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ONLINE HANDWRITING RECOGNITION

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Abstract: Handwriting is a natural way of putting information in legible form to be shared with readers. The scope and importance of handwriting is not all together out-shined with the creation of very sophisticated digital computers with facilitated input methods. In addition, for the new trend of small form factor computers and devices used for mobile computing, carrying a keyboard, even in miniaturized form, is becoming less and less of an option. It is particularly inconvenient to have keyboards in situations where one only has the need to jot down short notes. Another application is as a more natural and easier-to-use interface to the tasks involving complex formatting, like entering and editing equations, and drawing sketches and diagrams.

Keywords: Handwriting, recognition, online, offline, text, technologies, system, application.

Introduction. Since the conception of the first alphabet, handwriting has been a medium of communication. As the literacy rate in most societies improved, handwriting has played a major role in technological advancement, keeping historical records and also as a persistent means of communication [5]. With the advancement of technology more and more technical barriers have been broken. The advent of computers was a great enhancement to mankind's everyday life which also revolutionized writing systems. In addition to the automated writing systems, various technologies like foldable keyboards, virtual keyboards and speech recognition are some of the methods implemented so far. However these methods have encountered challenges that have made them ineffective at times. Both virtual and real-life keyboards have introduced stress related ailments like Carpal Tunnel Syndrome [2]. Additionally, these keyboard technologies are difficult to make use of when implemented in small cramped spaces. Speech recognition is plagued by environmental noise pollution. In order for this technology to function one needs a reasonably quite arena[1].

Through time, state of the art innovations led to the miniaturization of computing devices. The integration of communication technology and computing has opened the door to everyday use gadgets like the smart phone and PDAs. The pervasive

nature of small handheld computing devices is spear heading a new movement in information technology. Small devices like handheld computers; smart phones and PDAs are a few of the gadgets that are making this phenomenon become a reality. In spite of this, handwriting has still prevailed in this day and age of modern technology.

Interaction between human beings and most computing devices employed keyboards and pointing devices like the mouse. However, these input methods are inappropriate when it comes to the application of small devices; mostly because of their size [5]. This necessitates the need for innovative input methods. Handheld computing devices required easier methods of interaction for use. Researchers have come up with yet another means of interaction, handwriting recognition [5, 7, 10].

Smart Phones, Palmtop computers and PDAs utilize a stylus as one of their main input devices. The stylus is used as both a pointing device and also for text entry [13]. Handwriting Recognition systems (HWR) with PDAs, comprises of the software component that facilitates data entry, recognition and interpretation [7].

Handwriting recognition can be broadly classified into two groups: online recognition and offline recognition. Online handwriting recognition makes use of pressure put upon an electrostatic-sensitive writing surface upon which the user forms



handwriting with the stylus. Online recognition system considers samples of the movement of the pen-tip, the coordinates of the sampled points, and information on pen-up and pen-down states [5, 7, and 10]. On the other hand offline handwriting recognition utilizes the handwriting image after completion of the handwriting process [11, 9]. This type of handwriting recognition utilizes a scanner as an input to get the handwriting image. As a result it lacks the temporal input sequence information provided directly by the user. On-line data, in general, is more compact compared to off-line data because of the different dimensionalities in representation. The difference in the data size results in substantial difference in the processing time [9].

Another taxonomy in handwriting recognition is the classes of writer-independent and writer-dependent systems. Writer-independence means that the system can handle the idiosyncrasies of multiple individual writing styles, and a writer-dependent system is trained and optimized to recognize an individual's writing [5].

Handwriting recognitions systems are language specific. Both online and offline handwriting recognition system accuracy rates have been progressively improving for Latin based and other scripts. However, when it comes to the case of Ethiopic scripts very few researches have been conducted in this field. We will address these few researches that have shed some light for our work especially [10].

Literature Review. Writer Independent Online Handwriting Recognition for Ethiopic Characters by Daniel Negussie, Online Handwriting Recognition for Ethiopic Characters by Abenet Shimeles.

In Ethiopia, the creation of this system will enable individuals with poor English language and typing skills to have access to information technology regardless of their limited knowledge. Moreover, individuals that are computer literate still note flaws in conventional data entry methods that utilize keyboards and keypads. Therefore, individuals that use this system will be able to exercise the convenience of a much more facilitated data entry method in their native language[1]. In addition, this will also be highly beneficial for the circulation of information amongst individuals enabling knowledge and information transfer an easier task.

The current use of PDAs and other hand held devices in Ethiopia are not that common even though they are becoming widely available to most people in other countries. One of the technical reasons is that they are not suited for local languages. The goal of this research is to facilitate the localization of the online handwriting recognition system feature of handheld devices so that Ethiopians can benefit from this technology.

This thesis will explore various approaches and technologies, to design and develop an online writer independent handwriting recognition system for Ethiopic characters[1].

Materials and methods. Handwriting Recognition is the task of transcribing a language message represented in a spatial form of graphical marks, into a computer text [5]. Studies in this field of pattern recognition have been on going for more than four decades. Nevertheless, various applications exist that necessitate this ever continuing research in search of better, more robust and reliable recognition systems. One such application, handwriting interpretation, deals with the task of determining the most likely meaning of a sample of handwriting [5]. This can be observed in sorting mailing addresses from an envelope, and sorting cheques in the bank. Handwriting verification is another application that determines whether a particular handwriting belongs to a specific writer or not[1].

Handwriting recognition can be classified into various categories. At a broader level, handwriting recognition can be broken into offline and online. These two categories arise from the method of input and the information that is made available to the handwriting recognition system[1].

Offline handwriting recognition is the automatic transcription of handwriting, where only the image of the handwriting is available [9]. This hand writing needs to be scanned to the computer for the handwriting recognition system to access it and analyze it consequently. A host of applications of offline handwriting can be envisaged, including document transcription, automatic mail routing, and machine processing of forms, checks, and faxes [9]. A few numbered studies have been conducted in this category of handwriting recognition for the Ethiopic



text [12, 4 and 6]. One advantage of offline systems over online systems is that they are immune to the various stroke orders among writers. The scanned representation of the handwriting stays the same without regard to the sequence of strokes, which is not the case with online systems. This imperviousness helps offline systems handle various different handwriting styles, though not without a cost. In order to handle the variety of handwriting styles offline systems need to employ an extensive range of preprocessing tasks to the input strokes of handwriting.

Online handwriting recognition implements the use of a digital pen or stylus in conjunction with a pressure sensitive writing surface which is also called a tablet digitizer. The tablet detects the writer's movement of the stylus and records discrete X, Y coordinates. Furthermore, it records the state of the pen tip, when the pen is touching the surface and when lifted from the surface. A 'stroke' in online data is defined as a sequence of sampled points from the pen down state to the pen up state of the pen [8]. Application of online handwriting recognition systems consists of a more natural and easier to use interface, as well as a tool for diagnosing and teaching handwriting skills [9]. A minimal effort in the learning curve is observed with this mode of data entry. It can also be observed that the online handwriting signal contains more information on the writing process than the offline signal, especially regarding the temporal order and the dynamic information of the writing process, which has encouraged researchers to come up with higher accuracies compared to offline systems [9].

Constrained hand writing systems are those that incorporate restrictions. On the other hand, unconstrained hand writing systems allow writers to use their own individual writing styles. Constrained systems have achieved higher accuracy levels because character separation is greatly simplified and the stroke segmentation issue is non-existent. Furthermore, systems like Graffiti have assigned specific individual strokes for each character of the Latin alphabet to avoid problems in recognition and post processing [14]. Example single strokes used in Graffiti are shown in Figure 1.

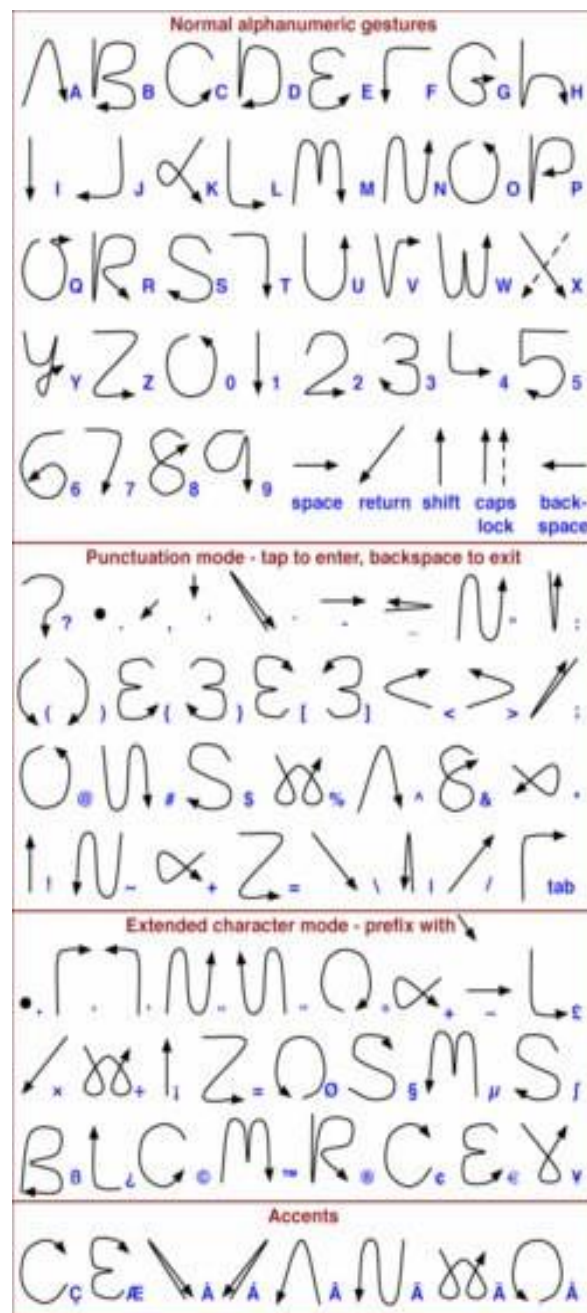


Figure 1 Single stroked samples

Even though, Graffiti does not cater to a wide range of writing styles and requires the writer to adapt to the restrictions imposed by the system to recognize the samples provided, its high accuracy rate has made it dominant in the market.

Nevertheless, with the advent of constrained writing systems a question might be asked: Is conventional handwriting facing extinction?

The theory that people will learn a new way to write the letters of the alphabet to achieve fast, consistent recognition may be true, but as the



algorithms and networks to recognize normal handwriting improve, then the need for Graffiti decreases, as happened with the Newton with the transition to version 2.0. [2].

Technology has lead to the detailed study and reinterpretation of handwriting which in turn has lead to the further classification of online handwriting systems into, writer-dependent and writer-independent writing systems. Figure 2 further shows the hierarchical classification of handwriting recognition.

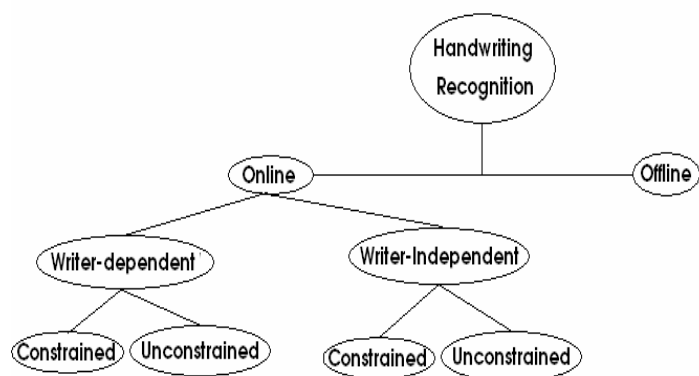
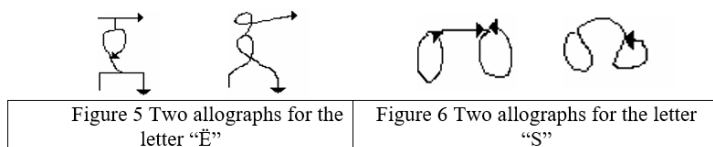
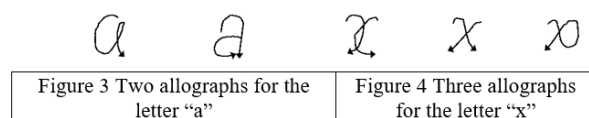


Figure 2 Various categories of HR system

Another classification of online handwriting recognition systems is based on the amount of data, and the number of users that the system is targeted for. Writer-independence means that the system can handle the variations in multiple people's writing styles, and a writer-dependent system is trained and optimized to recognize a single person's writing [5].

Some handwritten characters have substantial difference in their visual shape due to the different writing styles that exist. For instance, in Figure 3 and Figure 4 one can see that there are various ways/allographs that represent the same Latin character. Likewise, the same variations hold true for Ethiopic characters as shown in Figures 5 and 6. This variety in allographs coupled with different writers makes the task of designing a writer independent handwriting recognition system more challenging

Results



On the other hand, writer dependent systems deal with relatively lower handwriting variability. This leads to a higher accuracy in the developed writer dependent recognition systems. Nevertheless, a shortcoming of a writer dependent system is that such a system may encounter difficulties in handling variations of handwriting from the single individual. Hence, this may infer that a writer dependent system may present certain amount of constraints which may make it similar to a constrained handwriting recognition system. Alternatively, there is a considerable reduction of constraints in a writer independent system because writers are afforded flexibility with handwriting style variations.

Discussions. The recognition of individual handwritten characters can very easily be ambiguous to the human eye. Most handwriting recognition researches have evolved from the study of isolated character recognition towards the recognition of words and sentences. Handwritten word recognition is quite challenging as characters may overlap and some characters within a word may be vague. Neighboring characters may shade some light onto the identity of these ambiguous characters, due to the context or meaning of the word that is formed as a whole. An over-reliance on the potential contribution from the discriminative power of isolated level character recognizer is a contributing factor to this problem. Nevertheless, it is now being realized that the ambiguities encountered during the recognition process are better and more naturally resolved by drawing relevant information from the context rather than trying to put the discriminative capacity of the character recognizer to the limit. Underestimating the complexity of the string level recognition is responsible for hindering in-depth efforts to merge the research of word and character recognition [5].



No doubt, the character recognizer indeed plays an important role in the process, but more orchestrated and higher level integration of diverse information from the rest of the system is in strong demand to accomplish higher performance[5].

Conclusion. In this chapter various categories of online handwriting recognition systems have been identified, such as writer dependent and writer independent online handwriting recognition systems. The ability to cater to variations in writing styles makes a system more versatile and readily usable without requiring the user to learn or adapt to a new style of writing.

Based on these various classifications and their corresponding advantages and characteristics, in the study of this paper, it is the aim to develop a prototype of a writer independent, unconstrained online handwriting recognition system for isolated first order Ethiopic characters.

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