CAPTAIN: Automatic workflow manager

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Orthanc Con

13-16 December 2019

Liège (BE)

PROTON THERAPY
TODAY + TOMORROW

iba

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:

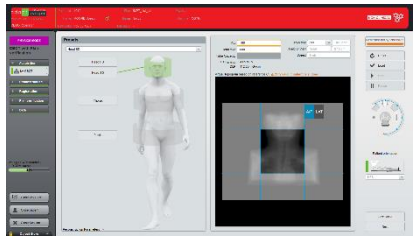
- Dicom web viewer used for online results review

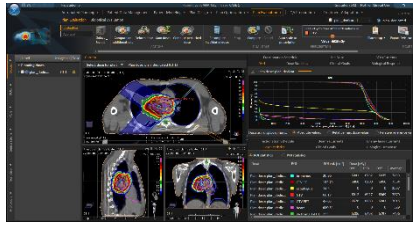
What is CAPTAIN ?

DICOM instances

On any web-browser

On central server





ORTHANC

Computation process.

aptain
automated PT platform

Automation tool

Why Captain was developed ?

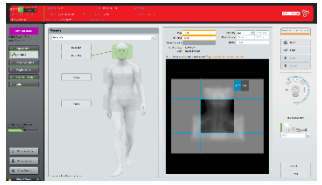
Origin: - Research project with University of Pennsylvania Proton therapy center.
- Computation of Proton therapy clinical indicators based on the virtual CT.

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

Time consuming.
Non efficient.
High risk of Human error

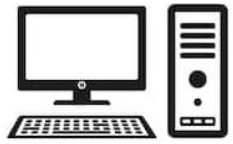
Why Captain was developed ?

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



Acquire CBCT

Data transfered automatically from AI



Matlab run automatically on a server

No need of user connected

Review results on web-browser

Suggested solution:

Automation

aptain
automated PT platform

RESEARCH

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

ORTHANC

OSIMIS
IMAGING · RE-WIRED

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.

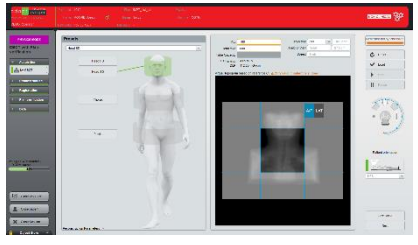
OSIMIS

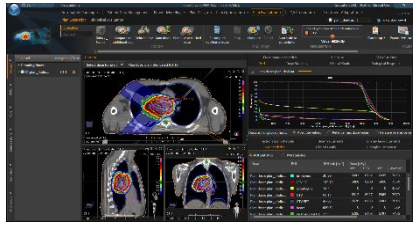
IMAGING · RE-WIRED

CAPTAIN Orthanc interface

In practice:

Image acquisition





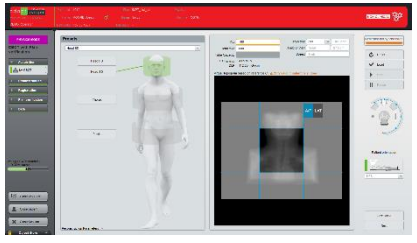
Treatment planning system (TPS)

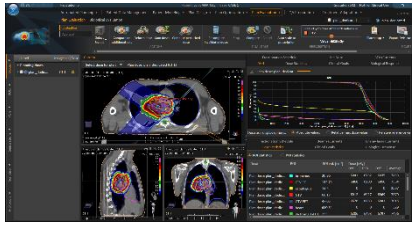
1. Data received on dicom interface (port 4242).
2. Orthanc server parse received data:
   - Lua script on Orthanc server
   - Notification to CAPTAIN (patient ID, study ID) on REST API

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

CAPTAIN Orthanc interface

In practice:





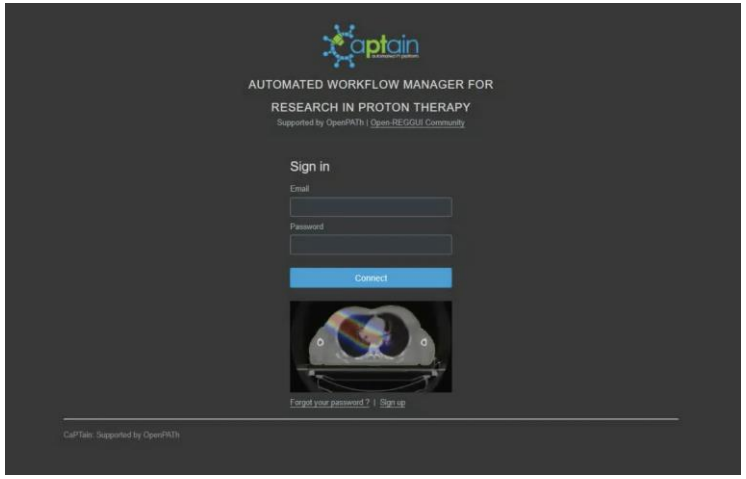
1. Data received on dicom interface (port 4242).
2. Orthanc server parse received data:
   - Lua script on Orthanc server
   - Notification to CAPTAIN (patient ID, study ID) on REST API

Orthanc Web API
Key feature of Orthanc
In CAPTAIN application

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

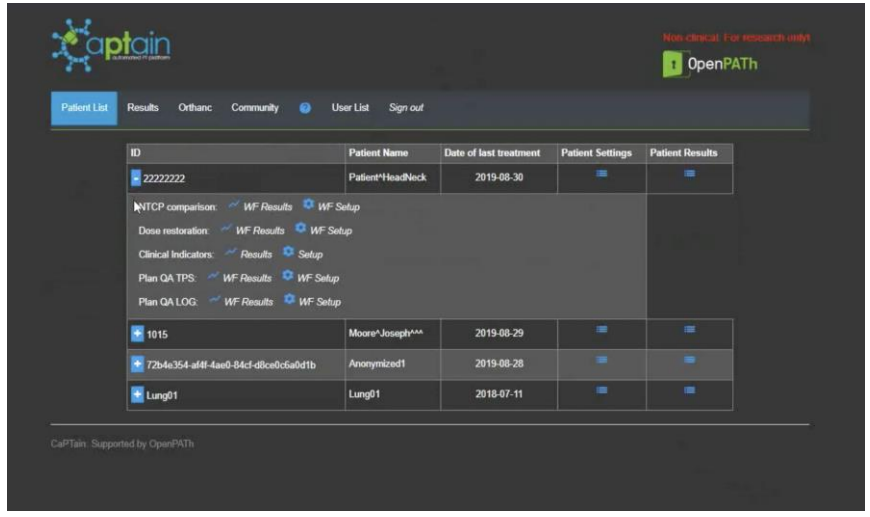
CAPTAIN workflow manager

1. Web-based interface

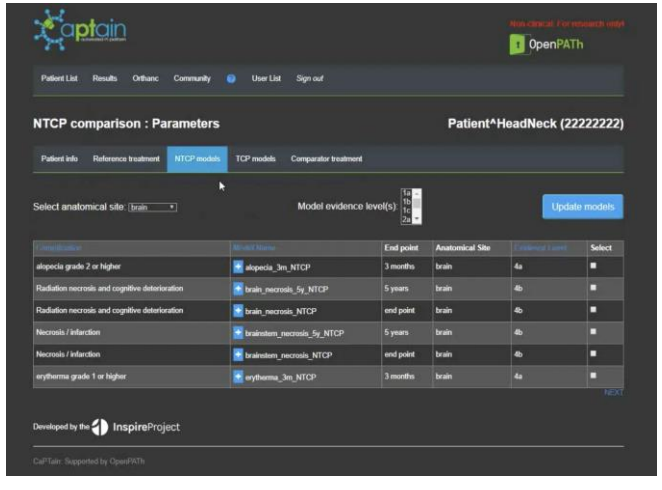


2. Access list of Patient:
   - Orthanc patient are automatically added in the app
   - Not All patient are in Orthanc (depend if presence of DICOM data)

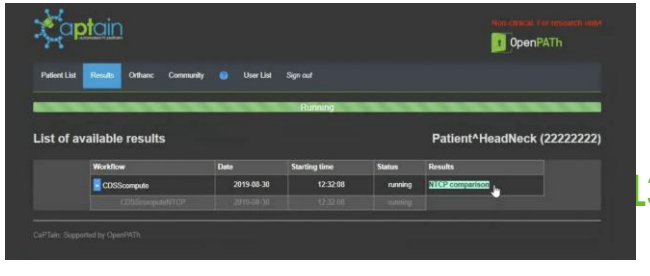
3. Display (by extending) workflow available for each patient



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:

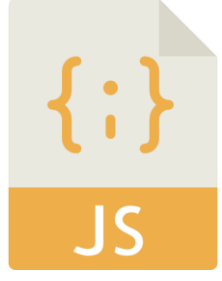
From the researcher. C/C++, python, MatLab, …

Can be use in standalone

- Task:

Load all input needed for the process, input json
Launch the process
Retreive 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

captain
automated PT platform

External Trigger

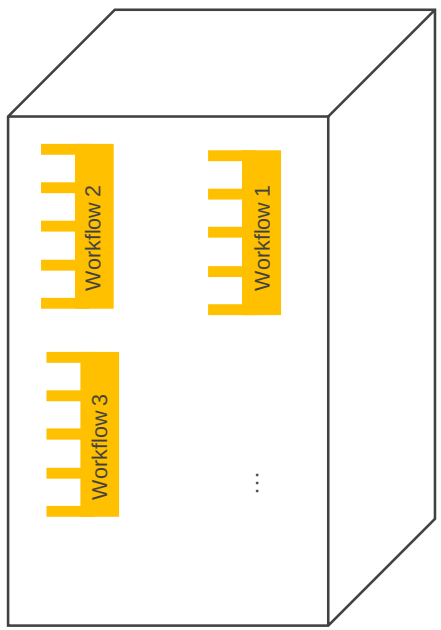
Workflow manager

Library of computation tasks

Dose computation	Launch Raystation
Clinical goals	…
DVH + gamma	…

- MatLab
- Python
- C++
- …

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

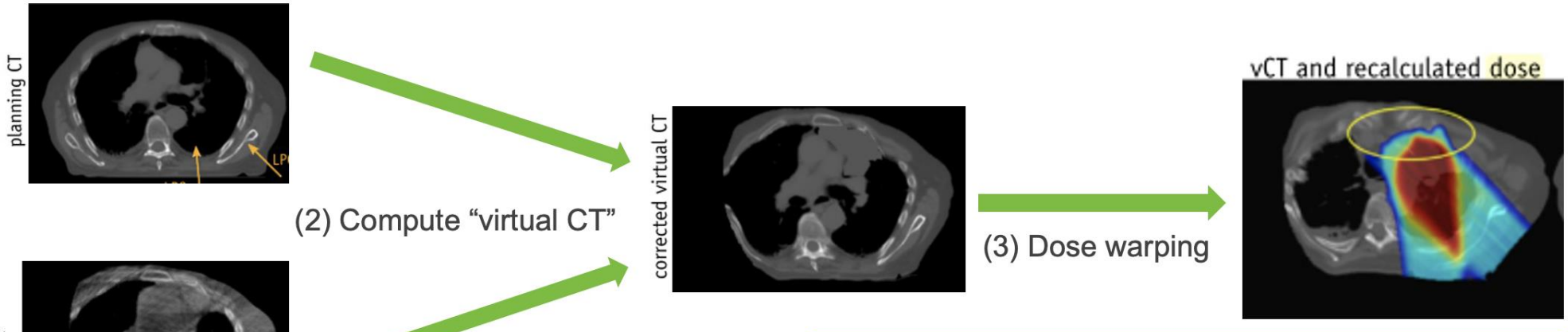


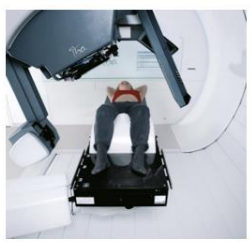
High Modularity

RESEARCH

Application of CAPTAIN: Case 1

- Clinical indicators:





(1) Daily CBCT

RTK

OpenReggui

International Journal of Radiation Oncology biology • physics

www.redjournal.org

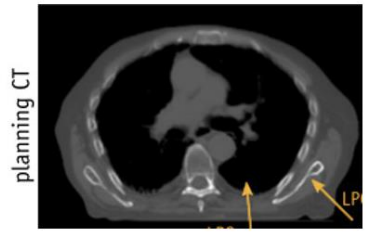
Thoracic Cancers

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

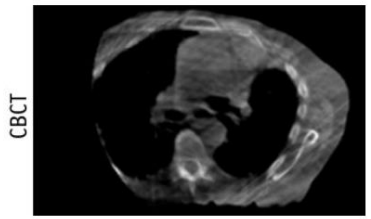
Catarina Veiga, MSc,* Guillaume Janssens, PhD,† Ching-Ling Teng, PhD,‡ Thomas Baudier, BSc,§ Lucian Hotoiu, PhD,§ Jamie R. McClelland, PhD,‖ Gary Royle, PhD,* Liyong Lin, PhD,‡ Lingshu Yin, PhD,‡ James Metz, PhD,‡ Timothy D. Solberg, PhD,‡

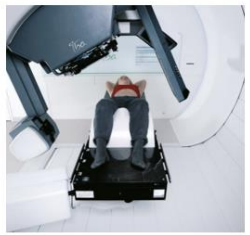
Application of CAPTAIN: Case 1

- Clinical indicators:

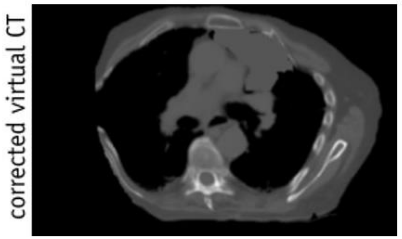


(2) Compute “virtual CT”





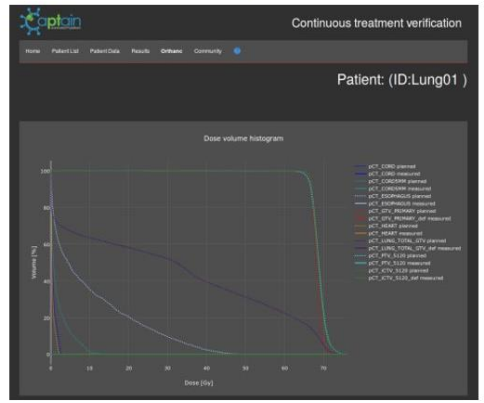
(1) Daily CBCT



OpenReggui
Captain
ORTHANC

RayStation

(3) Compute dose on v-CT



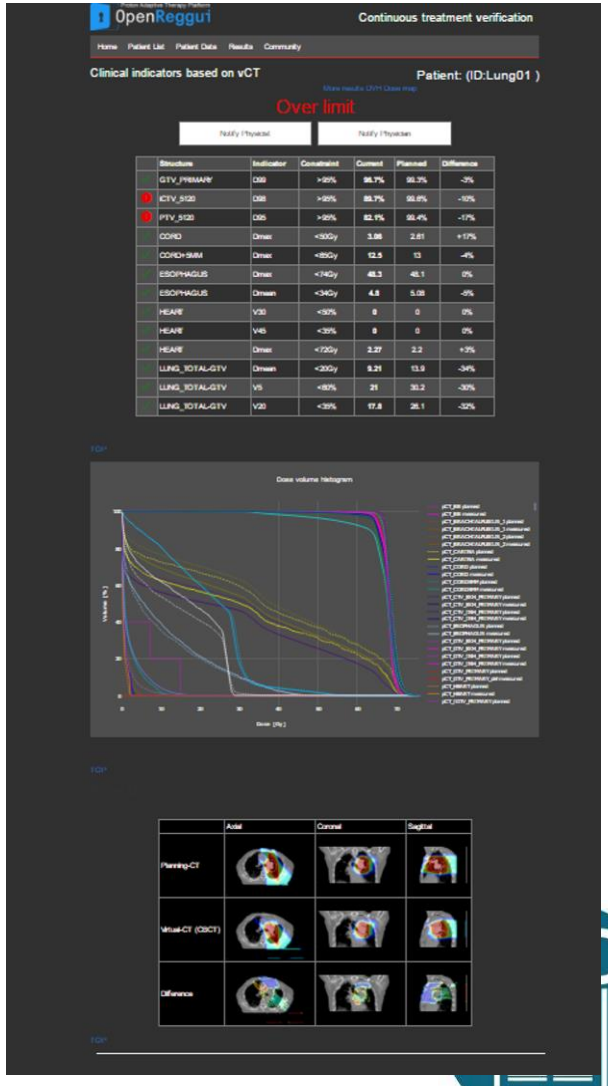
(4) Display DVH & clinical indicators

Dose restoration ?

Off-line replanni

Application of CAPTAIN: Case 1

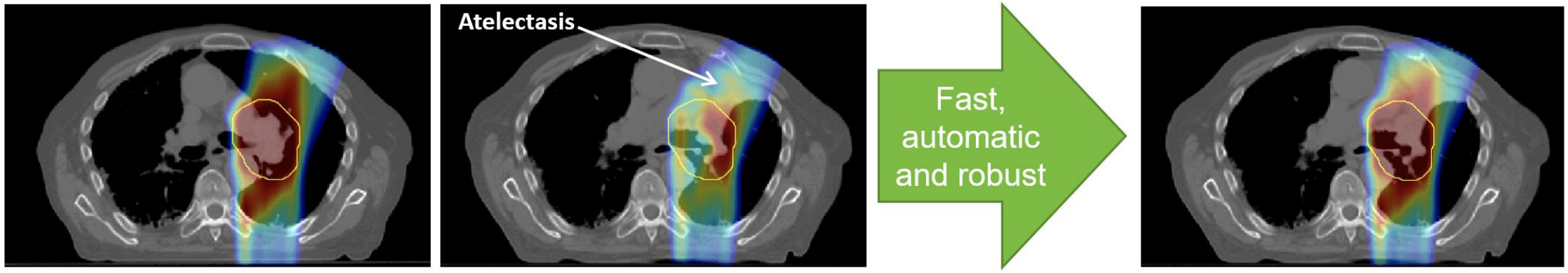
- Clinical indicators:
  - Partner: UPENN
  - 1st application (April 2017)
  - Version to display in Adapt insight
    (IBA imaging software for CBCT acquisition and Patient poistionning)
  - Version connecting to Raystation (TPS)
    - (demo at ASTRO 2017)
    - https://www.youtube.com/watch?v=edU5OTCWsP4



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



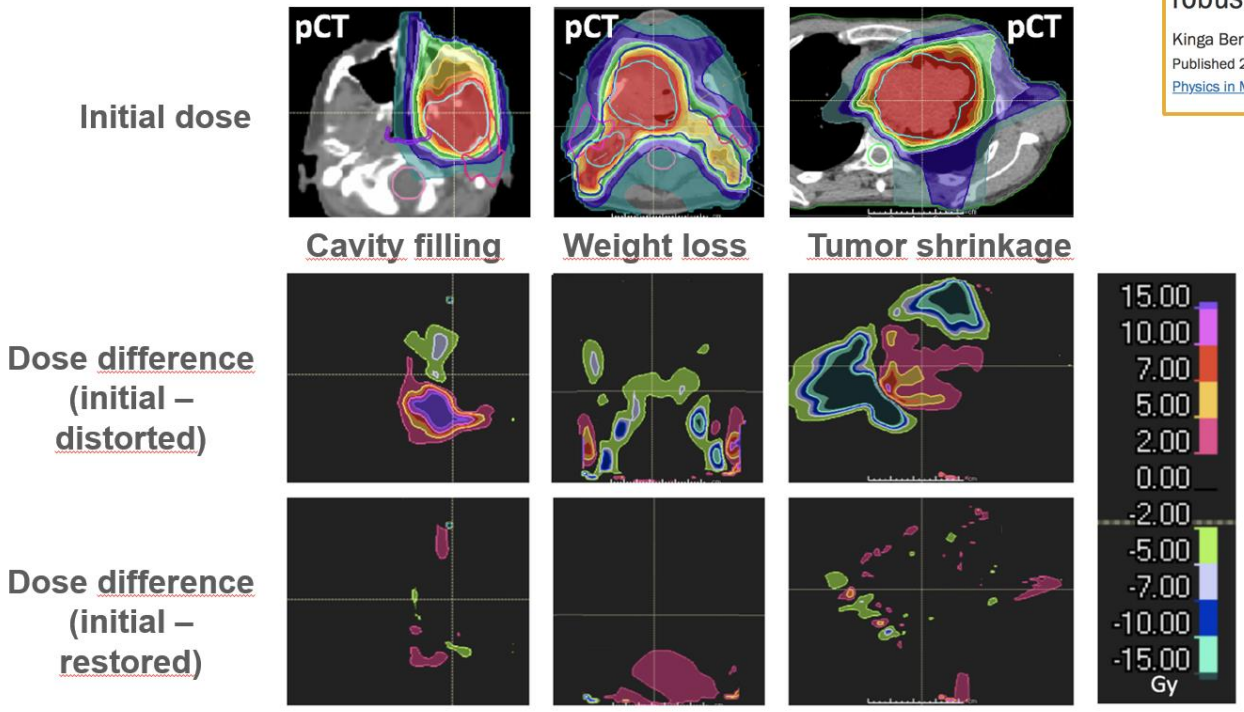
Planning CT (robust plan)

Repeated CT (anatomy change)

Restored dose on repeated CT

Application of CAPTAIN: Case 2

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



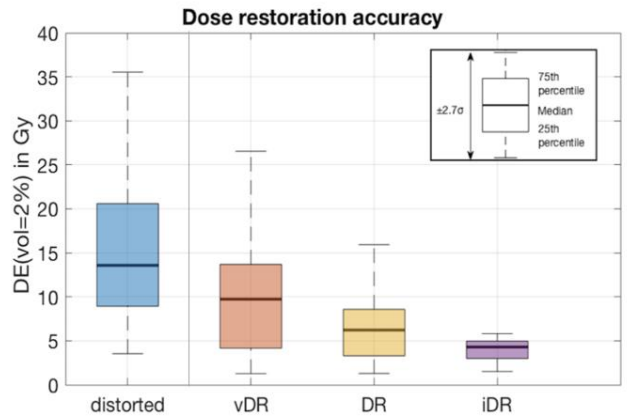
Physics in Medicine & Biology

PAPER

Feasibility of online IMPT adaptation using fast, automatic and robust dose restoration

Kinga Bernatowicz[1], Xavier Geets[1,2], Ana Barragan[1], Guillaume Janssens[3], Kevin Souris[1] and Edmond Sterpin[1,4]

Published 20 April 2018 • © 2018 Institute of Physics and Engineering in Medicine
Physics in Medicine & Biology, Volume 63, Number 8



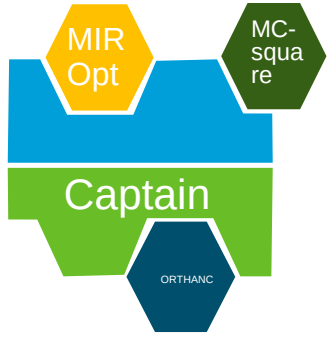
vDR: voxel-based dose restoration
DR: DVH-based dose restoration
iDR: isodose-based dose restoration

Application of CAPTAIN: Case 2

- Dose restoration (adaptive therapy):
  - Partner: KUL/UCL
  - Prototype January 2019
  - 4 workflows.
  - Online adaptive.

(1) In-room CT

(3) Iso-dose contours definition



(2) Automation server

RayStation

RESEARCH

(5) Review on web interface

Application of CAPTAIN: Case 3

- CDSS (NTCP automatic computation)

NTCP models

NTCP models validated by academia


Contents lists available at ScienceDirect

Radiotherapy and Oncology

journal homepage: www.thegreenjournal.com

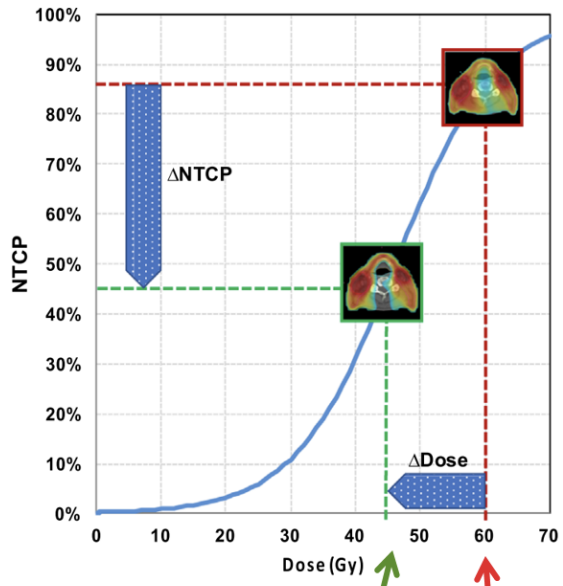
ELSEVIER

Swallowing dysfunction

A predictive model for swallowing dysfunction after curative radiotherapy in head and neck cancer

Johannes A. Langendijk[a,b,*], Patricia Doornaert[a], Derek H.F. Rietveld[a], Irma M. Verdonck-de Leeuw[c], C. René Leemans[c], Ben J. Slotman[a]

- Langendijk, J. A., et al.. (2009). A predictive model for swallowing dysfunction after curative radiotherapy in head and neck cancer. Radiotherapy and Oncology, 90(2), 189–195.
- Jackson, A., et al. (2010). The Lessons of QUANTEC: Recommendations for Reporting and Gathering Data on Dose-Volume Dependencies of Treatment Outcome. International Journal of Radiation Oncology Biology Physics, 76(3 SUPPL.), 155–160.
- .....



PT Dose map

RT Dose map

CDSS

$\Delta NTCP = NTCP_{\Phi} - NTCP_{p+}$

Prediction of DELTA Normal tissue complication probability

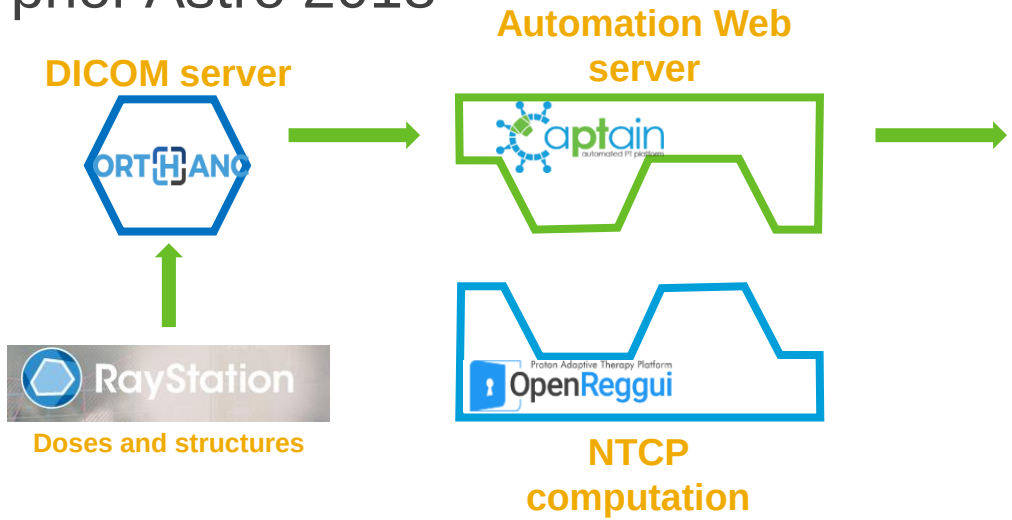
Application of CAPTAIN: Case 3

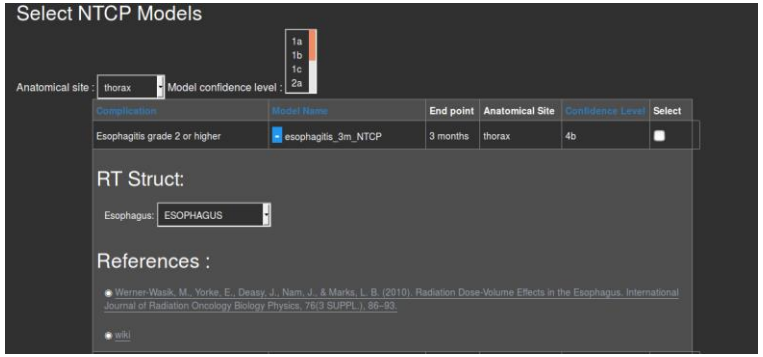
- CDSS (NTCP automatic computation):
  - Partner – UMCG (Groningen Netherland) – Miami Cancer institute
  - 1st prototype prior Astro 2018

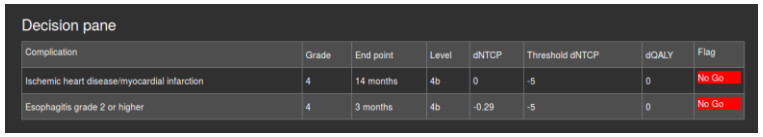
- Aim
  - Provide Automatic computation of probability of complication after radiation therapy.
  - PT/RT comparison
  - Based on delivered dose
  - NTCP models published

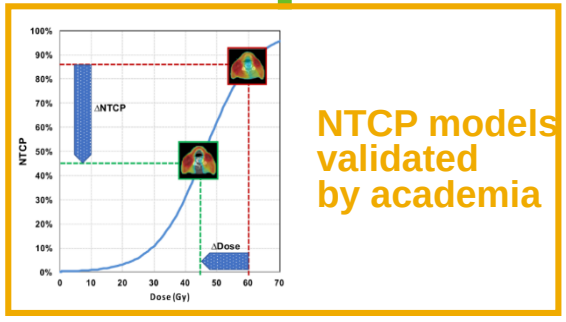
Application of CAPTAIN: Case 3

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







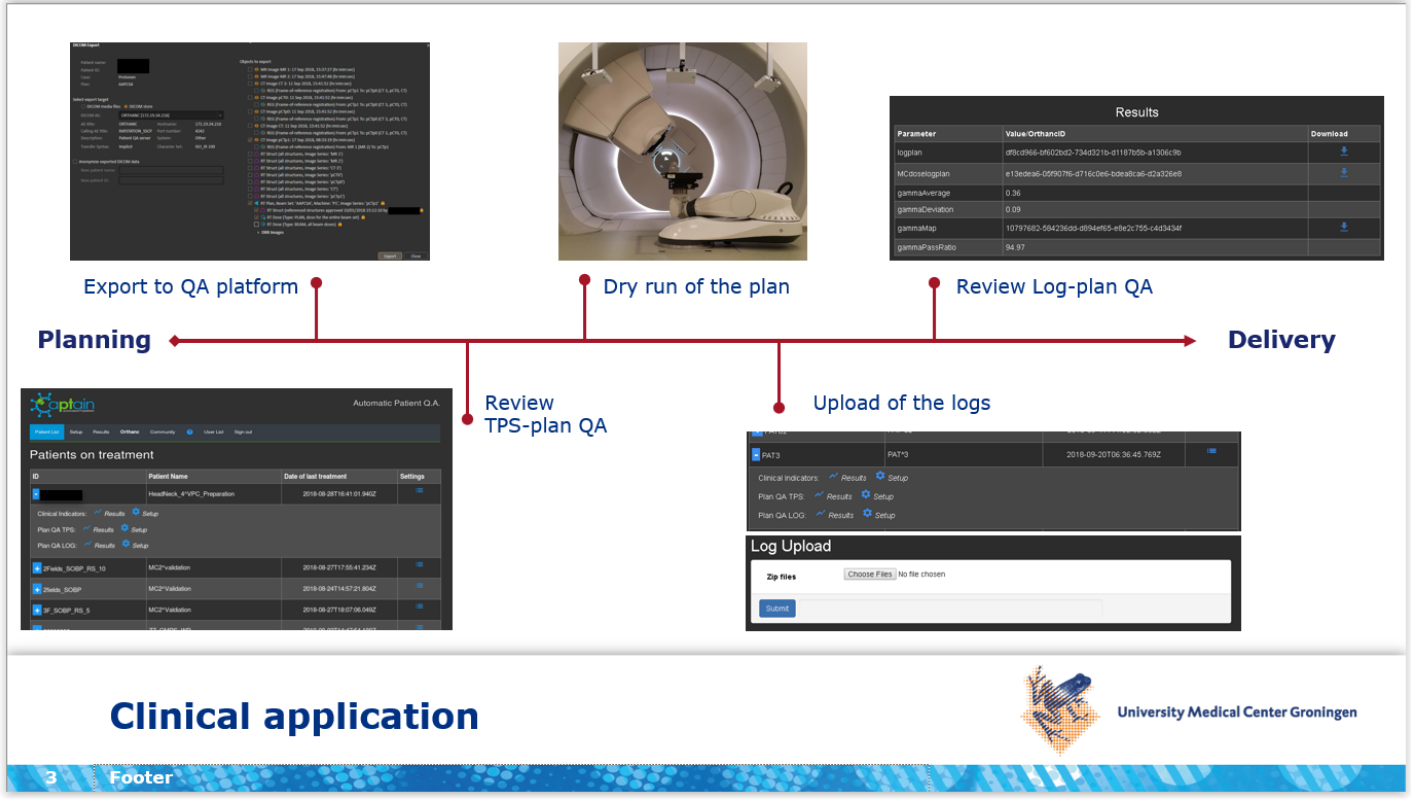


NTCP models validated by academia

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

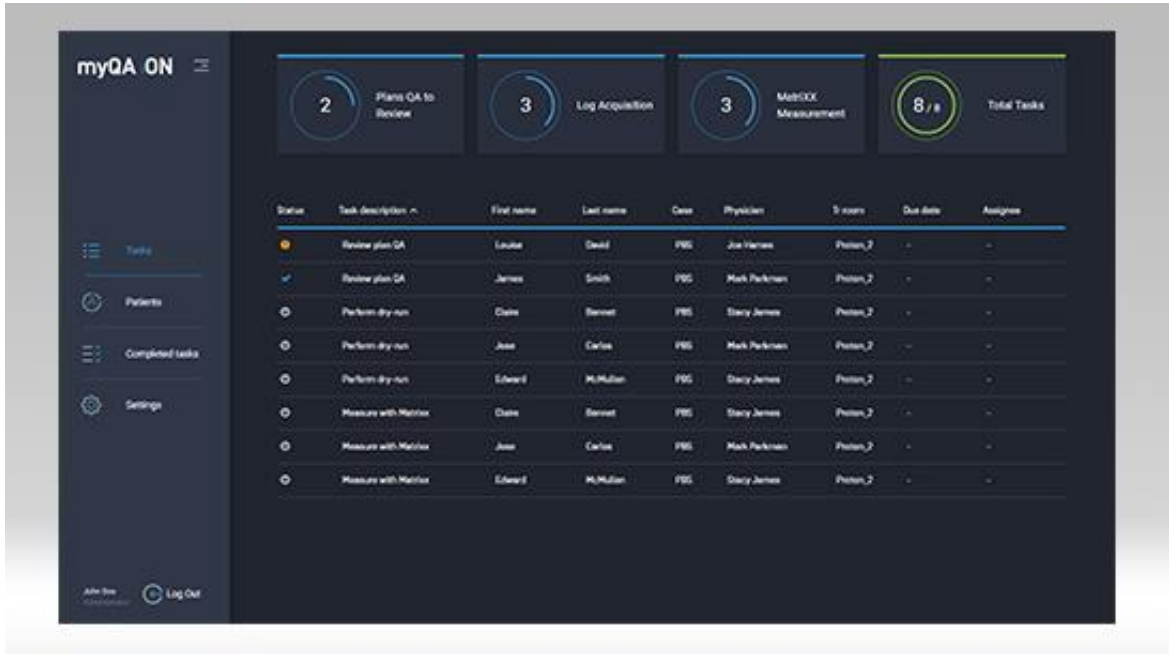
From the log-based QA workflow

- 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



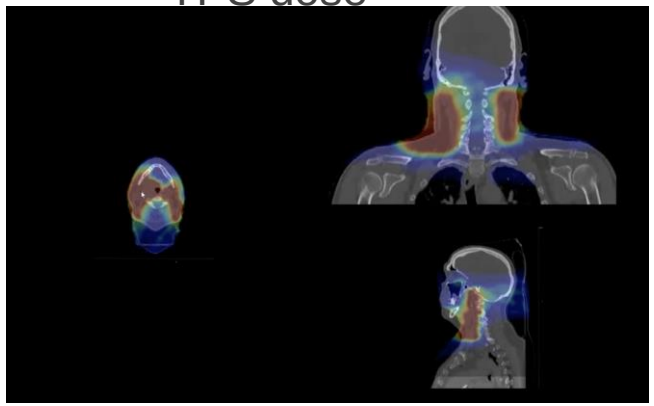
Use of Stone of Orthanc

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

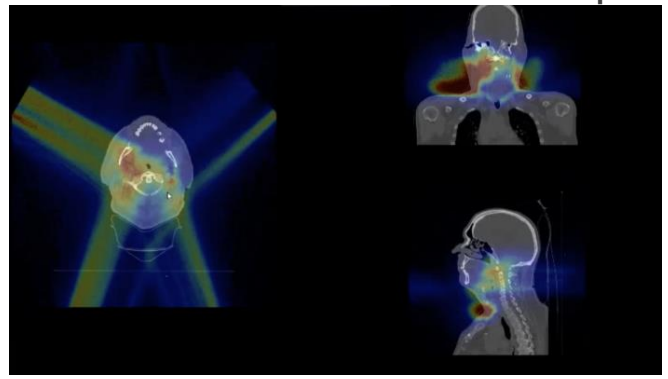
Review of:

- image produced: vCT vs CT/CBCT
- Dose map computed
- LET map
- Gamma map

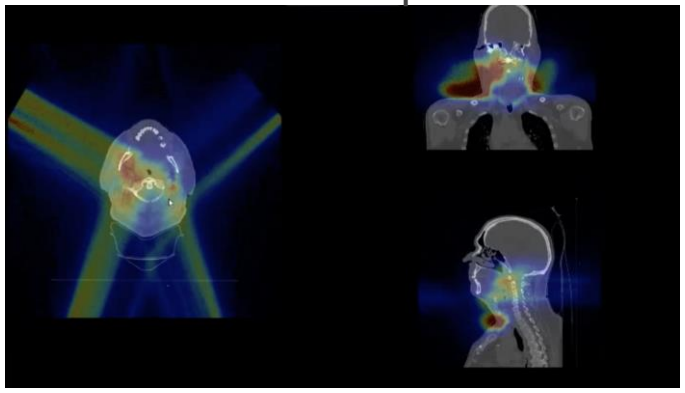
TPS dose

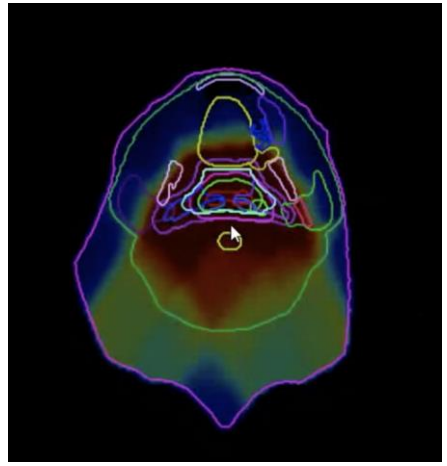


Monte-Carlo dose map



LET dose map





CAPTAIN – Orthanc users

N°	Status	User name	Installation	Location	Contact person	Installation by	Version date	Purpose
1	installed	UPENN	juil-17	Philadelphie		RLA - API		Clinical indicators
2	Installed - Active	UMCG	Feb 2018	Groningen	API	Done internally - API		QA - decision support
3	Installed - Active	MIRO	March 2019	BXL - St Luc		API		Dose restauration
4	installed	UFPTI	July 2018	Jacksonville		RLA - LHO		??
5	in progress	UZL-KUL	sept-19	Leuven	RLA	RLA-LHO-API		CDSS
6	compiled	Chicago	Jul 2018	Chicago	LHO	remote LHO		CDSS
7	in progress	Chicago	Oct-19	Chicago	LHO-API	remote		CDSS in CAPTAIN (for robust comparison)
8	Installed	BHSF	sept-19	Miami	API	remote by site engineer		CDSS in CAPTAIN
9	planned	Beaumont	Oct-19	Royal Oak	API	remote		CDSS in CAPTAIN

CAPTAIN – Orthanc: supported by openpath

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

MIROpt

4D robust dose optimizer

UCLouvain

RTK

Tomographic reconstruction toolkit

Creatis

MC SQUARE many monte carlo

Fast & accurate Monte Carlo dose engine for PBS

UCLouvain

RT K

MIR Opt

MC-squar e

OpenRegg ui

Captain

ORTH ANC

Proton Adaptive Therapy Platform OpenReggui

Image processing, proton physics (WET, LET,…)

UCLouvain LMU IBA Researc

aptain automated PT platform

Automation server and Web server

IBA Researc

ORTHANC

DICOM server

OSIMIS

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 fetaure 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 center use it.

- More to come ...

Thank you