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Image Classification using modified Convolutional Neural Network

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Abstract: - Image classification is the field of research since decades. With evaluation of new technologies, the performance of image classification has been improved and this is evident by it's us in routine life. However there are scopes to use the deep learning networks to further improve the complex image classification problems. In this paper, the Convolution neural network based(CNN) image classification is evaluated by changing the parameters of CNN like number of layers, number of neurons, block size of convolution operation etc. The parametric analysis in terms of accuracy number of iteration for convergence is illustrated in result section. The standard dataset of Intel image classification is used for evaluation of performance. The maximum accuracy has been achieved.

Keywords:Image classification, Deep learning, Neural network, CNN, KNN

I. INTRODUCTION *(HEADING 1)*

A Neural Network (NN) is a form of network which is completed of greatly organized processing nodes, identical to the neurons in our human mind, joined or divided by software that operates on the neuron, a small part of the human mind. Each node is connected to each other nodes from dissimilar levels like a mesh. Because feed-forward networking is used by these nodes, data can only flow across the system in one direction. The input layer, convolution layer, pooling layer, dense layer, and output layer make up the Deep Learning network; however, there are also hidden layers in between these layers [8]. As an alternative to the above scenario, a multi-layered neural network is using. Deep Learning is the existing period for a multi-layered neural network [9].

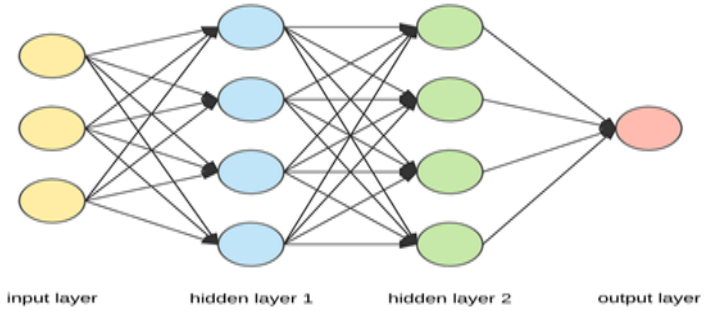

Figure: 1 Diagram of NN

Image classification is used to segregate various images in the defined sets. It can be done using algorithms like CNN, Swarm Intelligence and many more. This research concentrates on classification of images using CNN for Intel image classification data set. About 25,000 150x150 images from the Intel image classification dataset have been divided into 6 groups. This image classifier splits images into six categories: building, forest, glacier, mountain, sea, and street. The training folder contains fourteen thousand photographs, the testing folder has three thousand, and the prediction folder contains seven thousand. The data was published on https://datahack.analyticsvidhya.com to host a test by Intel. [7]. CNN is primarily concerned with designing its architecture to meet the needs of handling a specific kind of data. The layers inside CNNs are made up of neurons arranged in three dimensions (height, breadth, and depth), which is how CNNs vary from ANNs. The third dimension refers to activation volume[12]. CNN is supervised learning technique for finding patterns in images to classify and recognize objects, classes and categories. CNN architecture has three layers Convolution layers, Rectified linear unit, and Pooling layers. CNN also use to classify audio, time series and signal data. CNNs, have the capacity to take out low-, mid-, and high-level properties.

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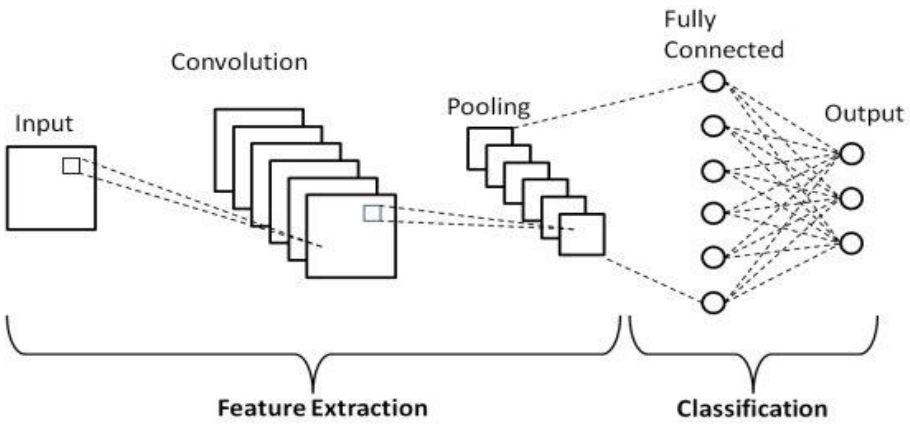


Figure: 2 Diagram of CNN

II. RELATED WORK

CNN is better than other classifiers. A model recognizes and classifies the image. By increasing the amount of input layers and hidden neurons, the findings can be more accurate. The object can be recognized even in the fuzzy image. Image recognition is an extraordinary prototype challenge for neural network expertise, and it provides an excellent means of developing more sophisticated deep learning methods [1]. To identify scaling, translation, and other types of deformation-invariant images, deep neural networks are employed. For the representation and categorization of picture features, the deep convolution neural network offers the highest reward. MNIST and CIFAR-10, two deep learning standard databases, have been used to evaluate M3 CE-CEc [2]. To classify image characteristics, the sophisticated XGBoost overcomes the limitations of a single classifier. A CNN-XGBoost image classification model optimized by APSO is designed in order to include the extracted image features. APSO optimizes the hyper-parameters on the overall architecture to aid in the two-stage model's combination[3]. Up to 23,440 photos from the research were used as training data, while 10,046 photographs were used as testing data. Convolutional neural networks (CNN) and deep learning are used to categorize photos. The CNN model's accuracy rating is determined by classifying images, and 78.5% accuracy is attained [4]. The basic model from LeNet to GoogLeNet, ResNet family, DenseNet family and deep convolutional neural network model finally summarizes and analyzes the experimental results. Different classification models' results are contrasted and examined [5]. One of the primary problems with using CNNs in new domains is that selecting the appropriate hyperparameters requires a great deal of practical knowledge. Additionally, because these hyperparameters have internal dependencies that make them difficult to modify, there is still room for improvement in terms of how to handle them [6]. For image classification tasks, Convolutional Neural Networks (CNNs) represent the state-of-the-art. Diverse CNN architectures for image classification give advancement in CNN from LeNet-5 to latest SENet model with the comparison among those models [11]. With the use of the transfer learning strategy, 102 flower species may be classified utilizing a potent deep learning method by classifying various species of the Oxford-102 flowers dataset using the DenseNet121 architecture. With an accuracy of 98.6% over 50 epochs, the three sets of datasets—train, validation, and test—outperform earlier deep learning-based methods for the same dataset alone[13]. The convolution technique is shown in Figure 3.

Its purpose is to take out local features of input neuron data. The size of the input element map is n×n and is represented by X. The size of the matrix with convolution kernel is k × k and that of the matrix with output represented by Y is m × m. The dimensional relation of the three is (m = n − k + 1) [10].

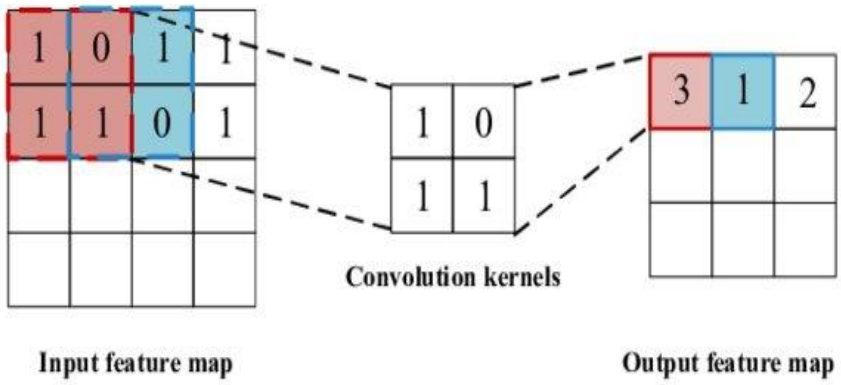


Figure: 3 Diagram of CNN Process.

The formula used for calculation is:

Yij = fs(X k i=1 X k j=1 (XijC) + a). ……..[10]

Additionally, the use of the Tensor Flow framework to do deep learning produced positive results because the model could simulate, train, and classify five distinct varieties of flowers with a high degree of accuracy[14]. CNN correctly identified the image's class. Convolution and pooling operations are making clear classification of the image. In MATLAB Trained datasets are used for the classification of the image [15]. Good classification accuracy is found using a new class detection model and CNN-based image classification for the CIFAR10 dataset. Using the novel class detection method, high classification accuracy is required. By updating the new class prediction model in Outlook, a new class can be accurately anticipated [16]. a deep learning model for image recognition and classification that is based on an examination of the fundamental principles of neural networks, including the different types of convolutional neural networks, and the fundamental steps involved in using them to classify images. Second, an image classification depth learning model was a better convolution neural network structure, and noise reduction and parameter adjustment were implemented in the feature extraction process based on the current convolution neural network model. Finally, the structure of the deep learning model was optimized to improve the classification efficiency and accuracy of the model [17]. In the research, the classification accurateness is used to assess the strength of the deep learning network model. According to diverse evaluation angles, classification accuracy usually includes on the whole accuracy and group classification accuracy [17] [18]. Optimized convolution neural model uses Softmax function to classify the images, and Softmax function uses supervised learning algorithm to retreat the features [17] [19]. The SAR target image classification researchers will always share their innovative findings using their own datasets and experimental setups. It creates ineptitude in the assessment of results and prevents this field from moving forward [20].

III. METHODOLOGY

The main objective is to apply the concept of convolutional neural networks for image recognition and classification. Convolutional Neural Networks extract attribute mappings from images through the application of filters. Convolutional neural networks map image pixels using region space rather than a ReLU of neurons.

Intel image classification database classify into training database and testing database after that pre processing is performed on training database and testing database. The result of preprocessing database is, we get images and label. Output of pre processing training database go as an input to CNN Training and achieved trained CNN as an output. Trained CNN go as an input to classification stage. Output of pre processing testing database are images and label and these images go as an input for classification stage and get classification label. Classification label and actually labeled stages go as an input in performance analysis stage and analyses accuracy, error and confusion matrix.

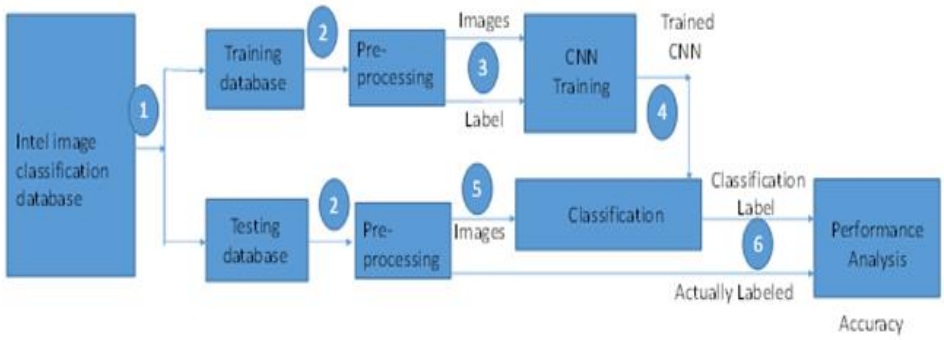
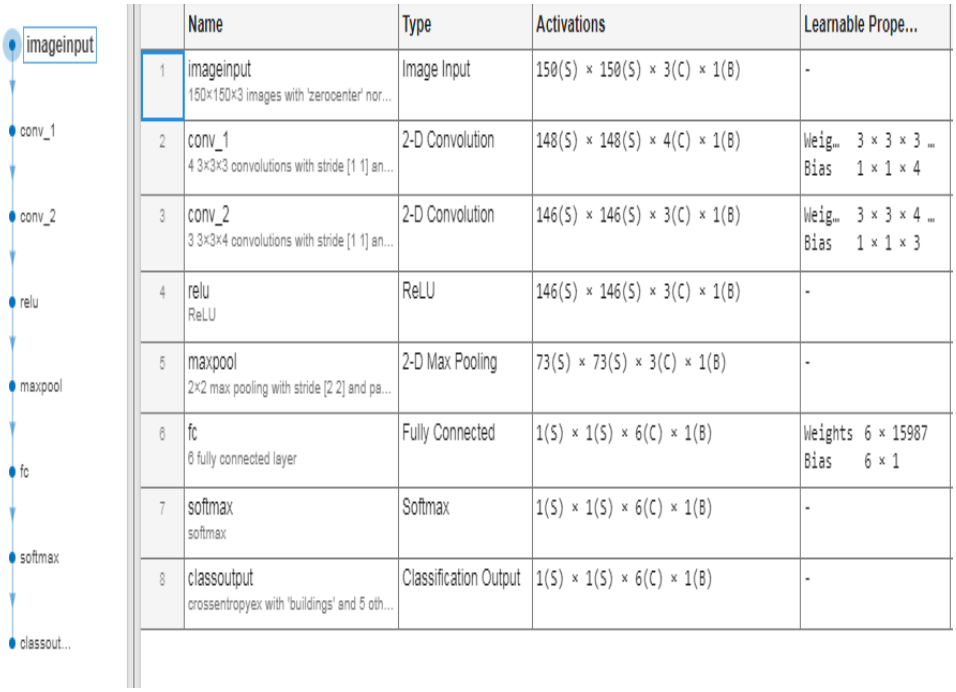


Figure 4: Proposed Methodology

Intel image classification database consists of 120 buildings, 120 forest, 120 glacier, 120 mountain, 120 sea, 120 street on these we perform KNN classification and Modified CNN based classification

CNN structure



	Name	Type	Activations	Learnable Prope...
1	imageinput 150×150×3 images with 'zerocenter' nor...	Image Input	150(S) × 150(S) × 3(C) × 1(B)	-
2	conv_1 4 3×3×3 convolutions with stride [1 1] an...	2-D Convolution	148(S) × 148(S) × 4(C) × 1(B)	Weig... 3 × 3 × 3 ... Bias 1 × 1 × 4
3	conv_2 3 3×3×4 convolutions with stride [1 1] an...	2-D Convolution	146(S) × 146(S) × 3(C) × 1(B)	Weig... 3 × 3 × 4 ... Bias 1 × 1 × 3
4	relu ReLU	ReLU	146(S) × 146(S) × 3(C) × 1(B)	-
5	maxpool 2×2 max pooling with stride [2 2] and pa...	2-D Max Pooling	73(S) × 73(S) × 3(C) × 1(B)	-
6	fc 6 fully connected layer	Fully Connected	1(S) × 1(S) × 6(C) × 1(B)	Weights 6 × 15987 Bias 6 × 1
7	softmax softmax	Softmax	1(S) × 1(S) × 6(C) × 1(B)	-
8	classoutput crossentropyex with 'buildings' and 5 oth...	Classification Output	1(S) × 1(S) × 6(C) × 1(B)	-

Figure 5: Proposed CNN structure

The first convolution layer in the CNN structure extracts different characteristics from the input images by performing mathematical operations between the input image and the convolution matrix. This allows for the extraction of features like corners and edges with weight and bias that can be learned.

After that Conv_2 perform to get more accurate extract features like corner and edge with learnable properties weight and bias. Output of Conv_2 goes as an input Rectifier layer unit and gets activation function for max pool. 2-D max pool is a bridge between the Convolutional Layer and the 6 Fully Connected Layers. The Fully Connected (FC) layer gives of the weights (6*15987) and biases (6*1) along with the neurons and joins the neurons between two different layers. Two fully connected layers carry out better than a single connected layer. After that activation function Softmax perform for multi-class classification whether a neuron activated or not and activation classification output 1(S)*1(S)*6(C)*1(B).

Simulation and Result:

KNN based classification:

Creating Bag-Of-Features:
---
* Image category 1: buildings
* Image category 2: forest
* Image category 3: glacier
* Image category 4: mountain
* Image category 5: sea
* Image category 6: street
* Choosing the Grid method's feature point positions.
* taking the chosen feature point positions and extracting SURF features.
* The Grid Step is [8 8] and the Block Width is [32 64 96 128].
* Extracting features from 540 images...done. Extracted 779760 features.
* Retaining eighty percent of each category's best qualities.
* Creating a 500 word visual vocabulary.
* Number of levels: 1.
* Branching factor: 500.
* Number of clustering steps: 1.
* [Step 1/1] Clustering vocabulary level 1.
* Number of features : 623808.
* Number of clusters : 500.
* Initializing cluster centers...100.00%.
* Clustering...completed 48/100 iterations (~5.05 seconds/iteration)...converged in 48 iterations.
* Completed the Bag-Of-Features creation

Training an image category classifier for 6 categories:
---
* Category 1: buildings
* Category 2: forest
* Category 3: glacier
* Category 4: mountain
* Category 5: sea
* Category 6: street
* Encoding features for 540 images...done.
* Finished training the category classifier. Use evaluates to test the classifier on a test set.

Evaluating image category classifier for 6 categories:
---
* Category 1: buildings
* Category 2: forest
* Category 3: glacier
* Category 4: mountain
* Category 5: sea
* Category 6: street
* Finished evaluating all the test sets.
* The confusion matrix for this test set is:

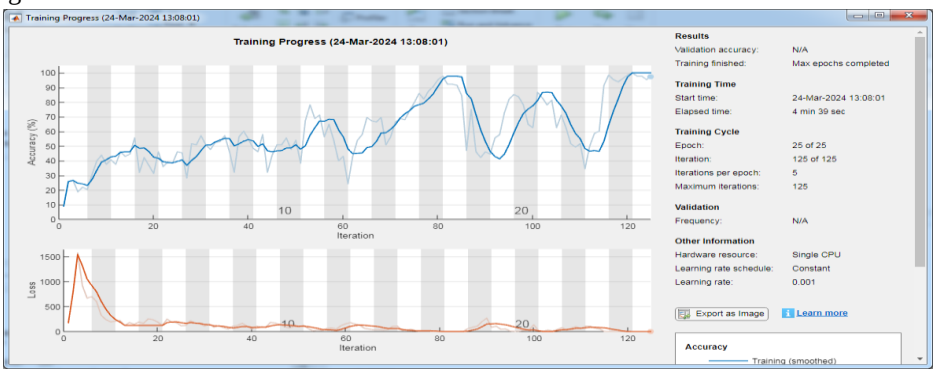
	PREDICTED					
KNOWN	**buildings**	**forest**	**glacier**	**mountain**	**sea**	**street**
Buildings	**0.87**	**0.03**	**0.04**	**0.01**	**0.02**	**0.02**
Forest	**0.01**	**0.93**	**0.00**	**0.01**	**0.02**	**0.02**
Glacier	**0.01**	**0.01**	**0.79**	**0.11**	**0.07**	**0.01**
Mountain	**0.02**	**0.01**	**0.06**	**0.82**	**0.09**	**0.00**

Sea	**|**	**0.00**	**0.00**	**0.02**	**0.07**	**0.88**	**0.03**
Street	**|**	**0.08**	**0.03**	**0.02**	**0.01**	**0.02**	**0.83**

*** Average Accuracy is 0.85.**
Accuracy = 85.3704

CNN based classification:

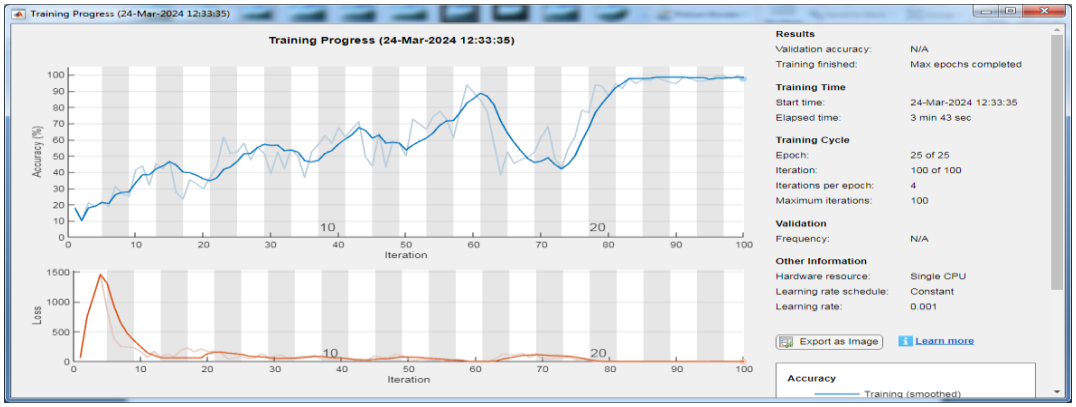
Image training =120 out of 120



Graph 1: Training progress accuracy

Accuracy on complete set = 0.9361
Accuracy2 = 0.5490

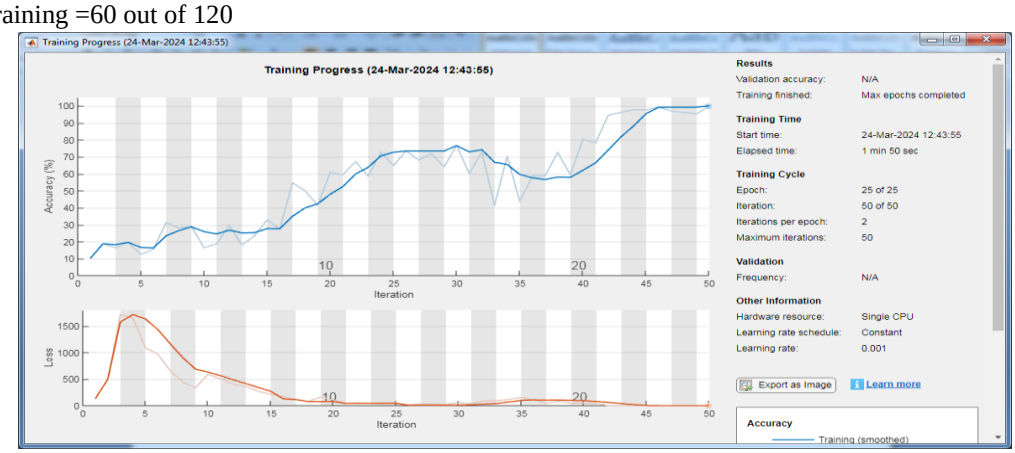
Image training =90 out of 120



Graph 2: Training progress accuracy

Self learning accuracy = 0.95
Accuracy on complete set = 0.83

Image training =60 out of 120



Graph 3: Training progress accuracy

Self learning accuracy = 0.85
Accuracy on complete set = 0.63
Accuracy2 = 0.4683

Table 1: Comparisons between KNN based classification and CNN based classification

Methodology	**KNN based classification (Average)**	**CNN based classification** Image training (120 out of 120)	**CNN based classification** Image training (90 out of 120)	**CNN based classification** Image training (60 out of 120)
Accuracy	**85.3704**	93.61	83	63

IV. Conclusion and Future scope

The CNN based classification has been implemented for natural image classification. The KNN based image classification is also applied in the paper. CNN is showing better result (~7 %) compare to KNN. However, the decrease of training images reduces the classification accuracy significantly. The structure of CNN may further optimized to improve the accuracy of the classifier. Other AI based techniques like GA, PSO, and MFO can be used to generate optimum CNN for the best image classification.

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