Conversion of JPG Image into DICOM Image Format
with One Click Tagging

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Abstract.

DICOM images are the centerpiece of radiological imaging. They contain a lot of metadata information about the patient, procedure, sequence of images, device and location. To modify, annotate or simply anonymize images for distribution, we often need to convert DICOM images to another format like jpeg since there are a number of image manipulation tools available for jpeg images compared to DICOM. As part of a research at our institution to customize radiology images to assess cognitive ability of multiple user groups, we created an open-source tool called Jpg2DicomTags, which is able to extract DICOM metadata tags, convert images to lossless jpg that can be manipulated and subsequently reconvert jpg images to DICOM by adding back the metadata tags. This tool provides a simple, easy to use user-interface for a tedious manual task that providers, researchers and patients might often need to do.

Keywords: Medical Informatics, Radiology Informatics, DICOM, Image manipulation

1   Introduction

A lot of research has been conducted on radiological reporting to determine how patients can be actively involved in their own healthcare delivery [1]. This includes improving patient understanding of the need for certain procedures, understanding own disease/condition, improving communication with clinicians and family members as well as improving participation in treatment. Recommendation from these studies have called for focus on patient education, and ways to improve patient's understanding of their radiological images [2] [6]. Moreover, it is imperative that radiological reporting moves from being radiologist-centric to being patient-centric through better use of patient's capabilities and establishing better fit with the cognitive abilities of the patients [3].

1.1   Background

Over the years, radiology informatics efforts have focused on improving imaging based on the cognitive abilities of the radiologist [6]. However, more recently there has

been clamoring for patients to be more actively involved in their healthcare, which begs the question - how do we represent images and radiology reports for consumption by patients? [5]. Thus, tools, image viewers and reporting verbiage need to be adapted for consumption by patients. Some researchers have developed methods, primarily in the patient portal space, but most have only provided high-level concepts without creating tools that implement those concepts into practice [4]. The aim of our study and the developed tool that we report in this paper is to support the ways in which radiology images can be fit with the cognitive abilities of patients, regardless of their level of education, socio-economic background and medical literacy.

1.2   Purpose

The metadata in Digital Imaging and Communications in Medicine (DICOM) images contains information about patient identification, imaging equipment, health facility, provider and procedure performed. Moreover, DICOM stores the sequential order in which the images were captured and this information is used by image viewers for image display. If these images are transformed in anyway, it is important to preserve the metadata information, in order to protect the integrity of the radiology images to support accurate clinical diagnosis disease under study. DICOM metadata is standardized and well adopted with a number of viewers that can understand the embedded XML tags from DICOM images. One of the goals of our research is to maintain the metadata information in the images during interconversion between DICOM and JPG, as this would let us keep all the metadata information that is embedded in the DICOM image.

2   Related Work

One of the research conducted to solve a problem usually encountered in radiology reporting was based on patient education [4]. The authors developed a portal system to extract salient findings from reports and place them where patients can read. However, the authors focused a little less on the level of education of the consumers and also the simplicity of the reports to the barest minimum. We decided to build on this to present information on the images that can be easily assessable to the consumers.

Ujare and Baviskar performed research to convert DICOM images to other formats which are usually smaller in size [1]. The authors designed and developed a framework to extract patient information from a DICOM image and save it in a separate text file. The authors were more concerned about size reduction for ease of transfer rather than metadata preservation, which is relevant for batch processing. So, we extended the concept of information extraction to metadata reintegration into the images, after we edited images in a way that enhanced a user's understanding of the images presented to them.

3 Method

3.1 Problems and Challenges

As part of our research on 'Customizing Radiology Images to Improve Patient-Provider-Radiologist Communication' (Imaging 3.0), we labeled and colored certain parts of the radiology images (See Fig. 1.) that are important to make observations related to the patient problem. Our study site is at a large tertiary hospital in central Indiana with over million outpatient visits each year, with many patients coming from low and middle income groups. This site was appropriate for our study, since it has patients with low medical literacy, but also has highly trained staff like nurses, physicians and radiologists from one of the largest medical schools in the US. As part of the study, we needed to customize images that fit the cognitive abilities of the three selected user groups – patients, referring physicians and radiologists. These three user groups were interviewed using a cognitive fit theory based semi-structured interview guide. To conduct the interviews and capture the effects of customized images on the user group's interpretation of the images, we needed a tool that will allow easy manipulation of radiology images. For the tool, our approach was to export the DICOM images from the Picture Archiving and Communication System (PACS), convert them into JPG format, then label/color the images either manually or automatically using image processing software and convert it back to DICOM images. These manipulated images can then be viewed in any DICOM viewer used by radiologists, physicians or patients.
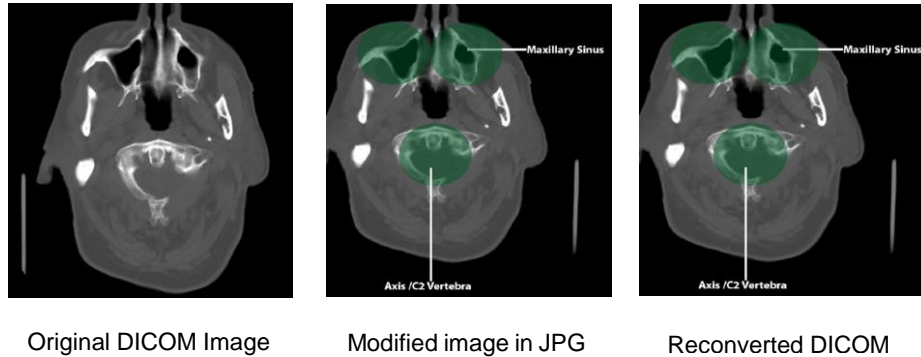

Original DICOM Image   Modified image in JPG   Reconverted DICOM

Fig. 1. The CT Head were edited and was uploaded as a DICOM image in a DICOM viewer.

Although, we currently have applications that perform similar tasks, such as J2D, the limitation of such applications is that, when used to convert DICOM to JPG, the images lose metadata information like seriesID, instanceID, patient demographics etc. Therefore, these converted images do not appear in correct series or order. Many converters do not always maintain the same fidelity or image encoding as the original image in the DICOM format. The DICOM standard part 3.5 2016e Data Structures and Encoding specifies the encoding of pixel, overlay and waveform data. Section 8.2 of part 3.5 also defines Native or Encapsulated Format Encoding, such as JPEG image compression, RLE compression, JPEG-LS image compression, JPEG 2000 image compression,

MPEG2, MPEG-4 AVC/H.264 video compression and lately even HEVC/H.265 video compression. The actual quality of the radiology image/video depends on this encapsulated format. Most conversion tools support only a single encapsulation format, most often with a lossy compression format. With the lack of a good converter, we developed a simple, yet novel DICOM image converter.

3.2 Solution to the problem

We developed a Java SE application called Jpg2DicomTags, which facilitates conversion of DICOM to JPG and back to DICOM while retaining the metadata of the original DICOM image. The converted files are saved in the same folder as that of the JPG and can be viewed as a series of a single study in a DICOM viewer. We use the batch processing technique for selecting all original and modified images, and copying the tags back to the modified DICOM. Apart from this, it also provides the feature of converting a file from any valid encapsulation format to DICOM file format. The application does not require prior training, since it is a single screen interface (See Fig. 3.), can be integrated with any Radiology Information System (RIS) or Electronic Health Record (EHR) system and works with all known DICOM – little endian or big endian file formats. We tested the converted DICOM images with Orthanc, dcm4chee, RadiANT, Horos, Osirix and MicroDicom viewers and PACS servers. We also tested the converted images to be accessed using Web Access to DICOM Objects (WADO) specification on browsers including on tablet and mobile devices. Our primary interface for the multi-user group interviews was on a tablet computer and a DICOM viewer, streaming images from a PACS server over WADO.

In order to have a near-accurate understanding of radiological images, we needed to enhance the images to aid participant's ability to interpret and be able to have a clear understanding of what is being shown to them. We started by exporting de-identified imaging studies from a proprietary PACS system at our research site. We then deployed the images creating fake patients on a PACS system that supports WADO standard called Orthanc[7]. We needed to use the DICOM web plugin with Orthanc to support our use-case. We selected different modalities of radiology images to ensure that our study covered a wide range of procedures. We selected 5 Magnetic Resonance Imaging (MRI) studies (Lumber spine – AX T1 TSE, T2 TSE, SAG STIR, SAG T1 TSE and SAG T2 TSE) with about 12 images in each study and 2 Computed Tomography (CT) – HEAD BONE and HEAD WO, one CHEST X-ray and one Ultrasound USG of the abdomen.

These images of the sample procedures used were still in DICOM format and the metadata tags were still intact. This is expected to support the associated batch processing activities used to guide participant's understanding of the study regardless of their level of education.

Following the selection of the samples, we needed to convert the DICOM images to plain jpeg, so that the image can be easily edited using automated or manual image

processing software applications. To measure any visible change in the participants' cognitive abilities for our study, we needed to edit images. The correct ordering of the images from a study to show the progression of the affected parts of the body is important to convey meaning and make accurate medical interpretation of a radiology study. This is the main reason why the metadata tags have to be retained when we modified the images. However, retaining the tags during image-conversion was a major challenge. Although jpeg images also have metadata, since we could not find an application that currently performs that task, we had to go through a long process which resulted in the development of Jpg2DicomTags application.

3.3   Image Conversion Process

Jpg2DicomTags is able to recognize the encapsulated encoding of the image and extract the image data into JPEG 2000 lossless format. This extraction process helps keep the fidelity of the image after the image has been enhanced or edited using commonly available image processing software. We initially used MicroDicom, a DICOM viewer with an image-conversion capability to convert the images from DICOM to a JPEG format. We then modified the JPEG images using Adobe Photoshop.

3.4   Image Enhancement Process

Participants of the Cognitive-Fit study vary based on familiarity with clinical images, so we needed to enhance the images to be easily understood by anyone regardless of their level of education. Enhancing the images was also done to measure the improvement on the participants' cognitive ability by asking relevant questions. These questions were asked intermittently after the original and the enhanced images were shown to the participants.
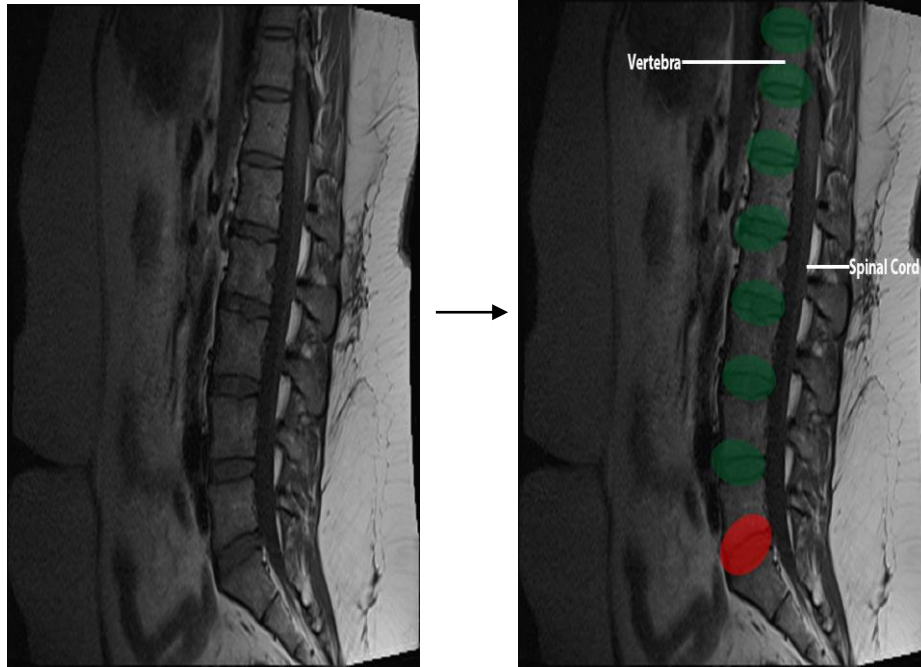
Fig. 2. Enhanced JPEG image Prepared in Photoshop

The next phase was the labeling and highlighting process using Adobe Photoshop. We started by labelling the images to show the affected part of the body it came from. We also used color-coding method to distinguish between the area on the image that was affected from the area that clinically unaffected. These steps were conducted on every image of the selected study procedures that we used for the research, while we maintained the serial identification assigned when the images were converted to JPEG. In the later phases of the study, we are automating the manual process by referring to the radiology report that has been interpreted by a radiology. We are using natural language processing and machine learning techniques to locate areas of interest that need to be labelled and colored automatically.

3.5 Development of Jpg2DicomTags Application

Following the completion of the image-enhancing process, we needed to convert the images back to DICOM format which would enable us to reintegrate the metadata into the images. DICOM viewers with conversion capabilities such as MicroDicom, and some other applications such as J2D were initially considered for this task. However, these applications were limited in their functionalities and could not retain the metadata information of the original DICOM images.

Jpg2DicomTags is licensed under the Apache License v2 because we believe that such a tool should be widely available for integration with viewers and PACS systems. The application was developed to support one-click tagging of a whole study during the conversion stage. The basic functionality of the application is to convert a JPEG format back to a DICOM format with the original tags added to the modified images in a study.

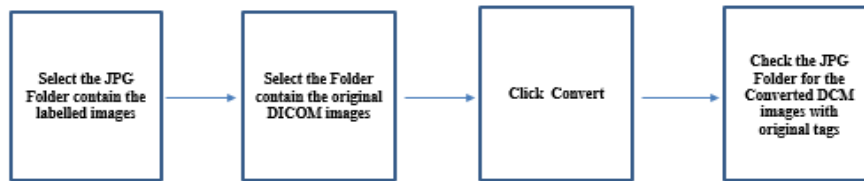### 3.6　JPEG Format to DICOM Format Conversion Process

Fig. 3. Conversion of Labelled JPG to DICOM with Original Tags.

We used the application to perform the conversion process and it took us just about four steps to complete:

1. The application was initiated to reveal a user interface with options of choosing the folders containing both the modified study in .JPG format and the original. DCM format.
2. We selected the first option to locate the folder containing the newly-modified study.
3. We also selected the second option to locate the directory of the folder containing the original DICOM folder.
4. We converted the images by clicking the 'Convert' button on the interface of the application.

After the action was completed, the modified images in DICOM format was saved automatically in the same folder as the JPEG folder. These newly saved DICOM images inherited the tags from the original DICOM study which allowed the study to be well arranged so as for the consumers to view it in the correct order and also for other DICOM compatible application to read it in the correct order.
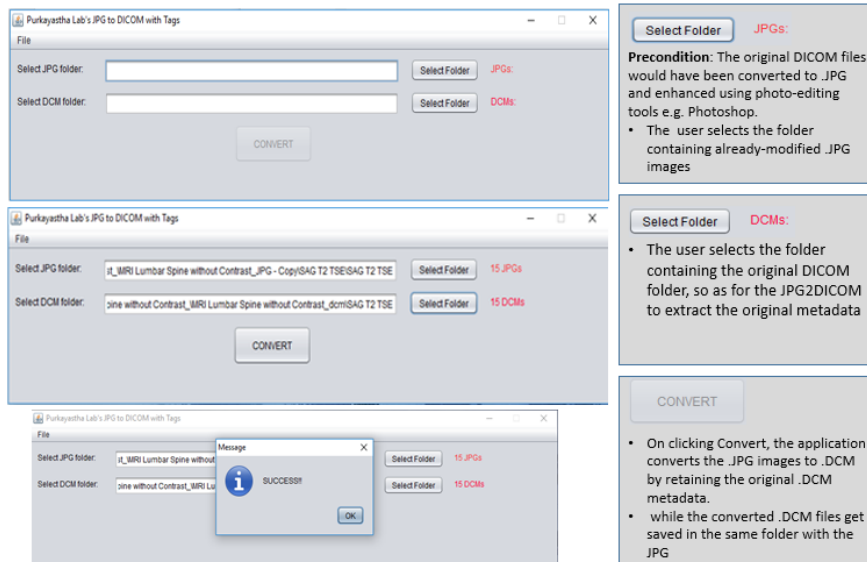
Fig. 4. Jpg2DicomTags Conversion Process

3.7 Comparative Analysis of the tools

The following table shows the advantages that Jpg2DicomTags has over other tools.

Features	Comparative Analysis of the Tools			
	RadiANT	**J2D**	**MicroDicom**	**Jpg2DicomTags**
Two-way Conversion	✓	✓	✓	✓
Converts DICOM to. dcm	`		✓	✓
Retains Resolution			✓	✓
One-Click Tagging				✓
No Brand Customization				✓

Table 1. – Comparison of different features in jpg and DICOM conversion tools

Two-way Conversion: Tool converts from JPG to DICOM and DICOM to JPG. There are some tools that can only convert one-way, which results in loss of metadata information.

DICOM to .dcm: Allows the tool to convert DICOM files without .dcm file extension for easy recognition by other viewers. Jpg2DicomTags can rename files, as well as encapsulate valid formats with DICOM metadata.

One-Click Tagging: allows tagging of a series of instances into a single study in one click.

Brand Customization: Many other tools produce a watermark of the name of application on the images. This is either on the image data itself or in the metadata, most often replacing the metadata device information such as from MRI machines. Jpg2Dicom-Tags does not change any metadata information, but simply copies the tags from the original DICOM image to the converted DICOM image.

4   Findings

Jpg2DicomTags application was used to convert the modified images back to DICOM with the original tags added to it. We have converted all the exported images using the Jpg2DicomTags application , and used the modified images in over 30 interviews with patients, referring physicians and radiologists using a tablet computer. The radiologists who often rate the fidelity of the images did not notice any quality differences between the original and the converted images. Our tests using image processing toolkits confirmed that there was no loss of data in the conversion process, with 100% pixel-to-pixel match between all the 112 images that were part of the four modalities that were used. Jpg2Dicom is able to successfully meet the main objective of being able to accurately convert the .jpg image to .dcm files. The application also injects the metadata of the original .dcm into the modified .jpg in the process. Our unit tests verified that there was 100% match in all the DICOM tags and metadata information between the 112 original and converted images. The performance of the application was excellent. The conversion process for all the 112 images took less than 2 seconds on a 2.0 Ghz Intel i3, 4GB RAM desktop computer. The binary size of the application is under 3Kb and only requires the Java Runtime Environment (JRE) v6 and higher. We also observed the application can handle as many images in a batch as possible. The criteria for the batch processing to begin is that, the count of the original DICOM images must coincide with the modified .jpg images.

Furthermore, it was observed that resolution of the images remains the same during the conversion from one format to the other. Most of the other applications capable of converting to or from DICOM format usually reduce the quality of the images in the process. However, Jpg2DicomTags retains the original quality and also leaves the images plain without any unwanted customization.

The converted images were tested with Orthanc, dcm4chee, RadiANT, Horos, Osirix and Microdicom viewers and PACS servers to examine any deviation from the original DICOM images. Our experience is that the tool works perfectly as expected. Therefore, it can be concluded that images converted with Jpg2DicomTags will be compatible with most viewers and PACS servers. The accuracy of the application is an important feature to be exploited in both research-based and clinical-based settings.

5 Discussion

Jpg2DicomTags was deliberately created as a single, one-click application so that it can be integrated with other tools such as DICOM viewers and PACS systems. In the process of developing this application, we realized that there is clearly a dearth of usable tools that can convert DICOM images in a simple and useful way. There are a number of DICOM manipulation software libraries, APIs and even software as a service (SaaS). Yet, most of these do not have a usable application that can be integrated easily with existing systems in the regular workflow of users. We also chose to develop the software application in Java, so that it was platform-independent and could be used on multiple platforms.

Jpg2DicomTags also has a few limitations. Firstly, it cannot work with video encapsulation formats such mpeg, which are also used in radiology. Since our modalities and use-case focused on the most common type of radiology modalities, we only work with images. Similarly, the tool is not able to process 3D images or audio that is used by the DICOM format. Secondly, the tool cannot use streaming data to convert data on the fly. It is designed to work in batch processing mode, primarily because our use-case was meant to work with batch data. Besides some rare edge cases, we don't see the need for a tool that does conversion and manipulation of the images to be able to perform conversion using streaming data source.

5.1 Contributions to Human Computer Interaction

This research serves as a template on which consumers' cognitive abilities can be examined to determine their preferences for radiology images. The process of preserving the metadata of DICOM images is a cog in a wheel of automated radiological reporting, which may be the next generation of reporting using more complex concept such as machine learning and analytics to determine patient's preferences and present images to patient's that can be easily understood.

6 Conclusion and Future Work

6.1 Future opportunity of the tool:

In future, we will integrate the editing features such as labeling, overview on hovering on sections of the images and also coloring in the same viewer/editor while retaining the metadata during the process of conversion. We will release the tool as a plugin that can be integrated with multiple DICOM viewers and we hope that further research can be conducted in this field by anyone who is interested in improving radiology reporting procedures.

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