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IMAGE RECOGONITION AND CLASSIFICATION USING CONVOLUTIONAL NEURAL NETWORK- DESIGN OF EXPERIMENTS PROJECT

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INTRODUCTION

Neural networks can be put together to recognize photos, digits, signs etc. Among this Convolutional neural network (CNN) is particularly good for image recognition has a basic unit of neuron which holds a number ranging from 0 to 1. It has these layers of neurons from the input layers, hidden layers and output layers.

An image is fed as input to the CNN. The image has 28*28=784 pixels. Each pixel is fed as input to each neuron of the first layer. Neurons of one layer are connected to the neurons of next layer through channels. Each of these channels are assigned a numerical value known as weight. Inputs and multiplied with corresponding weight and their sum are fed as input for the hidden layers. Each of these neurons are associated with a numerical value called the bias which is added to the input sum. Its value is then passed through a threshold function called the Activation function. The result of this activation function determines if the neurons get activated or not. An activated neurons transmits data to the neurons of the next layer over the channel. This manner the data is transmitted forward through the network. The neuron with highest value determines the output. These values are probability.

During the training process an output in fed to the neural network in which the predictions are compared to the actual output. Error is calculated and the magnitude indicated how wrong we are. This information are transferred back to the CNN by back propagation. Based on this information the weights are adjusted. This cycle of forward and backward propagation is iteratively performed with multiple inputs till CNN is ready to predict correctly.

This is the basis of Deep learning performed and are applied in many fields including facial recognition, forecasting, music composition etc.

In this article we describe the methods we carried out to find the optimum range of hyper parameters for the accurate prediction of CNN. For this we use design of experiments and statistical methods to perform our iterations.

EXECUTIVE SUMMARY

Our goal is to use design of experiments to find the best combination of hyper parameters that gives the highest validation accuracy in a neural network. The highest and lowest values of each parameter are found by running the codes keeping the respective parameter varying and others at the base. We selected Design of Experiments as a viable approach as it reduces the complexity and the time constrains. Fraction factorial experiment can be conducted to find the signification factor and interactions and errors that leading the demise in accuracy.

A ¼ th fractional factorial experiment was conducted in which we gave up two interactions and found the confounding structures and designed the matrix. Experiment was done to find the significant factors and interaction, thus a regression equation was formulated

7 out of 8 factors were found to be significant and the model has an R^2 value of 0. 98103.Comparison of the regression value and true value was performed, and we found that interaction BCDEF has the lower error of 1.20%.

PROBLEM DESCRIPTION AND OBJECTIVE

Neural network forms the base of deep learning a sub field of machine learning. The algorithms are inspired by the structure of human brains. They take in data, train themselves to recognize pattern and predict output of new set of data. The problem here is to find the optimum combination and range of hyper parameters inn order for the CNN to classify the images. We have 8 hyper parameters here which includes.

Kernel size, number of convolutional layers, number of filter conv 2D, number of neurons, learning rate, number of epochs, batch size, momentum ranging at different levels.

The photos provided are blurred and low pixelated. So, the CNN is to be trained to identify them by providing it with a good range of hyper parameters. We conduct design of experiments as it can be applied in a large data base and enables statistical modelling for IPC significant parameter identification. In DOE we were able to apply the fractional factorial design and compute the cofounding structures to find if the model is like the CNN model. Our project focuses upon finding pattern in different images and recognize them or classify single object accurately. This can be used in machines to detect the object and images. It has wide range of applications where it can be used in facial recognition, object identification testing etc.

METHODOLOGY

We performed DOE, as the testing of all the parameters on the images can be a tiring time taking process and lead to a combinatorial explosion. A physical model yet can’t be derived too. As it is necessary to model the influence of the IPC parameters, we decided to build the statistical model.

Our approach to tackle the problem was to design a $1/4^{th}$ fractional factorial in which we gave up two interactions and formed the confounding structure. We found the high and low values for each parameters setting the corresponding at varying levels and others the same. We gave up I1=ABCDG and I2=ABEFH as a result a third interaction I3=CDGEFH was also given up. The confounding structure was derived in which each major factor is confounded with 3 other interactions. This type of selection of factors allows us to retain the major interactions including the two level and three level. This indeed helped us to develop a model with 64 combination of experiments and 63 factors and interactions. The high and low values were plotted, and corresponding replicate outcomes were collected. We collected two set replicates because as the number of data points increases the beta error decreases and power of test increases.

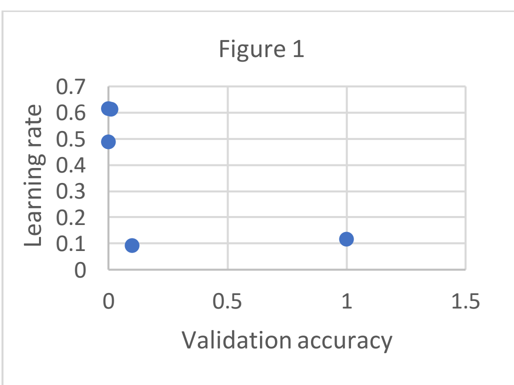
EXPERIMENT AND DATA COLLECTION

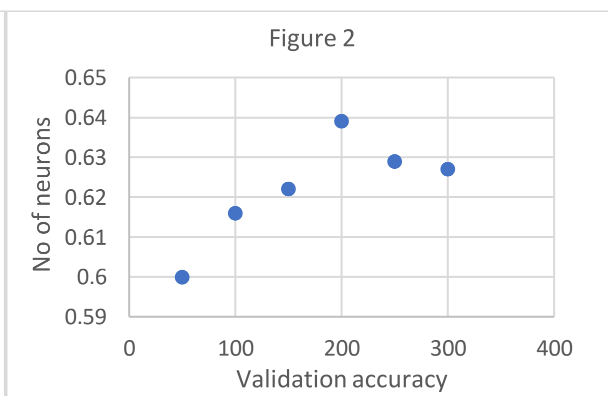
Experiment setup was built up. Following are the steps we performed

- Calculated the contrast
- Calculated the effect
- Calculated the Sum square of regression
- Degree of freedom of each were 1
- Mean square of regression was calculated
- Sum square of total and error and MSE were calculated
- An alpha of 5% was selected
- F0 and p value were calculated, and we got the significant factors
- A regression equation was developed on basis of this
- Residuals are plotted and Normality was checked

Some of the residuals were normally distributed maybe due to random errors and human errors. An R^2 value of 0.98 denotes the our model is highly similar with that of the coded.

The scatter plots for hyperparameters





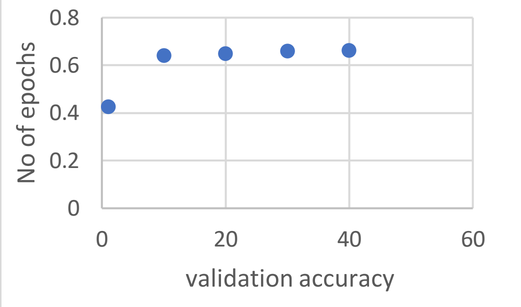


Figure 3

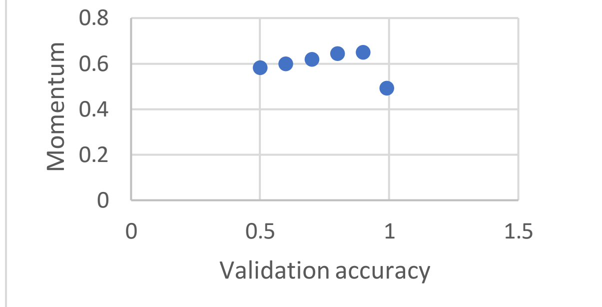


Figure 4

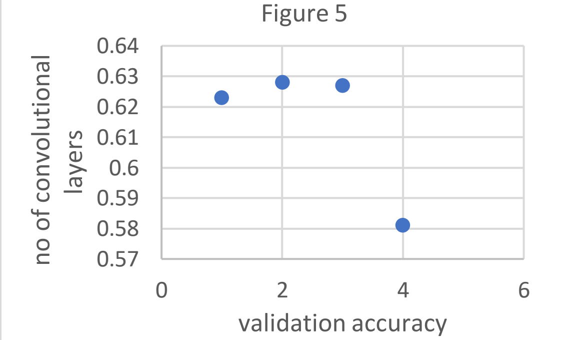


Figure 5

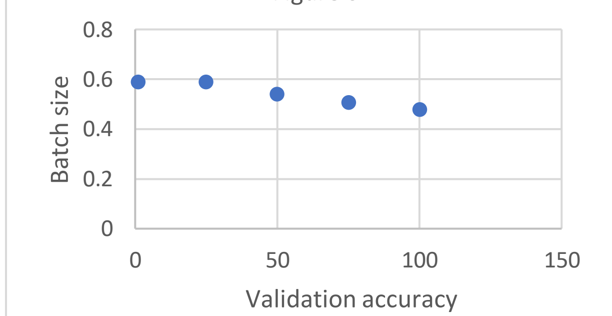


Figure 6

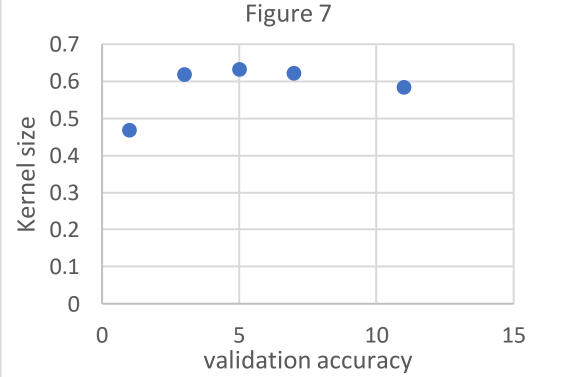


Figure 7

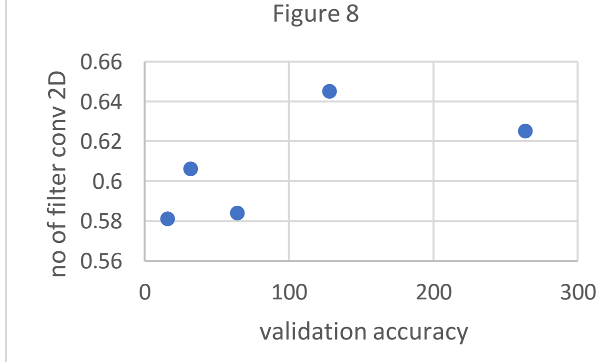


Figure 8

FACTORS	HIGH(+1)	LOW(-1)
Kernel Size	5	1
Number of Convolutional Layers	2	4
Number of filter conv 2D	128	16
Number of neurons	200	50
Learning Rate	0.001	0.1
Number of epoch	40	1
Batch size	25	100
Momentum	0.9	0.99

These are the high and low values got by running the codes. Performing the design of experiment, we got the regression equation

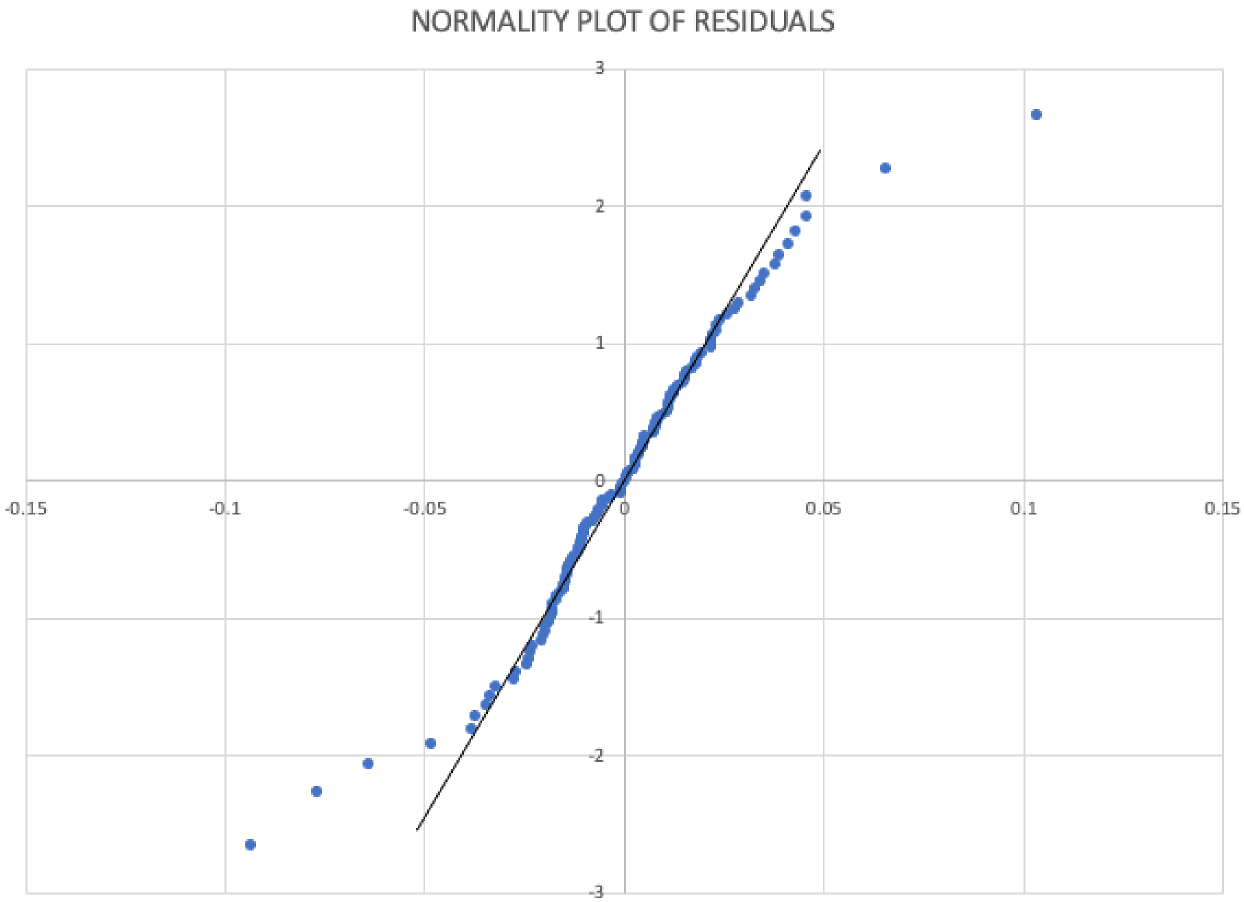
$$\begin{aligned}
Y=&0.256+(0.0482/2)XA+(0.0556/2)XB+(0.0388/2)XC+(0.0208/2)XD+(0.2337/2)XE\\
&+(0.1416/2)XF+(0.0217/2)XH+(-0.0146/2)XAXB+(-0.0103/2)XAXC+(0.104/2)XAXE\\
&+(0.0371/2)XAXH+(0.0176/2)XBXD+(0.0160/2)XBXF+(0.0123/2)XBXG+(0.0637/2)XBXH\\
&+(0.0484/2)XCXE+(0.0105/2)XCXF+(-0.0115/2)XCXG+(-0.0157/2)XDXG+\\
&(0.1089/2)XEXF+(0.0546/2)XEXG+(0.0562/2)XEXH+(0.0164/2)XFXG+(0.0197/2)FXH+(0\\
&.0215/2)XGXH+(0.0206/2)XAXDXE+(0.0174/2)XAXDXF+(0.01348/2)XAXDXH+(0.0214\\
&8/2)XAXEXG+(0.0179/2)XAXGXH+(0.0156/2)XBXCXE+(0.0184/2)XBXCXF+(-\\
&0.0189/2)XBXCXH+(0.027/2)XBXEXG+(-0.0132/2)XBXFXG\\
&+(0.0367/2)XBXGXH+(0.0125/2)XCXDXE+(0.0234/2)XCXDXF+(0.01832/2)\\
&XCXEXG+(0.0132/2)XCXFXG+(0.0105/2)XCXFXH+(0.0156/2)XCXGXH
\end{aligned}$$

DATA ANALYSIS

Factors such as kernel size, number of convolutional layers, number of filter conv 2D, number of neurons, number of epochs, momentum were found to be significant. Interactions such as a

AB,AC,AD,AE,AH,BD,BF,BG,BH,CE,CF,CG,DG,EF,EG,EH,FG,FH,GH,ADF,ADH,AEG,AGH,BCE,BCF,BCH,BEG,BFG,BDH,CDE,CDF,CEG,CFG,CFH,CGH

were found to be significant.
The Mean square error we got was 0.000835
Residuals were calculated and normality were plotted.



Some data lies outside the normality line as they are outliers and maybe due to random errors.

RESULT

A Comparison of the regression accuracy and that of the True value was conducted. The values of the terms were substituted, and accuracy were found. The same was done in the codes and the validation accuracy was found.

COMPARISON OF OUR MODEL TO THE REAL NEURAL NETWORK

EXPERIMENT	TRUE VALUE	REGRESSION VALUE	ERROR
ABCDEFGH	0.693	0.6337	9.30%
ABCEFH	0.662	0.63816	3.70%
BCDEF	0.557	0.55003	1.20%
BEF	0.196	0.14243	38%
DE	0.157	0.1136	38.20%

BCDEF Interaction has the minimum error while performing the analysis means that this combination of experiment and hyper parameter gives us better more accurate performance of the CNN

CONCLUSION

The proposed method is used to optimally design neural network with the help of design of experiments. The termination condition is achieved by training neural network and adjusting design parameter levels. The main idea behind using design of experiment is to save effort and time. Design of experiment can be employed to generate optimal experimental conditions. In conclusion, we compared the true value with the regression value of five experiments out of sixty-four experiments and found that BCDEF has the lowest error percentage. From this we can conclude that hyper parameters in the experiment BCDEF can generate a more efficient neural network image recognition. In future works we can conduct more than five experiments and find more efficient experimental results.

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