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A Dynamic Approach to Support Interoperability for Medical Reports Using DICOM SR

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Abstract. The standardization of data structures for clinical observations in medical imaging environments is a relatively recent effort. DICOM standard defines a set of supplements for different medical reports denominated as Structured Reports (SR). In 2013, Integrating the Healthcare Enterprise (IHE) also followed this trend by publishing the profile Management of Radiology Report Templates (MRRT). However, the generalized adoption of these normalized reports has been delayed due to several factors. In fact, numerous medical institutions still use proprietary formats that do not promote sharing and remote access. New strategies to incentivise the adoption of normalized report templates are needed to make them interoperable between distinct applications. This article proposes a new method to automatically generate DICOM SR from distinct data sources. It encompasses a flexible mapping schema that can be used with distinct medical imaging modalities. Our ultimate goal is to encourage the usage of DICOM SR by providing an effortless method to convert proprietary formats into standard ones. Moreover, the developed methods can be also used for supporting IHE MRRT profiles, making the reports accessible across different information systems and institutions.

Keywords. DICOM, Structured Reports, Interoperability, IHE.

1. Introduction

The interoperability of medical imaging information systems through the establishment of normalized communications and exchange formats has been an effort since the eighties. More recently, large-scale analysis of distinct databases has been growing for a wide variety of subjects in healthcare. In the medical imaging field, the workflows and normalization of examination reports are covered by the Digital Imaging and Communications in Medicine (DICOM) and IHE (Integrating the Healthcare Enterprise) standards. The complexity of medical imaging data and associated meta-data is huge. Moreover, it tends to increase mainly due to the complexity of the protocols, the different medical procedures applied, as well as the increase of information technologies being employed in the medical practice. Nonetheless, data need to be stored in standard vocabularies and terminologies that enable their usage by the community of professionals and their applications [1]. Furthermore, the

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vocabularies are constantly being updated due to changes in the medical processes and terminologies.

Picture Archiving and Communication System (PACS) concept includes a set of hardware and software elements responsible for the acquisition, storage, exchange and display of medical images. This equipment uses the DICOM standard and is commonly used in digital medical imaging laboratories. However, medical community's main complaint is related to the lack of integration between systems holding distinct data. A common problem is that PACS applications store the imaging studies, but the associated reports are managed by the RIS (Radiology Information Systems) or HIS (Hospital Information Systems) [2]. Moreover, while the interoperability and centralization of electronic health records have been gaining momentum in several countries, the sharing of medical reports is still based on non-standard channels, such as PDF or printed files. The solution was to shift the responsibility of handling medical reports from RIS to PACS, using the DICOM Structure Reports. Nevertheless, the implementation is heavy due to the wide variety and complexity of the DICOM Information Object Definitions (IODs) – i.e. modality templates. This article describes and proposes a new strategy to facilitate the interoperability between different information systems based on the DICOM standard. The main goal is to create a transparent strategy to generate Structure Reports independent of the information source and without being locked into a particular template or structure.

2. Background

DICOM is the standard for storage and transmission of medical imaging data, in electronic format. Throughout the years, the evolution of medical imaging environment has pushed this standard to encompass more modalities and services [3]. In this scenario, DICOM SR were created to support medical imaging reports, providing guidelines for structuring, storing and exchanging their data across multiple modalities. Following this trends, the SR is usually attached with images and stored both in the PACS repository. DICOM SR breaks the new ground and allows us to explore an extended amount of meaningful medical data, which was not possible if the reports were written in free text or in a proprietary format [4]. However, many medical imaging laboratories continue to not explore their advantages [5] mainly because of the complex implementation and difficulty in exporting structured reports data from different information systems. In the specification of DICOM SR, many different areas are covered. There are IODs for numerous modalities like, for instance, Dose Report for Mammography [6], Cardiology and CAD structures. Moreover, RSNA (Radiological Society of North America) launched the RadReports [7] with around 200 report templates for radiology subareas. The use of this kind of reports is increasing. For instance, it is possible to have links and relationships defined between concepts, and embedded references to images and similar objects [8, 9]. IHE initiative has also created a new profile MRRT, where a data model is specified for describing radiology templates and the way they should be exchanged across different medical institutions. However, its implementation demand a high IT capability, since the templates are defined in HTML and Dublin Core Metadata, using the combination of principles of XML and HTML5, which are complex for inexperienced users. There are already template designers, such as T-Rex[2] that aims to facilitate the creation of new MRRT templates. Moreover, there are already strategies to convert old radiology reports in this new templates [10].

3. Methods

Our method for converting general medical reports into DICOM SR is divided into three phases: loading, mapping, and assembly; and are handled by distinct components. Figure 1 provides an illustration of the system's phases and components. The first phase is responsible for loading the reports' data from the external application, which manages the reports. Due to recent advances with RadReports (RSNA) and IHE MRRT profile, we already provide components to automatically load those templates using normalized HTML/XML files. While, at the moment, they only support radiology, this kind of formats could be used to design templates for other modalities, using different taxonomies. Thus, we used Montra[3], a free and open source engine to generate an Information System (IS) from templates. The strategy was to automatically generate a graphical user interface according to the IHE MRRT. Nowadays, there are applications that already perform such transformation. They allow to export their data into well-known formats, such as CSV or Excel. In order to support multiple sources, the loading phase was implemented through a component called "external loader plug-in". As the name suggests, different implementations of this component may be coupled with our software. Each implementation is capable of handling a different source of reports.

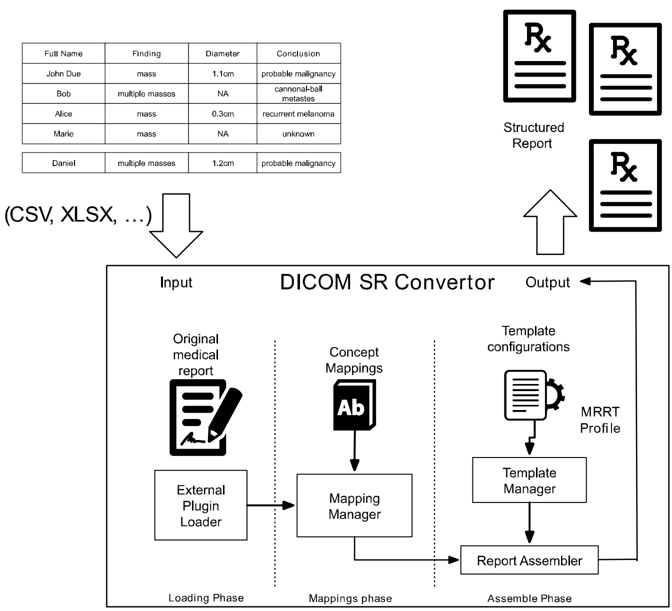

Figure 1. Illustration of the different components, and their role in the proposed method.

The mapping phase is crucial to our method. The goal in this phase is to translate the *external concept labels* into our dictionary of *well-known concepts*. These are key

[2] http://www.karoshealth.com/resources/report-template-editor/
[3] https://github.com/bioinformatics-ua/montra

points for our method, as they are concepts recognized by our components and, therefore, are correctly placed in the generated DICOM SR, following a well-defined nomenclature such as DICOM, RadLex SNOMED CT, or LOINC terms. This phase is performed by the mapping's manager component that starts by loading an external configuration file containing the mappings. Virtually, any mapping that transforms a particular data column according to its concept is supported. As a result, the data column is mapped with proper taxonomy and meaning in the structured report. In fact, this is a major requirement of our method, as different systems may use different names for concepts.

The last phase is the assembly phase, where all the mapped concepts will be placed at the correct nodes in the reports tree, and the DICOM SR objects will be created. DICOM supports structured reports for multiple modalities, since medical reports are a common practice transverse to all specialties. Actually, the standard defines specific templates for each modality and procedure [11]. These templates clearly state which concepts can be included in the report. There are two classes of templates: 1) CID (Context Identifier) are simple groups of concepts related to a specific function, for example, defining an anatomic region; 2) TID (Template Identifier) aggregate multiple groups of concepts, they are the actual definition of the template itself. A single report may include multiple TIDs, which in their turn may have other nested TIDS. In order to have the proper validation of the DICOM objects, they must be followed by the nomenclature of the template definition. Our method allows to easily translate what is defined in the DICOM standard through the supplements that define the Structure Reports for a variety of areas. Moreover, it permits to not only generate the reports based on the virtual structure created from the standard templates, but also organize the well-known concepts in the final report.

The major component responsible for this feature is the template loader. It is capable of loading the report structure from external configuration files. As opposed to the mappings file, the construction of the reports template file does not require knowledge of the original reports format. Actually, they are *JSON/XML* representations of the TIDS and CIDS defined in the standard. Anyone can construct a template file for a given TID or CID. Moreover, once the template is created, it may be shared by multiple users of our system regardless of their intentions. The *JSON/XML* representations are very easy to define accorting to the standards or we also allow to load hybrid information from the IHE MRRT format, which is available online in RadReports (or Open RadReports).

Lastly, the report assembler is responsible for creating the actual DICOM SR file. According to the desired template report, it retrieves one from the template manager. Next, for each concept in the document generated by the mapping manager, the report assembler looks in the template for its correct position in the report. Moreover, it also places the concept information and relation to its parent as required to produce DICOM compliant structured reports.

4. Discussion and Conclusion

We used the proposed framework for transcoding a research database used for breast cancer. The database contains DICOM images in a standard format, but the clinical findings and reports were stored in a proprietary information system. Supported on a template for Structure Reports for Breast Cancer [6], we successfully mapped 112 fields from the database, converted to CSV, and successfully translated them into 1492 DICOM SR. These reports conform to a format accepted by the international healthcare information standards-setting community, which allows to easily share complete studies, make them flow across institutions and readable in any compliant PACS system.

From an external user perspective, there are at least two key points to highlight. Firstly, the presented method has advantages for supporting DICOM SR along with legacy systems. Secondly, this method allows to easily integrate previously existing applications with their state-of-the-art counterpart, by allowing their data to be exported into DICOM SR. One possible hindrance is other information systems proprietary formats, such as image annotations. Some vendors do not export them to DICOM overlay and thus, it is not easily possible to link to the Report.

Looking deeply, a key point in our perspective is the capability to convert medical reports data despite their source. For that purpose, our method only requires the development of a loader plug-in and respective mapping file. The availability to load the reports template via the configuration files is also a novel feature since it broadens the scope of our application to virtually every supplement that requires the structured report. As future work, we intend to deploy this system on a web-platform to simplify its usage. In this scenario, the user would only need to supply the reports data and the concept mapping to generate the DICOM Structured Reports.

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