Practical Usage of Image Quality Verification Tools.

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Abstract

Recent standards and upcoming guidelines are beginning to address the issue of image display quality, and image presentation consistency. The DICOM standard has recently been extended to address the consistency of the grayscale presentation of images (DICOM part 14, Grayscale Standard Display Function), and it also addresses the consistency of presentation of associated information (text, graphics, annotation, zoom, rotation) with the recently approved addition of the Softcopy Presentation State, i.e. DICOM Supplement 33. These two new standards provide image consistency between viewing stations and printers independent of the manufacturer, brand and/or type. These services have been demonstrated at ECR, RSNA, and are also part of the continuing IHE demonstrations. In addition to the DICOM standards, work is being done by AAPM Task Group 18 to address the issue of Quality Control and Quality Assurance for electronic displays. However, even though the technology is available, there is a lack of practical tools, guidelines and test images to meet the DICOM standards for digital image quality and consistency between components within a PACS system. We have developed a set of procedures and images that are designed to evaluate the image quality and consistency based on the new DICOM services and upcoming AAPM guidelines, providing feedback to troubleshoot potential issues and verify the necessary corrections and calibration. Tools, images and procedures will be described.

Grayscale Image quality

Grayscale consistency is achieved by the support of the so-called Grayscale Standard Display Function (GSDF), which standardizes the mapping of input values to a display and hardcopy (film or reflective, i.e. paper) by specifying the corresponding output values in luminance or optical density. Because the output is defined by the DICOM standard, it can be measured and the display devices can be calibrated accordingly.

To make sure a printer complies; the DICOM standard defines the so-called Presentation Look Up Table, which allows these devices to support the specific mapping.

Independent from the characteristics and type of display device or printer, a consistent presentation of the images is guaranteed.

Presentation Consistency

Even if an image is displayed with the same grayscale presentation on two different viewing stations, there is no guarantee that the presentation of the image would be identical. The difference in the presentation can be as simple as looking at an image on one workstation using a specific zoom factor, to displaying it with a specific overlay or added text. Some viewing stations, for example, support the display of overlays while others don't, or store these in a proprietary format. The presentation of the image can also be considered as the "cosmetics", and depends on the features that the workstation supports.

The DICOM standard did address the presentation previously but with certain limitations. The specifications of the presentations, such as the operations performed (rotate, flip, zoom), were either not present, or, if so, often embedded within the actual image object. A good example is the Window Width and Level that is sent as part of the image. This is similar to overlay planes and even curves that are

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typically displayed with Nuclear medicine images, which were also sent together with the image. The recent extension of the DICOM standard, i.e. the Softcopy presentation State Storage, resolved a lot of ambiguities and provides a robust manner to encode and exchange the presentation information. Even more important, this information is decoupled from the image object itself, i.e. it is not embedded anymore within the image data but rather sent as a separate object. This allows multiple to multiple relationships between images and these presentation states, e.g. a single image can now have multiple presentation states, and a single presentation state (e.g. a zoom factor) can be shared between a whole series of images.

It should be noted that there are certain things that the presentation state does not (yet) address. For example, the order and position between individual images relative to each other is not addressed. This is, however, critical, to support what is commonly referred to as the hanging protocols. There are DICOM standardization activities to address this as well, even to the point that individual preferences of a specific physician can be accommodated. There are discussions to address other presentation related applications such as white boarding (displaying a cursor from one to the other workstation) too.

The Presentation State Storage is expected to address a wide area of applications. These range from preserving the zoom parameters or overlays and annotations from a CT or MR modality, the image rotation on a CR QA workstation, or the addition of annotations on a workstation by a physician. Support for these services has been demonstrated at several tradeshows and has become part of the IHE demonstrations during the annual RSNA and HIMSS meetings. Images with corresponding sample presentation states are available as open source and can be used for testing the applications.

Image display quality

Even though the grayscale consistency between different devices can been achieved by the earlier described grayscale display function, there are certain quality factors that are inherent and characteristic to the display itself that pose certain limitations on the quality. Quite often, these parameters can be manipulated and adjusted, and it is therefore critical to have a set of tools that can measure these parameters, evaluate them, identify the aberration, and than double check the changes made in the settings. The quantification of the inherent quality has been traditionally the domain of the AAPM, who is developing a set of guidelines, tools and test images to assist with the quality assurance of these devices. AAPM TG18's efforts include developing specifications to define standards of performance, methodology for evaluation of performance to the specifications (acceptance testing) and long-term quality assurance assessment. The tools are intended to provide a scaleable approach to image quality measurement that takes into account the range of facilities and their supporting staff capabilities. An example would be to perform QA testing with test patterns and observer to a high-end solution using sophisticated test equipment.

Practical Aspects

What are the practical aspects and implications? The problem is often that there are a certain set of guidelines and standards, but that there is a lack of very specific "how-to" rules for the people that are actually responsible for implementing or executing a QA program within an institution. One of the problems is that it is almost impossible to come up with one specific procedure and/or frequency of performing it. For example, some monitors might drift more than others, requiring them being calibrated everyday, instead of once a week. Some institutions might have set the brightness output very high because of its high ambient light level, which also impacts the changes in monitor characteristics and need for calibration. Some institutions leave their systems up 24 hours/day, some switch them on every morning, requiring a certain "settle-time". It is therefore prudent to come up with a customized procedure for each specific institution, and maybe even specific departments (Radiology vs. ICU vs. ER/OR). With regard to the tools and test images itself, there is standardization possible. Here is where there is a major benefit to be achieved from the images and procedures of AAPM. This will also help the vendors because if there is a uniform acceptance test that can be easily performed with a standard set of images, it will make it much easier to address image quality issues.

Another reason why these test images and procedures are so important is that it takes away the subjectivity. This became very clear for example at last years RSNA demonstration where we printed to several print manufacturers an identical image, with the same presentation and calibrated to the Grey Scale Display Function. It was obvious that there was a difference; some of the films have a bluer tint, or are not as "warm". But the image itself, the resolution, the grayscale presentation and contrast differences were all identical. This will help addressing problems that vendors have to address today because the images "do not look good" according to a physician, i.e. it takes away the subjectivity from the image quality assessment.

Conclusion

As of today, there are still many institutions that wrestle with image quality issues that especially arise when moving to a digital environment where everything is connected to everything. Printers are increasingly shared; images can be viewed on a variety of workstations from different manufacturers and resolution. With this increase there is a major need for standards that address these problems as well as tools and procedures to implement a quality assurance program. The standards are in place, even though many manufacturers are still in the process of implementing these in their equipment. However, a consistent set of tools, test images and procedures are still under development and being specified by organizations such as the AAPM. Ongoing development as well as training for the implementation of the tools is critical to the success of truly digital departments.