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Chronological Evolution: Development and Identification of an Odia Handwritten Character Dataset Using Deep Learning

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There is a level of saturation obtained about Online or Printed character recognition about Indian script. Comparing the research of different Indian languages obtained yet a few researches has been done for Odia characters. There are still more research remains valid while recognizing handwritten Odia script. To overcome this challenges a proper dataset is required for experimentation. The handwritten data collected from various Odia writers. There are four process carried out to generate dataset i.e. data collection, Pre-processing, Segmentation and classification. Data is collected from different sources like school and college students, village people etc. arranged them into different age groups, gender and education level. In pre-processing selection of image, noise removal, normalization, conversation of grey scale to binary image, then converted binary images to inverted images. In this paper we have focused only handwritten simple characters that included vowels, consonants, numbers and special characters. We have created 95000 of character data of different varieties compared with other availability dataset and to find its better accuracy we have used `deep learning approach like InceptionV3 with different batch size and epoch level and find its accuracy. We obtain an accuracy of 84.50 for the used model for our collected dataset. Our handwritten data is available publically and it will be useful for the researcher to continue their future research work and for the time being it can be available on request.

Keywords: Odia Simple Characters, VGG annotation, Binary image, Deep learning, InceptionV3.

1. Introduction

The recognition of handwritten characters is under the preview of pattern recognition and Computer Vision. There are three types of data set available i.e., IITBODIAV1, NITROHCS V.1 and ISI KOLKOTA represented for numerical dataset. Still now there is no bench mark of dataset is available and not created yet. There are few data set are experimented based on curvature features of handwriting style, F-ration based weighted feature extraction, Kohnonen neural networks and multi font for Odia simple characters.

A. Odia Character

Odisha is a constituent state of the Republic of India. Odia is the predominant language, as indicated in Figure 1, with around 80% of the population being native speakers. The remaining 20% of the population comes from various regions of border of odisha. Odisha state recognises it as an official language, and it is also the second official language of Jharkhand. Odia has been officially recognised as a classical language in India, making it the sixth Indian language to receive this designation [1-3]. This recognition is based on its extensive and ancient history, as well as its distinctiveness from other dialects [4-10]. Odia, an indigenous language in India, originates from the Kalinga script, which is a direct descendent of the ancient Brahmi alphabet. The language has been shaped by the poetic contributions of Achyutananda Das, Ananta Das, Balaram Das, Jasobanta Das, and Jagannatha Das. The present Odia script comprises of 12 vowels, 36 consonants, and 10 numerals. The structure of Odia characters is predominantly rounded, similar to the characters in Devanagari and Bengali. However, in later dialects, there is a flat line at the top (known as Sirorekha) which is absent in Odia. The Odia script is case-insensitive. A phrase is concluded with a vertical line ('|') instead of a period ('.'). An important characteristic of Odia basic characters is that the upper one-third of most of them is rounded, and few have a vertical line at the right side. In the character identification, it is assumed that the characters are clearly and coherently formed, resulting in less fluctuation in their shape as a character. [11-15].

Odia vowels are called 'swarnabarna'. Vowels can either be written as independent letter or combined with constant letters represented in Fig 2 and vowels in Fig.1.

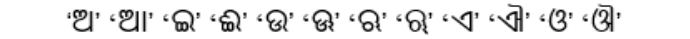


Fig 1: Odia Vowels

Each consonant has a unique form and the shape of the consonant changes depending on the vowels letter attached to it. It is represented in Fig 3. There are different types of consonants like velar consonant's, palatal consonants, Retroflex consonants, Dental consonants, Labial consonants. It is further divided into structured consonants and unstructured consonants character with circular form and Figure with vertical line, Odia character with matras and Odia lipi.

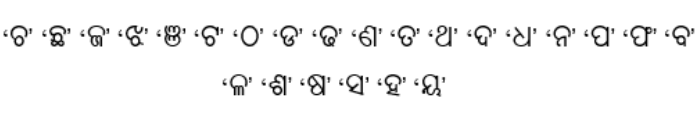


Fig 2 Odia Consonants

There are 10 digits odia digits as shown in fig. 3

Fig 3: Odia digits

There are specific challenges we have to faces like

- Like Hindi, Bengali, Kannada we have no connecting top line.
- To make separate word to character no hard and fast rule are there.
- Some of the character have mirror images like “Ga” and “Ma” has mirror image character as “Tha” and “Dha” respectively.

It is difficult to identify the character group due to its Abundance of roundish, similar and confusing character.

B. Motivation

Many dataset has created for simple character and some of them are publicly available but to find its better recoginization we need a huge amount of dataset. We decided to create a huge dataset for Simple characters of odia script. In the discipline of deep learning, various methods are employed to train machines. The experiments conducted in the field of pattern recognition demonstrate that the performance of a recognition system is influenced not only by the selection of features and classification technique, but also by the size and quality of the data. The process of creating the dataset without human interaction is a tough task. This dataset has the potential to significantly reduce the time and resources required for developing the dataset. The main obstacle is the absence of Odia databases for training the OCR engine [16-20]. Enhancements to the performance of Odia OCR are necessary for real-time recognition. This dataset substantially inspires the study community in the topic by providing a high-quality collection of Odia characters and numerals. Computer vision is commonly used for recognising handwritten characters. Researchers are urged to improve recognition outcomes by employing diverse pattern recognition algorithms, which have shown beneficial in the offline text and digitalization procedure.The aim of the research is to:

- Excessive survey focus on various dataset is provided with different orders for simple characters.
- Presents an innovative approach to generate a dataset for the Odia language in order to address the lack of available data. Using different deep learning technique to find its better accuracy and its recognition.

To test and validate the performance of the produced dataset, CNN models such as Resnet and Inception will be used.

C. Objective

The main objective of this study is

- to create a dataset for offline handwritten odia characters
- to apply deep learning techniques on the dataset
- to compare the different other language dataset

D. Paper Outline

The article is organized by starting with introduction with motivation and objective. section 2 describe the related study. Section 3 elaborate the Materials and Method of the research work. The paper describe the result in section 4 and finally it concluded in section 5 with future work.

2. Study of Related Works

In order to create effective offline recognition algorithms, Day and Balabantaray (2023) [1] created a benchmark database of Odia handwritten characters. In addition to compiling this database, their work offers a thorough overview of the field's historical developments. Insights on the development of character recognition approaches throughout time help researchers better understand the obstacles and advancements in Odia character recognition, which in turn helps them improve recognition systems that are specific to the Odia script. For the purpose of optical Odia character classification, Sethi and Mohanty (2020)[2] presented a deep learning method that makes use of convolutional neural networks (CNN) and transfer learning. Their approach represents a major leap forward in the quest for more precise character identification, especially for OCR systems. They show that CNNs can capture detailed Odia characters' features, which leads to better recognition results, by using deep learning approaches. Investigating Odia conjunct character recognition with evolutionary algorithms, Nayak and Nayak (2015) [3] provided important information for building stronger recognition methods. The use of evolutionary algorithms allows them to tackle the challenges of conjunct character identification, expanding the toolset for Odia character recognition. With a focus on compound characters, Dey, Balabantaray, and Mohanty (2022) [4] addressed offline Odia handwritten character recognition. Their study elucidates the unique difficulties of identifying compound characters in handwritten text and offers helpful suggestions for enhancing recognition precision in this area. In an effort to maximise the accuracy of handwritten Odia numeral recognition in altered domains, Dash, Puhan, and Panda (2015) [5] investigated feature extraction strategies. Their research adds to the current body of work that aims to improve numerical identification systems through the development of more precise feature extraction methods for the Odia script. To enhance the resources for study in handwritten character recognition, Das, Acraya, and Sarkar (2022) [6] introduced a benchmark image library that includes isolated Bangla handwritten compound characters. As a standardised platform for evaluating recognition algorithms and methodologies, this database is a great resource for researchers working on compound character recognition in Bangla script. In order to make study in this field easier, Mohapatra and Mishra (2015) [7] created a database specifically for recognising atomic Odia characters written by hand. Their atomic character database simplifies character recognition research, freeing up researchers to concentrate on optimisation of recognition algorithms and fine-grained analysis. An innovative deep learning method for identifying isolated Bangla compound characters written by hand was presented by Ray and Das (2017)[8], who established a new standard for character identification accuracy. By

successfully capturing the intricate structures of compound characters, their research demonstrates the promise of deep learning techniques in improving recognition accuracy. A deep learning approach for offline MODI script character recognition was suggested by Chandankhede and Sachdeo (2023)[9], demonstrating the promise of state-of-the-art machine learning techniques for solving script-specific identification problems. They show encouraging results in MODI script character recognition using deep learning, which opens the door to future improvements in script-specific recognition methods. Contributing to the progress of pattern recognition approaches suited for Odia script, Pujari and Ghosidas (2019)[10] used a clonal selection algorithm and gradient-based feature extraction to recognise Odia handwritten numbers. By including gradient-based features and evolutionary algorithms, their solution improves recognition accuracy and adds to the existing toolkit for Odia digit recognition. The paper (2017)[11] by Abhisek Sethy et al. aims to build a technique for identifying Odia handwritten characters and numbers by utilising the symmetric axis. This method is specifically designed for offline recognition, meaning it works with still photos rather than handwriting that is in motion. The approach utilises the symmetric axis as a distinguishing characteristic to accurately identify characters and numerals, hence contributing to breakthroughs in Odia language processing. In (2021)[12], M. Das and M. Panda introduce an ensemble technique with the objective of enhancing the precision of Odia character identification. This approach employs a combination of different classifiers to perform feature selection and classification, demonstrating the progress made in Odia character recognition technology. This work, which was presented at the Odisha International Conference on Electrical Power Engineering, is expected to provide valuable insights into innovative ways for improving character recognition systems. "Survey on Odia Handwritten Character Recognition" (2022) [13] authored by Dhabal Sethi is a comprehensive examination of the current methodologies and strategies employed in the domain of Odia handwritten character recognition. This survey study provides useful insights into the present state of research in Odia character recognition by examining different methods, problems, and breakthroughs. It has the potential to guide future research paths in this field. Debananda Padhi [14] presents an approach probably entails pioneering approaches or algorithms designed to enhance the precision and efficiency of Odia handwritten character recognition, hence contributing to progress in the domain of language processing (2019) [15] by K. Manjusha et al. outlines the creation of a database that encompasses handwritten character pictures specifically for the Malayalam language. This work offers useful resources for study and improvement in Malayalam handwritten character identification by providing a comprehensive explanation of the dataset collection, organisation, and annotation process. The paper by Raghunath Day [16] presents a new method for recognising handwritten characters using a sliding window technique. The publication does not specify the year or conference at which it was presented. This approach likely employs a methodology in which a movable window is traversed across the input image to extract characteristics for character identification, perhaps resulting in enhancements in accuracy and efficiency of recognition. Sampath AK and Gomathi (2017)[17] propose a method for effective handwritten character identification. This method utilises a N Fuzzy-based multi-kernel spherical support vector machine. This strategy is anticipated to include fuzzy logic and support vector machine techniques in order to enhance recognition accuracy, demonstrating breakthroughs in machine learning-based character recognition approaches. A. Sahu and S. N. Mishra (2020) [18] presents a method that utilises machine

learning to identify Odia handwritten characters even when there is noise present. This study provides solutions to issues associated with noisy input data in identification systems by providing techniques for preprocessing noisy images and training machine learning models. These developments contribute to the development of robust character recognition technology.

3. Materials and Methods

To complete our process we have followed with different technique step by step as shown in Fig 4. We have created an extensive survey of numerous publications and a number of researchers working [21, 22]. To complete this process, we have gone through many steps like collection of data from the people of Odisha by visiting different school, colleges and public. We have collected nearly from 800 different writer's handwriting depending on different age group, gender basis, education level and finally we created 95000 individual images data only for Simple characters and 18000 compound characters. We are planning to increase our volume in future. Here we have mentioned some of the simple character data set creation and its recognition depending on our cpu performance. To complete this process, we have gone through specific steps like pre-processing, segmentation, removing noise, feature extraction etc. After collection the handwritten data is scanned by scanner then applied Vgg annotation that creates a spreadsheet file which carries all the dimensional information of each character as per the sequence. It seeks to identify the presence of similar objects depicted in an image across an entire dataset. After annotation we have used the algorithm to create a gray scale image, converted them into binary and inverted images. We have used deep learning application to perform a wide range of Image processing .Each image of our data is dimensionally different so we used python software to remove the background colour and created all the image dimensionally equal in length .After creation of dataset the various forms of deep learning techniques are applied[23-27] for character recognition and the results are compared to obtain the suitable deep learning like Inception, Resnet with different batch size and epoch level then compared with other research work .The dataset is compressed and stored into the internet .For accessing this dataset it require author's permission. Here we have mentioned the link where all the Odia character dataset that included simple charaters and compound characters. The handwritten dataset is stored in the following cloud drive.

https://drive.google.com/drive/folders/13xrQdDXXZY5RWl3XtGFOtA5WX1HKQA-y?usp=sharing

https://github.com/rabi-panda2010/Odia-consonants-dataset-.git

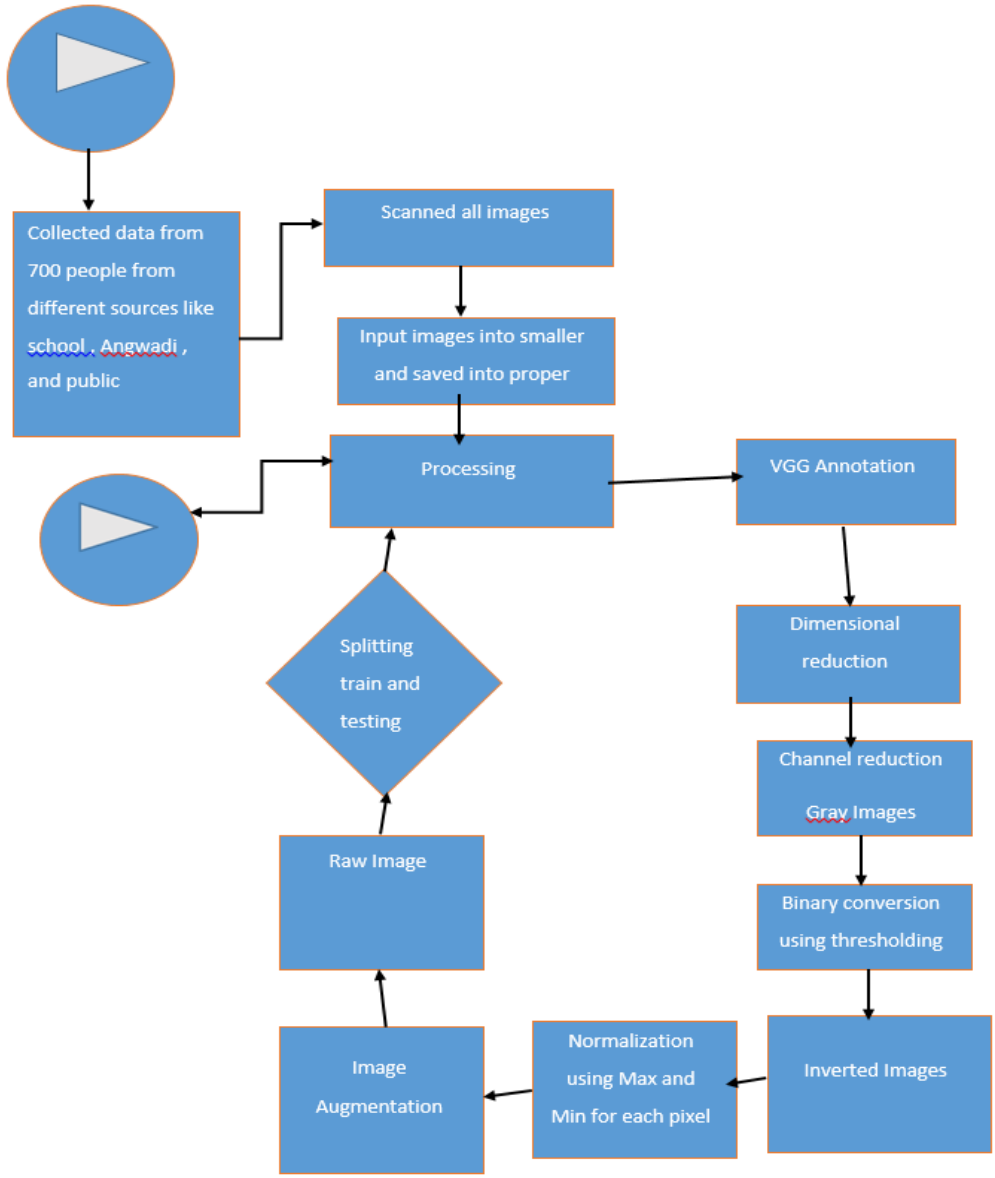


Fig 4 Proposed architectural configuration

A. Data Collection

To complete this process we have gone through many steps like collection of data from the people of Odisha by visiting different school, colleges and public places we have conducted an excessive survey from schools, colleges, Anganwadi and village people with different order like simple character including both vowels and consonant, as well as digits (0-9). Hand written Data collected from 1239 volunteers for Simple character irrespective of their age, gender and education level image dataset for further research work. We have collected the

data from plain paper, Newspaper etc. To make more challengeable we have taken noise paper. We have divided into different age group, different gender basis. Here we have represented some of the example of handwritten pages and we have mention one particular paper for its dataset creation.

Age group of participants:

We have collected and divided the handwriting document into different age

We have divided into three groups

5-15 age group (Fig 4(i), 15-50(Fig 4(ii) and 50-80 (Fig 4(iii)

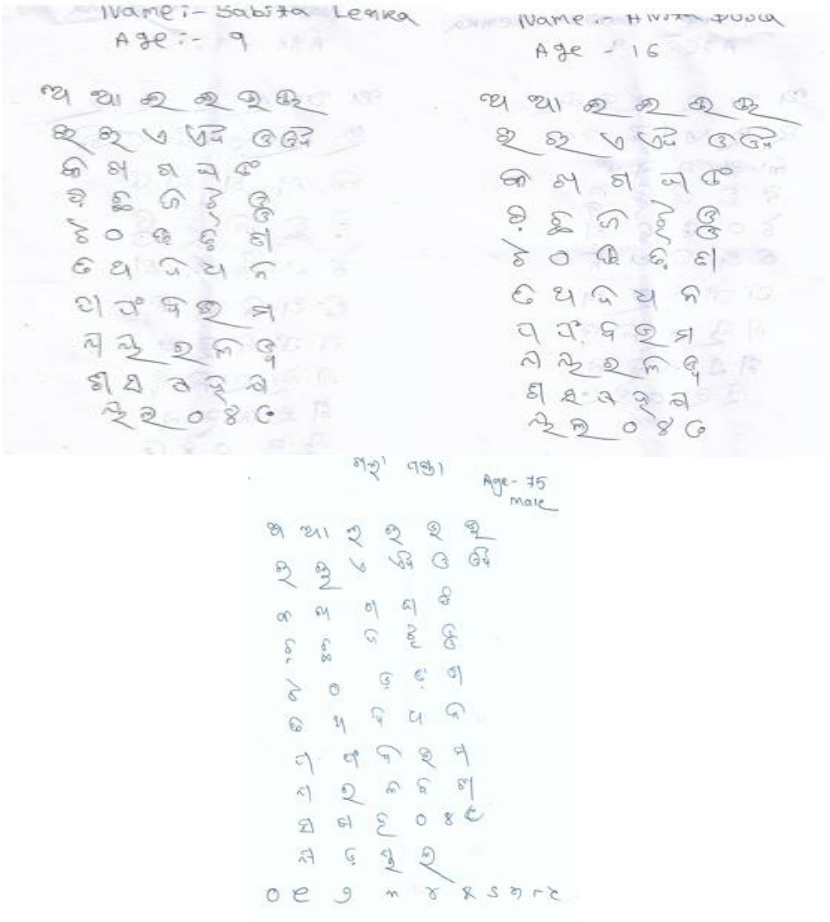
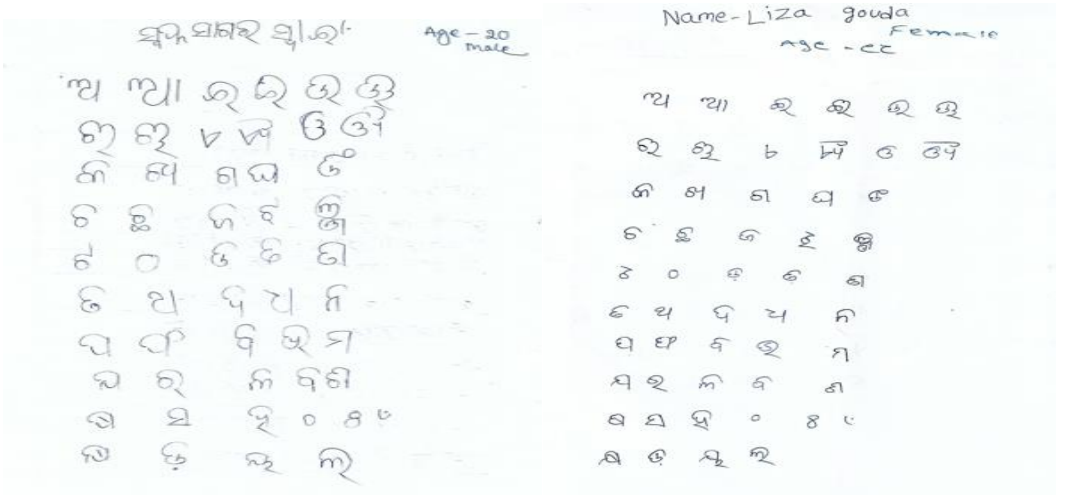


Fig 4

Gender basis data collection :

Data is collected depending on their gender basis male

Fig 5(i) and Female Fig 5(ii) is represented.



(i) (ii)

Fig 5

Newspaper data:

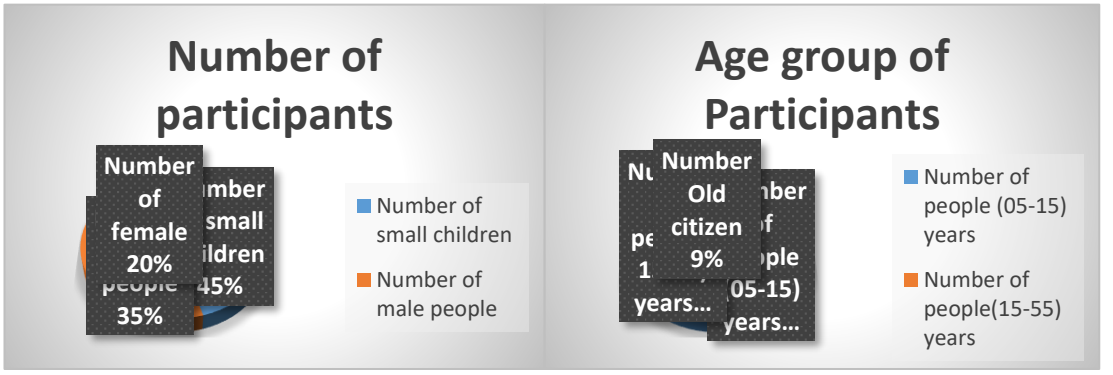
Fig 6: Data on newspaper

We have collected all the Indian language newspaper in Fig 9 and given public to write the characters. We have collected about 369 page of different new paper data to make our dataset creation and finding its accuracy more challengeable. (Fig 6)

Table 1. Distribution of participants based on age and gender category

Participants Type	Numver of involvements
Number of people (05-15) years	785
Number of people(15-55) years	346
Number Old citizen	108
Number of small children	564
Number of male people	432
Number of female	243

Table 1 shows the Distribution of participants based on age and gender category



(a) (b)

Fig. 7. Analysis of number of participanta based on a) Gender group b) Age group

Fig. 7 shows the Analysis of number of participanta based on a) Gender group b) Age group

B. Scanning:

It is the reading a text in order to find the specific information ,Here we have used HP scanner. Hp scanjet pro2600 scanner.

C. Annotation:

Image annotation is the process of labeling images in a given data set to train machine learning model, when the manual annotation is complete, a labelled images started processing by using machine learning or deep learning model to replicate the anootation without human intervation[28-32]. It can be both manually or automated. Automated annotation uses pre-trained alogorithms that can annotated the images with a level of accuracy .Manual annotation is generally assisted buy tools that help record key points for easy data labeling and storage of data. It is require for solving unique problem and AI is used in the relativly new domain. Choosing the right annotation tool require a deep understanding of the type of data i.e. being annotated and the task. It has three steps :

- Modification of the data
- The type of annotation it uses

- Format that data can be stored

D. Preprocessing:

Every sample image is converted into Grayscale. After gray scale image is obtained .thresholding of intensity is done to minimize the complexity of the image. The characters don't have any background information and can be overloaded thresholding eliminate the background. Its main objective is to enhance the quality of images for essential feature extraction. Each of the folder is fetched separetly and each images in the folder is reisize and normilised[33-37].

Dimension Reduction:

Image have same size to the extent that they do not loose their detail and those all have to be fixed size. More the image size increased, the bigger the input vector for the neural network will be and makes complex architecture and processing.

Binarization:

It is a process in a converstion of color or gray scale image into two color black and white images .We can use a parameter threshold t, with the value of which the brightness of all is assigned one tof the two possible value 0 (boundary object) and 1 (remaining object) it has two groups global and local .in a global thresholding the entire image is once and threshold remains constant but in adaptive or local the threshold is changing time to time .Here we have represented binary image of simple character is shown in Fig 8.

Binary image of simple character:

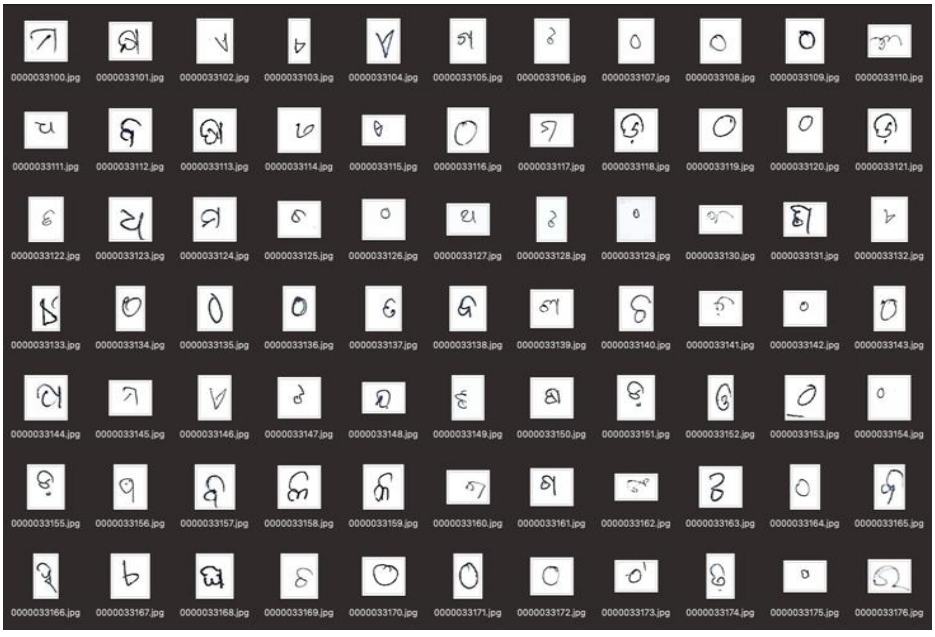


Fig 8 Binary Image sample of collected data

The Figure 8 shows the Binary Image sample of collected data

Segmentation and Reshaping:

Binary image undergoes the morphological operation to get true character information .there are two steps are morphological operations.

- Small noise is removed
- Larger connected area is identified

Noise reduction is achieved using opening operation.to locate the rectangular pixel boundary the pixel operation is collected will be further analyzed.

Normalization :

It is a process of adjusting the pixel values where each image consists of its pixel values. Images were normalized using Min-Max normlization method.

(i) Gray scale Image:

It is a kind of black & white or gray monochrome are composed exclusively of shades of gravity. It is one in which the only colors are shaded of grays. A pixel value is a scalar that quantifies the luminosity of a pixel. Each change in grey scale that occurs at an edge is accompanied by a description that includes the rate at which the grey scale changes at the edges. The grey scale undergoes a complete transformation in terms of edge length, curvature, and orientation. Gray scale images of characters shown in fig. 9.

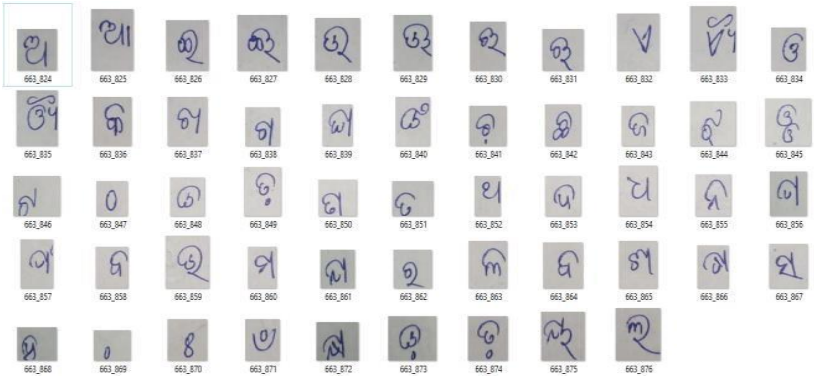


Fig 9 Simple grey scale image

E. Cropping:

To each form page to crop each letter block .the process was done manually using plain software. After cropped kept it is separate folder. All are saved, into same size .each letter is written by many writters, resulting about 1000 images. All the similarity letters are kept into a folders .each folder is resize and normalized .Median filter is used for removing salt and pepper noise.

F. Folder wise arrangement:

Each files and folder are aranged into equal size and arranged them as trained and validation set and applied convolutional neural network.

G. Inception V3:

The Inception V3 model is a complex convolutional neural network (CNN) structure specifically created for the purpose of image categorization tasks. The model was created by Google researchers and belongs to the Inception series of models, renowned for their effectiveness and precision in tasks related to image recognition. Inception V3 enhances previous iterations by incorporating advancements in both architectural design and training methodology. It is also called Google Net. It uses lot of tricks to push performance. Inception V3, a type of convolutional neural network, introduces a novel approach. These modules have parallel convolutional layers with varying filter sizes, which enhance the extraction of features across several scales. Factorized convolutions, such as convolutions with sizes of 1x1, 3x3, and 5x5, contribute to computational efficiency by maintaining representational power and improving performance without increasing the number of parameters. Using auxiliary classifiers during training helps to address the problem of vanishing gradient, promoting the reuse of features to enhance convergence and regularisation. Batch normalisation normalises the activations of each layer, which speeds up the training process and improves the ability of the model to generalise. Preprocessing input photos in a standard manner guarantees uniformity and enhances the effectiveness of training by shrinking them to a specific size and normalising the values of each pixel. Due to its high effectiveness, Inception V3 is commonly used as a pre-trained model for transfer learning. This allows researchers and practitioners to adjust it for specific datasets or tasks, taking advantage of the knowledge gained from the ImageNet dataset to improve model performance quickly in (Fig 10).

we have used Loss function i.e “Categorical_Crossentropy” and Optimizer =”adam” and find its accuracy.

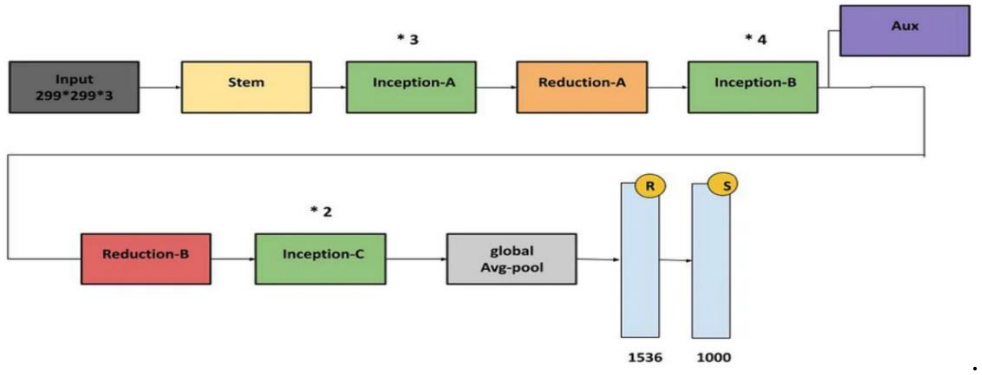


Fig 10 Inception V3 model

4. Result and Discussion

The dataset is implemented over inception V3 model and the following result obtained. The figure of the results are shown in fig. 11 and fig. 12.

Running Process :

```
['/content/drive/MyDrive/Datasets/train/Ea',
 '/content/drive/MyDrive/Datasets/train/Ai',
 '/content/drive/MyDrive/Datasets/train/a',
 '/content/drive/MyDrive/Datasets/train/Ee',
 '/content/drive/MyDrive/Datasets/train/O',
 '/content/drive/MyDrive/Datasets/train/ou',
 '/content/drive/MyDrive/Datasets/train/E',
 '/content/drive/MyDrive/Datasets/train/Aa',
 '/content/drive/MyDrive/Datasets/train/Ru',
 '/content/drive/MyDrive/Datasets/train/U',
 '/content/drive/MyDrive/Datasets/train/Ruu',
 '/content/drive/MyDrive/Datasets/train/Uu']
```

Batch Size :16 and Epoch 10

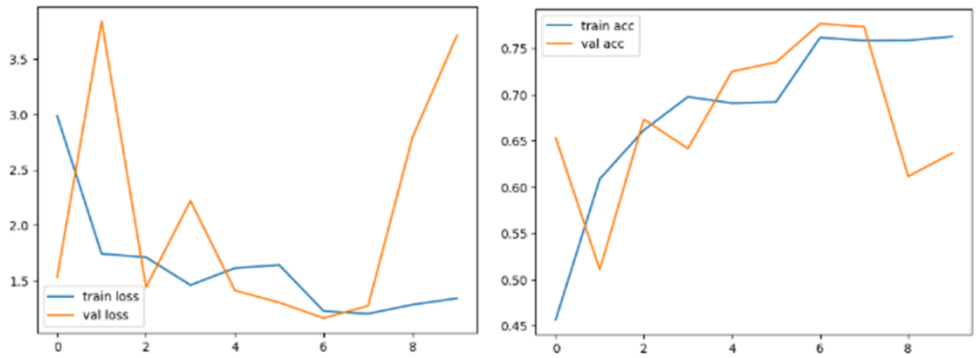
Fig 11 screen shot of trained Inception V3 model

```
Epoch 1/10
331/331 [==============================] - 2133s 6s/step - loss: 4.5686 - accuracy: 0.5409 - val_loss: 3.3224 - val_accuracy:
0.6515
Epoch 2/10
331/331 [==============================] - 86s 261ms/step - loss: 3.6072 - accuracy: 0.6766 - val_loss: 5.2560 - val_accuracy:
0.6364
Epoch 3/10
331/331 [==============================] - 87s 263ms/step - loss: 3.0326 - accuracy: 0.7377 - val_loss: 5.9137 - val_accuracy:
0.6470
Epoch 4/10
331/331 [==============================] - 91s 276ms/step - loss: 3.0505 - accuracy: 0.7612 - val_loss: 4.3466 - val_accuracy:
0.6932
Epoch 5/10
331/331 [==============================] - 87s 263ms/step - loss: 2.6679 - accuracy: 0.7875 - val_loss: 3.9541 - val_accuracy:
0.7326
Epoch 6/10
331/331 [==============================] - 91s 276ms/step - loss: 2.3819 - accuracy: 0.8045 - val_loss: 5.0901 - val_accuracy:
0.6902
Epoch 7/10
331/331 [==============================] - 86s 260ms/step - loss: 2.1423 - accuracy: 0.8278 - val_loss: 3.7670 - val_accuracy:
0.7614
Epoch 8/10
331/331 [==============================] - 87s 264ms/step - loss: 2.5302 - accuracy: 0.8183 - val_loss: 5.3615 - val_accuracy:
0.7189
Epoch 9/10
331/331 [==============================] - 87s 262ms/step - loss: 2.1375 - accuracy: 0.8372 - val_loss: 5.5184 - val_accuracy:
0.7144
Epoch 10/10
331/331 [==============================] - 97s 292ms/step - loss: 2.0570 - accuracy: 0.8450 - val_loss: 4.5173 - val_accuracy:
0.7379
```

Accuracy obtained : 84.50

Fig 12 screen shot of accuracy of Inception V3 model

The graph obtained LossVal_Loss and AccVal_acc by using train loss and validation loss for Vowel character data are shown in figure 13 (a)and (b). (Fig 13)



(a) (b)

Fig. 13. Graphical representation a) Loss data b) Accuracy data

5. Conclusions:

The quality and similarity exits with collected dataset is computed. We represented analysis report in tabular way but it is time consuming but better analysis. After comparing many literature we concluded that there need a benchmark character dataset for better research and it give ample opportunity for the researcher for their research work. We have created a bench mark dataset for both simple character that include vowels and consonant, special character, digits by collecting the data from 1239 contributors. After going through different processing steps are carried out to standardize the input images by using Python OpenCV. Finally we created a grayscale image but due to noise we converted into binary images and then inverted images. Finally we created huge dataset by 95000 of data sample. To extend our manuscript we have taken only vowels characters for further processing and created spastically analysis. Our dataset is publicly available and access right can be given by the owners concern. In the future we are planning to create a dataset from old letters, manuscripts, revenue handwritten data and news manuscript hand written data that boost our language for further level.

To extend our dataset we have created Odia Compound Character dataset and implemented different deep learning technique .we are going to publish our next article. We have collected different Indian language newspaper like kerla , tamil , telgu, bengli, hindi, odia, English and hindi etc and scanned and annotation work completed and created a dataset that we can represent our next manuscript .Here we have represented few example of some of the annotation data of compound character as well as newspaper handwriting character data.

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