

# A Study of Different Image Classification Methods by Using Machine Learning Techniques

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*Abstract- The Role of Artificial Intelligence and Machine Learning Techniques in Image Processing mainly in Image classification and registration becoming very prominent like in Research on Satellite Images , Medical Images like Computer Tomography Images, MR Images, Thermal Images. Image classification is getting more attention in the area of computer vision and artificial intelligence for the past decades. The classification is based on identifying the objects present in the image with adapting feature extraction approaches. The classification with earth observation (EO) data such as synthetic aperture radar (SAR), hyper spectral (HS) and light detection and ranging (LiDAR) are challenging in the field of remote sensing (RS). Satellite images are classified based on recognizing the objects and categorizing the scene based on the features and characteristics. Similar to that, different features are used in medical image data analysis and it has advantages sue to large data generation. The machine learning approaches in image processing is based on the objective of better classifying images. In this paper a Comparison study done on Satellite Images and Medical Images by using optimized Machine Learning Techniques.*

*Index terms: Earth Observation, Hyper spectral Images, Remote sensing, Earth observation, SAR, Hyperspectral imaging, LiDAR, Machine learning.*

## I. INTRODUCTION

In recent years, the utilization of computer vision technology describes the elementary characteristics such as shape, texture, color and motion with image descriptors for representing visual image features. With the widespread development of communication with internet and digital audio-visual information, it is essential to describe the contents using image classification. The techniques developed for image classification is based on the objective of improving the accuracy and by minimizing the issue with high dimension descriptors. High balanced datasets are required to be handled effectively by considering

intra-class and inter- class variability. Similarly, classifying medical images plays important role in clinical care and disease diagnosis. It identifies irregularities of different body organs such as blood cancer, lung cancer, brain tumor, retinal image analysis and so on.

Remote sensing satellite images are the essential data source for land cover mapping since extensive geographical coverage is cost effective for providing irreversible earth surface data. The satellite images are classified with spectral information in which HS image permits the discrimination of objects effectively by capturing the discrepancies from the shape of the signature associated with the pixel. When compared to RGB and multi spectral data, the detection and recognition from the objects of earth surface is accurately classified with HS imagery. Still there is a spectral mixing between the complex noise effects and spectral variability which complicates the extraction of discriminated information. However, the accuracy and processing time of satellite images are limited with data dimension. Huge variation in spectral variability of natural structures and the concept of mixed pixel imposes the demand of novel approaches based on real case applications.

## II. LITERATURE SURVEY

With the widespread development of communication with internet and digital audio-visual information, it is essential to describe the contents using image classification. In recent years, the utilization of computer vision technology describes the elementary characteristics such as shape, texture, color and motion with image descriptors for representing visual image features [1-3]. The techniques developed for image classification is based on the objective of improving the accuracy and by minimizing the issue with high

dimension descriptors. High balanced datasets are required to be handled effectively by considering intra-class and inter-class variability [4]. Similarly, classifying medical images plays important role in clinical care and disease diagnosis. It identifies irregularities of different body organs such as blood cancer, lung cancer, and brain tumor, retinal image analysis and so on [5]. Collecting and labelling medical images are complicated due to data privacy concerns and time consumption for the experts. For improving the performance of medical image classification more discriminative feature information is required to be extracted from the image [6], [7].

Remote sensing satellite images are the essential data source for land cover mapping since extensive geographical coverage is cost effective for providing irreversible earth surface data [8]. The satellite images are classified with spectral information in which HS image permits the discrimination of objects effectively by capturing the discrepancies from the shape of the signature associated with the pixel [9]. When compared to RGB and multi spectral data, the detection and recognition from the objects of earth surface is accurately classified with HS imagery. Still there is a spectral mixing between the complex noise effects and spectral variability which complicates the extraction of discriminated information [10]. However, the accuracy and processing time of satellite images are limited with data dimension [8]. Huge variation in spectral variability of natural structures and the concept of mixed pixel imposes the demand of novel approaches based on real case applications [11]. When the training samples used in the hyper spectral image is limited, increasing amount of spectral band results Hughes' Phenomenon. To resolve this, the approaches of artificial neural network (ANN), extreme learning machine (ELM) and transfer learning (TL) is developed. For HS image classification, the representation based approaches are developed recently with sparse representation, collaborative representation classification (CRC) which provides minimal representation residual [12]. These approaches requires the fusion of multiple features extracted. The performance of classification based on the quality of extracted features which improves the accuracy. Rather concatenating multiple features, high-order distance-based multiview stochastic learning is invoked for combining features and

labelled information into unified representation of image classification [13].

The performance of the system is greatly improved by preserving local geometry using p- Laplacian regularization. Tangent space CRC (TCRC) provides local manifold with tangent space of testing sample with simplified tangent distance. However, these technique are sensitive to regularization parameters [14]. The basic classifier of dictionary learning is applied with the adaptation of Bagging learning algorithms and random subspace learning. The integration of several collaborative representation and boosting algorithm propagates information distribution to ensure consistency [15]. At the same time, the class with low interclass variability has hard class distribution [16]. The classification problem with the presence of noise is considered with robust classification algorithm. It is categorized into label noise cleansing and label noise classification. It contains the strategies of boosting, bagging and decision tree based ensemble approach for filtering noise with prior knowledge of training samples [17]. Fully automated classification was performed with segmentation by considering Hue, Saturation, Value (HSV) equalization. In RGB plan, automated thresholding extracts classification features.

In recent years several approaches are developed based on machine learning approaches. The instances in the ML algorithms are described with the set of attributes. The attributes used are binary, continuous and categorical and supervised if they are classified with recognized labels [18]. It has the function of learning the model and creating same label for offered or unseen data. Each objective class is predicted with highest precision by determining the relationship between input and output attributes [19]. The common ML approaches used for image classification includes Support Vector Machine (SVM), Decision Trees (DT), Logistic Regression (LR), Ensemble Learning (EL) etc. In addition to that, the image labels generated are manual, expensive and it has number of limitations. Hence the issue related to higher correlation and limited labelled data is considered as a research issue. For tackling with labelled data deficiency, the enhanced ML approaches are required to be developed [20].

The work related to satellite and medical image classification based on deep learning approaches are described as follows.

Danfeng Hong, et al. [21] had proposed SpectralFormer as a backbone network model for resolving the issue related to the representation of sequence attributes of spectral signature. From neighboring band of hyper spectral image, local sequence information are spectrally learned for yielding group wise spectral embedding. In layer wise propagation process, the possibility of valuable information loss will be minimized with cross-layer skip connection. By adaptively learning the residuals across the layers, the memory like components are learned from shallow to deep. It was highly flexible to backbone network for considering both patch- wise and pixel-wise inputs.

Omid Rostami et al. [22] had proposed hybrid biogeography based optimization support vector machine (HBBOSVM) for classifying POLSAR images of RADARSAT 2 in band C acquired from San Francisco, USA. The preprocessing was accomplished with radiometric calibration, speckle reduction and feature extraction. For enabling optimal feature selection, the integration of migrator operator and onlooker bee of artificial bee colony (ABC) was performed. The pixels are classified into the labels of land cover with SVM technique. The accuracy and average accuracy of HBBOSVM reached up to 96.01% and 93.37% respectively.

K. Dhasaradhan et al. [23] had presented hybrid machine learning approach based on linear regression, support vector machine, K-nearest neighbour, random forest, logistic regression, naïve Bayes, decision tree, and convolution neural network for diabetes classification. This model was evaluated on Pima Indians diabetes dataset. The performance of the model was analysed with each classification algorithm in terms of precision, recall, f-measure and accuracy.

S. Krishnakumar et al. [24] had developed classification approach based on multi kernel support vector machine for brain tumor images. For improving the classification accuracy, the image segmentation approach was applied with rough k means clustering algorithm. Segmentation involves preprocessing and feature extraction with raised Gabor wavelet transform

(IGWT). Means of optimization with oppositional fruit fly algorithm were utilized rather considering Gabor wavelet transform. The feature values are fed to clustering process for segmentation. Efficient and accurate classification result was obtained with the accuracy rate of 0.99.

Meenakshi Garg et al. [25] had presented content-based image retrieval by focusing the reduction and extraction of multiple features. By extracting the approximated coefficients, multi-level decomposition was obtained with discrete wavelet transformation to RGB channels. Hence the approximation is applied to dominant rotated local binary pattern texture descriptor which is rotationally invariant. Minimal amount of features were selected with particle swarm optimization-based feature selector for CORAL dataset. After feature selection, the classification was applied with support vector machine, decision tree and K-nearest neighbour. The comparison table for the existing approaches are given in table 1. Shaik.Bajidvali, Anil Kumar Sharma, Syed Musthaq Ahmed [26] presented a modified Chan-vase algorithm which works on the principle of Global region based segmentation to identify the damaged part of the foot of the patient. Also discussed about the Risk identification is fundamental in the abnormal by using the abnormal neuropathy, the Risk identification can be done in the lower limbs of a diabetic patient, further it gives the abnormality of skin due to sweating, which involves the fissures, anhydrosis etc.

### III. METHODOLOGY AND METHODS

#### 3.1 COMMON CLASSIFICATION FRAMEWORK

Both medical and satellite image classification systems follow a generalized pipeline:

1. Data acquisition
2. Preprocessing
3. Feature extraction or representation learning
4. Model training
5. Evaluation and interpretation

#### 3.2 MEDICAL IMAGE CLASSIFICATION METHODS

Medical images are typically processed using intensity normalization, noise reduction, and region-of-interest extraction. Convolutional Neural Networks (CNNs), U-Net architectures, and 3D CNNs are widely adopted

for classification and segmentation tasks. Transfer learning is commonly used to compensate for limited labeled datasets.

### 3.3 SATELLITE IMAGE CLASSIFICATION METHODS

Remote sensing classification varies by sensor type:

- SAR: Requires speckle reduction and polarization-aware feature learning.
- Hyperspectral (HS): Uses spectral-spatial feature extraction and dimensionality reduction.
- LiDAR: Relies on point-cloud processing and height-based features.

And the entire Procedure can be briefly explained as below:

Hybrid CNN-Transformer architectures and multi-sensor data fusion models are increasingly used for EO data.

Spectral learning, adaptive soft residual learning, Spectral learning, adaptive soft residual learning, Mainly the Methodology deals with two major techniques. 1. Preprocessing 2. Segmentation. After segmentation of the image the classification can be done based on the 3. Machine Learning and Deep Learning Techniques which assigns the Label.

### 3.4 PREPROCESSING

In the Preprocessing removes the unwanted distortion and improves the image data for further process. Here the conversion of high resolution input satellite image into gray scale image which makes for easy segmentation.

### 3.5 SEGMENTATION

Segmentation means the division of image into smaller objects, which further can represent the image for further processing, means which can under goes some algorithms. The segmentation plays most significant role in computer vision of the Image.

There are different algorithms like K-means Clustering, C-Means clustering algorithms, further it can be used the classification techniques like Particle Swarm Optimization Algorithm (PSO) and Artificial Bee Colony Optimization (ABC) etc.[26]

There are many common methods for segmentation, such as edge detection, region growing, and most recently active contours. Active contours are the methods which iteratively modify an initial contour to fit the desired contour, it can work even when the contours are not sharp in some cases [27]. For effective segmentation the registration is more crucial, if the proper registration methodologies not used then the segmentation would not be done good. After this contour identification the registration of the image can be takes place which can be shown as below results. The Registration can be done by Iterative Closest Point (ICP) algorithm is the mostly used straightforward rigid registration method.

Hybrid machine learning model Raised Gabor wavelet transform (IGWT), rough k means clustering algorithm, multi kernel support vector machine algorithm content-based image retrieval, discrete wavelet Transformation, and dominant rotated local binary pattern. By this the advantages are content-based image retrieval, discrete wavelet Transformation, dominant rotated local binary pattern. High accuracy, and Low operational cost. High performance is obtained in terms of Accuracy, F-measure precision, and recall.

## IV. MACHINE LEARNING AND DEEP LEARNING ALGORITHMS

Image Classification is the most important task in Computer vision which provides the assignment of Label or category to an input image. This Classification can be applicable for the Machine Learning Techniques and Deep Learning Techniques. For this we have to use the Algorithms in M.L. we can list out the Algorithms like KNN, SVM, RFDT etc, in the case of Deep Learning we can see the CNN Technique again this CNN may consists different Architectures viz LeNet-5, AlexNet, VGGNet and ResNet. There are some advantages and disadvantages by this algorithms.

Also we can see the Advanced Deep Learning Architectures like Transfer Learning, Vision Transformers, and Hybrid Architectures.

There is a comparison between the Different Algorithm's nature as per the feature extraction, Complexity and Applications.

In most Algorithms the Accuracy is high except in Support Vector Machine, here the accuracy will be moderate.

## V. RESULTS & DISCUSSION

After achieving the results, we can get the clear Segmented Images for better assigning of Labels and Classification. We also discussed briefly about the Machine Learning and Deep Learning Algorithms in the image Classification and the significance of the different algorithms and discussed according to the characteristics like feature extraction, complexity and in terms of Accuracy. Here some Results are give after following the Classification Techniques.



Figure 5.1: Satellite Image as Input image (Courtesy Digital globe)

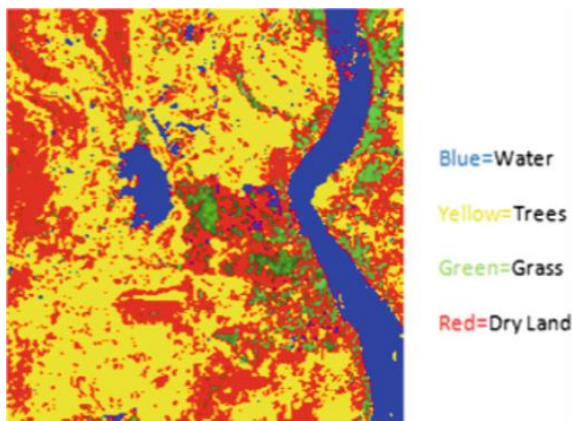


Fig 5.2: Output Image as Classified Image

The Flow Chart of Medical Images and Satellite Images are similar, but small differences are there, that can be shown in the figure Below

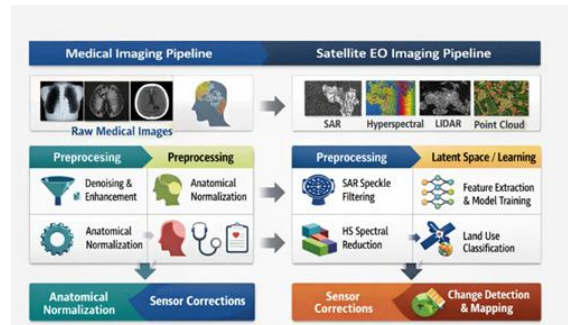


Fig 5.3 The Flow chart and Classification Techniques in Both Medical Images and Satellite Images.

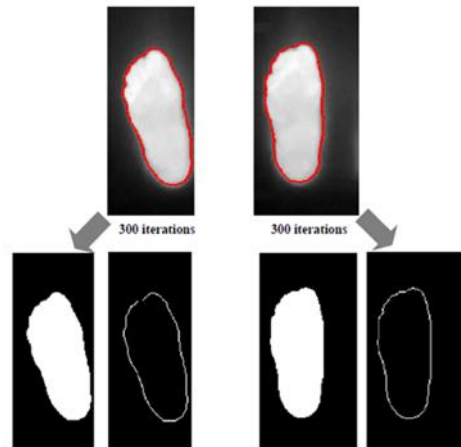


Fig 5.4: Region and contour of the both right and left foot can be shown

The Medical Images can be Region Based segmented, below shown the Thermal Imaging for the Determination of Diabetic Foot Ulcers, which can be followed by the Region Based Algorithms, here used the Chanvase Algorithm, this image is generated by employing a Thermal Camera to capture the human being foot temperature, after that the Algorithm would be executed for number of iterations, in the figure we can see the 300 iterated results diagram. This iterations can be done upto ten thousand iterations for better identification of the infected area in the feet of the diabetic patient.



Fig 5.6: The Classification Image based on the Label

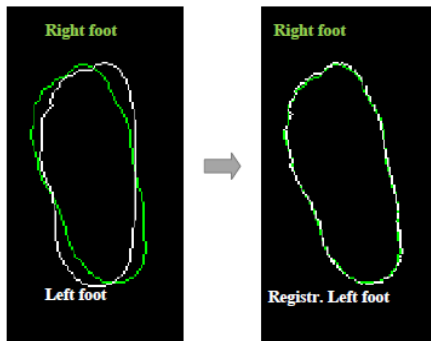


Table 2: The Comparison of the D.L Algorithms

Algorithm	Type	Feature Extraction	Complexity	Accuracy
SVM	Traditional	Manual	Moderate	Moderate-High
CNN(ResNet)	Deep Learning	Automatic	High	High
Vision Transformer	Deep Learning	Automatic	Very High	High
Transfer Learning	Deep Learning	Automatic	Moderate	High

Based on the Label the image can be classified, this can be shown in the Machine Learning and Deep Learning Algorithms, the below Figure shows the Classified Image on the basis of Label, which can be obtained by CNN.[28]

Deep Learning Algorithm. This can be possible when large amount of Data Set is available, when Less amount of Data sets are there this can be done by Machine Learning Algorithms based on some important Characteristics.

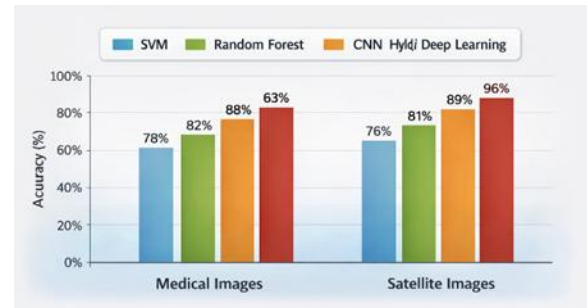


Fig 5.7: The Accuracy of the Classification Techniques used in Medical Images and Satellite Images

Comparison Table 1: Data Characteristics

Aspect	Medical image	Satellite Image
Data Type	MRI, CT, Histology	SAR, HS, LiDAR
Noise	Imaging artifacts	Speckle, atmospheric noise
Dimensionality	2D / 3D	High spectral & spatial
Label Availability	Limited	Sparse, large-scale
Risk Sensitivity	Very High	Moderate

Comparison Table 3: Classification Techniques

Method	Medical Images	Satellite Images	Strength
SVM	Moderate	Moderate	Low Complexity
Random Forest	Good	Good	Robust to Noise
CNN	Very Good	Very Good	High Accuracy
Hybrid DL	Excellent	Excellent	Best Performance

## VI. CONCLUSION

Satellite image classification is enabled as a task of pixel-wise classification in which the pixels belongs to the same classes are labelled. The high performance classifiers are desirable for the classification process but it is challenged due to the availability of hyper parameters.

The medical image classification is prone to error and hence it requires efficient interpretations with machine learning approaches for better throughput and accuracy. The problem of unbalanced dataset is handled effectively with hierarchical structure which improves performance across multiple domains. It can be done by Land cover classification has the capacity of reflecting social process and potential nature for providing essential information to the stockholder in urban development. The solution for land cover classification was provided using supervised classification approaches with remote sensed imagery. The images are segmented with Enhanced Gaussian Mixture model (EGMM). The medical images are diverse and they are varied for each person due to pathological conditions. The attribute variation is due to the variation in lighting condition, image extraction process and image dimension. The performance of both satellite and medical image performance are analyzed with the same image classification approach, the performance of the work will be evaluated with the standard performance metrics such as precision, recall, and accuracy.

The Classification can be done by Segmentation technique, whenever larger set of data is available the Machine Learning and Deep Learning Techniques will be used, which gives the more accurate image with respect to Feature Extraction and Accuracy. We can discuss more different algorithms for better results but at the same time the Complexity of the algorithms increases, which leads for computational delay while acquiring the Results.

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