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Hand Gesture Identification for Improving Accuracy Using Convolutional Neural Network(CNN)

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ABSTRACT

Hand gestures are a type of non-verbal communication that uses visible body movements to convey important messages. This paper presents a much better approach of hand gesture prediction. Image Identification is an important step in most of the modern hand gesture prediction system. A convolutional neural network are used for improving the accuracy of the system. Proposed system tested for large number of hand gesture images using Tensor flow tool. . The convolutional neural network (ConvNet) is a deep learning algorithm for learning and classifying hand gestures and achieved accuracy 93.61%.

Keywords: Hand Gesture, Machine Learning, ASL Data Set, Convolutional Neural Network;

INTRODUCTION

Generally, communication between people in our daily life is done by speaking with voice, but some communication is possible using hand gesture or body part movement, facial expressions .

Hand gestures are communally used by humans to exchange messages. So, it is normal for us to engage with machines in a comparable manner .For example, safety and comfort in vehicles can be improved using touch-less human–computer interfaces. Hand gestures provide an easy and innovative way to interact with computers to do task[20] , Basically two types of hand gesture recognition technique that are used, Sensor-based approach and Vision-based approach. In the first approach, require the use of sensor ,instrument to capture the image ,motion and velocity of hand for purpose of collecting the data by using the sensor the essential information is gathered by sensor ,so no need for data preprocessing and segmentation step in hand gesture prediction. In this method arise various issue such sensor sensitivity, connectivity and synchronization.

In Vision-based method are need to acquisition of image or video of hand gesture by only camera or scanner. By using this approach It generate as enormous amount of data which need to be process carefully for extracting only the significant information and more economical than former approach.

A gesture can be classified into two types' static gestures and dynamic gestures. Static gestures are postures that do not consider movements into account, e.g. thumbs up. Dynamic gestures consider the angles between fingers during certain start and end times, e.g. drawing letters in the air. Machine learning is used to solve various real-time problems. It is commonly used for classification, detection, recognition, and predictions problems. Machine Learning [10][18] is used to automate processes using data. A model is produced and is capable of returning an output, this output may be the new data or some predictions with the known data. Deep learning is a class of machine learning that uses more number of layers to extract higher-level features from the input.The Convolutional Neural Network (CNN) was first introduced by Yann LeCun et al. [1].

According to various researchers, it has been observed that Convolutional neural network are very effective

compare to other hand gesture recognition technique. The organic similarity among the ConvNets and the human visual gadget is the primary purpose for the compatibility of ConvNet. The processing gadgets of ConvNets consist of mul-tiple layers of neurons which might be allotted hierarchically. The parameters are shared amongst various neurons which can be present in specific stages within the network. This results in numerous connection styles with the connections having various weights. These weights are then used to finish the technique of class[12][13][15]

In recent years, the convolutional neural networks (CNN) overtake the complex pre-processing of images and assist in classifying and recognizing images, therefore, it is extensively utilized when handling images. Numerous researchers have started to implement CNN for recognizing human gestures and achieved good results [37]-[40]. In this paper, the proposed CNN framework works on recognizing static hand gestures for obtaining effective and accurate results

In this paper Convolutional neural network model are implemented for hand gesture prediction on ASl data set taking from kaggal. The implementation of CNN model is discussed and performance is find out in of accuracy.

The remaining part of paper are describe as follows: Section 2 describe related work, Section3: Proposed Method ,Section 4: Implementation, Section 5: Result analysis and Section 6: Conclusion

RELATED WORK

In recent year there are many researcher used machine learning technique and deep learning technique for image detection ,prediction and hand gesture recognition on different data set. and finding different observation. Some of the researcher work given below;

Paulo Triuerious et al.[2] The Author used two data set of hand gesture with different hand feature to test Various machine learning algorithms the author choose (k-NN, Naive Bayes, ANN and SVM) were applied to data set and implementation are performed under the assumption of k-fold method from the comparison all these ANN gives highest accuracy for data set with less feature value.

Kuntal KumarPal et al[3] In this paper Author will be dealing with the work done Pre-processing for image classification using Convolution Neural Networks and shown the importance of pre-processing techniques for image classification using the CIFAR10 dataset and three variations of the Convolutional Neural Network. The Author absorb The pre-processing techniques play a vital role in achieving the state of art on any dataset. and better accuracy for classification, author used Mean Normalization, Standardization and Zero component analysis and Author found raw data on CNN-1 achieved accuracy in range 51-56%. When are used mean normalization, the accuracies increase negligibly to range 55-58% and Standardization achieved 63-66% accuracy and for ZCA 64-68%; for CNN-2 ,ZCA(67-69%) and accuracies achieved with no preprocessing(43-50%), mean normalization technique (55-58%) standardization(63-67%). For CNN3 achieved accuracy ZCA (67-73%) without pre-processing (50-56%), mean normalization (61-66%) and standardization(65-69%).

Sanmukh Kaur, Anuran et al.[4] Author describe a real-time hand gesture recognition system with four phase such as Data acquisition, Pre-processing, Feature extraction, Gesture recognition, and the Real-time hand detection is done using Histogram of Oriented Gradients (HOG) as feature selection in MATLAB and the k-Nearest Neighbour (KNN) algorithm is used to classify the input images and achieved accuracy 87.1%.

Rajalakshmi J et al.[5] proposed based on combined Covolutional neural Network and Recurrent Neural Network ,the last three layer of VGG16 replaced by RNN withusing softmax layer to produce output .In which model extract efficient feature by CNN from gesture and RNN will identify the temporal pattern and obtain the accuracy of this model was 88%.

Ashish Sharma et al.[7] The Author used different Pre-processing Technique mainly Histogram of gradient, Principal component Analysis and Local Binary Pattern then processed data is test on several classifier (Random Forest, Support vector Machine, Naive Bayes, Logistic Regression, K-Nearest Neighbours) and the author ORB feature extraction technique will be tested against different pre-processing technique at HOG, LBP and PCA for same data set. This method examine successfully passed through various classifier achieve higher accuracy for 17400 images.

Phat Nguyen Huu et al [15] have discussed the support vector machine(SVM) and histogram of oriented gradient(HOG) for hand gesture recognition In this paper author use Conovolutional Neural Network model to classify hand gesture and accuracy of this mdodel was 90% and used 1000 training data.

Shruti Chavan et al[36] have discussed the transfer learning approach with for ImageNet weight is not fit for American sign language. ASL data used in experiment. In this model Author used other CNN model MobileNetV2,Vgg16, LeNet5 only 200image was tested, and obtain the training accuracy 91.37%, validation accuracy 86.30% and testing Accuracy 87.5 of this model.

Sahoo *et al.* [43], proposed a deep CNN feature-

based static hand gestures recognition system in which deep features are extracted using fully connected layers of pre-trained artificial neural network (AlexNet), then the redundant features are reduced by using the principal component analysis (PCA). After that, a support vector machine (SVM) as a classifier was utilized for classifying the poses of hand gestures. The system performance was evaluated on 36 gesture poses using american sign language (ASL) dataset, and the obtained average accuracy was 87.83%.

Ragini Patel and Parvinder(2020) presented recognition model of Hand Gesture Digit based on machine learning with image processing in scenario is to gesture from digital image or image capturing electronics device and covert it into text. The Author discussed the vision based method is reliable as compared to data glove-method, and finding It is coastally for practical setup. Through MATLAB2016a, identify hand Gesture digit and Accuracy of this model was 91.5%.

Mengumeng Han, Jiajun Chen et al.(2016) have explain the discussion is on convolution neural network method for reduce the the difficulty of gesture recognition from the camera. Which uses hand gesture 4800 image at two stage CNN with pre-processing layer to reduce the complexity of recognition task.

Most of research are to predict hand gesture using various technique and different dataset and find the accuracy. the accurate recognition of hand gesture poses is still a difficult task due to several aspects like the small size of the dataset, Here In this paper author select large data base size. this paper proposes an accurate and effective CNN framework which deals with a large dataset of infrared images for recognizing ten kinds of hand gesture poses .Show in Fig. 1 Our data set'

Fig. 1 Data Set [American sign language]

PROPOSED METHOD:

In our system first step is to collect the data. Many researchers have used sensors or cameras to capture the hand movements. But In this paper we have used the American Sign Language (ASL) data set that is provided by MNIST and it is publicly available at Kaggle. Our dataset has 34627 American sign gesture images out of which 27455 image for training and 7172 are testing purpose.

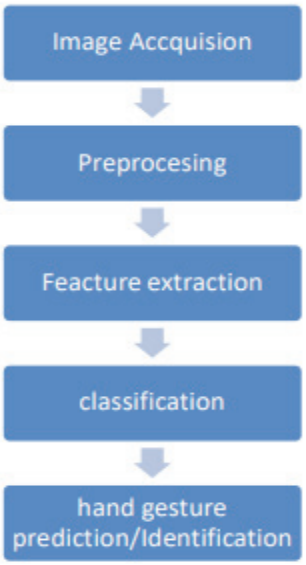

Fig. 2 Proposed system model

In prosed model divide mainaly four part 1. Data Acquision 2. Pre-processing 3. Feature Extraction 4. Classification. Step 3 and 4 are experiment on tensorflow using CNN.

Image Acquition: Any camera, even a laptop webcam can be used to acquire the image to be recognized. Because in the end the image captured will be reduced to the input size of the CNN. Hence the camera need not be high-resolution. paper we have used the American Sign Language (ASL) data set that is provided by MNIST and it is publicly available at Kaggle.

Data and Pre-processing: The biggest challenge we faced during the experiments was to find a suitable dataset The dataset consisting of various hand gesture images at different conditions such as lightning, varied backgrounds, dimensions and so on are collected and are subjected to pre-processing. The pre-processing of the image consists of the conversion of RGB to a greyscale image. Training the raw images as it is might lead to poor performance. Thus, simple image processing algorithms can be implemented to achieve maximum accuracy. Image

processing algorithms such as RGB to gray conversion reduce the training time and power consumption. The noise from the images can be eliminated. After data pre-processing we discussed CNN model

The proposed CNN framework is designed to obtain the best results for human hand gesture recognition. The CNN framework architecture is shown in Fig.3 , and its details are summarized in Table 1. The first layer in the proposed CNN framework is the input layer which provides the input data to the subsequent layers. After this layer, there are two phases; The first phase is the feature extraction and the second one is the classification.

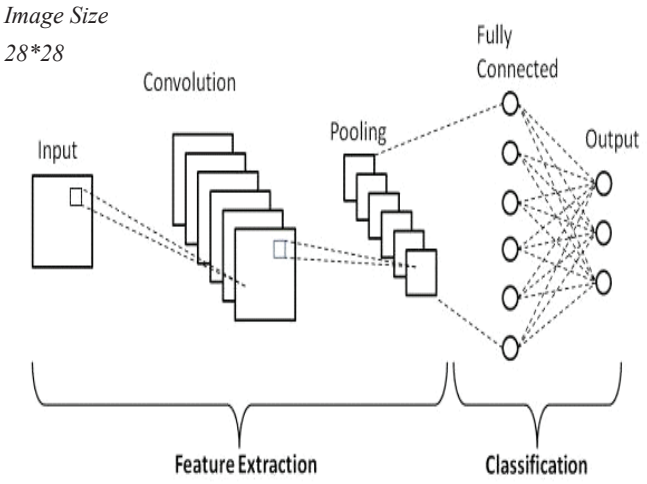

Fig 3. A simple CNN Architecture.

The Convolution layer is often the first layer. The picture is received by it (a matrix of pixel values). Assume the input matrix is read from the image's top left corner. After that, the programme selects a smaller matrix, known as a filter, to position there (or neuron, or core). Convolution is then generated by the filter, which passes along the input image.The task of the filter is to multiply its values by the pixel values from which they come. A number of these multiplications are combined. After that, a single amount is gathered. Since the filter has already read the picture in the upper left corner, it moves 1 unit to the right and repeats the process..A matrix is obtained after running the filter over all locations, but it is smaller than the input matrix.

The feature maps go through the activation function before feeding to the next layer. ReLU is one of the widely used activation functions.

- ***Pooling Layer***: The pooling layer reduces the size of the images by taking the maximum pixel value or the average pixel value from a group of pixels. Here the pooling areas or windows do not overlap on image regions. Pooling layers are useful for reducing computational loads.
- ***Flatten Layer*:** Output nodes from the previous layer are taken and are separated or flattened and weights are assigned to these individual nodes. Thus, the array or tensor of nodes is reshaped by the flatten layer.
- ***Dense Layer***: The output shape of the dense layer is affected by the number of units specified in the code. It is a regular NN layer that simply applies activation and gives output.

Dropout Layer: CNN architecture might undergo overfitting in which the model gets trained specifically to given training data and thus fails on any new data. Dropout is the solution to avoid over fitting in which involves the elimination of randomly selected nodes from each iteration learning process

Table 1. Show the Summary of Our model

Model: "sequential"

Layer (type)	Output Shape	Param #
conv2d (Conv2D)	(None, 26, 26, 32)	320
max_pooling2d (MaxPooling2D)	(None, 13, 13, 32)	0
conv2d_1 (Conv2D)	(None, 11, 11, 32)	9248
max_pooling2d_1 (MaxPooling2D)	(None, 5, 5, 32)	0
flatten (Flatten)	(None, 800)	0
dense (Dense)	(None, 512)	410112
dense_1 (Dense)	(None, 26)	13338

Total params: 433,018
Trainable params: 433,018
Non-trainable params: 0

In table 1. Show 3*3 filter It uses only small 3x3 filters with a stride of 1.and 32 filter and and 512 neuron and 32 feature and 26 classes.

3.3 Feature Extraction Phase: Afte Pre-processing data passed CNN model for feature extraction. In our model

we use 28*28 image size. The selection and extraction of key features from an image are one of the most critical steps in image processing. Images typically require a large amount of storage space when they are taken and kept as a dataset since they are made up of so much data by automatically extracting the most crucial aspects from the data, feature extraction assists us in finding a solution to this issue it also helps in preserving the classifier's accuracy and reduces its complexity. In The main reason for using the pooling layer is to minimize the dimensionality and reduce computations with fewer parameters. Moreover, it is working on regulating the overfitting and reducing the time of training. In this layer, the max-pooling is used which selects the maximum value in each window (2×2), therefore, the size of the feature map is reduced while keeping the significant information. good improvement in the predictions in which a predefined ratio of the neurons in a hidden layer is randomly dropped per each iteration of the training phase.

Many convolutions are conducted on an input matrix with various kernels for generating diverse feature maps. These diverse feature maps are aggregated to obtain the convolutional layer output. Each convolutional layer is followed by the rectified linear unit (ReLU). ReLU represents an activation function that works on thresholding the inputs (changing the inputs to zero when their values less than zero) and generating non-linear output as in the following equation

$$Af(n)=\max(n.0) \quad (1)$$

Classification Phase: The second phase of CNN architecture represents the classification phase which includes fully connected layers. In the fully connected layer, the neurons hold complete connections for every activation from the former layer. The fully connected layer performs its functions via implementing the same basics of a typical neural network. But, the 1D data can only be accepted via this layer. To transform 2D data to 1D data, the flatten function is utilized. The softmax layer works on taking the output of the final fully connected layer and transforming the real value into a distribution of probability. The SoftMax function can be given in ewuation (2) [23], [24] {from Assel Paper}

$$P_i e^{bibi} \quad (2)$$

By Wherew P_i is the number of softmax output i. b_i is the output i, beforesoftmax, and n is the number of output node. For the final layer, size of the output is equal to the number of hand gesture classes (here we used 26 class) Using a 3 by 3 filter, scan the images and A CNN model with a tensor flow library, the proposed system's dot product between the frame's pixels. The weights of the filter's convolution layers are computed from the supplied image, this particular stage extracts key traits that are then passed on. After each convolution layer, the pooling layers are then applied the activation map of the preceding layer is decreased by one pooling layer.

IMPLEMENTATION

In our study to develop a network that can accurately predict static hand gesture image used Keras and CNN Architecture with various layer for data pre-processing and training to get the result. In this proposed system summary show in Table1. Our data set is 27455 training data and 7172 for testing. Fig. 4 Show the sample of hand gesture image, poses from the MNIST data set. The MNIST data set is separated into 80% (for training) and 20% (Testing) with 30 batch size ,30 epochs. The main aim of our paper is to construct a model with less complexity and high accuracy. In this paper distribution of our data set are show in Fig. 5**.** We also done Data visualization and exploratory data analysis By using seaborn Command it show in Fig. 6 .

Fig. 4: sample of hand gesture image classes from MNIST dataset.

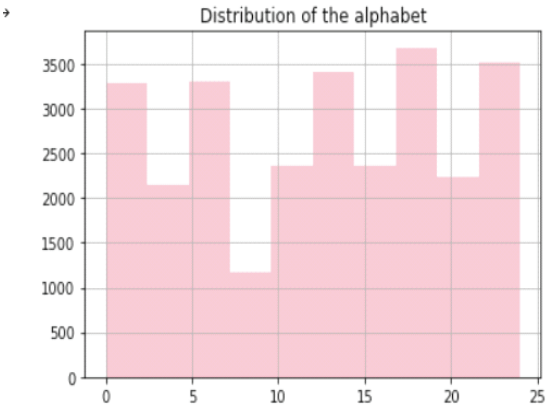

Fig. 5: show distribution of our system

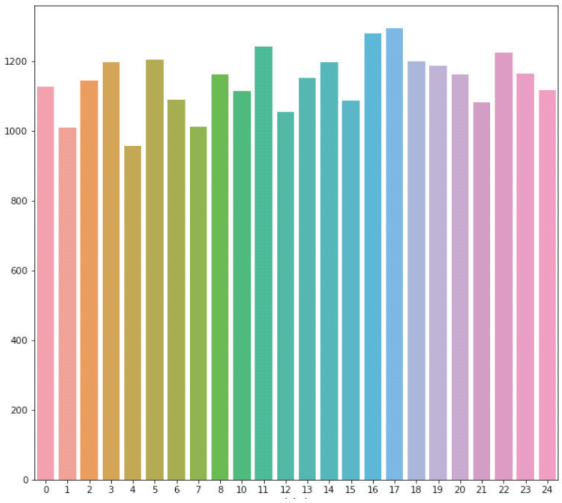

Fig. 6 data visualization

RRESULT ANALYSIS:

The result obtained with the proposed architecture are show Fig. 7. In which figure show their accuracy for 30 epoach.

```
Epoch 1/30
858/858 [==============================] - ETA: 0s - loss: 0.2019 - accuracy: 0.9349
Epoch 1: val_loss did not improve from 0.06672
858/858 [==============================] - 11s 13ms/step - loss: 0.2019 - accuracy: 0.9349 - val_loss: 0.0703 - val_accuracy: 0.9732 - lr: 1.6000e-06
Epoch 2/30
856/858 [============================>.] - ETA: 0s - loss: 0.1901 - accuracy: 0.9385
Epoch 2: val_loss did not improve from 0.06672
858/858 [==============================] - 11s 13ms/step - loss: 0.1900 - accuracy: 0.9386 - val_loss: 0.0702 - val_accuracy: 0.9735 - lr: 1.6000e-06
Epoch 3/30
856/858 [============================>.] - ETA: 0s - loss: 0.1893 - accuracy: 0.9381
Epoch 3: val_loss did not improve from 0.06672
858/858 [==============================] - 11s 13ms/step - loss: 0.1893 - accuracy: 0.9381 - val_loss: 0.0697 - val_accuracy: 0.9732 - lr: 1.6000e-06
Epoch 4/30
856/858 [============================>.] - ETA: 0s - loss: 0.1941 - accuracy: 0.9386
Epoch 4: val_loss did not improve from 0.06672
858/858 [==============================] - 11s 12ms/step - loss: 0.1945 - accuracy: 0.9384 - val_loss: 0.0692 - val_accuracy: 0.9734 - lr: 1.6000e-06
Epoch 5/30
858/858 [==============================] - ETA: 0s - loss: 0.1924 - accuracy: 0.9378
Epoch 5: val_loss did not improve from 0.06672
858/858 [==============================] - 11s 12ms/step - loss: 0.1924 - accuracy: 0.9378 - val_loss: 0.0701 - val_accuracy: 0.9732 - lr: 1.6000e-06
Epoch 6/30
857/858 [============================>.] - ETA: 0s - loss: 0.1979 - accuracy: 0.9368
Epoch 6: val_loss did not improve from 0.06672
858/858 [==============================] - 11s 12ms/step - loss: 0.1979 - accuracy: 0.9368 - val_loss: 0.0708 - val_accuracy: 0.9731 - lr: 1.6000e-06
Epoch 7/30


Epoch 7: val_loss did not improve from 0.06672
858/858 [==============================] - 11s 13ms/step - loss: 0.1983 - accuracy: 0.9364 - val_loss: 0.0706 - val_accuracy: 0.9732 - lr: 1.6000e-06
Epoch 8/30
855/858 [============================>.] - ETA: 0s - loss: 0.1945 - accuracy: 0.9391
Epoch 8: val_loss did not improve from 0.06672
858/858 [==============================] - 11s 13ms/step - loss: 0.1944 - accuracy: 0.9391 - val_loss: 0.0704 - val_accuracy: 0.9732 - lr: 3.2000e-07
Epoch 9/30
856/858 [============================>.] - ETA: 0s - loss: 0.1948 - accuracy: 0.9361
Epoch 9: val_loss did not improve from 0.06672
858/858 [==============================] - 11s 12ms/step - loss: 0.1950 - accuracy: 0.9361 - val_loss: 0.0702 - val_accuracy: 0.9732 - lr: 3.2000e-07
Epoch 9: early stopping
```

Fig. 7: Accuracy of Proposed CNN model

The experiments are accomplished via specifying different numbers of training epochs (from epochs 0 to 30) to obtain good results of accuracies is 93.61%. show in Fig. 7. Fig. 8 illustrates the increase of training and validation accuracy, Training and validation loss. Show blue and red line.

Fig. 4 illustrates the increase of validation accuracy with the final result of 100%, while Fig. 5 illustrates the decrease of validation loss with the final result of 0.0021. The obtained results of the proposed system and the previously indicated hand gesture recognition models using different datasets are summarized in Table 4. It is noticeable that the proposed system outperformed and the achieved accuracy is 100%. While working on an infrared hand gesture dataset of 38425 images, the accuracy of the recognition model in [21] is 92%. Based on these obtained accuracies, we notice that our proposed CNN framework is effective and achieved excellent results while using 20000 images.

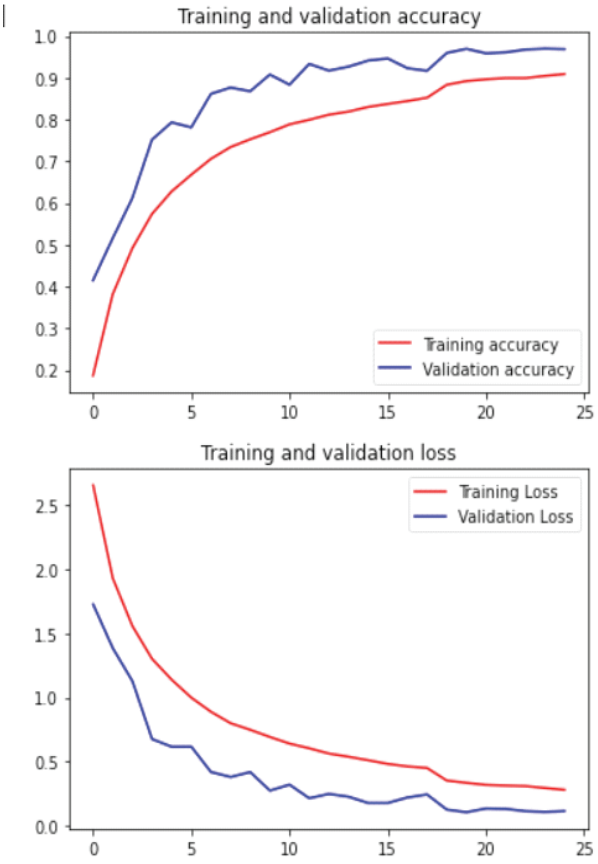

Fig. 8

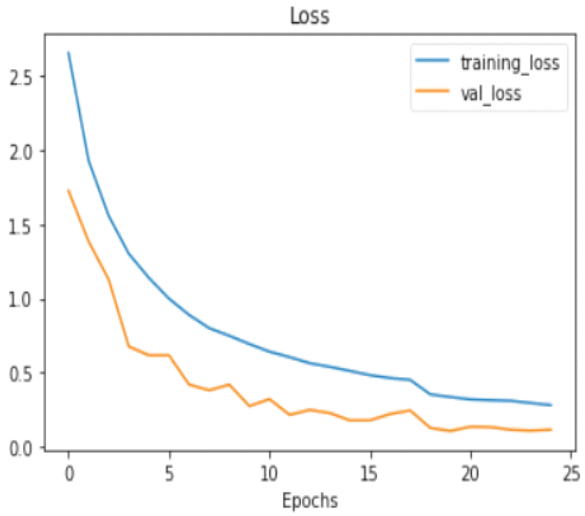

Fig. 9

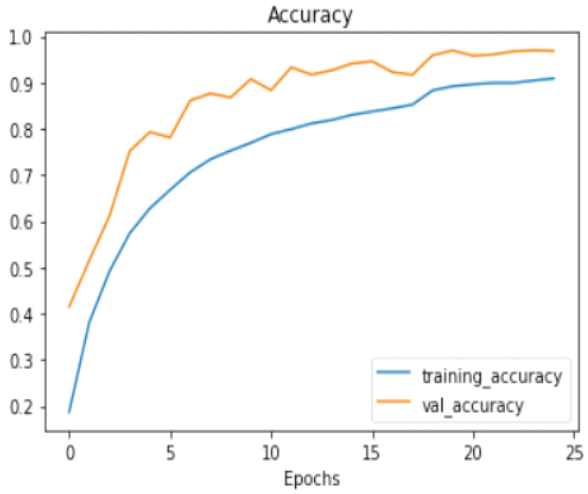

Fig. 10

In our proposed model validation accuracy are improved when increase from 20 to 30 epochs and reduce the loss show in Fig. 8 and Fig. 9 & Fig. 10 show validation loss and accuracy loss.

Table 2. Compression of CNN with published work for sign Language

Method	Accuracy
CNN(Shruti Chavan et al.[37],2021	87.5%
J.P Sahoo [43], 2019	87.83%
Tao Song [44], 2021	84.83%
Proposed system	93.61%

This method's effectiveness has been evaluated in this work in comparison to other methods that have been developed for the same classification problem of hand gesture recognition providing the broad details of this comparison. Since accuracy is the only performance factor that is consistently employed across all state-of-the-art methodologies, comparisons have only been made based on the accuracy achieved. Only, as it is the only widely used performance depends on all the state-of-art approaches. From this table, it has been found that Shruti Chavan et al. [37], and J.P Sahoo[43] and Tao Song[44] m have worked with limited numbers of signs, and their achieved accuracy is 87.5%, 87.83%, and 84.83% respectively. It is evident from these findings that the CNN model surpasses all the other methods as it achieves the highest accuracy of 96.61.0%, Sign Language Table 2 gives the comparison of this proposed work with the existing work.

CONCLUSION

In this paper an accurate and effective deep learning CNN model is proposed for prediction static hand gesture. In this model mainly used two phase feature extraction and classification. These phase involved various multi-layer ,each was design to obtain best result for human static hand gesture. The comparison between the proposed system and other related works proved that the proposed system is more effective and accurate than others. In future work, this proposed CNN framework will be prepared to be utilized for recognizing dynamic gestures

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Declaration: *We also declare that all ethical guidelines have been followed during this work and there is no conflict of interest among authors.*

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