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ADAPTIVE LUNG SBRT : DEFORMABLE REGISTRATIONS AND OTHER CHALLENGES

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Introduction

Many challenges must be solved to implement Adaptive Radiotherapy (ART) in Lung SBRT. Planning recalculation, dose accumulation, setup with limited field of view, operators time consuming are just some points. Between them validation of inter-fraction deformable images registration (DIR) seem to be the foundation on which the entire process have to be based. This study focuses on accuracy of deformable registration for Target and Organ at Risk (OAR) and highlight challenges.

Material and methods

8 patients with lung cancer treated by Tomotherapy using SBRT were enrolled in this retrospective study. Rigid and deformable registration of pre-treatment MVCT and planning kVCT have been performed by scripting automation to optimize human resources involved in process.

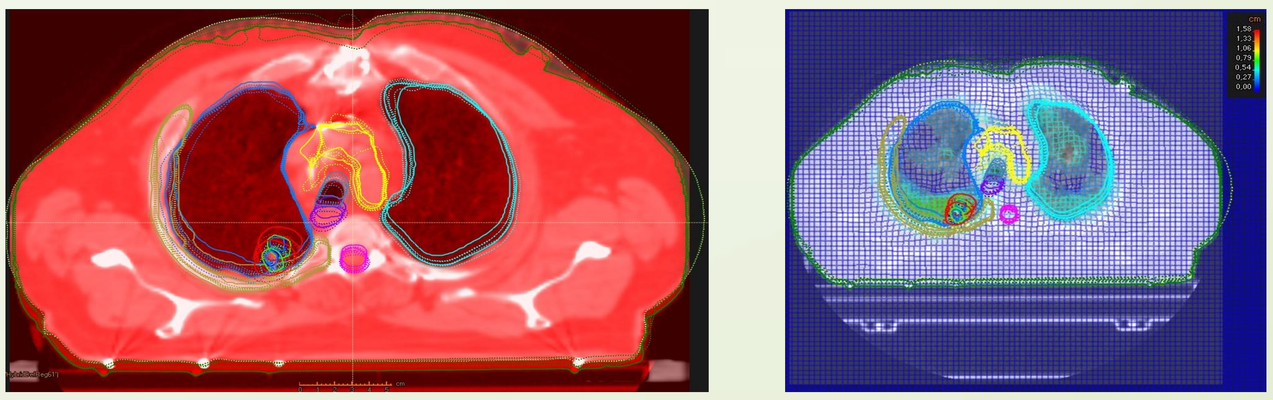


Figure 1 – Example of LUNG deformable registration (DIR) with deformed ROI 2- DIR Deformation Grid.

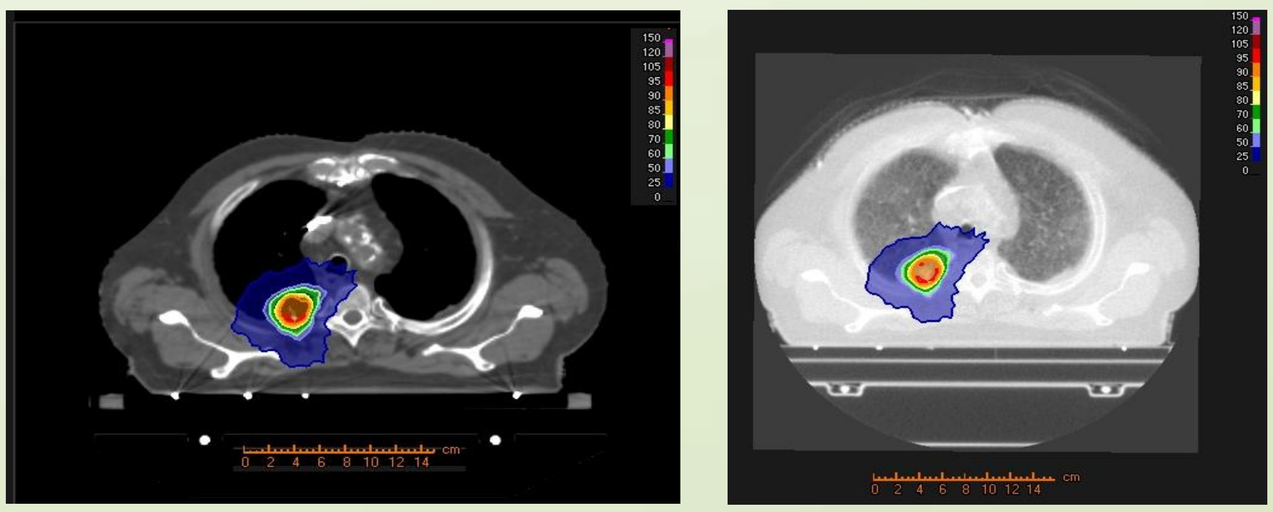


Figure 3 – Planned dose distriutin on kVCT 4 – Deformed dose distribution on MVCT

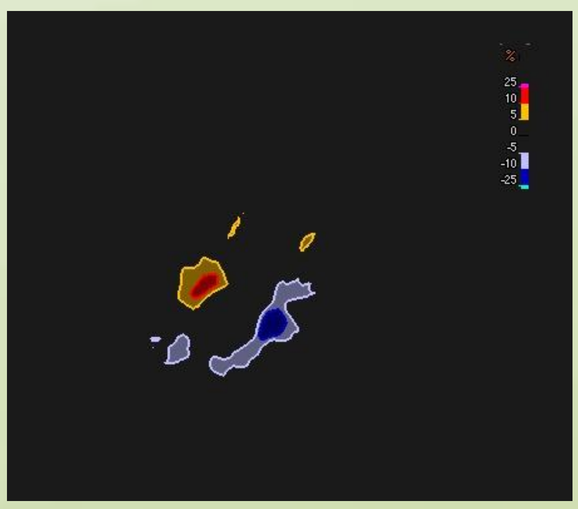
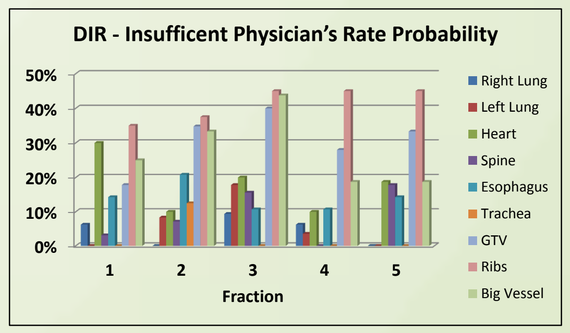


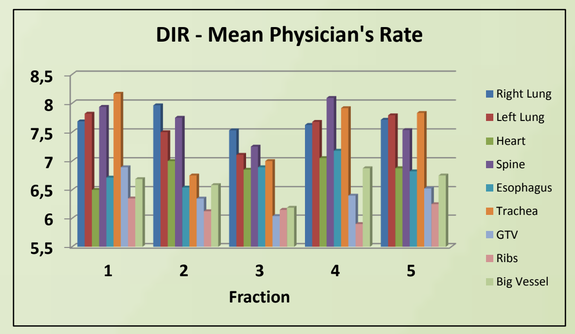
Figure 5 – Difference between planned (fig.3) and deformed dose (fig.4) distribution

Accuracy of the structures obtained by DIR have been evaluated in collaboration with 4 Radiation Oncologists. A score table rating ,from 1 to 10 (very bad – very good), have been implemented in a Bayesian Network to assess and develop a prediction tool for automatic structure deformation and propagation. For each fraction were obtained deformed doses to evaluate and track the dose as a first approach to dose accumulation process.

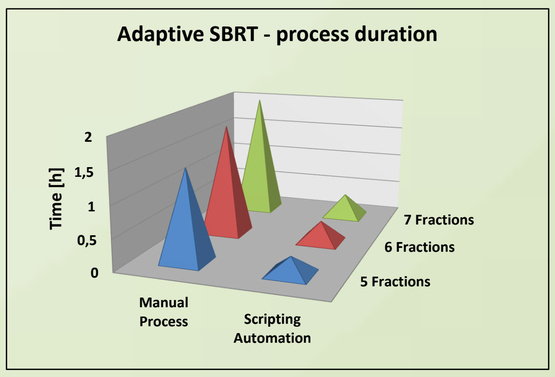
Results

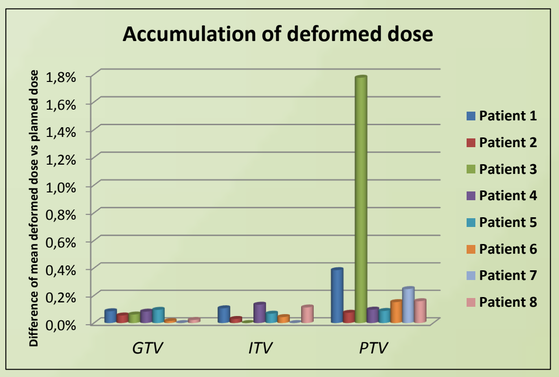
Physicians' rates were satisfactory and above the minimum acceptability criteria (rate=6). However some structures (Lungs, Spine cord, Trachea) seemed to be more suitable than others (GTV, Ribs, Great vessels) for the deformation process. Inter-judge variability have been quantified. Bayesian analysis showed that volume variation and physicians' ratings are not statistical independent but that large variation in structure size is strictly linked to bad rating (deformable failure). First assessment of dose accumulation showed an excellent agreement between planned and deformed doses in target, but non-negligible differences in OARs have been found (2/8 patients).





Plot 1 – Probability of insufficent (<6/10) physician's rate of deformable registration(DIR). Plot 2- Mean DIR physicians' rates for Target and OARs





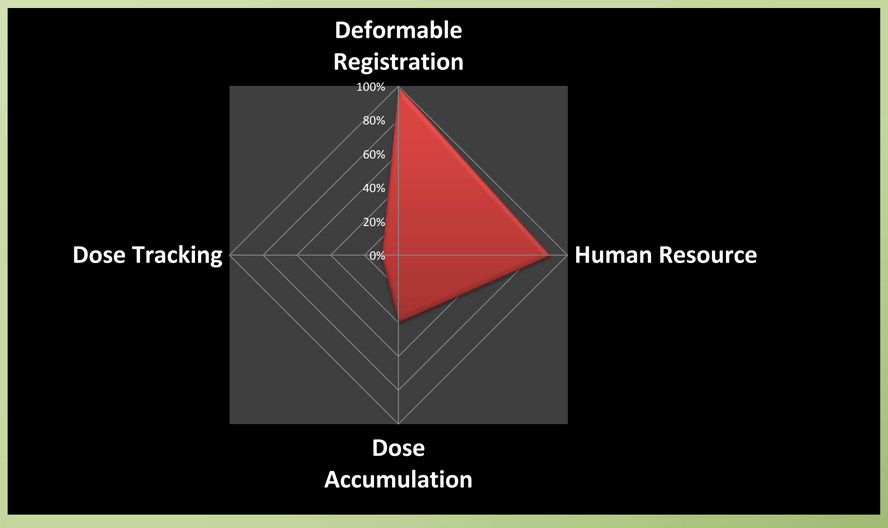
Plot 3 – Time sparing due to script automation. Plot 4 – Difference between planned dose and average of deformed dose for treated target.

Conclusion

First approach of ART feasibility in lung SBRT have been performed with good results. Automatic DIR for target and OAR have proven reliable and robustness using python scripting. Today SBRT and DIR workflow are applicable in clinical practice. Must be highlighted some challenges (summarized in table 1) due to automation of dose accumulation and tracking.

CRITICAL STEP	CHALLENGES	RESULTS
Deformable Registration	Limited FOV	*Validated*
	Inter-judge rate	
	DIR time consuming	
Human Resource	Scripting automation of images and structures for DIR	*Optimized*
	Dose tracking and accumulation must investigated	
Dose Accumulation	Discrepancy due to inter-judge of objects deformed and propagated	*First step*
	Limits due to different image quality and FOV limitation	
Dose Tracking	Available only for LINAC but not for Tomotherapy	*WIP*
	Not applicable in case of multiple lesions, re-treatments or recurrence	

Table 1 – Critical step and challenges for adaptive SBRT



Plot 5 – Prograss required before implementation of Adaptive SBRT in clinical practice

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