Watermark Embedder and Image Authenticator

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Title: *Watermark Embedder and Image Authenticator(WEIA)*

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ABSTRACT

This research paper discusses the development of a watermark embedder and image authenticator (WEIA) to ensure the authenticity and integrity of medical images. WEIA is also able to send and receive medical images within a peer-to-peer network. Experiments also shows that WEIA successfully embeds chosen watermarking scheme and able to detect tampering and recovers tampered image.

Keywords-component; watermark; authenticate; reversible; medical images.

I. INTRODUCTION

Digital image watermark technology can be used to protect digital content such as medical images. It can be used to detect unauthorized modifications of the content of a medical image.

Some researches related to watermarking scheme had been done, for example, reversible tamper detection and recovery watermarking scheme by Liew and Jasni [1]. Guo and Zhuang [2] proposed a reversible scheme with tamper localization based on difference expansion [3]. Zou et al. [4] proposed a semi-fragile reversible watermarking scheme based on integer wavelet transform. Tan, Ng, Poh, Guan and Sheah presents a fully reversible, dual-layer watermarking scheme in which tamper detection and localization was developed based on verifying cyclic redundancy check (CRC) in a block by block manner [5]. Dou, Poh and Guan have introduced an improved version that exploits the 3-D property of volumetric DICOM images [6].

However, there is no existing application with medical image watermarking scheme for the end users even though a set of requirements and design of watermark embedder and detector application for medical images had been established [7]. By using existing tools and library, a watermark embedder and detector application for medical images could be developed based on requirements and design concern. This application should provide a user friendly graphical user interface which could operate in Windows environment. It should able to handle the user input error and monitor performance for the embedding and authenticate process depends on the watermarking used.

In this paper, we propose an implementation of a watermarking scheme using a watermark embedder and image authenticator (WEIA). The design of the application is based on previous work [7] and the watermarking scheme used in this application is a tamper localization and lossless recovery scheme [8].

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II. BACKGROUND

A. JAVA

Java is a cross-platform programming language with object-oriented design. Java was first released by Sun Microsystems and currently in own by Oracle Corporation.

Java programming is similar to style of C++ programming language. Java programming language evolved from C++ programing language. A Java program consists of classes and a class consists of variables and methods. Task will be performed by the methods and information will be returned when a task is completed. There are a lots of existing pieces in Java class library, or also called as Java Application Programming Interfaces (APIs).

B. DICOM

DICOM (Digital Imaging and Communications in medicine) is a standard in medical imaging. DICOM consist of 18 independent parts, file format definitions, and network communication protocols. The communication protocol used by DICOM is TCP/IP (Transmission Communication Protocol/Internet Protocol), which allows systems with DICOM standard to communicate.

DICOM standard is widely used in the image generated by different modalities, such as digital x-ray and ultrasound images. DICOM image generated by modalities has information model consist of four levels, which are Patient, Study, Series and Image Level. Patient level is the top level, all the information of a patient is in this level. Study level stores information of a single examination request. Series level stores a collection of related images coming from a single modality. Image level stores positioning and acquisition information of image.

C. Peer-to-Peer

Peer-to-Peer is a communication principle for distributed data. A peer-to-peer network enable the application among the network can become either a client or server.

Peer-to-Peer allows the resources sharing among the computers in peer-to-peer network without any centralized server. A traditional client-server model is sending resources by server and client site is only receiving resources. In peer-to-peer model, a computer can act as both supplier and consumer of resources.

III.SYSTEM DESIGN AND ARCHITECTURE

A. Architecture

A design of watermark embedder and detector application for medical image is proposed by using existing tools. The design is a Java standalone desktop application that is able to communicate with PACS (Picture Archiving and

Communication System) using DICOM standard. The application is able to watermark medical image before sending it to a PACS server. The application can also reside at the PACS server to authenticate the received medical images.

A different design is developed based on the concept proposed [7]. The new design is a peer-to-peer WEIA for medical images. Previous architecture design was a centralized server-based service model, where all Java applications communicate with the PACS server, for example sending DICOM file and receiving DICOM file. For the design of a peer-to-peer WEIA, it is a system of nodes without central infrastructure. The application is able to send DICOM file to another application without server site. Figure 1 shows the scenario of peer-to-peer system.

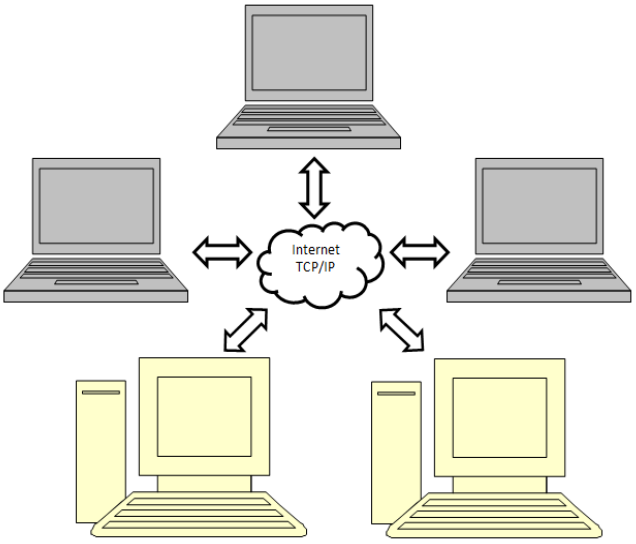

Figure. 1 The scenario of a peer-to-peer system.

B. Components

WEIA consists of few components as below and the operation model is shown in Figure 2.

- Application: The top of the Java application, with graphical user interface.
- Library: Consisting of open source library and library generated by Matlab Builder JA.
- MATLAB Compiler Runtime (MCR): A standalone set of shared libraries, execute MATLAB component without install MATLAB in computer.

IV. DEVELOPMENT

The development of this application is done using NetBeans Integrated Development Environment (IDE). Graphical user interface is created by using palette tool in the NetBeans IDE. Figure 3 shows the design of the graphical user interface for the application.

The application is divided into four parts, which are watermark, authenticate, send, and receive. Each part of the application is divided using tab panels.

Medical images can be sent using DICOM standard through the application. Before sending the DICOM file, user need to input receiver IP address and port number use by receiver for listening in TCP/IP.

To receive a DICOM image through the application, a receiver must enter an available port number and start a socket for listening. DICOM file will be automatically received when WEIA starts listening to the TCP/IP port.

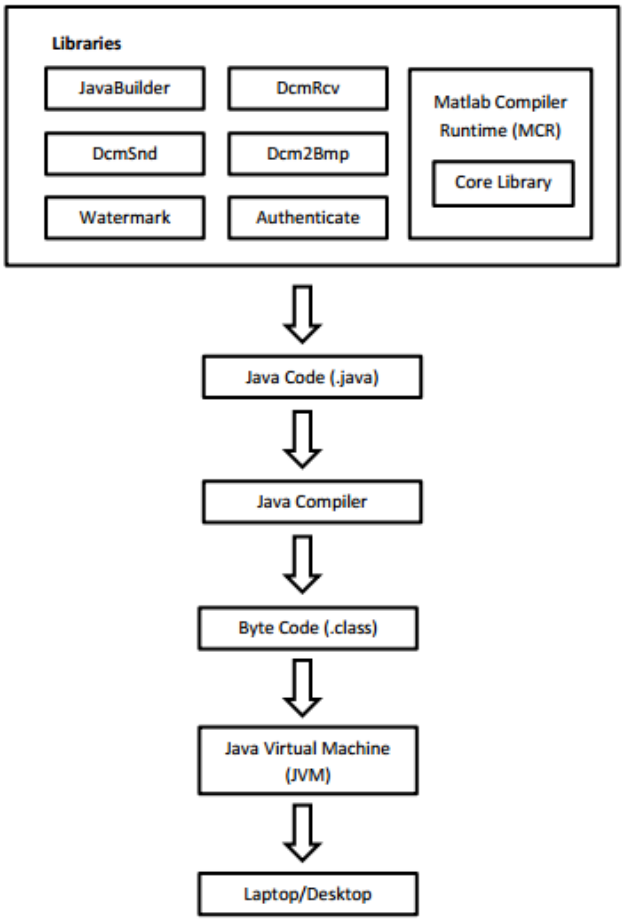

Figure. 2 The application operation model.

In the development phase, Java third party library is imported. The usage of third-party Java library is to support the DICOM standard and Matlab components. For DICOM standard, library from DCM4CHE2 is used. DCM4CHE2 is an open

source implementation of DICOM standard. Some modification of source code is required for Java graphical user interface application compatibility issues.

The imported third-party libraries are also used to support the Matlab components. Libraries used are generated by Matlab Builder JA, including the watermarking scheme. Besides that, a library for conversion between DICOM file and bitmap file had been developed using Matlab Builder JA. The purpose of the development of the library is for displaying DICOM images in the Java application. Table I shows the libraries provided by DCM4CHE2 and Table II shows the libraries generated by Matlab Builder JA.

TABLE I. DCM4CHE2 LIBRARY AND USAGE

Dcm4Che2 library	Usage
DcmSnd.jar	To send DICOM object to a SCP (Storage Service Class Provider)
DcmRcv.jar	Run DICOM listening port and store received DICOM file to specified directory

TABLE II . LIBRARY GENERATED BY MATLAB BUILDER JA AND USAGE

Matlab Builder JA	Usage
Javabuilder	A Matlab toolbox.
Watermark	Watermark DICOM file.
Authenticate	Detect and recover watermarked DICOM file.
Dcm2Bmp	Convert DICOM file to Bitmap file.

V. TAMPER LOCALIZATION AND LOSSLESS RECOVERY

To archive a better user experience in WEIA, an enhancement in the interface was done. Tamper localization and lossless recovery (TALLOR), which is a watermarking scheme proposed by Liew et. al [8] had been chosen for the purpose of enhancement. TALLOR is able to perform exact recovery of the tampered image.

The previous watermark function has predefined a watermarking area, and it didn't provide an option for user to select the watermark area. As an enhancement in WEIA, user is able to select the watermarking area by dragging the mouse pointer. It makes the watermarking area selection become more flexible (as demonstrated in Fig 4). Four ultrasound images had been used for the experiment. By default, the unavailable area for watermarking is shown in red color, and watermarking area selected by the user is shown in green color. System will detect if the area selected by the user is more than the allowed size determined by the algorithm.

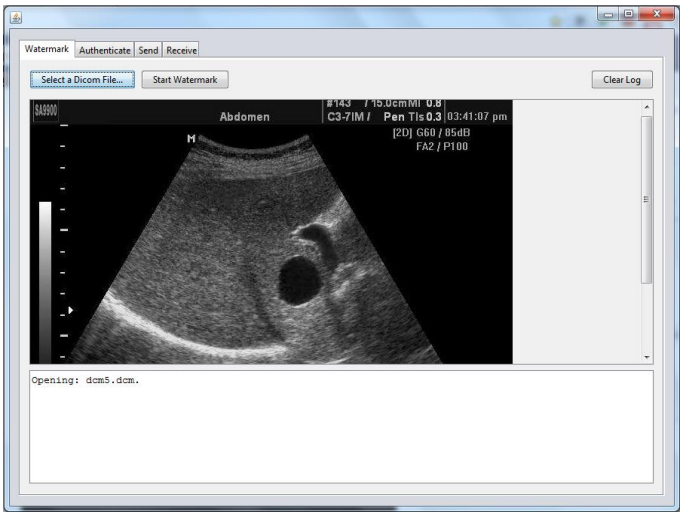

Figure. 3 Sample graphical user interface of WEIA.

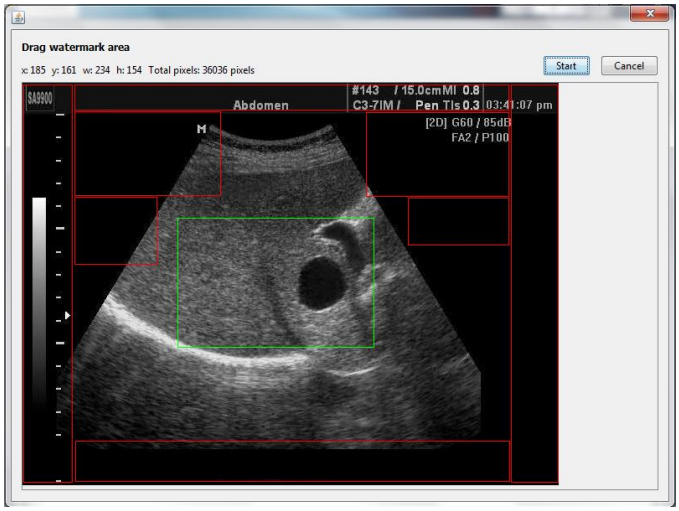

Figure. 4 Sample graphical user interface of watermarking function in WEIA.

VI. RESULTS

Our experiments had achieved all of the following functions using WEIA:

a) Watermark a DICOM file.
b) Detect and recover a watermarked DICOM file.
c) Send DICOM file using DICOM standard.
d) Receive DICOM file using DICOM standard.

Figure 5 shows a watermarked DICOM image of Sample 1 and followed by Figure 6, which is a tampered watermarked image of Sample 1. Figure 7 shows the exact recovery of tampered image using TALLOR. Table III shows the experiment results for all samples. The watermarked images show a high PSNR value which is identical with previous work [8]. All tampered samples were recovered successfully.

TABLE III. THE EXPERIMENT RESULTS FOR ALL SAMPLES USING TALLOR

Figure	**PSNR**
Sample 1	48.1
Sample 2	48.0
Sample 3	48.9
Sample 4	47.9

Figure. 5. Watermarked DICOM image of Sample 1 by the application.

Fig. 6. Tampered DICOM image of Sample 1 watermarked by the application.

Figure. 7. Exact recovery of tampered DICOM image of Sample 1 using TALLOR.

VII. CONCLUSION

WEIA for medical image is done by combining of existing library and watermarking scheme. This application is suitable for both server and client site since this application is uses peer-to-peer for file transmission. Automation functions for watermark and authenticate DICOM image can be done in future. Multiple watermarking schemes can be added into WEIA, in order to resolve the compatibility issue with different types of DICOM image.

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