Web based Bangla Online Handwritten Prescription system for Telemedicine through Multimedia Conferencing

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Abstract— **Handwritten text (Online and Offline) is potentially the most powerful and acceptable means of personal authentication in Human Computer Interaction, with applications to be found in intelligent telemedicine application, document analysis and many other areas. Handwriting is a complex perceptual motor task generating linguistic information. Characters reflect shape distinction needed to perceive different phonetic information of words. In this paper, Bangla Online Handwriting Recognition System for web based Telemedicine application developed at CDAC Kolkata is described as a computational model in the areas of Pattern Recognition and Human Computer Interaction. Bangla Handwriting Recognition system is discussed as a case to role a prescription in "Local Language Interfaces" for Telemedicine application for rural people. The paper report the development of "Web based Audio-Video Conferencing system for online prescription using Online Bangla Handwriting Recognition Sub-system".**

Keywords- Handwriting Recognition, Bangla OHR, Online prescription, Telemedicine, multimedia conferencing.

I. INTRODUCTION

Computer Recognition of Handwritten Scripts still presents a special challenge due to seemingly infinite varieties of handwritten scripts though modern computational techniques are adopted in personal computers to recognize handwritten characters. The production of handwritten texts in digital devices requires an organized flow of information with the help of stylus and writing pad.

In case of Bangla Handwriting, it is the second most popular script and language in the Southeast Asia. Almost 250 million people of Eastern India and Bangladesh use this language thereby making it the fifth most popular in the world. Script wise Bangla is quite complex, being alpha-syllabic and conjunct forming in nature. Experiments have revealed that human visual system has specialized neurons to detect the directional curve, corner and end point. So, they play significant role in perception and memorization of line drawing including alphabets. In our work, we propose to segment 2D curves at these "perceptual anchorage points", namely discontinuity points, angular points, critical or singular points and multiple points of order k. In our effort, a handwritten character/cluster is characterized by structure- or- shape based representation of a stroke in which a stroke is represented as a string of shape features. For plane curves the main properties are continuity, differentiability and curvature; therefore we define as "catastrophe points" the points where the curve is disrupted, the angular points and the cusps.

A system has been developed based on pattern recognition technique applied for recognizing handwritten Bangla characters online, using digital tablet and stylus as input devices. The basic engine developed has been utilized for online prescription form which will appear in webpage in multi-client environment to communicate between two remote ends (namely, Doctor's end and Patient's end).The complete system can be utilized for Web based Telemedicine application for rural Medical centers and is having the facility for audio and video conferencing along with online chat facility for communication purpose. Technological developments of R&D outcomes in the Tele-health domain is reported here.

Fixed telemedicine installations currently in use do not suit the needs of small nursing facilities due to their cost, size, and lack of portability. A portable telemedicine kit would obviate the need for a physical visit for minor consultations for these patients.

The important functional and technological features of the above developed system are a)Low-cost, virtual medical consultations between doctors and remote patients located in Nursing Homes, Primary Health Centers and Retirement-centers for situations where a physical visit to the specialist is not necessary or not possible ,b)Tablet-PC, which features a stylus that can be placed directly on the screen for additional input capabilities such as handwriting recognition and c)Two-way video conferencing with audio-input from digital medical peripherals ,as well as "Textual Inputs".

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II. BANGLA ONLINE HANDWRITING RECOGNITION

A. Background

On-line handwriting recognition means that the machine recognizes the writing while the user writes. The term real time or dynamic has been used in place of online depending on the type recognition technique and the speed [1]. Online handwriting recognition (OHR) consists of recognizing a script as it is written using an electronic stylus or a pen on a tablet [2]. There have been a very few work reported in case of Bangla on-line handwriting recognition. One approach was based on x-y co-ordinates values along with tangent slope angles as feature sets and Multilayer Perceptron based classifier [3]. Work reported in [4,5] presents direction code based features and MLP as classifier. The present work describes a system for online recognition of Bangla script; a language widely spoken in Eastern India. The approach presented here is structure or shape-based approach. The present method is based on earlier theoretical work which shows that the global shape of any handwritten character may be reduced to a small set of local shapes; the global shape is then a graph of local shapes [6].

Composite characters and Indian scripts:

Indian scripts pose a peculiar problem of composite characters (clusters) that is non-existent in European scripts. Unlike in Latin alphabets where a single character represents a consonant or a vowel, in Indian scripts a composite character represents either a complete syllable, or the part of one syllable and the onset of another syllable.

The Bangla Character Set: The writing style in Bangla script is from left to right. The concept of upper/lower case is absent in Bangla. Bangla script consists of a total of 495 classes (60 alphanumeric characters, 406 composite (valid clusters which includes 85 clusters that are used to accommodate foreign words written in Bangla) characters, 13 ligatures and 16 symbols).

B. The Program Flow

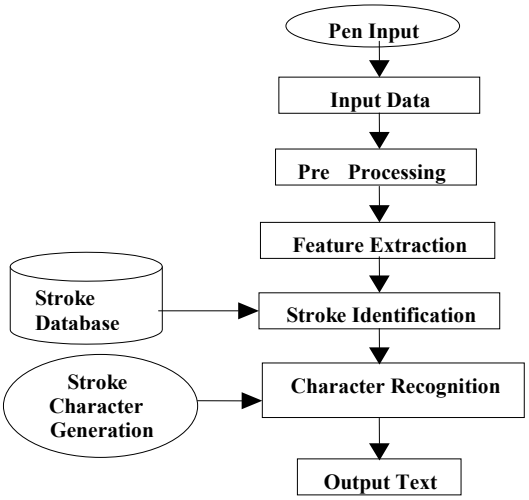

Figure 1. Flow Chart of Bangla OHR system.

In our approach, a handwritten character is represented as a combination of strokes. A stroke is defined as the trajectory traversed by the pen tip from the instant when it is first made of contact with the writing surface to the earliest moment when the contact is broken. Therefore, the first step in character recognition is to recognize all the component strokes in a character. Once the strokes are identified, the character itself can be easily identified. Following are the steps for Bangla OHR system.

1. Pen Input 2. Preprocessing 3. Feature extraction 4. Stroke Identification 5. Character recognition.

About 60 alphanumeric characters, 117 composite characters (clusters) including some modified characters and special characters written in single stroke, 13 ligatures and 16 symbols i.e. altogether 206 elements have been taken care to accommodate possible variation in data collection.

The flow diagram of Bangla OHR describes the basic principle of working of the online Bangla Character recognizer. The mail building blocks of the system consist of Input data Processing, Feature Extraction, Stroke Identification, Stroke Database generation and finally Character Recognizer. We have taken Morphological features (i.e. shape features) for our system. The classification is done by using Dynamic Time Warping Technique. The final output is shown in Unicode text as well as in html format.

C. Online Handwritten Data

Online handwriting data is typically a dynamic, digitized representation of the pen movement, generally describing sequential information about position, velocity, acceleration, or even pen angles as a function of time. Each component contains a sequence of pen tip information, which is sampled from the writer's pen movement, usually (but not exclusively) with regular interval in time. Here we solely refer to the horizontal and vertical coordinates. Pen down components are recorded when the pen tip touches the surface, pen-up components when it is lifted. In this paper, we focus on the situation where writing represents an isolated character or cluster.

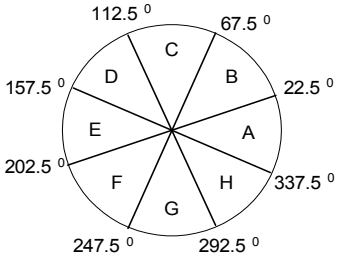

Figure 2. Line Terminal & Directional coding feature

Feature	Description	Example
R	Cusp Point	
S	Loop Point	
U	Angle Point	
X	Cross Point	

Figure 3. Critical Points

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Figure 4. Example of a Bangla Word "BATHA(BTH)"

For Bangla on-line handwriting, unfortunately we do not have any benchmark dataset available. So we had to collect some sample data and test our recognizer on that dataset. Total no. of data samples used for testing are 20,873 collected from 10 native writers.

For the specific application of online prescription we have collected 3 sets of 250 medicinal words from 10 native writers. Words have been selected from the book "Where there is no Doctor" by David Werner and translated in Bengali by Krishna Bandyopadhyay. Online data collection is done using Wacom Pen Tablet (Intuos3). Although the device provides pressure information, our algorithm does not use pressure. The front-end for data collection is developed using Microsoft Tablet PC SDK.

D. Preprocessing

It consists of Resampling, Smoothing and Normalization of strokes. Each stroke has been resampled to 50 equidistant points. To remove trembling from the handwritten text and to reduce the effect of noise, we replace every point x (t), y (t) in the trajectory by mean value of its two neighbors. Normalization of x- and y-coordinates of each strokes are done such that the stroke fits tightly inside a unit square; i.e., the time series values of co-ordinates x (t) and y (t) are normalized to lie between 0 and 1.

E. Feature Extraction

We have used two sets of features. Feature set1 consists of eight directional Line terminals using 8-directional chain coding system (Fig.1). Feature set 2 consists of 12 shape features (8 bump points and 4 critical points) Fig.2 shows the critical points. The shape features of handwritten characters are less susceptible to distortion introduced by writing. The features used may be further classified as:

Line Terminals: These are the ends of a stroke. They are of 8 different types-A (22.5°- 337.5°), B (22.5°-67.5°), C (67.5°-112.5°),D(112.5°-157.5°),E(157.5°-202.5°),F(202.5°247.5°),G (247.5°-292.5°), H (292.5°- 337.5°)

Bumps: These are points on the stroke where 1) a tangent exists, 2) the stroke is wholly on one side of the tangent, and 3) the slope of the tangent takes a small set of pre-specified values viz., 0, 45, 90 degrees. Conditions 2 and 3 together give rise to 8 bumps denoted by J, K, L, M, N, O, P, Q.

Cusp: A cusp is a point where dx/dt and dy/dt simultaneously go to zero. It has a sharp spiky appearance.

Loop point: A Loop (S) point can be formed by unification of interior point and end point.

Angle point: An angle (U) point can be formed by unification of two end points. It occurs when a stroke begins from where another stroke had ended.

Cross-point: A cross (X) point can be formed by unification of two interior points

Fig.4, shows the example of Bangla word "BATHA(BTH)".

F. Stroke Identification

In this step, the shape feature string of an unknown stroke is compared with a database of such strings.

This stroke database has feature strings of all the strokes that form handwritten Bangla Characters. A single stroke may have multiple variations. All variations of a single stroke are given a common integer identity- the stroke ID. The stroke identification step consists of mapping an unknown string of stroke features onto a stroke ID. By extensive manual analysis we have optimized the number of distinct 189 strokes in Bangla handwritten script.

DTW Classifier: We have used DTW (Dynamic Time Warping) based classifier to identify strokes from the unknown feature strings. Being an elastic matching technique, DTW allows comparing of two sequences of different lengths. This is especially useful to compare patterns in which rate of progression varies non-linearly, which makes similarity measures such as Euclidean distance and cross correlation unusable [7]. Here the time alignment is carried out using Dynamic Programming concepts. To align two sequences A & B of lengths m & n, respectively, using DTW, we can construct an n x m matrix, whose (i,j) th element = S(i,j) contains the cost measure of similarity between two points a_i & b_j. Each matrix element (i,j) corresponds to the alignment between the points a_i and b_j .

Once this matrix is created, an optimal warping path W is selected which is a contiguous set of matrix elements that defines a mapping between A & B, The kth element of W is defined as $w_k = (i, j)_k$. Where $w = w_1, w_2, w_3,.., w_k\ldots,w_K$ and K is the length of warping path. The warping path is subjected to several constraints such as, boundary conditions, continuity, and monotonicity.

DTW similarity measure between two sequences A &B can be calculated by constructing an (n+1) x (m+1) matrix from cost measure of similarity matrix and by using following recurrence relation using dynamic programming:

$$Y(i,j) = S(i,j) + \max \{Y(i-1,j), Y(i,j-1), Y(i-1,j-1)\} \quad (1)$$

DTW similarity between sequence A & B, is given by,

$$S(A, B) = \max \left[\sum_{W} W_k /K \right] \text{ for } k = 1 \text{ to } K \quad (2)$$

Where w is a set of all possible warping paths. The matching process is executed in two passes.

Pass 1: - In this pass only Line terminal of a stroke is used as features. A fixed cost measure of similarity Matrix is used to find out DTW similarity between unknown string of data and known string. Individual Strokes as well as Character sets (having wrong combination of strokes due to misrecognition), which are rejected by Pass1, are sent to Pass2 for final classification.

In Pass2: - Shape features like, cusp point, cross point, Loop point, angle points and bumps of a stroke are used as feature set. Fig.5 shows the fixed cost measure of similarity matrix. Output of DTW matching is based on some threshold, which has been decided experimentally.

For better performance of the DTW classifier, we have divided the strokes used in Bangla characters/clusters in to seven categories based on no. of strokes (1-7).We have designed the system in such a way that if Matra is detected, it will be

eliminated and Matra information is stored separately (System can detect character/cluster etc. for both the cases of with or without Matra). Now all the other strokes without Matra will be processed based on further subdivision of strokes in to three categories, namely upper, middle and lower. This reflects the position of the strokes with respect to the whole character/cluster.

The output of DTW matching in Pass 1(threshold is set to 0.4) and Pass2 (threshold is set to 0.2) together generates a sequence of identified stroke Id.

G. *Character Recognition*

Since a character is constructed by one or more strokes, recognizing a character consists of grouping stroke Ids into character Ids. Grouping of stroke Ids were done based on number of strokes used in the stroke Id generation module. Character Id is generated using Rule base to form Bangla Character or cluster.

Rule Base for character Recognition: Looking at the sequence of its strokes recognizes a character or a cluster written with single or multiple strokes. Maintaining a rule base against each Character or cluster checks this sequence. To tackle the stroke order variation problem, there are multiple definitions of the stroke sequences for the same character/cluster.

	A	B	C	D	E	F	G	H
A	1	.5	0	0	0	0	0	.5
B	.5	1	.5	0	0	0	0	0
C	0	.5	1	.5	0	0	0	0
D	0	0	.5	1	.5	0	0	0
E	0	0	0	.5	1	.5	0	0
F	0	0	0	0	.5	1	.5	0
G	0	0	0	0	0	.5	1	.5
H	.5	0	0	0	0	0	.5	1

Figure 5. Fixed cost measure matrix

Stroke database consists of 206 elements (60 alphanumeric characters and 117 clusters, 13 ligatures and 16 symbols) that are used for rule base creation. The 206 classes address 495 character/cluster classes of Bangla script.

For better recognition we have considered the relative position of a stroke with respect to the whole character or cluster etc. Based on a study we have stroke position in to three classes namely Upper, Middle and Lower along the vertical axis and Left, Center and Right along Horizontal axis. Rule base has been modified accordingly for some

character/cluster classes, which are having same sequence of strokes but with different position with respect to the character/cluster.

III. APPLICATION OF BANGLA OHR IN TELEMEDICINE

This work investigates whether or not telemedicine consultations can be successfully carried out over Web based multimedia conferencing in multi-client environment integrated with a tablet-PC based telemedicine kit.

The kit itself is based on a tablet-PC, which features a stylus that can be placed directly on the screen for additional input capabilities such as handwriting recognition. The software would allow two-way videoconferencing with audio, input from digital medical peripherals, as well as textual input.

Establishing the feasibility of telemedicine over multimedia conferencing requires evaluating the tradeoffs in feature set and quality of transmitted video with various limited amounts of bandwidth. This project illustrates to what degree effective telemedicine can be carried out over videoconferencing techniques. The findings may pave the way for further development of wireless telemedicine and thus solve the initial problem of extending the benefits of telemedicine to new populations. Block diagram of the online prescription system is shown in figure 6.

Steps of operation

- The nurse or primary care physician unpacks the kit, boots the tablet PC, and attaches peripherals required for the consultation.
- The remote physician and the local patient and nurse interact normally using the bidirectional audio and video streams.
- Textual notes, pen-inputted readings and observations, digital medical peripheral readings, are transmitted to the remote physician in real- or near real-time.
- The data for the session is encrypted and stored remotely and possibly locally as well.
- Telemedicine software features forms for these data that can be filled in automatically by digital medical peripherals, or through stylus or keyboard input from the nurse.

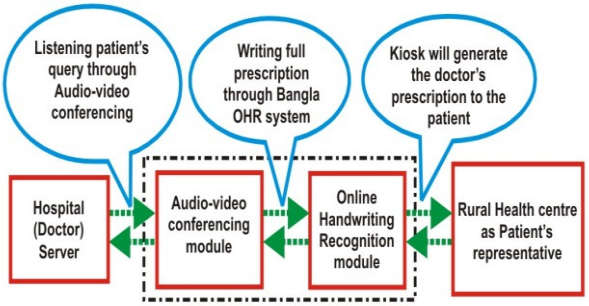

Figure 6. System Block Diagram

The overall integration process is depicted below in figure 7. The application runs as web based Telemedicine application using Audio-Video Conferencing System with Bangla OHR. Figure 8 and 9 represents templates for Handwritten prescription and corresponding output generated for patients.

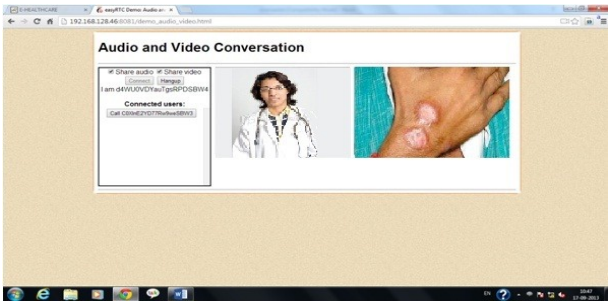

Figure 7. Web based Multimedia Conferencing

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Figure 8. Handwritten Prescription

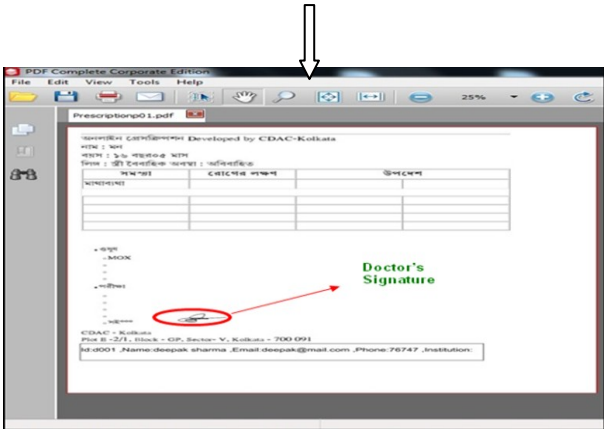

Figure 9. Signed Prescription generated for patients

II. FEATURES OF HANDWRITTEN PRESCRIPTION SYSTEM

The handwriting recognition system can handle all alphanumeric characters; compound characters used in "Bangla" handwriting and selected medicinal words. The system takes online pen tablet data as inputs. Output is stored in Unicode and html file format. The GUI is easy to operate and editing facility is available for wrong entry.

A. Features of Bangla OHR:

- It can handle all alphanumeric characters; compound characters used in Bangla Handwriting.
- It can handle selected Bangla Medicinal Words.
- System takes online pen tablet data as input.
- Output is stored in Unicode file format.
- Easy to operate.
- Editing facility for wrong entry.
- Acceptable Recognition accuracy in writer independent mode.

B. System Features of Web based Online Prescription:

Web based low-cost virtual medical consultations between doctors and remote patients located in various medical centres.

- Doctors can write Bangla prescription & patients can download it in pdf format authenticated by doctor's signature taken using HTML5.
- Seamless Conferencing :
  - The application represents web conferencing Scenario built with lightweight HTML5 components & javascripts with no plug-in installation.
  - Two-way video conferencing with audio input from digital peripherals, as well as textual inputs.

III. WEB BASED TELEMEDICINE SYSTEM USING BANGLA HANDWRITTEN PRESCRIPTION

The Integrated System at a glance:

I. Online Bangla OHR and audio-video conferencing is a real time communication between Doctor(s) and Patient(s).

II. Once users enter into the communicating system they can

1. Visualize and listen to the person at the opposite end through Audio-Video Conferencing.
2. Enter Bengali (in the first page) and English (in the second page) text through Online OHR to make the conversation more feasible and compact.

III. System provides facilities for audio-visual interaction as well as chatting facilities between the Doctor and the patient. Once the doctor is satisfied with the diagnosis process, the handwritten prescription with e-signature is transmitted.

IV. Once the doctor is satisfied with the diagnosis process, the handwritten prescription with e-signature is transmitted online to the patient's end for print out for record and further follow-up.

IV. CONCLUSION

The applications mentioned here are based on Handwriting recognition using shape based features which utilizes pattern recognition techniques. The goal of the work is to bring the benefits of telemedicine for rural patients in an inexpensive, convenient manner. This can be achieved by demonstrating the feasibility of producing a portable telemedicine kit that can be connected to a telemedicine network through videoconferencing. Local Language solutions through Online Prescription system integrated with multimedia conferencing will enable the process to be executed in a better and effective way. Current system developed by C-DAC is in a demonstrable prototype form and is undergoing trials applications and extensions.

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