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A NOVEL METHOD TO AUTO CONFIGURE CONVOLUTION NEURAL NETWORK MODEL USING SOFT COMPUTING TECHNIQUE TO RECOGNIZE TELUGU HAND-WRITTEN CHARACTER FOR BETTER ACCURACY

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ABSTRACT

The paper presents the performance optimization using Genetic Algorithm with Convolutional Neural Networks (CNN) architecture to recognize hand written digits written in Telugu Language. CNN is tested with multiple configurations for various numbers of convolutional layers, filter size in each convolution layer, number of convolution filters in each layer, and pool size (for down sampling). the images in order to get optimal performance. Researchers have been using the trial-and-error approach of picking configurations for a CNN Model. This may not always guarantee the optimal performance and it needs, the user to monitor the performance trend on a regular basis with the improvement in prediction accuracy for changes in number of layers, filter size and number of filters. The Genetic Algorithm is used in this research to change the configuration of CNN to achieve the best results (accuracy of image recognition). Various architectures have been proposed by researchers for producing better results in Image recognition and classification areas. Our paper has proposed a method by changing CNN configurations with Genetic Algorithm and evaluated the overall test accuracy to 99% for hand written telugu characters.

Keywords : *Genetic Algorithm , Convolution Neural Network , Telugu Character Recognition , Soft Computing*

1.INTRODUCTION

Artificial intelligence has made significant progress in closing the gap between human and computer capabilities. Researchers and hobbyists alike work on a variety of facets in the subject to achieve incredible results. Image Recognition [1,2], Image classification is one of the such disciplines. Regression and classification issues may be solved with Artificial Neural Networks. Any non-linear function may be approximated by a multi-layer perceptron (MLP) with a non-linear activation function (sigmoid, hyperbolic tangent function). MLP comprises three layers: input, hidden, and output. The other two layers, with the exception of the input layer, have neurons with nonlinear activation functions. Features in photos are frequently limited in a smaller 2D region. For example an image may have a dog or call object anywhere in the picture, To recognize or classify such objects in a picture requires a fully linked Multi-Layer Perceptron. Hence an MLP is not recommended for such applications. On the other hand, Deep Convolution neural networks are another variant of MLP that are used to recognise the features in an image. A 2D convolution kernel is

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utilised as weight instead of scalar weights for neurons in this variant of Multi-Layer Perceptron. The convolution kernel is used as a weight to transform the entire image. A spatially invariant CNN is created when the item is situated at different locations in the training picture. The details of this variant are provided in Section 2 of this paper. Obtaining the architecture for CNN in terms of number of convolutional layers, size of convolution kernel, and number of convolution filters in the hidden layer may need several attempts. This study used a Genetic Algorithm to do iterations in order to find the best architecture for CNN. The Genetic Strategy (GA) is a heuristic search algorithm for determining the best set of parameters for a given task. It accomplishes this by specifying a set of parameters in terms of a bit string (for logic problems) or a group of real integers known as chromosomes. GA continually performs crossover (combination of parent chromosomes to create offspring chromosomes), mutation (manipulating bit or real number in child chromosome), and selection after starting with a set of randomly generated chromosomes called the initial population (using a fitness criterion to select a fraction of parent chromosomes to next generation). The capacity of GA to converge to global minima is being employed. This reduces the requirement for the user to continually evaluate CNN performance (increasing prediction accuracy) while iterating through different architectural configurations. Section 3 describes the use of GA for CNN optimization. Section 4 discusses the recommended system setup for CNN architecture optimization utilising GA. Section 5 describes the tests undertaken to validate the proposed system's operation. The conclusion for this project is presented in Section 6.

2. CONVOLUTION NEURAL NETWORK

CNN is similar to a standard Artificial Neural Network. The weights, on the other hand, are in the form of 2D convolution kernels. A CNN can have several tiers of convolution layer and max pool layer combination (as shown in fig 1). Finally, CNN has a fully connected layer with outputs equal to the number of classes for training data and a SoftMax layer that outputs the most likely class with related probability. The first convolution layer is in charge of detecting the edges of an image, while the second layer is in charge of constructing forms out of the extracted edges, such as semi-circles and squares. Higher degrees of abstraction are acquired as we progress through the convolution layers. Given a set of training images , CNN develops its own feature extraction design. CNN configuration used for the experiment consists of an input layer, set of convolution layers, output layer . The following sections discuss CNN's activation function, convolutional layer, max pool layer, full connected layer, and SoftMax layers.

Image Pre Processing : The images must be normalized and transformed to the same size . It mean the image intensity mean value is subtracted from each pixel value

Activation Function : CNN employs the ReLU activation function because its gradient does not have saturation in the positive area (does not diminish learning rate when additional layers are added), it uses simple thresholding, and it has a quicker convergence rate than the tanh or sigmoid functions. In another way an artificial neuron computes the 'weighted total' of its inputs and adds a bias, as represented below

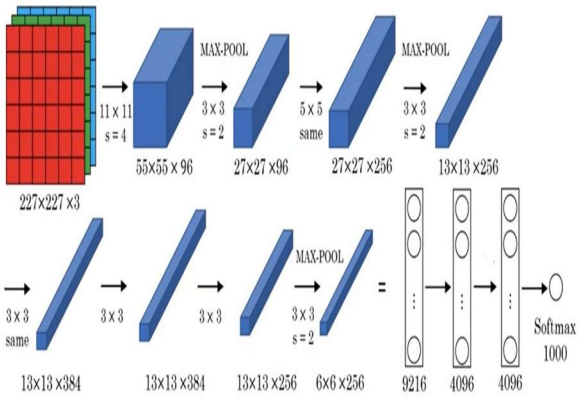

Fig . 1 : Alexnet – Pre Trained Model Of CNN Includes Numerous Stages Consisting Of Convolution And Max Pool Layers, Followed By Two Fully Linked Layers

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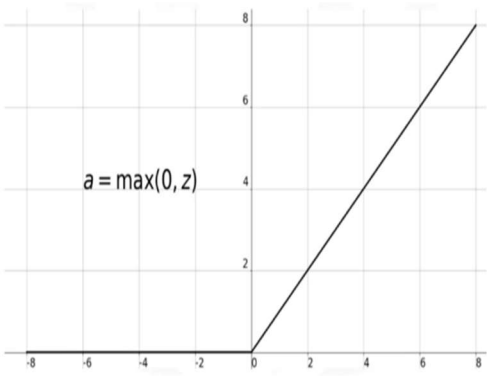

Fig 3 . ReLU Activation Function - f(x)=a=max(0,z)

The value of net input can now be anything between -inf and +inf. Because the neuron does not understand how to bind to a value, it is unable to determine the firing pattern. As a result, an artificial neural network's activation function is crucial. They basically determine whether or not to activate a neuron. As a result, the value of the net input is limited. The activation function is a non-linear change we do on input before transferring it to the next layer of neurons or finishing it as output. ReLU is the ideal activation function for big data sets since its convergence rate is higher than that of other activation functions.

Initialization of Weight: Weights for less than 5 hidden layers can be set to be random with a zero mean and a modest standard deviation. Consider a cuboid-shaped image of size 32x32x3 over which a cuboid-shaped filter of size 7x7x3 is applied. The resulting image is a weighted sum of the image with filter weights as the filter moves across the image. The resultant picture has dimensions of 26x26x10 where the boundary value of 2 discarded from each side of original image. When only one filter is employed, the depth of the produced picture is one. Since there are 10 filters here , the depth is 10.

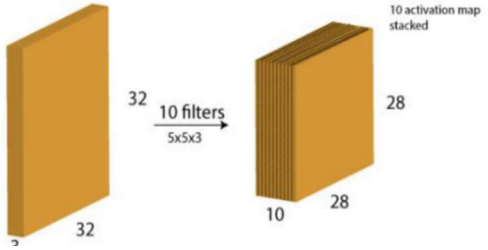

Fig 5. Convolution Operations When Filters Are Applied

Padding is used to ensure that the resultant picture is the same size as the source image. For example, a padding of 2 on the above image would yield 32x32x10 output.

Max Pooling Layer : The feature maps' dimensions are reduced by using pooling layers. As a result, the number of parameters to learn and the amount of processing in the network are both reduced. The pooling layer summarizes the characteristics in an area of the feature map produced by the convolution layer. Below is an example of obtaining the values using Max Pool layer

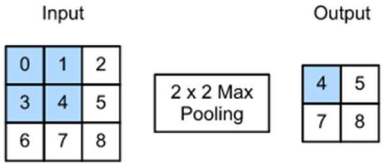

Fig 6 . 2 x 2 Max Pooling

Fully Connected Layer : In a neural network, fully linked layers are those where all of the inputs from one layer are connected to every activation unit of the following layer. The last few layers in most typical machine learning models are full connected layers that assemble the data retrieved by preceding layers to generate the final output. Fully Connected Layer[5] is similar to a standard neural network in that each pixel of the picture is sent into the Neural Network

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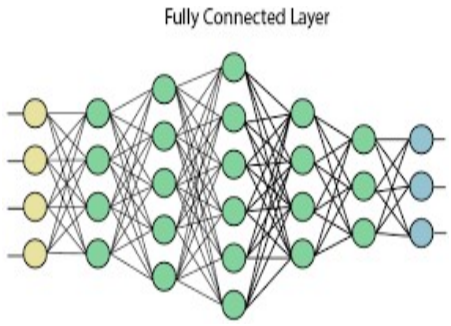

Fig 9 . Input Layer Hidden Layer Output Layer

SoftMax Layer : Softmax is used to solve multi-classification issues. Before using Softmax, certain vector components may be negative or higher than one, and they may not add to one. The softmax layer produces a probability distribution, and the output values sum to one. This added restriction allows training to converge faster than it would without. SoftMax layer produces probability of classes

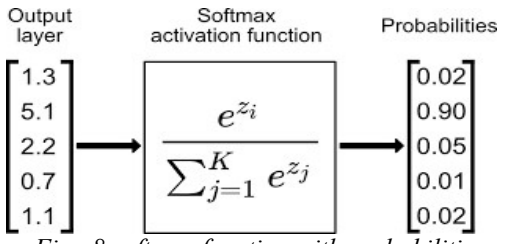

Fig . 8 softmax function with probabilities

Soft Computing Technique : The polar opposite of hard (traditional) computing is soft computing. Artificial intelligence (AI) and natural selection are used to describe a set of computing approaches. It offers cost-effective answers to difficult real-world situations for which there are no hard computer solutions. For real-world situations, soft computing gives an approximate yet exact answer. Soft computing methods are adaptable, thus any changes in the environment have no effect on the present operation. Soft computing is a concept based on learning from experimental data. Soft computing eliminates the need for a mathematical model to address a problem. Soft computing assists users in solving real-world issues by offering approximate outcomes that are impossible to address using traditional and analytical approaches. It uses fuzzy logic, genetic algorithms, machine learning, artificial neural networks, and expert systems.

3. GENETIC ALGORITHM

Genetic Algorithm[6] is heuristic search algorithm. It uses biological evolution analogy of crossing over fittest chromosomes to generate offspring. A fixed fraction of previous population having higher fitness and offspring's (produced from crossover[6]) are evaluated against a fitness function for their suitability. A fixed fraction of population that ranks low in fitness are eliminated and again the fittest chromosomes are crossed over to obtain offspring. This method is iterative. A stopping criterion needs to be mentioned in terms of number of iterations or threshold value of fitness, else the GA optimization could go forever with little or no optimization.

Below are the steps followed for implementing Genetic Algorithm

1) Determine chromosome structure
2) Set fitness function
3) Initialize the population
4) Set cross over function
5) Set mutation function
6) Generate iterations
7) Population

Chromosome Structure: The number of filters and the size of the filters are represented by two vectors on the chromosome. GA finds the best settings for "number of filters" and "size of filter" in each layer given the number of layers in CNN. The chromosome is made up of two vectors with lengths corresponding to the number of layers. The values for the number of filters and filter size are included in these two vectors. The cost value associated with each configuration (number of filters and filter size) is also retrieved and updated.

Set fitness function: A CNN is constructed for each chromosomal configuration and then trained using the training data. The resulting CNN is then put to the test using the entire set of training data. To achieve the cost value, the classification accuracy is computed in percentages and then deducted from 100. The lower the expense, the better the fitness.

Initial population : A set of randomly produced chromosomes makes up the initial population. A random integer generator creates initial population based on the "maximum limit for the number of filters" and "size of filter." A parameter determines the size of the beginning population.

Cross over function : To create the child chromosome, two parent chromosomes are crossed across. Bit mask is used to create children when

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chromosomes are described in terms of bit strings. In the current situation, when the chromosome is made up of numbers, a cross over function must be created.

Parent 1 and Parent 2 are two chromosomes having the number of filters at each line and its size. For cross-over operations, a random index generator creates indices . The child chromosome is generated using indices in the cross over procedure. The components acquired by child from parents 1 and 2 are shown by the direction of the arrow in the above figure from parent to child.

Set mutation function: A random index generator was employed in this example, although fixed index cross over can also be utilised. The author has not compared the performance of these two crossover approaches.

Generate Iterations: The genetic algorithm generates three sorts of children: a) Individuals in the current generation with the highest fitness values are considered elite. These individuals are destined to live to the next generation. b) The vectors of two parents are combined to form crossover. c) Mutation offspring are formed by infusing a single parent with random mutations.

Population: A population is a collection of individual chromosomes that includes parent chromosomes passed down to the next generation, children produced by crossover, and mutations.

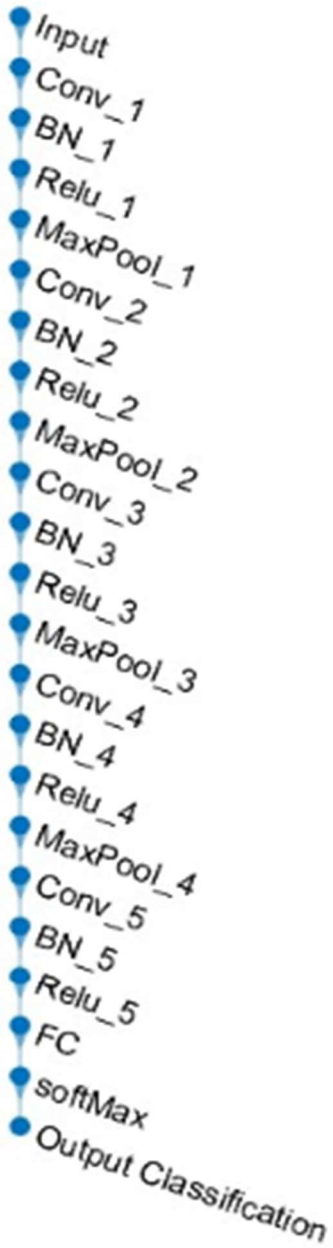

Fig 10 .CNN model

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4.PROPOSED SYSTEM ARCHITECTURE

Researchers in various papers have presented different solutions in identifying Telugu Hand written characters such as Image Processing Techniques , , Histogram based , Machine Learning Techniques and Convolution Neural Network Models . The Parameters for CNN Model are randomly fine tuned till the desired accuracy is achieved . \

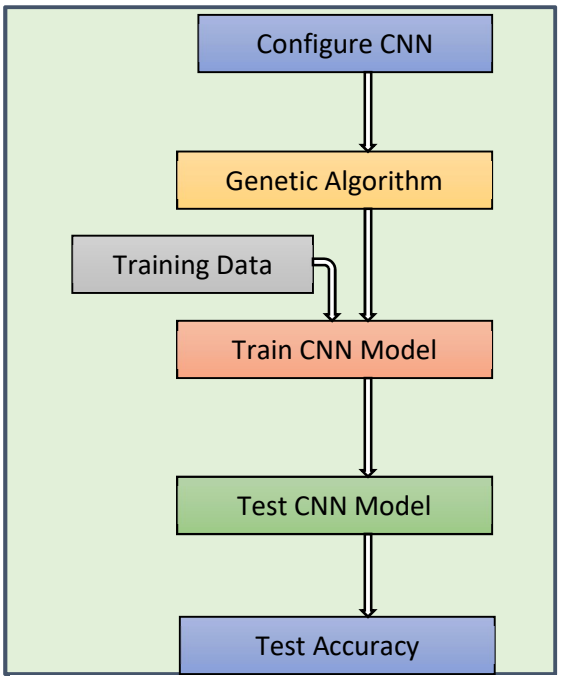

Fig 11 . Proposed CNN Architecture using Genetic Algorithm

Our Proposed system to get optimized results uses Genetic Algorithm to auto configure the model and is depicted in the below figure with six blocks where the Convolution neural network is configured with set of input layer, convolution 2D layer , ReLU Layer with Max pool year and a fully connected layer with eight classes with a softmax layer and a classification layer . This architecture is experimented in four ways and the results are depicted in Results section.

Experiment 1: In first experiment there are 3 convolution layers along with the input layer and output layer . Each convolution layer set has a 2D layer + Batch Normalization Layer + ReLU Layer + Max Pool Layer . Here the filter size is 3 and number of filters are 8,16,32 for each layer . These values are configured to Genetic Algorithm Configuration block along with the image size . The Genetic Algorithm Block will perform the operations such as initialize the population , apply crossover function and mutation function and perform the iterations then train the CNN Model .

Experiment 2: In Second experiment there are 4 convolution layers along with the input layer and output layer . Each convolution layer set has a 2D layer + Batch Normalization Layer + ReLU Layer + Max Pool Layer . Here the filter size is 3 and number of filters are 8,16,32,64 for each layer . These values are configured to Genetic Algorithm Configuration block along with the image size . The Genetic Algorithm Block will perform the operations such as initialize the population , apply crossover function and mutation function and perform the iterations then train the CNN Model

Experiment 3: In third experiment there are 5 convolution layers along with the input layer and output layer . Each convolution layer set has a 2D layer + Batch Normalization Layer + ReLU Layer + Max Pool Layer . Here the filter size is 3 and number of filters are 8,16,32,64,128 for each layer . These values are configured to Genetic Algorithm Configuration block along with the image size . The Genetic Algorithm Block will perform the operations such as initialize the population , apply crossover function and mutation function and perform the iterations then train the CNN Model

Experiment 4 : In fourth experiment there are 3 convolution layers along with the input layer and output layer . Each convolution layer set has a 2D layer + Batch Normalization Layer + ReLU Layer + Max Pool Layer . Here the filter size is 3 and number of filters are randomly given for each layer . These values are configured to Genetic Algorithm Configuration block along with the image size . The Genetic Algorithm Block will perform the operations such as initialize the population , apply crossover function and mutation function and perform the iterations then train the CNN Model

5.EXPERIMENTS & RESULTS

Data Sets : The dataset used in the model are created by own. Few of them are drawn in the editor and some of them were hand written images collected from different age group of 5 to 10 years, 20 to 40

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years. Some of them are generated in the system . There are 8 classes. Each class consists of 400 images of size 28 x 28 of RGB .

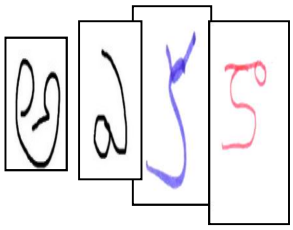

Fig.12.Telugu Vowels Telugu Consonants
(Hand Written Samples used in Dataset)

Results : The below table – Fig 13 narrates the experiments and its results for each class

Class	Experiment 1	Experiment 2	Experiment 3	Experiment 4
'A'	95.66	98.00	**98.75**	38.50
'Aa'	96.00	99.00	**100.00**	73.00
'Ai'	97.50	99.50	**99.50**	84.50
'E'	99.75	99.25	**99.75**	72.00
'Ee'	90.00	99.25	**100.00**	79.75
'U'	90.00	100.00	**100.00**	76.50
'ka'	96.66	98.33	**99.75**	73.00
'kaa'	90.00	96.00	**98.66**	67.50
AVG	**94.45**	**98.67**	**99.55**	**70.59**

Fig 13 . Experiment Results Table

Graph:

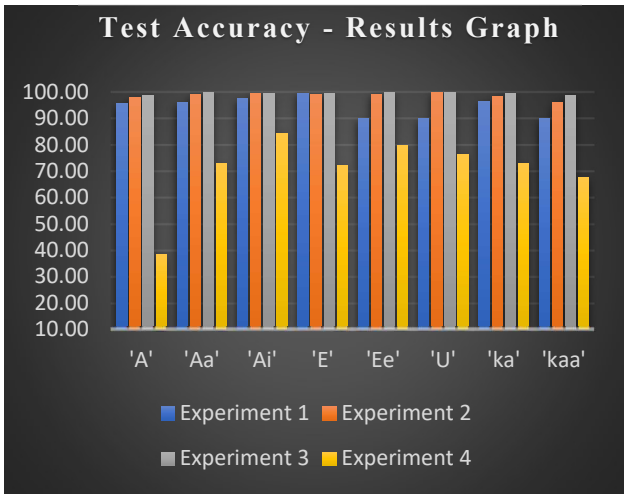

Fig 14 . Experiment Results Graph

6.CONCLUSION

Finally, this work has shown the usage of a Genetic Algorithm (GA) to find the best parameter settings for a Convolutional Neural Network. This study developed a method for determining the best Convolution Neural Network settings. To autoconfigure the model, the user must first plan for the number of convolutional layers, then define the maximum number of filters, maximum filter size for convolutional layer, and maximum number of generations for GA. The Classification accuracy for overall dataset is 99.55%.

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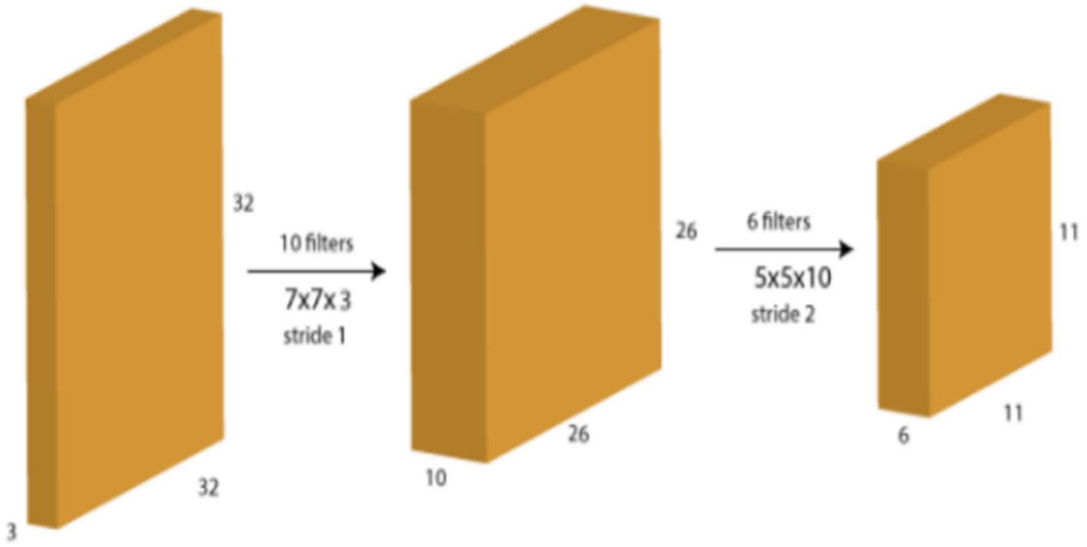

Fig 4 : Convolution Operation Example

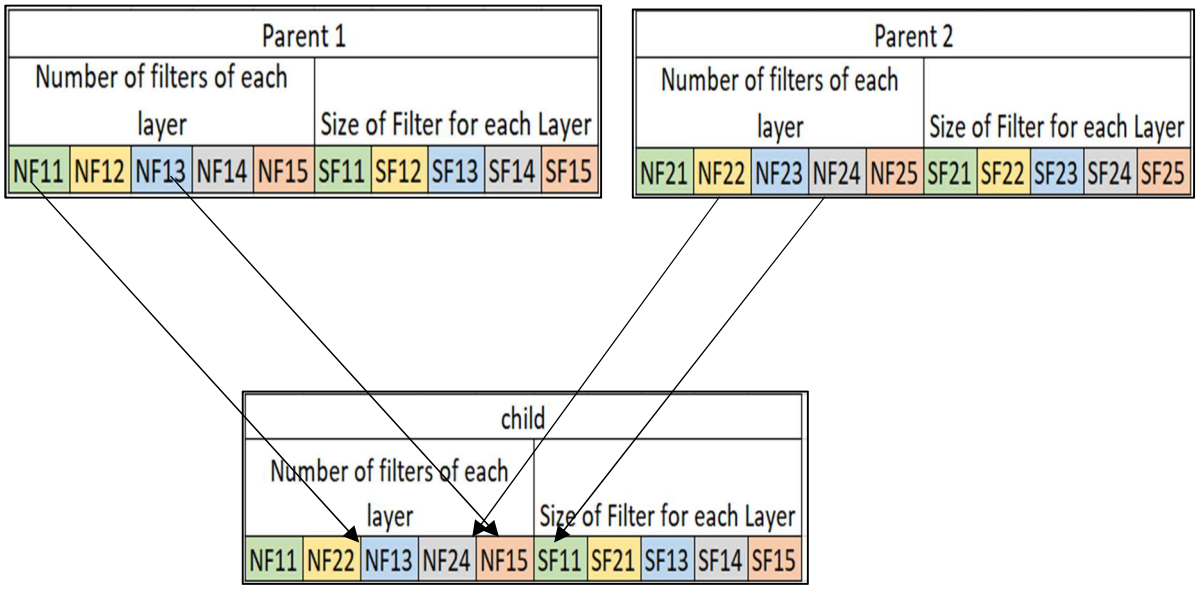

Fig 9 : Genetic Algorithm – Cross Over Operation

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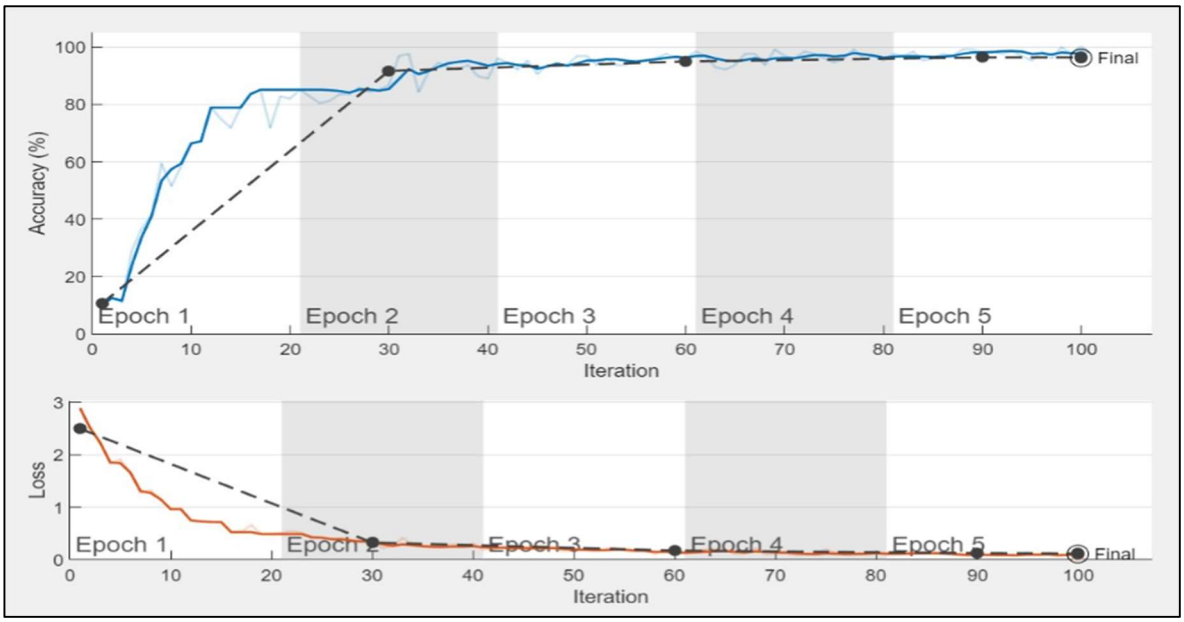

Fig 15 : Accuracy And Loss Graph During Experiment Execution