

# MaRRS: A Software System for Generating Multimedia Radiology Reports using Adobe Acrobat

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**Abstract.** Despite the proliferation of mature multimedia software technologies, radiology reports continue to lack image content and structure that would improve the ability of referring clinicians to fully interpret and analyze radiological findings. This paper introduces an intuitive and interactive radiology report authoring system that provides enhanced visual multimedia capabilities, structured content, and reduced report production time, using a well-known PDF program, Adobe Acrobat. The system, which we call the Multimedia Radiology Report System (MaRRS), allows radiologists to quickly and simply create and deliver effective interactive multimedia medical reports.

**Keywords:** multimedia, interaction, medical imaging, radiology report.

## I. INTRODUCTION

The radiology report is essentially the sole measure by which referring clinicians judge a radiologist's diagnostic ability. Yet despite this importance, most reports still consist primarily of a large amount of unstructured text and lack clear, concise, consistent content-rich information [13]. This outmoded format makes it very difficult for the clinicians to interpret and analyze the document [9]. Furthermore, with the development of new, existing, and hybrid imaging modalities, new approaches to processing and reporting are needed that convey the key information in this visual data. Radiologists must be able to quickly and simply generate a secure, shareable, standardized report [2][3][7]. Furthermore, radiologists should be able to directly embed two-dimensional (2D) and three-dimensional (3D) images, volume renderings, 3D data representations, and web hypertext links to address the problems of report timeliness, lack of content, and lack of structure [5][13][17].

Fortunately, the advent of new multimedia authoring programs and web-based technologies has created the potential to radically transform radiology reporting to meet these requirements. Mature, inexpensive software technologies now exist that provide the ability to generate a consistently structured, content-rich multimedia report that can be electronically signed and securely emailed to referring clinicians. Furthermore, these technologies also allow real-time discussions and synchronized viewing of documents over the internet.

In this paper, we present a software prototype called the Multimedia Radiology Report System (MaRRS). MaRRS was created to allow radiologists to simply and intuitively generate a content-rich report of a patient's medical results using the standard Adobe Systems Portable Document Format (PDF). MaRRS is designed as an integrated system, connecting any image visualization package<sup>1</sup> to the well-known PDF-authoring program Adobe Acrobat. This allows radiologists to retain the use of their preferred visualization software and generate a report in a standard, well-accepted document format. MaRRS allows for the creation of standardized, well structured, visually enhanced reports that can include both 2D and 3D images, video, audio, and even 3D geometrical models of anatomical structures. Such multimedia content can be immediately transferred with the click of a button from any visualization package to a PDF document and automatically displayed in an adjacent window on the computer screen. Furthermore, the PDF report can be viewed and interacted with using the standard, freely available Adobe Reader program.

MaRRS provides a software 'bridge' to Adobe Acrobat. In turn, Acrobat offers functionality for creating, viewing, and managing PDF files. More recent versions of Acrobat also provide extensive functionality for forms, multimedia content, hypertext links, password protection, permission settings, and real-time collaboration of PDFs with synchronized document views. While the idea of a multimedia report is not new, the mature and practical Acrobat technology provides the capability to create reports that are securely and reliably accessible by both radiologists and clinicians.

## II. RELATED WORK

For many years radiology reports have essentially consisted of typed or handwritten text [2][3][4]. With text only reports, accurate patient diagnosis was not always achieved. As time progressed, some radiologists used structured report templates classified as automated reporting systems which allowed them to input text under each corresponding heading [17]. *InfoRAD* [18] is an example of such a system designed to automatically structure medical information contained in a radiology report using a natural language processor. The medical

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<sup>1</sup> A small amount of custom software must be added to the visualization package in order to use MaRRS.

multimedia document described in [10] is another application that maintains structure for DICOM solutions. These systems had great potential for improving the structure and organization of radiology reports.

The goal of many radiology reporting applications has been to reduce the overall report production time for radiologists. Among the earliest examples of these applications were those that included speech recognition systems. *MedSpeak* [6] developed by IBM in 1996, was the first speech recognition solution enabling radiologists to dictate information pertaining to patient x-rays. More recently, a new system called *SpeechMagic* [15], developed by Philips, is recognized as among the most advanced speech recognition technology currently available and is widely used in healthcare.

Another radiology report system currently in use is known as *StructuRad ReportNow* [4][11]. Like *MedSpeak* and *SpeechMagic*, *ReportNow* was developed to decrease report production time as well as to promote its easy and flexible Microsoft Word-based interface. *SoftRad* [16] is also a Microsoft Word based system and provides custom reports, templates, and the inclusion of 2D images. *SoftRad* also provides digital dictation, integrated voice recognition, automatic document delivery, and electronic signatures. Finally, *VoxReports* [1] is a program designed as a speech-recognition workflow management system with the goal of faster and easier interpretation and delivery of reports. All these applications focus on minimizing report production time, improving the structure and management of reports, and providing automatic voice dictations for simple report generations. In the following section, we provide a detailed description of MaRRS, illustrating some of its unique features that have currently not been integrated by any other system.

### III. MaRRS

MaRRS is designed to enable radiologists to generate well-structured reports containing 2D and 3D images, 3D data models, textual descriptions, and/or audio descriptions. Recent versions of Acrobat incorporate Flash-based media handling, allowing the inclusion of videos in various formats which can be played in Adobe Reader. MaRRS allows radiologists to record a short video of a volume rendering and instantly send it to the PDF report. Acrobat also enables 3D model insertions which can then be rotated in 3D space, relit, and re-rendered.

MaRRS may be perceived as a “middleware” component, bridging the software gap between a medical image visualization package and Adobe Acrobat (Figure 1). The MaRRS middleware utilizes plug-ins to start-up and remotely control Acrobat. MaRRS also provides a well-defined interface to the image visualization package allowing it to employ the functionality of MaRRS. In turn, any multimedia component sent to the report is instantly visible within a new Acrobat window. In addition, rich annotation features provided by Acrobat may be used to label and highlight features anywhere within the document. Text may also be directly typed into the report to record diagnostic results observed by radiologists. Another option

is to input text naturally through voice dictations using a speech recognition system.

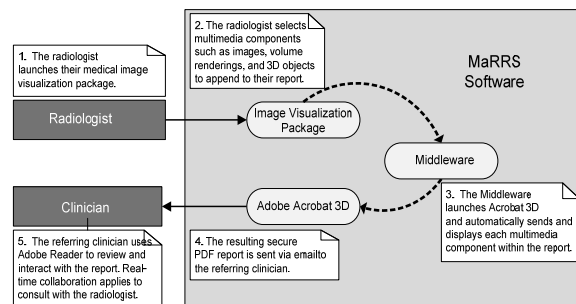


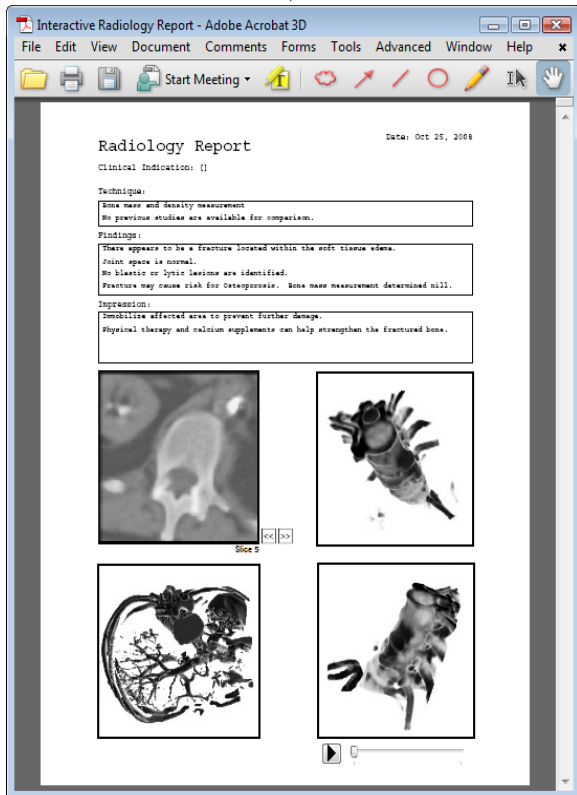
Figure 1.0: MaRRS flow diagram

The MaRRS middleware interface was designed such that any image visualization package can utilize it with minimal software adjustments. Currently, our prototype system uses *MeVisLab* [11], a freely available, extendible medical visualization system. We have also attempted to design the custom user interface software on *MeVisLab* to make the report generating process intuitive and functional, with a minimal learning curve on the part of the radiologist. The radiologist has the ability to select a specific data view and simply click a button labeled “Send to PDF” to instantly embed the data view into the report. For example, the radiologist may navigate through slices of a volume image and decide that only a specific set of slices are significant to a patient’s medical condition (Figure 2.0). Accordingly, the radiologist inputs the desired slice range and clicks the “Send to PDF” button. In turn, the MaRRS middleware is immediately activated and automatically creates an Acrobat window containing a new PDF report. It then instantly transfers the image slices to this report file and makes the first image slice visible (Figure 3.0). As previously mentioned, other useful data views that can be transferred include 3D geometric models of anatomical structures generated using segmentation tools of the visualization package (Figure 3.0, bottom left of Acrobat window) and a video of a volume rendering view (Figure 3.0, bottom right of the Acrobat window).

Upon receiving the PDF report, the referring clinician may view and interact with it using Adobe Reader. The clinician can traverse through the embedded image slices using buttons (Figure 3.0) to move forward and backwards. Volume rendering videos may be automatically played and/or manually controlled using a slider (Figure 5.0). Furthermore, rotate, pan, and zoom controls are provided to interactively view a 3D model (Figure 4.0). At any time, the radiologist or clinician may annotate and mark-up the document using a variety of Acrobat’s advanced *comment and markup tools* such as arrow, highlighting, and pencil tools (Figure 3.0 top toolbar). For example, the radiologist may highlight and/or create a link from a word or phrase to a close-up rotated view of a corresponding 3D anatomical model. As a result, by clicking on this highlighted word, the 3D model is automatically animated to align with this view.

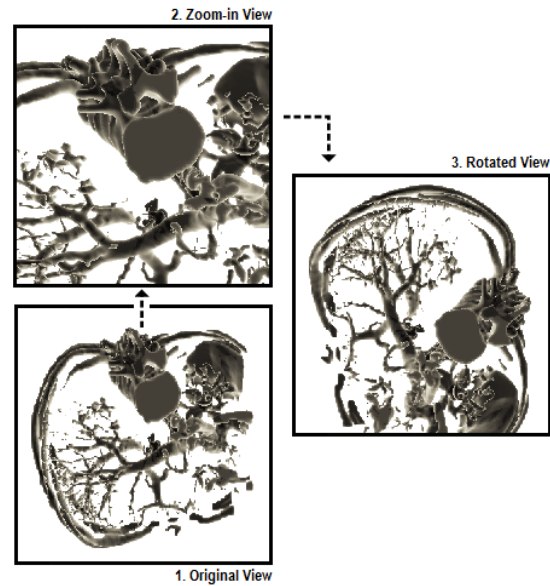
<FONT SIZE=+1><A>Yeuh-Shan Shih,  
M.Sc (CS)</A>

**Figure 2.0:** A radiologist uses MeVisLab to scan slices from a volume image and then decides to transfer slices 5 through 20 to a report.

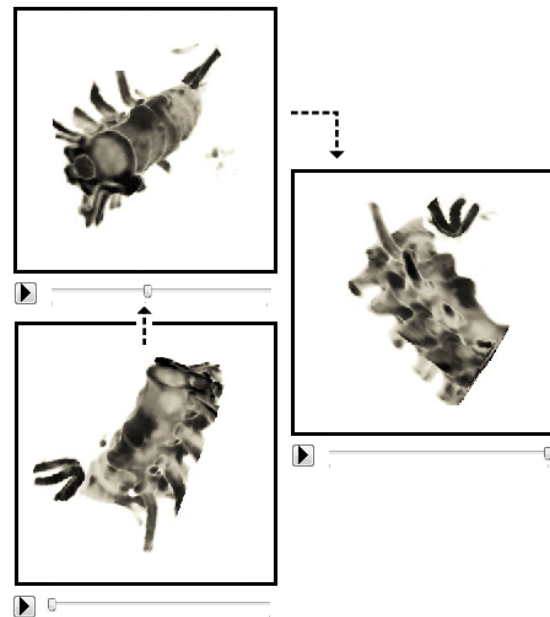


**Figure 3.0:** A new PDF report is automatically created and the slices are instantly visible. Other data views can be transferred, text can be entered and annotation can be made at any time.

MaRRS also promotes a secure environment for reviewing radiology reports via Adobe Acrobat's extensive security features. For example, once the report is complete, the radiologist may set a password to access the document prior to forwarding it to physicians. Furthermore, all reviewers have the ability to place electronic signatures [14] at the bottom of the document. As a result, the time between transcription and finalization of the report is reduced [7][8]. These characteristics may be activated on any PDF document to help protect confidential information as well as control the information held within the document while it is shared outside a firewall. Hence, the use of PDF based reports make it easy to communicate and collaborate with confidence.



**Figure 4.0:** Adobe Reader provides controls that allow referring clinician to rotate, pan, and zoom a 3D anatomical model embedded in the report.



**Figure 5.0:** Adobe Reader also provides controls to play an embedded video of a volume rendering or to manually scan the video using the slider.

#### IV. FUTURE WORK

Today many new web-based computer supported cooperative work systems are available that enable real-time synchronized viewing and discussion of documents. Adobe Acrobat includes this ability, allowing radiologists and referring physicians to discuss and markup the report over the internet. Hence, we plan to explore this feature in a radiological report context. More specifically, our goal is to create an integrated multimedia and collaborative based system that can accommodate a variety of image

visualization packages. We are also currently exploring the use of speech recognition software with Adobe Acrobat.

## V. CONCLUSION

MaRRS presents an integrated system designed to connect existing image visualization packages to Acrobat, for the generation of PDF-based radiology reports. This environment provides radiologists with the ability to quickly and simply generate multimedia reports while minimizing production time and improving structure. In fact, radiologists may instantly transfer various multimedia components to the report during the examination process. Furthermore, radiologists may markup or annotate the document prior to sending the report to referring clinicians. Radiologists also have the ability to review, markup, and interact with the report with referring clinicians simultaneously through live meetings offered by the Acrobat Connect feature. As a result, accurate patient diagnosis and treatment plans can be attained more quickly and efficiently.

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