CAPTAIN: Automatic workflow manager

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Outline

- CAPTAIN, the origin
- Why working with Orthanc?
- Interface Orthanc-CAPTAIN
- Workflow manager structure
- Application examples
- Who use it?
Context

- Research activities in proton therapy:
  - Dedicated to increase indication for proton therapy

- Need tool to support research activities:
  - Imaging: image quality to compute proton dose
  - Clinical workflow: how to go to adaptive proton therapy
  - Comparison Proton therapy (PT) with photon therapy (RT)

- Need platform to support research
  - CAPTAIN – Orthanc platform.
What is CAPTAIN?

Open-source platform:
- Automatic workflow manager.
- Web-based
- High Modularity

Interfaced with Orthanc:
- Dicom PACS used as dicom interface

Interfaced with Stone of Orthanc:
- Dicom web viewer used for online results review
What is CAPTAIN?

DICOM instances
On central server
Computation process.
Automation tool
On any web-browser
Why Captain was developed?

**Origin:**
- Research project with University of Pennsylvania Proton therapy center.
- Computation of Proton therapy clinical indicators based on the virtual CT.

- Acquire CBCT
- Manual transfer data
- Researcher physically move
- Load data
  - configure indicator
  - run analysis in MatLab
- Review results individually in Matlab

**CAUTION**
- Time consuming.
- Non efficient.
- High risk of Human error
Why Captain was developed?

**Origin:**
- Research project with University of Pennsylvania Proton therapy center.
- Computation of Proton therapy clinical indicators based on the virtual CT.

- Acquire CBCT
  **Data transferred automatically from AI**

- Matlab run automatically on a server
  No need of user connected

- Review results on web-browser

**Suggested solution:**
Automation
CAPTAIN Orthanc interface

Need of a DICOM PACS

Requirements:
- A Dicom interface to receive data from imaging system, TPS and OIS:
  - PT/RT plan
  - PT/RT dose map
  - Structure set
  - CT – CBCT – vCT – 4DCT
- Open-source tool
- Dicom standard interface
- Web API available
CAPTAIN Orthanc interface

Requirements:
- A Dicom interface to receive data from imaging system, TPS, OIS and to store dicom results
- Open-source tool
- Dicom standard interface
- Web API available
CAPTAIN Orthanc interface

Requirements:
- A Dicom interface to receive data from imaging system, TPS, OIS and to store dicom results
- Open-source tool
- Dicom standard interface
- Web API available
- Dicom web-viewer for workflow result review

Stone of Orthanc
Lightweight, cross-platform C++ framework for the CPU-based rendering of medical images.
CAPTAIN Orthanc interface

In practice:

1. Data received on dicom interface (port 4242).
2. Orthanc server parse received data:
   • Lua script on Orthanc server
   • Notification to CAPTAIN (patient ID, study ID) on REST API

1. CAPTAIN received notification from Orthanc.
2. CAPTAIN request detailed information:
   • Contact orthanc API (port 8042)
   • Retreive all information needed to trigger WF.
3. CAPTAIN launh computation WF:
   • Contact Orthanc API to download dicom files (series/instances) – Plan, CT, structure set.
4. CAPTAIN post Dicom result on Orthanc PACS
   • Upload dicom result to Orthanc PACS
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4. CAPTAIN post Dicom result on Orthanc PACS
   - Upload dicom result to Orthanc PACS
CAPTAIN workflow manager

1. Web-based interface

2. Access list of Patient:
   - Orthanc patient are automatically added in the app
   - Not All patient are in Orthanc (depend if presence of DICOM data)

3. Display (by extending) workflow available for each patient

4. Workflow configuration

5. Trigger the workflow manager:
   - When new data arrives on Orthanc -> Automatic
   - When new WF configuration
   - When force by the user
CAPTAIN workflow manager

- **Process:** From the researcher. C/C++, python, MatLab, …
  - Can be use in standalone

- **Task:**
  - Load all input needed for the process, input json
  - Launch the process
  - Retrieve and store data

- **Workflow:**
  - Chain of tasks
  - Contains rules to start the workflow.
  - Trigger each task sequentially.
  - Save all data.

- **Application:** Workflow(S) to tackle the issue
CAPTAIN workflow manager

Library of computation tasks

- Dose computation
- Launch Raystation
- Clinical goals
- DVH + gamma
- MatLab
- Python
- C++
- ...

Workflow:
- = combination of tasks.
- 100% customizable

External Trigger

Workflow manager

High Modularity

Workflow 1
Workflow 2
Workflow 3
...
Application of CAPTAIN: Case 1

Clinical indicators:

1. Daily CBCT
2. Compute “virtual CT”
3. Dose warping

Thoracic Cancers
First Clinical Investigation of Cone Beam Computed Tomography and Deformable Registration for Adaptive Proton Therapy for Lung Cancer

Catarina Veiga, MSc, Guillaume Janssens, PhD, Ching-Ling Teng, PhD, Thomas Baudier, BSc, Lucian Hotoiu, PhD, Jamie R. McClelland, PhD, Gary Royle, PhD, Liyong Lin, PhD, Linshu Yin, PhD, James Metz, PhD, Timothy N. Solharm, PhD
Application of CAPTAIN: Case 1

- Clinical indicators:

1. Daily CBCT
2. Compute "virtual CT"
3. Compute dose on v-CT
4. Display DVH & clinical indicators

Dose restoration?  Off-line replanning?
Application of CAPTAIN: Case 1

- Clinical indicators:
  - Partner: UPENN
  - 1st application (April 2017)

- Version to display in Adapt insight
  (IBA imaging software for CBCT acquisition and Patient poistionning)

- Version connecting to Raystation (TPS)
  - (demo at ASTRO 2017)
  - [https://www.youtube.com/watch?v=edU5OTCWsP4](https://www.youtube.com/watch?v=edU5OTCWsP4)
Application of CAPTAIN: Case 2

- Dose restoration (adaptive therapy):
  - Partner: KUL/UCL

Dose restoration aims to stabilize the dose i.e. **restore the clinically approved IMPT dose** distribution on the treatment day, **independently** on anatomical changes in patient.
Application of CAPTAIN: Case 2

- Dose restoration (adaptive therapy):
  - Partner: KUL/UCL
Dose restoration (adaptive therapy):
- Partner: KUL/UCL
- Prototype January 2019

- 4 workflows.
- Online adaptive.
Application of CAPTAIN: Case 3

CDSS (NTCP automatic computation)

NTCP models validated by academia

ΔNTCP = NTCP_Φ - NTCP_p+

Prediction of DELTA Normal tissue complication probability
Application of CAPTAIN: Case 3

- CDSS (NTCP automatic computation):
  - Partner – UMCG (Groningen Netherland) – Miami Cancer institute
  - 1st prototype prior Astro 2018

- Aim
  - Provide Automatic computation of probability of complication after radiation therapy.
  - PT/RT comparison
  - Based on delivered dose
  - NTCP models published
Application of CAPTAIN: Case 3

- CDSS (NTCP automatic computation):
  - Partner – UMCG (Groningen Netherland) – Miami Cancer institute
  - 1st prototype prior Astro 2018

https://www.youtube.com/watch?v=O9vtF0x90wE&t=8s
Application of CAPTAIN: Case 4

- **Log-based QA:**
  - Partner: UMCG
  - Prototype started spring 2018 – last update September 209

- Automatic dose recomputation with secondary dose engine
- Dose recomputation based on irradiation log for QA
  - A lot of data stored on Orthanc.
  - Used of stone of Orthanc dicom viewer
Application of CAPTAIN: Case 4

- Log-based QA:

  - My QA ions

From the log-based QA workflow

- Based on same code for the computation
- Same architecture (JS to java).
- Use Orthanc as PACS.
- Continue observing evolution at UMCG to help defining roadmap in dosi.
- Show interest in features:
  - NTCP computation
  - Machine file QA

Product developed by IBA Dosimetry
Use of Stone of Orthanc

- Major feature of the platform.
- Web-based dicom viewer
- Allow fusion and overlay

Review of:
- image produced: vCT vs CT/CBCT
- Dose map computed
- LET map
- Gamma map
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CAPTAIN – Orthanc: supported by openpath

- CAPTAIN is a central piece of OpenPath
- The open source research strategy: https://openpath.software
So what is CAPTAIN

- The CDSS: NO
- The Log based QA: NO
- Clinical indicators: NO
- OpenPath: NO

It is a tool.
A web-application providing an automatic workflow manager

YES

Fully customizable
Could be use for other purposes than PT clinical workflow
Conclusion

- CAPTAIN is an open-source platform for research.
- Orthanc is used as Dicom PACS for CAPTAIN application.
- Orthanc web API is a key feature in our application.
- High value with the Lua scripting in Orthanc.
- Results display with Stone-of-Orthanc Dicom web viewer.
- Used for research in proton therapy.
- Multiple research centers use it.

- More to come ...
Thank you