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CHARACTER ANALYSIS USING SPACE IN HANDWRITING IMAGE TO DETERMINE SPECIALIZATION IN BUSINESS

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ABSTRACT

Specialization selection in business has been a subject of research study for several years. In our work, it begins with collecting the handwriting samples on plain white A4 size paper. Initially color image or gray scale image is taken as an input then thresholding is done to convert the image into binary image and noise removal technique is also applied. Skew-normalization techniques have been applied to find out space between lines, words and letters in handwriting images after segmentation of lines, words and characters have been performed. Finally, the mean of the space between all the closed loops formed by the characters has been found out and compared with the word spaces to determine the character. The characters are then matched with the requirements of each specialization. Accordingly, the candidates select their specialization and their performance in the exam has proved it to be a healthy match for them. This paper focuses on selection of specialization in business based on behavior from space analysis in handwritten document. The proposed method was tested on more than 500 text images of IAM database and sample handwriting images which are written by different writers on different backgrounds, detects the exact space in between lines, words and characters after skew normalization of a document. The experimental result shows that proposed algorithm achieves more than 63% accuracy for all type skew angles.

Keywords: Skew Normalization, Space Analysis, Character Analysis, Business Requirements, Performance Analysis

INTRODUCTION

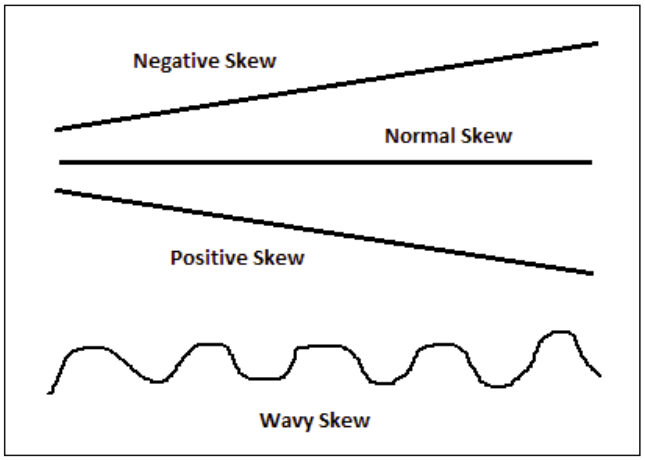
During the last few years specialization selection in business has been an intensive research topic. It can be done based on characteristics or behavior of an individual. The initial phase of business is dedicated towards completion of the core studies, designed to build a strong foundation of basic concepts across various areas of business. In the latter part, an individual can choose to specialize in an area. There may be numerous factors that influence the decision regarding the area of specialization. Depending upon the priority, the individual may choose the field as per the market demand, interest area, job profiles and the compensation packages offered by the companies. But prior to that the most important basis should be the parity of the skills required for a field with the characteristics or behavior of the person. The person would not be able to fulfil the expectations of the area or business if he/she lacks the skills. Adaptability being an alternative, could not deliver 100% in the case. This proposed work assumes that scanned handwriting document may only consist of Salt and Pepper noise and Background noise, caused by dirt on the document and can be removed by filters like median (Solihin & Leedham, 1997) and k-fill (Story *et al.*, 1992) filter. Skew (Sarfraj & Rasheed, 2008; Bal & Saha, 2016; Panwar & Nain, 2012) in handwriting document can occur due to the human's behavior as well as by the scanner during the scanning process. In the case of correct orientation of the pages, handwriting document still consist of smaller and larger skew (Sarfraj & Rasheed, 2008; Bal & Saha, 2016; Panwar & Nain, 2012) due to writer variation. Thus, on its application, the results on the now rotated lines are found to be more accurate.

The next step segmentation (Nicolas, Paquet & Heutte, 2004; Marti & Bunke, 2001; Simistira, Papavassiliou & Stafylakis, 2011; Zimmermann & Bunke, 2002; Luthy, Varga & Bunke, 2007) which partitions the binary image into multiple segments depending on requirement. The present segmentation methods are K-mean segmentation (Nicolas, Paquet & Heutte, 2004; Marti & Bunke, 2001; Simistira, Papavassiliou & Stafylakis, 2011; Zimmermann & Bunke, 2002; Luthy, Varga & Bunke, 2007) and projection profiles (Nicolas, Paquet & Heutte, 2004) etc. The last step is classification (Otsu, 1979) method which is the heart of the handwriting recognition technique. This paper

concentrates on selection of specialization through space analysis i.e. determination of behavior based on comparison of space between words and the space between the closed loops formed by the characters. Accordingly, the matching of those with the required skills for a specialization are done.

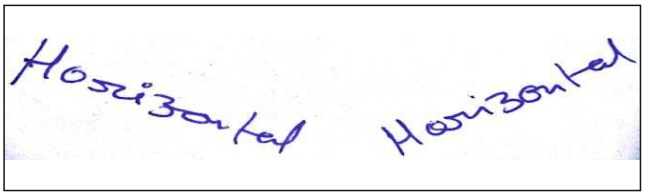
Technically skew is defined as the alignment of the text lines and words with respect to the horizontal direction. Skew can be either clockwise, called positive skew or anti- clockwise, called negative skew. But at the time of recognition process, handwriting document should be free from the skew for better recognition. Skew normalization is required for vertically character segmentation. There are four types of skew available, that are Negative or Ascending skew, Positive or Descending skew, Normal or straight skew and Wavy skew, which are shown in figure 1.

Figure 1: Orientation of Skew



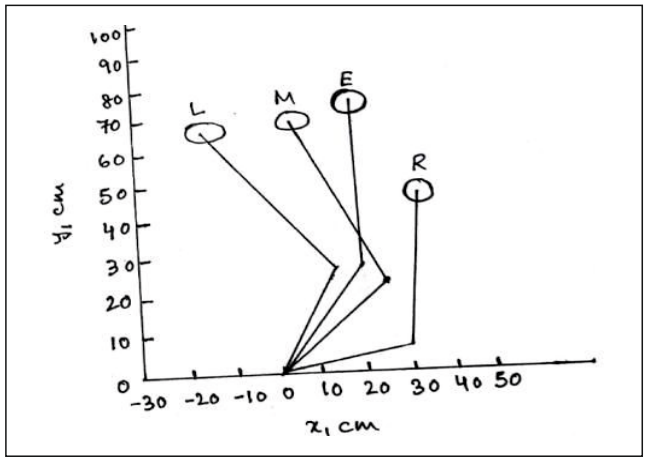
Example of the positive skewed word and negative skewed words are shown in figure 2(a) and 2(b). The movement of the positive skew towards the clockwise direction and movement of the negative skew towards the anti-clockwise direction.

Figure 2: (a) Example of positive skewed and (b) negative skewed words



Let us consider a document having positive or negative skew. When the segmentation of lines, words and characters is performed, it is often found that due to too much slanting of lines, the top or bottom or both sides of the lines are getting cut-off. As a result, the space calculations in between lines, words and characters are getting deviated. In case of overlapping lines in the original document also, this segmentation is having errors. There are numerous previous methods that have been proposed in past research i.e. Sarfraj & Rasheed (2008). Skew Estimation and Correction of Text using Bounding Box, Fifth IEEE conference on Computer Graphics, Imaging and Visualization, (Nicolas, Paquet & Heutte, 2004). Text Line Segmentation in Handwritten Document Using a Production System, Proceedings of the 9th Int'l Workshop on Frontiers in Handwriting Recognition (IWFHR-9), for skew detection and normalization of document image such as Global Hough Transform (Srihari & Govindaraju, 1989), Local Hough Transform (Srihari & Govindaraju, 1989), Projection Histogram (Otsu, 1979), etc. On applying any of these methods, skew normalization is possible.

Figure 3: Closed loop of letters in words



The figure 3 shows the closed loop of letters in words of the handwriting image. The handwriting is written on a blank plain A4 sheet of paper. Wherever words like "and", "gap", "boy", etc. are found, the proposed method detects the closed loop of "a", "d", "g", etc. and calculates the radii of all such characters and stores in an array (Papavassiliou *et al.*, 2010). Then the sum of the diameters of all such characters is calculated and their mean is found out. Now, this mean space between the loops of these characters is compared with the space between the words of that document. If double the loop space is found greater than the word space, then the person is narrow-minded and vice-versa and possesses some pre-defined qualities in previous papers (Kedar, Nair & Kulkarni, 2015; Champa & AnandaKumar, 2010; Das Gupta, & Chanda, 2012).

LITERATURE REVIEW

In 2007, Luthy, Varga & Bunke proposed

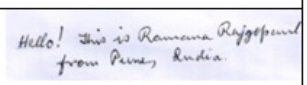
segmentation of line using Hidden Markov Models (HMMs) and these models have been tested on the text line, where the aim was to be able to differentiate between inter- word gaps and intra-word gaps.

Marti & Bunke (2001) introduced a system for reorganization English handwriting text based on large vocabulary. The proposed method segments complete lines of text lines into single words. The algorithm tested on 541 text lines containing 3899 word and performed correct segmentation rate of 95.56%.

Story *et al.*, in 1992 have identified an electronic based browsing system for recognition of the patterns from scanned image.

In 2015, Kedar, Nair & Kulkarni proposed a Personality Identification through Handwriting Analysis. In graphology, spacing implies the distance maintained between the lines, words and letters by the writer. Spacing can reveal various personality constructs. Spacing can be identified into two main groups as wide or narrow as shown in table 1 below:

Table 1: Spacing and Related Personality Traits

Sr. no	Type	Personality Traits	Writing Sample
1	Wide Spacing	discrimination, good taste, independence, exclusiveness, isolation, loneliness, snobbery, and pride.	
2	Narrow Spacing	warmth, sympathy, gregariousness, obtrusiveness, poor taste, and inability to be alone	

In 2016, Bal & Saha proposed and discussed about skew normalization procedures. In 2012, Panwar & Nain proposed the amount of space left between one line and the next establishes how well she organizes her life. The method has been evaluated on various styles of handwritten text documents, and it is found that it detects the exact skew angle with more than 98% accuracy.

In 2010, Champa & AnandaKumar proposed a method that classified Human Behavior: it shows that the writer is independent, cautious and a reserved person, he may also be experiencing loneliness at the time he wrote the sample.

In 1997, Solihin & Leedham proposed Narrow spacing: the writer who uses close spacing needs constant contact with people that could make him sociable and may also have feelings of insecurity.

In 1979, Otsu proposed a Normal spacing: as usual whenever there is a balance in the element under examination then we can say that the person has got a balanced attitude.

In 2012, Das Gupta & Chanda proposed a slop or slant recognition theory to identify the effect of skew normalization.

Proposed Work

Generally, skew is measured depending on the baseline. Space calculation between lines, words and characters are done after skew normalization on sample document. According to the review (Kedar, Nair & Kulkarni, 2015; Champa & AnandaKumar, 2010; Das Gupta, & Chanda, 2012) in the previous section, there are several pre-defined behavioral characteristics analyzed based on spacing. Previously proposed methods (Kedar, Nair & Kulkarni, 2015; Champa & AnandaKumar, 2010; Das Gupta, & Chanda, 2012) only state the characteristics based on assumptions but do not match it with the calculations and thus it is tested here.

In the proposed work deal with identification of behavior traits with the help of space analysis comparing the space between the closed loops of letters with the space between the words and this proposed method is not concerned about the other characteristics of handwriting analysis.

At first, in our proposed work, the color handwriting documents are collected from surroundings, converted to gray scale handwriting document from the IAM database (Solihin, & Leedham, 1997; Story *et al.*, 1992). Proposed approach assumes that the given handwriting documents are perfectly scanned so only the skews which are introduced by the writers are considered. Initially noise removal techniques (Solihin, & Leedham, 1997; Story *et al.*, 1992) have been applied on the scanned handwriting document. Skew normalization (Sarfraj & Rasheed, 2008; Bal & Saha, 2016; Panwar & Nain, 2012) is applied on segmented lines to normalize them. Then this proposed method is applied on the segmented lines to find the space calculations between lines, words and characters on the modified skewed document to get accuracy.

In the proposed method for calculating the space

between lines, words and characters, it is required to find out first the space between the words by segmentation (Nicolas, Paquet & Heutte, 2004; Simistira, Papavassiliou & Stafylakis, 2011; Zimmermann & Bunke, 2002; Luthy, Varga & Bunke, 2007) and projection profile (Nicolas, Paquet & Heutte, 2004). Now, the mean of the diameters of all closed looped characters is calculated. This mean space between the loops of these characters is compared with the space between the words of that document (Champa & AnandaKumar, 2010). The details approach for space calculations according to original and skewed documents are explained in the experimental section.

After all, the behavior traits received from comparison of the space calculated from their samples and the mean of the diameters are matched with the pre-defined ones required for selecting a specialization.

RESEARCH METHODOLOGY

A. Algorithm 1

Skew Normalization on the document:

This is applied on the document to make it free from positive and negative skews and convert it into a straight line.

Steps:

1. if(x1>x2)
2. % negative skew
3. t=x1;
4. x1=y1;
5. y1=t;
6. t=x2;
7. x2=y2;
8. y2=t;
9. y2=y1+y1-y2;
10. slope=(y2-y1)/(x2-x1);
11. angle=atand(slope);
12. rot=imrotate(new, -angle);
13. imshow(rot);
14. [rr,cc]=size(rot);
15. rend=rstart+rr-1;
16. rotated(rstart: rend,1:cc, :)=rot;
17. rstart=rend+1;
18. else
19. %positive skew
20. t=x1;
21. x1=y1;
22. y1=t;
23. t=x2;
24. x2=y2;
25. y2=t;
26. y2=y1+y1-y2;
27. slope=(y2-y1)/(x2-x1);
28. angle=atand(slope);
29. rot=imrotate(new,angle);
30. [rr,cc]=size(rot);
31. rend=rstart+rr-1;
32. rotated(rstart: rend,1:cc,:)=rot;
33. rstart=rend+1;
34. end
35. end
36. imshow(rotated);

B. Algorithm 2

Line spacing calculation on skewed document:

Steps:

1. hor<- horizontal_projection(rotated); // hor is an array which stores sum of pixels of a row
2. for (each element in hor)
3. if value>10000 // checking presence of written pixel start of new line
4. for (each element in hor)
5. if(value>10000)
6. else
7. line ends;
8. store starting and ending points in "lines" matrix
9. End-if
10. Exit inner loop;
11. Continue outer;
12. Lines (3)-lines (2) gives the space between Line no. 1 and Line no. 2, lines(5)-lines(4) gives the space between Line no. 2 and Line no. 3.
13. using this we calculate total space and the "total space/total linecount" operation gives the line space mean result.

In the above Algorithm (Algorithm 2) we have calculated the space between the lines on the skewed document.

C. Algorithm 3

Word spacing calculation on skewed document:

Steps:

1. linestart=1; pos=size_of(lines) // no. of lines*2
2. while(linestart<=pos) do
3. new=img(lines(linestart): lines(linestart+1)) // assigning image of a line in new matrix
4. ver<-vertical_projection(new)//finding vertical projection in order to separate words
5. for (each element in ver)
6. if(value>450)//checking presence of written pixel
7. hash (I) = hash (i-1) +1; // hash matrix defines consecutive written pixels depicting a word
8. else
9. hash(i)=0;
10. endif
11. endfor
12. word_extract(new); //extraction of words
13. wordstart=1; posw=size_of(words) //words contains starting and ending position of all words in the line
14. while(wordstart<=posw) do
15. new_word=img(words(wordstart):words (wordstart+1)) // assigning image of a line in new matrix
16. totalwordspace=totalwordspace+words(wordstart) - words(start-1) //calculation of word space
17. char_extract(new_word);

In the above Algorithm (Algorithm 3) we have calculated the space between the words of a line in the original document. During word extraction, we are storing the starting column pixel and the ending column pixel in an array named "Words". For e.g., Words (1) and Words (2) depict the starting and ending column pixel respectively of Word no. 1 and likewise Words (3) and Words (4) depict word no. 2. Now we can calculate the space between words by calculating the difference between Words (3) and Words (1).

D. Algorithm 4

Character spacing calculation on skewed document:

Steps:

1. ver<-vertical_projection(new_word) //finding vertical projection in order to separate words
2. For (each element in ver)
3. if(value>450)//checking presence of written pixel
4. hashw(i)=hashw(i-1) +1; //hash matrix defines consecutive written pixels depicting a character
5. else
6. hashw(i)=0;
7. endif
8. endfor
9. /*same steps as in word_extract and here we store characters in "chars" array. */
10. /* calculation of space*/
11. start=3;
12. while(start<=posc) //posc signifies no. of chars in the word
13. totalcharspace=totalcharspace+chars(start)-chars(start-1);
14. endwhile

In the above Algorithm (Algorithm 4), we have calculated the space between the characters of a word in the original document. During character extraction, we are storing the starting column pixel and the ending column pixel in an array named "Chars". For e.g., Chars (1) and Chars (2) depict the starting and ending column pixel respectively of Character no. 1 and likewise Chars (3) and Chars (4) depict word no. 2. Now we can calculate the space between characters by calculating the difference between Chars (3) and Chars (1).

E. Algorithm 5

Calculation of radii of the closed loops of the letters in a skewed document:

Steps:

1. rgb=imread(img);
2. gray_image=convertToGrayScale(img);
3. [centers, radii] = imfindcircles(gray_image, [130],"Object Polarity","dark","Sensitivity",0.9);
4. [centersBright,radiiBright] = imfindcircles(rgb, [130],"Object Polarity","bright","Sensitivity",0.9);

In the above Algorithm (Algorithm 5) we use the function imfindcircles () to detect circular objects within the radius range of 1 to 30 units. By the "bright" keyword we mean all the bright circular objects which we eventually take into the calculations of mean (refer to table 2).

Table 2: Function Description

Function Name	Function Description
imfindcircles	Find out the closed loops of word image
hash	To implement hash matrix
horizontal_projection	Horizontal Projection
lines	Assigning image of a line in a new matrix
vertical_projection	Vertical Projection to separate words
word_extract	To extract words
char_extract	To extract characters
rotate	Rotate the image with given degree

RESULTS

Outputs

The proposed work implemented in MATLAB on IAM database (Nicolas, Paquet & Heutte, 2004) over 500 text images containing 3500 words and some sample handwriting image which are written by different writer on different background. Previous proposed algorithm can measure any amount of skew angle and take the appropriate normalization approach and now proposed method can calculate the space between the lines, words and characters on the original document and on the skewed document from these segmented lines.

Figure 4: Sample original text line from IAM database

The text line shown in figure 4 contained the negative skew and after applying skew normalization method where line is totally balanced and normalized with respect to baseline shown in figure 5. After lines segmentation and normalization, the words are segmented from the text lines and two ample of segmented words are shown in figure 6(a) and 6(b). Training set of all the experiments has been carried out on total number of 500 text image and sample handwriting image by different writer on different background. The experimental result of skew normalization process shows in figure 5 and figure 6(a) and (b).

Figure 5: Sample normalized text line from IAM database

Figure 6: (a) Sample normalized word (b) Sample normalized character

(a) *(b)*

The above figures 6(a) and 6(b) contains extracted word and character from skew normalized document respectively after applying the skew normalization method. The space between the lines, words and characters are thus calculated from these images.

Figures and Tables

The significant efficiency to deal with the overlapping sample, negative or positive skewed samples, etc. is shown in table 3.

Table 3: Space Calculation Result Produced by Proposed Method on Skew Normalized Document

Sl. no	Line Space after Skew Normalization	Word Space after Skew Normalization	Character Space after Skew Normalization
1	33.25	13.95	1.0932
2	11	11.73	1.0932
3	38.40	22.86	1.21
4	18.52.	32.33	8204
5	9.4286	11.5625	3.7165
6	6.6429	6.3333	1.7964
7	14.1429	27.2581	1.1779
8	5.5	10.96	1.73
9	29.45	24.20	1.58
10	6.78	11.777	1.704
11	8.700	14.75	1.22
12	10.50	18.67	1.55
13	5.619	14.868	1.51
14	8.88	15.52	1.17
15	7	4.400	1.28

The original text sample along with patterns of closed loop letters recognized from it is provided in the figures 7(a) and 7(b) below.

Figure 7(a): Sample Original Text Image from IAM Database

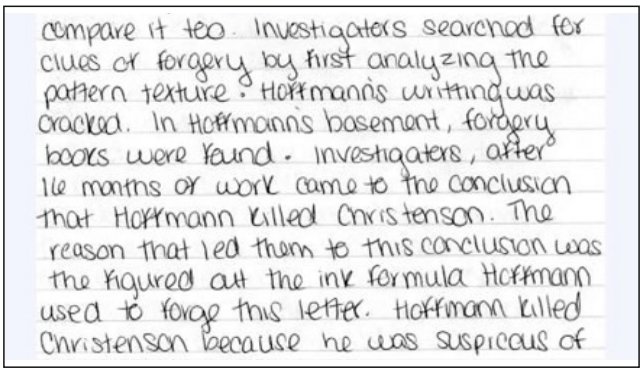

compare it too. Investigaters searched for clues of forgery by first analyzing the pattern texture. Hoffmann's writting was cracked. In Hoffmann's basement, forgery books were found. Investigaters, after 16 months of work came to the conclusion that Hoffmann killed Christenson. The reason that led them to this conclusion was the figured out the ink formula Hoffmann used to forge this letter. Hoffmann killed Christenson because he was suspicous of

Figure 7(b): Sample Recognized Closed Loops of the Words of Image from IAM Database

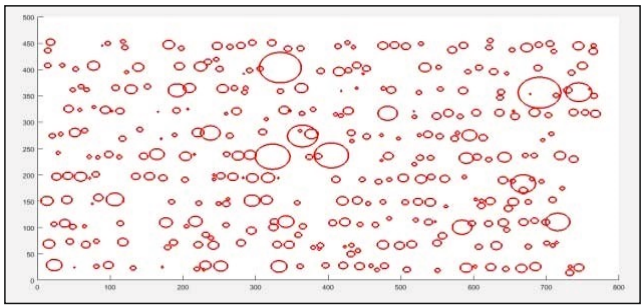


Table 4: Character Analysis Based on Space

Sl. No.	No. of Loops Detected	Radius(mean)	Diameter(mean) *2	Character Analysis
1	767	4.16	16.64	Narrow-minded
2	100	3.24	12.96	Narrow-minded
3	723	3.46	13.84	Broad-minded
4	872	5.10	20.40	Broad-minded
5	521	3.21	12.84	Narrow-minded
6	484	3.17	12.68	Narrow-minded
7	560	3.22	12.88	Broad-minded
8	540	3.05	12.20	Narrow-minded
9	691	4.31	17.24	Broad-minded
10	367	2.88	11.54	Narrow-minded
11	418	2.86	11.44	Broad-minded
12	449	2.50	10.00	Broad-minded
13	576	3.22	12.88	Broad-minded
14	454	3.84	7.68	Broad-minded
15	100	5.15	10.30	Narrow-minded

From the above table 4, it is cleared that proposed method is much efficient for behavior analysis and can deal with any types of skew angle up to 360º. If double the diameter mean is less than word space after skew normalization, the person is broad-minded and vice-versa (Story *et al.*, 1992). The success rate for this process of the proposed method is 63% better than the other methods. More results with details are shown in table 2. The failure cases of the proposed method are mainly caused by misclassified to lower case letters.

Table 5: Traits Based on Character Analysis

Narrow-minded	1. Stereotyping 2. Judgemental 3. Restricted 4. Introvert 5. Pin-pointing shortcomings of others 6. Not open to new ideas 7. Cannot interact with negative people 8. Cannot accept disagreeableness 9. Obsessed with righteousness
Broad-minded	1. Can accept new ideas 2. Flexible or can adapt to changes 3. Curious/ open to experience 4. Not judgemental 5. Extrovert 6. Do not categorize people 7. Live in the present 8. Handle complex situations 9. Turn problems into opportunities
Balanced	1. Think out of the box 2. Socialize with others 3. Emotionally stable 4. Practical/ realistic 5. Skilled people 6. Self-insight 7. Values in life 8. Aligned to goals 9. Confident 10. Actives

From table 5, each category of people and their detailed character traits are described.

Table 6: Skills Required for Selection of Specialization in Business Based on Character

Types of Specialization in Business	Character Traits Required	Character Available Matched
Finance	Innate Problem Solver	Broad-minded
	Analytical Skills	Balanced
	Exceptional Leadership	Balanced
	Adaptable Communication	Broad-minded
	Confidence	Balanced
	Self-management	Balanced
	Technological Skills	Balanced
	Curiosity	Broad-minded
	Compatible with others	Broad-minded
Marketing	Self-awareness	Balanced
	Open to ideas	Broad-minded
	Agreeableness	Broad-minded
	Think out of the box	Balanced
	Extrovert	Broad-minded
	Aligned to goals	Balanced
	Balancing between customers and management	Balanced
HR	Patience	Narrow-minded
	Trustworthy	Narrow-minded
	Multi-tasker	Balanced
	Ambitious	Narrow-minded
	Team Player	Broad-minded
	Positive Attitude	Narrow-minded

In table 6, the skills and personality required for each domain in business is shown. On comparing those features with the already available traits, we specify the type of specialization each one should acquire or take up in business.

Table 7: Performance Based on Specialization Selection

Sl. No.	Character Analysis	Specialization	Performance
1	Narrow-minded	Marketing	7.5
2	Narrow-minded	HR	9
3	Broad-minded	Finance	8.75
4	Broad-minded	Marketing	8.5
5	Narrow-minded	Finance	7.25
6	Narrow-minded	HR	8.75
7	Broad-minded	Finance	9.25
8	Narrow-minded	Marketing	7.75
9	Broad-minded	Marketing	9.5
10	Narrow-minded	HR	9.25
11	Broad-minded	Finance	8.75
12	Broad-minded	Finance	9
13	Broad-minded	Marketing	8.5
14	Broad-minded	HR	7.25
15	Narrow-minded	HR	8.5

In table 7, the performance of the people selecting their choice of specialization is shown. The performances have been good when the people select the correct specialization according to their character analysis and vice-versa.

DISCUSSION

Initially, the handwritten manuscripts in A4 sheet papers are collected from different writers in the environment. Then the scanned images are used as input to the model and the noise removal algorithms are applied to make the image noise-free. Then K-mean segmentation came into play to convert the color image into gray scale and form clusters from it for better identification of the lines by extracting the image of lines from the background.

Since, many a times, the lines of a document are not aligned to the same baseline, skew normalization becomes necessary to get more accurate results about one's characteristics. It basically rotates the lines to remove the skew angle and brings them to the same baseline. This is followed by segmentation methods and projection profile algorithms. They are used to extract the lines, words and characters (Nicolas, Paquet & Heutte, 2004; Simistira, Papavassiliou & Stafylakis, 2011; Zimmermann & Bunke, 2002; Luthy, Varga & Bunke, 2007). The space between the words are thus calculated in pixels. The mean of the spacing between the words is required for comparison.

The whole handwritten image is used for identifying the closed loop letters by pattern recognition. The diameter mean of all the closed loops are calculated and matched against the mean word space to understand the nature of the person. This was further granularized into character elements of a person. This was important to understand which specialization in management will suit the person best by matching the characteristics with the requirement of the job to be expected out of it in the future so that the one can do justice to it. Their performances throughout the course has been analyzed and matched to validate that the prediction exactly fits their performance.

CONCLUSION

The method has been proposed to select the desired specialization in business based on the writer's handwriting in current scenario. Using the proposed method 96% lines and words were normalized perfectly with very small error rate and the character analysis based on space calculation is found with 63% accuracy. This method deals with exact classification of the inner traits and match them with the specialization best suited for them. It is very efficient to compare to existing technique and can work with skew up to 360º.

The future work can include more handwriting features with the proposed method removing the overlapping loops detected and some constant factor and obtain the more robust system.

ACKNOWLEDGMENT

The authors are very much grateful to the IBS, Kolkata for giving the opportunity to work on 'Character Analysis Using Space in Handwriting Image to Determine Specialization in Business'. All the authors sincerely express their gratitude to Dr. Ajay Pathak, Director of IBS, Kolkata for giving constant encouragement in doing research in the field of innovation of digital trends in business methods.

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