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ONLINE KANNADA HANDWRITTEN WORDS RECOGNITION USING DEEP LEARNING

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Abstract - *The main objective of this paper is to recognize online Kannada handwritten alphabet, kagunita and ottakshara. Data collection is done using the graphics tablet and stylus pen. Data collection consists of 25 samples of 49 characters of Kannada alphabet, 25 samples of kagunita of all the consonants, and 25 samples of 34 ottakshara. In total, 15,675 samples are collected. The main techniques used here are Image Processing and Deep Learning. 80% of data is used for training and 20% for testing. The classifier used in the Deep Learning is CNN which yields 97.09% accuracy.*

Key Words: *Graphics Tablet, Stylus Pen, Deep Learning, CNN, Image Processing*

1. INTRODUCTION

Basically, Kannada is a major language in Karnataka. Kannada is the official language in Karnataka and all the notifications in government institutions are in Kannada language. Recognizing the handwritten Kannada words is the intention of this paper. Instead of using the keyboard and typing Kannada by Nudi in laptop or computer, if graphics tablet is used to write, whatever we give input, that will be automatically printed. This decreases the burden. One who is unaware of keyboard, even he can write and get the written words in the standard text form.

Recognition is done by using Image Processing and Deep Learning. In Deep Learning Convolution Neural Network is the best classifier that suits proper recognition of online Kannada handwriting.

Data collection of 15,675 samples is collected to recognize alphabet, kagunita as well as ottakshara. The pen movement on the tablet helps to collect the dataset. Each data is stored in different folders. Each folder consists of 25 samples of Kannada character. Python language is used to write code for data collection and data prediction.

2. LITERATURE SURVEY

Research is going on regarding recognition of Kannada handwriting in online mode. Keerthi Prasad G, Vinay Hegde [1] proposed online Kannada handwriting recognition. Data is collected through the pen movement on the graphics tablet. It can be writer dependent or independent. This work focused on writer independent handwriting recognition. Anirudh Ganesh[2] proposed for Kannada numbers using CNN and DBN. The data collection is 74,000 and the accuracy of recognition is 97% in CNN and 98% in DBN. Salma Shofia Roshyda, Tito Waluyo Parbuda[3] proposed for various handwriting recognition. After reviewing they concluded CNN is the best classifier which yields more accuracy. Gandhana M[4] propsed for recognition of online Kannada characters and numbers. B Vijay Kumar and Ramakrishna[5] proposed for recognition of Kannada printed text. Rampalli and Krishnamurthy[6] proposed for recognition of characters in online and offline. Recognition in online is 11% more than offline. Ragha L R *et al.,* [7] the recognized for characters with recognition results 86% for vowels and 65% for consonants. Shashikala Parameshwarappa *et al.*,[8] proposed for Kannada handwritten character recognition with 99.09% accuracy using SVM Classifier. Parikshith H *et l.,*[9] proposed a method in which any new style characters can be predicted. Ganapatsingh G Rajputh *et al.,* [10], proposed a method to recognize characters with K-NN and SVM classifiers.

3. DATASET

The dataset is collected through graphics tablet and stylus pen.to collect dataset we use command prompt. The steps are as follows.

1. Create a folder and label it. Open command prompt by the instruction 'cmd' the command window will be displayed. Type, 'code .' the code will be opened, make necessary changes regarding character count and folder name. Save it by pressing 'S'.

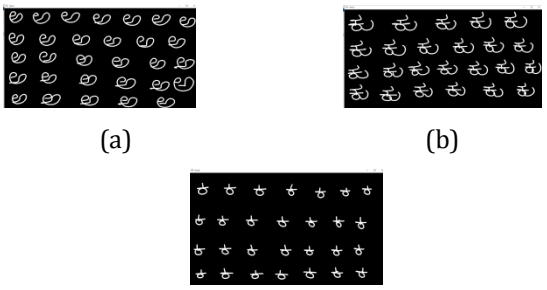
2. Go to the command prompt window, type 'activate project'.

3. Next, type 'python dataset_main.py'. It provides a check window to collect dataset. Collect dataset of 25 samples of a specified character. Press 'S', to save. Press 'Q' to exit.

4. The data will be cropped and stored in the specified folder.

5. Create new folder before collecting data for the specified character and label it. Repeat step 3, until the collection of data for all the characters.

6. Close the window after the collection of data.



(a) (b)

(c)

Fig-1 Dataset collection (a) alphabet, (b) kagunita (c) ottakshara

Fig-2 Cropping of ottakshara

Fig-3 Dataset collected in folders

4. METHODOLOGY

This section describes the methods that are employed.

Data acquisition

The dataset is collected by using the Graphics tablet and stylus pen. Once the graphics tablet is connected to laptop, the connection is set up. Then thee dataset is collected and saved in the specified folder. The size of the ottakshara should be less than 50% size of the alphabet or kagunita. So that it will be appended to the main character.

Pre-processing

Here the collected data is subjected to the resizing. Whatever the size of input, the image will be resized to 52 X 52. Data collection is through online, so there is no need to remove noise. The collected data is also subjected to binarization. The characters appearing on the black colored check window will be white. The data will be segmented into three types, namely, character segmentation, word segmentation, sentence segmentation.

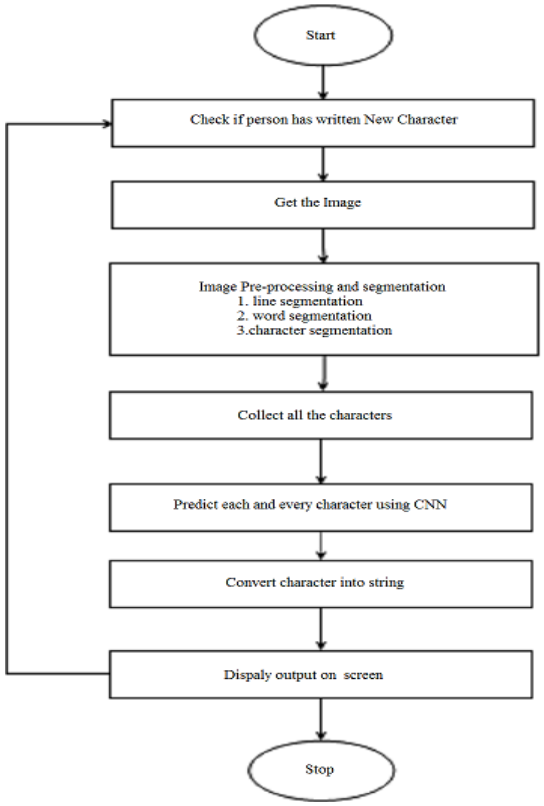


Fig-4 Flow diagram of proposed methodology

The flow diagram of the proposed methodology is shown above. It depicts the flow of the procsses that are involved.

It mainly uses the techniques of Image Processing and CNN in Deep Learning which are best suited for this paper. As online recognition is implemented there is no overhead of noise removal, scanning the characters etc. Online recognition is very interesting and can be widely used. Online recognition gives better results and more accurate when compared to that of offline recognition. There will be no discontinuties because dilation, a morphological opration is employed. The color images are converted to gray then to black and white for preprocessing.

Segmentation

After data collection, the data need to be segmented. The segmentation is of three types.

Character Segmentation

Word Segmentation

Sentence Segmentation

Let us take an example of sentences in which alphabet, kagunita and ottakshara are present.

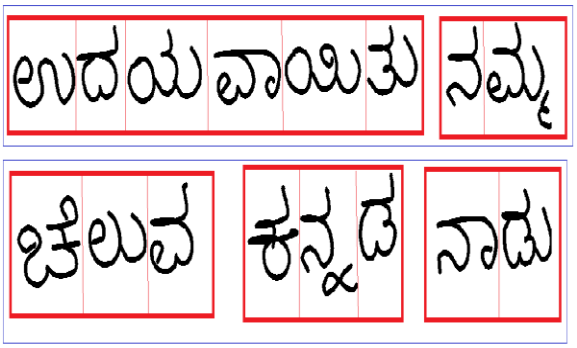


Fig-5: Segmentation of character, word and sentence

In the case of ottakshra, when the image is taken, the color conversion of characters from color to gray and then from gray to black and white conversion takes place.

Bonding boxes are applied. To identify the presence of ottakshara, the height of the ottakshara should be less than 50% height of the original character. If not, there is no ottakshara appended to the character.

In the above depicted figure 5, the character segmentation is shown in thin red line, word segmentation is stored in the thick red rectangular box. The sentence segmentation is shown in blue color rectangular box.

In the output window when the user gives the input, the segmented characters, words and sentences are saved in a folder. Let's take an example. If the image is saved as 01-01-01-0.png, it means that thee segmentation is done for first sentence, first word and first character. 0 at th end tells that there is no ottakshara. If 1 is present at the end it means that there is a presence of ottakshara.

Each character extends pixel to 5 pixels towards right. So that one word is recognized.

If 50 pixels are extended then it considers it as sentence. Rectangular shape is used to recognize the different words. To recognize the characters 5 pixels are extended.

Image processing is the main technique that is employed here to do segmentation. Cropping is done in this process. The pixels are extended mainly to get the content of data, so that no information is lost.

After character segmentation, if the segmented characters that are stored in the folders are not properly segmented, it leads to wrong recognition of characters. Such data need to be discarded.

If the segmented characters contain the proper character that are written by the users, then such data is considered as it gives the best accuracy in the output. Data segmentation plays a very important role. If segmentation is done properly then the remaining next processes are easily carried out. After data collection the characters need to be segmented. The data collection contains 25 characters in each folder. There will be 15,675 characters need to be segmented and saved in the respective folders. The dataset includes these characters which are shown below.

Fig-6 Kannada Alphabets

Fig-7 Kannada Kagunita

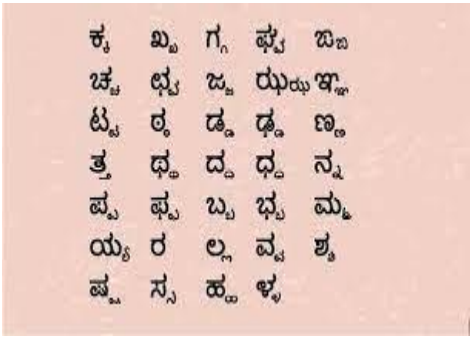


Fig-8 Kannada ottakshara

CNN

Using the CNN model, 80% of the data is used for training and 20% of the data for testing. Among the available neural network algorithms CNN is considered as the best. It consists of three layers, namely 1. Input Layer 2. Hidden Layers 3. Output Layer

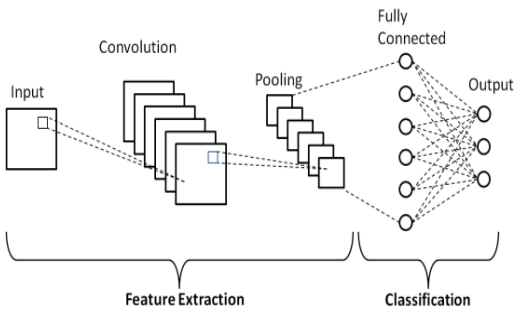


Fig-9 CNN Architecture

Feature extraction and classification are done using CNN. Hidden layers in CNN are: 1.Convolution Layer 2.Pooling Layer 3.ReLU Correction Layer 4.Fully connected layer 5. Softmax layer.

Labeling the data

Each collected data is assigned with a number. The folder name that is assigned to the character is assigned to the standard characters. So that computer recognizes easily and efficiently.

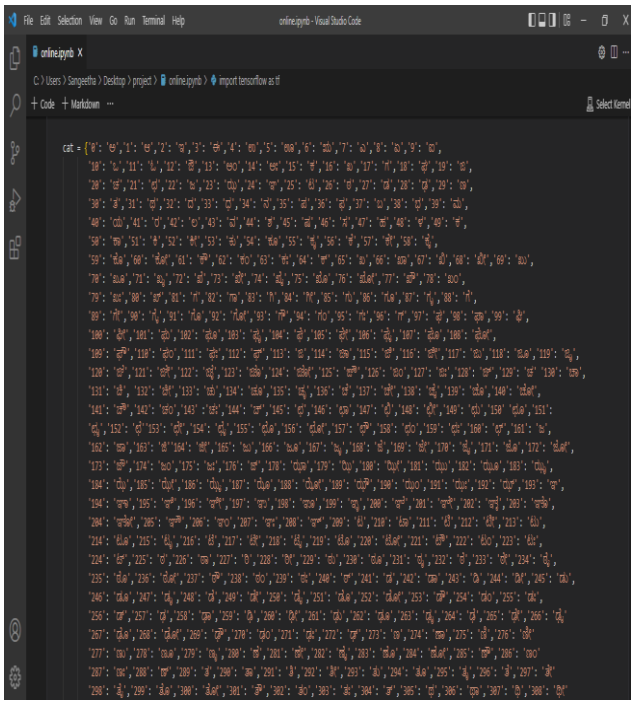


Fig-10 Labeling the data

Training and Testing

In the training phase 80% of the collected data is used and 20% of the data for testing. The accuracy of training and validation increases and the training and validation loss decreases.

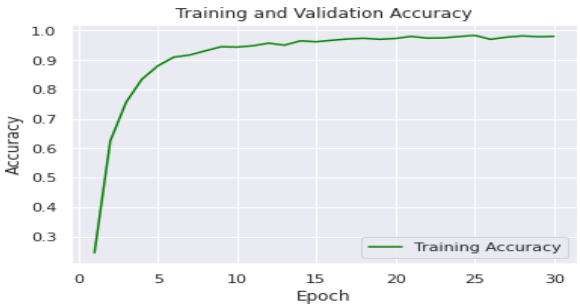


Fig-11 Training and validation Accuracy

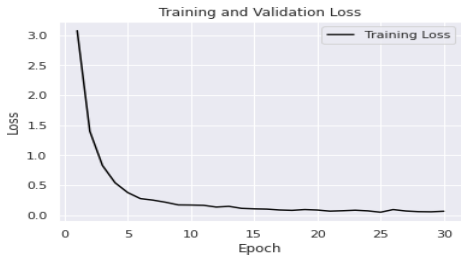


Fig-12 Training and validation loss

5. RESULT

Anaconda prompt is used here to get output window. There are three windows which display the result. First window enables user to give input and in same window output will be displayed.

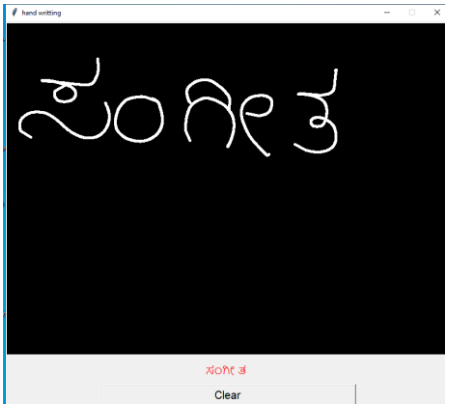


Fig-13 Input and output displayed in the same window

The second type of output window enables user to give input in one ‘check’ window and after saving it by pressing ‘S’, the result will be displayed in the ‘result’ window.

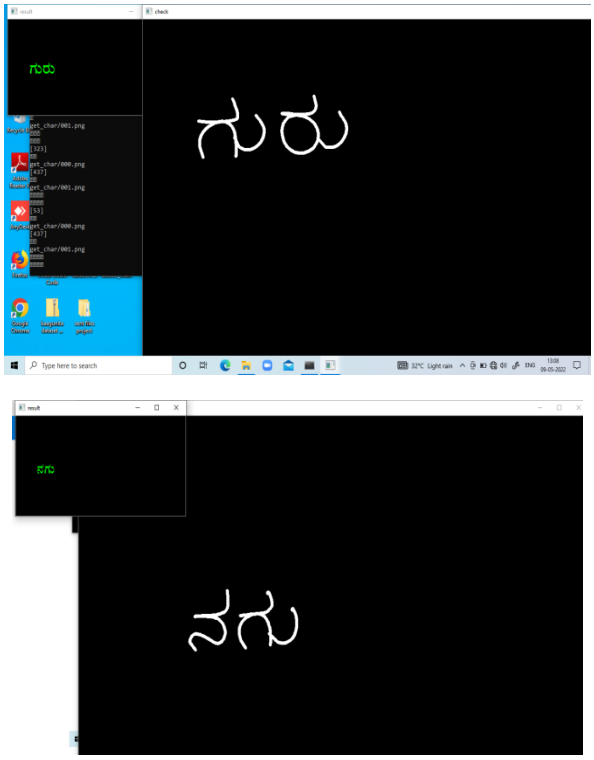


Fig.14 Input and output displayed in separate windows

This window not only displays the combination of kagunita, it can also execute characters of alphabet. As we give some space after each character, the space will also be displayed in the output 'result' window. This is illustrated in the figure 14.

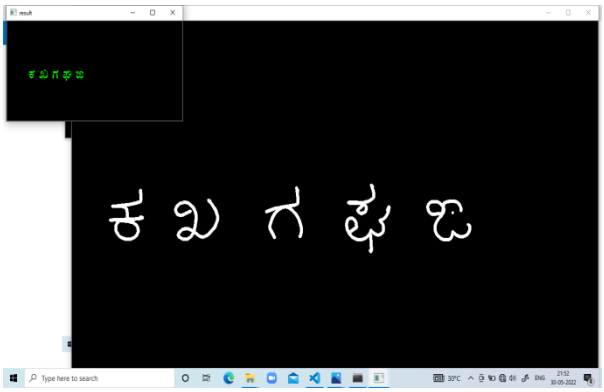


Fig-16 Output displayed in notepad

The output window in which input and output are displayed in the same window, the size o input window is small. The input can be cleared by the user by pressing 'clear' button that is present below the output display.

The output cannot be edited. In other words, the output cannot be copied to any other files. cut , copy, paste options are not available.

The next type of output window in which input and output are displayed separately enables the user to write in 'check' window and displays the output in the 'result' window. Here, the input can be cleared by pressing 'C' on the keyboard. If the input is properly written the output will be displayed as soon as the user press' S' on the keyboard.

This window also does not provide editing the output, means increasing the font size or changing the font style or copying the content etc.

The input window is somewhat wider, but the output window is very small. It does not display if the user gives input as a paragraph. But it will recognize the characters perfectly. It does not need much time to receive input and display it. The output style can be changed when the user has some different font styles downloaded in the system.

In the third type, the input and output window both are wide.

In the input window, where user gives the input, if he writes anything wrong he may clear the screen. The input can be cleared by using 'C' button on the keyboard. Then user can give a new input in the input window. This process goes on for every new input.

Once the input is fed to the input window, the user has to press 'S'. it takes some time to accept the input. Then the user has to open the 'data' file in his system which is saved before.

As soon as the file is opened, output will be displayed in thee notepad. The user can change the font style, font size, save the output. These changes can be made by the user in this output window.

This window enables user to get the standard Kannada text for characters, words, sentences, paragraph etc. So this window is considered as the best among the three output windows.

The main problem in this paper is huge data collection. The user has to know how to hold the stylus pen, how to hold the graphics tablet, where to start and where to stop writing.

Fig-17 Graphics tablet connected to the laptop

It is easy for user one who knows all these techniques. That person can collect data very fast. There will be no overhead of discarding the characters once they are cropped and saved in the respective folders. If any characters are not cropped properly, or if two or more characters are cropped in the same image, such images can be discarded.

Fig-18 Cropped images are stored in the folders

While collecting dataset for ottakshara, the size of the data should be small and many of the collected data is discarded. Only the properly cropped characters are considered. Again the remaining samples are collected.

While collecting dataset for kagunita, some characters are wider but they should be collected in the specified size. If the supporting characters that are appended to the main characters are missing it is also a overhead. Such data need to be collected till the collection of 25 samples is collected.

The accuracy is not 100%. If more samples are collected, then the accuracy will be increased. The input for some characters needs to be written in a specified format. If the input is not fed in that specified format, the detection of such characters is wrong.

If any scratches are made to the words in the input window will not be displayed in the output window. If any symbols are fed by the user in the input window, those are not executed in the output window, because the dataset collection is composed of characters only. The dataset is not collection of symbols.

The output presented in the third type is very helpful and can be used to copy the output in the desired format in the other files or folders. In Karnataka this as the official notices are circulated in government institutions and offices is in Kannada language, there will be variation in the font size in the heading and content. Such modifications can be made in the output which is displayed in the standard Kannada text format.

The output can be obtained at that instant as soon as the user provides the input in the input window. This makes the time to be saved. Instead of typing Kannada in laptop and get it printed, if digital pad is connected and written it is easy to use and easy to get the output.

Many people are unaware of typing Kannada in the laptop or in the computers. It is very useful for them. As the technology is rapidly increasing from day to day everyone has to know and implement and gt the work to b done in easy way with less time. Input given to the system can even be a song or proverb, it will be printed.

In this last method, thee background is white and the input is black color. The output displayed is also in black color. Color conversion process uses the Image Processing technique. The thickness of input characters is more when compared to that of the output. The thickness of output characters can be increased by increasing the font size in the notepad.

It enables user to give more input words and sentences, and displays the output. It is the most beneficial and the best window for user to give input and get the output and increase the font size to the desired font size of the user. The ottakshara will be appended to main character. If the ottakshara is less than 50% of the main character. Training accuracy is 99.23%, training loss is 0.0251%, testing accuracy is 97.09% and testing loss is 0.210% by Tensor Flow frame work.

As CNN classifier is used, it gives the more accuracy when compared to that of other methods. CNN is used in the Deep Learning that is employed here. It trains the system as we train our mind.

CNN classifier is selected after reviewing so many reference papers. Other classifiers are also used in the reference papers but CNN gives the best result. So that the prediction loss can be minimized and accuracy is more during training as well as testing the data.

The ottakshara are collected in a manner that the main character is not used along with it in the dataset. This enables to get the output in such a manner that any ottakshara can be appended to any consonant or any kagunita . it gives a wide variety of characters, words and sentences to be available in the standard Kannada text form.

The output execution in the third type is more preferred and wider output display enables to make so many changes like changing the font size and other benefits.

The output can be saved in the standard text and can be opened at any time anywhere if it is saved in the laptop. There is no need of internet to open the saved file in the system. No need of other huge external devices to be connected, it just needs a light weight digital pad to be connected to the laptop.

The accuracy will be 100% if data is collected from many people which consists a sample of 100 or 200. The chance of getting the best accuracy is there for huge data collection of Online handwritten Kannada characters. There is no overhead of misplacing and losing the data s it may occur in the offline character recognition.

The available dataset can give a wide variety of words in a standard Kannada text form. Online Kannada Words recognition is very helpful and easy to implement in many institutions and universities where Kannada is used the most for circulars which are in Kannada language. As the accuracy is more there is less overhead of wrong recognition of the characters. The accuracy can be known by 'Tensor Flow'. The confusion matrix also tells about the accuracy of the output for the proposed method.

The calculation can be made for output display in terms of centimeter and pixels.

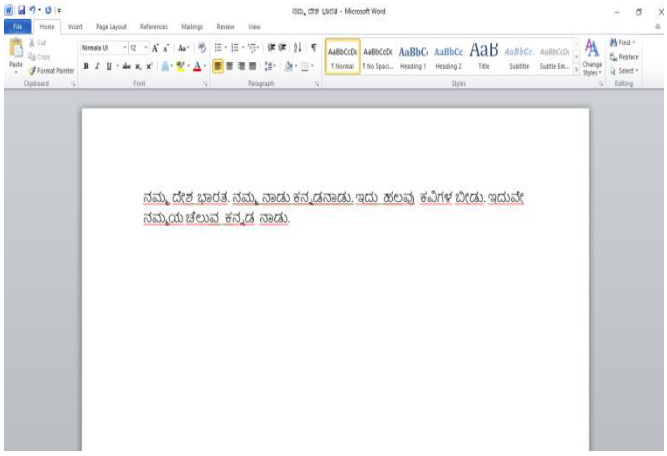


Fig-19 Output in the Microsoft Word

Let us consider the above figure. 19. The output of notepad is displayed in the Microsoft Word. The page size is A4. The length and width of the A4 sheet is 21 X 29.7 cm. The margin consumes 2.54cm in the left and 2.54cm in the right side of the A4 size page.

There are 33 Kannada characters in the first line. 11Kannada words can be written in the above considered example in A4 size page as illustrated in the figure 19. After 11 words, 12th word cannot be executed in the first line. It has move to the next line of the sentence.

CALCULATION

Size of A4 sheet : 21 X 29.7 sq.cm

Margin left in the left side : 2.54cm

Margin left in the right side : 2.54cm

Total width left for margin : 5.08cm

Available space for executable line (A) :-

A = Total width – 2(margin)

A = Tw-2M

Width of A4 sheet : 21cm

Available width for the first line: 21cm-2(2.54)cm

Available width to for first line :15.92cm

2(margin) is considered in calculation. It is because, the margin left in the left side as well as right side.

where, Tw is total width of A4 sheet

2M is margin in left and right

If the above calculation is written in terms of pixels,

Margin left in left side = 96 pixels

Margin left in the right side = 96 pixels

Total width for margin (2M) = 192 pixels

Width of A4 sheet (Tw) = 793.7007874 pixels

Width provided to print a line (W)

W= Tw- 2M

W= 601.700784 pixels

Width available for executing a line is given by the formula:

Wc = ∑Wn + ∑Gw

Where, Wc refers to available width to execute a line consisting of characters and space after each word.

Wn refers to width occupied by sum of characters in the first line

Gw refers to gap left after the execution of each word in a sentence in the first line.

6. CONCLUSION and FUTURE SCOPE

In this paper, online Kannada handwriting is recognized in the online mode using the graphics tablet and stylus pen. Data collection is very easy. Preprocessing, segmentation are also important in this paper. Training and testing are done using CNN classifier. Python is the language used to write the coding for data collection and data prediction. Image Processing and Deep Learning techniques are used in the proposed paper. This is very beneficial especially in Karnataka as Kannada is an official language of Kannadigas.

In spite of wasting time in typing in the keyboard, the output will be displayed in the standard form as we write the words on the graphics tablet. The output is displayed in three different windows, among them the last window is the best. Because the user can modify the font style and size, copy the output, cut it or paste it anywhere, the user wishes to do it in other folders.

There are many methods to get the characters to be printed, among them this is the best method to be employed. It is very helpful as the loss of data is less, it does not need ink to write, it just uses thee stylus pen. As the technology is improving this kind of techniques need to be employed to get the work to be done even by a user who is unaware of using 'Nudi'.

This paper recognizes the Kannada characters in online mode which is very beneficial an there is no loss of images that are collected and no overhead of noise removing. Nowadays, there is a huge scope for handwriting recognition. This paper explains the handwriting recognition of Kannada language which is very helpful. It not only displays output in words or sentence format, but also in paragraph format also. It enables user to modify the font style and size according to user wish.

There is no tension for the user regarding losing the data collected, or misplaced or lost due to any reason. There is no need of pen and paper. There is no need to scan the data for saving and segmenting in the laptop or computers.

There is no need o battery for stylus pen. If the nibs are flattened they can be removed and other nibs can be easily inserted which takes only few seconds of time. Any number of data can be collected without pen and paper. There is only one time investment for the graphics tablet. There is no interference of noise which is the main problem in audio to text recognition.

The execution of Online Kannada characters in the standard text is easy and helpful for many purposes with less time and less resources anywhere and anytime without learning 'Nudi' which is popularly used by most of the Kannadigas to get the standard Kannada text format in the laptop or personal computers.

Online Kannada Recognition is very beneficial for many Kannadigas present across the world. It recognizes the characters, words, sentences and paragraphs and gives the output at that instant only.

There is no need to depend on the people who can type 'Nudi' very well. One is unaware of Kannada typing can also get the Kannada in the standard text format. Once the process from data collection to testing is completed, the user can get any kind of output whether in the form of single character or in the form of paragraph of many pages.

In future, characters or words with two or more ottakshara can be executed which gives a completion of executing any characters / words. More accuracy can be made available in future. The biggest challenge for the researchers in Kannada handwriting recognition in online mode is to get 100% accuracy. No loss in accuracy need to be achieved. There are many words in Kannada with two ottakshara, such words are included in the many sentences. If those words are also included, then only there is recognition of such words makes the words and sentences meaningful and appropriate in Kannada language.

The execution of 'O' with any Kannada characters should also be made to execute them in the standard form. Only the consonants attached with 'O' are executing, but other kagunita should also be made executed with 'O'(anuswara). Some characters which are used in Kannada but not included in characters, kagunita and ottakshara need to be executed.

The above mentioned points can be implemented in offline as well as online character recognition. There is a huge scope in future for implementing the above mentioned points to make a blended recognition in a single system which recognizes the Online Kannada characters as well as the offline Kannada characters so that whichever method is convenient for user, user can use it according his choice.

Accuracy need to be increased by trying some other different methods that are widely available. There is a chance to get the 100% accuracy for the input provided by the user in the future with no delay.

Instead of writing in the input window all the characters can be made available in the portion of a window, in one click on that character that character need to be printed in the future.

Even with the less data collection the accuracy of the output has to be made 100% in the future.So that the writer independent system is implemented and can be used in the future. So that there is no necessity of writing the words in the input window as it is in the data collection. It recognizes for any user handwritten characters in Kannada language which is widely used in Karnataka by Kannadigas.

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BIOGRAPHIES

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