Anatomy of Picture Archiving and Communications Systems: Nuts and Bolts—Image Acquisition: Getting Digital Images From Imaging Modalities

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Digital acquisition of data from the various imaging modalities for input to a picture archiving and communication system (PACS) is discussed. Essential features for successful clinical implementation including Digital Imaging and Communications in Medicine (DICOM) compliance, radiology information system (RIS)/hospital information system (HIS) interfacing, and workflow integration are detailed. Image acquisition from the inherently digital cross-sectional modalities are described, as well as digital acquisition of the conventional projection x-ray using computed radiography (CR), direct digital radiography (DDR), and film digitizers.

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Image ACQUISITION is the first point of data entry into a picture archiving and communications system (PACS), and as such, errors generated here can propagate throughout the system, adversely affecting clinical operations. General predictors for successful incorporation of image acquisition devices into a digital imaging department include the following: ease of device integration into the established daily workflow routine of the clinical environment, high reliability and fault tolerance of the device, simplicity and intuitiveness of the user interface, and device speed.

Imaging modality conformance with the Digital Imaging and Communications in Medicine (DICOM) standard is critical. DICOM consists of a standard image format, as well as a network communications protocol. Compliance with this standard enables an open architecture for imaging systems, bridging hardware, and software entities, allowing interoperability for the transfer of medical

images and associated information between disparate systems.

Equally essential, particularly at acquisition, is interfacing the radiology information system (RIS)/hospital information system (HIS) with the PACS. This greatly facilitates input of patient demographics (name, date, time, medical record number, accession number, examination type), imaging parameters, etc, and enables automatic PACS data verification, correlation, and error correction with the data recorded in the RIS/HIS. Several imaging modalities are tightly coupled with the RIS (ie, some computed radiography [CR] manufacturers) and provide automatic downloading of demographic information from the RIS, via barcode readers, to the modality, and hence the DICOM header. This eliminates the highly error-prone manual entry of data at acquisition. Some vendors also provide the capability to download RIS/HIS schedules and worklists directly to the imaging modality.

Health Language 7 (HL7) is the RIS/HIS standard and compliance with it is desirable. RIS/HIS databases are typically patient centric enabling query and retrieval of information by the patient, study, series, or image data hierarchy. Integration of RIS/HIS data with the PACS adds intelligence to the system, helping to move data around the system based on “*how, what* data should be delivered *where* and *when*.”

Digital image acquisition from the inherently digital modalities such as computed tomography (CT) and magnetic resonance imaging (MRI) just makes sense. There are two methods for accomplishing this, direct capture and frame grabbing. Direct digital interfaces allow capture and transmission of image data from the modality at the full spatial resolution and bit depth or gray scale inherent in the modality, while analog (video) frame grabbers digitize the video signal voltage output going to an image display, such as a scanner console monitor,

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and image quality is limited by the process to only 8-bits (or 256-gray values). Thus, direct capture of digital data from the inherently digital data is the preferred method of acquisition.

Methods for digital image acquisition of the conventional projection x-ray include currently clinically utilized devices such as CR or imaging with photostimulable or storage phosphors, and digitization of existing analog film, as well as direct digital detectors falling under the general heading of direct digital radiography (DDR) that are beginning to be utilized clinically. Digital acquisition of images already on film can be accomplished using a variety of image digitization devices. These include the infrequently used analog video cameras with analog-to-digital converters (ADC), digital cameras, charge coupled devices (CCD), and laser scanners.

The analog video camera with ADC, or camera on a stick, has been used in low-cost, entry-level teleradiology applications but is infrequently used in PACS applications today because of the manual nature, requiring an illumination source and careful attention to lens settings, focus, f-stop, etc, as well as the maximum resolution limitation of 1,024 by 1,024 by 8 bits (256 grays). Digital cameras produce a digital signal output directly from the camera at a maximum resolution of 2,048 by 2,048 by 12 bits (4,096 grays), but are still infrequently used in PACS.

Commonly used in PACS are the CCD or Flat-Bed Scanner, which utilizes a row of photocells and uniform bright light illumination to capture the image. They have a maximum resolution of 4,096 by 4,096 by 8 to 12 bits, but have a narrow film optical density range to which they can respond. CCD scanners have been used in high-end teleradiology or entry-level in-house film distribution systems. They are cheaper than laser scanners,

the other commonly used PACS film digitizer. Laser scanners use a fine laser beam of generally variable or adjustable spot sizes down to 50 μm (producing an image sharpness of approximately 10 line pairs per mm). They have maximum resolution of 4,096 by 5,120 by 12 bits, and can accommodate the full optical density range of film. They are semi- or fully automatic in operation.

CR and DDR are modalities that digitally acquire projection radiographs without the use of film. CR utilizes a photostimulable phosphor (PSP) imaging plate in a cassette design similar to that of screen-film cassettes. The PSP imaging plates have the property that, when exposed to x-ray, a latent image is formed in the plate until it is subsequently stimulated to luminesce by a laser. The emitted light is then captured and converted to a digital image. DDR uses direct conversion of x-ray energy to charge collected by a thin-film transistor pixel array, offering electronic readout initiated immediately at the time of exposure.

Both CR and DDR have all the benefits of digital (filmless) images, the ability to acquire, transmit, display, manipulate, and store data digitally. Each have wide latitude response detectors, potentially reducing retakes resulting from poor exposure in the screen-film based environment, and equivalent spatial resolution capabilities. DDR has a higher efficiency detector and immediate image readout. Some current DDR problem areas include ease-of-use and portability issues, the requirement for a single device per radiographic room ("one room at a time technology"), and its high production cost. CR has superior procedural flexibility, can accommodate portable bedside examinations, and is a proven clinical modality. It is likely that CR and DDR will coexist as digital radiographic devices for a long time.