MEDINFO 2007
HISA Ltd Australia
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Developing a Digital Form Generation Systemfor Ubiquitous Computing Environments of EMR

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Abstract

Recently, several hospitals have changed their systems from legacy system using paper to electronic medical record (EMR) system for inpatient and outpatient. There are several obstacles to this change such as user resistance; expense of education, time spent due to entering data, and etc. So there is a significant need for easy and user-friendly data entry system using digital pen for collecting electronic medical record. Also flexible form for digital pen must be promptly created by clinical staffs. The purpose of this study is to develop the digital form generation system using digital pen to support outpatient treatment rapidly. So we implemented the digital form generation system which is consisting of digital form generator interface and digital pen data entry system. To evaluate the digital form generation system we developed prototype of EMR system and tested data processing procedure. We expect this system using digital pens can be the helpful and the easiest migration tool in successful adaptation of the EMR.

Keywords:

electronic data entry system, image, digital pen, electronic patient record, digitalized data

Introduction

The effort for computerization of the medical record has been accelerated rapidly in recent years. However, computerization of the medical record is the repetition of trial and error due to the complexity of medical record and the very nature of medical environment, which is different from computerization of other industry areas.

According to NCA (National Computerization Agency) CIO REPORT (June, 2006) of Korea National Information Society Agency, EMR system introduction rate of Korea is only 2.6%, and it is mainly conducted by giant-scale University hospitals. The main issue related to medical informatics of Korea is rigidity of hospital organization against change and expenditure [1].

Some hospitals have developed electronic data entry system and let their staffs enter data at the time of medical treatment. But the systems are used only for some limited departments. The reasons EMR systems of some hospital could not be used for the entire hospital are assessed as follows. First, it is not easy for the clinic staffs to input prescriptions and medical treatments after reviewing history and medical record. Time is the critical issue here. Second, most health care systems still use some combinations of electronic medical records and paper charts because some kinds of sheets are inefficient to become electronic data via keyboard entry system. Last, electronic medical record system does not have reliability, stability, enough scale, and fast response time to support outpatient treatment smoothly [2]. To overcome the rigidity of organization against change and to ensure the reliability, and fast response time to support outpatient treatment, EMR systems should be kept in electronic form with various input devices (i.e., Personal Digital Assistant, Digital Pen, Tablet PC, etc.). Recently, digital pen is used as one of the EMR data entry devices, and electronic medical data entry systems using digital pen are researched and developed in Europe and America [3].

According to recent researches, the digital pen is an easy, fast, and cost-effective tool, supporting rapid adaptation of EMR. At the Lineberger Comprehensive Cancer Center in USA, Elodia Cole and her fellows (2005) accomplished a comparative study to determine the speed, accuracy, ease of use, and user satisfaction of various electronic data entry platforms for use in the collection of mammography clinical trials data. Four electronic data entry platforms were tested: standalone personal digital assistant (PDA), Tablet PC, digitizer Tablet/PDA Hybrid (DTP Hybrid), and digital pen. Research shows that Tablet PC and digital pen were equally fast and easy-to-use data entry methods that were well tolerated by radiologist users. Handwriting recognition review and correction for the digital pen were significantly faster and more accurate than secondary manual keyboard and mouse data entry. Also, digital pen showed much(or significantly) lower expenditure of hardware cost and higher satisfaction than other devices [4].

Martin Schiavenato (2006) remarked on his review paper "Technology Brief: Digital Pen and Paper" about Digital pen and paper systems as an expedient and innovative way of adapting the familiar handwriting medium into the EMR. She thought the advantages of the digital pen and paper system are ease of use and small need for training. An example of Cherokee Indian Hospital case is cited. The

hospital reported savings in its insurance processing transactions using a digital pen and paper system on a per form basis from $2.00 to $0.50[5]. Martin Schiavenato recognized the digital pen and paper as a potential and promising element in the evolving pursuit of the application of technology in healthcare. And she came to the conclusion that this system can transform the familiar process of pen and forms into an expedient and effective way to document and process clinical, research, and financial/ administrative data [6]. Bethesda Emergency Associates (2006) implemented the BARTCHARTS ™, a comprehensive, paper-based template charting system using digital pen. This new system provided emergency department physicians the power of electronic documentation with the ease of paper and pen. On the other hand, Robert R. Rothstein, MD, Medical Director of BEA(Bethesda Emergency Associates in the United States of America) explained the efficiency and ease of use as following statement: "None have been as easy to use or actually have improved my efficiency like this. Within 5 minutes of sitting down with the digital pen solution for eBC I was documenting 100% of my charts." [7].

Still now, Cherokee Indian Hospital (USA), Hôpitaux Universitaires de Genève (HUG, Swiss), Royal Ottawa Healthcare Group (Canada), etc have used digital pen for the effective and easy adapting method into EMR [8-9].

In Korea, some hospitals adopted the digital pen systems from the beginning of the EMR system design, especially for reducing resistance for EMR systems, effective recoding of the physical assessment data, and for the completion of the consent [10]. The extension of adaptation area was asked by many users for several times during two years. But it takes approximately one month for collecting proposals, implementing and printing new forms. And sometimes forms for digital pen system (the following of paper - digital form) are changed for some reasons, so printed digital forms became useless. Prompt digital form generation in hospital by user and time saving for developing and printing to add new forms at existing digital pen system are requested.

So, I suggest a digital form generation system which enables clinical staffs to use digital pen and digital form at ubiquitous computing environment of EMR system. Through this system the digital form can be promptly created and printed by clinical staff.

Methods

1.Anoto functionality

Anoto functionality is technology related to digital pen and paper, which is supported by Anoto AB in Sweden. This technology allows man to continue using pen and paper to capture information and digitalize the data. This technology, entailing interpretation and transmission of handwritten texts and images, is based on a special digital pen and a paper printed with a pattern that is invisible to the eyes. The pattern consists of small dots (100 μm in diameter) arranged with a spacing of approximately 0.3 mm on a square grid. The dots are slightly displaced from the grid, each dot in one of four possible positions. It is the pattern that makes it possible for the pen to know what is written and where it is written. Each dot carries two bits of information and since the pen registers positions by reading an area of 6 x 6 dots (which can have 46 x 6 = 436 = 272 unique combinations) unique pattern is ensured on a very large area. The displacement of the dots makes it possible to uniquely identify each pattern area [11]. In this study, Anoto Functionality is used for entire system construction.

2. System Configuration

Logitech® io™2 pen was used as digital pen, and Anoto Functionality(software development toolkit, form development toolkit, pattern license) of Anoto AB is used for developing digital pen data entry system and postscript file for printing. AFPL Ghostscript 8.54 and GSview are employed to print PS (Postscript) file.

C#.NET was used for software language. Visual studio 2003 was used as a language tool. Operation environment was the Windows XP with Microsoft.NET Framework version 1.1. Microsoft.NET Framework essentially was installed first in order to install Logitech® io™2 pen. Microsoft SQL database was used for saving the vector and result value, which is recognized and converted via recognition process.

3. System development

First of all, we mapped out a scenario for hospital setting (Figure 1). We designed digital form generator to load the existing clinical documents (ex. Hangeul (Korean editor), PowerPoint, Excel, Word file). After the existing document file loaded, user can set the user-area for saving the pen-data

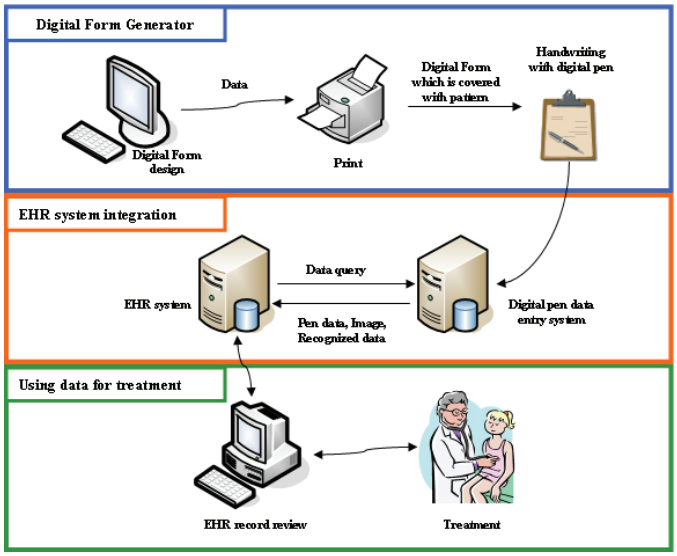

Figure 1 - System scenario

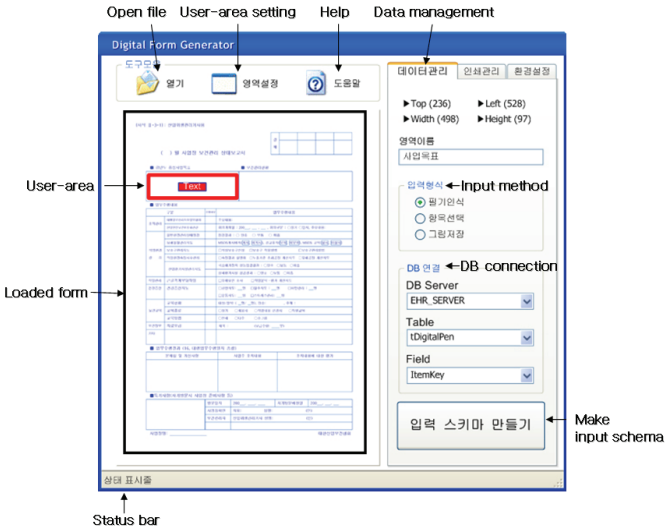

Figure 2 - User-area setting in Digital form generator

After user-area setting via digital form generator interface, digital form, which is covered with patterns would be printed out. Then the user can write treatment result or physical assessment data on the digital form freely. When the user put the digital pen into the cradle, which is connected to local PC by USB cable, the data synchronizing would be aroused and pen data would be converted into images, recognizing data and saving these in EHR system server. These data could be reviewed and used as treatment data or research data. On the base of this scenario, we planned to develop the digital form generation system, which is consisting of digital form generator interface and digital pen data entry system. To evaluate the digital form generation system, we developed prototype of EMR system and tested data processing procedure.

Results

1. Digital form generator

The user can load the existing form and easily set the user-area with dragging red box and can view the area size and position information via right side bar. The data management tab provides three ways for setting the input method (Handwriting recognized data, check box data, image) for each user-area. Database connection part shows the database server, table, field name of EMR server. As the making input schema button pressed, PAD file including user-area information and INI file for database information is generated (Figure 2).

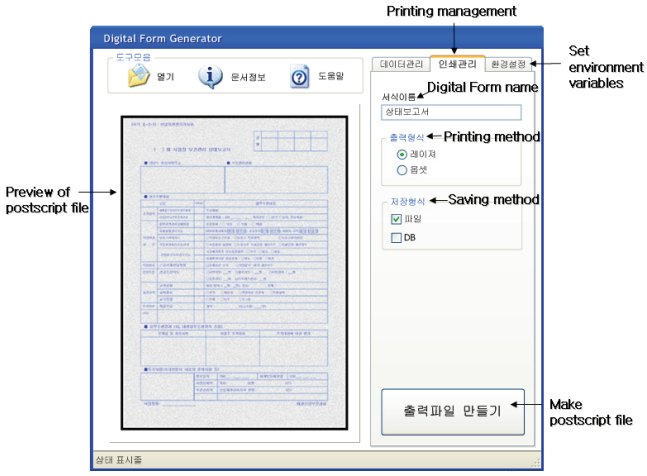

Figure 3 - Make postscript file in form generator

At the printing management tab, user can select the printing method. When user wants to print at the local or network printer, laser option could be selected. But when user wants to print a large amount of digital form at once, offset option should be selected (Figure 3).

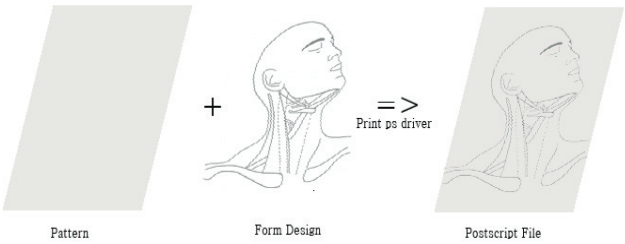

Figure 4 - Postscript output

When making postscript file button pressed, the existing form and Anoto pattern are merged and a postscript file is created for printing using postscript printer driver (Figure 4).

As the result of digital form generator, PAD file, INI file, and postscript file are generated. The digital form is printed by using postscript file.

2. Digital pen data entry system

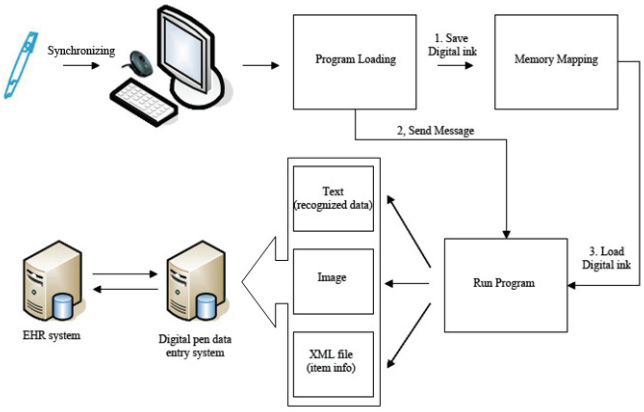

Figure 5 – Data digitalizing process

EHR system integration part of scenario can be explained as data digitalizing process perspectives. After the user handwrite on the digital form and put the pen into the cradle, the new instance of digital pen data entry system is loaded. The instance reads digital ink using address of memory map, which is transmitted to windows message. The application handles the pen data for various formats (handwritten recognized data, check box data, and image) according to input schema. After data handling is completed, the event message is transmitted to EHR system. Then EHR system reads the saved data from digital pen data entry system.

We implemented the digital form generation system, which enables user to generate digital form easily, and print whenever it is needed. This system converts handwriting data to digital data automatically, and put these into EMR database at once.

At first, we developed the digital pen generator in order to print digital form. Digital form generator interface is developed to allocate the user-area for recognition and to save data into database.

Secondly, digital pen data entry system is developed. When user uses digital form with digital pen, digital pen data entry system enables handwriting data saved as a recognized text data, image into database automatically. After handwriting and putting the digital pen in the cradle, pen data are transmitted to PC as vector format.

Conclusion

The digital form generator is an independent solution from EMR system. So when it adapted to other EMR system, less initial expenditure and more rapid adaptation are expected. Especially, in cases of questionnaire of patient symptom, consent, physical patient assessment using background image, this system would be very useful for digitalizing the patient records. The immediate use of the collected patient survey data for the patient treatment would be available. User satisfaction for EMR system would increase when this system is embedded to EMR system, because the user can create and print digital form when it is needed. Also, economic migration toward EMR system would be achieved because the repository is not necessary, and there is no need to buy another special printing system. If the printer dpi is over 1500dpi, any printer can be used. The clinic staff, even the ones, who are not familiar with a computer, would accept the collecting the electronic health record as easy and fast task. We have a plan to integrate this system with real EMR systems. We hope this system to contribute rapidly and smoothly to support medical treatment and to computerize the medical data with low cost.

Acknowledgments

* This study was supported by a grant of the Korea Health 21 R&D Project, Ministry of Health & Welfare, Republic of Korea (code: A040032)

* This study was supported by a grant of the Korea Health 21 R&D Project, Ministry of Health & Welfare, Republic of Korea (code:A060677)

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