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QC Considerations for Mobile Devices

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No disclosures.

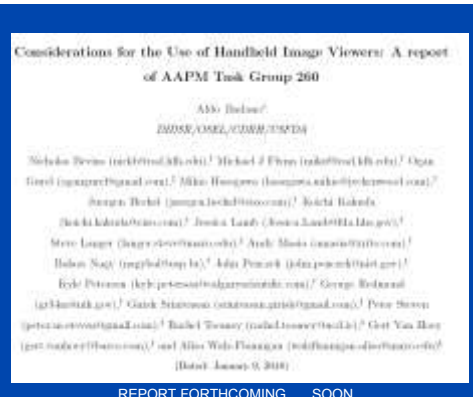
Any commercial products referenced in this talk should not be construed as an endorsement of those products.

Outline

- TG260 charge and scope
- Mobile Image viewing use cases
- Overview of mobile display technology
  - Differences and similarities between image viewing with mobile devices and standard fixed displays
- Calibration and QC approaches for mobile device displays

Learning Objectives

- To become aware of challenges with mobile-device viewing of images
- To understand options for calibration and QC for mobile-device displays and how that may be different from standard fixed-displays.


Considerations for the Use of Handheld Image Viewers: A report of AAPM Task Group 260

REPORT FORTHCOMING….. SOON


Examples of Pre-Market Submissions that Include MMAs Cleared or Approved by FDA

Draft (12/8/2017) FDA guidance update states they will continue to review mobile apps/devices intended for diagnostic use

Many apps are FDA cleared for primary diagnostic use with specific mobile devices


Image credit: Comstock

Source:
https://www.fda.gov/medicaldevices/digitalhealth/mobilemedicalapplications/ucm368784.htm

https://www.fda.gov/downloads/MedicalDevices/DeviceRegulationandGuidance/GuidanceDocuments/UCM587820.pdf

Mobile devices (phones and tablets) are omnipresent, providing quick and easy access to patient images.

Image source: http://amil.engineering.asu.edu/wiki/doku.php?id=projects:esmd

TG260 Scope

- Provide users in healthcare imaging with an understanding of considerations for use in patient care
- Provide examples of potential use cases, review current technological offerings, and highlight procedures to promote best practices in the use of handhelds.

"Handheld image viewers are practical and widespread. Understanding the limitations of their use and knowing when and how to use them is paramount to high-quality patient care delivery." [TG260]

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Use cases for mobile viewing of medical images in radiology

- Viewing an examination that is currently in progress
- Consulting with a trainee
- Offer opinion to emergency interventionalists.
- Real-time, in-person or remote consultation with other providers (eg, surgical planning).
- Communicating imaging findings to patients, for teaching
- Tele-presence applications

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Mobile Viewers generally sold as adjuncts to a full-radiology workstations and for clinical review and communication

- FDA-approved for clinical reading, even on mobile devices.*

When used on a mobile device, ResolutionMD is not intended to replace full radiology workstations.

This product is not to be used for primary mammography diagnoses.

Mobile MIM provides wireless and portable access to medical images. This device is not intended to replace full workstations and should be used only when there is no access to a workstation.

This device is not to be used for mammography.

Studies show diagnostic concordance of mobile devices with fixed PACS workstations

De Maio et al. [14] analyzed the accuracy of mobile diagnostics related to intra-articular knee pathology

Park et al. [15] examined the potential of the iPad 2 as a teleradiology tool for evaluating brain CT scans with subtle hemorrhage

Schlechtweg et al. [16] investigated one hundred patients with a clinical suspicion of abdominopelvic hemorrhage. The results showed that this type of exam can be diagnosed on a tablet computer with a high diagnostic accuracy allowing mobile on-call diagnoses.

From Venson et al. International Journal of Medical Informatics 113 (2018) 1-8

Other Perspectives

"Mobile devices are currently not recommended as tools for primary interpretation of radiologic studies."
European Society of Radiology (2018)

ACR-AAPM-SIIM Technical Standards for display in diagnostic viewing (2017).

Standard tied to function. Device agnostic. Could mobile meet the standard?

Workstation Display vs Handhelds

What all is the same?
What is different?
What should we be aware of?

Major considerations for the use of handheld image viewers

- Image size and Resolution
- Variable viewing angle and viewing distance
- Motion
- Calibration
- Variable ambient illumination
- Touch
- Connectivity
- Compression

From TG 260 Draft (2018), Badano et al.

Overview of Mobile Display Technology

Display Comparisons

A large, handheld, 10-inch diagonal 3MP display, held at 30 cm gives an equivalent visual experience as a 20-inch medical monitor at twice the distance.

Perceived resolution for a given pixel size depends on viewing distance

	PACS display	iPhone 8	Samsung Galaxy 9	iPad pro 10.5	Galaxy Tab S3
Native resolution (pixels)	2048 x 1536	1334 × 750	2960 x 1440	2224 × 1668	2048 × 1536
Display size (cm)	54.1	11.9	14.7	26.7	24.6
Pixel size (mm)	0.211	0.078	0.045	0.096	0.096
Typical Viewing distance (cm)	75	30	30	38	38
Limiting resolution in cycles per degree for typical viewing distance	31.0	33.6	58.5	34.6	34.5

Visual contrast sensitivity (at 100 cd/m^2) is less than 10% of max at 28.4 cpd
For lower luminance or higher spatial frequencies, contrast sensitivity is lower.

Overview of Mobile Display Technology

- ***Intrinsic*** Display Performance
  - -spatial resolution
  - -luminance ratio
  - -noise

Can be as good or better than desktop monitors
[Yamazaki et al., PLOS ONE 2013]

Factors that can affect perceived display resolution

- Pixel structure
- Luminance
- Color
- image rendering for display matrix

Image source: Yamazaki et al., PLOS ONE 2013

- panel reflections
- panel protectors
- viewing angle

- Viewing Distance

- Motion

Image source: https://www.iphonehelp.expert/step/make-sure-youre-holding-iphone-right-distance-away-from-face/

Matters of size

Image source: https://www.biomorphdesk.com/

Matter of workflow efficiency

Matter of availability and timeliness

Image source: http://amiil.engineering.asu.edu/wiki/doku.php?id=projects:resmd

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Resolution: can be as good or better, but different with affect of motion, screen protectors, higher variability in viewing angles and distance and panel types

DEMO TIME

BYOD (bring your own device: smartphone or tablet)

not unlike current clinical situations

DEMO TIME: grab an app

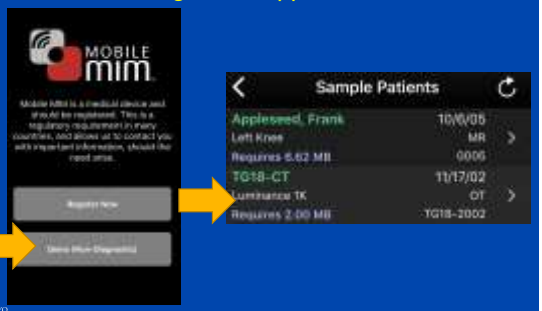
For Apple product users:
download mobile MIM

Android users:
Find a friend to look on with
Browse for apps with demo functions

Demo screen shots will also be shown

Used for educational purposes with permission from MIM

DEMO TIME: grab an app from the store



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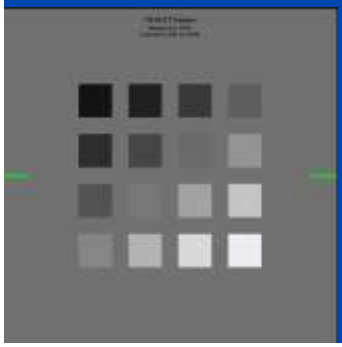
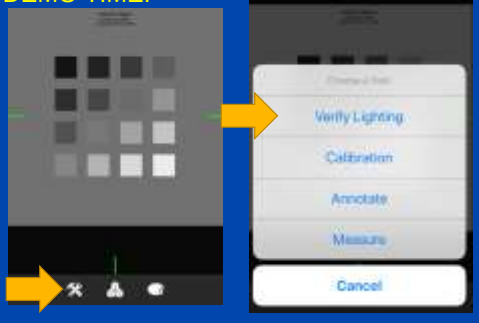
DEMO TIME



NO ZOOM

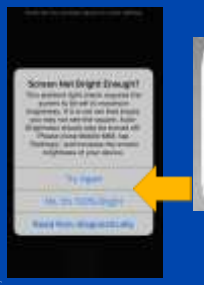
1. Can you see the two half-moons in each square?
   - If not all, which are not seen?
2. If all half-moons are seen, can you see the four squares in the corners?
   - If not all, which are not seen?

DEMO TIME:



How is your viewing?

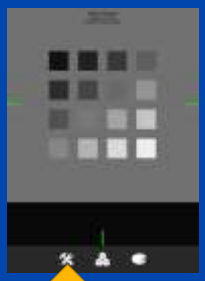
DEMO TIME:



- Go out of the application
- Maximize your display brightness

DEMO TIME:

DEMO TIME



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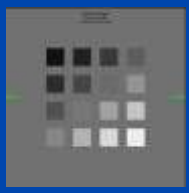

1. Can you see the two half-moons in each square?
   - If not all, which are not seen?
2. If all half-moons are seen, can you see the four squares in the corners?
   - Which?
   - Or, if not all, which are not seen?

Variable Ambient Illumination

Image from: Mobile MIM

Ambient illumination is more significant concern for handhelds

Image from: https://www.segurancadopaciente.com.br

- *Handhelds often have higher reflectance than reading room displays. [Liu and Badano, JDI 2013], can be made worse with panel protectors, especially the specular reflectance.*
- Handhelds are used in variable lighting environments.
- Evaluation of the environment is crucial.
- The impact of ambient light while reading patient image can be difficult to assess, as one cannot notice what one does not see.

Major considerations for the use of handheld image viewers

- Image size and Resolution
- Variable viewing angle and viewing distance
- Motion
- Calibration
- Variable ambient illumination
- Touch
- Connectivity
- Compression

Calibration: typical calibration sRGB color and not conforming to DICOM GSDF. Variable user brightness settings, Variable ambient illumination can affect contrast resolution. End-user calibration is app dependent and unless using external measurement is not DICOM GSDF.

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- Compression
- Security

Infrastructure and settings considerations for both app and implementation:

- Institutional wifi only/cellular?
- Data rate requirement for use?
- Restricted compression?

Calibration approaches

(as accommodated by the application)

1. End-user calibration (as in the demo)
   - *User-tailored for their eyesight*
   - *Accommodates current ambient lighting when performed*
   - Not DICOM GSDF
   - Time consuming and could make things worse if not done well
2. Initial device panel characterization and DICOM GSDF conforming LUT created for a reasonable ambient illumination.
   - Should be stable over typical device lifetime
   - Can be modified for varying ambient conditions (within limits)

Thoughts on Calibration Approach

- One and done approach alleviates burdens for end user .
  - *handheld paradigm is all about timely ease of access*
- Operating system access to color management would allow for ease GSDF calibration for multiple apps.

QC Approaches

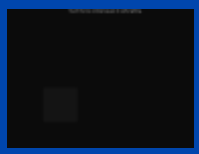
- Test of Calibration
  - Confirmation of initial calibration by professional
  - End-user visual test of calibration
- Ongoing end-user testing for changes related to viewing conditions
  - Clean screen
  - Lighting check

QC Approaches: end-user testing

Low contrast visibility test

- User has to score a test pattern
- User needs special information to conduct
- User must determine their threshold

More burdensome for user



- Forced choice
- Simple and quick
- Doesn't require special information

Less burdensome for user

QC Approaches: end-user testing

Testing Trigger

1. Voluntary access when a user is concerned for IQ
   - Found in a settings menu somewhere (typical of current mobile viewers if provided)
2. Prompted access in response to triggering circumstance

   Possibilities :
   - Before viewing exam that is "in progress"
   - When opening an application
   - When camera senses significant deviation from calibration conditions
   - Logged override

Summary

- Standards for diagnostic viewing are device agnostic
- Mobile devices could (in principle) be set up to conform to standards
- Platform differences suggest different use cases and strategies for calibration and quality control

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Questions & Discussion