



PRESIMAL Workshop at  
Solstrand, 2022

Digital Imaging and Communications in Medicine

# DICOM – there can be only one

“DICOM ensures that all computer systems in clinics, medical imaging centers, and hospitals will work together and distribute the digital medical images correctly, across countries, modalities, and clinics.”

# Experiment

<https://haukebartsch.github.io/dicom-meta-data-viewer/>

SCAN ME



### About

Review a zip file with DICOM inside to make sure we forward the right information.  
This page will not transfer any files to our server.

Looking for test data?

```
git clone https://github.com/ImagingInformatics/hackathon-dataset.git
cd hackathon-dataset
git submodule update --init --recursive
Afterwards zip this folder or sub-folders and upload at "Browse File".
```

### Contact

Hauke Bartsch

DICOM is complete

[git source code](#)

This page only accepts zip folders and parses them for DICOM files. It is safe to use this application on sensitive data as no part of your zip-files will be uploaded to any server. If this application is used on a hosted system, that system might track who or how often this service is used. All data stays on your system and computations are done in your web-browser.

Browse File

hackathon-images.zip

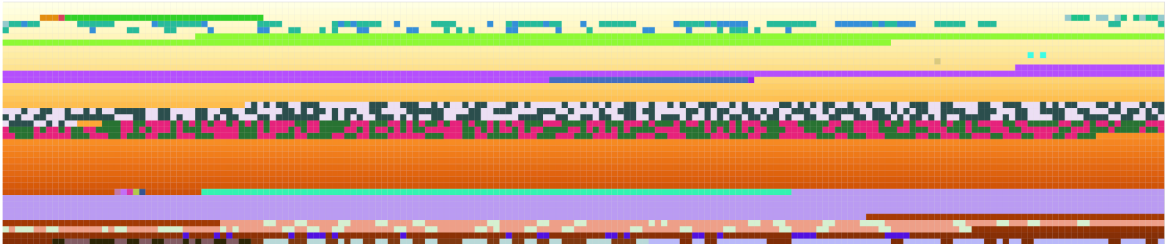
### Summary

Number of files: 3,666/7,706  
Number of series: 37

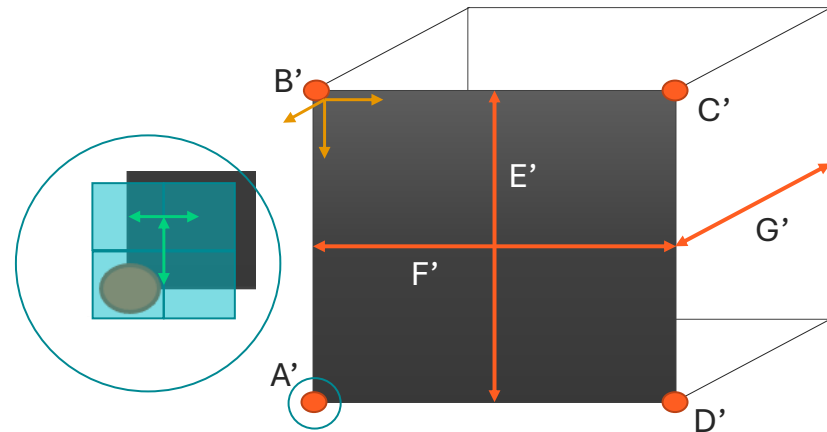
#files: 34 SeriesNumber: Modality:	TCGA-17-Z058, Sun Mar 30 1986 Topogram 1.0 T20s #files: 2 SeriesNumber: 1 Modality: CT	TCGA-17-Z058, Sat May 31 1986 #files: 1 SeriesNumber: 000002 Modality: CT	TCGA-17-Z058, Tue Apr 22 1986 Abd.CT 5.0 B30s #files: 127 SeriesNumber: 2 Modality: CT
TCGA-BA-4077, Tue May 14 1996 CT 5.0 B40s #files: 26 SeriesNumber: 2 Modality: CT	TCGA-50-5072, Wed Apr 19 2000 WB_2D AC #files: 267 SeriesNumber: 5 Modality: PT	TCGA-50-5072, Fri Feb 11 2000 WB_2D NAC #files: 267 SeriesNumber: 6 Modality: PT	TCGA-50-5072, Wed Apr 19 2000 WB_2D NAC #files: 267 SeriesNumber: 6 Modality: PT
TCGA-BA-4077, Sun Apr 28 1996	TCGA-17-Z058, Tue Apr 22 1986	TCGA-BA-4077, Tue May 14 1996	TCGA-BA-4077, Tue May 14 1996

### Details

hackathon-images.zip (loaded in 3309ms)



# How do we describe things in space?



We need conventions on how to store data for 2D and 3D:

bounding-box + matrix size + encoding per value + number of values per pixel

Tricky corner cases!

What about rotations?

What could possibly go wrong?

# Interfile

```
-----  
#define MDC_INTF_MAXKEYCHARS 256  
char keystr[MDC_INTF_MAXKEYCHARS];  
/* the data type */  
#define MDC_INTF_STATIC 1  
#define MDC_INTF_DYNAMIC 2  
#define MDC_INTF_GATED 3  
#define MDC_INTF_TOMOGRAPH 4  
#define MDC_INTF_CURVE 5  
#define MDC_INTF_ROI 6  
/* the process status */  
#define MDC_INTF_ACQUIRED 1  
#define MDC_INTF_RECONSTRUCTED 2  
/* gated spect nesting outer level */  
#define MDC_INTF_NESTING_SPECT 1  
#define MDC_INTF_NESTING_GATED 2  
typedef struct MdcInterFile_t {  
    int data_type, process_status, pixel_type, gspect_nesting;  
    Uint32 width, height, images_per_dimension, time_slots;  
    Uint32 data_offset, data_blocks, imagesize, number_images;  
    Uint32 energy_windows, frame_groups, time_windows, detector_heads;  
    float pixel_xsize, pixel_ysize, slice_thickness, centre_centre_separation;  
    float study_duration, image_duration, image_pause, group_pause, ext_rot;  
    Int8 patient_rot, patient_orient, slice_orient;  
    double version;  
} MDC_INTERFILE;  
-----
```

.hdr

.img

Error prone

Difficult to add new things

```

short qform_code ;    /*!< NIFTI_XFORM_ code.    */ /*-- all ANALYZE 7.5 ---*/
short sform_code ;    /*!< NIFTI_XFORM_ code.    */ /*  fields below here  */
                                     /*  are replaced        */

float quatern_b ;      /*!< Quaternion b param.    */
float quatern_c ;      /*!< Quaternion c param.    */
float quatern_d ;      /*!< Quaternion d param.    */
float qoffset_x ;      /*!< Quaternion x shift.    */
float qoffset_y ;      /*!< Quaternion y shift.    */
float qoffset_z ;      /*!< Quaternion z shift.    */

float srow_x[4] ;      /*!< 1st row affine transform. */
float srow_y[4] ;      /*!< 2nd row affine transform. */
float srow_z[4] ;      /*!< 3rd row affine transform. */

char intent_name[16]; /*!< 'name' or meaning of data. */

char magic[4] ;        /*!< MUST be "ni1\0" or "n+1\0". */

} ;                    /**** 348 bytes total ****/

```

## NIFTI header (Mayo/SPM Analyze format + orientation information) —

[https://en.wikipedia.org/wiki/Analyze\\_\(imaging\\_software\)](https://en.wikipedia.org/wiki/Analyze_(imaging_software))

# DICOM<sup>®</sup> is a **Standard** for communication of **medical imaging** information.

## History of DICOM 1980 -

<https://www.dicomstandard.org/history>

### History

DICOM<sup>®</sup> is a **Standard** for communication of **medical imaging** information. Selected highlights of its history are shown below:

#### 1980

In the beginning... it was very difficult for anyone other than manufacturers of **computed tomography (CT)** or **magnetic resonance imaging (MRI)** devices to decode the images that the machines generated, or to print them.

#### 1983

The **American College of Radiology (ACR)** and the **National Electrical Manufacturers Association (NEMA)** joined forces and formed a Standards committee to meet the combined needs of radiologists, physicists and equipment vendors.

# How is position described in DICOM?

### 1 Patient Level:

Patient's Name

Patient ID

### Patient's Sex

### Patient's Birth Date

### Specific Character Set

## 2 Study Level:

Study Instance UID

Study Date

## Study Time

Referring Physician's Name

Study ID

Accession Number

### 3 Series Level:

Series Instance UID

Series Number

Manufacturer

### Attributes

(group)      (tag)

(0018,0051) - Patient Position relative to the imaging equipment space : “FFS” – Feet first - Supine  
(Face up)

(0020,0032) – Image Position (Patient): "-142.7265625\ -302.7265625\ -270.5"

(0020,0037) – Image Orientation (Patient): "1\0\0\0\1\0"

(0020,1041) – Slice Location: "270.5" (rows) (columns)

(0028,0030) – Pixel Spacing: “0.703125, 0.703125”

Even more details:

<https://dicom.innolitics.com/ciods/ct-image/general-series>

# Create a DICOM file

```
hauke@Haukes-MacBook-Pro-4 DICOM % ls -laghtr
total 0
drwxr-xr-x  2 wheel   64B Sep 14 07:26 .
drwxr-xr-x  5 wheel  160B Sep 14 07:26 ..
hauke@Haukes-MacBook-Pro-4 DICOM % touch empty.dump
hauke@Haukes-MacBook-Pro-4 DICOM % dump2dcm empty.dump one.dcm
W: output transfer syntax unknown, assuming --write-xfer-little
hauke@Haukes-MacBook-Pro-4 DICOM % dcmftest one.dcm
yes: one.dcm
hauke@Haukes-MacBook-Pro-4 DICOM % dcmdump one.dcm

# Dicom-File-Format

# Dicom-Meta-Information-Header
# Used TransferSyntax: Little Endian Explicit
(0002,0000) UL 194 # 4, 1 FileMetaInfo
(0002,0001) OB 00\01 # 2, 1 FileMetaInfo
(0002,0002) UI [1.2.276.0.7230010.3.1.0.1] # 26, 1 MediaStorage
(0002,0003) UI [1.2.276.0.7230010.3.1.4.0.74507.1663133221.580797] # 50, 1 M
(0002,0010) UI =LittleEndianExplicit # 20, 1 TransferSynt
(0002,0012) UI [1.2.276.0.7230010.3.0.3.6.6] # 28, 1 Implementati
(0002,0013) SH [OFFIS_DCMTK_366] # 16, 1 Implementati

# Dicom-Data-Set
# Used TransferSyntax: Little Endian Explicit
hauke@Haukes-MacBook-Pro-4 DICOM % dcmdump one.dcm > step1.dump
hauke@Haukes-MacBook-Pro-4 DICOM % vim step1.dump
hauke@Haukes-MacBook-Pro-4 DICOM % dump2dcm step1.dump two.dcm
hauke@Haukes-MacBook-Pro-4 DICOM % dcmdump two.dcm

# Dicom-File-Format

# Dicom-Meta-Information-Header
# Used TransferSyntax: Little Endian Explicit
(0002,0000) UL 194 # 4, 1 FileMetaInformationGroupLength
(0002,0001) OB 00\01 # 2, 1 FileMetaInformationVersion
(0002,0002) UI [1.2.276.0.7230010.3.1.0.1] # 26, 1 MediaStorageSOPClassUID
(0002,0003) UI [1.2.276.0.7230010.3.1.4.0.74507.1663133221.580797] # 50, 1 MediaStorageSOPInstanceUID
(0002,0010) UI =LittleEndianExplicit # 20, 1 TransferSyntaxUID
(0002,0012) UI [1.2.276.0.7230010.3.0.3.6.6] # 28, 1 ImplementationClassUID
(0002,0013) SH [OFFIS_DCMTK_366] # 16, 1 ImplementationVersionName

# Dicom-Data-Set
# Used TransferSyntax: Little Endian Explicit
(0010,0010) PN [WORKSHOP01] # 10, 1 PatientName
(0010,0020) LO [WORKSHOP01] # 10, 1 PatientID
hauke@Haukes-MacBook-Pro-4 DICOM %
```



# Magic numbers

1.3.6.1.4.1.45037.5.2.1.6279.6001.314138616411061948052843767346

Organization root: 1.3.6.1.4.1.45037 (whodunit)

Descriptive suffix: 5.2.1

Unique suffix: 6279.6001.314138616411061948052843767346

Get an organization id if you generate DICOM files:

<http://www.oid-info.com/get/1.3.6.1.4.1.45037>

SOPInstanceUID, SeriesInstanceUID, StudyInstanceUID, Frame of Reference UID

```

[hauke@Haukes-MacBook-Pro-4 DICOM % img2dcm --series-from two.dcm image.jpg three.dcm
[hauke@Haukes-MacBook-Pro-4 DICOM % dcmdump three.dcm

# Dicom-File-Format

# Dicom-Meta-Information-Header
# Used TransferSyntax: Little Endian Explicit
(0002,0000) UL 196 # 4, 1 FileMetaInformationGroupLength
(0002,0001) OB 00\01 # 2, 1 FileMetaInformationVersion
(0002,0002) UI =SecondaryCaptureImageStorage # 26, 1 MediaStorageSOPClassUID
(0002,0003) UI [1.2.276.0.7230010.3.1.4.0.15096.1663134574.193501] # 50, 1 MediaStorageSOPInstanceUID
(0002,0010) UI =JPEGFullProgression:Non-hierarchical:Process10+12 # 22, 1 TransferSyntaxUID
(0002,0012) UI [1.2.276.0.7230010.3.0.3.6.6] # 28, 1 ImplementationClassUID
(0002,0013) SH [OFFIS_DCMTK_366] # 16, 1 ImplementationVersionName

# Dicom-Data-Set
# Used TransferSyntax: JPEG Full Progression, Non-hierarchical, Process 10+12
(0008,0005) CS [ISO_IR 100] # 10, 1 SpecificCharacterSet
(0008,0016) UI =SecondaryCaptureImageStorage # 26, 1 SOPClassUID
(0008,0018) UI [1.2.276.0.7230010.3.1.4.0.15096.1663134574.193501] # 50, 1 SOPInstanceUID
(0008,0020) DA (no value available) # 0, 0 StudyDate
(0008,0030) TM (no value available) # 0, 0 StudyTime
(0008,0050) SH (no value available) # 0, 0 AccessionNumber
(0008,0064) CS [WSD] # 4, 1 ConversionType
(0008,0070) LO (no value available) # 0, 0 Manufacturer
(0008,0090) PN (no value available) # 0, 0 ReferringPhysicianName
(0010,0010) PN [WORKSHOP01] # 10, 1 PatientName
(0010,0020) LO [WORKSHOP01] # 10, 1 PatientID
(0010,0030) DA (no value available) # 0, 0 PatientBirthDate
(0010,0040) CS (no value available) # 0, 0 PatientSex
(0020,000d) UI [1.3.6.1.4.1.45037.5.2.1.123456789] # 34, 1 StudyInstanceUID
(0020,000e) UI [1.3.6.1.4.1.45037.5.2.1.987655444] # 34, 1 SeriesInstanceUID
(0020,0010) SH (no value available) # 0, 0 StudyID
(0020,0011) IS (no value available) # 0, 0 SeriesNumber
(0020,0013) IS (no value available) # 0, 0 InstanceNumber
(0020,0020) CS (no value available) # 0, 0 PatientOrientation
(0028,0002) US 1 # 2, 1 SamplesPerPixel
(0028,0004) CS [MONOCHROME2] # 12, 1 PhotometricInterpretation
(0028,0010) US 10 # 2, 1 Rows
(0028,0011) US 10 # 2, 1 Columns
(0028,0100) US 8 # 2, 1 BitsAllocated
(0028,0101) US 8 # 2, 1 BitsStored
(0028,0102) US 7 # 2, 1 HighBit
(0028,0103) US 0 # 2, 1 PixelRepresentation
(0028,2110) CS [01] # 2, 1 LossyImageCompression
(0028,2114) CS [ISO_10918_1] # 12, 1 LossyImageCompressionMethod
(7fe0,0010) OB (PixelSequence #=2) # u/l, 1 PixelData
  (fffe,e000) pi (no value available) # 0, 1 Item
  (fffe,e000) pi ffd8\xff\db\00\43\00\03\02\02\03\02\02\03\03\03\04\03\03\04\05... # 326, 1 Item
  (fffe,e0dd) na (SequenceDelimitationItem) # 0, 0 SequenceDelimitationItem
[hauke@Haukes-MacBook-Pro-4 DICOM %

```

# Private Tags

---

(0013,0000): "6"

(0013,0010): "CTP"

(0013,1010): "TCGA-LUAD"

(0013,1013): "77779002"

# DICOM is complex because medical imaging has many components, but it is not difficult.

---

Meaning of DICOM tags:

<https://dicom.innolitics.com/ciods/rt-plan/rt-series/00080060>

# How to build a medical workstation

All tools are freely available, reliable and fast



# Hospital Systems

PACS

Modality

Modality

PACS

Modality

PACS

Workstation

Workstation

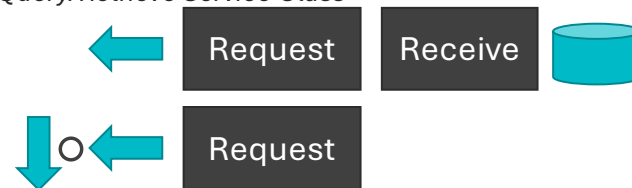
## Workstation



## Orchestration

*Service Class User (SCU) for  
Query/Retrieve Service Class*

*SCP for the Storage Service Class*



# DCMTK

(C++ solution for Mac, Windows, Linux)



Home  
General Information  
• Standardization  
• Introduction to DICOM  
DICOM Demos  
• DICOM Networks

## DCMTK - DICOM Toolkit

dicom.offis.de

Version in

### Description

DCMTK is a collection of libraries and applications implementing large parts the DICOM standard. It includes software for examining, constructing and converting DICOM image files, handling offline media, sending and receiving images over a network connection, as well as demonstrative image storage and worklist servers. DCMTK is written in a mixture of ANSI C and C++. It comes in complete source code and is made available as "open source" software.

Example:

<https://github.com/HaukeBartsch/data-transfer-station>

