International Journal of Computer Theory and Engineering, Vol. 1, No. 5, December, 2009
1793-8201

The Mathematical Formula Recognizing System Based On Web Service

Qi Xiangwei and Yusup Abaydulla, *Member, IACSIT*

***Abstract*—This paper focused on mathematical expression recognizing, we have designed online handwriting recognizing systems of mathematical expressions, MatheWriter and Embedded-MatheWriter, which have succeeded to be embedded in Office (like Word) and mobile equipments (like PDA). The paper expounds the system structure and basic functions of recognition system. On the basis of these studies, it also expounds the recognizing technology of mathematical expressions based on the Net and Internet Explorer, and from the perspective of Web's characteristics, the Web-Based MatheWriter is developed to help the mathematical workers find a more convenient and free model to solve difficult problems of expression input. Furthermore, it sets up a platform for inquiring into how to build a more natural and harmonious human-computer environment under the environment of Ubiquitous computing through the design and realization of expression editor of this non-keyboard input.**

***Index Terms*—Formula Recognizing, Web Service, Handwritting input, human-computer environment.**

I. Introduction

A. Ubiquitous Computing

The thought of Ubiquitous Computing is seeking a more friendly human-computer interface, which emphasizes that computers should be embedded in the environment and daily instruments and that peoples' concentration should go back to the task which needs accomplishing. Some drawbacks related to WIMP have been described by Van Dam[2]. He points out: under the WINP interface, users spend lots of time on the operation rather than the task itself. Some professional users are often tired of so many "Point and Clicks". They afresh choose quick means by using keyboard to operate. It is very convenient to use each single interactive component, like button and menu, under the WIMP style, but if they are combined with the requirement of the application system, the result is that the interface complication and interactive complication will increase nonlinearly, which finally will greatly add cognitive burden of users.

Additionally, according to the findings data of Computer Newspapers, it shows that global notebook computers increased in the range of 15% in 2008, which exceeded desktop computer in the increase range of 4%. It is estimated that till 2010, the sales of notebook computers will exceed that of desktop computer. And from the idea of Microsoft's mobile PC development, we can see that notebook computers will be developed with following characteristics: the appearance and size of notebook computer is convenient to carry, its interactive functions are rich and natural, it can keep connected or keep power off during whole days, and it has software with integrated digital ink.

The development of handwriting input just caters to this development trend. On the one hand, a keyboard is becoming the bottle-neck that blocks notebook computers to be thinned and lightened, but the handwriting input makes the keyboard become decoration and caters to the trend. On the other, though nowadays the person-computer interactive technology has changed the ways of man's exchanging information from many perspectives, paper and pens are still entirely preserved in daily life. The reason for studying the handwriting input and digital ink technology is to make the contents originally on paper be directly a part of electronic word.

B. Handwriting mathematical expressions

In recent years, with the use of products of education with electrical audio-visual aids, the work efficiency and the teaching quantity of high efficient teachers are both improved greatly. While it is upsetting that till now the mathematical expression input only can adopt the Equation Editor, which not only is no- audio-visual but also costs much time to input and revise the expressions at each time and even sometimes only can be replaced by the form of scanning paper. This way does not match electrical teaching plan which is convenient and quick.

The purpose of this paper is to solve the problem of expressions' natural handwriting input and to realize the handwriting expression depending on the common handwriting pens and handwriting software. The system can send the mathematical expressions to other software (such as Word), which supply users a more natural and convenient expression input means.

II. The System Structure of the MatheWriter

The mathematical expression expresses the mathematical meaning with a two-dimensional structure. These characteristics decide that it is rather difficult to divide and recognize characters of the mathematical expression, which is somewhat like the case: when a person is faced with a

Manuscript received May 9, 2009. This work was supported in part by National Natural Science Foundation Project (No.60463005) ,the Xinjiang Normal University graduate students scientific and technological innovation fund (No.20081201)

*Contact author: Yusup, E-mail:47266861@qq.com

formula, the first step is to know its characters and symbols and then the next is to analysis its structure to make sure what it wants to convey. Sometimes, we can interpret some former vague characters and structures with later structures. The computer recognizing process should also obey this rule. When recognizing characters, the data-in are defined as single characters and symbols, and when analyzing the structures, two-dimensional spatial relations of this collection of characters and symbols are proceeded to display the information of the given mathematical expression. Thus the recognizing of the mathematical expression involves the recognizing of characters and the analyzing of structures[3,4].

The handwriting recognizing system has five subsystems, showed by the following figure 1:

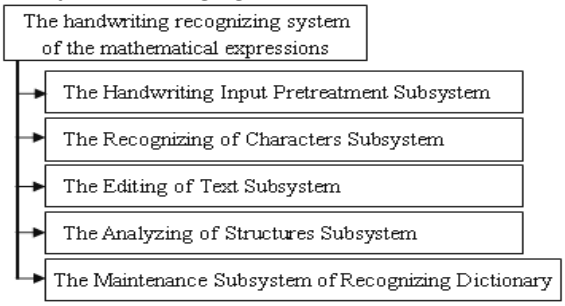

Figure 1 Five subsystems of the handwriting recognizing system

The Handwriting Input Pretreatment Subsystem: Because of the different sizes of characters input by users, the direction of writing strokes and the order between them may show difference, and the expressing format of characters also may not be identical. In other words, after the pretreatment of characters is finished, half of the work of recognizing characters has finished.

The Recognizing of Characters Subsystem:The subsystem mainly handles such problems as difficulties of dividing modules: space is too large to search, the clues to search space: the distance of strokes, the describing of the expression structure's analyzer, the categorizing of characters, and the analysis strategy of the expression structure's analyzer.

The Editing of Text Subsystem: Except for the function of inputting texts, the subsystem also functions as proofreading of texts, which realizes the proofreading of every recorded character by using of the technique of dictionary and the method of matching characters. Besides, the subsystem provides the function of editing and disposing handwriting, which solves the problems such as the limitation of small screens, disposing of recognizing mistakes, and implicit human-computer interaction.

The Maintenance Subsystem of Recognizing Dictionary: Hunting users' habits and adding newly discovered characters and words is one of the inevitable important tasks. The Maintenance Subsystem of Recognizing Dictionary is composed of the hunting module of users' habits, the discovering module of new characters and characters high frequently appearing, building module of expressions' structure features.

The Analyzing of Structures Subsystem: The subsystem chiefly achieves of spatial structures analyses, logical structures analyses, semantic analyses and the disposition of analyzing and proofreading based on the structure analyses and semantic analyses, which is a complicated process. There is no need to talk about the problem of this respect further more which has been expounded in another paper.

The handwriting recognizing system includes the module of handwriting input, the module of pretreatment, the module of dividing characters, the module of studying, the module of matching characteristics, the module of after treatment, the module of recognizing characters and the module of the disposition of analyzing and proofreading based on the structure analyses and semantic analyses. The recognizing process of the system is simply described as the following figure 2:

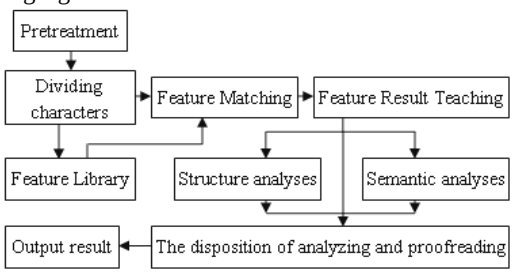

Figure 2 The recognizing process of the system

In the condition of the PC, the system has achieved the support to Uyghur and Kazakh languages. The picture bellow is a testing interface of the recognizing system which supports Uyghur writing:

Figure 3 Uyghur writing

III. WEB-BASED ONLINE RECOGNIZING TECHNOLOGIES

A. The Web-Based applications

The handwriting recognizing system of mathematical expressions efficiently decreases the excessively detailed degree to which the mathematical expressions can be inputted only with the help of Equation Editor. Though, to some extent, it solves the expression input's problem, still it needs the support of client software. At many occasions, people need conveniently input mathematical expressions in time, so we put forward to develop an expression input system under the environment of Web. Only with the help of Internet Explorer and the net, the expression input can be realized, which embodies "computing centering on person" further.

The handwriting input system of mathematical expression we mentioned in Web is based on distributed system style of SOA(Service Oriented Architecture). The browser is treated as the client users use to interact with the system. It

completes the collection and classification of strokes and the timely feedback of users' interactive information, and structurally analyses the recognition results given back by the server. At the server, we adopt the way of WCF (Windows Communication Foundation) to supply the serving interface and to finish the recognizing of single characters.

B. The Silverlight page display technology

Under the environment of Web, the strokes' input must have the corresponding carrying controllers. The ordinary HTML controller does not support the strokes' input. The Web researchers commonly collect strokes by the way of developing ActiveX controller or the use of Flash component embedded in the webs. After Microsoft's release of Silverlight in 2007, the Silverlight becomes the exciting Web's new technology. Someone even said that Silverlight is the ending of the Flash, we are realizing the client's design based on this component technology.

One of Silverlight's important functions is the InkPresenter controller. When using the Inkprenter controller, from its browser the Internet users can directly draw pictures in Silverlight's application program. Because the Silverlight is suitable to various operation systems and browsers, so is Inkpresenter, which gets rid of the limitation of the browsers operation system and hardware.

C. Using Inkpresenter to input strokes

Inkpresernter makes application program realized, each stroke of the centralized strokes is composed of a group of StylusPoints. The strokes have some DrawingAttributes, which can definite the stokes' features such as their colors and size. Every point in the strokes also has features: coordinates X and Y representing the place and PressureFactor. Figure 4 shows its arrangement structure.

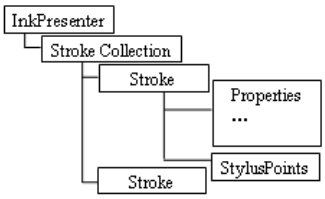

Figure 4 The arrangement structure

InkPresenter is just a stroke container. Using of InkPresenter actually is creating strokes and interacting with strokes. But under the tacit condition, InkPresenter does not carry out these operations. It supplies some events and methods, which allows users to add and delete StrokeCollection and furthermore allows users to visit Stroke to interact with it. The key events of catching strokes are MouseLeftButtonDown、MouseMove MouseLeftButtonUp. When InkPresenter receives MouseLeftButtonDown event, a new stroke needs creating in the memory and adding into the StrokeCollection of InkPresenter. When it needs to move the mouse to create the Mousemove event inner the InkPresenter, the StylusPoints shoud be added to the stroke. As long as the users contact the MouseLeftButtonUp event, it needs to finish the stroke.

D. The classification of strokes and serialization of strokes collection

In order to transmit the strokes from InkPresenter to service through the net, the strokes should be serialized. The serialization refers to the process of changing the object's condition to the form that can preserve and transmit. Anti-serialization, contrary to the serialization, converts the data flow to the object. Combining these two processes can easily store and transmit data. In the system, we create the XAML presenting way based on characters for the classified strokes collection. Thus, the characters can be serialized and sent to the service.

In Silverlight, the LINQ to XML can be used to create the XAML presenting way. LINQ to XML is a XML memory programming interface which starts using of LINQ. Through the LINQ to XML way, we can go deep to the inner part of the strokes collection object, and use the stokes' inquiring results as the parameters of XElement's and XAttribute' s constructor to realize the XML tree expressing of strokes collections.

E. Supplying the recognizing service of a single symbol by the WCF way

The Windows® Communication Foundation (WCF) service supplies the system's recognizing functions. To a distributed application program, its transmission of the message is based on the rule of data exchange made in advance. The rule is the basis on which both sides for data exchange (like the server and the client) can understand each other. In WCF, the rule made in advance is called the Contact. Our system uses two of the rules. ① Service Contract,②Data Contract. In the system, the result of the recognizing includes not only the 'int' type's symbols(Unicode) itself but also the Rectangle type' s Bounding Box of characters. We transmit these result data from the server to the client and analyze and use them. Except for the definitions already contracted, the communication ways between the client and the server and the address where the service is supplied should be assigned to realize the communication between the client and the server. These three things compose the Endpoint's parts respectively 1）Address 2) Binding 3) Contract. In the system, we use BasicHttpBinding to appoint http to transmit and the data form is text/xml, which are in accord with the basic web services norms.

For the recognition of a single mathematical symbol, we define it as RecognizeSymbol, a service contact. The process by which we realize the service at the server is as follows. The sequenced character collection gained at the customer end is created as the InkCollector object by the Ling to XML way. Then the stroke collection should be transmitted to the stroke collection of RecognizeSymbol's object in recognition engine. The recognition engine uses the Recognize way to recognize the stroke collection, makes a alternative character list as to the recognition result according to the matching probability, computes the bounding box for the strokes involved in the recognizing, and finally gives the result list of recognition back to the client.

F. The presentation of the recognition result and the MathML conversion

The presentation of the recognition result includes two aspects. One is the real-time presentation during the input process. The other is the MathML form display of mathematical symbol language converting after the input finishes.

After inputting an expression, we will convert the expression to the form presented by the mathematical symbol language MathML and then insert it into the web's HTML. MathML is based on XML, whose aim is to present, process and share the mathematical expressions on the web. After the phase when structure analysis is completed, a baseline tree confirmed by the users is produced representing the mathematical expression structure. Here we convert it into the MathML form according to the character model dictionary by the Ling TO XML way. During the process of traversing the structure tree, the symbol nodes obtained after the traversing are matched other nodes connected with them and then go on a corresponding conversion. Finally the expression will be displayed in the Internet Explorer.

IV. SUMMARY AND PROSPECT

The design of this paper realizes the online handwriting recognizing system of mathematical expression based on the net and Internet explorer. The experiment's result shows that this system can recognize the numbers, the letters, the symbols and embedded mathematical structures. In the future we will continue perfecting the system, enlarging the recognition range and improving the correctness. The figure 5 lists some mathematical expressions which are recognized by the current system:

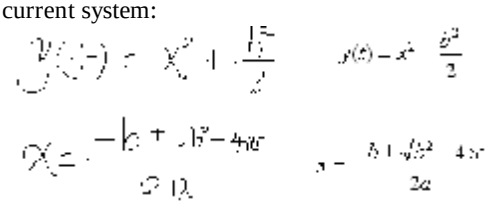

Figure 5 Recognition results

REFERENCES

[1] E. Tapia, etc.Recognition of On-Line Handwritten Mathematical Expressions in the E-Chalk System. In Proceedings of the Seventh International Conference on Document Analysis and Recognition, Aug,2003.

[2] Zhang Jian-cheng, etc.A Survey on Recognition of On-line Handwritten Mathematical Expression, Journal of Huaibei Coal Industry College, 2008

[3] Xiao Jian-yu, etc.Determine superscript and subscript relations in mathematical expressions based on fuzzy theory.Computer Engineering and Design.2008.

[4] Zanibbi,D Blosteing,J cordy.Recognizing mathematical expressions using tree transformation.IEEE Trans.on Pattern Analysis and Machine Intelligence,24(11),Nov 2002.

[5] Hong Liurong, etc.Recognition of Spatial Relationships between Symbols or Characters in Mathematical Expressions.Computer Engineering and Applications,2006

[6] Li Lina, Embedded System Status and Development, Journal of Changchun Industrial University,2004

[7] The Intelligent Transportation Society of America.http://www.itsa.org

[8] Wei Yongming, etc. Embedded software development and C language realize, Electronics Industry Press, 2008.

Qi Xiangwei Living in Urumqi, China, received his B.Sc. degree from Liaocheng University, study Master's degree at Xinjiang Normal University now; His major research interests include human-computer interaction and pattern recognition.