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Dysgraphia disease detection using handwriting analysis

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ABSTRACT

Dysgraphia is a term in Greek as 'dys' means having some disability and 'graphia' means handwritten letter. Dysgraphia is a disease which causes writing disability. In this disease, the child faces huge difficulties in putting their thinking on paper which can be noticed in terms of wrong spelling, irregular letter size, and spacing between letters. The children suffering from such disease should get the treatment so that these symptoms get reduced in the future. We aim to develop an application that can be used for the diagnosis of Dysgraphia disease. Dysgraphia is a disease that can seriously impair children in their day to day life. Early detection of handwriting difficulties is therefore of great importance in paediatrics. The project mainly focuses on handwriting analysis which is achieved using machine learning and image processing techniques. The project model focuses on performing handwriting analysis on image. The model extracts features like letter size, the slant of letters, spacing, and pressure from the image of a child. These features are evaluated for the detection of Dysgraphia presence in that child. The project model is mainly customized for 5-12 years old children. The aim is to keep assessment simple and it only requires mobile, pen and paper.

Keywords :*Dysgraphia, handwriting, learning disability, technology.*

I. Motivation

When thinking about childhood when children start speaking and try to catch chalk or pencil. We feel that the child is about to learn or try to do something and want to show something through drawing, making lines, shapes, alphabets, and numbers. Every parent has a dream

that his child should learn something. Some students are not capable of reading, writing, understanding things properly. This happens when the child has some disease, such as Dyslexia, Dysgraphia.

We choose this topic because every disease has a solution. He/she can overcome that disease or we can help. This model helps to know whether the person has Dysgraphia or not. The most important thing that a person is suffering from this disease is the handwriting which is difficult to understand for other people. Different models have fun activities which attract the children and we use them as a test, to identify disease. This model collects different information from users through tests. Based on the submitted information the result is given

Dysgraphia is a condition, if it happens at childhood, it lasts long. There is no cure for it, so it doesn't mean that the person can't succeed with it thoughts, his writings.

II. **INTRODUCTION**

Modern medical science always believes in detecting disease without any invasion into the human body. The applications which can effectively detect disease based on human activities like speaking, writing, body posture and their way of expressing their thoughts and also the factors like impaired concentration and environment movement, are always appreciated for clinical examination [5]-[6]. Brain has different motor skills and that skill helps a person for thinking, writing and from that lack of it we can't say that the person has dysgraphia. One of the basic learning things that children learn is to read and write. As means, it is taught in early stages when they grow. In school sometimes teacher misinterprets that their students are lazy or dumb as they don't try to catch up things easily [10]. They might be affected through some learning problems such as Dysgraphia or Dyslexia [1].

Dysgraphia is a disorder in which the person can't properly read or write, also not able to analyse the words [3]. The child suffering from mild dysgraphia remains unnoticed most of the time and hence they lack treatment. The most common things about their handwriting is spacing between letters, or misspelled words, also basic things like confusion between similar letters like b and d [3]. Children with this disorder may not only affect their daily habitat, but also their learning, thinking, and expression as they don't have any social contact. In addition to poor handwriting, dysgraphia is characterized by wrong or odd spelling, and production of

words that are not correct (i.e., using “boy” for “child”). This disease not only affects the child group but also adults. It affects some parts of the brain in adults.

In children, the disease is most often about 5 to 13 percent and as dysgraphia doesn’t grow, many adults are still with this learning disability. Diagnosis and useful treatment of this disability at an early stage is very important to enhance the child’s abilities to learn as well as to reduce different psychological factors. In this paper, we developed an application model to diagnose Dysgraphia. The tool is mainly customized for children of the age range of 2 to 9 years old [4]. The assessment in this application consists of handwriting analysis technology which takes images of handwritten samples as input. This test would be used to derive the level of dysgraphia in a child.

III. **Handwriting analysis for diagnosis**

Handwriting plays a vital role in the detection of cognitive impairment. Handwriting samples are easily available and do not require any invasion. Handwriting analysis is also called graphology. Graphology is termed as to determine personality and characteristic of a person. Also to determine that the person is feeling loneliness, having lack of confidence, low interest. The handwriting is a valuable tool in the assessment of disease in the medical field. Handwriting samples are used for the diagnosis of Alzheimer’s and Parkinson’s diseases. Online handwriting analysis is used in most important applications i.e signature analysis. The person’s state of mind and emotions can be predicted using handwriting analysis [7]. In future, Handwriting analysis can be used in improving the mental health of a person.

In Dysgraphia patients, letter sizes are irregular, margins are not effectively used, the spacing between letters is unusual, incorrect spelling, poor pen grip, odd hand posture, and patients spend more time in thinking [2].

The algorithms perform handwriting analysis on the image of the handwritten sample. This algorithm can perform handwriting analysis of letter size, letter slant, pressure, and spacing. These algorithms are more efficient and less time consuming as compared to an offline study of handwriting samples.

IV. **Overview of model**

Writing on a mobile/tablet screen is different from writing on paper. The friction between the screen of mobile/tablet devices and pen is less because of which children face difficulty in writing on the screen. We choose to keep assessment tests restricted to pen and paper so that we get natural samples. The user will click the images of a handwritten sample of a candidate whose Dysgraphia test needs to be done. Since the prediction is done only based on the images of a handwritten sample, the images should have good quality. The handwriting sample should contain one paragraph and should be written on white paper having no lines. The pen ink should be dark enough to be detected by algorithms, black or blue pen ink is most suited. Then the clicked image is then sent to our website. The image should be good enough to be visible as shown in Fig. 2 of handwriting sample of student with no disability and handwriting sample of student with Disability in Fig. 3.

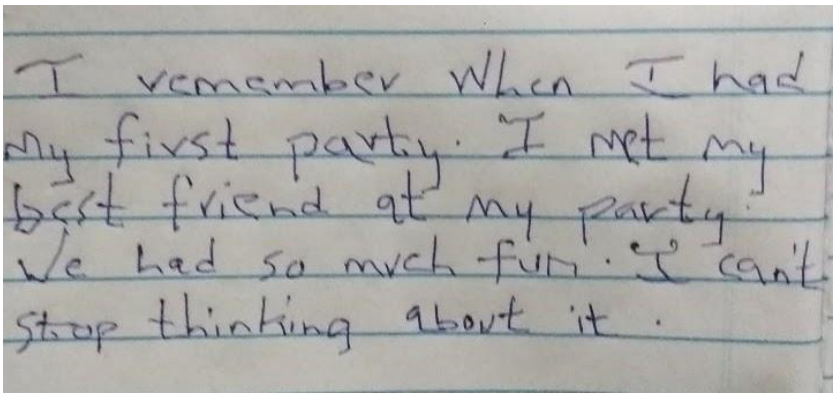

Fig. 2. Student handwriting sample with no disability.

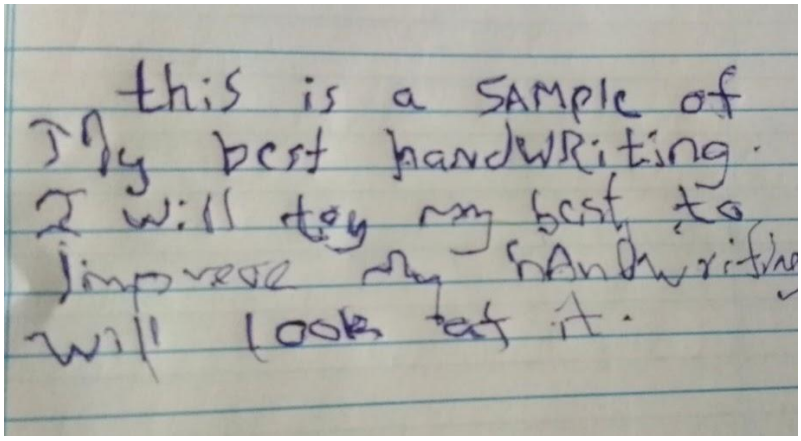

Fig. 3. Student handwriting sample with Disability.

At the server, Images are processed using image processing code. Then the machine learning algorithms are applied to it and features are extracted. The extracted features are then given to the SVM model where the model does its prediction and results are returned to the user's device [1]. The user can see results on its device and can provide their feedback which will help in further improvement of the model. Architecture diagram of the model is shown in Fig. 1.

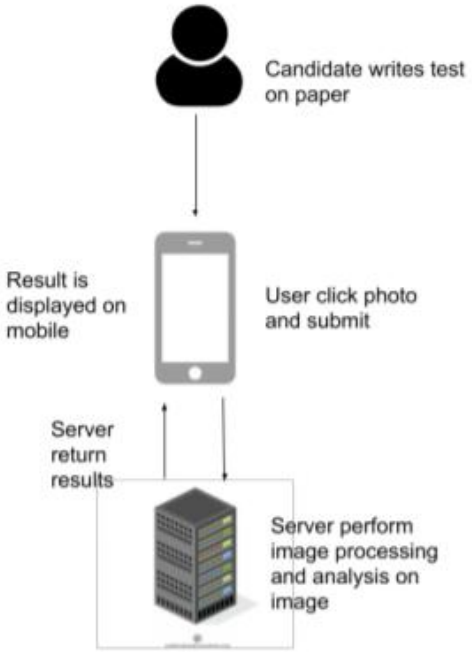

Fig1. Architecture diagram of model

V. Overall description of project model

1. Design specifications:

The project model consists of various python files. These python files are run and tested on a well-known integrated development environment, PyCharm along with Anaconda. It was used for debugging, code and testing. Anaconda was used to deal with machine learning algorithms.

Handwriting analysis is the most important part of this model which was implemented using OpenCV. The success of the development of this model highly depends on how efficiently algorithms can perform Handwriting analysis. The task design for assessment was kept simple. So the candidate just has to write a paragraph and submit it to our server. The server consists of python files that process these images and give responses based on the result. Python files have very little run-time and require very few CPU resources and hence the response is fast. The responses are based on features and there are two classes in responses (has Dysgraphia or has no Dysgraphia).

2. Working of model:

The user will click the images of a handwritten sample of a candidate whose Dysgraphia test needs to be done. Since the prediction is done only on the basis of the images of a handwritten sample, the images should have good quality. The handwriting should contain one paragraph and should be written on white paper having no lines. The pen ink should be dark enough to be detected by algorithms, black or blue pen ink is most suited. The clicked image is then sent to our website. At the server, Images are processed using image processing code. Then the machine learning algorithms are applied on it and features are extracted. The extracted features are then given to the SVM model where the model does its prediction and results are returned to the user's device. The user can see results on its device and can provide their feedback which will help in further improvement of the model. Initially, images of normal handwriting are used for the training of models. To classify these images we use convolutional neural networks (CNN) from Keras library of python. Convolution and pooling techniques are applied to these images. The pooling helps in choosing the most relevant feature in collected images. The techniques like dropout which is used to improve convergence, flatten which is used for reshaping matrices and these matrices are then fed to respective layers. This model is then tested on some other images and the model is perfectly able to classify these images into right and left slant.

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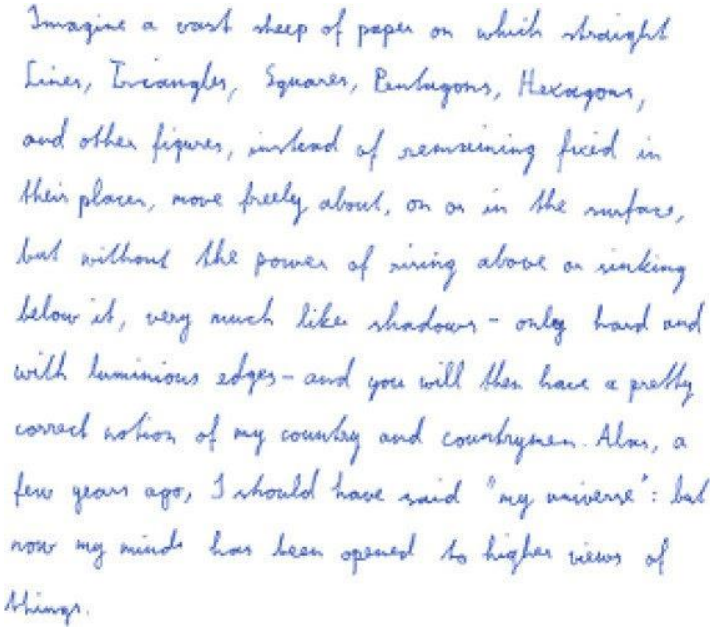

Fig. 4. Original image

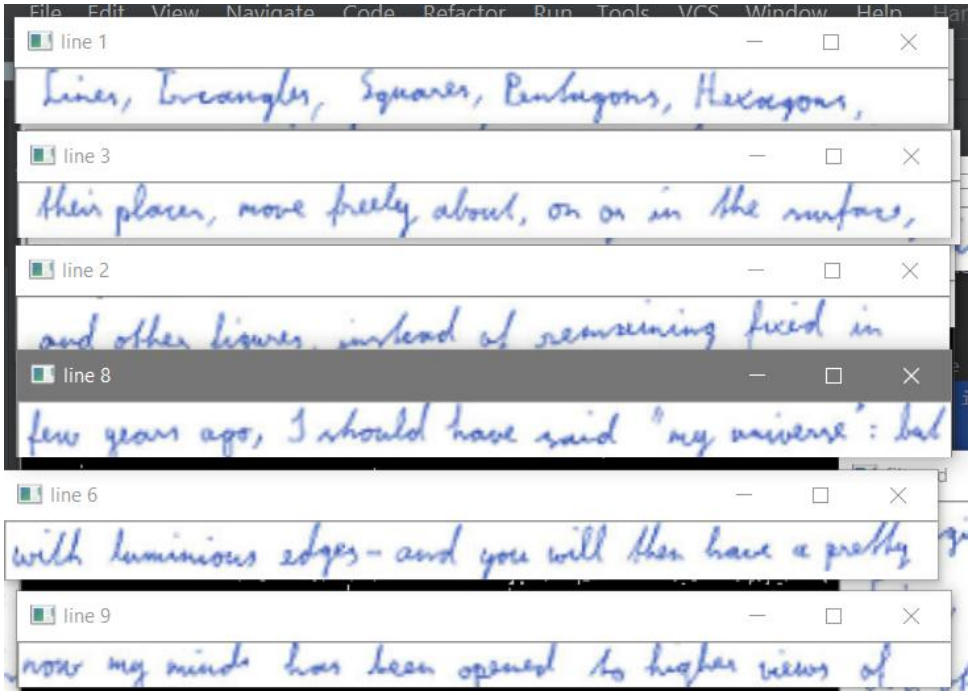

Fig. 5. Extracted Lines

For extraction of lines from the input image (Fig. 4), bilateral filter to apply filter and threshold to convert image to gray-scale and perform inverted binary threshold on an image which helps to remove unwanted marks in the image. The horizontally all pixels are counted and stored in the list. The Sum of pixels is zero which means there is blank space. After that if pixel value > 0 then new line is started. After contour if blank space comes then it means it is the end of line and in this way, lines are extracted(Fig. 5). If the height of pixels is 20 then that contour is considered as printed lines or defect and they are ignored. The number of pixels present is added and the sum is divided by the number of lines which will provide us with an average letter size.

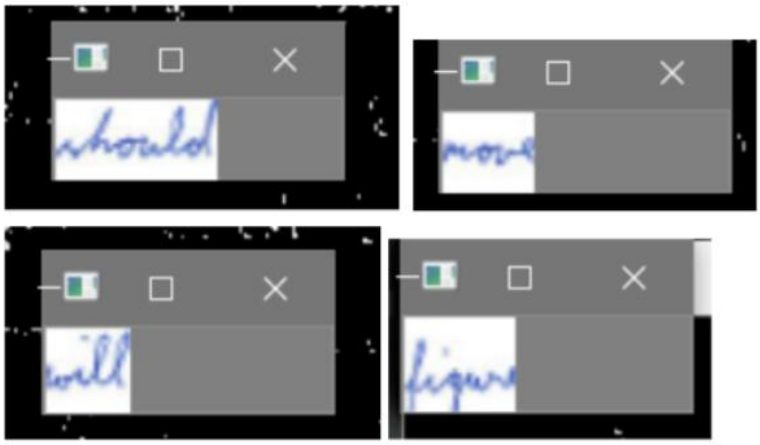

Fig. 6. Extracted words

For extraction of words, bilateral filters and threshold of OpenCV are applied to the image. Then pixels present on a vertical projection of images are stored in the list. The list is iterated and the presence of a series of zero values means space between words and series of values greater than zero means a word. In this way, each word is extracted (Fig. 6). For calculating average pressure, the image is first converted into gray-scale. The value of each pixel is subtracted by 255(max value) and in this way the image is inverted. Then bilateral filtering is applied to this image. Then pixel value less than the threshold (100) is made to zero by applying a threshold to zero feature of the threshold function of OpenCV. The sum of values

of all pixels is calculated and divided by the number of pixels that provide average intensity or average pressure.

Images of handwriting samples of groups of Dysgraphia children and non-Dysgraphia children are taken. Using the above-mentioned techniques, the features are extracted and saved with labels in a CSV file. This CSV file is passed to the SVM algorithm for classification.

3. Data Collection:

The development of advanced features in mobile has made human life easier and faster. This model aims to give a better solution for the diagnosis of Dysgraphia by using a computerized platform in the replacement of regular pen and paper tests. The advantage of such data collection is that the handwriting pattern is extracted very accurately with less time consumption.

The group consisting of children having Dysgraphia disease is made to write a paragraph on paper. The photo of each paper is taken from mobile Redmi 4. The images are converted into various forms by applying bilateral Filter, threshold, dilate and erode functions of python library OpenCV. These image forms help in efficient extraction of features. Features like slant angle, pressure, average letter size, and spacing are extracted from those images. The same process is repeated for children having no difficulty in writing. These extracted features serve as input to the SVM algorithm and a trained model is built which can effectively distinguish between children having Dysgraphia and Not having Dysgraphia. The images are taken from mobile Redmi 4 but it can be captured from any device which has good camera quality. The model can be made more accurate by taking more samples for training.

VI. CONCLUSION

In this paper, we discuss our project model which can detect the presence of dysgraphia in a child and help parents to take necessary action on time. Feature extraction using image processing and CNN is quite effective and accuracy can be increased by using more images for training. The SVM model is used to classify whether the child has any kind of writing disabilities or not, based on input features (slant of a letter, letter size, spacing, and pressure).

The features are limited and more features like pen grip, thinking time can be recorded and used for better prediction. This research can be used for making an application that can effectively understand the patterns of the handwriting of Dysgraphia children and help them to improve their writing skills. The model can be used along with other technology to make diagnoses faster and less costly. The image processing works well if the ink is dark-colored (blue or black) and paper is white-colored but if the background paper is dark-colored then the results are not good.

The image processing only works well if image clarity is good enough. Also, the model accuracy can be improved by providing more images. The model run-time is less and can provide results within a few seconds.

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