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Deep Learning through Convolutional Neural Networks for Classification of Image: A Novel Approach Using Hyper Filter

Kshitij Tripathi[1*], Rajendra G. Vyas[2], Anil K. Gupta[3]

[1]Department of Computer Applications, The Maharaja Sayajirao University of Baroda,Vadodara, India
[2]Department of Mathematics, The Maharaja Sayajirao University of Baroda, Vadodara, India
[3]Department of Computer Science and Applications, Barkatullah University, Bhopal, India

Corresponding Author: kshitij.tripathi-compapp@msubaroda.ac.in

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***Abstract*:** The convolutional neural networks (CNN) are artificial neural networks (ANN) having many similarities like layered architecture, neurons, activation function, and learning rate are some of them. There are some differences also like in CNN we can also deal with tensors which is the most distinguishing feature of CNN and these are just multidimensional 2D or 3D arrays. Another difference is layers in CNN are not same as in ANN. The common layers present in CNN are called as convolutional, relu and maxpool and these are generally connected sequentially so that the output of one layer acts as input to another layer. In the current article, the hybrid approach of filters or kernel is proposed and is giving better results in comparison to other kernel initializers like variance scaling normally used in CNN. The dataset used is CIFAR-100.

Keywords: Deep learning, Convolutional Neural Network, Image Classification, CIFAR-100,CIFAR-10.

I. INTRODUCTION

The CNN [2-4] are now an integral part of deep learning algorithms as these are implemented easily through Deep Neural Networks. The convolution neural networks are few steps further than artificial neural networks [5-6,8]. Figure 1 given below describes the architecture of convolution neural networks.

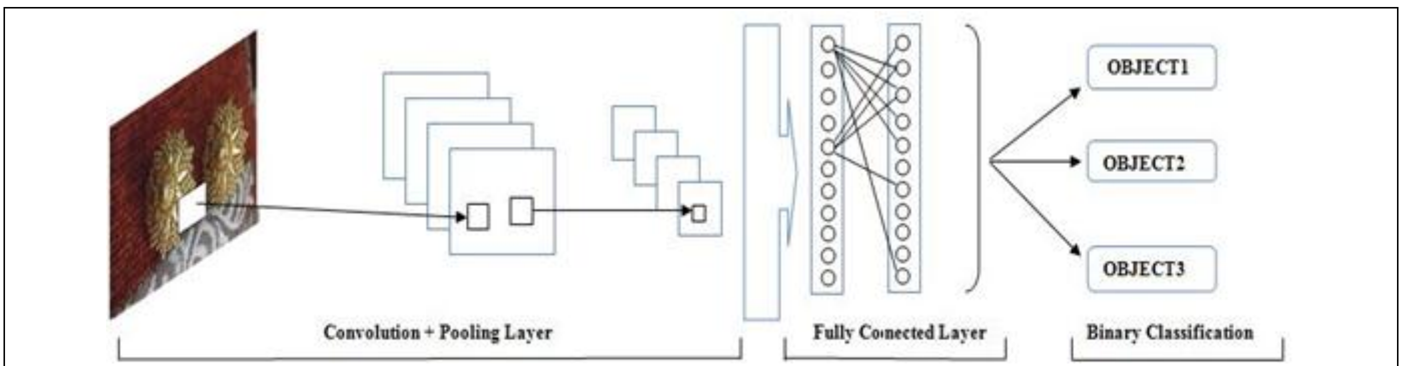

Figure 1. Convolution neural network

It describes the layers used in deep neural networks apart from the image which is used as a dataset for image classification. The main layers are input, convolution, pooling, fully connected and output layer. The input layer contains the image to be processed. The convolution layer convolves the image with the help of filters which is then processed through relu and maxpool layer. Finally, fully connected layer generates the output class to which the image belongs.

CNN's are most dominant in the classification of images and performs well in this area. But still, there are huge chances of improving the classification accuracy on some datasets. Further CNN have some drawbacks like over-fitting that is they perform well in the training phase but not as good in the test phase. In this article, the experiments are performed on CIFAR-100 dataset to improve classification accuracy but without employing any technique of over-fitting. Experiments are also performed on the CIFAR-10 dataset.

Section I contains the introduction of the convolutional neural network. Section II contains the datasets used in the experiments. Section III contains the related work done in the area of CNN. Section IV describes the proposed approach. Section V elaborates results obtained from the experiments performed. Section VI concludes with future possibilities.

II. DATASET

In this experiment, we use CIFAR-100 [1] dataset which contains small images of objects. Each color image has a fixed size of 32X32 pixels. There are total 60,000 images of which 50,000 are for training and 10,000 are for the test. Experiments are also performed on CIFAR-10 dataset which has similar features but contains only 10 classes while CIFAR-100 contains 100 classes.

III. RELATED WORK

Many researchers have worked on CIFAR-100 dataset like Liu et.al (2018) discuss convolutional fusion networks for classification. Geo et.al (2017) proposes a combination of Convolutional Neural Networks (CNN) and Recurrent Neural Networks (RNN) for classification. Some other contributions on CIFAR-100 are Zhou et.al. (2019) and yanping et.al.(2018).

IV. THE PROPOSED APPROACH

It is already concluded [10] that initialization of weights is a major factor of artificial neural network for obtaining high classification accuracy. [9] and [11] also have done work related to weights configuration of deep neural networks. In the proposed approach the filters or kernels which are generally initialized through a kernel initializer [7] function like variance scaling or glorot_uniform [7] are avoided and a hybrid approach is adopted in which selected group of filters is used on first convolution layer which is given in figure 6. The purpose of this approach is each unique filter tries to extract a unique feature of the image which reduces the complexity of calculations of normal approach. In the normal approach, filters are generated randomly using variance scaling or glorot uniform. This is implemented with the help of symmetric multiplication between the proposed subordinate matrix (figure 6) and corresponding kernel initializer matrix as shown in Table 1-3. Single kernel initializer matrix is employed which is generated through variance scaling. The configuration of CNN used in the experiment is described in table 4. If there are 3 channels in an input image, that the same 32 filters are used to extract features. Initially, this unique filter matrix has to pass through symmetric multiplication with single kernel initializer weight matrix to generate final weight matrix (filters). In the proposed approach first and the single layer is engaged with hybrid 32 filters so if we apply on other convolutional layers (may be of size 64 or 128) then we will have to write that number of unique filters but the results obtained are very improved.

Table 1

Kernel initialize matrix		
f11	f12	f13
f21	f22	f23
f31	f32	f33

Table 2

Subordinate filter matrix		
1	0	0
0	1	0
0	0	1

Table 3

Weights based on the proposed approach		
f11*1	f12*0	f13*0
f21*0	f22*1	f23*0
f31*0	f32*0	f33*1

Table 4 Configuration parameters of used CNN

Configuration of CNN			
No.	Layer	Dimension(Size)	Kernel
1	Input	32X32X3	--
2	Convolution	32	3X3
3	Relu	--	--
4	Convolution	64	3X3
5	Relu	--	--
6	Maxpooling2D	--	2X2
7	Dropout(0.25)	--	--
8	Flatten	--	--
9	Dense	512	
10	Relu	--	--
11	Dropout(0.25)	--	--
12	Dense	12	--
13	Activation	Softmax	--

V. RESULTS AND DISCUSSION

After performing the experiments on CIFAR-100 dataset for 10 epochs it is observed that our proposed approach is giving better results than the normal approach in which default initializer is used i.e. variance scaling present in keras library[7]. Table 5 and Table 6 displays the training and test accuracy on CIFAR-100 data set which generates 26.4 and 13.8 percent improvement in training and test accuracy. Figure 2-5 displays considerable improvement in mean square error and accuracy. The experiments are also performed on

CIFAR-10 [1] dataset and the results (accuracy) obtained are very better than normal approach as shown in table 7. As shown in table 7 the accuracy obtained after epoch 1,2 and 3 is far good through the proposed approach than normal approach. Further, there is no technique involved of avoiding over-fitting in our experiments except dropout as shown in configuration.

Table 5 Training accuracy on CIFAR-100

Epoch	Training Accuracy		Improvement (%)
	Our approach	Normal approach	
1	0.0511	0.0476	7.352941176
2	0.1379	0.1177	17.16227698
3	0.2062	0.1571	31.25397836
4	0.2566	0.1905	34.69816273
5	0.3003	0.2228	34.78456014
6	0.3368	0.2552	31.97492163
7	0.3679	0.2845	29.31458699
8	0.3945	0.3106	27.01223439
9	0.4179	0.3333	25.38253825
10	0.4398	0.3495	25.83690987
		Mean	26.47731105

Table 6 Test accuracy on CIFAR-100

	Test Accuracy		
	Our Approach	Normal approach	
Epoch			Improvement (%)
1	0.1121	0.1057	6.05487228
2	0.1851	0.1625	13.90769231
3	0.2342	0.1872	25.10683761
4	0.2616	0.2088	25.28735632
5	0.2918	0.2491	17.14171016
6	0.303	0.2718	11.4790287
7	0.32	0.2881	11.07254426
8	0.3271	0.29	12.79310345
9	0.3345	0.3108	7.625482625
10	0.347	0.3203	8.335935061
		Mean	13.88045628

Table 7 Test accuracy on CIFAR-10

Epoch	Our proposed approach	Normal approach
1	0.4273	0.3837
2	0.5755	0.5113
3	0.6512	0.5040

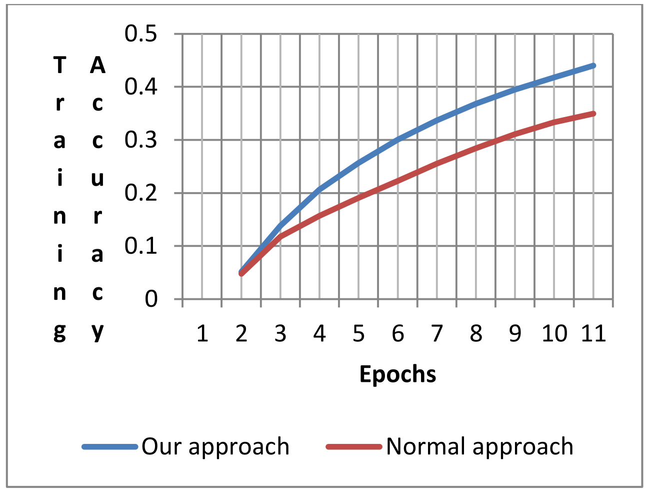

Figure 2. Training accuracy on CIFAR-100

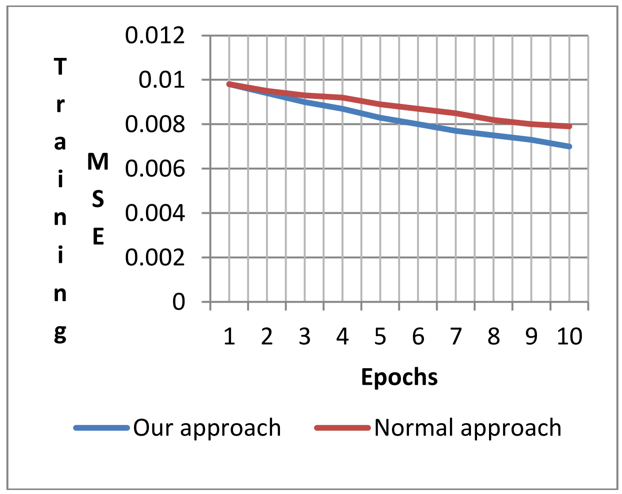

Figure 3. Training MSE on CIFAR 100

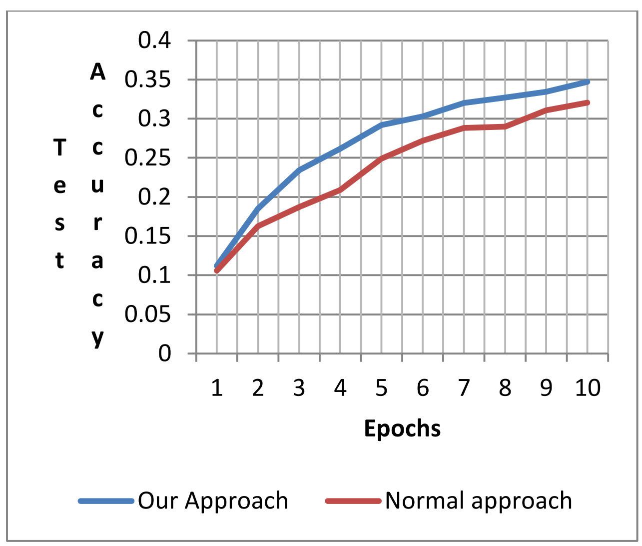

Figure 4. Test accuracy on CIFAR-100

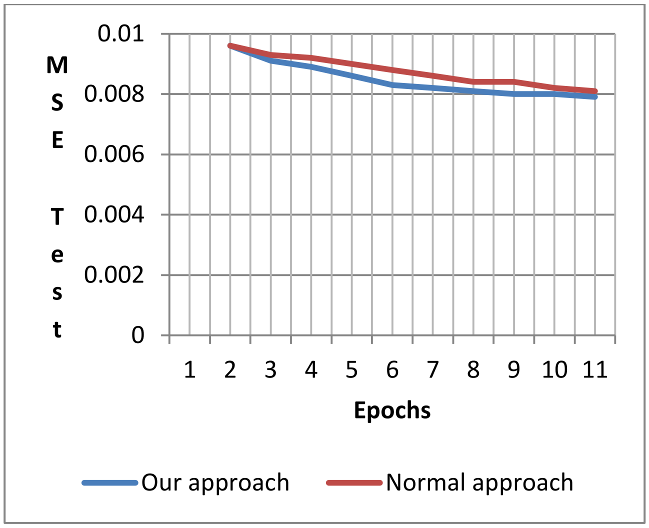

Figure 5. Test MSE on CIFAR-100

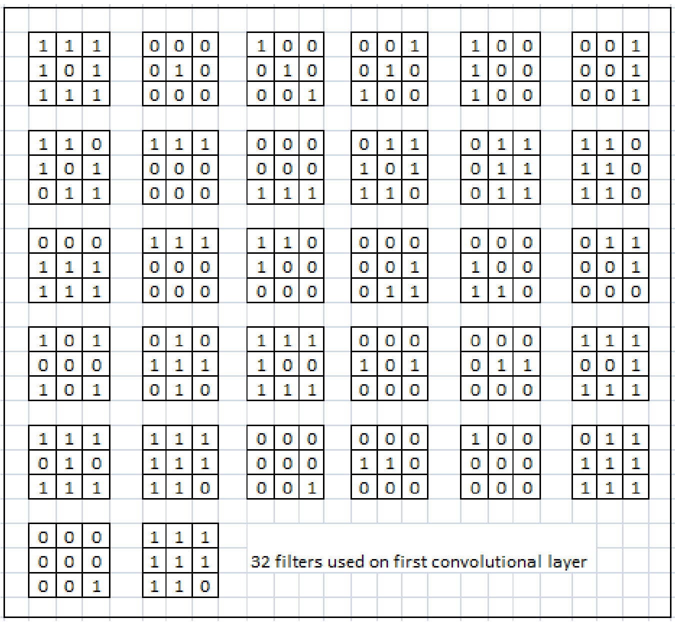

Figure 6. Sub-ordinate filters of the proposed approach

VI. FUTURE WORK AND CONCLUSION

It is concluded that the proposed approach is giving better results than normal approach. Further, the future possibilities are to explore the proposed approach with proper handling of over-fitting techniques like image augmentation, batch normalization, regularization and other such related techniques so that the results obtained are more accurate. It may also possible that we will have to deploy and write more lengthy filter for other convolutional layers which may be of bigger dimensions which is a tedious task but classification accuracy obtained will be much improved. Good results will be possible if these unique filters apply with residual neural networks.

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AUTHORS PROFILE

Mr. Kshitij Tripathi did his graduation in Mathematics and Masters in Computer Science from Barkatullah University Bhopal. Thereafter he completed M.C.A. He has obtained diploma in advance computing from C-DAC (A research & development organization belongs to

Pune University). He has cleared UGC accredited examination for the post of Assistant Professor. Currently, he is pursuing Ph.D. in Neurocomputing and working as a faculty in Department of Computer Applications, The Maharaja Sayajirao University of Baroda, Vadodara, India.

Mr. Rajendra G. Vyas did his Ph.D. in Mathematics, in the Field of Fourier Analysis from Department of Mathematics, The Maharaja Sayajirao University of Baroda, Vadodara, India, in 1996. He is currently working as a Professor in the Department of Mathematics, Faculty of Science, The Maharaja Sayajirao University of Baroda, Vadodara, India. He has published more than 45 research papers in national and international journals of repute. He is a member of the editorial board in many Mathematics journals, a reviewer for Mathematical Reviews, published by American Mathematical Society as well as a reviewer for Zentralblatt, published by European Mathematical Society.

Mr. Anil Kumar Gupta is actively involved in Data Mining and Pattern Recognition research. His research work brings many new ideas in Classification and Clustering techniques. He has a Ph.D. in Computer Science. He is currently serving as H.O.D of the Department of Computer Science and Applications, Barkatullah University, Bhopal. Currently, he is guiding 7 Ph.D. research scholars. He has ten years of research and over twenty years of teaching experience.

