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ORIGINAL RESEARCH

Self-Learning Based Cognitive Reading and Character Recognition in Image Processing Techniques

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Abstract
There are many techniques involved in Handwritten character recognition and many of the methods uses common process like pre-processing, segmentation, stroke identification and character interpretation. But the technique applied for these steps differ from different implementation. Building the training data is a tedious task but it is more important as the success of entire recognition system lies on the amount of training the neural network and building the knowledge base. Hence this is an important task and it is costly due to amount of time and resource used for training the dataset. This article explains some of the methods in Cognitive reading in image processing for character recognition and introduces a self-learning based training system which provides improved method in less time/resource consuming in automatically training the knowledge base.

Keywords Cognitive reading · Neural network · Image processing · Character recognition

Introduction

There are many works done in handwritten character recognition both for online and offline recognition and some of these researches are generalized to multiple types of languages and some of them are rationalized to specific language detection.

There are some works done specific to one type of characters (e.g.: cheque processing or number plate processing) by reducing the scope of error handling and increasing the efficiency of processing the data in a specific format.

Though there are many researches done in handwritten character system, as explained below in "Related works" section, application of one single algorithm cannot solve global processing of multiple language handling in character processing.

Also, there are many pre-processing steps involved like noise reduction in order to reduce the recognition error.

This article discusses the research study done in Character recognition proposed by different people and does a comparative analysis on these processing techniques to understand the weak areas in these algorithm/implementation techniques.

Pattern Recognition

Pattern recognition is one of the key areas of application of neural networks and it is termed as the ability to recognize a pattern on its own using its knowledge base.

This article explains a recognition system which follows self-training process to improve its knowledge base, but the key success lies in that the pattern must be recognized even when that pattern is distorted. Practically, it is used in human life in many ways.

A vehicle driver driving a car should be able to accurately recognize a traffic signal and react to it. This is one of the complex and critical pattern recognition procedure practiced by numerous drivers in day to day life. Even though, not all traffic signal looks like same or it can be altered depending on the time of day or the season, the task for the driver is to recognize it properly.

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For instance, there are many variations of these traffic signals exist in roads it is not a hard task for a human driver. But when someone writes a program to mimic this operation (to write a computer program that accepts an image and tells if it is a traffic signal), then it would be a very complex task.

Off-line character recognition usually handles the process by scanning the text document into an image which is used as input for the character recognition system. This image will be processed to identify, classify and recognize each character in the image in the form of group of characters using text extraction tool.

However, this is not an easy task as extraction of text from image involves lot of complex sub-tasks like pre-processing, skew correction, noise reduction and character recognition to name a few.

Training the neural network to get a group of character patterns in terms of segmented character is an important element of a cognitive character recognition system.

Usually training the neural network to make the recognition efficient is a tedious task for both online and offline recognition system due to its time-consuming activity.

Noise Reduction

In an offline character recognition system, one of the important step is Noise reduction and it is based on language using which the character is written. As a simple example, characters in Hindi has specific pattern of strokes where noise reduction is usually based on segmented strokes used. On the other hand, character sets of Telugu or Kannada language are purely based on shapes and curves involved in forming the character.

For a mixed language text script, there is a greater complexity involved in noise reduction as noise reduction to be done for each word based on the language it is written. Also, it is important to identify the language first and decide the noise reduction. For example, if the system considers a word as Telugu word and does noise reduction whereas it is actually a Malayalam word means the noise correction may not work as expected.

During offline recognition, the end-user may not provide online feedback about wrong interpretation, and hence retrain or re-analyze such misinterpretation is impossible. Image recognition is based on a technique where recording and matching of image characteristics such as size, segmented groups (strokes) and character interpretation is carried out.

Both recording of an image and its subsequent matching with other images will be carried out through a series of stages of processing. There are six major such stages of processing as explained below.

The six stages involved in the processing of image in the proposed system in this article are:

1. Image creation
2. Image markup or reduction
3. Segment group storage
4. Searching for segment group
5. Matching first stroke
6. Character interpretation

The purpose of such processing step is to convert an image's graphic form into a binarized format which can be accessible and retrievable from a conventional and easy to process group of attributes (indexed store) and at the same time maintains relationship among the segmented group which helps to retain all information necessary to describe the image's characteristics.

Accordingly, the idea presented in the functional system is based on a recognition method comprising of the step of getting an input as an image which contains one or more handwritten characters from any source like image sensor.

This image received as an input to the system will then be processed to extract one or more nodes and segments also called as edges of each character from the input image and a graphical representation of group of such related segments represented in the form of a character is generated based on the one or more edges.

Character Segmentation

In Cognitive based interpretation, many of Character recognition techniques are using segmentation-based text recognition approaches, where sentences are split into words and words are stoke interpreted into individual characters and every character is divided further into group of strokes and these stroke groups are used for recognizing the characters.

When there is a low-resolution image or degraded image (text not clearly visible), then segmentation may not work as expected in both printed and hand-written characters as it requires noise reduction and image cleansing for higher accuracy.

Modern segmentation techniques has been applied by many researches but getting higher accuracy during such degradation is still not to the expected level even with combination of techniques.

Some techniques uses word level pattern matching instead of character level matching in order to get higher accuracy in recognition by avoiding degradation caused. Such "holistic or complete word recognition system" use word level features like b-loop, d-loop, T-junctions, ascenders/descenders interpretation for complete word recognition. But the drawback of such holistic system is that it is capable of handling

small vocabularies and generally applied for single language recognition.

Another method in segmentation is Recognition based segmentation where the scanned image is split into many overlapping image segments and each of these combinations will be used for pattern matching. Generally, a hypotheses graph is created by using a classifier and character segmentation boundaries is drawn using interpretation procedures.

In this article such segmentation problem is addressed with first stroke-based character recognition and adjacent cell-based matrix level stroke preparation which helps in low cost solution where training is automatic and self-correction of character to be recognized can be taken care with intelligent genetic solution.

In last two decades, statistical or geometrical model-based solutions like Hidden Markov Models (HMM) is very popular as it is able to do segment free character recognition.

There are many HMM based approaches or algorithms developed for long time and they are capable of handling machine printed or handwritten or cursive character interpretation. But such HMM methods are unable to model contextual information holistically due to independent observation assumption during state transitions of such system.

One more key problem of HMM is that it lacks discriminative capabilities, which is very good in discriminative models for recognition task.

Self-Training

During the initial step called self-training process, a character set for a language is taken and the strokes for the characters will be built by its own. The intelligent system will prepare all combinations of strokes from the characters and prepare and auto-associative character stroke sets from which character segments can be identified.

This process is an auto processing activity and there is no manual intervention or manual processing or training repeatedly (to record the training) is not required. From a hard copy document, image will be extracted for offline character recognition (Fig. 1).

For an offline character recognition system, there exists few conventions in determining the input to be given to the system as listed below:

- To scan the document into an image
- To scan the document into multiple images where each has segmented document like word or sentence or paragraph
- Direct feed of scanned image into the system to interpret the sentence or group of words or characters.

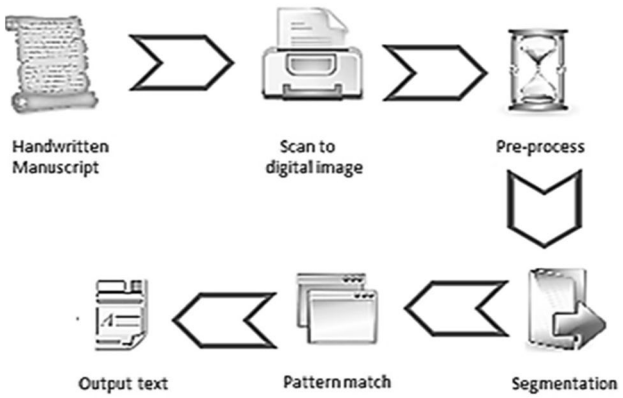


Fig. 1 Processing steps of character recognition system

This required offline character recognition from a handwritten, multi-lingual document with mixed-language content as shown in above Self-training based character recognition system.

AI techniques like neural network based pattern recognition framework is applied to simulate how human brain does interpretation. The motivation of this work is to analyze such technique to mimic human brain and recognize text and identify language and interpret to any target language (translate the content) by creating a unified system for the entire process.

Developing these intelligent components for recognizing characters is not an easy task; this is because a character can be written in different ways. Many imperfections and text variation of handwritten text like cursive interpretation, text alignment, noise and angles makes it difficult to implement such a unified system. The steps involved are:

1. The first step in this system is to scan the document into image and do pre-processing like noise reduction and skew correction.
2. The next step is to extract the content into character groups by segmenting sentences to word and words to characters.

This character group is used to segment into stroke groups which is then used to interpret the character by pattern matching with the trained knowledge base (neural network) and produces the final result which is having higher accuracy in pattern matching.

Hence this unified system does not involve a single step or process where it is a combination of algorithm execution in digitization and then pre-processing and image correction, segmentation and stroke creation, feature extraction from stroke group, classification and post-processing the characters identified.

The key idea of self-training is to improvise the overall efficiency of the system. In any character recognition system based on neural network and artificial intelligence, preparing the trained neural network by repeatedly practicing the character recognition engine is one of the tedious process and the success rate of the entire system is based on the efficiency and variance of this kind of training system.

Also, there is higher involvement in designing the training activities as the system should be capable of handling variances of the input provided—for example, different writing patterns of the customers.

This complexity grows when the recognition engine is expected to handle mixed language recognition as there are many combinations of character patterns and it will be a tedious task to organize and handle them efficiently.

Apparently, this kind of hindrances lead to higher time consumption. Hence, this work mainly targets to address this key problem by introducing an efficient and novel concept called self-training where training time can be highly reduced and efficiency in handling variances is improved implicitly.

Related Works

Yin et al. [1] proposed a method which uses templates based on clustered stroke inputs which is used for identifying the script in a given document. This method creates a set of representative symbols called as templates of strokes for any given script which makes clusters of textual symbols based on training the input document.

This method is tested on Chinese scripts [1] to create clustered symbols for words and also tested on Arabic script to create word segments. For a given new scanned document, the script used in the document is identified by word matching of symbols in form of templates.

Using Hamming distance [2], best match of a given script is selected from given templates. In the experimental evaluation using 13 scripts, this method recognizes characters more predictably on all test documents whereas if the fonts differ from the fonts of trained set, then the recognition fails.

Most of the existing methods for character recognition are grouped into either global or local approaches [3]. This classification is based on feature extraction method used at the global approach (entire document or blocks of text or word) or using local approach (character or group of character or words or text level) for any given script document.

Wanchoo et al. presented [4] a research article where a survey on some of the commonly used methods are analyzed based on visual appearance and structure of the script.

Majority of the script recognition method evaluates at global level and considers evaluation that different scripts only exists in some portion of scripts (e.g.: paragraph or columns or lines of sentences) from a given scanned document. Few methods are based on local level for a given word or text line level recognition.

Mukarambi et al. proposed a language identification method which classifies script given as input into two classes as Han-based and then Latin-based. This classification is decided based on spatial relationship of the text or script features from upward concavities in the given script having different character structures [5].

Han script is used for language text like Chinese, Japanese, and Korean which analyzes text based on optical density of characters in the input image of scanned script. In another research work by Mukarambi et al. [5] which does Latin based script identification based on frequently occurring shapes of word sequences in a given language.

This method creates list of connected components from the given image. This method extracts such components and processes for language and script identification. There is no classification error in this system for Han or Latin-based script from a given test samples of size 240 script document [6] each having at least two text lines of words.

For a Han-based script identification [7], the classification of document was near perfect for given text samples with six or more lines of text. For a Latin-based script [8], language categorization was based on statistical model using linear discriminant analysis and it is tested with cross validation of test scripts. This method gives almost 90% language recognition for given 23 languages as test samples.

Izadi et al. in their research paper presents a method which uses texture as a method for identifying script from a given scanned document. A number of commonly classified textured features are used to evaluate for script identification in their work [9].

They evaluated on different scripts like Latin, Chinese, Greek, Cyrillic, Japanese, Farsi and Sanskrit language-based text where input samples are evaluated using Gaussian mixture model commonly called as GMM classifier [10] and it attempts to evaluate the model of each feature class in combination of Gaussian model distribution. In this method, a wavelet log based on co-occurrence of feature based on texture using script classification where a overall error rate is logged as 1% error [11].

Al-Marakeby et al. [12] explains a script identification method based on separated text lines based on evaluation of Devanagari and Bangla language-based script evaluation. This method separates Han and Latin-based scripts like Devanagari and Bangla based characters in one set and English, Arabic and Chinese character-based script in another set. The first set is further evaluated [13] into Bangla script-based lines of text and Devanagari script-based lines based on shape features. On the other hand, second set is further evaluated to separate English character-based script

[14] from Chinese or Arabic based script lines using vertical stroke-based text alignment [15].

Al-Marakeby et al. [12] in another research article explains vertical black run evaluation on English script or Arabic and Chinese script text lines using text lines from books or journals and their observation is that around 57% of Chinese characters have four or more vertical black run [16] and for lesser vertical black line runs like English script has less than 14% characters.

This difference in vertical black run line is used to separate Chinese or Arabic characters from English characters. Based on distribution of lowermost points Arabic text script and English script text gets evaluated again.

Thus, this experimental evaluation gets 97.32%, 98.65%, 97.53%, 96.02% and 97.12% of character identification rates for script-based English, Chinese, Arabic, Devanagari and Bangla script respectively when tested on scanned images of about 700 documents [17].

Venkatesh et al. proposed a method using multi-channel log-Gabor filter based on multiple text orientation in identification of ten Indic scripts. This classifier is hierarchical script-based evaluation based on globally extracted features. This method groups script into five major text classes based on global features [18]. In the next stage of evaluation, a subclassification is performed using script specific feature-based character identification. By this approach, overall 97.11% accuracy in test data classification is achieved.

Kong et al. [19] has presented a research work which evaluates various technical advances of character and scanned document recognition for over 40 years of evaluation. For pattern recognition algorithms, such document recognition methods provide a universal benchmark because of commonality nature of evaluation. Such research work explains most common problems arise in pattern recognition [19] by comprehending input used and output achieved during test evaluations. These experiments evaluate most commonly used pattern recognition techniques to demonstrate and to test their strengths and weak areas.

Shah et al. presented their research report based on work level single-language script and multi-language script evaluation which uses Gabor and discrete cosine transform (DCT) feature based evaluation [20] and they also tested experimental evaluation on bi-script or tri-script and evaluates up to eleven-script scenario-based evaluation.

This study uses three different text classifiers for evaluation of character recognition such as nearest neighbor-based classification, linear discriminant-based classification and SVM or Support Vector Machine based classification [21]. These evaluations achieve 98.4% accuracy of script recognition based on testing with eleven Indic scripts when used in combination of SVM with Gabor features [22].

In the other side, there are many optical character recognition (OCR) system based on printed character based scanned document analysis methods were improved in past few decades [23].

These OCR systems has achieved higher recognition rates as compared to handwritten character recognition. For example, recognition of English or Latin script in different printed fonts is a solved problem and many recognition systems exists to handle such recognition. But these systems may fail when there are degradation or noise based printed characters when scanned image is having broken or improper printed characters.

Such degradation can happen in handwritten character recognition system as well when there is deep cursive script. But there are many industrial applications requires to solve such problems. For example, Handwritten character interpretation in Bank cheque processing system or document registration system [24].

Also, such system is important in mail sorting machines [25] or in text to speech conversion system which is very useful for visually impaired people. There are system exists [26] which has higher accuracy as high as 94.65% or 92.14% when the training is more efficient. Artificial Neural Network (ANN) based information processing system are inspired from human interpretation which mimics biological nervous system to a neural network application as proposed by Kim et al. [27] in their research work.

This system is based on novel structure of processing characters called processing elements (neurons) which are interconnected to identify the character. These ANN based system is configured for one or more application like pattern recognition or data classification through a training process [28].

Sundaramoorthy et al. [21] has developed a hybrid system [28] for online handwritten recognition and it is based on multi-state time delay neural networks shortly called as MSTDNNs. This method is an modified method of time delay neural networks or TDNNs which combines a nonlinear time alignment method in finding an optimal alignment in between character strokes of an handwritten words.

Venkatesh et al. [18] proposed a simple method for cognitive character recognition which uses nearest neighbor classifier in employing a feature-based extraction which means extracting text in employing string connectivity.

Vinayakumar and Paul [29] devised a complete OCR system for recognizing printed Bengali characters which combines a template and feature matching approach [30] and it converts the image into binary formats of character strokes. This method [30] uses histogram to get two prominent peaks which corresponds to white or black regions in a clear document in which skew angle is identified from skew shaped characters.

In another recognition system by Mitra et al. [7] partitioning of characters in an image is done into three zones where vertical and horizontal projection profiles are applied to get

segments of document image into lines of text and words and characters in deeper learning. The actual classification of characters is done after getting primary grouping of basic, modified or compound character grouping in the scanned document.

A tree classifier and a stroke-based feature are used for this method in which decision in recognition of a character is done based on presence or absence of a specific feature based on previously trained data set stored in the system.

This is done by evaluation of feature recognition into two stages of process viz:

1. The first stage of this feature-based evaluation groups the character strokes into smaller subsets in the form of tree classifiers.
2. In the second stage of evaluation a run-based template matching is done for analysis of scanned image to obtain the desired feature.

This kind of evaluation is based on a hybrid approach using HMM and MLP methods and experimental evaluation of these methods shows recognition accuracy as near as 92.2% on a subset of CENPARMI database as explained by the research work by Kumar and Sharma [31].

Zhu [32] defines a Statistical online character recognition which is for Online character recognition using Feature extraction from sample character using Gabor filter and handles Noise removal for size and shape normalization and imaginary strokes are defined. Pattern generation based on training with input feature vectors and handwritten character Feature identification using Gabor filter is the key idea of this technique where Pattern generation and classification (statistical analysis) and Comparison of generated pattern with reference patterns to recognize the character is discussed. This is a costlier system where manual feed of character strokes has to be done and improvising of the training system is time consuming.

Gabor filter is the key idea of this technique where Pattern generation and classification (statistical analysis) and Comparison of generated pattern with reference patterns to recognize the character is discussed. This is a costlier system where manual feed of character strokes has to be done and improvising of the training system is time consuming.

Deduction Based Recognition

This is a reasoning process implemented in the system to derive a conclusion based on given axioms (knowledge) and facts (observations) (Fig. 2).

The Algorithm steps involved in such deduction process is explained below:

Step 1: Get list of character groups from user input

Step 2: Process the character sets and prepare list of strokes

Step 2.1: Order the list of strokes in relative stroke order

Step 2.2: Take first stroke in a separate map with character as key and first stroke as value (key-value pair)

Step 3: Group first strokes based on similarity and assign weightage to character to be identified

Step 4: Store the character sets and first stroke for each language set in separate list

Stroke weightage In this process, when a given character is evaluated, it processes a general rule (axiom) from background knowledge and observation and based on best stroke weightage (higher confidence of matching) the trained stroke set is chosen.

The solution design is done in such a way that this weighted stroke ordering is carried out for stroke sets which

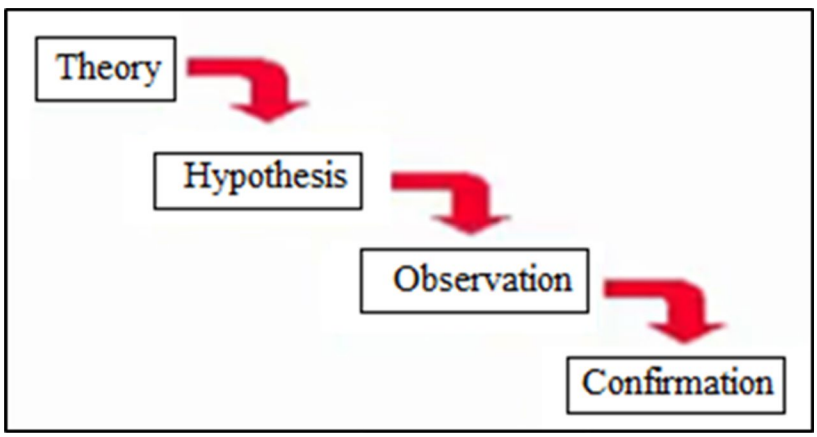


Fig. 2 Steps in detection based recognition

has more similar matching first stroke patterns (example: characters in Hindi has more than one character having similar first strokes).

Applications of Text Recognition System

When designing the recognition system, consideration of offline recognition methods which involves converting text to an image automatically which contains character groups for any given text processing applications which interprets the characters from the scanned image. This system uses a representation of handwritten characters and it is difficult in processing different styles of handwritten formats.

The approach towards creation of AI in machines has spawned numerous techniques. Statistical Learning Algorithms are based on slow learning algorithms that draw inferences from previous data. They however do not have the capability to make any differentiation between separate behavior patterns. The results however can be applied to a number of applications concerning quantitative data.

First stroke detection algorithm used in this system helps to handle Cluster descriptors in terms of a relatively small set of characteristics (e.g.: stroke groups). It is also used to Test hypotheses concerning differences among populations (more than one-character group matches and confidence in recognition is derived out of weighted average).

It is also used to perform trend analysis, as in the case of time series analysis and construct correlations among sets of variables in character to word formation (grouping characters to form words for translation stage). Many of the OCR/ICR engine supports minimal support for multilingual handwriting recognition as of today.

There are two major techniques and devices in character recognition called OCR and ICR. OCR, which is termed as Optical Character recognition, is based on legacy model where character recognition is based on optical scanning. ICR, which is termed as Intelligent Character recognition, is a modern engine, which has different pattern of character recognition including but not limited to handwritten character recognition.

Learning Methods

Supervised learning In this method training is done on labelled examples. For example, input is processed for getting known output of characters. It attempts to generalize a mapping from inputs to outputs which is used in getting output from a previously trained input.

Unsupervised learning This method is opposite to Supervised learning where algorithm runs on unlabeled examples. For example, input is processed for getting unknown output of characters. The training attempt is not to generalize input mapping to get output.

Semi-supervised learning This method combines above two learning and handles both labeled as well as unlabeled examples in order to generate a classifier to get desired output.

Transduction This method predicts desired output from fixed testcases using observed or specific training cases.

Reinforcement learning This method uses intelligent agent to act in any given environment to get desired output. These agents runs some event, which makes the environment to change to get desirable output.

From a given sequence of events, these agents gets knowledge on the environment and simulates a sequence of events to improve a cumulative response of getting desired event.

Learning to learn This method learns like humans by observing patterns on inductive bias from its previous learning.

Developmental learning This method is commonly used in Robot learning and it generates sequence of learning situations and it cumulatively gets self-explorative skills using guided training like active learning or imitation.

Pattern Evaluation

Pattern evaluation system and calculations applied in the system designed in this research which are proven valuable in solving a particular problem like:

Behavior analysis Identify persistent trends or patterns in behavior over time.

Event/alert A discrete signal generated when certain threshold conditions are met.

Cluster analysis Based on entities' cohort characteristics.

Correlation analysis Measures the correlation of entities against their prescribed attributes over time (Fig. 3).

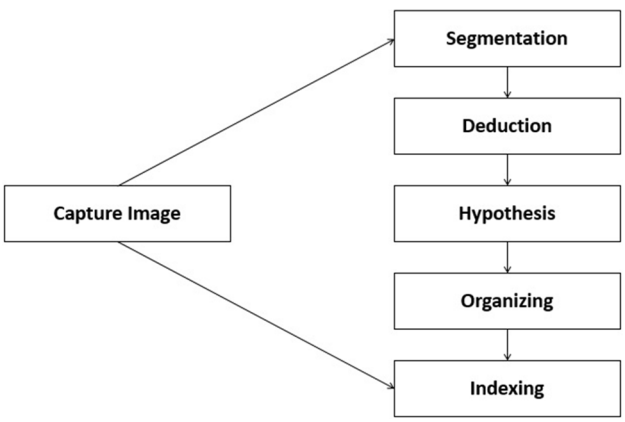


Fig. 3 Pattern evaluation process

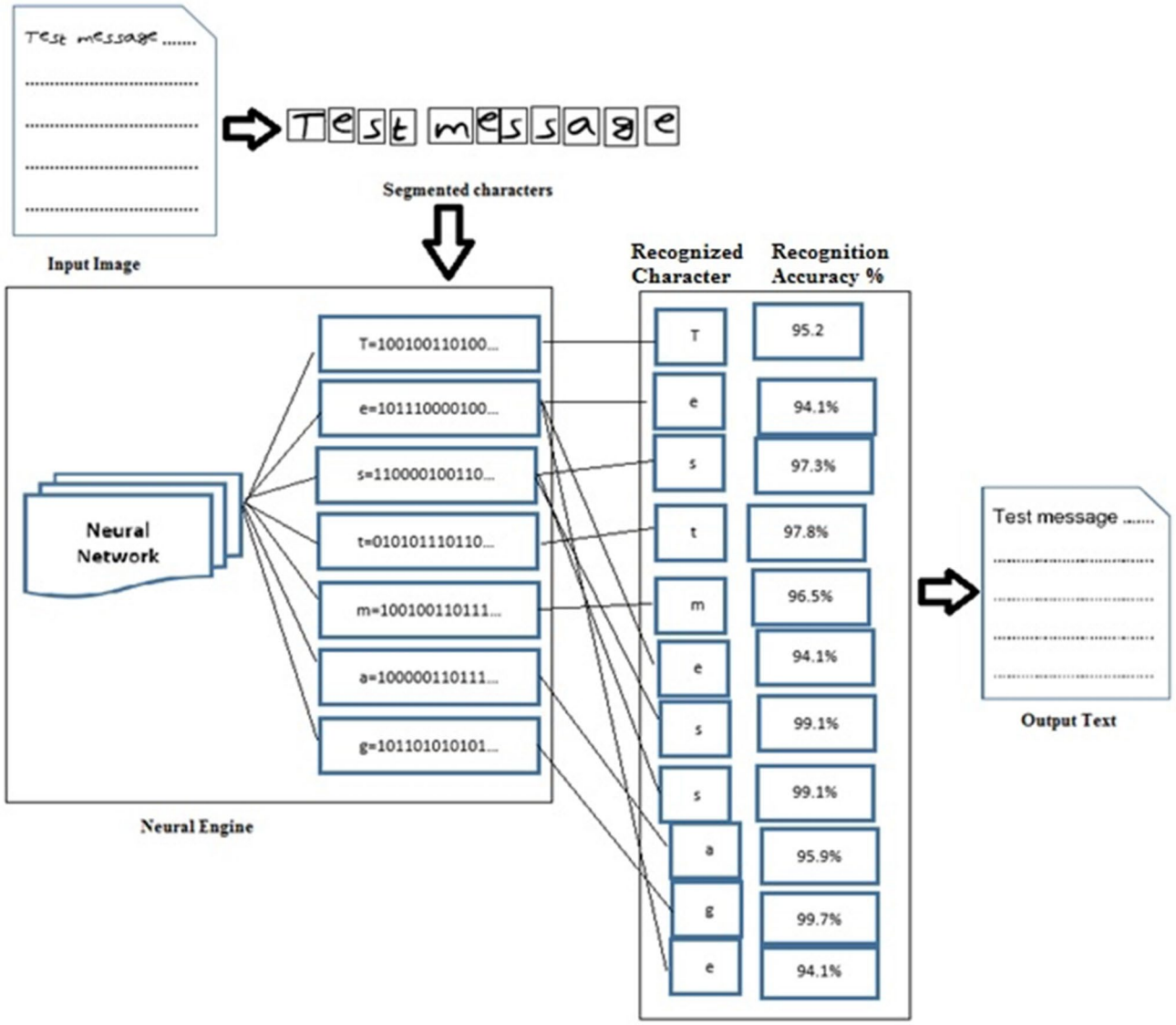


Fig. 4 Sample image recognition process

Logical Landscape of Self-Training System

The proposed system uses cognitive algorithm to self-train the system with various character sets. The system builds knowledge base with unique stroke set for each language by segmenting each character in the character set into stroke sets and keeping them as a group of strokes (Fig. 4).

The proposed system uses a unique pre-processing technique where each interpreting character is adjusted to match the stroke set group together to identify the characters (Fig. 5).

Technical Implementation

The implementation of this proposed algorithm is done in Java language using java.awt API on a windows environment using Spring Tool Suite (STS) IDE as development environment and tested with different scanned images of handwritten text in different degraded stages. The test results are evaluated on recognition accuracy on individual characters and the complete text as an average thus getting higher level of confidence in terms of percentage for the

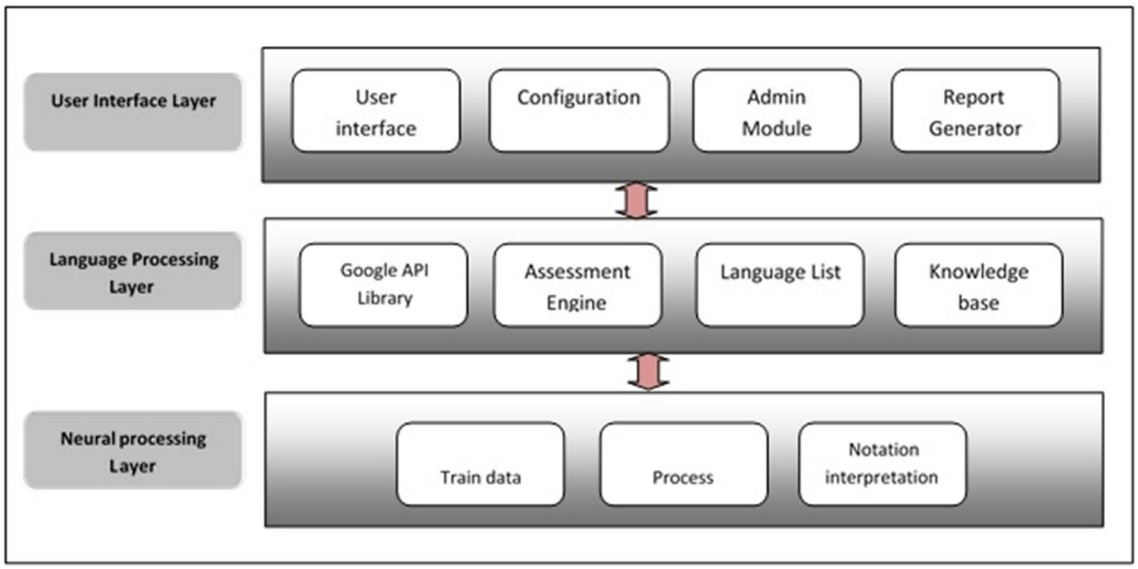
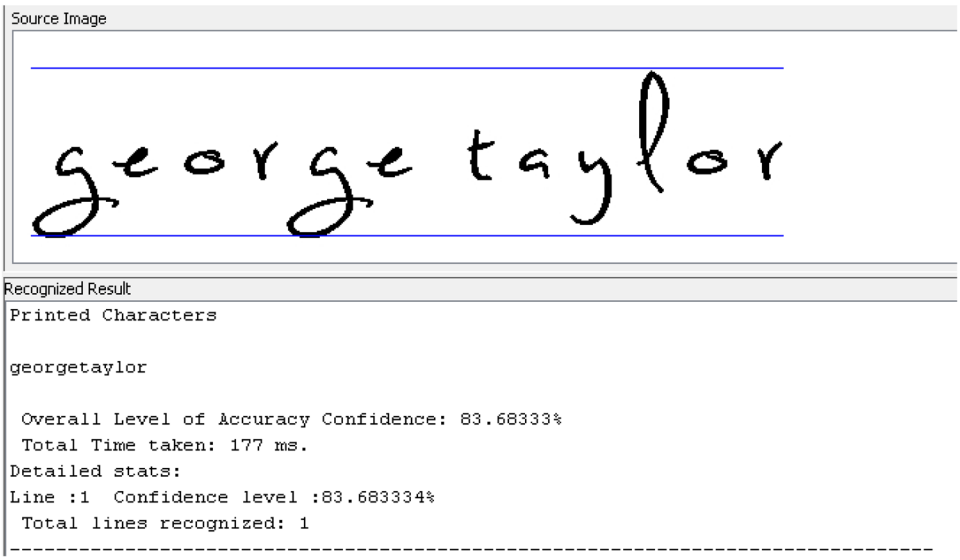


Fig. 5 Logical landscape of Self-training system

Fig. 6 Sample execution of a handwritten recognizer



complete experimental evaluation of script recognition. The test program requires at least 64 MB RAM and 1 GB storage (to have the IDE) with 2.1 Ghz processor speed in order to execute and achieve results with good processing rate. Screenshot showing the evaluation of individual characters from a single line of text and the statistical evaluation of individual characters are shown in Figs. 6 and 7.

Performance Evaluation

It is challenging for image-based Text detection and character recognition as there are potential of varying degrees of quality expected from the input data for both handwritten and printed text. Hence development of combination of algorithms to satisfy accuracy percentage in recognition is required which involves several stages of implementation

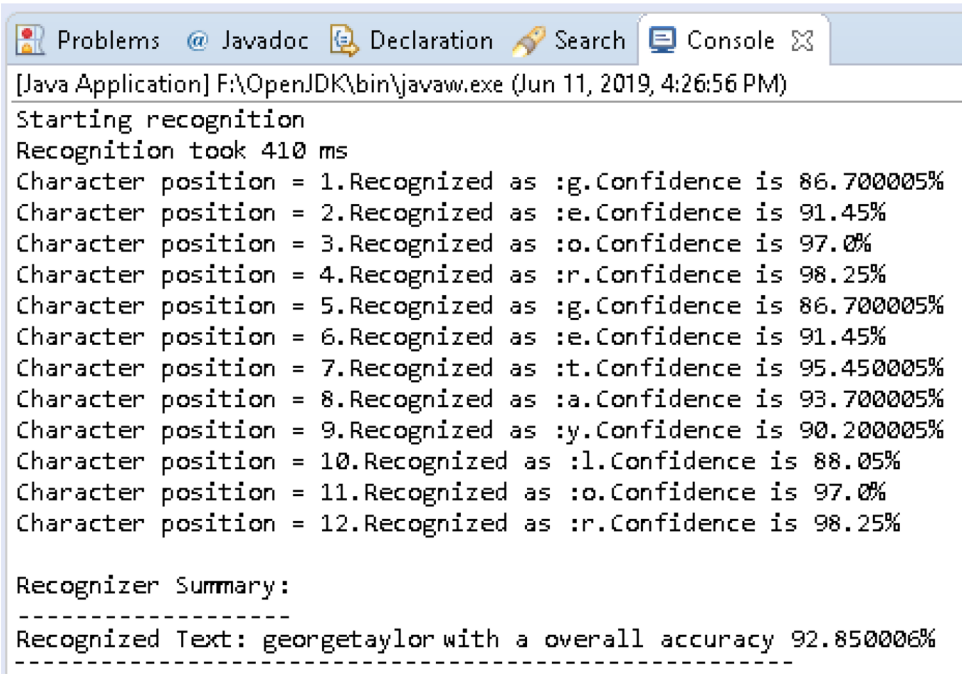


Fig. 7 Test execution results as captured in the console showing recognition accuracy

like pre-processing, image correction, cleansing, processing and post-processing (Fig. 8).

In the proposed system text detection algorithm is integrated which takes scanned image as input and provides visual recognition stages a output which helps user to re-process or accept based on accuracy in recognition. The Results gathered from such experiments helps to identify the strengths and weaknesses of the techniques employed.

OCR methods are chosen based on the quality of the input image (scan quality), ambient conditions (noise due to background shadow) and different parameters used in the algorithm are impacts the ability to accurately detect text (Table 1).

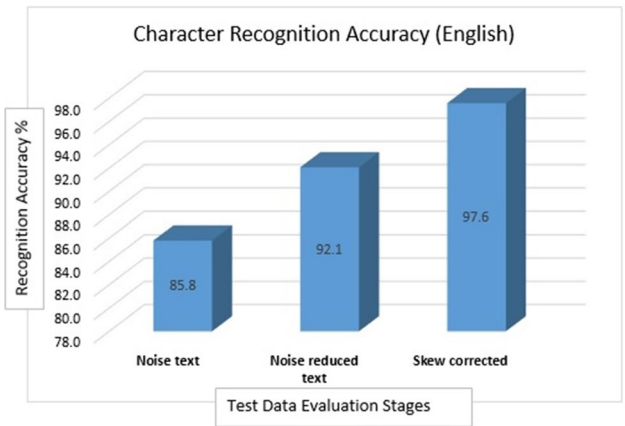


Fig. 8 Character recognition accuracy at different stages

Conclusion

Character recognition by processing scanned image in general and text interpretation in particular is important area in the pattern recognition world using cognitive theory of neural network-based processing technique and modern OCR system is built based on such techniques to address wide-ranging requirements in image processing. As discussed above, there is no single unified solution available for solving global character recognition comprising characters of any language and one has to use a specific technique listed above based on the requirement.

There is also a widely experimented method in cognitive reading called Self-learning which reduces manual effort of training the system and improves the knowledge base by doing repetitive combinations of learning by itself with different variants of character strokes. A further study in this research topic is to integrate Speech recognition system (for example: Text to speech recognition engine) to read out the interpreted text from the unified system. Such system can be an excellent use case for visually challenged people where they struggle (or manual need to support) to get proper interpretation of text books and pdf documents.

Table 1 Evaluation of recognition test at different stages

No. of lines	No. of neurons built during self training	Noise text	Noise reduced text	Skew corrected
1	192	89.9	96.2	97.7
2	246	92.2	93.0	96.9
3	335	90.6	98.5	98.9
4	486	92.3	94.6	97.2
5	542	64.0	80.6	96.7
6	681	89.1	99.2	96.8
7	725	74.8	85.3	98.4
8	843	87.7	95.3	96.1
9	943	93.1	95.3	97.3
10	1012	84.6	87.5	97.4
11	1123	93.8	99.2	96.8
12	1214	92.2	93.0	98.4
13	1356	96.9	95.4	96.8
14	1489	84.6	96.8	96.9
15	1641	85.3	89.9	97.5
16	1785	85.8	89.9	97.5
17	1820	95.4	89.9	98.9
18	1931	76.6	83.1	98.8
19	2001	72.9	82.3	96.8
20	2141	96.1	98.5	96.9
21	2235	80.2	93.1	96.8
22	2349	77.2	95.4	97.7
23	2452	76.0	86.0	98.7
24	2501	87.7	91.5	98.8
Mean (%) [M]	1335.1	85.8	92.1	97.6
Standard deviation [S]	726.0	8.3	5.4	0.9
Error of mean (%) $S/\sqrt{N}$ where N is sample size	145.2	1.7	1.1	0.2

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Compliance with Ethical Standards

Conflict of interest The authors declare that they have no conflict of interest.

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