Baybayin Character Recognition Using Deep Learning

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***Abstract*— Baybayin is an ancient script used by the native Filipinos and has been a core part of the culture in the early age of Philippine history. It has been the way of communication and literature of our early ancestors. Recently, a House Bill 1022 or the proposed "National Writing System Act" aims to declare Baybayin as the Philippines' national writing system, thus promoting greater awareness on the existence of Baybayin, as well as promoting wider appreciation for it. It has been approved by the House Committee on Basic Education and Culture and has received various support from different agencies. In light of this, this study focused in developing a system that could translate Baybayin Character into its equivalent text. The system was able to recognize in two ways; through real time recognition using camera and through uploading a photo. A testing accuracy of 99.54% was obtained and 98.84% testing accuracy using real-time evaluation. Lighting condition and background of the hand greatly affects the accuracy.**

Keywords—baybayin recognition, charater recognition

I. INTRODUCTION

Baybayin is a writing system used in the Philippines from before Spanish colonization through to at least the eighteenth century [1]. The word baybay means "to spell" in Tagalog. Baybayin was also used to write Ilocano (Iloko), Kapampangan, Pangasinan, Bisaya and Bikol with some necessary changes. The identification of baybayin with languages other than Tagalog is a contested subject. Some have incorrectly attribute the Baybayin to Alibata but that term was coined by Paul Rodriguez Verzosa after the arrangement of letters of the Arabic alphabet (alif, ba, ta (alibata), "f" having been eliminated for euphony's sake [2]

Baybayin is an abugida: that is, a writing system whose units are composed of a consonant letter followed by a vowel notation. Thus, baybayin resembles other Indic scripts, e.g., Devanagari (used for Hindi), Tamil, and Javanese (all of which are derived from the Brahmi script of ancient India). The use of special mark, i.e. *kudlit* (dot), to change the sound for consonant characters end in an "e" or "i" sound is placed above the letter, while for an "o" or "u" sound is placed below. When unmarked, it automatically ends in an "a" sound. Baybayin is read from left to right, though some early examples may have used a top-to-bottom order. Today, the font used to write baybayin is based on the type used in the 1593 Doctrina Christiana. In 2018, The House approved the House Bill 1022 or the proposed "National Writing System Act" which declares the Baybayin as the official national writing system [3].The proponents aim to support the preservation of Baybayin both in education and in usage of daily communication by providing a software which will enable the translation of Baybayin characters into Tagalog words automatically.

There had been several studies of research that use machine learning techniques such as Hidden Markov Model (HMM) and Support Vector Machine (SVM) to perform the classification task with several feature extraction techniques. Widiarti and Wastu [4] used HMM to classify the extracted vertical and horizontal features of Javanese characters. Shubhangi and Hiremath [5] used multiclass SVM and micro features. The skeleton serves as the feature for extracting handwritten alphabets and numbers that were produced using a vector skeletonisation algorithm. Hanmandlu and Murthy [6], [7] proposed a Fuzzy model based recognition of handwritten Hindi numerals and characters and they obtained 92.67% accuracy for Handwritten Devnagari numerals and 90.65% Some research uses different neural network to classify handwritten character. Attigeri [8] employs feed forward back propagation neural network in their system. Basu et al. [9] used MLP based pattern classifier for recognition of handwritten Bangla digits with a feature set of 76 features. Several other studies [10], [11] show that were able to perform image classification task with good performance if they are combined with other appropriate feature extraction techniques.

This led our team to study about the character recognition and make use of the current state – of – the – art model to implement in Baybayin recognition. The focus of this proposed study is to translate *1593 Doctrina Christiana* characters of Baybayin into its corresponding Tagalog word equivalent. The proposed software employs Deep Convolutional Neural Network (DCNN) model with VGG16 as the architecture and image processing module using OpenCV library to perform character recognition.

There are two (2) ways to input data into the system, real – time translation by using web camera or by uploading image file into the system. The model was trained using the data acquired that reached up to 2400 per character multiplied by 17 characters, 3 for vowels (A, E/I, O/U) and 14 for consonants (Ba, Ka, Da/Ra, Ga, Ha, La, Ma, Na, Nga, Pa, Sa, Ta, Wa, Ya), with a total number of images contained in the dataset of 108,000. The proponents were able to achieve 95% accuracy in the recognition of characters.

II. METHODOLOGY

A. Data sets

The dataset used in training the network was composed of images of Baybayin Characters, different strokes of baybayin writings per character were taken into considerations. The model is composed of 45 classes respectively named after Baybayin characters. (A BA KA DA GA LA for example). Multiple sessions were conducted to collect different sets of handmade baybayin characters writings from different people. Each writing was scanned and cropped to be able to group them according to each its own class. Each class contains 1500 images as data for each class. Fig. 1 shows some samples of the dataset trained.

Fig. 1. Sample data set

B. Network Architecture

Given an image of a Baybayin character writing at a test time, our goal is to construct a network that can properly classify the image to its corresponding character using a convolutional neural network. In order to achieve this, we used Keras and a Convolutional Neural Network architecture containing set of different layers for processing of training of data. Fig. 2 shows the network later of the architecture.

C. Data Implementation

We have partialy divided our dataset of in 80 by 20; 80% of the data was used for training and 20% for testing. This was done to test the performance of the algorithm used.

The network was implemented and train through Keras and Tensorflow as its backend using a Graphics Processing Unit GT-1030 GPU. The network uses Adam as its optimizer used to train the network having a learning rate of 1e-3. The total number of epoch used tp train the network is 50 epochs with a batch size of 32. The images were resized to (50, 50,1) for training and testing.

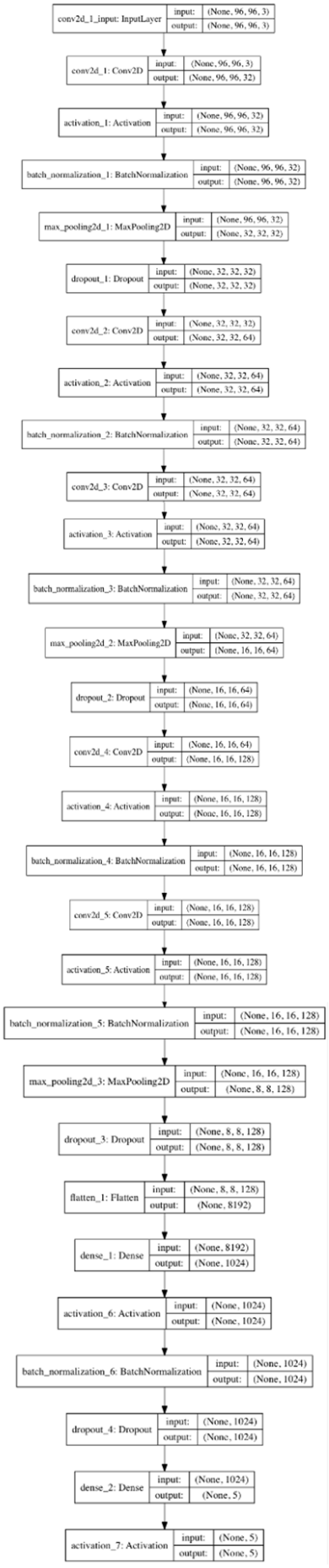

Fig. 2. Network Architecture

III. TESTING

The project was deployed in language department of Technological University of the Philippines and aims to test and verify the accuracy of the system with the datasets we gathered from the students. Along with testing and verifying is the learning of the user who will be using the system to translate the Baybayin character into their respective equivalent in Filipino syllable.

The project was tested by 30 individuals, 2 of them are language professors which are knowledgeable in Baybayin. The remaining users are students with and without knowledge in Baybayin characters. There are three trials in each character and has a duration of 15 seconds per character. If the system does not print the equivalent of the character within the allotted time it is considered as incorrect.

A. Testing Procedure

Upon conducting the testing, the background should be in uniform color because it affects the recognition since other object could possibly detect by the system if the background is not in uniform color. Also, the paper to be used in writing the character should be plain white because any unnecessary lines can affect the detection of the characters.

To ensure that the character will recognize correctly, the character written in white paper should be horizontally aligned. User may also move the paper back and forth depending on the size of their writing.

B. Testing Accuracy Formula

To verify the accuracy of the Baybayin translator, the number of correct recognition appeared on the screen was added and divided to the product of the total number of users and number of trials.

$$Accuracy\ rate\ (\%) = \frac{Total\ Number\ of\ correct\ recognition\ of\ letter\ from\ all\ the\ users}{(Total\ number\ of\ users)(Number\ of\ Trials)}$$

The computed accuracy rate for each character are shown in the table below which give an overall rating of 98.84%.

IV. RESULTS AND DISCUSSION

In this section the accuracy of the system is validated through the results of the testing conducted.

Table 1 shows the accuracy of the Character recognition system. The overall recognition of the system was determined by getting the average accuracy result of all the baybayin characters. thus, obtaining a 98.84% accuracy result. The average time of recognition of each character was also recorded ad averaged, resulting to a 1.95 sec. average recognition time.

To further validate the effectiveness of the system, Fig. 3 shows an evaluation report from the users who tested the system. The orange line represents the target effectivity rating while each blue bars represent the rating in each category.

In here, it can be seen that the system was able to perform at the user's expectation. The usability result is also admirable as well as the learning impact which is the main objective of the system, it can be concluded that the users were able to learn how to write in baybayin given the results.

TABLE I. TABLE FOR CHARACTER RECOGNITION ACCURACY

BAYBAYIN CHARACTERS	Correctly Recognized Gestures	Incorrect Recognized Gestures	Accuracy (%)	Ave. Time (s)
A	89	1	98.89	1.65
BA	90	0	100	1.6
KA	90	0	100	1.79
DA/RA	87	3	96.67	2.37
GA	89	1	98.89	1.88
HA	85	5	94.44	2.61
LA	87	3	96.67	2.21
MA	89	1	98.89	1.9
NA	88	2	97.78	2.2
NGA	89	1	98.89	2.32
PA	89	1	98.89	2.08
SA	89	1	98.89	2.27
TA	87	3	96.67	2.26
WA	86	4	95.56	2.45
YA	88	2	97.78	2.06
E/I	89	1	98.89	1.71
BE/BI	90	0	100	1.83
KE/KI	90	0	100	1.86
DE/RE/DI/RI	89	1	98.89	2.15
GE/GI	90	0	100	1.83
HE/HI	89	1	98.89	1.73
LE/LI	89	1	98.89	1.69
ME/MI	90	0	100	1.68
NE/NI	89	1	98.89	2.07
NGE/NGI	90	0	100	1.98
PE/PI	90	0	100	1.71
SE/SI	89	1	98.89	1.7
TE/TI	89	1	98.89	1.82
WE/WI	89	1	98.89	1.84
YE/YI	89	1	98.89	2.02
O/U	90	0	100	1.54
BO/BU	89	1	98.89	1.73
KO/KU	90	0	100	1.88
DO/RO/DU/RU	90	0	100	2.13
GO/GU	90	0	100	1.93
HO/HU	90	0	100	1.84
LO/LU	90	0	100	1.87
MO/MU	90	0	100	1.8
NO/NU	88	2	97.78	2.2
NGO/NGU	90	0	100	1.9
PO/PU	85	5	94.44	2.66
SO/SU	90	0	100	1.82
TO/TU	90	0	100	1.66
WO/WU	89	1	98.89	1.71
YO/YU	89	1	98.89	1.91
Overall Rating			98.84	1.95

V. CONCLUSION

A convolutional neural network (CNN) based handwritten character recogniton system using Keras and deep learning for classifying and recognizing the 45 character of baybayin has been introduced in this paper. The architecture utilizes smaller, more compact type of VGGNet network. The pixel values derived from the resized characters (50x50 pixels) of the segmentation stage have been used for training the system, thus, achieving a 99.54 % accuracy. As a result, the handwritten recognition system

described in this paper will find potential applications in character extraction in documents and any related conversion of handwritten document to structural text form.

Fig. 4 shows the confusion matrix for Baybayin Character Recognition having 45 classes results to an accuracy equal to 0.9954 and having a misclass of 0.0046.

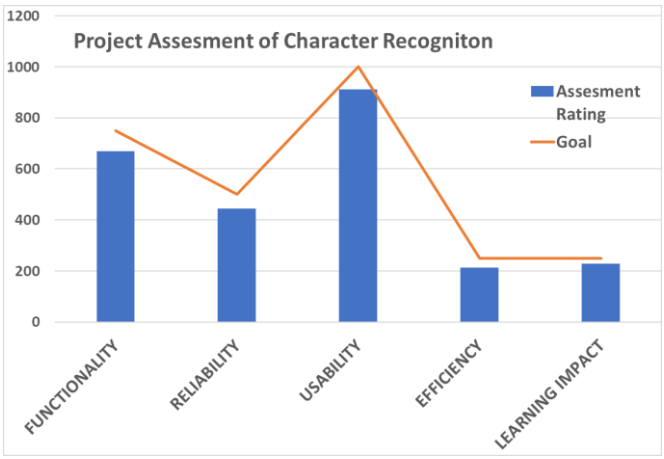

Fig. 3. Project Assesment Graph in terms of functionality, reliability, usability, efficiency and learning impact

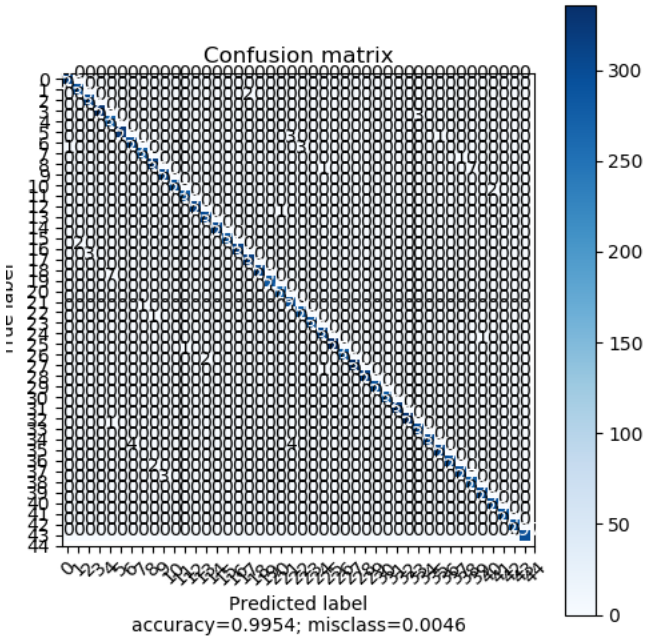

Fig. 4. Confusion matrix of the Chracter Recognition Sytem

VI. ACKNOWLEDGMENT

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