An Overview of Handwriting Recognition Systems

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Abstract: Handwriting is a uniquely human act, performed daily by millions of people. “Graphology” would be the first idea to hit your mind if you are about to present the concept of “decoding”, (or rather the more non-scientific determination of some psychological character traces of the writer). But the more mundane and more frequently overlooked, “decoding” of handwriting is the process of figuring out the letters and symbols written for recognition. Handwriting recognition cannot be underestimated, it has its own huddles in the process of recognition. A common complaint of people is that they couldn’t read their handwriting. A very useful one for handwriting recognition and one that is used in several recognizers, is a neural network.

Key words: Structural Techniques % Aspect Ratio % Stylus % Graffiti, % Personalization wizard

INTRODUCTION

Handwriting Recognition: Paper documents, photographs, touch-screens and other devices are the sources of feed for computer to interpret characters for recognition. The image of the written text may be sensed “off line” from a piece of paper by optical scanning or intelligent word recognition [1]. Alternatively, the movements of the pen tip may be sensed “on line”, for example by a screen surface with pen as an input device.

Handwriting recognition principally entails optical character recognition. However, formatting and correct segmentation are also falls under the process of handwriting recognition.

There are two forms of recognition

C Off line recognition ii) on line recognition

In Off-line handwriting recognition, the text in an image are converted into letter codes, which are used by text processing application developed for the purpose of handwritten recognition. Off-line handwriting recognition is not easy to recognize and, as of today, OCR engines are primarily focused on machine printed text and ICR for hand "printed" (written in upper case letters) text. There is no OCR engine that supports handwriting recognition as of now.

Problem Domain Reduction Techniques: We have to narrow the problem domain to increase the accuracy of handwriting recognition systems.

Primary Techniques:

C Have to specify specific character ranges
C Utilization of specialized forms

Character Extraction: Off-line character recognition often involves scanning a form or document written sometime back. This requires to extract each and every characters in scanned image. Tools exist that are capable of performing this step [2, 14]. The most common hurdle we face is when connected characters are considered as a single sub-image containing both characters. This causes a major problem in the recognition phase. But still we have handful of algorithms to face this problem at recognition stage

Character Recognition: Recognition engine helps to match each and every extracted character to a matching computer character for further processing.

Methodologies of Cr System: We focus on the methodologies of Character Recognition systems, emphasizing the off-line handwriting recognition issues that we face. For most of the system hierarchical
approach, would be from pixel to text, as follows: Pixels Features Characters Subwords Meaningful Text. This bottom up approach varies a great deal, depending upon the type of the CR system we use and the methodology we follow [3,9]. The expert review in the field of character recognition indicates that the above mentioned hierarchical tasks are grouped in the different phases of the CR for Pre-processing, segmentation, representation, training and recognition, post processing. The process of CR will complete after following these stages with at most perfection

Pre-processing: Based on the source of input, raw data should undergo number of preliminary phases to make it suitable for CR system [4]. The process varies from one source of input to other source of input. Pre-processing facilitated CR system to operate accurately by providing data which more suitable to it. The main objectives of pre-processing are:

C Noise reduction,
C Normalization of the data,

Segmentation: Segmentation is an important stage, as segregation of words, lines or characters has a huge impact on how CR system handle the input [6,13]. The four types of segmentation are

External Segmentation
Internal Segmentation
Explicit Segmentation
Implicit Segmentation

Representation: Image representation plays vital roles in a recognition system. To put it simple, gray-level or binary images are feeded to a recognizer [4,12]. However, in most of the available recognition systems, inorder to get rid of complexity and tune-in the accuracy of the algorithms, a more compact and characteristic representation is required. Hundreds of documents provide feature extraction methods for character recognition. Image representation methods are categorized in three major groups as:

-Global Transformation and Series Expansion
Statistical Representation, Geometrical and Topological Representation

Training and Recognition Techniques: CR systems uses different methodologies pattern recognition it assigns a sample which is unknown into a predefined class. Below approaches to pattern recognitions can explain about CR, as suggested as

C Template Matching,
C Statistical Techniques,
C Structural Techniques,
C Neural Networks.

Post Processing: It is well known that humans read by context up to 60% for careless handwriting. The review of the recent CR research indicates minor improvements, when only shape recognition of the character is considered. This is done in the post processing stage with a feedback to the early stages of CR. The simplest way of incorporating the context information is the utilization of a dictionary for correcting the minor mistakes of the CR systems.

Feature Extraction: Feature extraction works in a similar fashion to neural network recognizers however, it is mandatory for programmers to manually determine the properties they feel as important

Some Example Properties Might Be:

C Aspect Ratio
C Percent of pixels above horizontal half point
C Percent of pixels to right of vertical half point
C Number of strokes
C Average distance from image center
C Is reflected y axis
C Is reflected x axis

Recognizer gain more control over properties considered for recognition by using these approaches. Still any system using this approach requires more development time than a neural network because of the reason that properties are not learned automatically.

On-line Recognition: On-line handwriting recognition will automatically recognize input characters on the go, input source for this varies based on the technology used (example: PDA). Input character should be recognised immediately once it is given as input, sensor will be picking up a pen tip movement and pen switchings. This is called digital ink and it’s a source of input for character recognition. The signal captured from input device will be converted into a matching computer input and computer will proceed with further processing.
The elements of an on-line handwriting recognition
interface typically include:

- a pen or stylus, user should write with this.
- a touch sensitive surface, which may be integrated
  with, or adjacent to, an output display.
- a software application which interprets the
  movements of the stylus across the writing surface,
  translating the resulting strokes into digital text.

**General Process**: The process of online handwriting
recognition can be broken down into a few general steps:

- preprocessing,
- feature extraction and
- classification.

Preprocessing discards irrelevant information
that can affect CR system performance. This can put
speed and accuracy at risk. Preprocessing usually has
phases like binarization, normalization, sampling,
smoothing and denoising. The second step followed will
be feature extraction. From 2 or more dimensional vector
field fetched from pre-processing algorithm, higher
dimensional data is fetched. This step is for projecting
important information for recognition model. This data
may include data like pen pressure, velocity or the
changes of writing direction. The last important and
crucial step is classification. In this step various models
are used to map the extracted features to different classes
and thus identifying the characters or words the features
represent.

**Hardware**: Commercial products with handwriting
recognition as an alternative for keyboard input came into
market in the early 1980s. Examples include handwriting
terminals such as the Percept and the Infortake point-of-
sale termin With the advantage of the huge consumer
market for personal computers, several commercial
products were introduced to replace the keyboard and
mouse on a personal computer with a single
pointing/handwriting system, such as those from
PenCepCIC and others. The first commercially available
tablet-type portable computer was the GRiDPad from
GRID Systems, released in September 1989. Its operating
system was based on MS-DOS.

Advancements in electronics allowed the computing
power necessary for handwriting recognition to fit into a
smaller form factor than tablet computers and handwriting
recognition is often used as an input method for
hand-held PDAs. The first PDA to provide written input
was the Apple Newton, which exposed the public to the
advantage of a streamlined user interface. However, the
device was not a commercial success, owing to the
unreliability of the software, which tried to learn a user's
writing patterns. By the time of the release of the Newton
OS 2.0, wherein the handwriting recognition was greatly
improved, including unique features still not found in
current recognition systems such as modeless error
correction, the largely negative first impression had been
made. Palm later launched a successful series of PDAs
based on the Graffiti recognition system. Graffiti improved
usability by defining a set of "unistrokes", or one-stroke
forms, for each character. This narrowed the possibility
for erroneous input, although memorization of the stroke
patterns did increase the learning curve for the user. The
Graffiti handwriting recognition was found to infringe on
a patent held by Xerox and Palm replaced Graffiti with a
licensed version of the CIC handwriting recognition
which, while also supporting unistroke forms, pre-dated
the Xerox patent. The court finding of infringement was
reversed on appeal and then reversed again on a later
appeal. The parties involved subsequently negotiated a
settlement concerning this and other patents Graffiti (Palm
OS).

A Tablet PC is a special notebook computer that is
outfitted with a digitizer tablet and a stylus and allows a
user to handwrite text on the unit's screen. The operating
system recognizes the handwriting and converts it
into typewritten text. Windows Vista and Windows 7
include personalization features that learn a user's
writing patterns and/or vocabulary for English, Japanese,
Chinese Traditional, Chinese Simplified and Korean. The
features include a "personalization wizard" that prompts
for samples of a user's handwriting and uses them to
retrain the system for higher accuracy recognition. This
system is distinct from the less advanced handwriting
recognition system employed in its Windows Mobile OS
for PDAs.

Although handwriting recognition is an input form
that the public has become accustomed to, it has not
achieved widespread use in either desktop computers or
laptops. It is still generally accepted that keyboard input
is both faster and more reliable. As of 2006, many PDAs
offer handwriting input, sometimes even accepting natural
cursive handwriting, but accuracy is still a problem and
some people still find even a simple on-screen keyboard
more efficient.
Software: Initial software modules could understand print handwriting where the characters were separated. Commercial examples came from companies such as Communications Intelligence Corporation and IBM. In the early 90s, two companies, ParaGraph International and Lexicus came up with systems that could understand cursive handwriting recognition. ParaGraph was based in Russia and founded by computer scientist StepanPachikov while Lexicus was founded by Ronjon Nag and Chris Kortge who were students at Stanford University. The ParaGraphCalliGrapher system was deployed in the Apple Newton systems and Lexicus Longhand system was made available commercially for the PenPoint and Windows operating system. Lexicus was acquired by Motorola in 1993 and went on to develop Chinese handwriting recognition and predictive text systems for Motorola. ParaGraph was acquired in 1997 by SGI and its handwriting recognition team formed a P andI division, later acquired from SGI by Vadem. Microsoft has acquired CalliGrapher handwriting recognition and other digital ink technologies developed by P andI from Vadem in 1999. Wolfram Mathematica (8.0 or later) also provides a hand writing or text recognizing function can be called by writing command TextRecognize user can then drag the picture to be analysed on the place of "^".

DISCUSSIONS

In this study, we have overviewed the basic approaches in the CR domain attempting to bring out the present status of CR research. Although each of them methods mentioned have their own advantages and limitations, the success level is achieved by each method. However, taking in and account various databases, constraints and sample spaces it is difficult to comment about the success of recognition methods, especially in terms of recognition rates. An improved approach in almost all stages of CR research is needed in case of texts which are handwritten under poor conditions or for free style handwriting. Number digit or limited vocabulary form (bank checks, envelopes and forms designed for specific applications) recognition is a popular application area.

REFERENCES

