SHOULD THE DEFORMABLE IMAGE REGISTRATION METHOD BE INCLUDED IN THE CLINICAL ROUTINE?

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Contents

1. About the WP11
2. The in-house DR algorithm
3. Two phantom studies
4. A GYN-patients study
   - the poor contrast issue
   - the organ deformation
   - the DVH calculation
5. Conclusions

WP11 - To establish a software platform for evaluating combined modality treatment plans

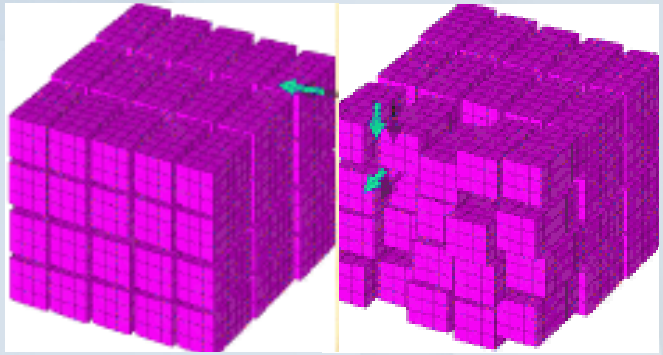
Deliverables & Milestones:

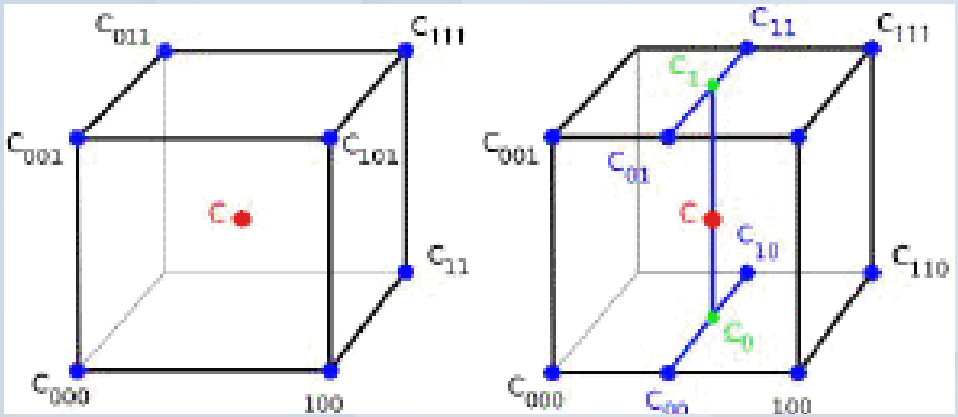
1. Patient image data – Data set
2. Patient treatment plans - TPS output reports
3. Image deformation models – Report (model description)
4. Final report on strategies for adaptive treatment – Final report

+ Many trainings!!

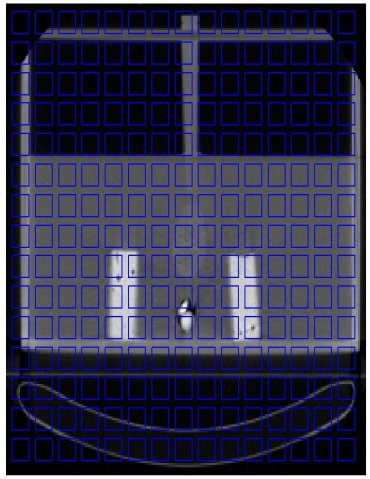
The in-house DR algorithm

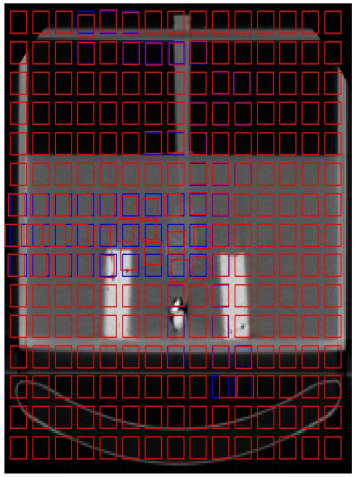
In the image deformable registration method both source and target images are divided into mega-volxels which are then independently rigidly registered as sub-images.



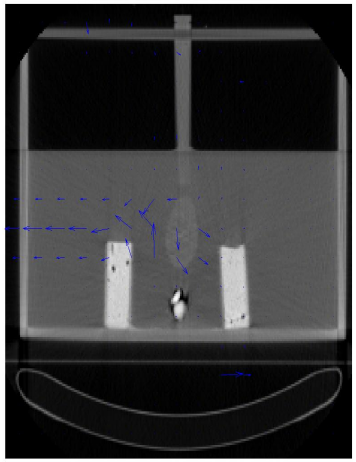


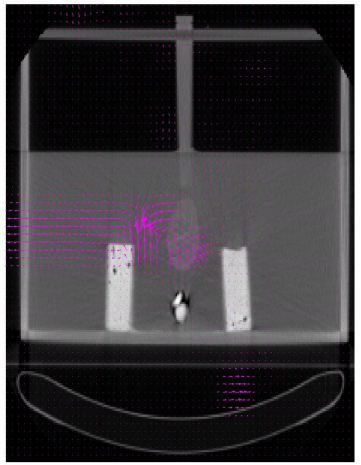
The interpolator will assign displacement values to the mega-voxels (featurelets) center's neighbours.

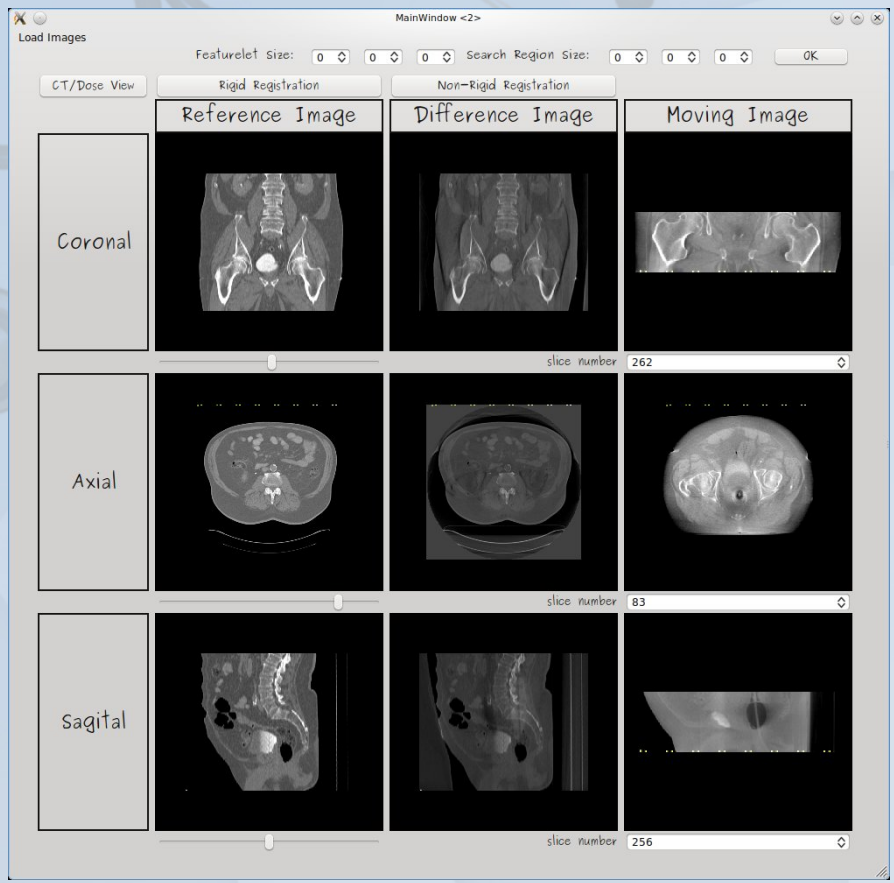


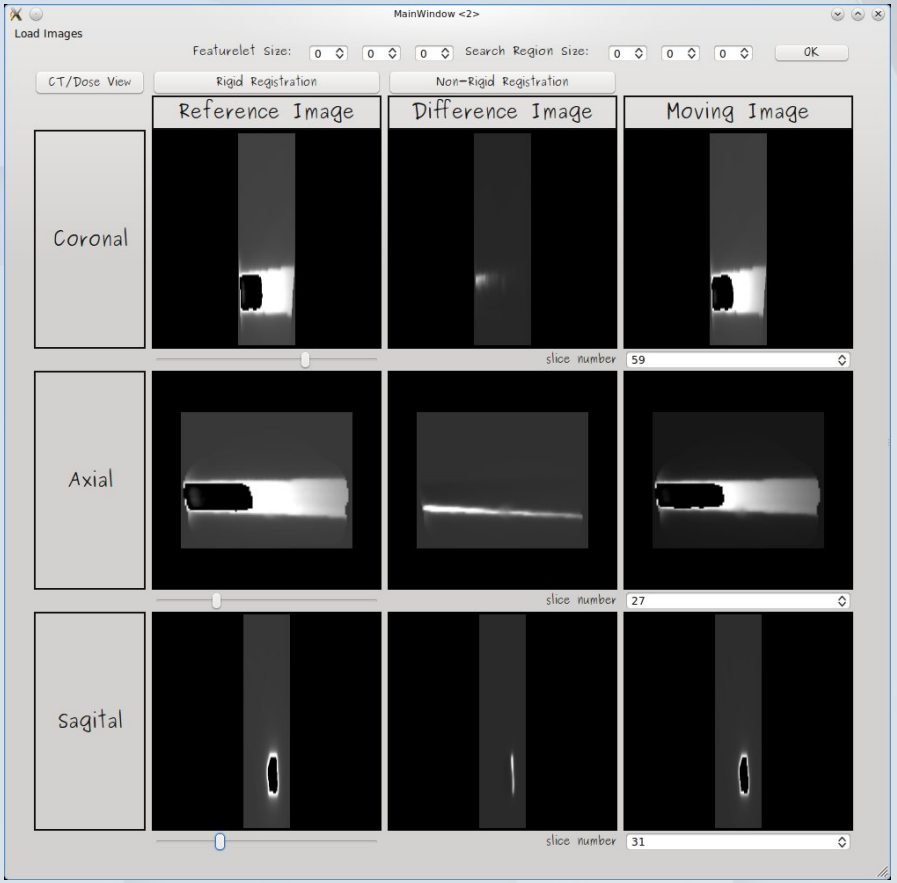


The deformation field is extracted from the featurelet registration and it can be visualised or applied to other images, such as dose or organ files.







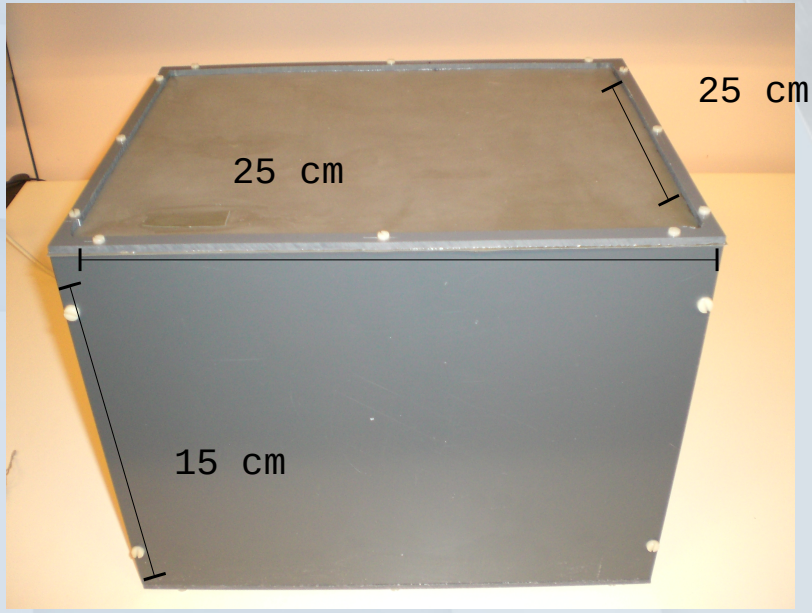


The visualisation tool allows to see both Source and Reference images as well as their „difference image“ before and after the registration, for CT/CBCT scans, dose and structure files.

Two phantom studies

1

The inside of the first phantom.



The first phantom.

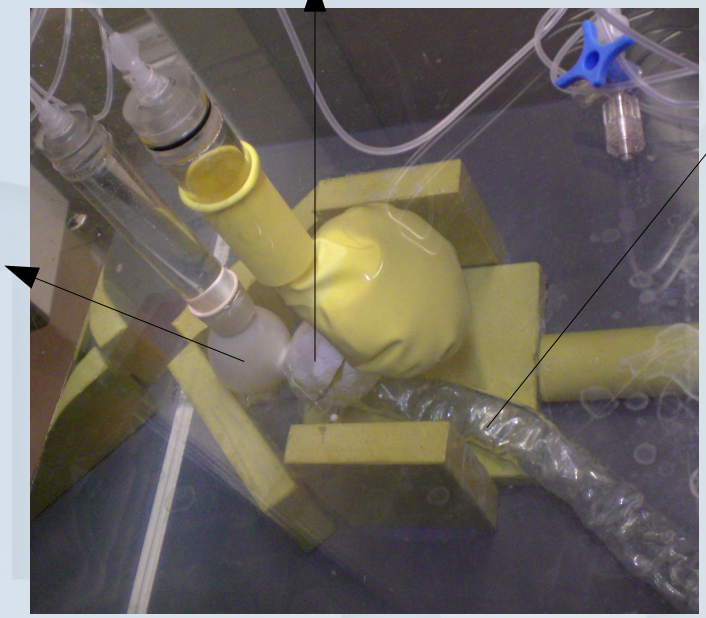
The first phantom scanning.

	Truth [mm]		Rigid [mm]		B-spline [mm]		Featurelets [mm]	
	First	Second	First	Second	t-Student First p-value	t-Student Second p-value	First 10vx - 20vx	Second 10vx - 30vx
Mean	4.57	3.84	2.78	1.86	2.72 2.43 0.009	2.08 1.84 0.05	1.40	1.43
SD	1.25	1.41	1.58	1.12	1.46	1.13	1.15	0.91
max	7.83	6.90	7.15	5.00	6.16	5.08	5.62	4.30
min	2.50	1.45	1.04	0.71	0.47	0.21	0.00	0.48

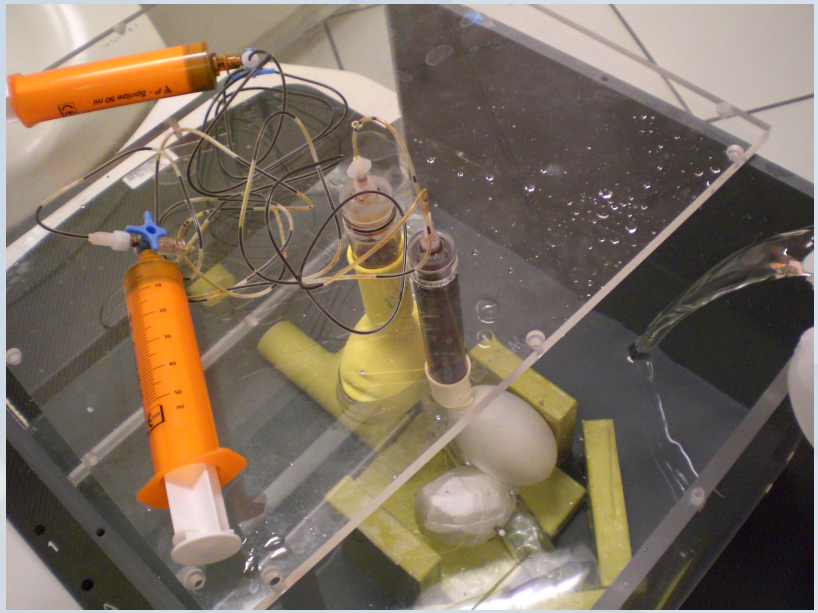
The two-sided paired t-Student test gave significant results at 95% C.L. as well as the p-value did for both phantom's configuration.

2

The bottom inside of the second phantom.



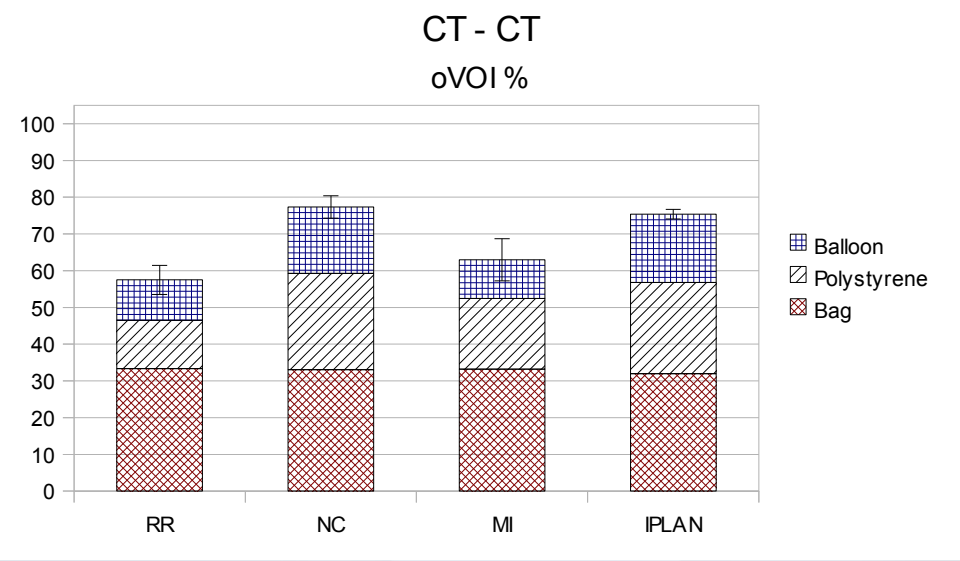
The second phantom.

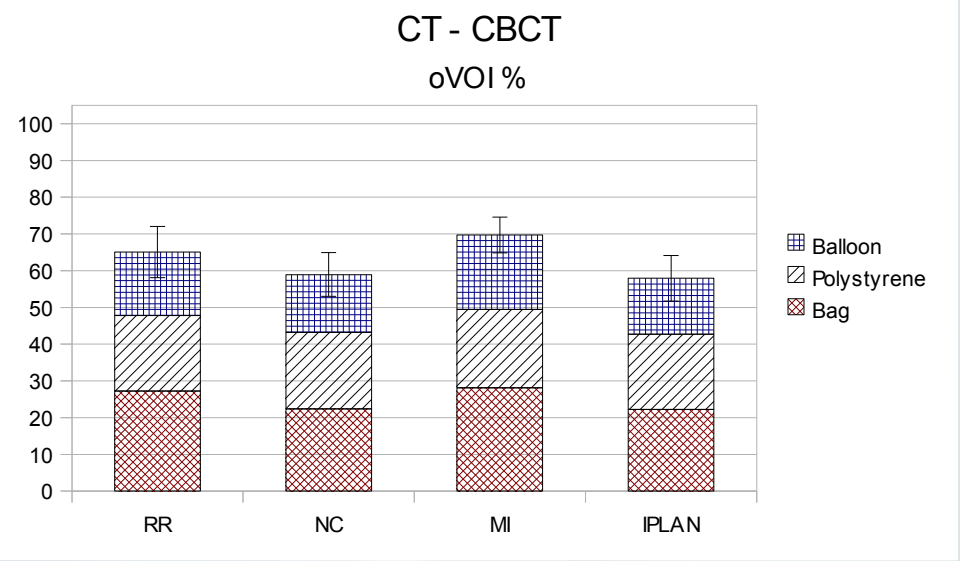


The second phantom's filling system.

The second phantom scanning.

The overall VOI (Volume Overlapping Index, oVOI) percentage was calculated for the three structures in the four registration modalities.





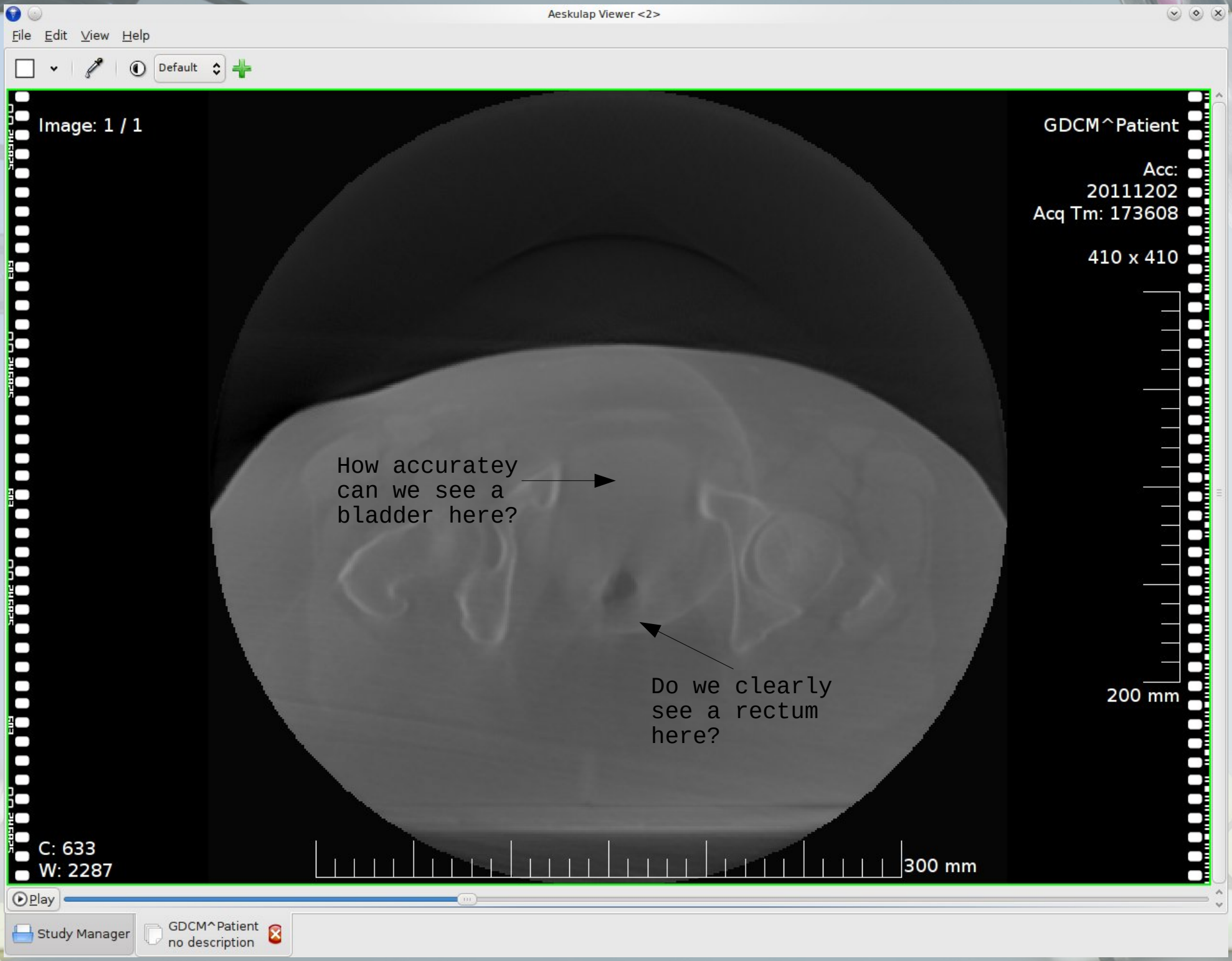
	Rigid		Featurelets NC		Featurelets MI		iPlan	
	CT-CT	CT-CBCT	CT-CT	CT-CBCT	CT-CT	CT-CBCT	t-Student CT-CT p-value	t-Student CT-CBCT p-value
oVOI%	57.48	65.07	77.36	58.93	62.97	69.72	1.28 75.39 0.26	3.27 57.90 0.01
SD	3.97	6.95	3.04	5.96	5.74	4.88	1.30	6.23

A two-sided paired t-Student test at 95% C.L. and the p-values were calculated.
The featurelets algorithm showed an improvement when compared to the iPlan software, although the result was statistically significant only for the inter-modality approach when the MI method was used.

A GYN-patients study

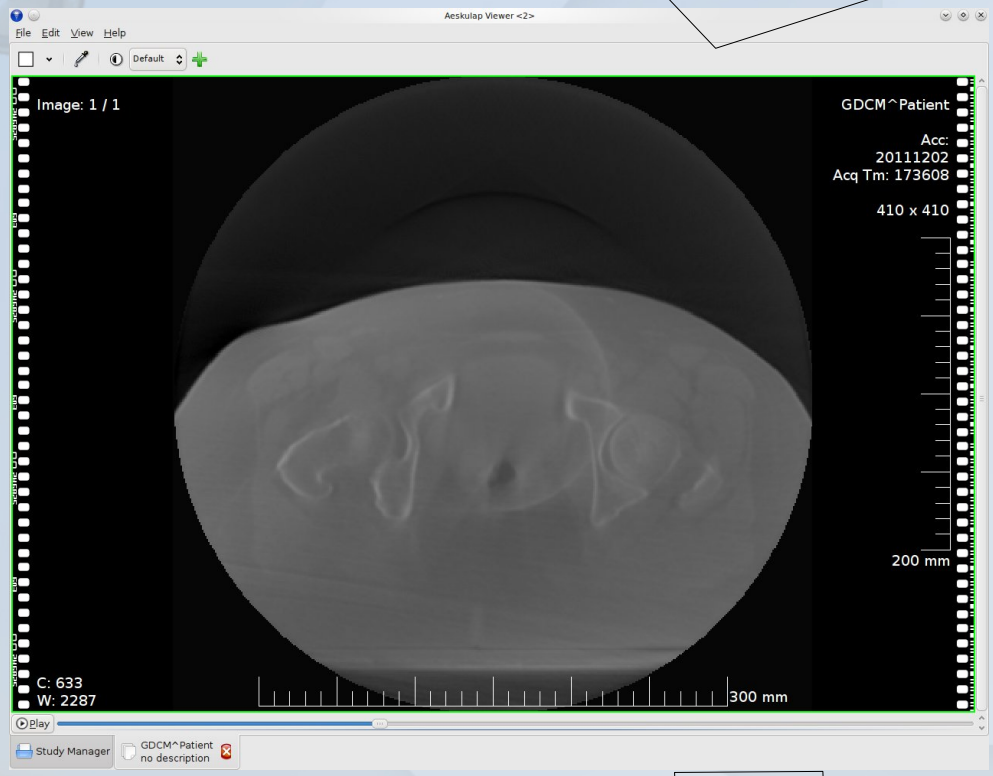
The study consists of 10 patients having repeated CTs and weekly CBCTs. The original structures and dose files are also available for all of them.
Furthermore each repeated scan has manually contoured OARs (so far available for 4 patients).

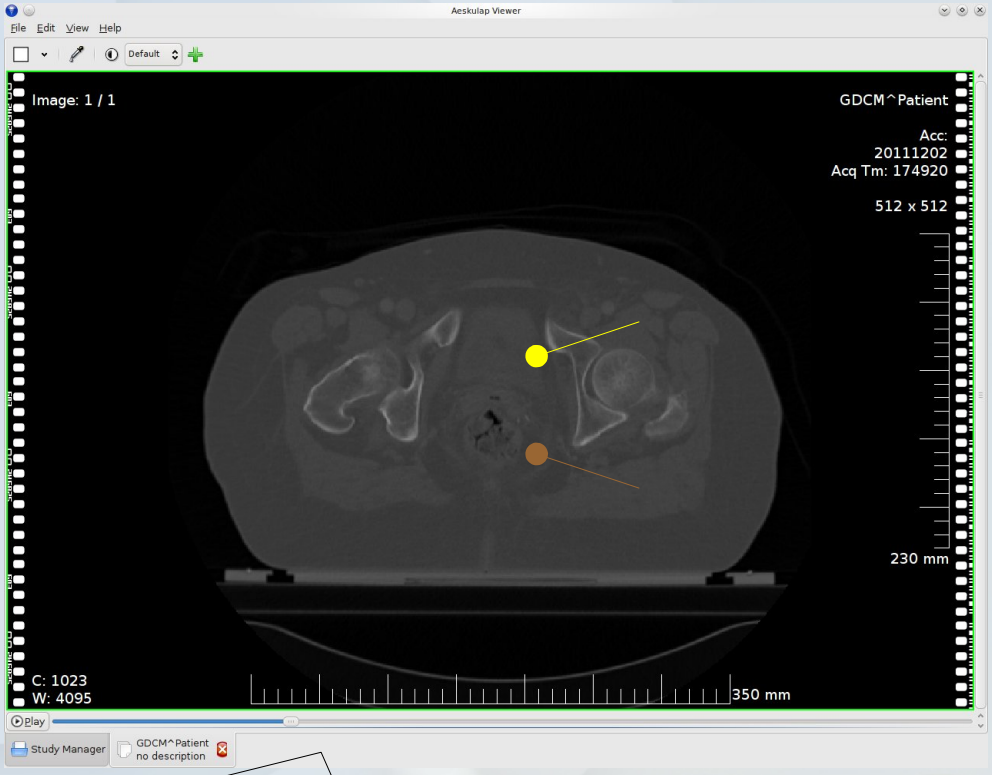
The GYN images' poor contrast issue...


Aeskulap Viewer <2>
File Edit View Help
Default
Image: 1 / 1
GDCM^Patient
Acc:
20111202
Acq Tm: 173608
410 x 410
How accuratey can we see a bladder here?
Do we clearly see a rectum here?
200 mm
300 mm
C: 633
W: 2287
Play
Study Manager
GDCM^Patient
no description

The poor contrast images are not only an issue for the structures contouring but also for the registration...

DR



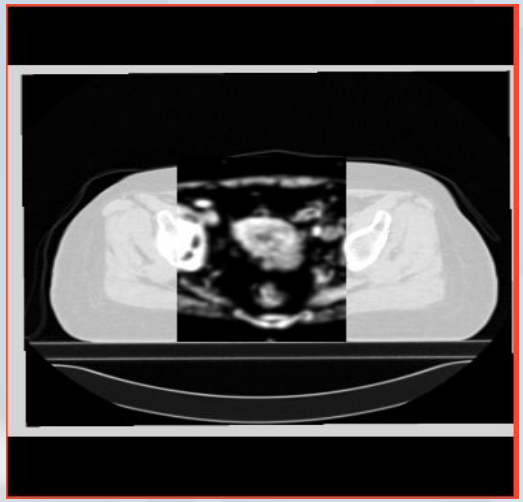


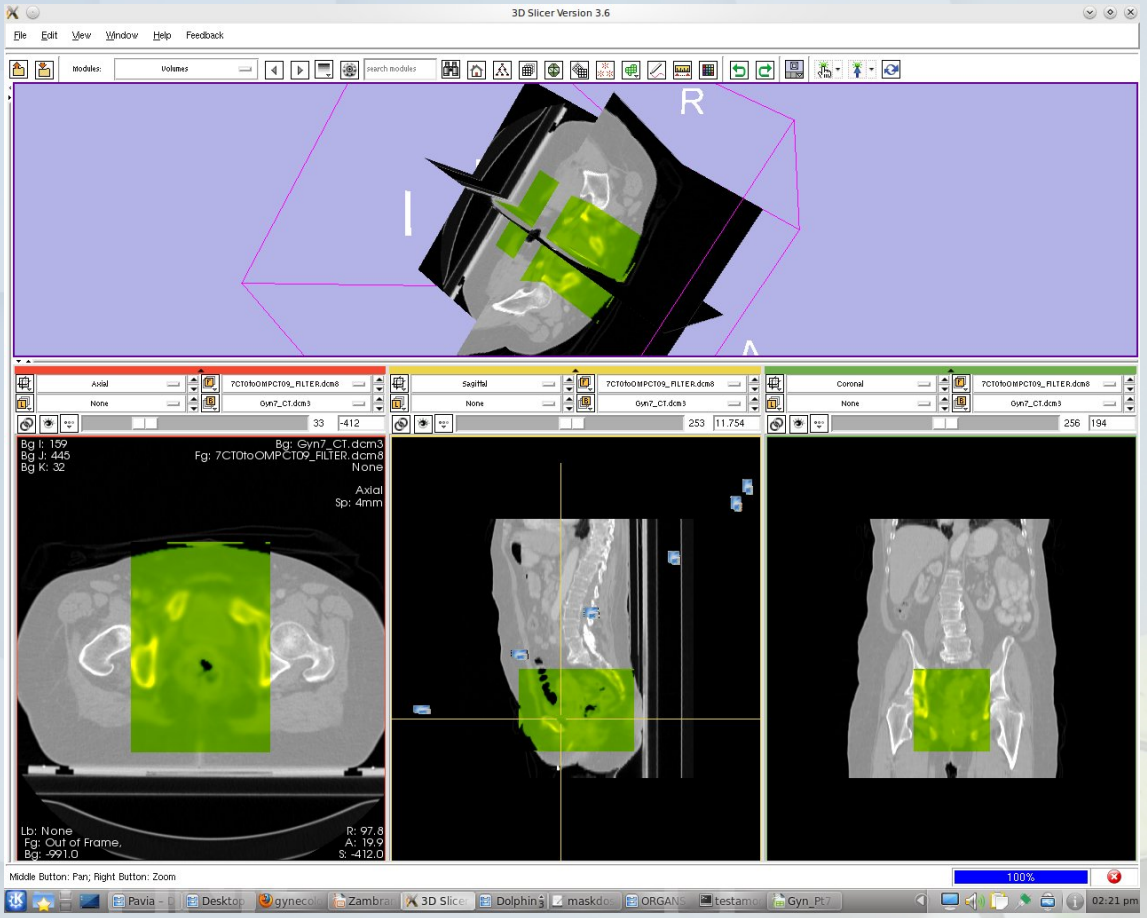
RR

How to overcome the poor **image quality?**

It is possible to use many techniques for image pre-processing, i.e.

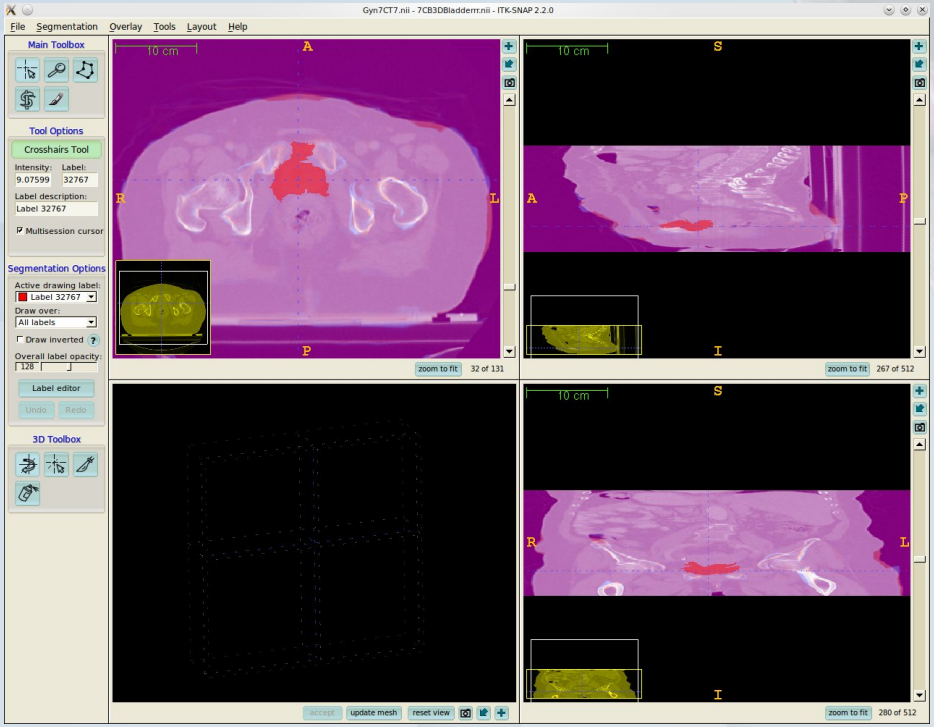
1. select a ROI (green)
2. change the intensity window

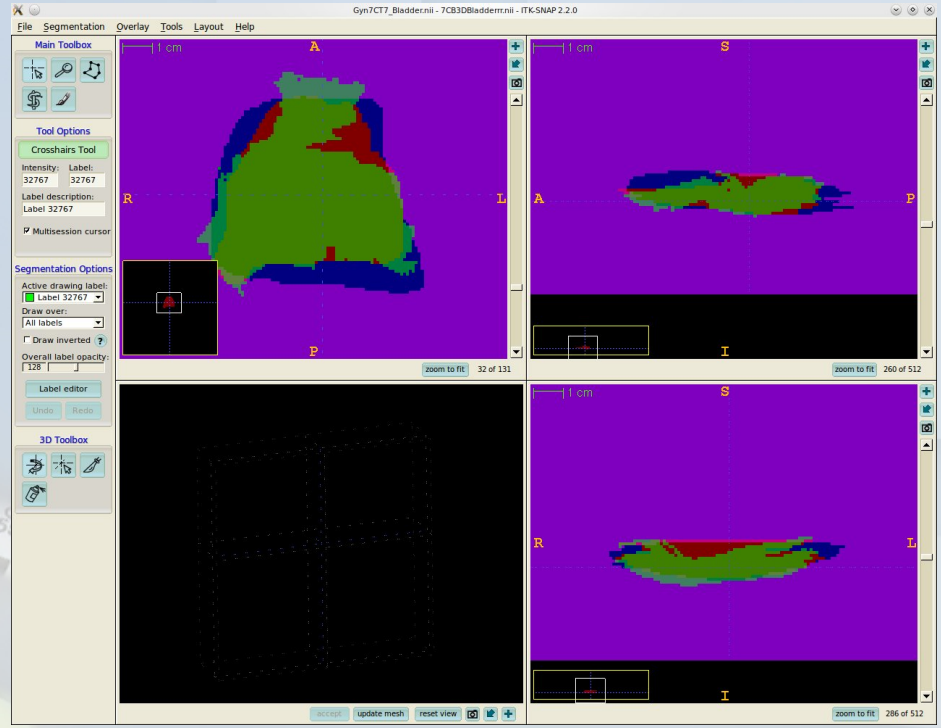




The after-image-registration *step one: deforming the structures*

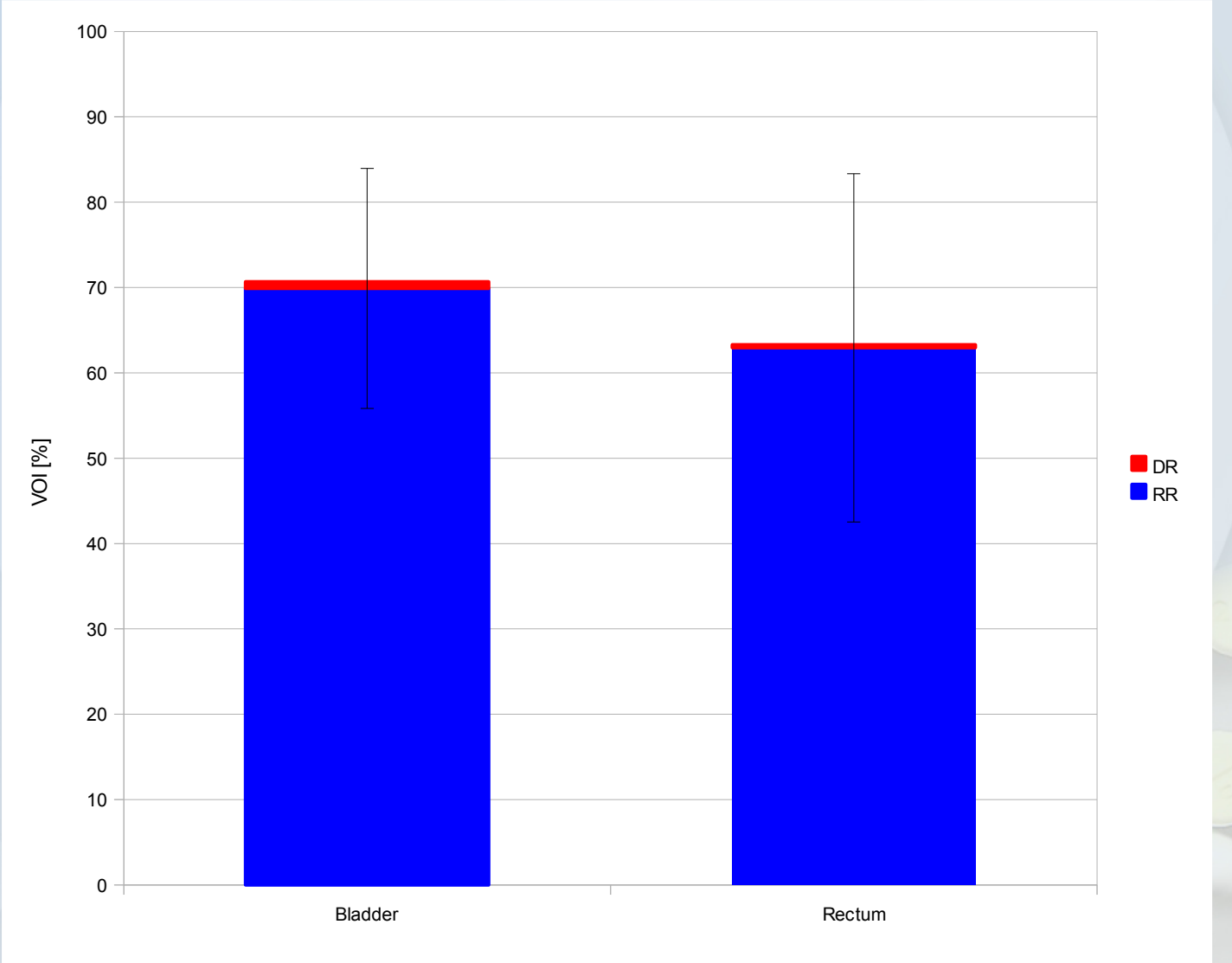
The planning CT and the deformed follow-up CBCT can be visualised together with the corresponding deformed bladder (red).





The three bladders are compared: the planning CT's contour (blue), the follow-up CBCT's contour (red) and the deformed bladder (green) – where the target image is the CBCT's contour – can be visualised.

The average OARs VOI percentages were calculated after the Nucletron's Oncentra Masterplan TPS' RR and the in-house deformable algortithm respectively.

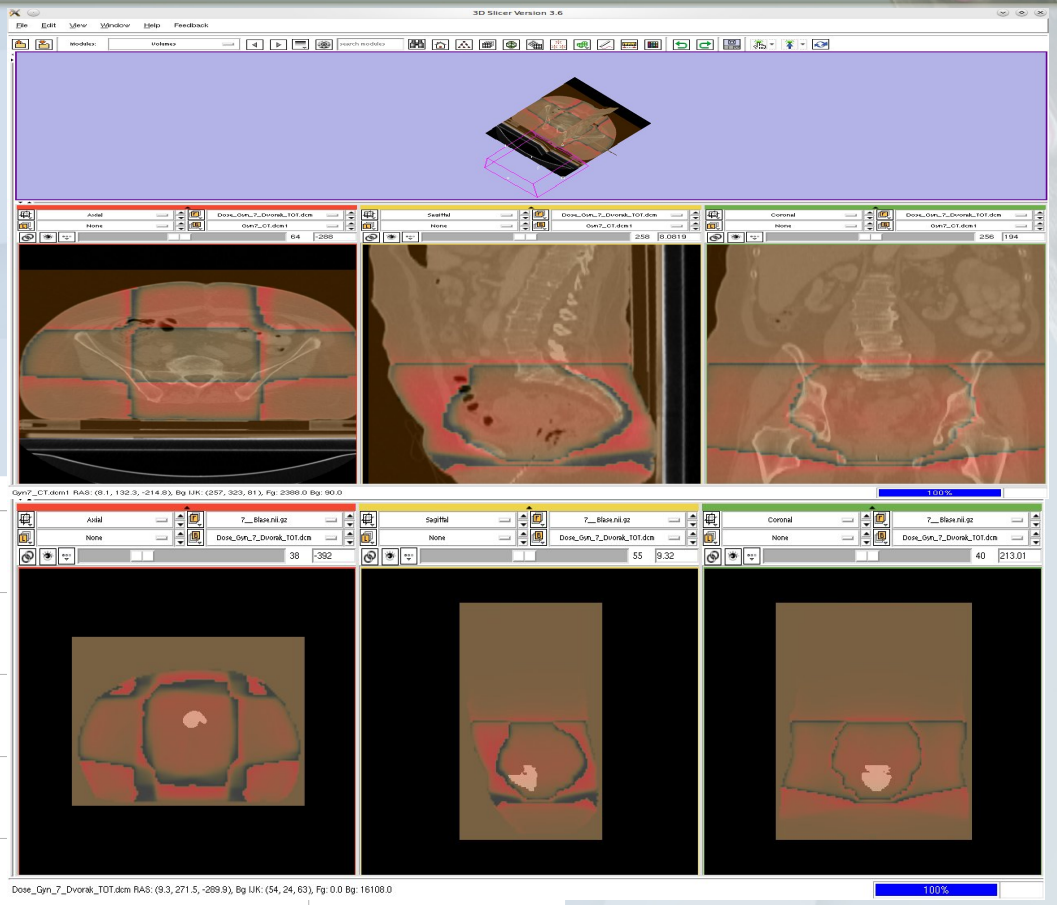


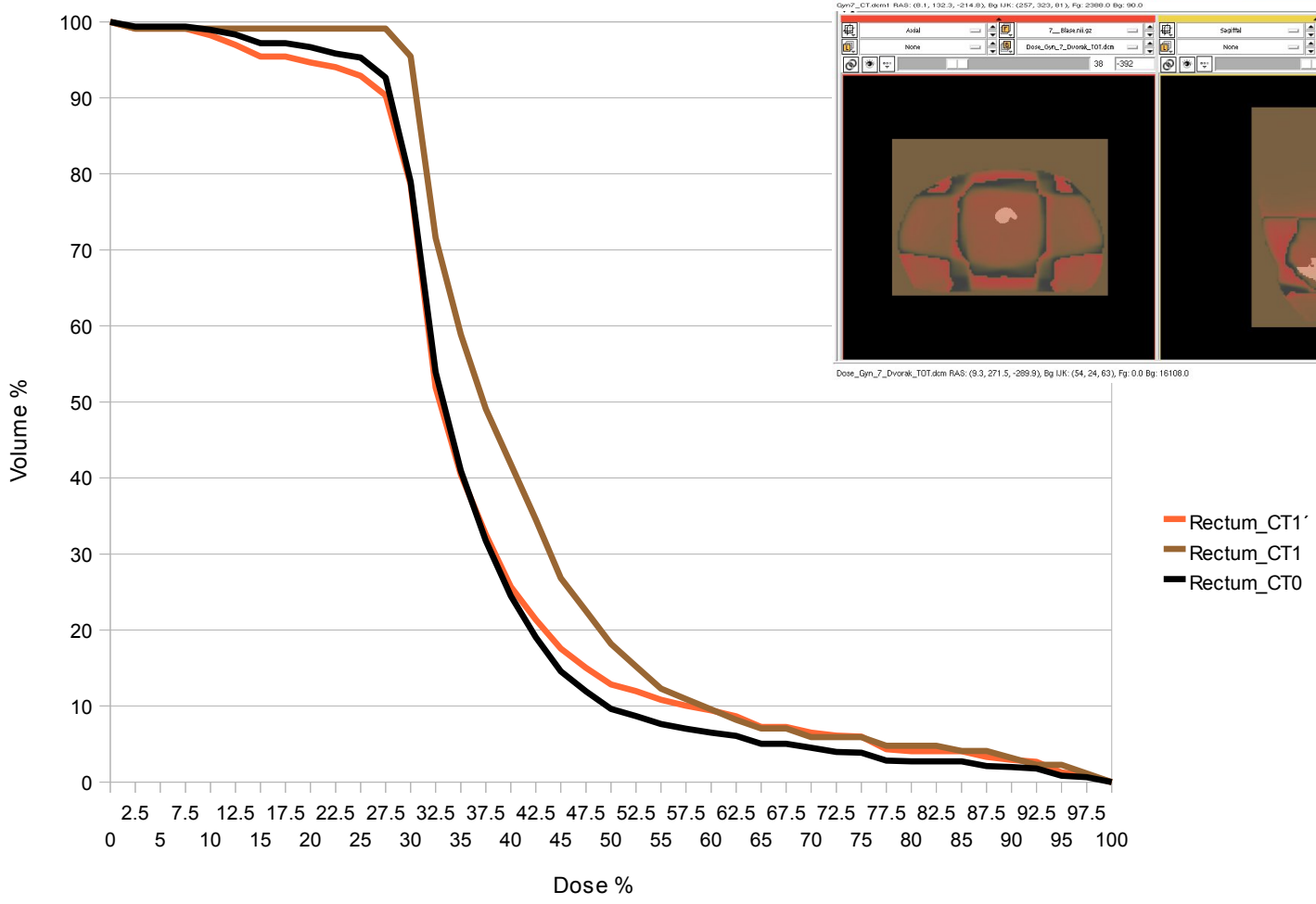
	Rigid		Featurelets	
	Bladder	Rectum	Bladder	Rectum
VOI%	69.90	62.93	+0.80	+0.36
SD	12.94	18.93	-	-
max	81.51	87.13	83.39	87.38
min	44.10	34.37	43.24	35.57

The values were calculated for the first patient (6 repeated CBCTs). The single repeated CT was excluded to keep the sample homogeneus although the results obtained were about **10 times** better. The CoMs (Centers of Mass) were also computed although no significant variation was observed for the CT-CBCT registration (<0.1 mm) and an overall change of up to 5.0 mm for the CT-CT approach. Performing a DR after the RR is usually improving the results, although finding the right parameters to make it robust is still under investigation.

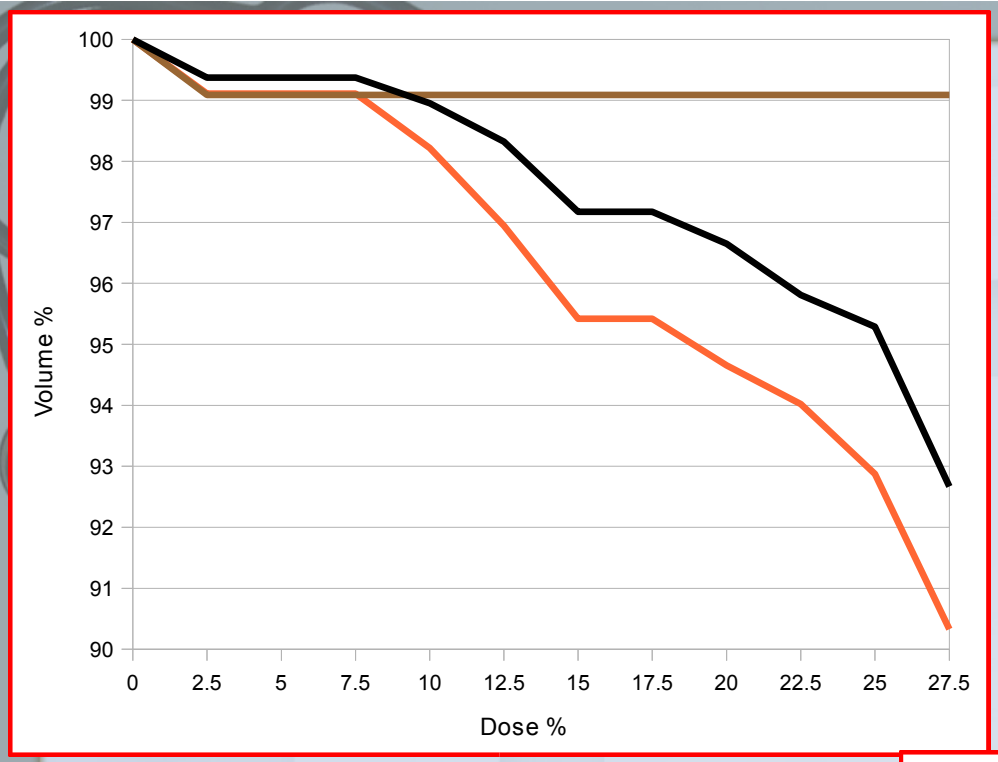
The after-image-registration *step two: computing the DVHs*

The OMP TPS treatment planning dose output consists of separate dicom files for each dose beam. It is therefore necessary to first sum them up together.





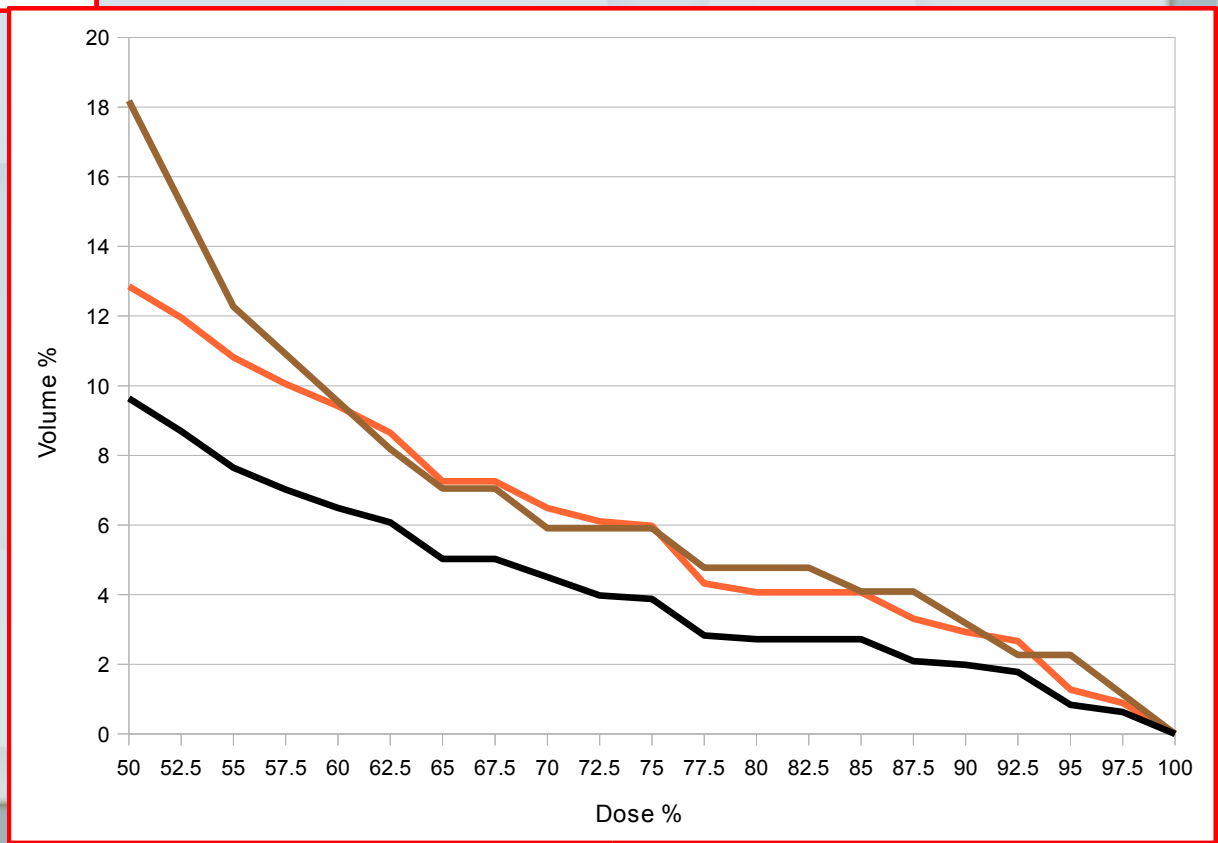
The DVHs are obtained using the extracted OARs as mask images for the dose file.



Rectum_CT1´

Rectum_CT1

Rectum_CT0



Conclusions

The featurelets deformable registration algorithm provides promising results in both phantom studies showing comparable, if not better, results against commercially available algorithms for deformable registration.
Performing a deformable registration in the clinical routine could really help to account for the uncertainties in dose delivery and therefore correct them. For this purpose it is going to be investigated which are the best parameters to be used for patient images.

Acknowledgments

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THANK YOU!

...any question?