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Chinese Script Handwriting Pattern Introduction Application Design with Algorithm CNN-SVM

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Abstract

The Chinese script has a high level of visual complexity because each character consists of thousands of intricate strokes. This is a big challenge for second-language learners, especially in recognizing the various variations of human handwriting. This study aims to design an accurate and efficient application for the recognition of Chinese handwriting patterns based on Android using a hybrid model of Convolutional Neural Network (CNN) and Support Vector Machine (SVM). In this system, the CNN works like a human eye that distinguishes the details of the shape of an image, while the SVM serves as the brain that decides what characters are being written. The data used in the training process included 7,330 Chinese characters pulled from the Kaggle platform. The results of the study show that the application was successfully designed and able to display character shapes, how to read (pinyin), and the meaning of words offline without the need for an internet connection. Based on testing the Black Box method, all of the app's features are proven to work validly. The study concluded that the use of the CNN-SVM hybrid model was highly effective in recognizing diverse handwriting variations, although the degree of accuracy remained dependent on the clarity of the quality of the images taken by the user.

Keywords: *Chinese Characters, Handwriting, CNN, SVM, Android.*

1. Introduction

China's rapid development has placed Chinese in an important position on the international stage. Indonesia is one of the countries that feels this impact, marked by the increasing popularity of Chinese among the public. The modern era, especially with technological advances, has also influenced the high demands on human resource development. Indirectly, this condition challenges the education sector to adapt to the progress of the times. Educational institutions need to prepare and hone the provisions, abilities, and skills of each student, especially in mastering foreign languages such as Chinese [1].

Handwriting recognition systems allow computers to identify characters written by humans for further processing. This technology functions to convert handwritten documents into digital formats. Broadly speaking, the system can recognize writing because of the distinguishing characteristics between the characters being read. An identification error can occur if there is a similarity in features in the recognized characters. This is a challenge for the recognition machine to learn the distinguishing features. In addition, the variation of handwriting is also another challenge, considering that each individual has different styles, slopes, and sizes of writing. [2].

Based on research conducted by Savita Ahlawat et al. (2020), a CNN-SVM hybrid model for handwriting digit recognition is proposed. This model automates feature extraction using CNN and performs output predictions with SVM. By combining the classification advantages of CNN and SVM, this approach shows significant results. Experiments proved that the model managed to achieve a classification accuracy of 99.28% in the MNIST dataset [3].

This research aims to design a more accurate and efficient Chinese handwriting pattern recognition application through the use of the CNN-SVM hybrid algorithm. Thus, the resulting system can be applied in various fields, such as Optical Character Recognition (OCR), Chinese language education, and as an input system for electronic devices. Based on the background that has been described, the researcher is interested in conducting research with the title "**DESIGNING A CHINESE SCRIPT HANDWRITING PATTERN RECOGNITION APPLICATION WITH CNN-SVM ALGORITHM**".

2. Literature Review

2.1. Planning

The development of digital technology today allows the cultivation of software to create or implement Artificial Intelligence (AI). This AI functions to process information from images, especially in recognizing and predicting digital handwriting. Basically, handwriting detection is a type of study that studies the characteristics or pattern of the shape of an image based on the group or class of the image. Various studies related to handwriting recognition in the form of letters or scripts continue to be developed through deep machine learning or deep learning based on artificial neural networks, this concept is the definition of deep learning [4].

2.2. Application

Applications are understood as uses, instructions or statements that are arranged in a computer in such a way that computers can process inputs into outputs [5]. According to the Great Dictionary of Indonesian Language (KBBI), Application is the application of a system design to process data that uses the rules or provisions of a certain programming language. In general, an application is defined as a computer program that is created to complete and execute a specific task of the user [6].

2.3. Mandarin Script

Chinese has two types of scripts, namely the traditional script also called 简 体字繁体字 Fántǐzì and the simplified script called Jiǎntǐzì. In 1949, there was a simplification of the letter called Chinese Simplified. The difference between these two types of scripts is evident in their shape. Traditional scripts tend to be more complicated due to the greater number of strokes compared to simple scripts. For example, the word "Opening" in Mandarin is read Kāi. In the traditional script it is written 開 , while in the simple script it is written 开 [7]. Examples of the differences between traditional and simple scripts, attached in the following Figure 1

Figure 1 **The Difference Between Traditional and Simple Scripts)**

2.4. Convolutional Neural Network (CNN)

CNN is one of the methods that is often applied in image data analysis. The inspiration is taken from the visual working mechanism of the primate cortex. CNN is composed of several main components that play an important role in image processing. These components include, convolutional layer, input layer, output layer, and a number of hidden layers. This hidden layer consists of a pooling layer, a normalization layer, a Rectified Linear Unit (ReLU layer), and a fully connected layer, and a loss layer. Each layer has a specific function that contributes to the overall performance of this neural network in recognizing and classifying features of the image. CNN has proven to be highly effective in a wide range of applications, from object recognition to image segmentation, thanks to its ability to efficiently capture visual patterns and details [8].

The working mechanism of the CNN algorithm can be seen in the figure 2.

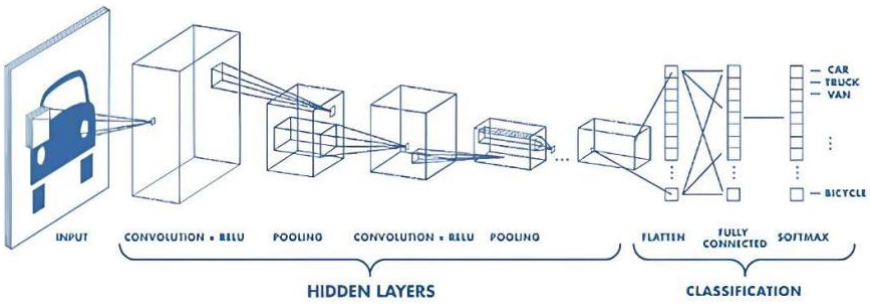

Figure 2: Mechanism Of The CNN Algorithm
Source :: L. Abdiansah, Sumarno, A. Eviyanti, and N. L. Azizah (2025)

2.5. Support Vector Machine

SVM is an algorithm with a supervised learning method that analyzes data and recognizes patterns. The advantage of the SVM algorithm is its ability to handle classification and regression problems using linear and non-linear kernel functions. The use of this kernel function is one of the main advantages of SVM in achieving high accuracy for classification and classification learning. SVM was developed by Vapnik, Guyon and Boser [9].

2.6. The SVM Used In The Study

In this study, non-linear SVM with *a Radial Base* kernel was used
Function (RBF) because:

1. The handwriting pattern of the Chinese script is complex and non-linear,
2. *The RBF kernel* is capable of handling complex data distributions.

For classification of more than two characters, *a multiclass One-vs-Rest* strategy is used.

3. Research Methods

3.1. Problem Analysis

In conducting the research, gradual, orderly and systematic steps have been implemented. These stages include data collection, data processing, training in *Convolutional Neural Network* (CNN) and *Support Vector Machine* (SVM) models. Furthermore, tests and evaluations were carried out on the results of the implementation of the Chinese script handwriting pattern recognition system using a hybrid CNN and SVM algorithm. All stages are interrelated and serve as the foundation for the next stage, ensuring that the research objectives are achieved effectively and efficiently.

The main procedures are as follows:

1. Problem Identification, This stage aims to formulate the main problem, namely how to achieve a high level of accuracy in Chinese handwriting recognition using a hybrid of CNN and SVM. The researcher collected information on the challenges in Chinese character recognition, including complex strokes, variations in writing between individuals, and guidance on a system that can operate without an internet connection.
2. Preliminary Study and Data Collection, consisting of:
   a. Collecting information related to the Chinese script (*Hanzi*) and the characteristics of its letterforms. In addition, theoretical studies were also carried out
   about the CNN and SVM methods. This study aims to help researchers understand the theoretical basis that supports the research to be conducted.
   b. *The dataset* used is in the form of Chinese handwritten images obtained from *https:// www.kaggle.com* with the name *dataset* (*Handwritten Chinese Character* (*Hanzi*) *Datasets*). The *dataset was* retrieved through two methods, namely observation and literature study. Observation was carried out by collecting handwritings from several respondents who wrote Chinese characters. Meanwhile, literature studies were conducted to obtain *additional datasets* from previous research sources.
3. Preprocessing includes image resizing, normalization, image conversion to grayscale, and binarization. This step is important so that the data is ready for use for model training.
4. CNN-SVM Model Design and Development, consisting of:
   a. The CNN model design is tasked with recognizing the shape structure of each Mandarin letter through a processed image.
   b. CNN and SVM integration, connecting CNN to SVM algorithm to significantly improve the accuracy of each image's recognition results.
   c. System training, training the system through a series of experiments and tests until optimal results are achieved.
5. Model Implementation
   After the CNN–SVM hybrid model goes through the testing and training stage, it is then integrated into an application created using Android Studio. The application is designed to have the following key capabilities:

a. Retrieve input in the form of user's handwritten images.
b. Perform the character recognition process by utilizing the CNN-SVM model that has been integrated.
c. Displays the recognition results offline, so the app can be used at any time without the need for an internet connection

6. Application Performance Testing and Evaluation involves several stages, consisting of:
   a. Test the app's ability to use new, untrained handwritten images.
   b. Measure the success rate of the application in recognizing handwriting.
   c. If needed, the application will be repaired and retested until it reaches the expected level of accuracy.

Application design that focuses on an easy-to-use user interface (UI). With a good interface, users can enter images that contain Chinese handwriting. Next, the application will analyze the image to display the results of the printed script, which will then be translated into Indonesian.

The research procedure plan can be seen in the following figure 3

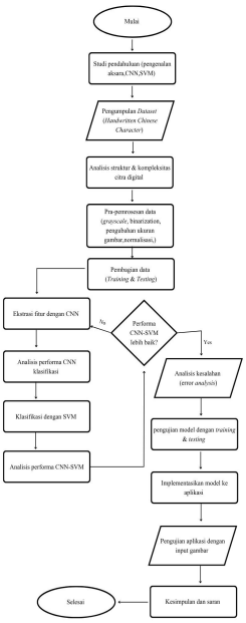

Figure 3: Mechanism Of The CNN Algorithm

3.2. Analysis of processes that run appropriately in the field

At this stage, the image analysis process is explained using examples of handwritten character images entered by the user. The images used as examples are the following characters:
which has pinyin *wǒ* and the meaning of "I".

The analysis process is carried out by the system in stages starting from image input to producing recognition results.

3.3. Developed Methods

In this example, the successful character of recognition is affected by several factors:

1. The form of writing approaches the training data
2. The images have a clear quality
3. The character's position is centered and not truncated

If the shape of the text is too different, too thin, or the image is not clear, it is possible that a misclassification may occur.

The following is a diagram of the CNN-SVM model workflow used in this study. Figure 4 below shows the elaboration of the CNN-SVM model

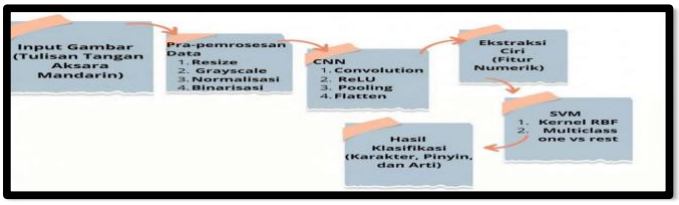

Figure 4: CNN-SVM Model Diagrams and Workflows

3.4 System Planning

The analysis methods used in this study include:

1. Preliminary study
   The initial stage is carried out to understand the basic concepts related to the research, including the recognition of the Chinese script, the basic concepts of *the Convolutional Neural Network* (CNN), and the *Support Vector Machine* (SVM) classification algorithm. The study also includes a review of previous relevant studies.
2. Dataset collection
   The data used is in the form of handwritten *Chinese character images*. This *dataset* is collected from sources from *https:// www.kaggle.com.* Each image represents one Chinese characters manually which are then converted into digital format.
3. Image Structure and Complexity Analysis
   At this stage, an analysis of image characteristics is carried out, including:
   a. Variations in handwriting form
   b. Line thickness
   c. Character Size
   d. presence of *noise* or background
   This analysis aims to determine *the appropriate* preprocessing method.
4. Pre-Processing of Data
   The *preprocessing stage* is performed to standardize the image before it is processed by the model, including:
   a. *Resize* to 64×64 pixels
   b. Konversi *grayscale*
   $\text{Gray} = 0.299R + 0.587G + 0.114B$
   1. Normalization of pixel values
   $$x' = \frac{x}{255}$$
   2. Binary by changing the image to black and white to clarify the shape of the character.
5. Data Sharing (*Training* and *Testing*) *The Dataset* is divided into two parts:
   1. Training data (e.g. 80%)
   2. Data *testing* (20%) Training data is used to build models, while testing data is used for evaluation.
6. Feature Extraction Using *Convolutional Neural Network* (CNN)
   The CNN used is a simple architecture that adapts the basic concept of LeNet to be lightweight and suitable for implementation on Android devices.
   The *preprocessed image* measuring 64×64 pixels is inserted into the CNN network and processed through several stages, namely convolution, activation, pooling, and fully connected.
   The main process on CNN is a convolutional operation that aims to extract patterns such as lines, angles, and character shapes. Convolutional operations are expressed by equations:
   $$S(i,j) = \sum_m \sum_n I(i+m, j+n) K(m,n)$$
   where:
   1. I is the *input image*
   2. K is a kernel or filter
   3. S is the *convolutional* feature map
   After the convolution process, the ReLU activation function is used to add non-linear properties:
   $f(x) = \max(0, x)$

   Next, the max pooling *process is carried out* to reduce the dimension of the *feature* map and retain important information. The pooling results are then converted into a one-dimensional vector (*flatten*) and processed on the *fully connected layer*. *The final output* of CNN is in the form of *a feature vector* that represents characters in numerical form. *This feature vector* is then used as *an input* at the classification stage using the *Support Vector Machine* (SVM).
1. Classification Using *Support Vector Machine* (SVM)
   SVM works by looking for an optimal *hyperplane* that can separate data between classes by maximum margin. The basic equation of SVM is expressed as follows:
   $w \cdot x + b = 0$
   where:
   1. x is the *feature vector* of CNN extraction
   2. w is the weight
   3. b is biased
   This study uses non-linear SVM with a Radial Base *Function* (RBF) kernel to handle complex and nonlinear handwriting patterns. RBF kernel functions are expressed as:
   $K(xi, xj) = \exp(-\gamma \,||\, xi - x_j \,||2)$
   Since the number of classes is more than two characters, the *One-vs-Rest* multiclass method is used. Each *feature vector* from CNN will be compared to the entire class model, and the class with the highest decision value will be selected as a result of the classification.
   The result of this process is a character label that is then used to display *pinyin* and meaning in the app.
2. CNN–SVM Model Performance Evaluation
   Performance evaluation was carried out to determine the ability of the CNN-SVM model to recognize characters in the test data. The test was carried out using testing data that was not used during the training process.

The evaluation process is carried out by comparing the model's prediction results with the actual labels on the *dataset*. The model's performance level is calculated using an accuracy value, which is formulated as follows:

$$Accuracy = \frac{Jumlah\ prediksi\ benar}{Total\ data\ uji} \times 100\%$$

In addition, evaluations can also be displayed in the form of ***a confusion matrix*** to see the number of correct and false predictions for each character class.

The results of this evaluation were used to determine how well the combination of CNN as *a feature extractor* and SVM as a *classifier* was in recognizing Chinese handwriting patterns.

3. Error Analysis

After the evaluation process, an analysis was carried out on the misclassification that occurred. This analysis aims to find out the factors that affect the inaccuracy of the identification results.

Some of the causes of errors that can occur include:

1. Character shapes that have structural similarities.
2. Different handwriting variations are far from the *training dataset*.
3. Poor image quality, such as blurry or low contrast.

a) An inappropriate position or character size.

The results of error analysis are used as evaluation materials to improve the quality of *the dataset* and model performance.

4. Model-to-Application Implementation

The best-performing CNN–SVM model is then saved and integrated into the Android application. At this stage, the model no longer performs the training process, but is only used to make predictions on the images entered by the user.

The processes carried out on the application include:

1. Shooting from a camera or gallery.
2. *Image preprocessing* according to the training stage.
3. Feature extraction using CNN.
4. Classification using SVM.
5. Displays results in the form of characters, *pinyin*, and meanings. This application is designed to recognize Chinese handwriting offline

5. Application Testing

The application test is done to ensure that the system can run properly on the user's device. The test is done by inserting some handwritten character images and observing the results displayed by the system.

The success of an application is determined based on:

1. The conformity of the introduction results with the actual character.
2. The app's ability to display *pinyin* and meaning.
3. The system*'s response* time in displaying results.

This stage is the final step to ensure that the model that has been developed can be used optimally in the form of an application.

6. Conclusions and Suggestions

The final stage is the drawing of conclusions from the research results and providing suggestions for further development of the system in the future.

4. Result and Discussion

In this chapter, the author discusses the results of the application of the methods used in this study, namely the hybrid model of Convolutional Neural Network (CNN) and Support Vector Machine (SVM). At this stage, the author presents the results of the implementation of the Chinese handwriting recognition system that has been built in the form of an Android-based application.

The discussion focused on the final results of the handwritten image processing process, starting from the image entered by the user to the system displaying the results of Chinese character recognition. The CNN model was used to extract pattern details from handwritten images, while SVM was used to classify characters based on the pattern details found.

The following are some of the results of the implementation and final look of the Chinese handwriting recognition application that has been developed.:

4.1. Splashscreen Design Display

The initial display is the first page that appears when the user opens the Chinese handwriting recognition application. This page functions as an application identifier as well as providing users with an initial overview of the main functions of the application before entering the menu page. OnThe initial view, the app displays the app logo indicating that the app is used for Chinese handwriting recognition. This view is designed with a simple design to be easy to understand and give users a clear initial impression. Once the initial view is displayed within a few moments, the system automatically redirects the user to the main menu page. This move aims to speed up the user's access to the app's key features without requiring additional interaction. The initial view does not have complex interaction buttons, as it only serves as an introduction before the user fully uses the app. With this initial view, users can know the identity and purpose of

the app from the first time the app is launched. Figure 5 shows the initial view of the app.

Figure 5: Splashscreen Initial Appearance

4.2. Menu View

The menu display is a display in the Chinese script handwriting recognition application. This display serves as a navigation center that makes it easier for users to access the main features of the application. On the menu page there are several main components, namely the text display, the image preview area, and the navigation buttons consisting of *Gallery*, *Camera*, *Scan*, and *History*. Figure 6 shows the menu display.\

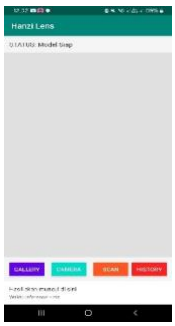

Figure 6: Menu View

4.3. Gallery View

The Gallery *View* is a display that functions to allow users to select Chinese handwritten images stored on the device. By pressing this button, the application will open the device's gallery so that users can select the desired image. After the image is selected, the image will be displayed in Image *View* as a preview before the analysis process is carried out. This feature makes it easier for users who already have a handwritten image before without the need to take a new image. Figure 7 shows the *Gallery view*.

Figure 7: Gallery View

4.4. Camera Display

The *Camera* button functions to take a picture of Chinese handwriting directly through the device's camera. When this button is pressed, the application activates the camera and allows the user to take a picture of the handwriting. The image taken by the camera will be displayed directly on the *Image View* to ensure that the photo is clear and ready to be processed. This feature is useful for users who want to make an introduction directly and quickly. Figure 8 shows the *camera view*.

Figure 8: Camera Display

4.5. Cropping Display

Once the handwritten image is taken through the camera, the user can crop the image to adjust the area of the character to be analyzed. This feature aims to focus the recognition process only on Chinese characters and eliminate unnecessary parts of the image. Figure 9 shows the *Cropping display*.

Figure 9: Cropping Display

4.6. Tampilan Hasil

The result button is the main button in this application that is used to display the results of the Chinese handwriting analysis. After the user enters the image in the form of Chinese characters, either through the *gallery* or *the camera*, the user presses the *scan button* to start the recognition process. At this stage, the system analyzes the image of the entered letters using the CNN–SVM model. The results of the analysis are then displayed at the bottom of the image, in the form of the recognized Chinese characters along with *pinyin* and their meaning or meaning. Thus, the user can immediately find out the results of letter recognition and its explanation after the scanning process is complete. Figure 10 shows the Results display.

Figure 10: Results View.

4.7. History View

The *History* button functions to display the history of character recognition results that have been done before. This history contains information about images that have been scanned and the results of Chinese character recognition. This feature helps users to review the results of previous analysis without having to rescan. Figure 11 shows the *History view*.

Figure 11: History View.

5. Conclusions and Suggestions

5.1. Conclusion

Based on the results of the design, implementation, and testing of the system that has been carried out, it can be concluded that the Chinese handwriting recognition application based on *Convolutional Neural Network* (CNN) and *Support Vector Machine* (SVM) has been successfully developed and can function according to the research objectives. A number of conclusions that can be drawn as the final result of the design of the Chinese handwriting pattern recognition application are as follows:

1. An Android-based Chinese handwriting recognition application using the CNN–SVM algorithm has been successfully designed and can be used to recognize Chinese characters from handwritten images.
2. The use of the CNN and SVM hybrid models was shown to be able to recognize Chinese handwriting patterns that have a variety of shapes, although the recognition success rate is still influenced by the quality of the *input* image. In this case, CNN serves as an extraction of a character while SVM serves as a classification of characters that have been trained and tested from CNN.

5.2. Suggestion

Even though the application has run well, there are still some aspects that can be further developed to make the system more optimal. Some suggestions that can be given for further research and development are as follows:

1. Image Preprocessing is needed, which is a clearer feature or clearer quality of an image to be analyzed.
2. It is necessary to implement the *transfer learning* method or *few-shot learning,* which is a feature that can include more data so that the results of the analysis are more optimal
3. It requires the integration of structural feature analysis (*Radical Decomposition*), so that it can reduce errors when recognizing characters with very similar shapes.
4. It is necessary to develop a context-based translation module (Neural *Machine Translation*), so that it can translate into Indonesian more optimally.
5. The addition of multimedia education features (*Text-to-Speech*), namely learning support features such as pronunciation and sentence use, is needed.

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