STATIC HAND GESTURE RECOGNITION

Submitted in partial fulfilment of the Degree of

Bachelor of Technology

2011 to 2015

Enrolment Nos. -111020, 111025, 111059

Name of Students - Yashwant Singh, Rahul Upadhyay and Shivendra Raj Singh

Name of supervisor - Mr. Mohammad Wajid

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

JAYPEE UNIVERSITY OF INFORMATION TECHNOLOGY,

WAKNAGHAT

DECLARATION

This is to certify that the project entitled "**Static hand gesture recognition**" has been submitted by **Yashwant Singh (111020), Rahul Upadhyay (111025)** and **Shivendra Raj Singh (111059)** for the partial fulfillment of the award of degree of Bachelor of Technology in Electronics and Communication Engineering to Jaypee University of Information Technology, Waknaghat, Solan. We declare that the work submitted is genuine and has not been in any way copied or obtained from any other sources thereof.

Signature of Students

Yashwant Singh

Yashwant Singh (111020) | Rahul Upadhyay (111025) | Shivendra Raj Singh(111059)

Date: May 25th, 2015

CERTIFICATE

This is to certify that project report entitled "**Static hand gesture recognition**", submitted by **Yashwant Singh (111020), Rahul Upadhyay (111025)** and **Shivendra Raj Singh (111059)** in partial fulfillment for the award of degree of Bachelor of Technology in Electronics and Communication Engineering to Jaypee University of Information Technology, Waknaghat, Solan has been carried out under my supervision. To the best of my knowledge, this work is not submitted partially or fully to any other University or Institute for the award of this or any other degree or diploma.

Wajid 25/05/15

Date: 25th May, 2015

Supervisor's Name: Mohammad Wajid

Designation: Assistant Professor

ACKNOWLEDGEMENT

We are very grateful and highly acknowledge the Continuous encouragement, invaluable Supervision, timely suggestions, and inspired guidance offered by our guide Mr. Mohammad Wajid, Department of Electronics and Communication Engineering , Jaypee University of Information Technology, Waknaghat, Solan in bringing this report to a successful completion.

We are grateful to Prof. Sunil Bhooshan, Head of the Department of Electronics and Communication Engineering, for permitting us to make use of the facilities available in the department to carry out the Project successfully. Last but not the least we express our Sincere thanks to all our teachers and friends who have patiently extended all sorts of help for accomplishing this undertaking.

Date:

Yashwant Singh (111020)

Rahul Upadhyay (111025)

Shivendra Raj Singh (111059)

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1. ABSTRACT

We have presented two hand gesture recognition methods, namely, edge detection based recognition and correlation based recognition of images of hand gestures of American Sign Language (ASL) in a constrained environment. Both above mentioned methods are image-comparison method, in which various parameters are compared, namely, edge count in edge detection based recognition and correlation coefficient in correlation based recognition. Edge detection based method was motivated from image-subtraction method and edges were detected based on sobel edge detection method. Test image is compared to all the images of corresponding letters of ASL and gesture are recognised based on the percentage of match of edge count in edge detection based recognition and correlation coefficient in correlation based recognition, among the database and test images. To evaluate the performance of the algorithms it is tested on 4200 images for edge detection method and 260 for correlation method. Results show that excluding some similar hand shapes and testing in constrained environments, accuracy is more than 90 percent for both the methods in a constrained environment.

Signature of students :	Signature of Supervisor
Yashwant Singh (111020	Mr. Mohammad Wajid
Rahul Upadhyay (111025)	
Shivendra Raj Singh (111059)	

2. INTRODUCTION

Communication is an integral part of our society. We can hardly imagine life without any type of communication. Animal communication is based on sensory organs. There are various modes of animal communication, for instance, visual, auditory, olfactory, electro, touch, seismic, thermal and auto communication. Visual communication is based on our eyes and auditory to our vocal system.

Mainly we use verbal communication to interact with each other in which our eyes, ears and mouth play a key role. So eyes, ears and mouth should in sound condition for a perfect communication. Dumb, Deaf and Blind have impaired sensory organs. Therefore, verbal communication is not a viable solution for them. Sign language has been developed so that a dumb person can easily express himself or herself.

Though we have sign language following are the main problems which still needed to be overcome:

1. A deaf or a dumb can't communicate naturally. They need to learn sign languages and so do the people who are trying to perceive them.
2. Two dumb persons from different countries again can't communicate as different countries have different sign languages. For instance, ASL (ASL), British Sign Language, Afghan Sign Language etc.
3. Sign Language fails when a dumb person wants to convey something to a blind person.

All the above problems could be solved if there is mechanism that recognises sign language and converts it into apprehensible text and a human voice. In this project we have tried to recognise static gestures of ASL and found out how viable various algorithms are for successful recognition with complete statistics of our testing phase.

ASL has 26 signs for corresponding English alphabets out of which 24 are static gestures and two (J and Z) are dynamic gestures. Currently we are only focusing on static gestures. Total of 19 hand shapes are used for 26 letters. Similarity of hand shapes leads to decrement of robustness of recognition. So, we have to omit some signs.Objective of our project is static hand gesture recognition of ASL using Edge detection and Correlation method

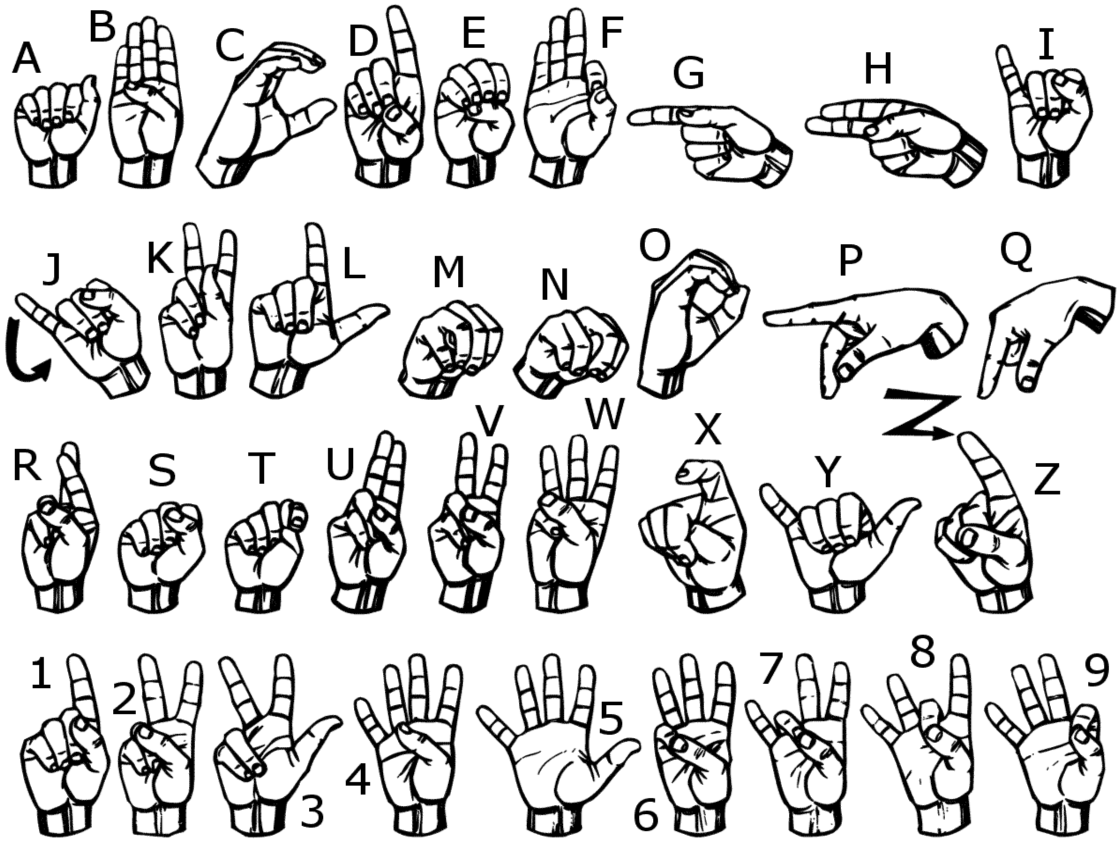

Figure 1: American Sign Language

3. METHODOLOGY

The following methods are used to show static hand gesture recognition.

3.1 IMAGE SUBTRACTION METHOD (Motivation)

In image subtraction method we have taken gray images (G_1) as direct input for creation of database for each letter and then (G_1) is converted to a binary image (G_2) based a threshold value. Many samples are taken for each letter and mean of total number of white pixels is counted from all the samples (G_m). For testing purpose input test image, which is also converted to a binary image and its total number of white pixels is calculated(N), N is subtracted from (G_m) of each letter and database image that gives minimum result after subtraction is recognised as the requisite gesture.

3.1.1 PROCEDURE:

Following are the steps for implementation of image subtraction method

1. Acquire 120 images for a particular gesture with a slight variation of palm for each image.
2. Convert it into the gray scale
3. Convert the image from step 2 into a binary image based on a skin threshold parameter.
4. Analyze statistic parameter G_m for each gesture and set the recognition parameter limits.
5. Acquire the test image and perform step 2 and 3 on it.
6. Subtract the total number of white pixels of images from step 3 and step 4 and find the difference between the two values.
7. An ideal match will give zero.

3.1.2 OBSERVATION AND INFERENCES

This is a very simple method to implement but not a very efficient one since the result generated may be highly inaccurate. A slight displacement of the position of palm of the test image relative to the database image gives ambiguous result. Skin detection and deletion of the background from the image is not easy. To overcome these defects of image subtraction method we move on to more vital algorithm, edge detection based recognition.

3.2 EDGE DETECTION BASED RECOGNITION

In this method, gray image (B_1) of a hand gesture is captured and is subjected to 2-Dimensional median filtering to remove the salt and pepper noise and preserve the edges, resulted image is B_2. Later sobel filter is used on digital gray source image (B_2) of test hand gesture to obtain a digital binary image (B_3) having 1s at the edges and 0s elsewhere. Here source image (B_2) is convolved with two 3x3 kernels to approximate the derivatives in horizontal and vertical direction. Now the total number (N) of 1s is counted in B_3. N is nearly different for all the gestures.

Following are the steps taken to obtain the recognition parameters for various signs:

1. $Gray\ Source\ Image_A\ (B_1) \xrightarrow{Median\ Filtering} Fitered\ Image_A\ (B_2)$

2. $Filtered\ \ Image\ _A\ \ \ (B_2) \xrightarrow{Sobel\ Edge\ detection} Binary\ Image_A\ (B_3)$

3. $N = \sum_{i=1}^{M} \sum_{j=1}^{N} B_3(i,j)$

4. Step 1 to 3 is repeated k times for a particular gesture and corresponding value of N is stored in a array of resolution 1x120, for instance N_A for letter ‘A’

5. $Max_A = Maximum(N_A)$, $Min_A = Minimum(N_A)$, $Range_A = Max_A$-Min_A , $Mean_A\ = \sum_{i=1}^{120} N_A(1,i)$

6. Step 1 to 5 is repeated for all 26 letters and we finally have the parameters, $Max_{Letters}\ = (Max_A, Max_B, \ldots Max_Z)$, $Min_{Letters}\ = (Min_A, Min_B, \ldots Min_Z$, $Range_{Letters}\ = (Range_A, Range_B, \ldots Range_Z)$

Mean: Mean can be defined as total sum of data divided by total number of data. Mean mathematical expectation and average is the same thing. The arithmetic mean of a sampleX_1 , X_2 , … , X_K usually denoted by $\bar{\boldsymbol{x}}$, is the sum of the sampled values divided by the number of items in the sample:

$$mean = \sum_{k=1}^{k=n} (X_k)/n \tag{1}$$

Variance: Variance can be defined as the measurement of spreading of data. It is always non-negative. Lesser value of variance indicates that data is very close to mean and more value indicates that it is away from mean and it is spread out around mean. The variance of a random variable X is its second central moment, the expected value of the squared deviation from the mean μ = E[X]:

$$\mathrm{Var}(X) = \mathrm{E}[(\mathrm{X} - \mu^2)] \tag{2}$$

Standard deviation: It can be define as amount of variation or dispersion of a set of data values. It is the square root of its variance. Algebraically it is simpler. It can be expressed in the same units as the data. The standard deviation of X is given below (3)

$$\sigma = \sqrt{E[(X - \mu)^2]} \tag{3}$$

Kurtosis: The kurtosis is defined as

$$\beta_2 = \mu_{4} / \sigma^{4} \tag{4}$$

Where, μ_4 is the fourth moment about the mean and σ is the standard deviation.

3.2.1 PROCEDURE

Following are the steps for implementation of edge detection based method

1. Acquire the database images. At least 120 images for a particular gesture with a slight variation of palm for each image on a uniform background.
2. Convert the images acquired from step1 into gray images.
3. Detect the edges in the image of step 2.
4. The images with detected edges will be black and white.
5. pixel value at edge is unity
6. pixel value elsewhere is equal to zero
7. Count the total number of 1s in the images of step 3.
8. Create threshold for edge count(N) of various gestures based on the maximum, minimum and mean of the N
9. Gesture is recognized based on the N value of corresponding letters.

3.2.2 RESULT

After performing the edge detection and counting the whites pixels we found out the mean of all the 120 samples of a particular gesture and these means are sorted out and maximum and minimum values of total white pixels are also calculated to find out the range of variation. Outliers are removed; ten from top and ten from bottom, to further enhance our results.

Clusters are made based on the mean values and corresponding ranges of all letters taking care of any overlapping in total number of white pixels so that each sign can be recognised independently and correctly.

Based on our work we can easily recognise any K (where K depends on range of *N*) numbers of signs from ASL such that there is no overlap in edge count range of any particular gesture from figure 6.

Figure 2 : Database Images

Figure 3: Test Image

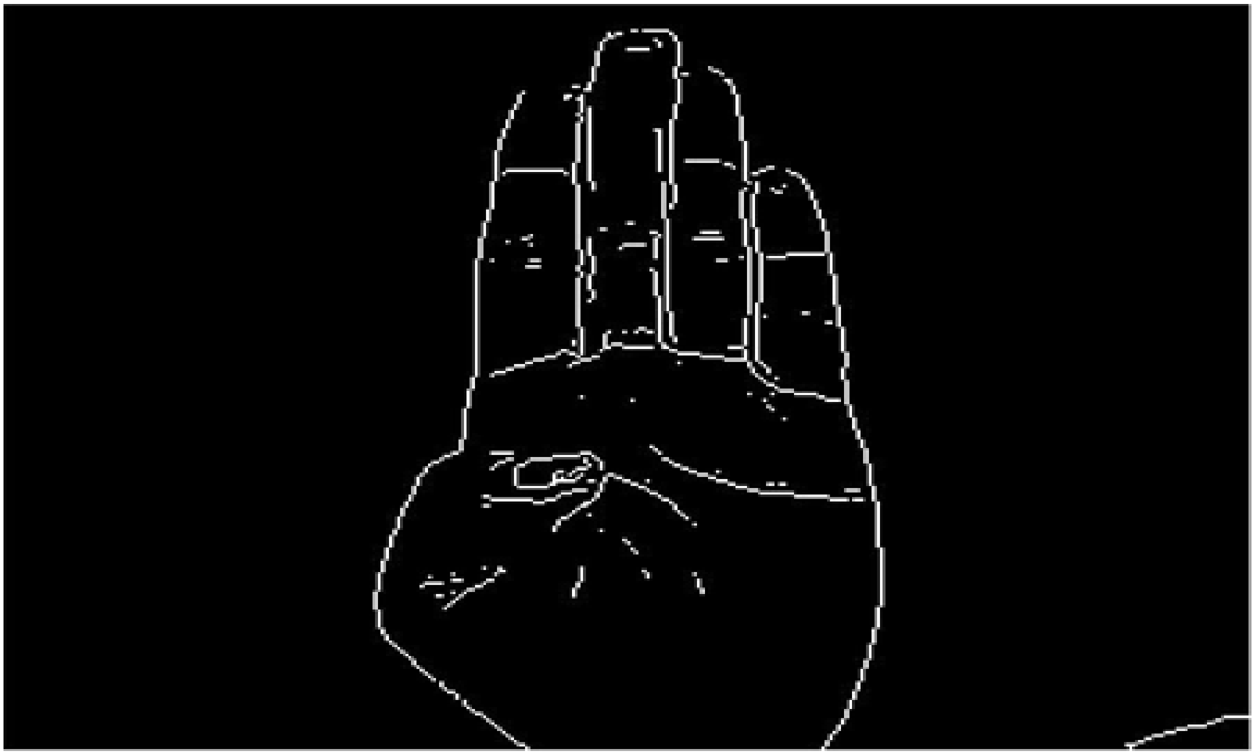

Figure 4**:** Edge of Test Image

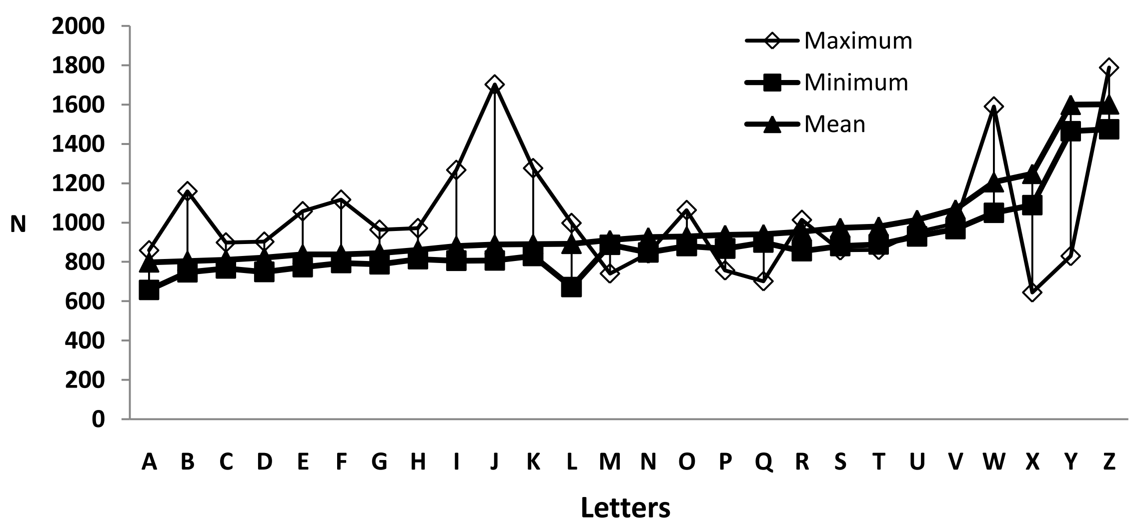

Figure 5 : Parameters of all the Gestures

In the above graph maximum, minimum and mean value of total number of edge count of each letter is shown. For example for letter ‘J’ maximum, minimum and mean edge count is around 1800, 700, 800.

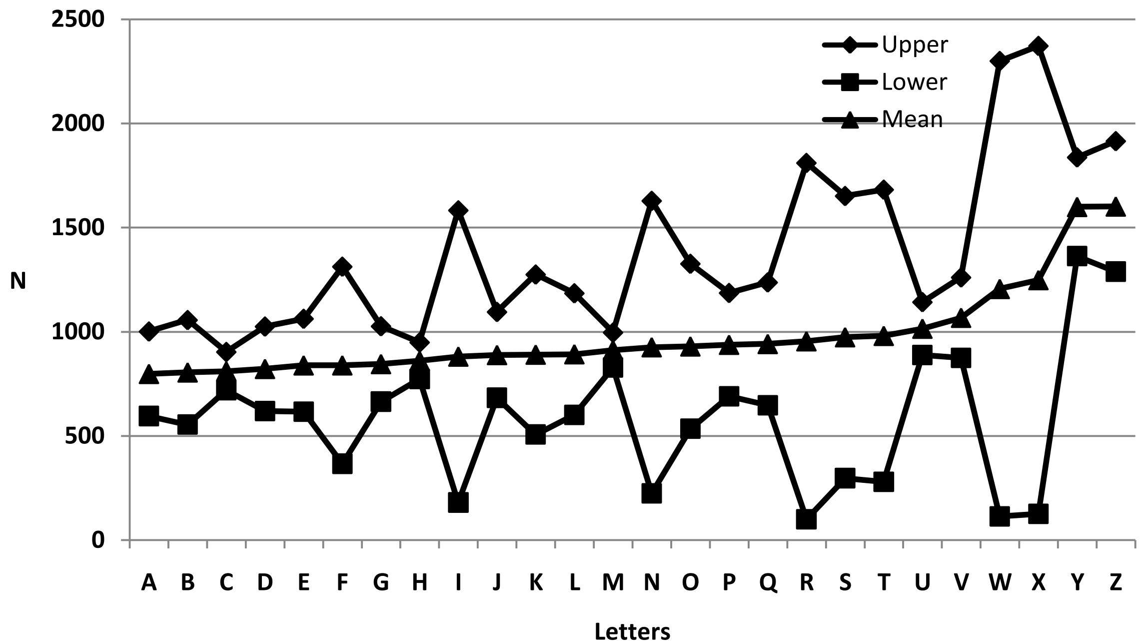

Figure 6 : Range

In the above graph upper, lower and mean value of range of edge count of each letter is shown. For example for letter ‘an’ upper, lower and mean range is around 1000, 600, 800.

3.3 TWO DIMENSION CORRELATION METHOD

In this method of gesture recognition, we have used two-dimensional correlation method. We have taken 26 letters of English Alphabet and their corresponding gesture in the ASL for recognition purpose. Just to get an insight of this method, we found out the correlation of a single gesture with all other gestures. For instance, the test image of Gesture ‘A’ is correlated with all the letters (‘A’,’B’,’C’,…, ‘Z’) Correlation of A with itself (auto-correlation) gives correlation coefficient, r=1 and for all other images it was less than 1.So, for 26 letters we have a correlation matrix is of dimension 26x26.

$$\boldsymbol{r} = \frac{\sum_m \sum_n (A_{mn} - \bar{A})(B_{mn} - \bar{B})}{\sqrt{\sum_m \sum_n (A_{mn} - \bar{A})^2 (B_{mn} - \bar{B})^2}} \tag{5}$$

Where r is the correlation coefficient and ranges from 0 to 1, 0 signifies no match at all and contrary to it 1 signifies a perfect match.

Where A and B are images of resolution m x n

$\bar{A}$ is the mean pixel value of image A

$\bar{B}$ is the mean pixel value of image B

$$mean = \sum_{k=1}^{k=n}(X_k)/n \qquad (6)$$

3.3.1 PROCEDURE

Following are the steps of correlation based gesture recognition method:

1. A database of 26 gray images corresponding to each letter of English Alphabet of resolution 160x120 each is made.
2. A gray snapshot (S) of 160x120 resolutions is taken from a continuous video input.
3. Image S is correlated with all the 26 databases images and corresponding correlation coefficient (r) is stored in an array(R) of size 26
4. Maximum value in R gives the corresponding letter with maximum match.
5. The test image which gives maximum value of r with S is recognized as the input image.

3.3.2 RESULT

From observations it was concluded that a single letter matches more than 70 % with many letters though they are very different and this could lead to a possible mismatch.

In the second instalments we took 26 images of a single letter with slight variations in the hand orientation and found its correlation matrix of 26x26. It was observed that variation in hand for the same letter causes a variation of the value of r up to 0.300.

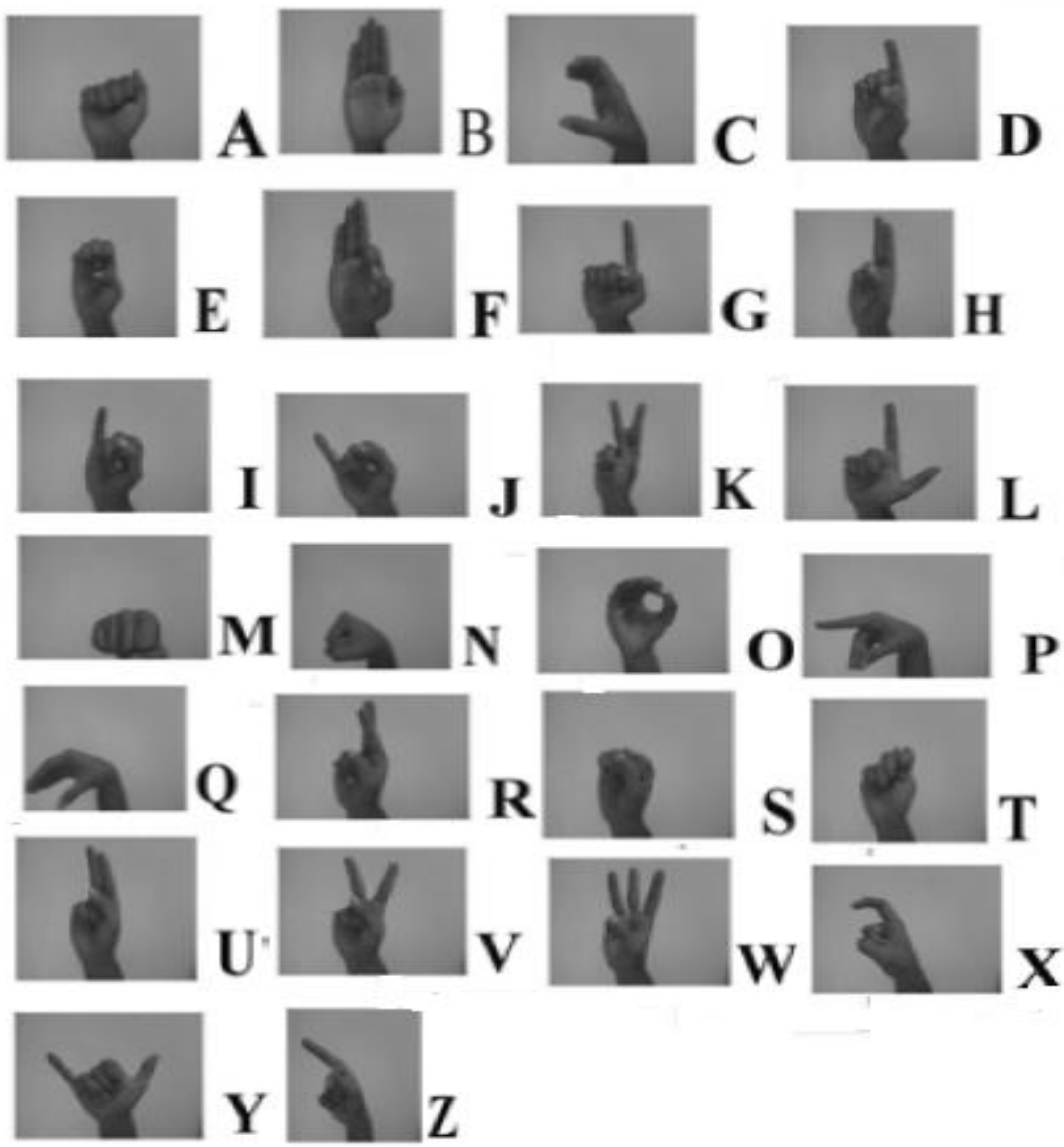

Figure 7: Database used for correlation

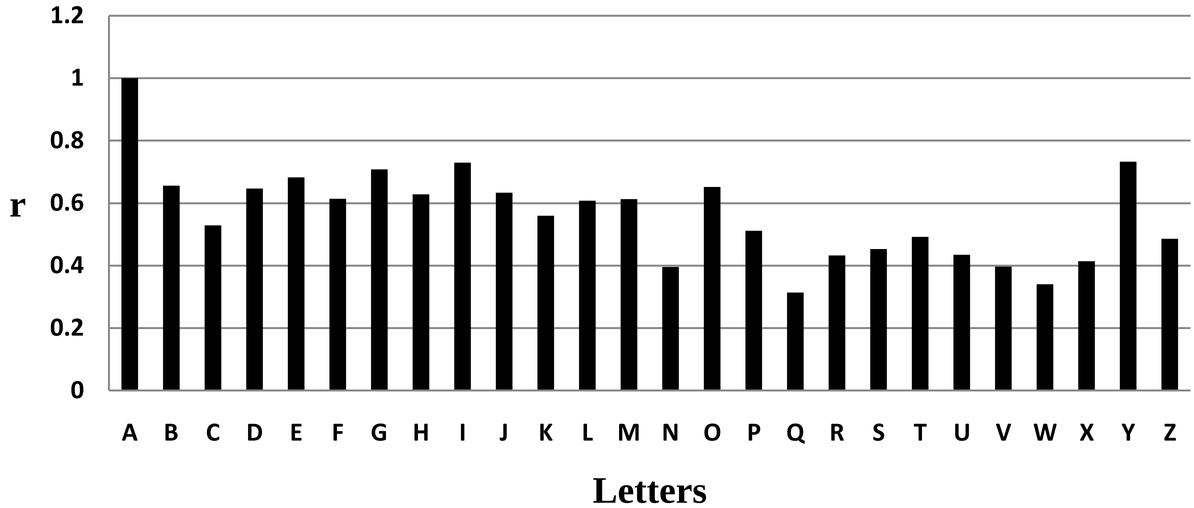

Figure 8: Correlation of 'A' with other letters

In this case **'A'** is more probable to match with **'B, D, E, G, H, I, J, L, M, O, Y'**

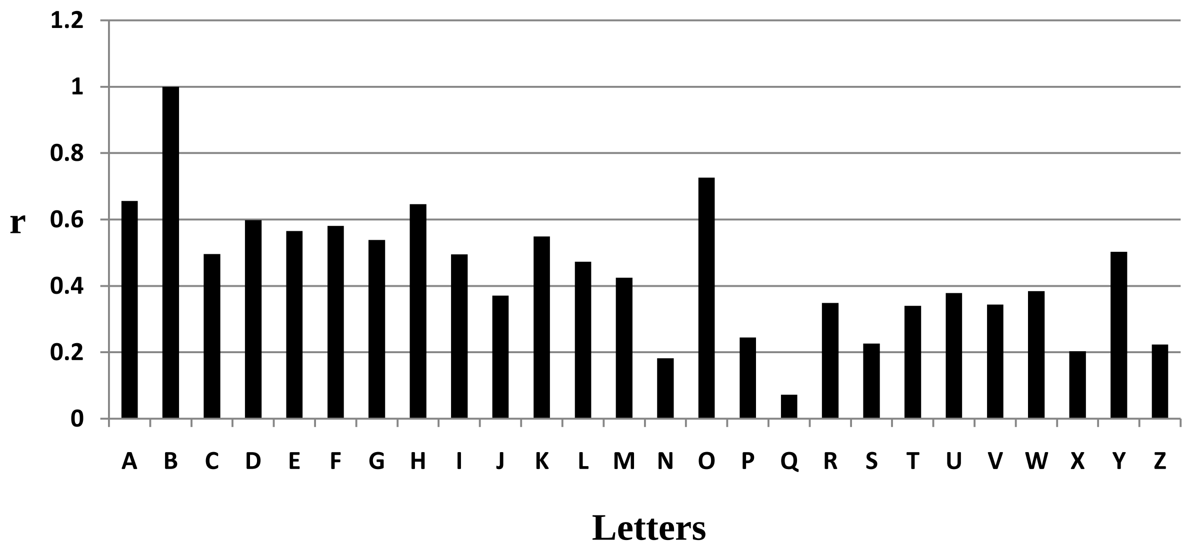

Figure 9: Correlation of 'B' with other letters

In this case **'B'** is more probable to match with **'A, H, O'**

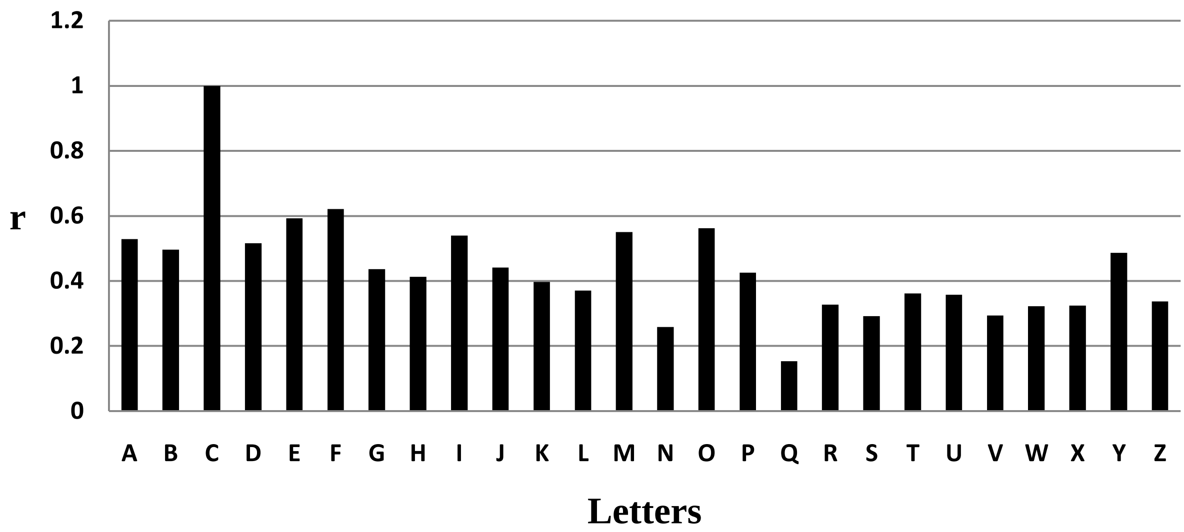

Figure 10: Correlation of 'C' with other letters

In this case **‘C’** is more probable to match with **‘F’**

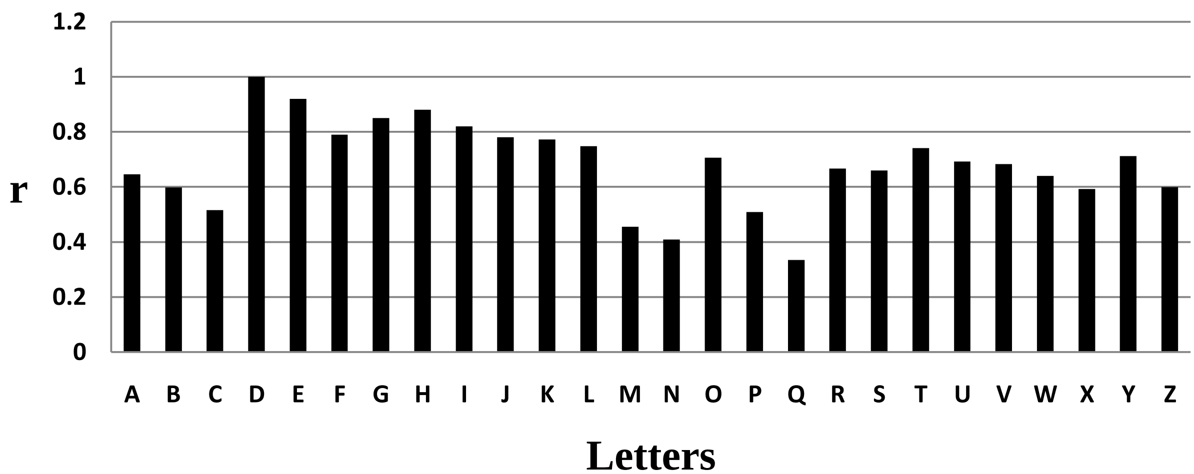

Figure 11: Correlation of 'D' with other letters

In this case **‘D’** is more probable to match with **‘A, E, F, G, H, I, J, K, L, O, R, S, T, U, V, W, Y’**

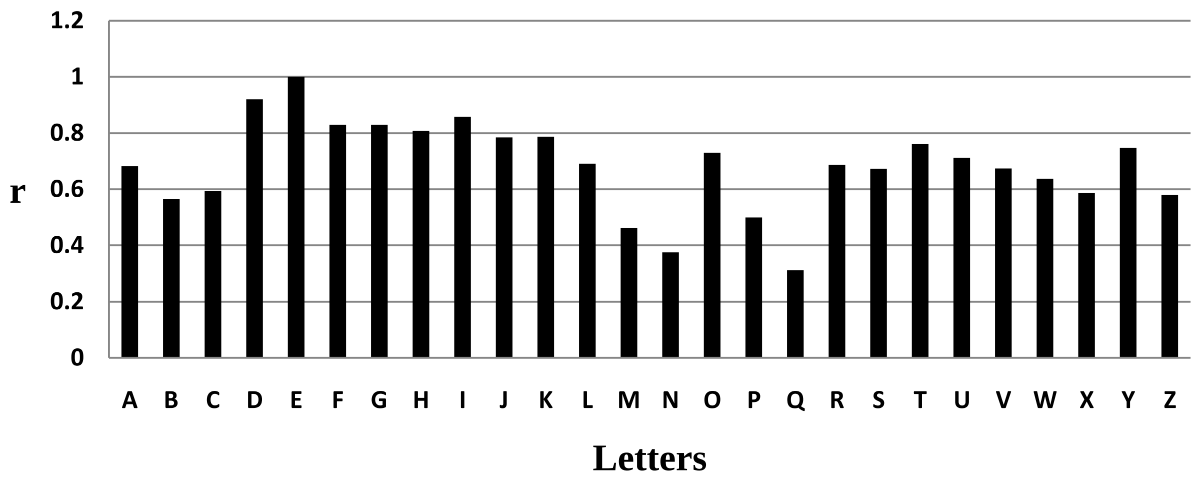

Figure 12: Correlation of 'E' with other letters

In this case **‘E’** is more probable to match with **‘A, D, F, G, H, I, J, K, L, O, R, S, T, U, V, W, Y’**

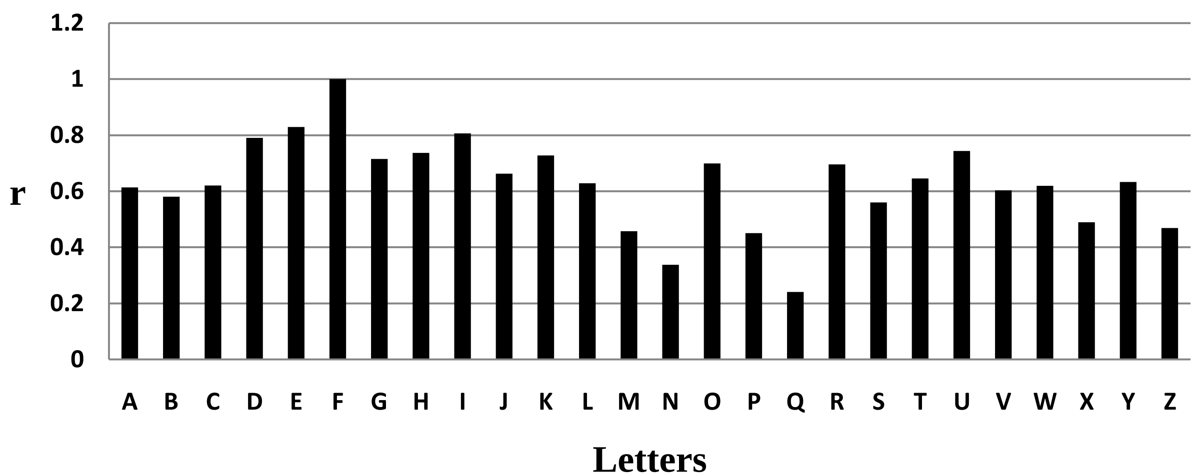

Figure 13: Correlation of 'F' with other letters

In this case **‘F’** is more probable to match with **‘A, C, D, E, G, H, I, J, K, L, O, R, T, U, W, Y’**

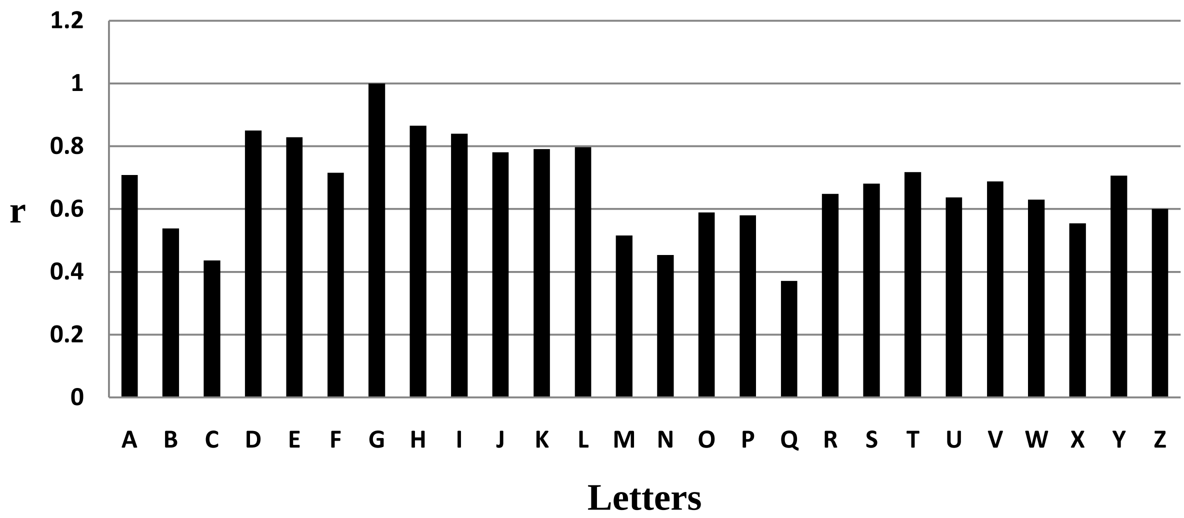

Figure 14: Correlation of 'G' with other letters

In this case **‘G’** is more probable to match with **‘A, B, E, H, I, J, K, L, R, S, T, U, V, W, Y ’**

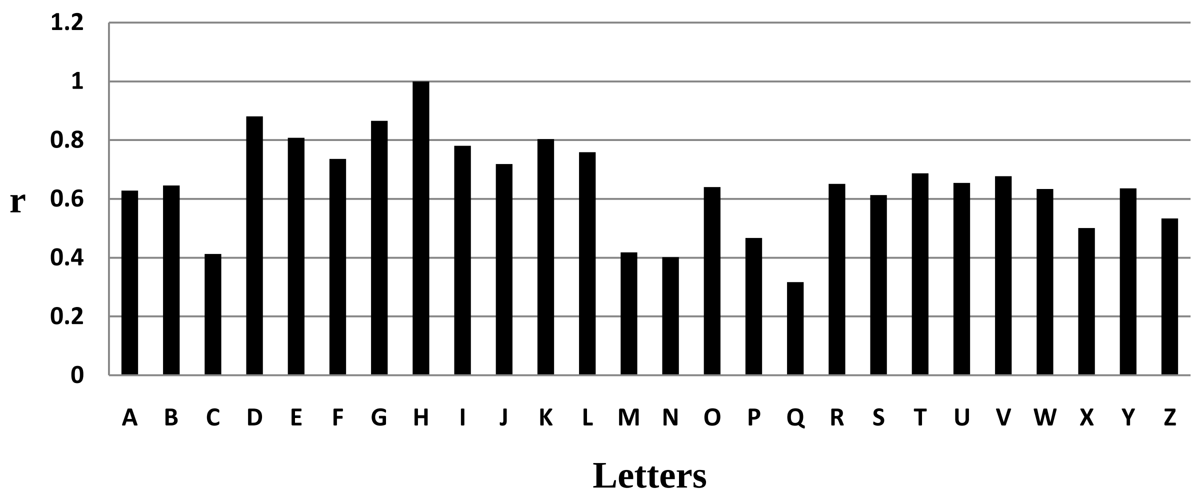

Figure 15: Correlation of 'H' with other letters

In this case **‘H’** is more probable to match with **‘A, B, D, E, F, G, I, J, K, L, O, R, S, T, U, V, W, Y ’**

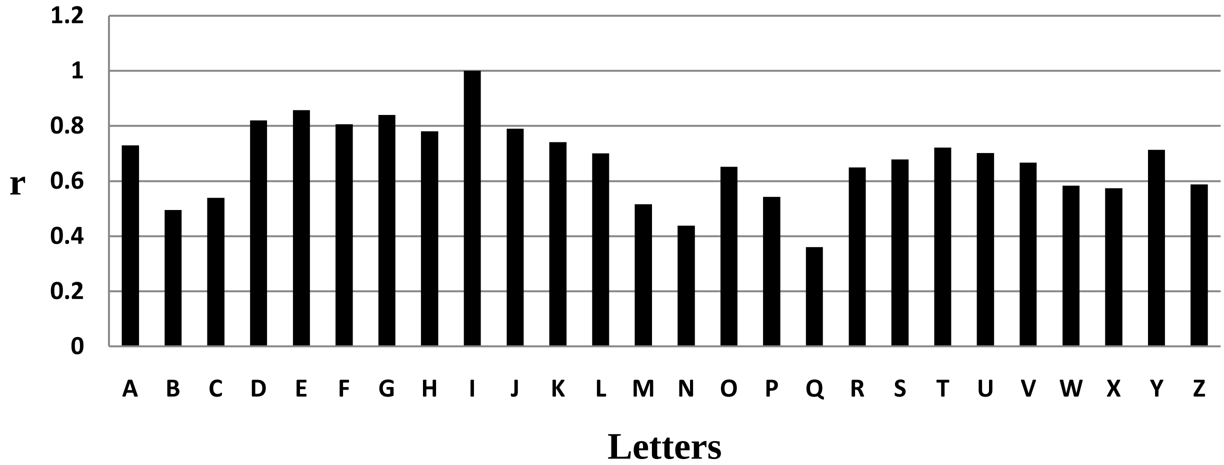

Figure 16: Correlation of 'I' with other letters

In this case **'I'** is more probable to match with **'A, D, E, F, G, H, J, K, L, O, R, S, T, U, V, and Y '**

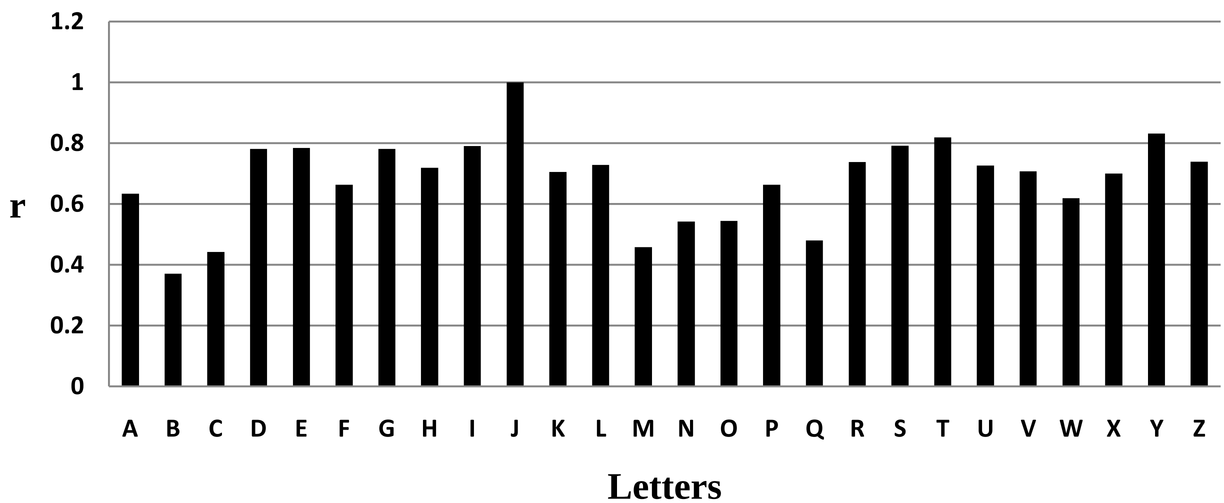

Figure 17: Correlation of 'J' with other letters

In this case **'J'** is more probable to match with **'A, D, E, F, G, H, I, K, L, P, R, S, T, U, V, W, X, Y, Z '**

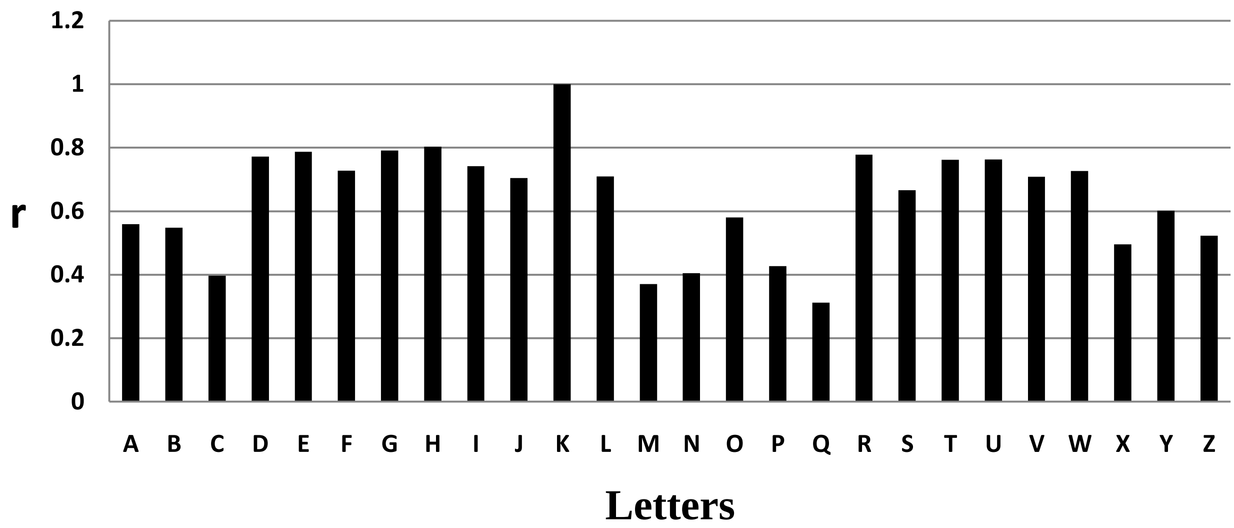

Figure 18: Correlation of 'K' with other letters

In this case **‘K’** is more probable to match with **‘D, E, F, G, H, I, J, L, R, S, T, U, V, W ’**

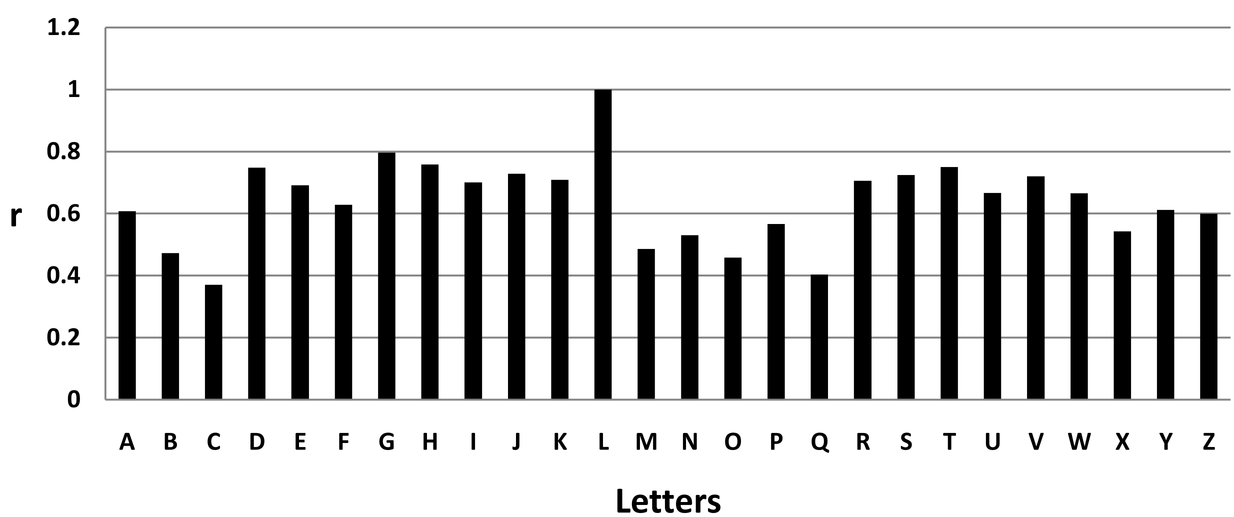

Figure 19: Correlation of 'L' with other letters

In this case **‘L’** is more probable to match with **‘A, D, E, F, G, H, I, J, K, R, S, T, U, V, W, Y’**

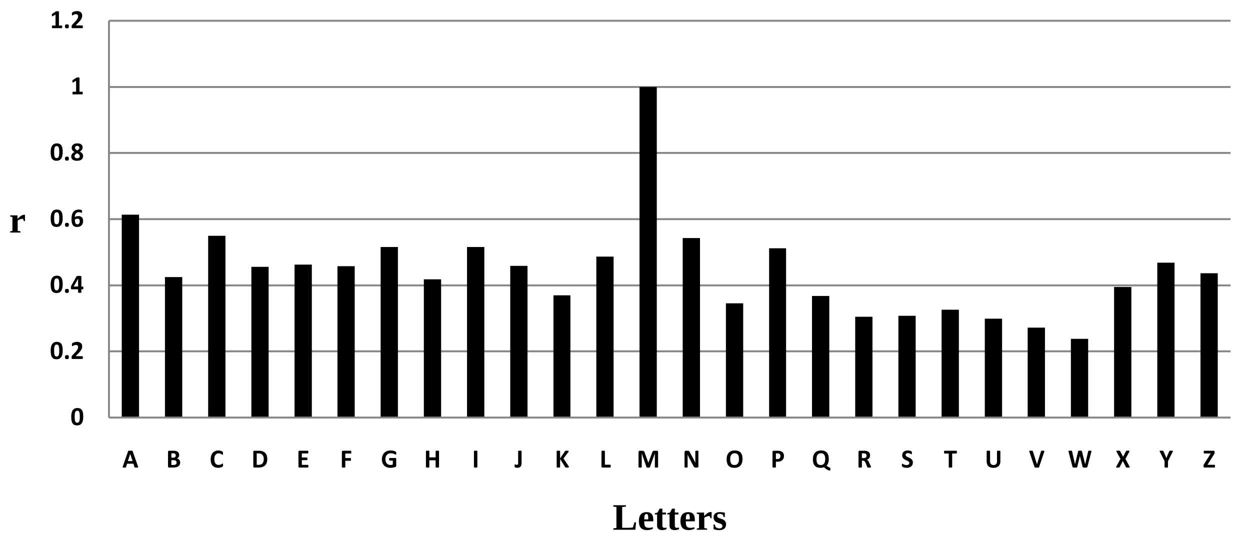

Figure 20: Correlation of 'M' with other letters

In this case **'M'** is more probable to match with **'A'**

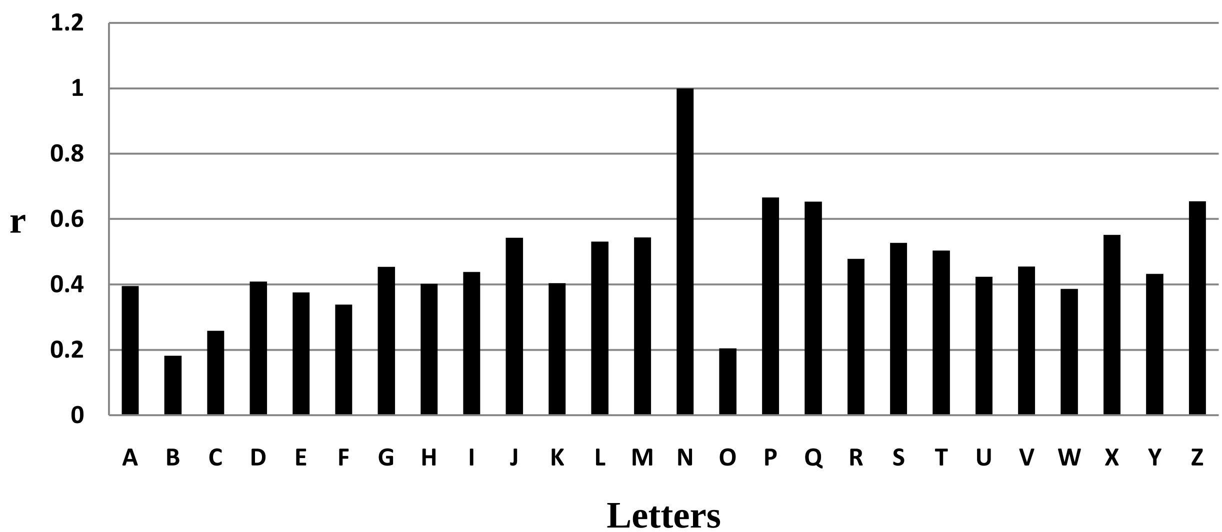

Figure 21: Correlation of 'N' with other letters

In this case **'N'** is more probable to match with **'P, Q, and Z'**

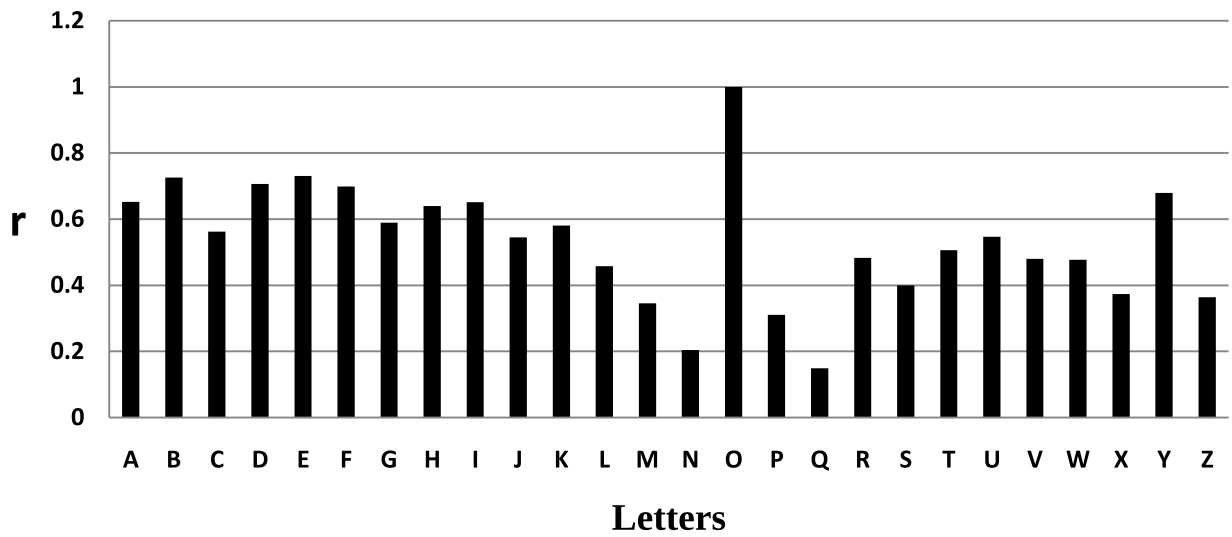

Figure 22: Correlation of 'O' with other letters

In this case **'O'** is more probable to match with **'A, B, D, E, F, H, I, Y'**

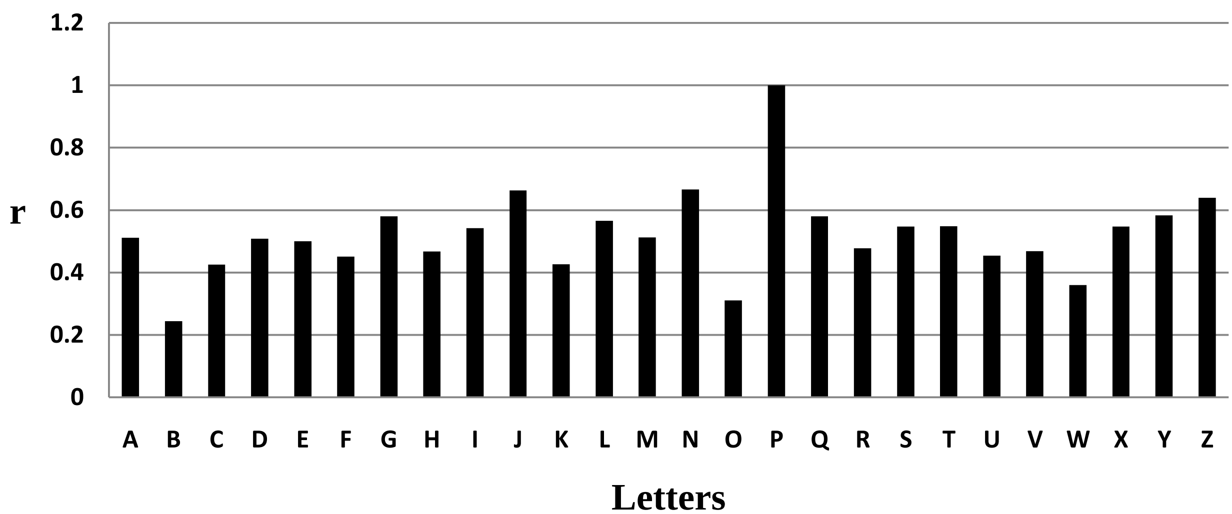

Figure 23: Correlation of 'P' with other letters

In this case **'P'** is more probable to match with **'J, N, and Z'**

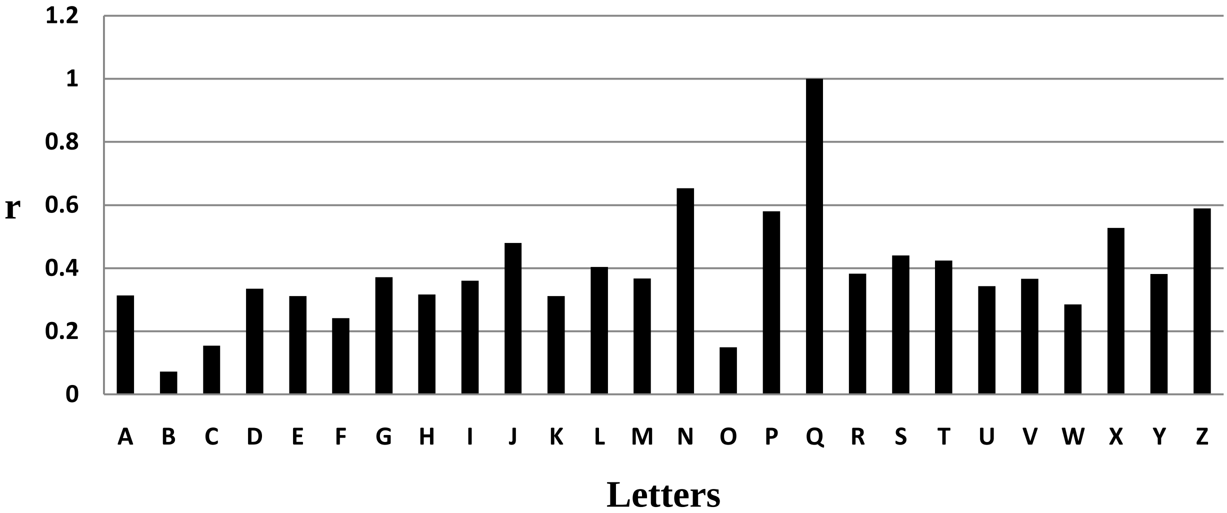

Figure 24: Correlation of 'Q' with other letters

In this case ‘**Q**’ is more probable to match with ‘**N**’

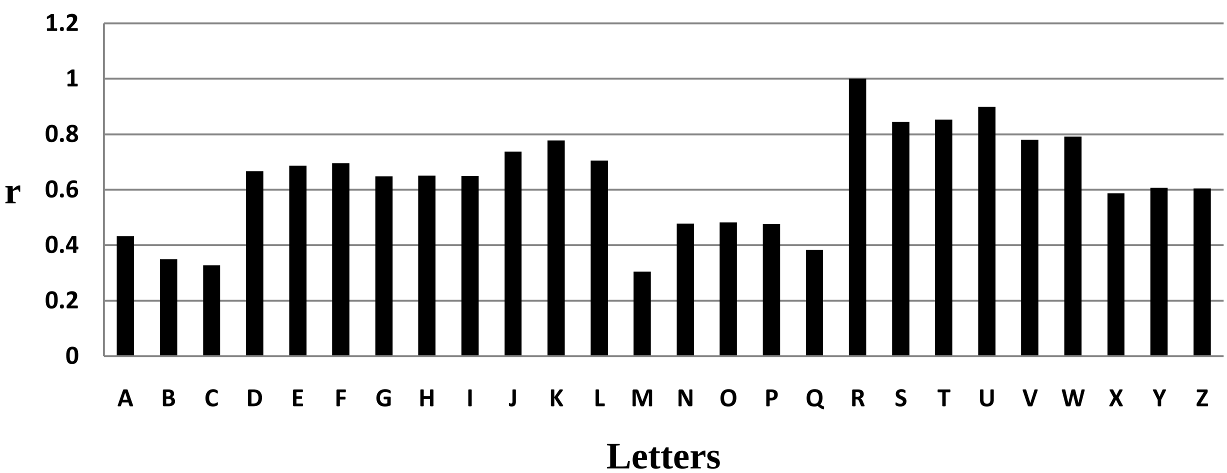

Figure 25: Correlation of 'R' with other letters

In this case **‘R’** is more probable to match with **‘D, E, F, G, H, I, J, K, L, S, T, U, V, W, Y’**

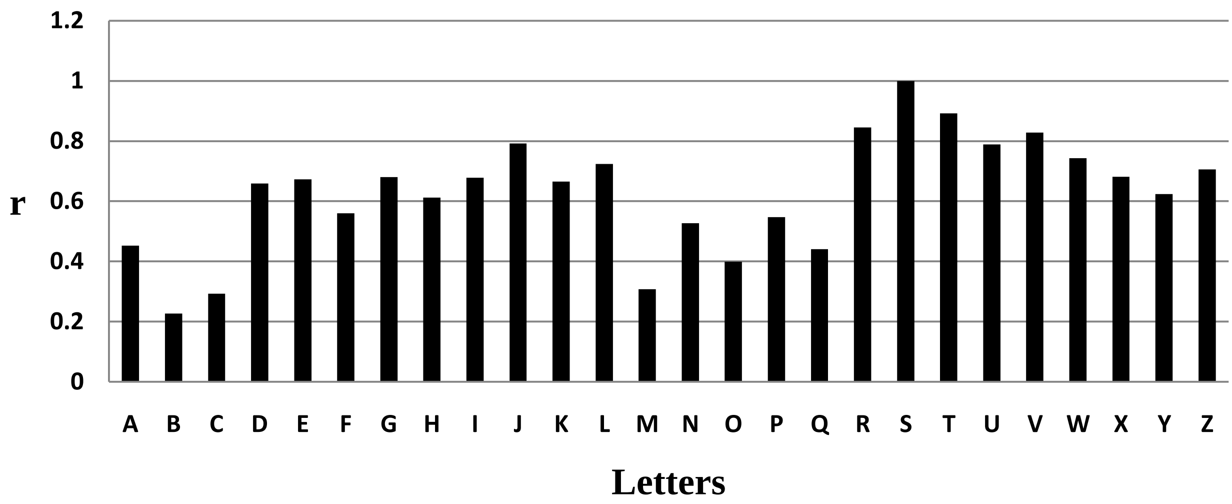

Figure 26: Correlation of 'S' with other letters

In this case **‘S’** is more probable to match with **‘D, E, G, H, I, J, K, L, R, T, U, V, W, X, Y, Z’**

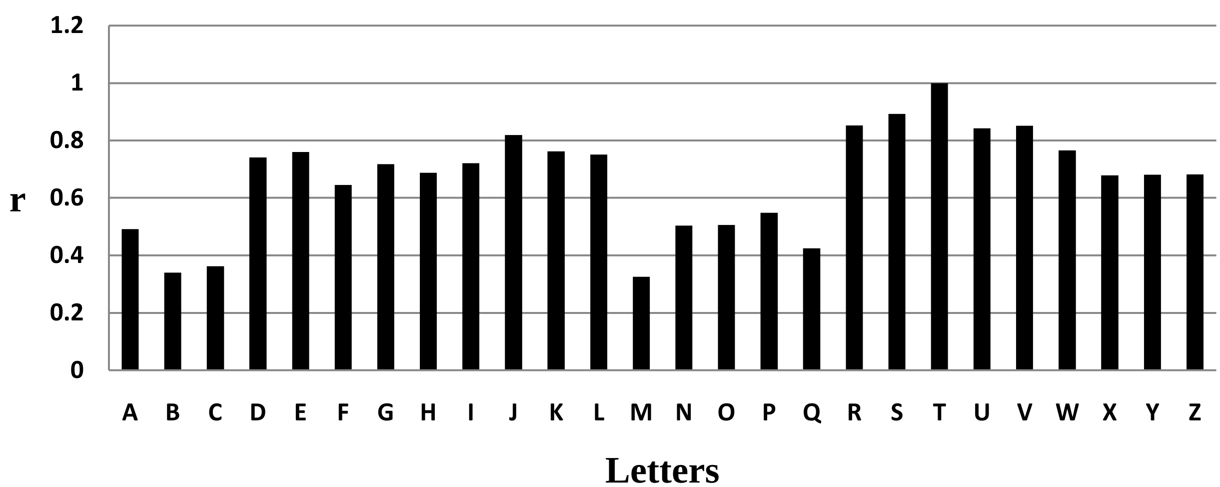

Figure 27: Correlation of 'T' with other letters

In this case **‘T’** is more probable to match with **‘D, E, F, G, H, I, J, K, L, R, S, U, V, W, X, Y, Z’**

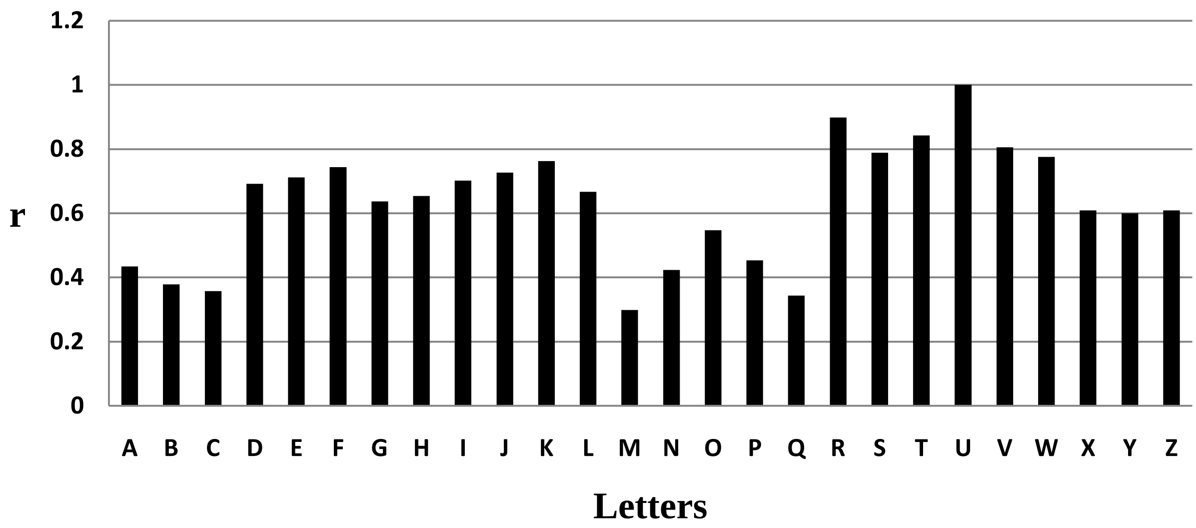

Figure 28: Correlation of 'U' with other letters

In this case **‘U’** is more probable to match with **‘D, E, F, G, H, I, J, K, L, R, S, T, V, W’**

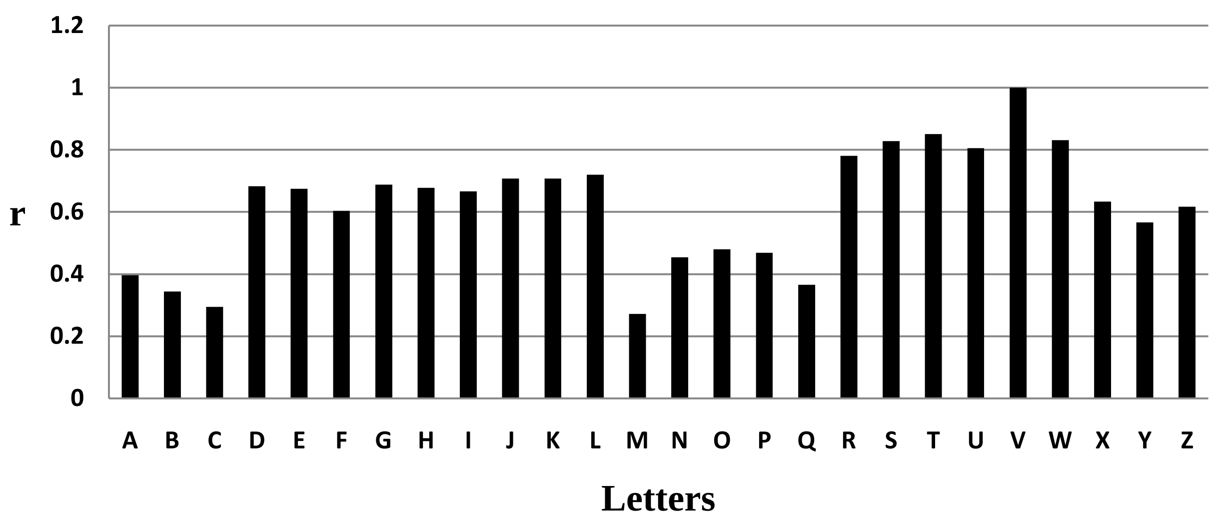

Figure 29: Correlation of 'V' with other letters

In this case **‘V’** is more probable to match with **‘D, E, G, H, I, J, K, L, R, S, T, U, W, X, Z’**

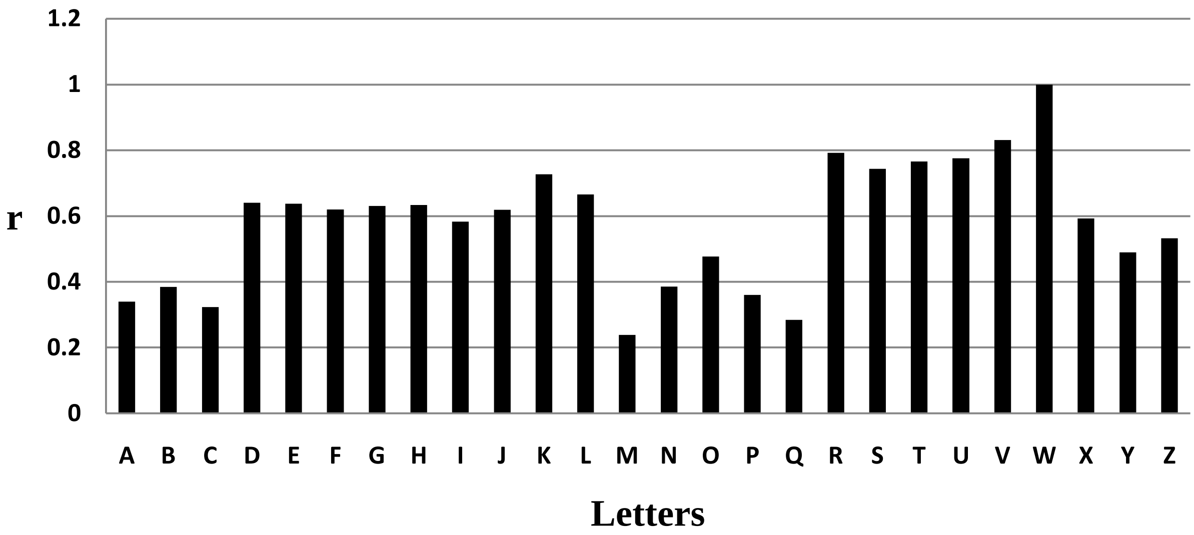

Figure 30: Correlation of 'W' with other letters

In this case **‘W’** is more probable to match with **‘D, E, F, G, H, K, L, R, S, T, U, and V’**

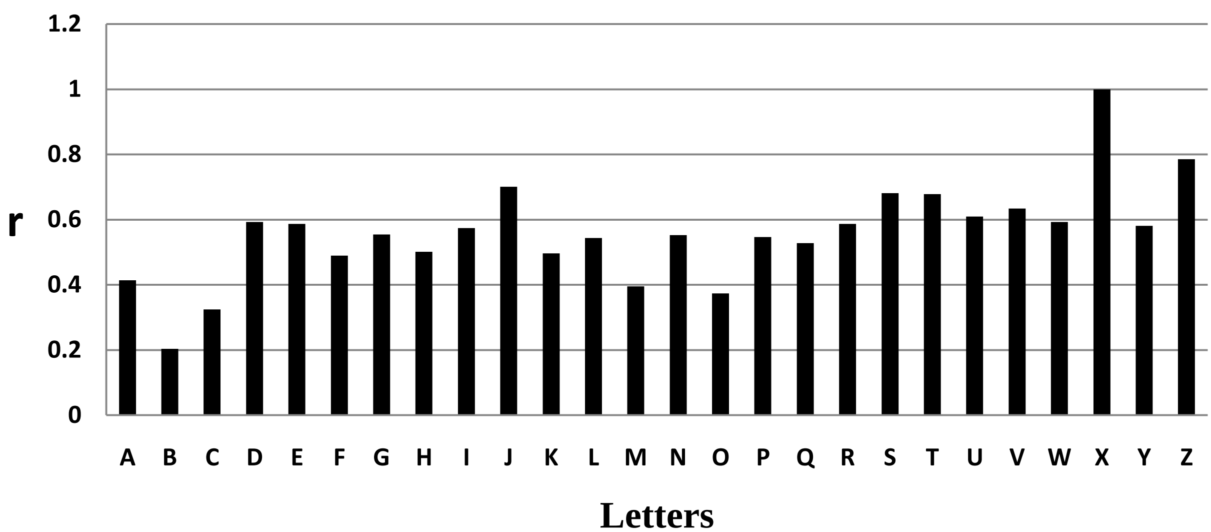

Figure 31: Correlation of 'X' with other letters

In this case **‘X’** is more probable to match with **‘J, S, T, U, V, and Z’**

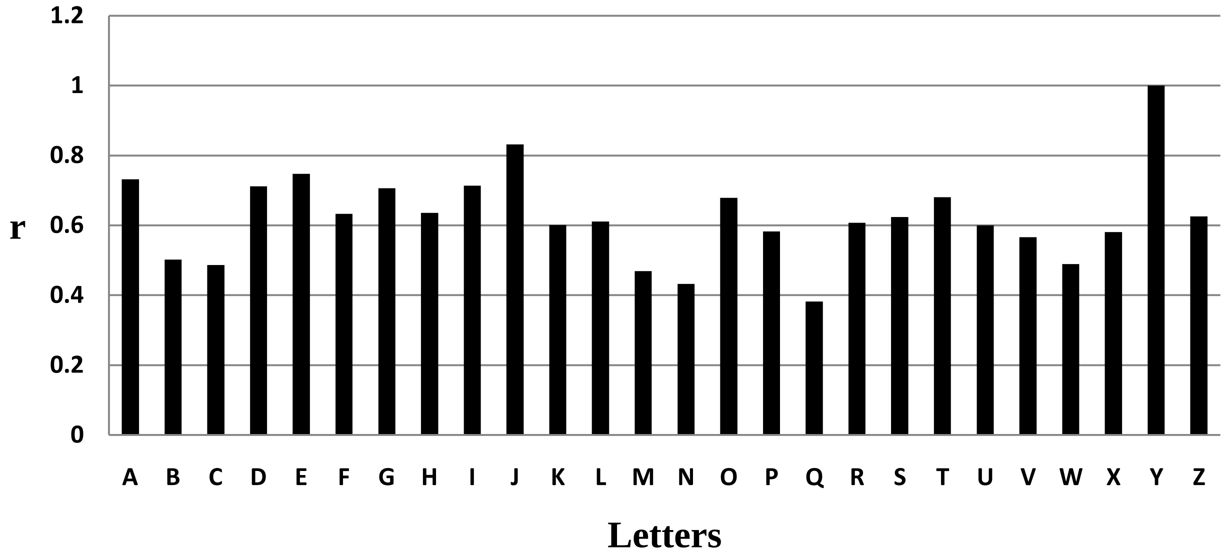

Figure 32: Correlation of 'Y' with other letters

In this case **‘Y’** is more probable to match with **‘A, D, E, F, G, H, I, J, L, O, R, S, T, Z’**

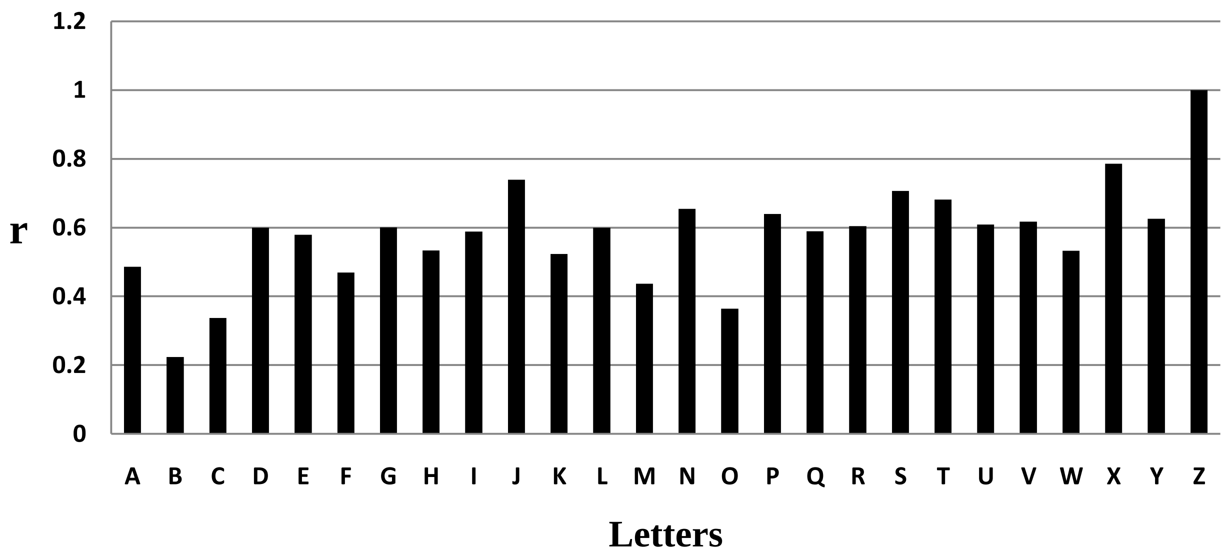

Figure 33 : Correlation of 'Z' with other letters

In this case **‘Z’** is more probable to match with **‘J, N, P, S, T, V, X, Y’**

3.3.1 CONCLUSION

From the table 2 it can be concluded that letters ‘ Q, C, M, B, N, P, O, A, X, W, Z ’ can be easily detected and there are less chance for them to be match with other letters because their probability of matching with other letters are less than 60% .

Q	C	M	B	N	P	O	A	X
0.3663	0.4168	0.4217	0.4227	0.4483	0.5031	0.5143	0.53802	0.5109
W	**Z**	**V**	**Y**	**S**	**F**	**E**	**R**	**U**
0.5628	0.565	0.6048	0.6093	0.6139	0.6144	0.6156	0.6168	0.6184
L	**K**	**H**	**T**	**I**	**G**	**D**	**J**	
0.6258	0.6264	0.6348	0.654	0.6594	0.661	0.669	0.6704	

Table 2 : Sorted average correlation coefficient of a letter with all other letters

But the letters like ‘V, Y, S, F, E, R, U, L, K, H, T, I, G, D, J’ are highly probable to match with others letter because their probability of matching with other letters are more than 60%.

In Fig. 36, correlation of each letter with all other letters has been shown. From plot it can be observed that a single letter matches more than 60 % with many letters though they are very different and this could lead to a possible mismatch. Correlation of each letter with itself gives correlation coefficient, r=1 and for all other images it is less than 1.

LETTERS	AMBIGUITY
A	B, D, E, G, H, I, J, L, M, O, Y
B	A, H, O
C	F
D	A, E, F, G, H, I, J, K, L, O, R, S, T, U, V, W, Y
E	A, D, F, G, H, I, J, K, L, O, R, S, T, U, V, W, Y
F	A, C, D, E, G, H, I, J, K, L, O, R, T, U, W, Y’
G	A, B, E, H, I, J, K, L, R, S, T, U, V, W, Y
H	A, B, D, E, F, G, I, J, K, L, O, R, S, T, U, V, W, Y
I	A, D, E, F, G, H, J, K, L, O, R, S, T, U, V, Y
J	A, D, E, F, G, H, I, K, L, P, R, S, T, U, V, W, X, Y, Z
K	D, E, F, G, H, I, J, L, R, S, T, U, V, W
L	A, D, E, F, G, H, I, J, K, R, S, T, U, V, W,Y
M	A
N	P, Q, Z
O	A, B, D, E, F, H, I, Y
P	J, N, Z
Q	N
R	D, E, F, G, H, I, J, K, L, S, T, U, V, W, Y
S	D, E, G, H, I, J, K, L, R, T, U, V, W, X, Y, Z
T	D, E, F, G, H, I, J, K, L, R, S, U, V, W, X, Y, Z
U	D, E, F, G, H, I, J, K, L, R, S, T, V, W
V	D, E, G, H, I, J, K, L, S, T, U, W, X, Z
W	D, E, F, G, H, K, L, R, S, T, U, V
X	J, S, T, U, V, Z
Y	A, D, E, F, G, H, I, J, L, O, R, S, T, Z
Z	J, N, P, S, T, V, X, Y

Table 1 : Letters with their ambiguity

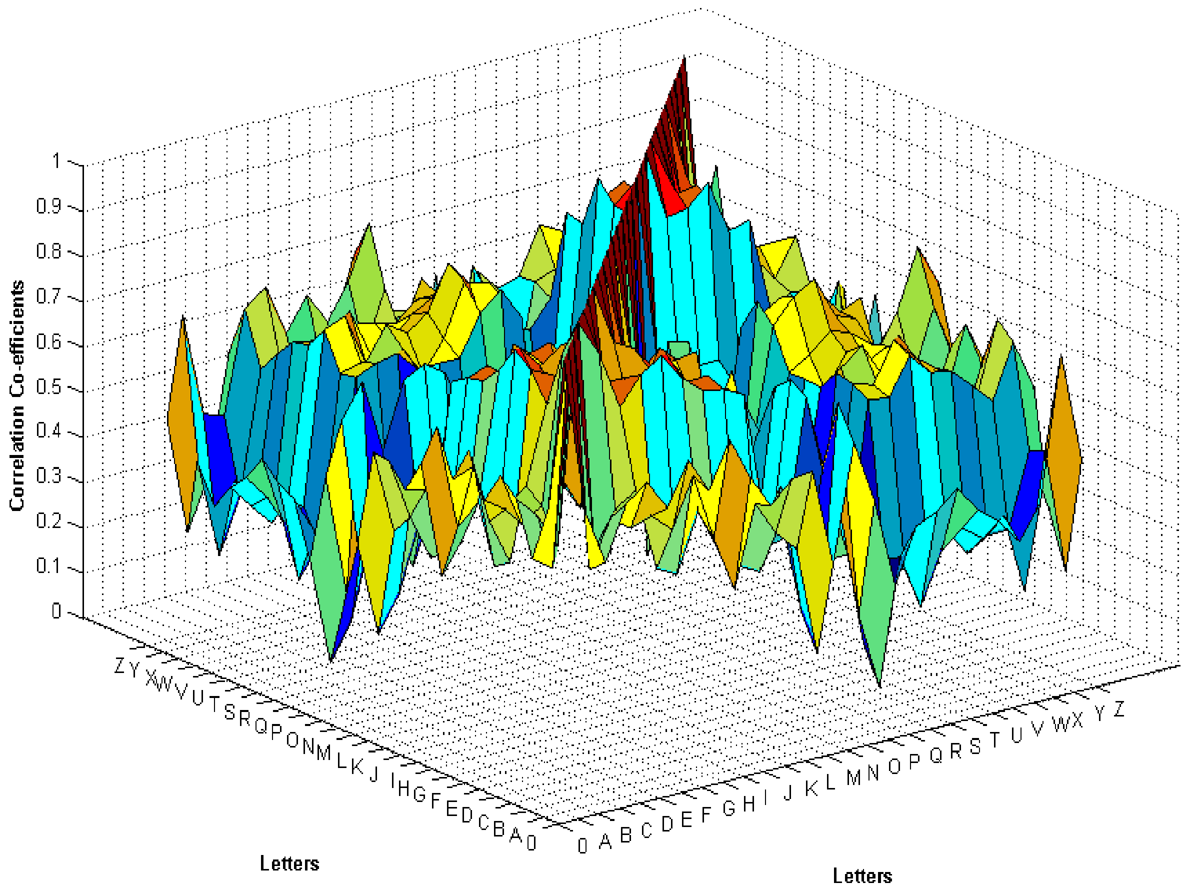

Figure 34 : Relation between correlation coefficient and letters

4. RESULTS

We have taken 120 images for a particular gesture. So for 26 signs we have taken a total of 26x120 imags which consist our database.

Image subtraction is a very simple method to implement but not a very efficient one since the result generated may be highly inaccurate. In this method an ideal match will give zero. A slight displacement of the position of palm of the test image relative to the database image gives ambiguous result. Skin detection and deletion of the background from the image is not easy.

After performing the edge detection and counting the whites pixels we found out the mean of all the 120 samples of a particular gesture and these means are sorted out and maximum and minimum values of total white pixels is also calculated to find out the range of variation. Outliers are removed to further enhance our results.

Clusters are made based on the mean values and corresponding ranges taking care of any overlapping in total number of white pixels so that each sign can be recognised independently and correctly.

Based on our work we can easily recognise any K(where K depends on range of *N*) number of signs from ASL such that there is no overlap in edge count range of any particular gesture from figure 6.

In correlation method we found out the correlation of a single gesture with all other gestures. For instance, the test image of Gesture A is correlated with all the letters (A, B, C, and Z). Correlation of A with itself gives correlation coefficient, r=1 and for all other images it was less than 1.So, for 26 letters we have a correlation matrix of dimension 26x26.

From observations it was concluded that a single letter matches more than 70 % with many letters though they are very different and this could lead to a possible mismatch. In the second installments, we took 26 images of a single letter with slight variations in the hand orientation and found its correlation matrix of 26x26.It was observed that variation in hand for the same letter causes a variation of the value of r up to 0.300.In this project we have successfully implemented and tested two algorithms.

5. CHALLENGES

These are the challenges facing the project.

1. Uniform background is needed for this algorithm to work as for edge detection and conversion of a RGB image to a binary image, there must be uniform background. So that foreground and edges are extracted without any hastle. In this algorithm we are using gradient method to detect the edges. Once we switch to skin detection method for foreground extraction we can work with any natural background easily.

2. Creation of the database is another problem. For each gesture we have taken 120 sample images. So for 26 signs we have taken 26x120 images which is not an easy task. We insist for database creation from direct video input.

3. Hand position relative to camera must not change. If hand position is relatively changed more than 1 inch from our predefined position, it could lead to drastic changes in our result and signs could be recognized wrongly.

4. Accuracy could be increased. Accuracy is limited to restricted hand motions only. For increasing accuracy we must move to some vital algorithms.

5. Processing delay. As we have performed the demonstration on the Matlab, it is not viable for real time processing. So using any DSP would be better for real time scenario.

6. FUTURE WORK

The following are the future work that can be done on further study of the project.

1. Finding the best prevailing algorithms for recognition purpose and deducing new algorithms, if possible, is our main concern. In next phase we will test Principal Component Analysis, Rotation Invariant Method and some other algorithms for recognition purpose. We have to deduce which fits best for ASL recognition.

2. Testing on FPGA board. Once we are done with the demonstration version. We will write the equivalent cod in any HDL and will test this version on FPGA for real time implementations.

3. Making a handy device that can work in real time. An android App capable of performing the same functions would be highly viable and could be used widely. So if time permits we will make an equivalent android App for ASL recognition.

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