Technology Standards in Imaging: A Practical Overview

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Technology standards form the basis for clinical workflow in radiology. This article reviews 3 types of standards relevant for radiology: the DICOM standard for handling images; the Health Level 7 standard for communicating with the health care enterprise; and standards in coding and terminology such as International Classification of Diseases, Current Procedural Terminology, and RadLex. This third category has an impact on radiology reporting and practice management. Familiarity with all these standards can help radiologists optimize operations and plan for the future.

Key Words: DICOM, lexicon, ontology, medical coding

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OVERVIEW

Technology standards serve as the basis for interoperability between imaging-related systems and across the health care enterprise. Thus, they are critical to a radiology department's clinical workflow. Although the technical details of how these standards are set up and function is not of key importance for most radiologists, an informed perspective on the role of standards is critical to planning equipment purchases, managing relationships with hospital IT departments, optimizing imaging workflow, and developing strategies in the era of meaningful use of health IT. In addition, an understanding of the evolution and trends in standards development efforts will help radiologists prepare for future innovations in the practice of radiology. This article aims to provide a clinically oriented overview of relevant technology standards in imaging.

DICOM

Background

DICOM is a standard for the transmission, storage, and display of medical images [1-5]. DICOM has its roots in the early 1980s, when the clinical importance of digital medical imaging modalities was rapidly increasing. That time period was also one of widespread innovation in computer technologies, characterized by many competing proprietary products and designs. Although this proliferation ultimately culminated in many watershed technologies, such as the personal computer and graphical user interfaces, the lack of standards complicated the task of interconnecting equipment.

Within this environment, the ACR and the National Electrical Manufacturers Association (NEMA) began a collaboration in 1983 to define standards for the handling of digital medical imaging data. This collaboration initially produced ACR-NEMA 1.0 in 1985. The standard included a hardware-level network protocol specification (ie, a description of the physical cabling and electrical signals to be used in connecting 2 devices), an indicator of the technical challenges at that time [6].

The ACR-NEMA standard was renamed DICOM in 1993. Over time, certain portions of DICOM have been superseded by broader industry standards; other portions have been elaborated and refined. The DICOM committee has maintained its focus on facilitating the handling of medical imaging data, and the standard has broadened to address many emerging technology trends. The DICOM standard now represents the collective body of work of hundreds of medical and technical experts, performed over the course of many years, with participation from vendors, professional societies, government organizations, and other interested parties.

Today, DICOM is the universal standard for communications between medical imaging devices and applications. As such, DICOM constitutes the lingua franca for interoperability of medical imaging equipment. The ability of radiology departments to coordinate the use of many systems of varying ages from a wide range of manufacturers is due in large part to the DICOM standard.

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However, although DICOM defines standard mechanisms for data interchange and handling, there are several things that DICOM is not. First, DICOM is not an implementation of the standard: there is no "official" piece of DICOM equipment or software. DICOM does not provide for enforcement of the standard, and no central body certifies DICOM compliance of imaging equipment. Rather, the onus is on equipment purchasers to understand what DICOM functionality they require and to determine whether specific pieces of equipment support that functionality. Vendor DICOM conformance statements provide the basis for making these assessments. Finally, DICOM does not specify the ways in which its mechanisms are used. For example, although DICOM allows for the use of various image-compression techniques, no one specific technique, or any compression at all, is required for a particular type of image transaction.

Technical Details and Practical Implications

The DICOM standard is continuously evolving, and updates to the standard are released periodically. As of this writing, the most recent release was in 2011. Each DICOM release consists of a series of documents, or "Parts," each detailing a specific portion of the standard. In addition, corrections and supplements to a release may be published. The full set of documents defining the current DICOM standard is hosted by NEMA on its website [7] and may be accessed free of charge. To date, DICOM has 20 parts, which address a wide range of topics including the DICOM information model, network communications protocols, portable media, grayscale display, data security, and web technologies.

Areas of ongoing work, such as 3-D imaging, reporting, and the handling of images from non-radiology specialties and disciplines, are assigned to an overall total of more than 25 DICOM working groups. These working groups maintain relevant portions of the standard and develop material for possible future incorporation into the standard. Clearly, the scope of the standard and its ongoing efforts are broad.

A comprehensive review of the entire DICOM standard is beyond the purview of this article. However, several areas are discussed that are relevant to practicing radiologists. In particular, those aspects of the standard that relate to DICOM conformance statements, grayscale image display, enhanced CT and MR objects, structured reporting, radiation dose tracking, and web technologies are briefly summarized.

Conformance Statements

DICOM represents a large body of work, addressing many aspects of imaging workflows. For example, DICOM currently defines 65 distinct types of data, or information "objects," many of which extend beyond typical radiologic images. These include many objects related to radiation therapy treatments, waveform representations such as those for electrocardiogram data, visible light images such as those from endoscopic procedures, and dental images (see DICOM Part 3 for a complete listing). As a result, no single notion captures "DICOM compliance," as any specific piece of equipment and any particular imaging workflow will use only a small subset of the full DICOM standard. For example, an MR scanner would not use the breast tomosynthesis DICOM information object.

Understanding DICOM conformance, then, requires an understanding of the specific DICOM data types, data services, and communication mechanisms supported by a particular device. A fundamental portion of the DICOM standard (ie, DICOM Part 2) defines a document format through which vendors describe these technical details. For a specific piece of equipment, this documentation is called the DICOM Conformance Statement, and careful review of this documentation and consideration of its details regarding the existing and planned local infrastructural environment should be an important part of any equipment purchasing process.

The information contained in DICOM Conformance Statements is by necessity technical, and familiarity with a few essential bits of jargon will make these documents more meaningful. The term "SOP Class," or service-object-pair class, refers to a type of data and an associated function. For example, "CT Image Storage" is one example of an SOP Class. A device might use an SOP Class (in which case the device is a service class user [SCU]), provide an SOP Class (in which case the device is a service class provider [SCP]), or both. A CT scanner would be an SCU of the CT Image Storage SOP Class, and the archive used to store images from this scanner would need to be an SCP of this SOP Class.

The DICOM Conformance Statement for a particular piece of equipment, whether a modality, PACS, advanced visualization system, film printer, or other device, constitutes the manufacturer's declaration of its intended DICOM functionality. Matching such functionality between devices is the key to achieving interoperability. Maintaining these documents as reference for installed equipment is important, as is review of such documents for equipment under consideration for purchase. IT staff and PACS administrators will generally be key collaborators in the close interpretation of these documents.

For a full description of the DICOM Conformance Statement format and relevant aspects of the DICOM information model, please see DICOM Parts 2-6 as well as the excellent text by Pianykh [5].

Grayscale Standard Display Function

Drawing upon extensive research in image display and human perception, Part 14 of the DICOM standard addresses issues related to consistent, optimized display of grayscale images. This portion of the standard provides a basis for the uniform display of images regardless of the medium or display technology. The DICOM grayscale standard display function (GSDF) constitutes a principal element of Part 14.