ORTHANC — Lightweight, RESTful DICOM Server for Healthcare and Medical Research

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FOSDEM, FOSS for Scientists, February 2nd, 2013
1 Introduction
   - What is Radiotherapy?
   - The Radiotherapy Process
   - DICOM Format and Protocol

2 Orthanc
   - Philosophy
   - Orthanc in Action
   - Current Applications

3 Conclusions
   - How to Contribute?
   - Summary
What is Radiotherapy?

“The medical use of ionizing radiation, generally as part of cancer treatment, to control or kill malignant cells.”

At CHU of Liège (Belgium)

- ≈ 2400 new cases per year.
- First radiotherapy department in Wallonia.
- Second in Belgium (KUL).
Modern Treatment Machines at Liège

Elekta
- Linear accelerator ($\approx 20$ MV).
- Embedded imaging for positioning (2D or 3D).

CyberKnife
- Linac on a robotic arm.
- Very high doses.
- Breath tracking.
The Evolution of Radiotherapy

Surgical Strike

Main Problem
How to identify the target? ⇒ Medical Imaging
Multimodal Medical Imaging for Radiotherapy

CT + MRI + PET-CT
 Overall Process

- CT
- MRI
- PET-CT

**Contouring**
(orans, tumor)

**Ballistics**
(optimization)

- Elekta
- Cyberknife

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Orthanc
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What is Radiotherapy?
The Radiotherapy Process
DICOM Format and Protocol
Software Challenges of Modern Radiotherapy

- Many images are produced and analyzed.
- Exchange of images between several medical departments.
- Each image is heavyweight (≈ 512MB per 3D image).
- Many manufacturers are involved ⇒
  - Proprietary, costly, closed software.
  - Limited interoperability.
What Is DICOM?
What Is DICOM?

1. File Format:

One **image slice** + Patient **metadata**
What Is DICOM?

1. **File Format:**
   - One image slice + Patient metadata

2. **Network Protocol** — Early example of Web services:
   - Search remote images,
   - Send local images,
   - Retrieve remote images.
What Is DICOM?

Part of the Solution

- De-facto standard in medical imaging.
- Mature (30 years old).
- Supported by any medical device.
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Part of the Problem
- Large and complex (over 4000 pages).
- Old format and protocol (redundant with XML, SOAP,...).
- Huge number of files (3D images split slice-by-slice)
  ⇒ Redundancies between DICOM files,
  ⇒ Need for automated indexing.
- Not developer-friendly (complex parsing).
Main Open-Source Software for DICOM

<table>
<thead>
<tr>
<th>DICOM Toolkits</th>
<th>DICOM Databases (aka. PACS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>DCMTK (format, protocol),</td>
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Main Open-Source Software for DICOM

**DICOM Toolkits**
- DCMTK (format, protocol)
- GDCM (format only)

**DICOM Databases (aka. PACS)**
- Dcm4chee
- Dicoogle

**Limitations**
- Close-to-metal (network administrators?)
- No indexing
- Windows support

**Limitations**
- Heavyweight
- Database administration
- Still need a DICOM toolkit to automate tasks
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Philosophy

1. **Compromise** between a DICOM toolkit and a PACS.
2. **Lightweight** DICOM store (standalone, cross-platform).
3. **Immediate to deploy** on any PC (no external database).
4. **RESTful API** to DICOM format and protocol.  
   ⇒ DICOM scripting (network administrators).
5. Convert DICOM files to **modern formats** (JSON and PNG).
6. Simple **Web interface** to explore the content of the store.
7. ...And, of course, **open-source :)**
Software Architecture
Features

- “Patient → Study → Series → Instance” transparent indexing.
- Preview of images inside the browser.
- Send to other DICOM modalities.
- Download ZIP files.
- Anonymization.
sys.path.append('Orthanc/Resources/Samples/Python')
from RestToolbox import *

# Event polling loop
current = 0
while True:
    # Wait for the occurrence of new events in Orthanc
    r = DoGet('http://localhost:8042/changes', {'since': current})

    # React when a new instance is received
    for change in r['Changes']:
        if change['ChangeType'] == 'NewInstance':

            # Send the new instance to the PACS
            instanceld = str(change['ID'])
            DoPost('http://localhost:8042/modalities/pacs/store', instanceld)

            # Remove the instance from Orthanc
            DoDelete('http://localhost:8042/instances/%s' % instanceld)

    current = r['Last']
time.sleep(1)
Current Applications of Orthanc

- **DICOM buffer** for transmission errors:
  - Nuclear Medicine → Radiotherapy,
  - Treatment Planning System → Treatment machines.
- Collect in-room images for **adaptive radiotherapy** research.
- **Anonymization platform** for clinical research with firms.
- Automated **quality control** of PET-CT scanners.
- Automated **quantification of focal fibrosis** on cardiac MRI.
- **Mini-PACS** on desktop computers ⇒ medical and image processing research.
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How to Contribute?

- Develop a professional, Web-based DICOM viewer (WebGL) ⇒ MIP, PET/CT/MRI fusion, windowing, projection,...

- Port to OS X, RHEL and CentOS.
- FUSE filesystem on the top of the REST API.
- Support WADO, standardize WADO-RS (RESTful DICOM).
- Implement DICOM-RT primitives (for radiotherapy).
- Develop a Matlab/Octave toolbox.
Summary

https://orthanc.googlecode.com/

- Open-source DICOM store.
- Lightweight, scriptable, versatile.
- Availability:
  - Part of Debian Med,
  - Fedora package waiting for approval,
  - Windows binaries.
- Publications: ISBI 2013, ESTRO 2013, 2 @ BHPA 2013.
Appendix
Ohloh Statistics

Languages

- C++: 73%
- C: 13%
- CMake: 6%
- 6 Other: 8%

Lines of Code

- Code
- Comments
- Blanks

2013
Focus on Automated Testing

- Continuous Integration Server,
- Unit testing,
- Integration tests through REST API,
- Valgrind,
- Trello to track developments.
Desirable Features for a Novel DICOM Viewer

- Web-based ⇒ accessible from any PC in the hospital without installation.
- Cross-platform, lightweight (WebGL, XTK, Slice:Drop).
- Side-by-side display, link the two series of images (with zoom).
- Windowing (Hounsfield units, 16bpp).
- 3D view + 2D projections (axial, coronal, sagittal).
- PET/CT/MRI superposition and alignment (offsets).
- MIP rendering (Maximum Intensity Projection ⇔ EXT_blend_minmax).
- Display DICOM-RT (doses and structures).
- Possibility to use non-destructive image compression.
- Speed, smoothness, stability, simplicity (of course).
- Other features: Consider OsiriX (but OS X only!).