A Hybrid Approach Handwritten Character Recognition for Mizo using Artificial Neural Network

1st J. Hussain
Department of Mathematics and Computer Science
Mizoram University
Aizawl, India
jamal.mzu@gmail.com

2nd Vanlalruata
Department of Mathematics and Computer Science
Mizoram University
Aizawl, India
ruata.mzu@gmail.com

***Abstract*— In the past decade we have seen a rapid advancement in object recognition, however Mizo Handwritten Character Recognition (MHCR) remains an untapped field. In this study a handwritten is collected from 20 different writers each consisting of 456 Mizo characters. In total 20 X 456= 9120 characters are used for testing the proposed system. In this process of recognition, the challenging factor is due to the fact that Mizo handwritten consists of vowels character that are made up of multiple isolated blobs (pixel) such as circumflex (ˆ) on top vowel character. This make segmentation of each individual character difficult and challenging. Therefore, to implement MHCR, a hybrid approach character segmentation using bounding box and morphological dilation is combined, which merges the isolated blobs of Mizo character into a single entity. A hybrid approach feature extraction using a combination of zoning and topological feature is implemented. These features are used for classification and recognition. To evaluated the performance of MHCR model an experiment is carried out using 4 different types of Artificial Neural Network Architecture. Each Architecture is compared and analysed. The Back Propagation Neural Network has the highest accuracy with a recognition rates of 98%. This proposed hybrid technique will help in building an automatic MHCR system for practical applications.**

Keywords—Handwritten Mizo Characters; Character Recognitio; Mizo handwritten OCR, Pattern Recognition, Hybrid OCR, Hybrid Segmentation Technique for isolated character, Hybrid Feature Extraction, Artificial Neural Network, Mizo handwritten image to text, Character Image Processing.

I. INTRODUCTION

Handwriting character recognition has gain interest in both academic and commercial aspects. The primary challenge in handwritten character recognition is to deal with the enormous variety of handwriting styles by different writers. These challenges are identified and improvement is made by many researchers in the field of Natural Language Processing (NLP) [1]–[3]. As compare with the printed machine character handwritten is more challenging due to its un predicted variation of the writer style.

In this paper, we proposed an efficient hybrid character segmentation technique which is suitable for Mizo character using a combination of bounding box and morphological dilation. A hybrid Feature extraction is performed using zoning and topological feature extracted from each zone. In this technique a segmented character are subdivided into 4 equal zones and from each zone 4 topological feature is extracted, forming a total of 4X4=16 features for each character. These features are used for classification and recognition. We tested the proposed hybrid technique and achieves a state-of-the-art accuracy of 98% using back propagation neural network

The primary problem that is encounter in Mizo character segmentation is the Image that we are going to segment consists of two separate isolated blobs (collection of connected pixel) which form vowels in Mizo Script as indicated in Table I. These vowels make Mizo a tonal language.

The existing technique of character segmentation, result in segmentation fault as depicted in Fig. 1. To address this blobs problem, a hybrid technique is introduced.

The Mizo language is main language spoken in the state of Mizoram, it is also widely spoken in the neighbouring states including Manipur, Nagaland, Tripura, and even in some part of Bangladesh and Burma. Therefore, there is a great need of accurate handwritten recognition for Mizo character as important older information has been held captive in the form of handwritten documents.

TABLE I. MIZO VOWEL CHARACTER

Isolated Blobs	Isolated Blobs	Mizo Character
^	A	Â
^	E	Ê
^	I	Î
^	O	Ô
^	U	Û

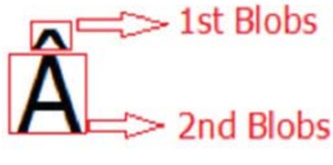

Fig. 1. Problem of mizo character segmentation

978-1-5386-5367-8/18/$31.00 ©2018 IEEE

II. RELATED WORK

A related work in the field of handwritten recognition is discussed in this section.

Hassiba Nemmour et al [4] had work in the field of Arabic handwritten recognition. Analytic and holistic approaches are used for recognizing word. Feature extraction is implemented by Ridgelet transform. SVM is used for the classifier. The output is clamed to be 84% efficiency in terms of recognition.

Nusaibath C et al [5] works with offline handwritten character recognition, where the input image is obtained by scanner and digital camera. Preprocessing, binarization and skeletonization along with line, character and word segmentation is used. Gabor filtering is used for feature extraction. An Artificial Neural network is used for classification. 96.80% accuracy of recognition is obtained in this study.

Pritpal Sigh et al [6] have study handwritten character recognition for numeral in Gurumukhi language. Pre-processing, extraction of feature and classification of character are the stage of his study. Images are converted into binary and normalized into a size of 32 X 64. 16 zones division is used for feature extraction. Multi layer neural network using algorithm known as back propagation is implemented as a classifier. 88.8% of recognition is obtained.

Abdul Rahiman M et al[7] studied Malayalam handwritten character recognition. Scanner were used to obtain the input image. The Pre-processing involved noise removal and skeletonization. For feature extraction counting technique of vertical and horizontal projection output is used. Decision tree is used for classification by taking the extracted feature as an input parameter.

Karanbir Kaur et al [8] works with English handwritten character. The pre-processing stages involves cropping the image and converting the image to binary. In feature extraction 40 isolated feature point is extracted. ANN is used for classification and recognition.

Alvaro Gonzalez et al [9] work in a natural scene consisting of character image. Gradient feature is used for feature extraction. The direction of these feature is used for classification using KNN. 85.8% accuracy is clamed to be obtained.

VedPrakash Agnihotri et al [10] works with Devanagari script. Converting the image to binary, noise removal, edge detection and dilation are used for image enhancement. Enhance image is separated into 54 equal zones. From each zone one feature is extracted. This extracted features obtain from each zone are classified using genetic algorithm.

Sumedha B. Hallale et al [11] works with handwritten character recognition by using direction as its feature. Pre-processing involves noise removal, extracting skeleton of the character and normalization. Sobel mask is used along with the direction feature. Neural network is used for classification and recognition.

Ashutosh Aggarwal et al [12] works with Handwritten Devanagari Character to extract the isolated character. Converting the image to binary used a fixed thresholding technique. Horizontal and vertical segmentations is implemented to dived its character. In feature extraction gradient method is implemented. In classification SVM is used. 94% recognition accuracy is clamed.

III. METHODOLOGY

This Mizo MHCR using hybrid approach system can be divided into several stages as depicted in Fig. 2

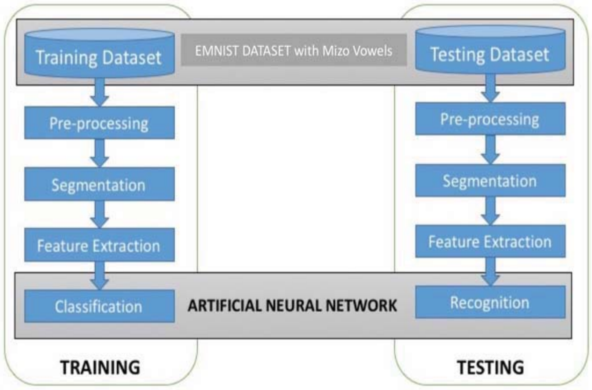

Fig. 2. Stages of Mizo handwritten Character Recognition

Preprocessing

Preprocessing is a vital stage in Mizo handwritten character recognition, this stage includes noise removal, and binarization. The sample output is depicted in Fig. 4

Noise Removal: The Quality of the actual text and the presence of noise has a direct impact on the recognition accuracy rates [13]. In this experiment, one type of noise variation known as salt and pepper noise is taken into consideration. Padding is applied in Median filter , Average filter and wiener filter [14]. Padding preserves the edge of each connected component pixel. In this finding, the Median filter performed against the Salt and Pepper noise is found to be the best noise removal. This evaluation is performed by taking Root Mean Square Error (RMSE) as in Eqn. (1).

$$\mathrm{RMSE} = \sqrt{\frac{\sum\big(f(i,j) - g(i,j)\big)^2}{mn}} \tag{1}$$

Here $f(i,j)$ is the original image input image with noise a given salt and pepper noise, $g(i,j)$ is the output enhance image and m,n are the total number of pixel counting in horizontal and vertical direction of the input image. Better enhance is generated by lower RMSE values. Comparison for the filter under consideration is given in below Fig. 3.

Binarization: In this stage of implementation the input character image are first converted to grayscale image (0-256 in range). This greyscale image is then converted to a binary image (0 or 1) . This process of conversion reduce the

978-1-5386-5367-8/18/$31.00 ©2018 IEEE

complexity of the pixel image composition. Performing this reduction technique down scale the resolution of the input image with out diluting the patter of the image which will be use for recognition. This process of down scaling the composition of the pixel value also reduce the computational time complexity. Otsu thresholding is used to converting the input handwritten image to binary.

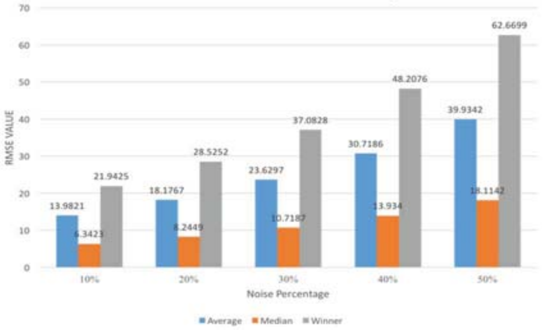

Fig. 3. RMSE for 1024*800 image with 300 dpi of Salt and Pepper noise ranges from 10 to 50 percentage

Fig. 4. Output of pre-processing stage

Segmentation

In MHCR two type of segmentation known as line segmentation for separating each line of the input image and character segmentation are for separating the isolated character of the input image are performed.

Line Segmentation: In line segmentation a hybrid technique form by combination of morphological dilation and horizontal projection is implemented. Morphological dilation [15] is performed so that the isolated pixel of an individual character present in the Mizo vowel can be combined into single entity. After this vowel character component are merge into single entity, horizontal projection is performed for line segmentation. The line co-ordinate drawn based on this horizontal projection is duplicated on the skeleton image. The coordinate location of the generated lines shown in Fig. 5 are use for line segmentation in the skeleton image obtained from the pre-processing stage. The segmented lines are shown in Fig.6below.

Character Segmentation: The vertical projection [16] profile returns a range of value, when the character is detected these values tend to have higher magnitude, when there is a gap between the character than the magnitude of these values falls back to zero. In a point where the value is zero implies there is a gap between the character, therefore a segmentation can be directed performed. However, there is a variation in a handwritten character, as most people rather tend to connect each character unlikely. Therefore, to deal with this uneven, connected character a vertical projection is combined with a technique in which will find the average magnitude value return by the vertical projection. This return average value will be used as a threshold value, where ever the algorithm finds the returned magnitude value by the vertical projection is smaller than the threshold value, that point will be segmented to separate the connected character. However, using this technique results in a segmentation error for characters such a v, u, w, as depicted in Fig 7.

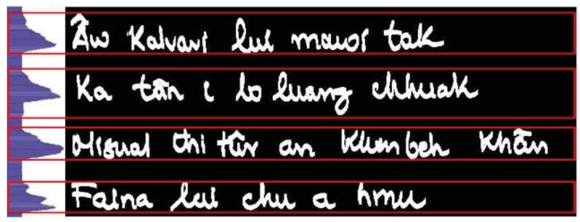

Fig. 5. Generated line using horizontal projection

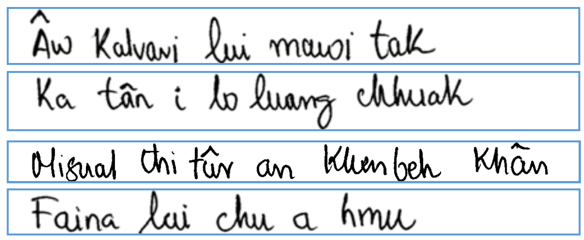

Fig. 6. Output of line segmentations

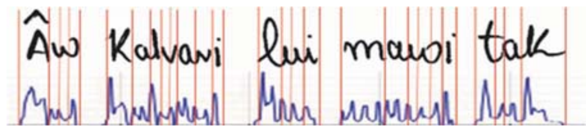

Fig. 7. v, u, w segmentation problem

To address this problems of Fig. 6, average width (avgw) and average height (avgh) is determined between the segmented points as depicted in Fig. 7. Considering these two parameters avgw and avgh the following algorithm is implemented.

Step 1: Find avgw and avgh

Step 2: Find the consecutive point lower than the determined threshold value

Step 3: Find the width and height between determined point from step 2

Step 4: Perform looping between the point determined from step 2

Step 4.1: If height > avgh and width < avgw perform segmentation

Step 4.2: If height <avgh and width >= avgw perform segmentaion

978-1-5386-5367-8/18/$31.00 ©2018 IEEE

Step 5: Repeat Step 2 to 4 for all the consecutive points.

The above algorithm step 4.1 will take care of letter "l" and step 4.2 will address a segmentation problem for letter "u, v, and w"

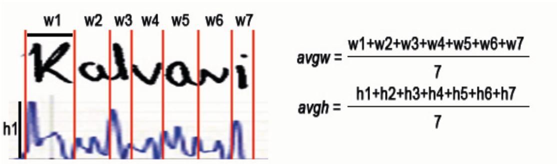

Fig. 8. avgw and avgh graphical representation

Feature extraction:

Feature extraction is a critical part of OCR in Neural network, the challenging factor is to extract a unique feature to represent each segmented character. A unique feature enhances the performance of an OCR in terms of recognition [17]. In this process, we derived a hybrid algorithm which fuses together a technique known as zoning [18] and Topological feature [19]. To maintain uniformity with the multi-font size we resized the segmented image into an equivalent scale of size 12 X 9 pixel, and then it is separated into 4 equivalent zones. From each zone topological feature is extracted which gives details pattern of information for each character. The Zoning is depicted in below Fig. 9.

After Zoning a process known as thinning [20] is performed. The output is given in Fig. 10. This process also known as a skeletonization is an important stage. Iterative technique is implemented, by removing the contour pixels iteratively till it reaches one-pixel width [100]. This thinning process enhance the rate of recognition accuracy by generalizing the feature. It also reduces the computation time complexity as fewer number of pixel have to be computed in the latter stage of feature extraction and classification. The overall process depicted in Fig. 10.

This simplifies the topological feature extraction process, by reducing the computation cost, as the number of pixels to compute are reduced. After these process of Zoning and thinning, topological features are extracted. To achieve this a 3 X 3 matrix is used as represented in Fig. 8. In this matrix, the center pixel is represented by C. The neighboring pixel is numbered starting from the pixel below the center pixel with 1 till 8 in a clockwise direction. To extract topological vector, the algorithm will travel the entire pixels where character image are found by overlapping the 3 x 3 matrix over each pixel from each zone. When the pixel is aligned with the center 'C' of this 3 x 3 matrix, a number label is assigned to the aligned pixel base on the position of its next corresponding pixel. If the corresponding pixel is present in the top left corner then 4 is given as a label, 5 is given if, in the top horizontal, 6 is given if top right corner and so on. However, Topological feature is not exposed by this labelling using number. Therefore, rules are defined to generate information about the topology from this labelling using number. If the maximum occurring label is 2 or 6, the type of topology from this zone is identified as a right diagonal. If the maximum occurring label is 4 or 8, then it is identified as left diagonal. If the maximum number of occurring label is found to be 1 or 5, then it is categories as a vertical line. If the maximum occurring label is 3 or 7, then it is categories as a horizontal line.

Based on this information 4 topological feature vector are generated. 1) Horizontal lines. 2) Vertical lines. 3)Right Diagonal lines and 4) Left diagonal lines. These feature vectors are extracted individually from each zone. For ex, if there are N zones, there will be 4 X N feature vector. So in our case, there will be 4 zones where each zone will be having 4 features.

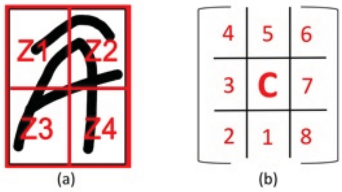

Fig. 9. Graphical representation of Zoning and 3X3 matrix.

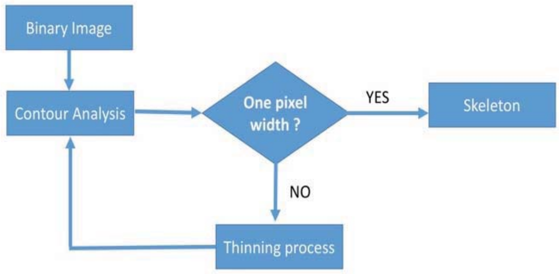

Fig. 10. Thinning / Skeletonization technique.

Fig. 11. Output of thinning.

A. Classification and recognition:

In Classification and recognition, 24 feature vector obtained from feature extraction and 62 possible target value which represent the Mizo handwritten Character both capital letters and small letters are feed to the Artificial Neural Network during training. In this experiment, an attempt is made to train using different neural network Architecture such as BPNN (Back Propagation Neural Network), RBF (Radial Basis Function), RNN (Recurrent Neural Network and LVQ (Learning vector Quantization) [21]. After training the weight of the network is saved. In Recognition stage using the saved

978-1-5386-5367-8/18/$31.00 ©2018 IEEE

weight, a test data is simulated. The testing dataset is a data consisting of actually Mizo handwritten character on which an Optical Character Recognition are performed

IV. Experinement And Result

This testing phase is classified into four phases. In the first phase Mizo special characters, in this phase of testing the dataset is obtained from first writer handwriting which has variation from the dataset used for training. In this phase of testing four architecture of neural network named BBNN (Back Propagation Neural Network), RBF (Radial Basis Function), RNN (Recurrent Neural Network), and LVQ (Learning vector Quantization) are tested against a Mizo special character. The result obtains in depicted in Fig. 12. In the second phase of testing the handwritten character is acquired using both camera of 20 Mega pixel and scanner of 300 DPI. Each of these two device are compared with the rates of their mean square error. The obtain result is given in Table: II. In the third phase of testing 20 writers where asked to write the same document each consisting of 456 similar Mizo characters, forming total of 9120 characters with different style of writing. These9120 characters are use for evaluating the performance. The obtain result is given in Table: III. The final test finds the misrecognized character and the result if given in Table: IV

The first phase and third phase test result of Fig. 12 and Table: III, is used to draw a conclusion, that among the four types of ANN architecture, Back Propagation Neural Network perform better than the other type of architecture. Therefore, using this BPNN architecture a second test phase is conducted. The obtain result of Table: II clearly identified the test image obtain using scanner with 300 DPI is better in the rate of recognition. Therefore, in the final testing phase known as the fourth test phase, the test dataset is acquired using scanner and testing is performed using BPNN. The obtain result listed in Table: IV give all the misrecognized character from a total of 9120 characters.

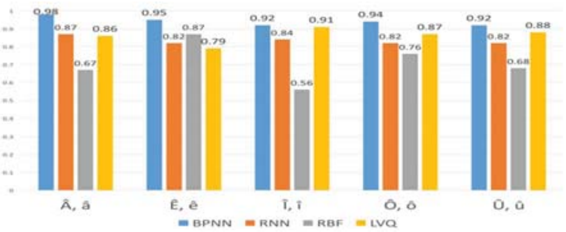

Fig. 12. Mean Square Error.

TABLE II. SECOND TESTING PHASE

Letter	MSE for camera images	MSE for scanner images
Â, â,	0.97	0.98
Ê, ê	0.93	0.95
Î, î	0.91	0.92
Ô, ô	0.94	0.94
Û, û	0.81	0.92
Ţ, ţ	0.96	0.96
Letter	MSE for camera images	MSE for scanner images
Â, â,	0.97	0.98
Average MSE	**0.92**	**0.945**

TABLE III. THIRD TESTING PHASE RESULTS

Neural network classifier	No of characte r tested	Accuracy	Time taken in second
BPNN	9120	98.32	**95.18**
RBF	9120	93.52	162.34
LVQ	9120	96.86	137.87
RNN	9120	97.12	128.75

TABLE IV. FOURTH TESTING PHASE RESULTS

Sample	No of characte r tested	No of character Misrecognized	Misrecogni zed character	Recognized as
Doc1	166	7	**Û, ê**	**Ô, ô**
Doc2	166	7	Ô, w	Û, vv
Doc3	166	7	V,w,	W,vv,

V. CONCLUSION

The misrecognized Characters from Table II, clearly indicate that the pattern (feature) of these misrecognized characters exhibit very similar feature when taken in a pixel depth orientation. However, an improvement may be achieved by refining the feature extraction algorithm. In future, various advancements could be made to the system like adding Text to Speech which will the blind or visually impaired users by enable them to read the Mizo text using speech synthesizer. In fact, this work is a Milestone with a promising application, as the Mizo text remains mostly untapped in this field of computing.

REFERENCES

[1] Qi-Jin Yin, Shao-Ping Wang, Yi-Nan Miao, Dou Xin, "Chinese Natural Language Processing Based on Semantic Structure Tree", *Computer Science and Applications (CSA) 2015 International Conference on*, pp. 130-134, 2015.

[2] Batoul Haidar, Maroun Chamoun, Ahmed Serhrouchni, "Multilingual cyberbullying detection system: Detecting cyberbullying in Arabic content", *Cyber Security in Networking Conference (CSNet) 2017 1st*, pp. 1-8, 2017.

[3] Riad I. Hammoud, Cem S. Sahin, Erik P. Blasch, Bradley J. Rhodes, "Multi-source Multi-modal Activity Recognition in Aerial Video Surveillance", *Computer Vision and Pattern Recognition Workshops (CVPRW) 2014 IEEE Conference on*, pp. 237-244, 2014.

[4] Nemmour, Hassiba, and Youcef Chibani. "Handwritten Arabic word recognition based on Ridgelet transform and support vector machines." *High Performance Computing and Simulation (HPCS), 2011 International Conference on*. IEEE, 2011.

[5] Nusaibath, C., and PM Ameera Mol. "Off-line Handwritten Malayalam Character Recognition Using Gabor Filters." International Journal of Computer Trends and Technology (2013): 2476-2479.

[6] Singh, Pritpal, and Sumit Budhiraja. "Offline handwritten gurmukhi numeral recognition using wavelet transforms." International Journal of Modern Education and Computer Science 4.8 (2012): 34.

[7] Rahiman, M. Abdul, et al. "Isolated handwritten Malayalam character recognition using HLH intensity patterns." Machine Learning and Computing (ICMLC), 2010 Second International Conference on. IEEE, 2010.

[8] tech Student, M., and G. Z. S. P. T. U. Campus. "Use of 40-Point Feature Extraction for Recognition of Handwritten Numerals and English Characters."

[9] Gonzalez, Alvaro, et al. "Text location in complex images." Pattern Recognition (ICPR), 2012 21st International Conference on. IEEE, 2012.

[10] Agnihotri, Ved Prakash. "Offline Handwritten Devanagari Script Recognition." Information Technology and Computer Science,(8) (2012): 37-42.

[11] Hallale, Sumedha B., and Geeta D. Salunke. "Twelve directional feature extraction for handwritten english character recognition." International Journal of Recent Technology and Engineering 2.2 (2013): 39-42.

[12] Singh, Sukhpreet, Ashutosh Aggarwal, and Renu Dhir. "Use of Gabor Filters for recognition of Handwritten Gurmukhi character." International Journal of Advanced Research in Computer Science and Software Engineering 2.5 (2012).

[13] Bieniecki, Wojciech, Szymon Grabowski, and Wojciech Rozenberg. "Image preprocessing for improving ocr accuracy." Perspective Technologies and Methods in MEMS Design, 2007. MEMSTECH 2007. International Conference on. IEEE, 2007.

[14] Chen, Tao, Kai-Kuang Ma, and Li-Hui Chen. "Tri-state median filter for image denoising." IEEE Transactions on Image processing 8.12 (1999): 1834-1838.

[15] Jackway, Paul T., and Mohamed Deriche. "Scale-space properties of the multiscale morphological dilation-erosion." IEEE Transactions on Pattern Analysis and Machine Intelligence 18.1 (1996): 38-51.

[16] Zhang, Yungang, and Changshui Zhang. "A new algorithm for character segmentation of license plate." *Intelligent Vehicles Symposium, 2003. Proceedings. IEEE*. IEEE, 2003.

[17] Kimura, Fumitaka, Malayappan Shridhar, and Z. Chen. "Improvements of a lexicon directed algorithm for recognition of unconstrained handwritten words." *Document Analysis and Recognition, 1993., Proceedings of the Second International Conference on*. IEEE, 1993.

[18] Kumar, Gaurav, and Pradeep Kumar Bhatia. "A detailed review of feature extraction in image processing systems." *Advanced Computing & Communication Technologies (ACCT), 2014 Fourth International Conference on*. IEEE, 2014.

[19] Allili, Madjid, and Djemel Ziou. "Topological feature extraction in binary images." *Signal Processing and its Applications, Sixth International, Symposium on. 2001*. Vol. 2. IEEE, 2001.

[20] Li, Quannan, Xiang Bai, and WenYu Liu. "Skeletonization of gray-scale image from incomplete boundaries." *Image Processing, 2008. ICIP 2008. 15th IEEE International Conference on*. IEEE, 2008.

[21] Dayhoff, Judith E. *Neural network architectures: an introduction*. New York: Van Nostrand Reinhold, 1990.

978-1-5386-5367-8/18/$31.00 ©2018 IEEE