

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, or MaRRS, allows radiologists to quickly and simply create and deliver effective interactive multimedia medical reports. This paper will introduce MaRRS, outline some related radiology report systems, and describe the unique structure and functionality of MaRRS in order to demonstrate its advantages for both radiologists and referring clinicians.

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

1. 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 primarily consist of a large amount of unstructured text and lack clear, concise, consistent, content-rich information [5][12][15]. This outmoded format makes it difficult for clinicians to interpret and analyze medical documents [6]. Furthermore, with the development of new, existing, and hybrid imaging modalities, new approaches to processing and reporting are needed that convey visual information. Radiologists must be able to quickly and simply generate a secure, shareable, standardized report [2][12]. 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 [14].

Fortunately, the advent of new multimedia authoring programs and web-based technologies has created the potential to radically transform radiology reporting and 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 for real-time discussions and synchronized viewing of the report over

the internet, as well as for interfacing to popular speech recognition software.

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 package¹ 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. By identifying and then quickly and easily embedding relevant images from large datasets into the report document, and performing annotations using the Acrobat toolset, the radiologist can provide the clinician with the necessary quantitative measures along with helpful visual aids to assist in decision-making.

2. RELATED WORK

For many years radiology reports have essentially consisted of typed or handwritten text [2][3]. With text only reports, accurate patient diagnosis was not always achieved. As time progressed,

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

some radiologists used structured report templates classified as automated reporting systems which allowed them to input text under each corresponding heading [15]. *InfoRAD* [15] 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 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* [11], 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* [3][9]. Like *MedSpeak* and *SpeechMagic*, *ReportNow* was developed to decrease report production time and promote its easy and flexible Microsoft Word-based interface. *SoftRad* [4] is also a Microsoft Word-based system and provides custom reports, templates, and options to include 2D images. *SoftRad* also provides digital dictation, integrated voice recognition, automatic document delivery, and electronic signatures. Finally, *VoxReports* [1] is designed as a speech-recognition workflow management system with the goal of faster and easier interpretation and delivery of reports. Overall, these applications focus on minimizing production time, improving the structure and management, and providing voice dictations. In the following section, we provide a detailed description of MaRRS, illustrating its quality features which make it different from any other system.

3. 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. Acrobat incorporates 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. Radiology reports that include 3D anatomical structures [12][15] can be immensely helpful in visualizing anatomical structure/function and/or patient pathology.

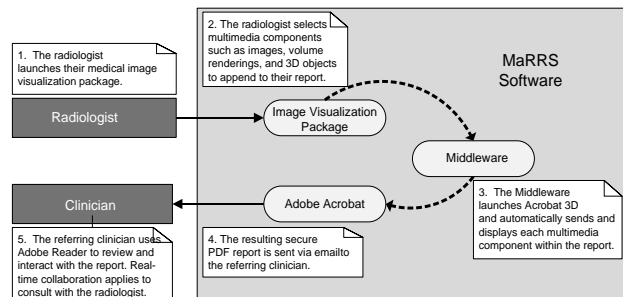


Figure 1.0: MaRRS flow diagram.

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.

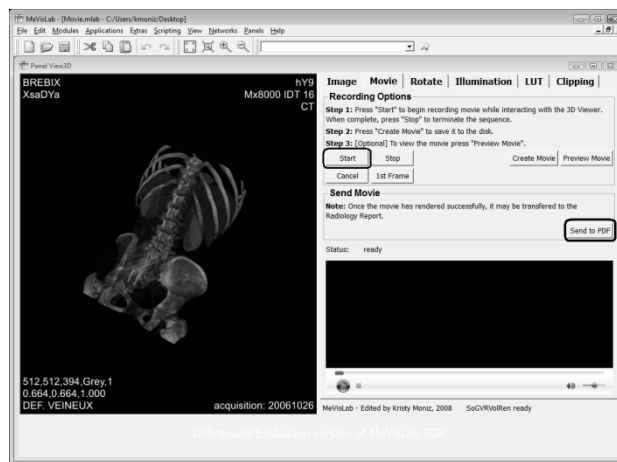


Figure 2.0: A radiologist uses MeVisLab to record a volume rendering represented as a video to be included in the report.

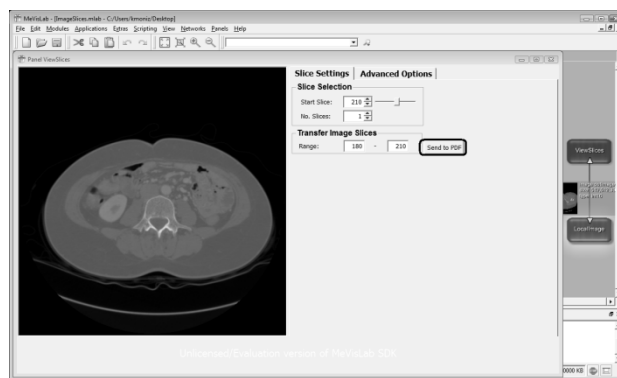


Figure 3.0: A radiologist uses MeVisLab to scan slices from a volume image and then decides to transfer slices 5 through 20 to a report.

The MaRRS middleware interface was designed such that any image visualization package can utilize it with minimal software adjustments. Currently, this prototype system uses MeVisLab [8], 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. In any situation, the radiologist has the ability to select a specific data view and simply click a button labelled “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 3.0). Accordingly, the radiologist inputs the

desired slice range and clicks the “Send to PDF” button (Figure 3.0). In turn, the MaRRS middleware is immediately activated where it automatically creates an Acrobat window containing a new PDF report. In addition, MaRRS instantly transfers the image slices to the report making the first image slice visible (Figure 4.0, middle left).

Similarly, other useful data views can be transferred to improve the quality of the report. Such views include 3D geometric models of anatomical structures, volume rendering videos, and 2D images. Firstly, 3D models may be appended to the report once it is generated using segmentation tools of the preferred visualization package (Figure 4.0, bottom left). Secondly, a radiologist may include a video of a volume rendering view (Figure 4.0, bottom right) in the report by initiating the recording feature using the “Start” button, interacting with the 3D model while it records, and then clicking on the “Send to PDF” button (Figure 2.0). Lastly, 2D data images of any relevant or significant area (Figure 4.0, middle right) may be selected in the same manner as previously mentioned. Through the simple click of a button, MaRRS enables radiologists to instantly generate a structured PDF report that includes any specified multimedia component (Figure 4.0).

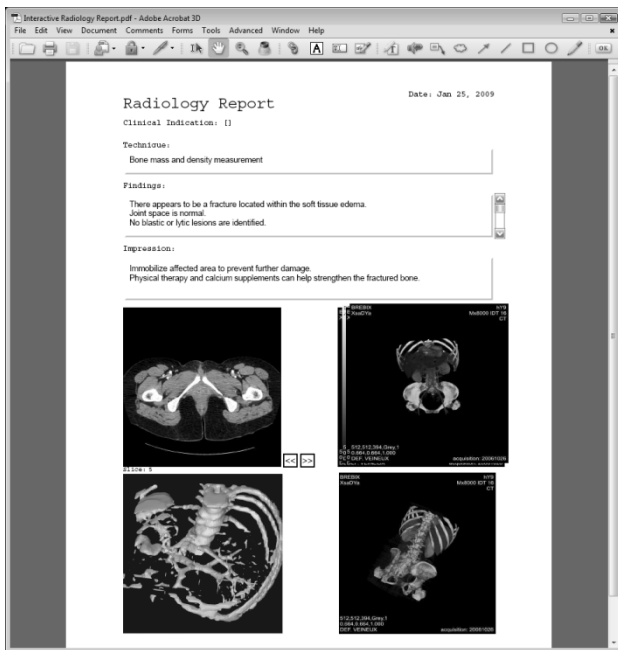


Figure 4.0: A new PDF report is automatically created and the slices are instantly visible. Other data views can be transferred, text may be entered, and annotations can be made at any time within the document.

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 4.0) to move forward and backwards. Volume rendering videos may be automatically played and/or manually controlled using a slider (Figure 6.0). Furthermore, rotate, pan, and zoom controls are provided to interactively view a 3D model (Figure 5.0). 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 4.0 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.

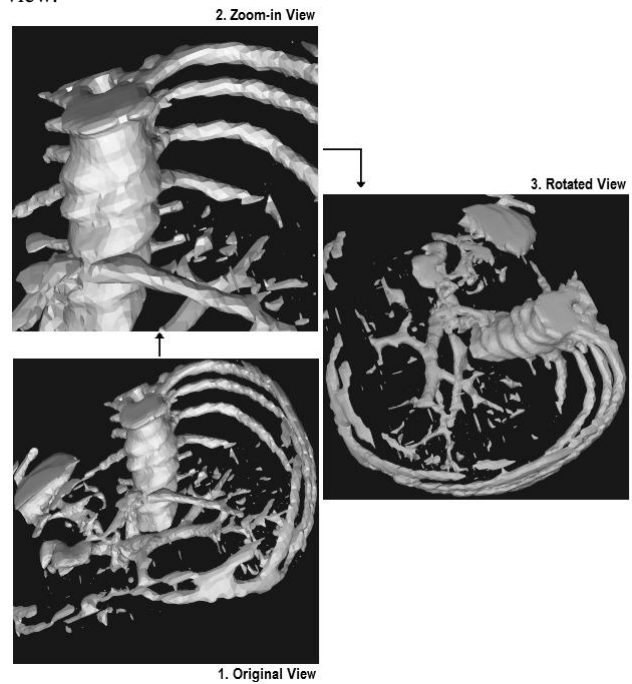


Figure 5.0: Adobe Reader provides controls that allow referring clinicians to rotate, pan, and zoom a 3D anatomical model embedded in the report.

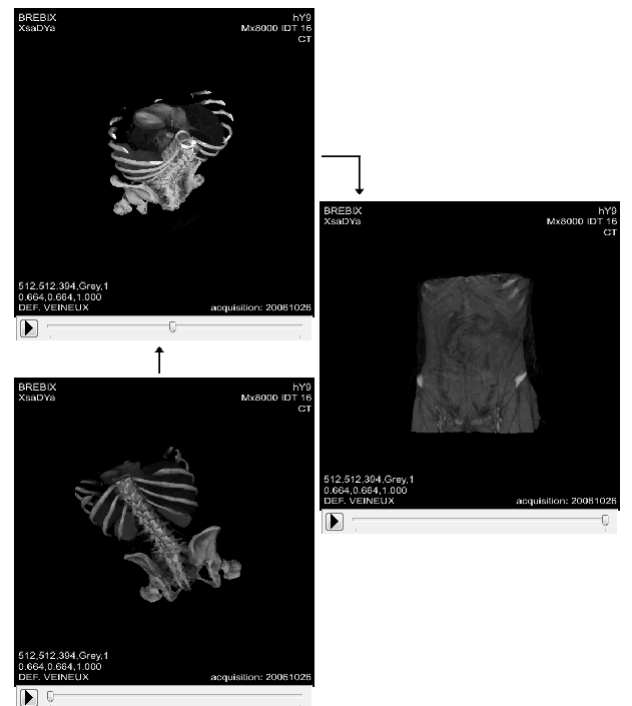


Figure 6.0: Adobe Reader also provides controls to play an embedded video of a volume rendering by clicking the play button or scan through the video using the slider.

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 [7][13] at the bottom of the

document. As a result, the time between transcription and finalization of the report is reduced [7]. 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 makes it easy to communicate and collaborate with confidence.

4. 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.

5. 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 cross-platform support for 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.

6. REFERENCES

- [1] Atirix Medical Solutions. "VoxReports: Speech-driven radiology reporting improves productivity". Retrieved on May 12, 2008 from <http://www.provox.com>, 2004.
- [2] Bardram, JE. "Hospitals of the Future-Ubiquitous Computing support for Medical Work in Hospitals". **Centre for Pervasive Healthcare**, 2005.
- [3] Berman, GD., Gray, RN., Liu D., & Tyhurst, JJ. "Structured radiology reporting: a 4-year study of 160,000 reports". **Integrating the Healthcare Enterprise Symposium of the Radiological Society of North America (RSNA)**, 2001.
- [4] Hakim, G. "SoftRad Radiology Information Systems (RIS)". Retrieved on May 12, 2008 from <http://www.softcomputer.com/products-services/radiology/soft-rad-ris/>, 2004.
- [5] Johnson, AJ., Ying, J., Swan, JS., Williams, LS., Applegate, KE., & Littenberg, B. "Improving the quality of radiology reporting: A physician survey to define the target". **Journal of the American College of Radiology**, Vol. 1, No. 7, 2004, pp. 497-505.
- [6] Lai, J., & Vergo, J. "MedSpeak: Report creation with continuous speech recognition", **Proceedings of the SIGCHI conference on Human factors in computing systems**, 1997, pp. 431-438.

- [7] Lepanto, L. "Impact of Electronic Signature of Radiology Report Turnaround Time". **Journal of Digital Imaging**, Vol. 16, No. 3, 2003, pp. 306-309.
- [8] Link, F. "MeVisLab: Medical Image Processing and Visualization." Retrieved on May 2, 2008 from <http://www.mevislab.de/>, 2004.
- [9] Liu, D., Berman, G., & Gray, R.N. "StructuRad ReportNow: Radiology Reporting for RIS and PACS". Retrieved on May 12, 2008 from <http://www.structurad.com/reportnow.html>, 2002.
- [10] Noumeir, R. "Radiology interpretation process modeling". **Journal of Biomedical Informatics**, Vol. 39, No. 2, 2006, pp. 103-114.
- [11] Nuance Communications Austria. "SpeechMagic". Retrieved on May 12, 2008 from <http://www.speechrecognition.philips.com>, 2003.
- [12] Reiner, BI., & Siegel, EL. "Reinventing the Radiology Report, 2: Time to Adapt", **Journal of Imaging Economics**. Retrieved on May 10, 2008 from http://www.imagingeconomics.com/issues/articles/2004-12_04.asp, 2004.
- [13] Reiner, BI., Siegel, EL., Siddiqui, K. "Evolution of the Digital Revolution: A Radiologist Perspective". **Journal of Digital Imaging**, Vol. 16, No. 4, 2003, pp. 324-330.
- [14] Sistrom, CL., & Langlotz, CP. "A framework for improving radiology reporting". **Journal of the American College of Radiology**, Vol. 2, No. 2, 2005, pp. 159-267.
- [15] Taira, RK., Soderland, SG., & Jakobovits, RM. "Automatic Structuring of Radiology Free-Text Reports". **RSNA**, Vol. 21, 2001, pp. 237-245.