THE DICOM 2013 INTERNATIONAL CONFERENCE & SEMINAR

March 14-16 Bangalore, India

DICOM℠

Digital Imaging and Communications in Medicine

Making it with quality: Tools for DICOM

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With Thanks to David Clunie for “loan” of slides!

Medical Connections

Conflict of Interest

- **I write and sell a DICOM toolkit**
- **This talk is not about my toolkit!**
- **Please stop me if I “stray”!**

The Tools you Need

- **Learn about DICOM**
  - **Books, meetings, the standard itself**
  - **Review other implementations & images**
  - **Loggers and Analysers**
- **Implement your application**
  - **Toolkits**
- **Test**
  - **Testing and validation tools**

Toolkits

- **DICOM is complex**
  - **There is a lot to:**
    - Understand
    - Get wrong
    - Cope with from others
- **A good toolkit protects you from many of the above problems**
- **Almost all developers use a toolkit of some sort**

Toolkit Functionality

- **Toolkits hide details of encoding from programmer**
- **Typical Toolkit features**
  - **read/write DICOM “files” and messages**
  - **access to lists of DICOM attributes**
  - **convenient access to pixel and other bulk data**
  - **memory management for large images**
  - **compressed image support**
  - **simplify creating/writing “correct” objects**
  - **implement network services**
  - **read/write DICOM media (DICOMDIR)**

Choice of Toolkits

- **Many variables**
  - **Languages and platforms**
  - **Level of abstraction**
  - **Free & Open Source vs. Commercial “black box”**
  - **Support and expertise available**
  - **Advanced viewing capabilities – e.g. 3D**
  - **Performance and robustness**
  - **Validation**
- **Updates**
  - **Is it still actively developed?**
  - **Does it incorporate recent DICOM additions?**

Data Abstraction Level

- **Lists of attributes (data elements)**
- **Create/extract structure (e.g., trees for sequences)**
- **Create/extract entire objects, modules, macros**
- **Create/extract abstract models (e.g., in 3D space)**
- **Support for enhanced multi-frame descriptors**

Network Abstraction Level

- **High Level**
  - **“send set of images” (all negotiation automatic)**
- **Low Level**
  - **Create list of presentation contexts**
  - **Add transfer syntaxes**
  - **Send to remote AET**
  - **Receive acceptance/rejection**
  - **Decide which context to use**
  - **Send data**
  - **Received response to each**
  - **Check errors**
  - **Close**

Know what your toolkit does and does not support

- **Display:**
  - **Full greyscale pipeline**
  - **Shutters**
  - **Masking**
  - **Sigmoid LUTs**
  - **Multi-frame extensions**
  - **PDF/CDA etc.**
- **Network**
  - **Async operations**
  - **Out of band messages – C-CANCEL etc.**
- **General:**
  - **SOP Class specific or neutral?**
  - **Transfer syntaxes**

Toolkit Limitations

- **Even with a good toolkit, you can still get a lot wrong!**
  - **Application design**
  - **Completeness of data objects**
  - **Internal relationships within objects**
  - **Relationships between objects and services (e.g. MWL data ➔ images)**
- **And toolkits can have bugs**

Test Tools

- **Only DICOM specific aspects here…**
- **Does it seem to work as expected?**
  - **Test objects for "consumption" by your system**
  - **Viewers to visualise the images you make**
  - **Servers to connect to**
  - **"Passive" sniffers**
- **Specific validators**
  - **Validators for what you produce**
  - **"Active" network test systems for protocol ± content validation**

Image and other composite objects

- **Synthetic – generated de novo**
- **Real – from modalities (de-identified)**
- **Combination – modified real images**
- **Niche tests – e.g. character sets and measurements (David Clunie's)**

“See” what your doing

- **Viewer to see your images**
  - **DicomScope**
    - http://dicom.offis.de/dscope.php.en
    - Old, but still useful as it faithfully uses the entire greyscale “pipeline”
- **Wireshark to see your networking**
  - **Has evolved into a good DICOM dumper**
  - **Can actually save DICOM file from packet capture**
  - **Beware privacy concerns!**

Test Servers

- **Public**
  - **www.dicomserver.co.uk**
  - **Handles receive/query/retrieve, avoiding configuration issues**
    - C-GET
    - C-MOVE assume same port as retrieve command
  - **Beware – it contains a lot of junk!**
- **Local**
  - **within company or hospital or lab**
  - **tunnel in firewall to DICOM port**

Validators

- **Validate for compliance with DICOM**
  - **images and other composite objects in files**
  - **from media or received/captured from network**
  - **captured network messages (queries, etc.)**
- **What to validate**
  - **compliance with IOD (defined by SOP Class)**
  - **compliance with template (Structured Reports)**
  - **correct encoding of attributes**
  - **compliance with “profiles” (media, IHE)**
  - **warn of “undesirable” characteristics**

Validators

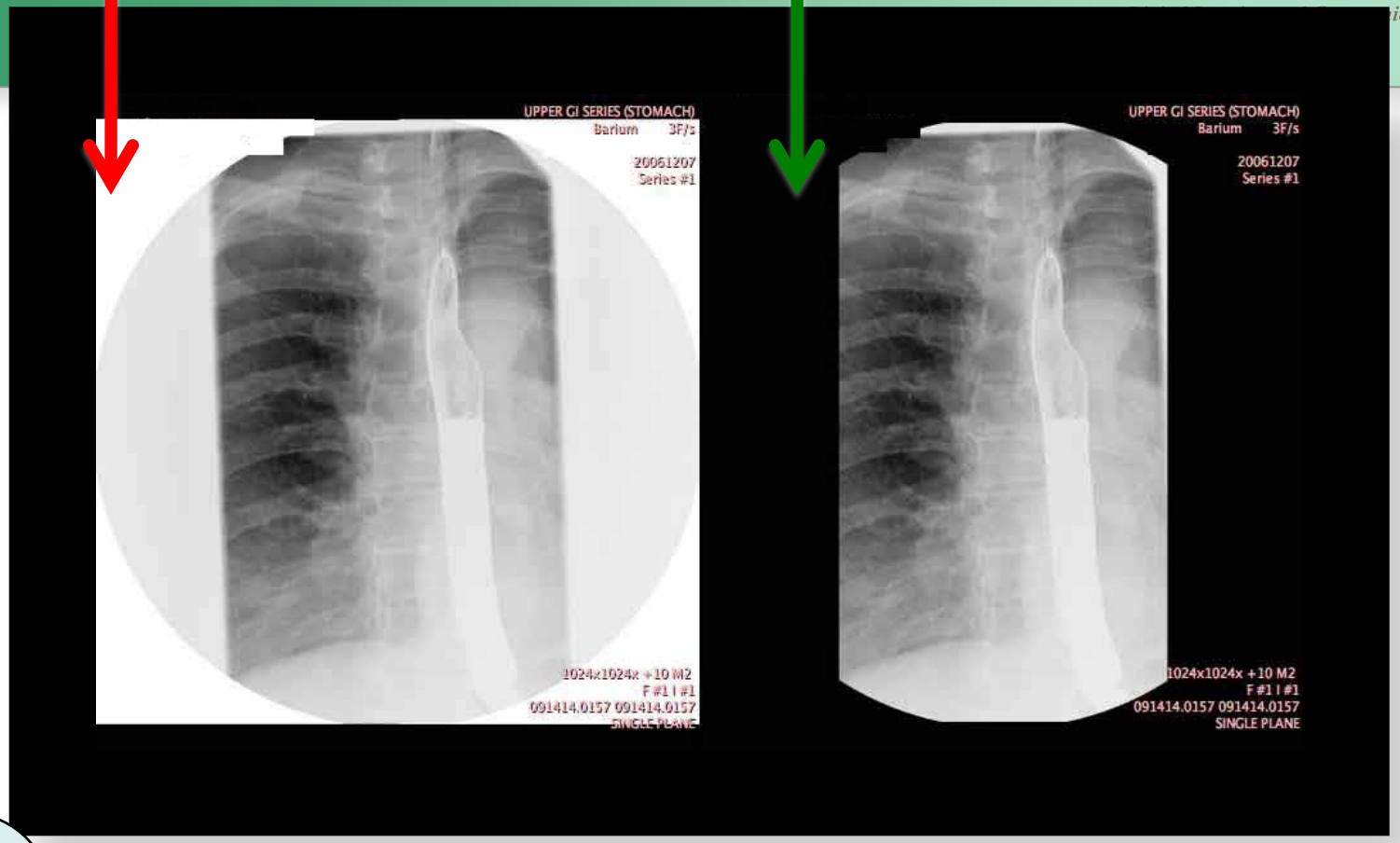
- **DVTK**
  - **http://dvtk.org**
  - **Test scenarios and general emulators**
- **David Clunie's test tools**
  - **http://www.dclunie.com/dicom3tools/dciodvfy.html**
- **Both can to "over call" issues, but it is better to be alert to possibilities and choose to ignore them once you are certain than to be ignorant!**

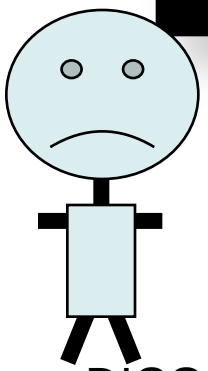
What standard to test against

- **What needs to be tested**
  - **does it “work” ?**
  - **is it “correct” ?**
- **Compliance with DICOM standard**
  - **does NOT mean that it will “work”**
  - **may not be necessary for it to “work”**
- **For example**
  - **device may “interoperate” by ignoring non-compliance**
  - **a compliant device may fail by ignoring a “feature”**

White Background - BAD

Black Background - GOOD





Failure to apply Display Shutter to inverted DICOM image
Modality vendor is compliant – sends Display Shutter
PACS vendor is “compliant” – allowed to ignore Display Shutter
PACS vendor promises this “feature” in new version only
– requires complete PACS server hardware replacement !@#$

Customer “unsatisfied”

IHE and testing

- **Original RSNA DICOM testing initiative**
  - **central test node(s), test tools and plans**
- **IHE developed “integration profiles”**
- **IHE “connectathons”**
  - **standalone testing with tools**
  - **test scenarios between “actors”**
  - **tests against reference implementations**
  - **tests between actual implementations**
  - **check logs to be sure “work” for right reasons**
- **Test tools are free and open source**
- **A connectathon is the best education!**

Finding tools

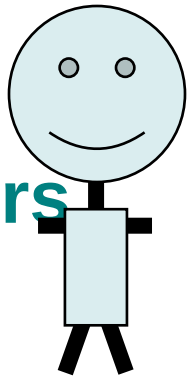
- **Google**
  - **“dicom toolkit”**
- **Some useful web sites with links**
  - **http://www.dclunie.com**
  - **http://www.idoimaging.com**
- **Forum for dicom discussion**
  - **news:comp.protocols.dicom**
  - **http://groups.google.com/group/comp.protocols.dicom/**

Finding test images

- **Not quite as easy as finding tools**
- **Google**
  - **“dicom samples”, “dicom images”**
- **Some useful web sites with links**
  - **http://www.dclunie.com**
  - **http://barre.nom.fr/medical/samples/**
  - **http://gdcm.sourceforge.net/wiki/index.php/Sample_DataSet**
  - **http://www.nibib.nih.gov/Research/Resources/ImageClinData**
- **There is no “official” test library**
  - **ftp://medical.nema.org/MEDICAL/Dicom/DataSets**
  - **Used to be private, but now appears to be open for all**
- **NO-ONE seems to have made “minimalist” objects for testing that you don’t rely on optional elements**

Conclusions

- **Plethora of implementations and tools**
  - **many are free and open source**
  - **many are well supported**
  - **so, do not fear DICOM's "complexity"**
- **Testing is important**
  - **failure to test is inexcusable**
  - **good testing leads to happy customers**
- **IHE can help**
  - **use the profiles, use the tools, participate**



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Thank you for your attention !