Abstract

Lists of Figures

Acknowledgements

1. Introduction
   1. Online Hand Writing Recognition
   2. Arabic
   3. Previous work
      1. An overview of Online Handwriting recognition
      2. Arabic Cursive text
   4. Database
   5. Outline of forthcoming chapters
2. Background /Background and Methods
   1. Metrics
      1. DTW
      2. EMD
   2. Features
      1. Shape Context
      2. Multi Resolution Shape Context
   3. Fast Retrieval data structure
      1. Kdtree
      2. LSH
   4. EMD embedding
   5. PCA
   6. LDA
   7. Nearest Neighbors
      1. Most Centrally object
3. Phase 1: Offline Handwriting recognition
   1. Implementation
   2. Results
   3. Discussion
4. Phase 2: Progressive/Just-In-Time (Dynamic) Arabic Online Handwriting Recognition
5. Discussion
   1. Introduction
   2. Summary of results
   3. Contribution to the field
   4. Conclusions
   5. Future Directions
6. Bibliography

Introduction

Online Hand Writing Recognition

The field of personal computing has begun to make a transition from the desktop to handheld devices, thereby requiring input paradigms that are more suited for single hand entry than a keyboard. Data entry using a pen or even by using the finger forms a natural, convenient interface.

The large number of writing styles and the variability between them makes the problem of writer-independent unconstrained handwriting recognition a very challenging pattern recognition problem.

Nowadays, the primary mode of data input from a human to a computer is still the keyboard. However, the amount of information processed by computers is rapidly increasing. Given this, the time consumption of information exchange between human and computers is becoming a serious bottleneck. In order to be effective, the user interface has to be both effective and natural. Thereby, requiring no learning curve to the user.

[Talk about smartphones/Tablets/etc.]

While much of the today’s data is directly entered into computers using the keyboard, many tasks still exist in which people tend to prefer handwriting over keyboard entry. Note taking (e.g. in classrooms) is a task that can still be done more effiecientlu by hand for most users. In addition, while people can produce annotated hand sketches very quickly, data entry into a computer using a combination of the mouse and keyboard is relatively time consuming.

Smartphones and tablets are pocket sized cosumer devices that can store calendars and address books, provide access to emails, the web, and contain other productivity tools. These devices are too small to have full sized keyboards, or sometimes may be too small for any keyboard at all, requiring pen, hand gestures, figure gestures or voice interface to enter data.

The problem of handwriting recognition has now been a topic of research for over four decades. There are many types of problems (with varying complexity) within handwriting recognition, based on how the data is presented to the recognition system, at what level the data can be unambiguously broke n into pieces (e.g. individual characters or words), and the transcription complexity of the language used.

At the highest level. Handwriting recognition can be broken into two categories: offline and online.

Offline handwriting recognition focuses on documents that have been written on paper at some previous point of time. Information is presented to the system in the form of scanned image of the paper document. In contrast, online handwriting recognition focuses on tasks where recognition needs to be performed at the time of writing. This requires the use of special equipment, such touch screen or digitizing tablet, to capture the strokes of the pen as thet are being written. The trace od a writer’s pen is stored as a sequence of points sampled at equally spaced time intervals. The information captured for each sample is the  coordinates. While this sequence can be used to construct a static image of the writing, thus allowing offline character recognition techniques to be applied, it has been shown [63] that the information about the pen dynamics can be used to obtain a better recognition accuracies than the static data alone. Therefore, it is beneficial to capture the data in an online form, even if the real-time processing requirements can be relaxed.

Another advantage of online handwritten data over offline data is the availability of the stroke segmentation and the order of writing. Ink in static images must first be separated from the image background, creating a potential source of error. The ability to detect the states of “pen-down” (when the pen touches the tablet or the finger touches the touch screen) and “pen-up” can also be used. A single stroke is defined as the sequence of sample points occurring between consecutive pen-down and pen-up transitions. However, a complication occurs when a stroke is added to a character in a word after the rest of the word has already been written, such as the cross of a ‘t’ or an ‘x’, or the dot of an ‘i’ or a ‘j’. These types are called delayed strokes.