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Skew Detection and Correction for Gujarati Printed and Handwritten Character using Linear Regression

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Abstract—In this paper, we have proposed approach for skew detection and correction of handwritten and printed Gujarati document using Linear Regression method/technique. Skew detection and correction is important for any recognition system as it directly affects the recognition process of characters/documents. The proposed method work involves linear regression formula for detecting angle of rotation and correcting it for printed and handwritten document/characters. With this approach for skew detection and correction we get up to 59.63% of accuracy for printed and 45.58% of accuracy for handwritten document/characters. This proposed method is simple and fast for detecting angle of rotation as well as it corrects the skewed image fast.

Keywords— Character recognition system, Handwritten character recognition, Optical character recognition, Skew detection and correction, Linear regression.

I. INTRODUCTION

Gujarati is an indo-Aryan language, and part of the greater indo-European language family. It is derived from a language called old Gujarati which is the ancestor language of the modern Gujarati and Rajasthani languages. There are 12 vowels and 34 consonants in Gujarati language. Optical character recognition (often abbreviated as OCR) involves reading text from Paper and translating the images into a form (say ASCII codes) that the computer can manipulate. It allows a machine to recognize characters through optical mechanisms. Although there has been a significant number of improvements in languages such as English, but recognition of Gujarati scripts is still in its preliminary level.

Handwritten Character Recognition (often abbreviated as HCR) is a system in which handwritten text from document is taken in form of image from sources such as Scanner or captured image. Later they are analyzed as per HCR's Processing stages and we get text file as output. Committing words to paper in handwriting is a uniquely human act, performed daily by millions of people.

II. REVIEW WORK

In the paper of [1], the authors have presented a method for skew angle detection of Printed Document which is based on Linear Regression & Wavelet Transform(Range of angle 0° - 180°). In this work, anistropic diffusion was introduced as a step of Pre-Processing step for reinforce the difference between area & to eliminate the noise. The Linear Regression Formula is applied on black pixels in order to estimate their skew angle. According to paper of [2], the authors have described the behaviour of different model of neural network used in OCR. They have considered different parameters like hidden layer, size of hidden layer and epochs. They have used the back propagation neural network. The implementation of the fully connected back propagation network gave reasonable results toward recognizing characters.

As proposed in [3], the authors has worked upon a Gujarati script document and used Hough transform technique for the skew detection and correction. In this paper, the author described a number of sub process that are to be applied while using Hough transform technique for skew detection. As in paper [5], the authors have used same formula i.e. Linear Regression formula for skew estimation for English language. But they have used Static and Dynamic Thresholding Technique for Binary document image.

The authors have proposed technique in paper of [6], that works fine for scaled text binary documents also. The technique works based on the assumption that the space between the text lines is greater than the space between the words and characters. Finally, in order to evaluate the performance of the proposed methodology and they compare the experimental results with those of well-known existing methods.

III. SKEW DETECTION AND CORRECTION

Skew Detection and Correction methods are used to align the paper document with the coordinate system of the scanner. Main approaches for skew detection include correlation, projection profiles, Hough transform, Linear Regression.

For any image taken by scanning the document may have some human mistakes such as while setting the document for scanning, the paper may be placed with some tilt in either of the direction which cause the rotation of image. It is also possible that, for handwritten document the writer did not have written in perfect alignment causing the rotation. An important part of any document recognition system is detection and correction of skew in the image of a page [7].

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IV. PROPOSED APPROACH

In this paper we have described Linear Regression method for detection of skew/ skewed angle. Linear Regression is a very powerful statistical technique. Linear Regression uses the fact that there is a statistically significant correlation between two variables to allow you to make predictions about one variable based on your knowledge of the other. You should not do Linear Regression unless your correlation coefficient is statistically significant. For Linear Regression to work there needs to be a Linear relationship between the variables [4].

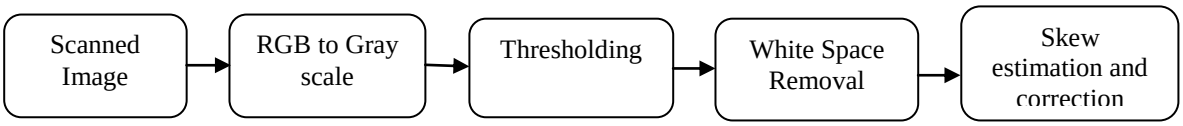


Fig. 1 Block diagram of Proposed Approach

- Algorithm for white space remove:
  - Convert image into gray scale and apply thresholding.
  - Take 3 different points i.e mid, upper and lower for four boundaries i.e. right, left, top and bottom.
  - Find the X_{min} , X_{max} , Y_{min} and Y_{max} points.
  - Plot new image using new x and y coordinates.

- Algorithm for skew angle estimation(detection) and correction:
  Input: skewed document
  Output: skew angle
  Method:
  Step1: Get the skewed binary image
  Step2: Apply the white space remove algorithm
  Step3: Apply the Linear regression formula and compute the slope using the following formula,

$$M = \frac{n\sum_{i=1}^{n} x_i y_i - \left(\sum_{i=1}^{n} x_i\right)\left(\sum_{i=1}^{n} y_i\right)}{n\sum_{i=1}^{n} x_i^2 - \left(\sum_{i=1}^{n} x_i\right)^2}$$

Where, (x, y) = co-ordinate value of the pixel
n = number of black pixels present in the text line

Step 4: Compute the skew angle using the formula

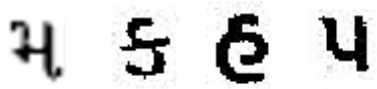
$$A = \tan^{-1}(M)$$

Step 5: Apply rotation of negative of angle(skew angle) to character image.

V. RESULT AND DISCUSSION

A *Printed Document*

We done skew detection algorithm for printed characters. For printed characters we get around 59.63% accuracy. Figure 2 Shows the printed characters used in our approach.Figure 3 shows different rotational angles we considered in our approach and Table I shows results we got.



"Ma" "Ka" "Ha" "Pa"

Fig. 2 Printed character used in our approach

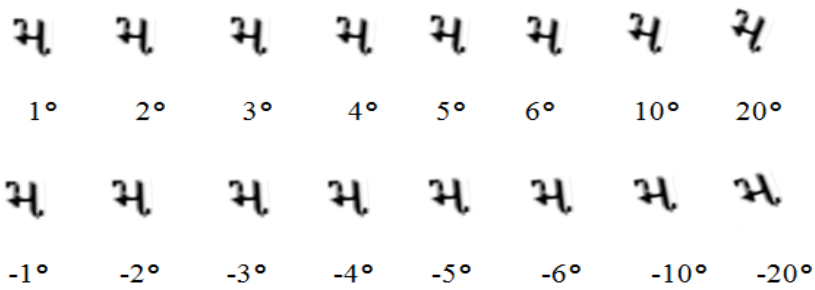


Fig. 3 Different Rotational Angle

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TABLE I
RESULT FOR PRINTED CHARACTERS

Actual Rotation Angle (Degree)	Estimated Rotation Angle for "Ma" (Degree)	Estimated Rotation Angle for "Ka" (Degree)	Estimated Rotation Angle for "Ha" (Degree)	Estimated Rotation Angle for "Pa" (Degree)
0	0	0	0	0
1(Clock wise)	-1.25	0	-0.34	0.606
2	-0.88	0.480	0.698	0.299
3	-0.225	2.631	1.398	0.111
4	1.298	2.17	2.563	-0.557
5	1.353	1.99	2.713	0.512
6	1.761	2.823	2.758	1.693
10	3.867	5.136	4.448	2.807
20	8.844	10.724	9.355	6.181
-1(Anti clock wise)	-0.5099	0	-0.348	-1.880
-2	-2.083	-0.20	-0.303	-1.922
-3	-2.175	-2.18	-1.701	-0.931
-4	-2.497	-2.19	-2.293	-0.609
-5	-3.629	-2.84	-2.539	-1.044
-6	-2.787	-2.45	-2.799	-1.188
-10	-4.144	-4.41	-4.718	-1.992
-20	-6.238	-8.85	-9.490	0.406

B ***Handwritten Document***

For handwritten document the skew detection and correction is quite difficult as the shape of character varies from person to person's handwriting. For some characters it is very worst but for some characters we got very good result. So according to all results the accuracy of this technique for angle detection is about 45.58%. Also we got best result for range of angle in between 15° to 40°.Figure 4 and 5 shows handwritten characters we took from different person used in our approach. Table II, III, IV, V & VI shows the results we got. Figure 6 shows the Accuracy Graph of result for both Printed and Handwritten document.

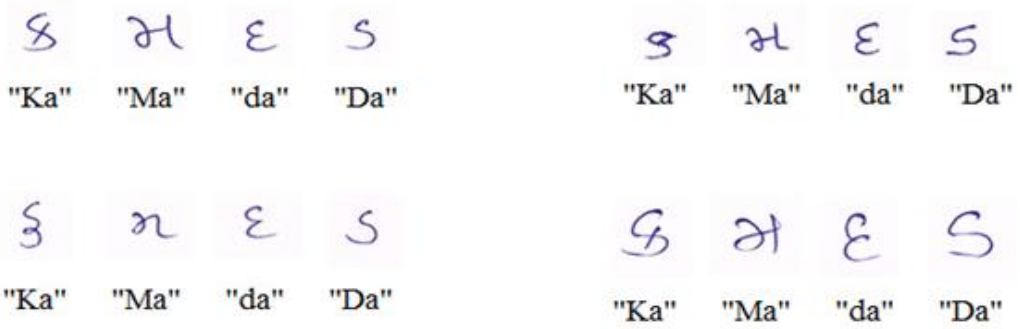

Fig. 4 Handwritten characters used in our approach

TABLE II
RESULT FOR HANDWRITTEN CHARACTERS FROM PERSON A

Actual Rotation Angle (Degree)	Estimated Rotation Angle for "Ka" (Degree)	Estimated Rotation Angle for "Ma" (Degree)	Estimated Rotation Angle for "da" (Degree)	Estimated Rotation Angle for "Da" (Degree)
0	0	0	0	0
1	2.72	-9.99	3.44	0.94
2	0.18	-10.01	3.43	0.48
3	4.17	-13.65	4.20	1.69
4	4.61	-6.72	3.25	1.86
5	4.53	-12.34	7.05	1.34
10	5.46	-5.54	12.97	8.13
20	13.14	-16.18	15.85	14.85
-1	3.36	-0.78	5.22	-0.71
-2	3.37	1.416	3.87	-1.90

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-3	-1.303	3.41	2.80	-1.99
-4	-2.64	3.22	0.0754	-1.46
-5	-1.55	7.79	3.75	-3.54
-10	-2.86	5.86	-4.81	-6.25
-20	-9.18	21.12	-11.74	-16.04

TABLE III
RESULT FOR HANDWRITTEN CHARACTERS FROM PERSON B

Actual Rotation Angle (Degree)	**Estimated Rotation Angle for "Ka" (Degree)**	**Estimated Rotation Angle for "Ma" (Degree)**	**Estimated Rotation Angle for "da" (Degree)**	**Estimated Rotation Angle for "Da" (Degree)**
0	0	0	0	0
1	-2.38	5.41	-0.498	6.429
2	-1.32	-0.86	1.42	7.661
3	0.18	-2.35	0.99	-0.764
4	-0.87	0.034	1.38	-0.045
5	-6.56	-3.1433	1.50	-1.609
10	-2.76	-16.94	5.969	4.044
20	-1.11	-21.54	16.18	-3.293
-1	-11.98	-8.11	0.0900	4.959
-2	-12.04	3.42	1.861	2.859
-3	-13.45	12.24	1.889	0.555
-4	-12.64	17.28	1.0281	0.445
-5	-7.306	20.71	2.12	-0.973
-10	-0.888	19.59	-6.826	-1.357
-20	-9.81	45.08	-9.98	1.026

TABLE IV
RESULT FOR HANDWRITTEN CHARACTERS FROM PERSON C

Actual Rotation Angle (Degree)	**Estimated Rotation Angle for "Ka" (Degree)**	**Estimated Rotation Angle for "Ma" (Degree)**	**Estimated Rotation Angle for "da" (Degree)**	**Estimated Rotation Angle for "Da" (Degree)**
0	0	0	0	0
1	-2.866	0.681	2.223	0.469
2	-0.135	-2.554	3.618	0.053
3	1.73	-2.635	3.549	-0.505
4	2.331	-2.909	4.132	-3.278
5	2.868	-1.5238	4.688	-4.5627
10	6.09	-3.686	9.688	-0.931
20	14.02	0.787	21.124	-1.802
-1	-1.944	0.1061	0.785	-0.611
-2	-0.545	-0.106	-1.313	-2.791
-3	-3.158	0.7081	-2.57	-10.32
-4	-3.402	0.9703	-1.86	-10.86
-5	-4.043	-0.783	-2.24	-12.64
-10	-10.291	12.80	-5.18	-10.54
-20	-17.77	15.28	-14.84	-9.029

TABLE V
RESULT FOR HANDWRITTEN CHARACTERS FROM PERSON D

Actual rotation Angle (Degree)	**Estimated Rotation Angle for "Ka" (Degree)**	**Estimated Rotation Angle for "Ma" (Degree)**	**Estimated Rotation Angle for "da" (Degree)**	**Estimated Rotation Angle for "Da" (Degree)**
0	0	0	0	0
1	-2.822	1.46	0.46	-3.57
2	0.370	1.50	2.41	-5.79
3	-0.6877	-4.5903	2.83	-4.26
4	-2.5481	2.5454	3.18	-2.60

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5	-1.434	-0.558	4.13	1.52
10	1.757	-8.004	8.62	-0.85
20	4.125	-14.27	17.28	3.026
-1	-10.44	5.447	-0.82	-0.94
-2	-5.369	5.43	-2.05	-4.003
-3	-3.8857	4.099	-2.56	-2.04
-4	-3.1248	4.12	-2.16	0.011
-5	-5.931	14.96	-2.81	-2.78
-10	-6.493	12.15	-6.64	-3.842
-20	-12.119	20.29	-16.13	-7.488

TABLE VI
RESULT FOR HANDWRITTEN CHARACTERS FROM DIFFERENT PERSON

Person	**Estimated Rotation Angle for "Ka" (Degree)**	**Estimated Rotation Angle for "Ma" (Degree)**	**Estimated Rotation Angle for "da" (Degree)**	**Estimated Rotation Angle for "Da" (Degree)**	**Estimated Rotation Angle for "Pa" (Degree)**
1	14.23	22.57	-16.53	41.65	-5.23
2	-16.75	-13.14	-37.53	-27.81	-2.76
3	9.50	5.75	-12.95	11.29	22.14
4	20.54	-7.84	2.19	16.63	13.57
5	3.66	-7.54	-6.85	5.33	1.41
6	1.92	11.96	11.11	27.29	4.35
7	3.89	-12.71	14.23	18.05	-13.84
8	4.34	-19.56	6.45	7.80	-7.371
9	24.97	19.20	-9.64	25.33	7.21

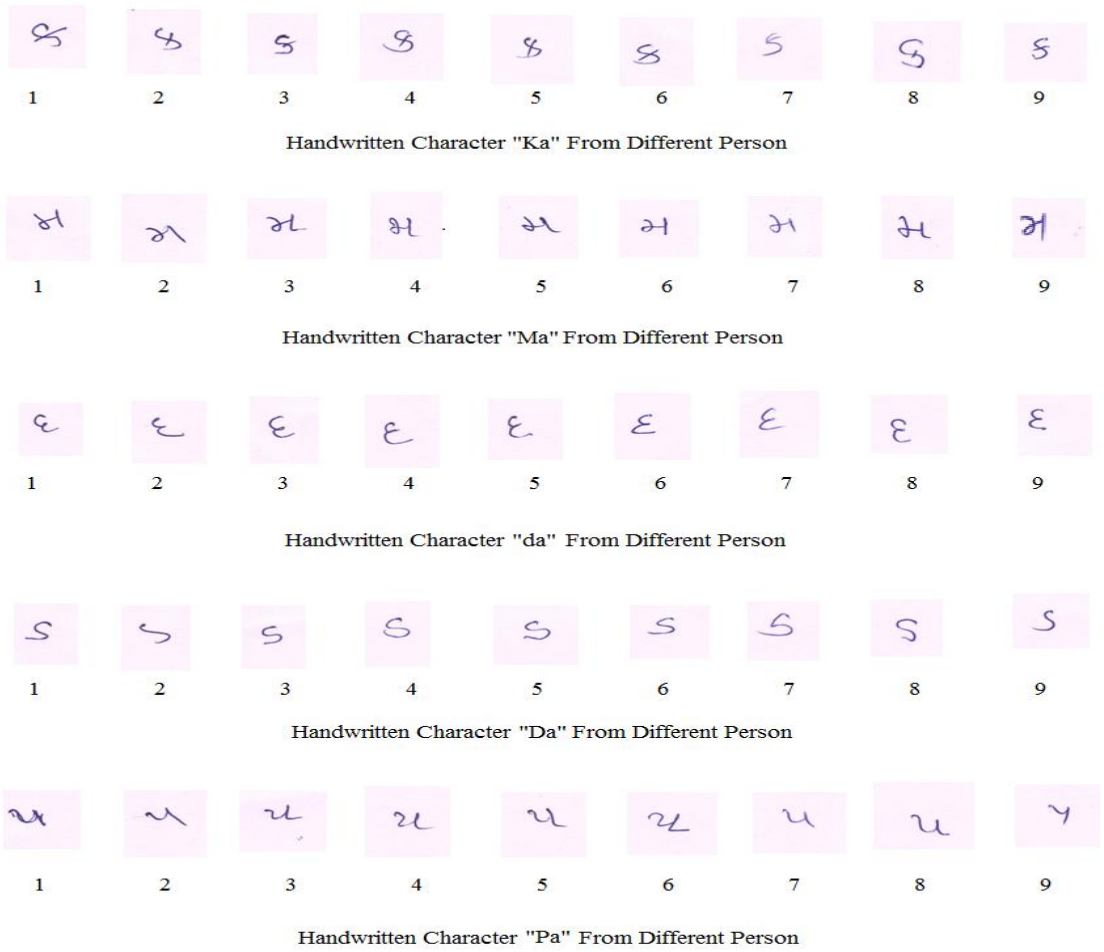

Fig. 5 Handwritten characters from different person used in our approach

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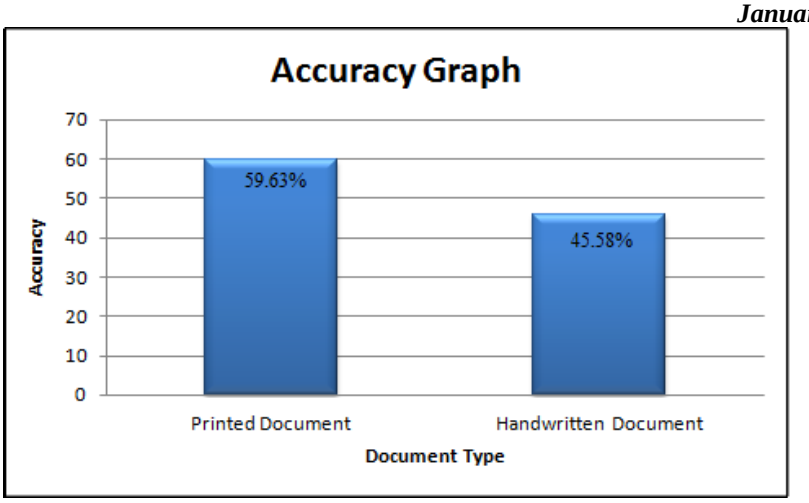

Fig. 6 Accuracy Graph

VI. CONCLUSION

After a meticulous study of the proposed technique it can be concluded that linear regression techniques fails to handle minor variation of rotational angle but holds good in the case of major rotational angle variation. Though, it gave good results in the range between 15° to 40° angle, the accuracy varies above this defined range.

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