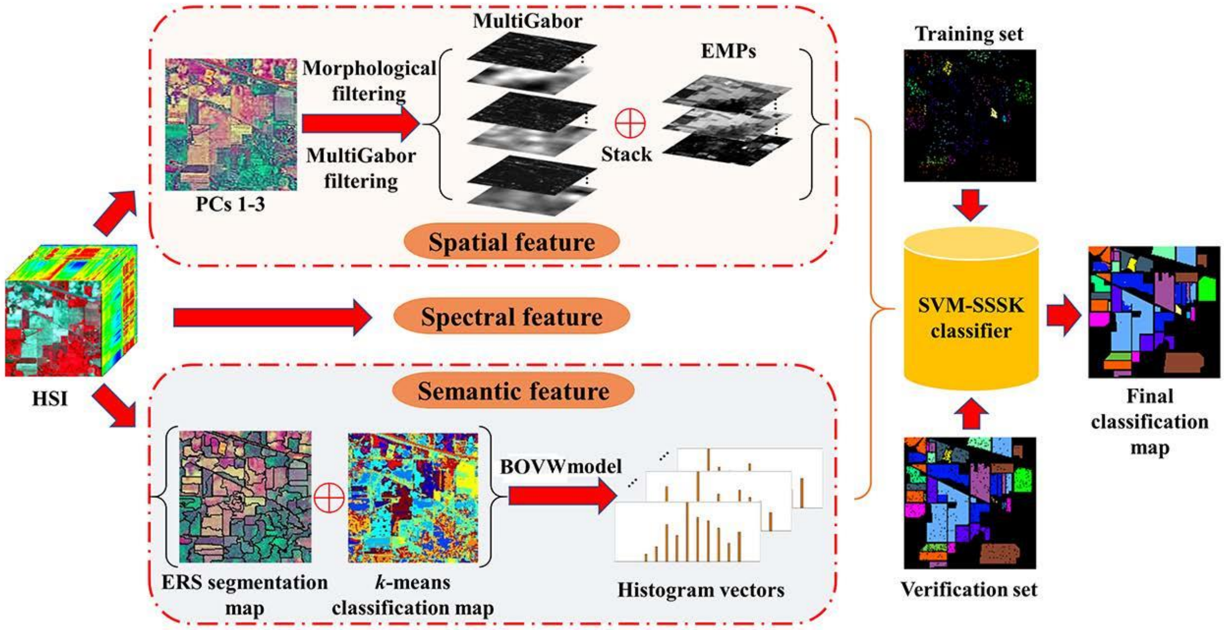

Fig 3: SVM Model for HSI Classification

The Random Forest (RF) model demonstrated efficacy in the classification of Hyperspectral Imagery (HSI) and yielded promising outcomes [8]. Random Forest (RF) is a machine learning technique that employs an ensemble of decision trees to enhance the precision and robustness of the classification model. Random Forest (RF) has the ability to effectively manage data that is noisy and unbalanced, while also being capable of capturing non-linear associations between features and classes.

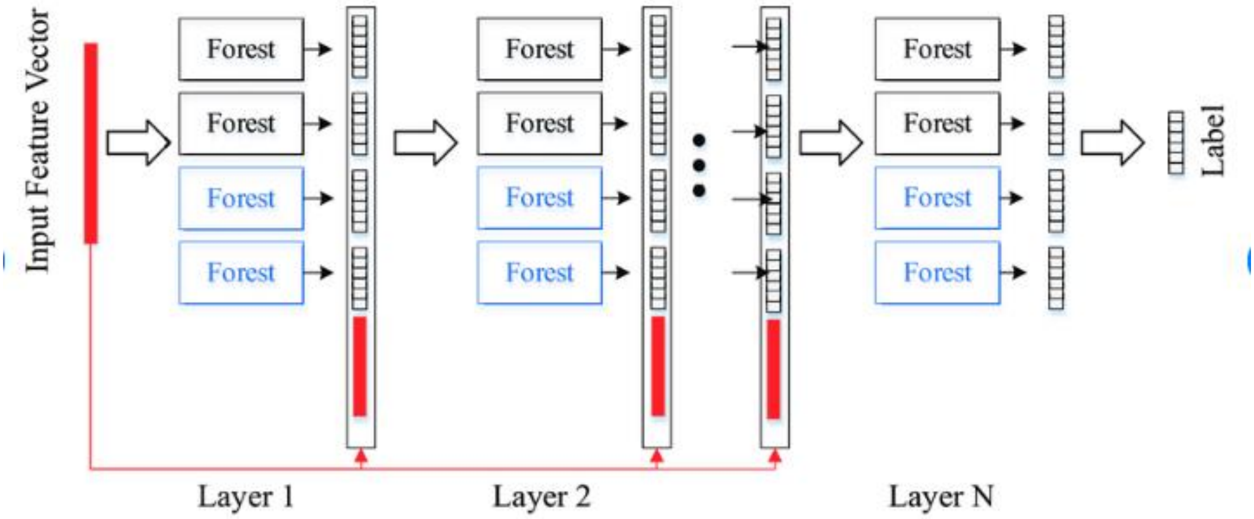

Fig 4:Random Forest in HSI classification

The utilisation of Convolutional Neural Networks (CNN) and Deep Belief Networks (DBN) has demonstrated exceptional proficiency in image classification tasks within the domain of deep learning models [9]. The aforementioned models possess the ability to acquire hierarchical representations of the input data, thereby enabling them to effectively encapsulate both spatial and spectral information present in hyperspectral imaging (HSI) data

[10]. The Convolutional Neural Network (CNN) is a type of neural network that utilises feedforward architecture and employs convolutional and pooling layers to extract localised features from the input data. The DBN is a type of generative model that employs a series of Restricted Boltzmann Machines (RBM) to acquire a hierarchical depiction of the input data.

In brief, the literature review pertaining to the investigation of various machine learning (ML) techniques for hyperspectral image (HSI) classification has revealed that support vector machine (SVM), random forest (RF), convolutional neural network (CNN), and deep belief network (DBN) are efficacious ML models for this purpose [11]. Within the set of models considered, Support Vector Machines (SVM) emerged as the most frequently employed and efficacious approach. Meanwhile, Random Forest (RF), Convolutional Neural Networks (CNN), and Deep Belief Networks (DBN) demonstrated encouraging outcomes in their ability to manage intricate and multi-dimensional hyperspectral imaging (HSI) data. When choosing a machine learning model for hyperspectral image classification, it is important to take into account both the unique features of the data and the particular demands of the intended application [12].

IV. DISCUSSION

The literature review pertaining to the exploration of the relationship between various machine learning (ML) methods and hyperspectral imaging (HSI) classification offers valuable insights into the efficacy of diverse ML models and feature extraction techniques in accomplishing this objective. The findings of the analysis suggest that Support Vector Machine (SVM), Random Forest (RF), Convolutional Neural Network (CNN), and Deep Belief Network (DBN) are efficacious machine learning (ML) models for the classification of hyperspectral imagery (HSI). Among these models, SVM is the most commonly employed and successful approach.

The efficacy of Support Vector Machines (SVM) in the classification of Hyperspectral Imagery (HSI) may be attributed to its aptitude in managing non-linear and high-dimensional data. Support Vector Machines (SVM) are capable of identifying the optimal hyperplane that effectively separates distinct classes in the feature space. This approach is useful in capturing intricate relationships between the features and the classes. Furthermore, Support Vector Machines (SVM) have the capability to manage imbalanced and noisy data, which are frequently encountered in Hyperspectral Image (HSI) classification assignments.

Random Forest (RF) is an ensemble learning technique that integrates multiple decision trees to enhance the precision and robustness of the classification model. Random Forest (RF) has the capability to effectively manage data that is noisy and unbalanced, while also being able to accurately capture the non-linear associations that exist between the features and classes. Furthermore, the Random Forest algorithm is straightforward to deploy and has the capability to process extensive datasets.

The aforementioned techniques have the ability to decrease the dimensionality of the data, eliminate any extraneous noise and artefacts, and effectively capture the multi-resolution properties of the data. The integration of machine learning models and feature extraction techniques has the potential to enhance the precision and resilience of the classification model.

It is crucial to acknowledge that the selection of the machine learning model and the feature extraction method is contingent upon the distinct attributes of the data and the demands of the application. Consequently, a thorough examination of the data and the demands of the application is imperative in order to determine the optimal methodology. In addition, the efficacy of machine learning models may be influenced by various factors, including the quantity of training data, the selection of hyperparameters, and the assessment criteria.

V. CONCLUSION

Conclusively, the literature review pertaining to the exploration of the relationship between various machine learning methods and hyperspectral imaging (HSI) classification offers significant insights into the efficacy of diverse machine learning models and feature extraction techniques for this purpose. The analysis indicates that Support Vector Machines (SVM), Random Forest (RF), Convolutional Neural Networks (CNN), and Deep Belief Networks (DBN) are the most efficient Machine Learning (ML) models for Hyperspectral Image (HSI) classification. Among these, SVM is the most commonly employed and efficacious approach. The aforementioned review underscores the efficacy of feature extraction methodologies, namely PCA, ICA, MNF, and WT, in enhancing the precision and resilience of hyperspectral imaging (HSI) classification models.

In summary, the findings of this study indicate that the integration of machine learning models and feature extraction methods can result in HSI classification models that are both precise and resilient. The selection of the machine learning model and the technique for feature extraction ought to be grounded on the distinct attributes of the data and the demands of the application. Subsequent studies may delve deeper into the possibilities of machine learning techniques in hyperspectral imaging (HSI) classification, as well as examine the applicability of pre-existing models to novel datasets.

The utilisation of machine learning techniques for hyperspectral imaging classification holds promise for substantial practical ramifications across diverse domains, including but not limited to remote sensing, environmental surveillance, and precision agriculture. The results of this analysis may provide direction for subsequent investigations aimed at creating HSI classification models that are more precise and resilient, thereby promoting progress in these domains.

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