Practical Examples of AutoPlanning Via Advanced Scripting

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Conflicts of Interest

No relevant financial relationships to disclose

ICON group has a development working relationship with Varian Medical and Breathwell devices

Personal non-financial affiliation with the University of Wollongong

The above working relationships are free of impact for the following research

Sydney NSW

UNIVERSITY OF WOLLONGONG AUSTRALIA

ICON INTEGRATED CANCER CENTRE

- Raystation, Eclipse, Tomotherapy, Varian, Elekta, Velocity

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API- Differences from Eclipse

- WPF integration
- More developed with greater functionality
- Interactions are within the software- live updates of UI

```
ui.TitleBar.MenuItem['Plan Optimization'].Click()
ui.TitleBar.MenuItem['Plan Optimization'].Popup.MenuItem['Plan Optimization'].Click()

await_user_input("Select the Beam Optimization Settings Tab and ensure\n\n - Collimator is included \n - Wedge is NOT included \n - If ChestWall treatment add Bolus to each beam")
```

```
plan = case.AddNewPlan(PlanName=plan_name, PlannedBy="Auto", Comment="", ExaminationName=examination.Name, AllowDuplicateNames=False)
beam_set = plan.AddNewBeamSet(Name=set_name, ExaminationName=examination.Name, MachineName=str(machine), Modality="Photons", TreatmentTechnique="DMLC", PatientPosition="HeadFirstSupine",


with CompositeAction('Set default grid'):
    retval_0 = plan.SetDefaultDoseGrid(VoxelSize={ 'x': 0.3, 'y': 0.3, 'z': 0.3 })
    plan.TreatmentCourse.TotalDose.UpdateDoseGridStructures()
```

```
def RunOptimization(patient,case, beam_set,plan, technique, plan_opt):

    patient.Save()

    plan_opt.RunOptimization()
    algorithm = beam_set.AccurateDoseAlgorithm.DoseAlgorithm
```

```
    if laterality=="Left":
        dvh_of_interest_list[1][2]=plan_dose.GetRelativeVolumeAtDoseValues(RoiName=Left_Lung,DoseValues=[500])[0]
        dvh_of_interest_list[1][3]=plan_dose.GetRelativeVolumeAtDoseValues(RoiName=Left_Lung,DoseValues=[1000])[0]
        dvh_of_interest_list[1][4]=plan_dose.GetRelativeVolumeAtDoseValues(RoiName=Left_Lung,DoseValues=[2000])[0]
        dvh_of_interest_list[1][5]=plan_dose.GetRelativeVolumeAtDoseValues(RoiName=Left_Lung,DoseValues=[3000])[0] #2, 3, 4, 5
        dvh_of_interest_list[1][6]=plan_dose.GetRelativeVolumeAtDoseValues(RoiName=Right_Lung,DoseValues=[500])[0] #6
```

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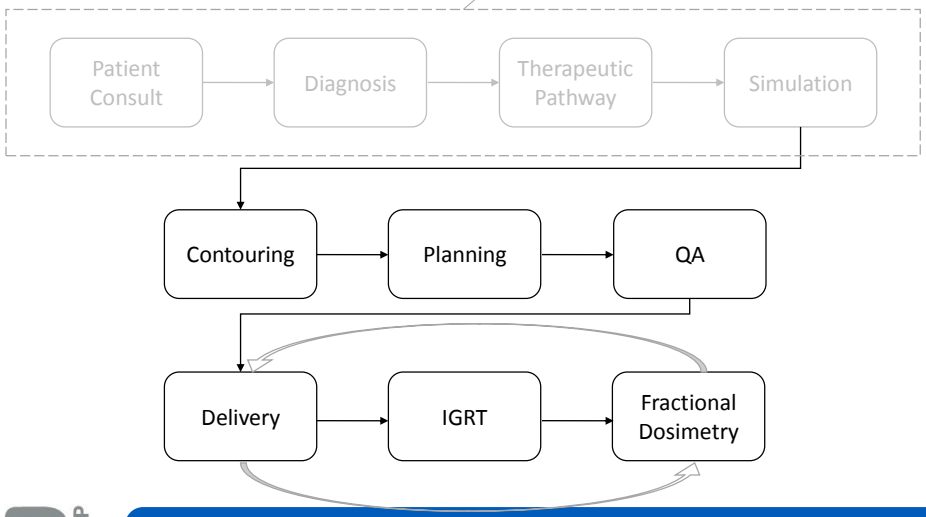
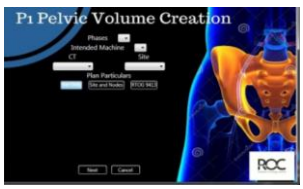
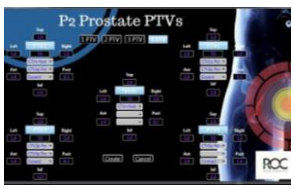
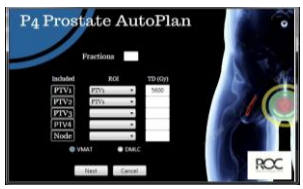
Promise of the future

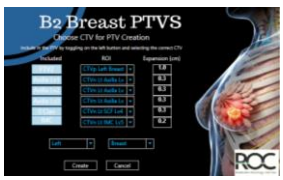
Deep Learning, Clustering, Nearest Neighbours

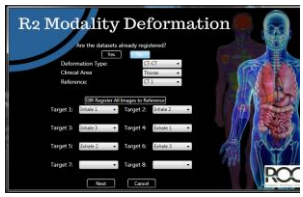






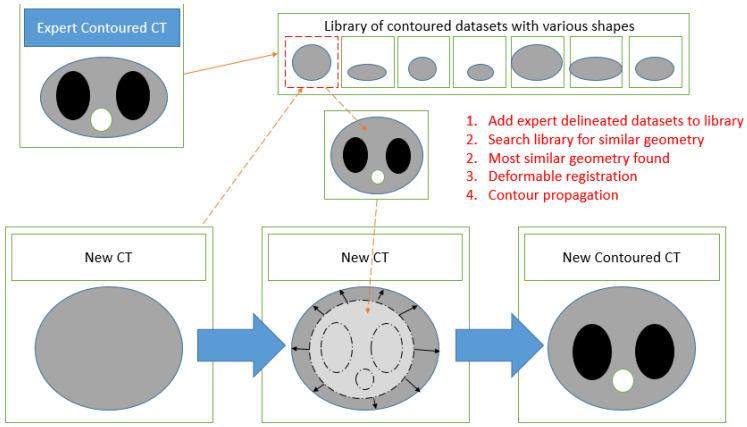






Contouring

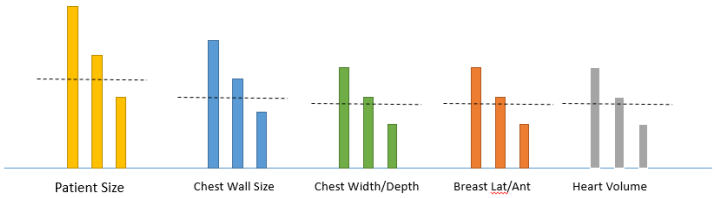
- ABS limitations



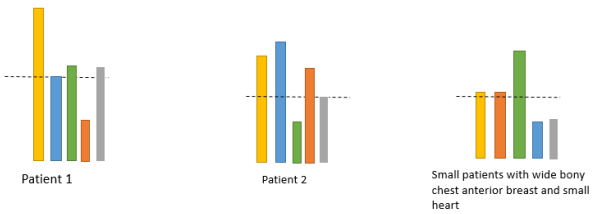
- Similarity term is general
- No focus on regions of datasets to compare
- Increasing included datasets increases processing time
- Highly mobile tissues perform poorly

Atlas-based segmentation technique incorporating inter-observer delineation uncertainty for whole breast

Contouring combined approach

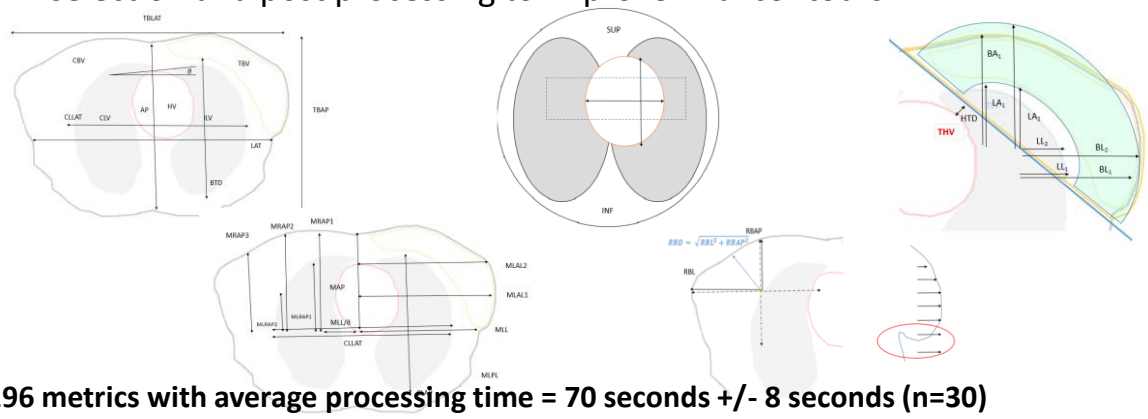


We can then determine a "fingerprint" for individual patients as well as groups of patients



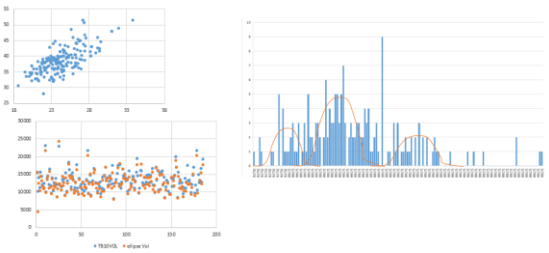
Measurements

- Using measurement metrics to drive atlas based segmentation selection and post processing to improve final contours

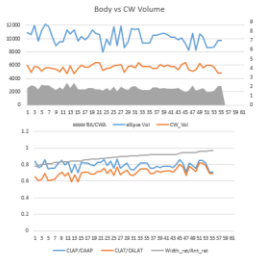


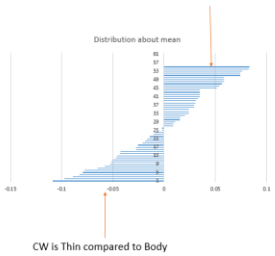
196 metrics with average processing time = 70 seconds +/- 8 seconds (n=30)

Categorising Data- Patient Sizes

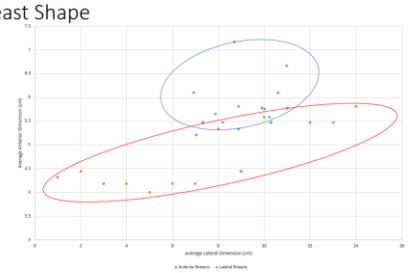


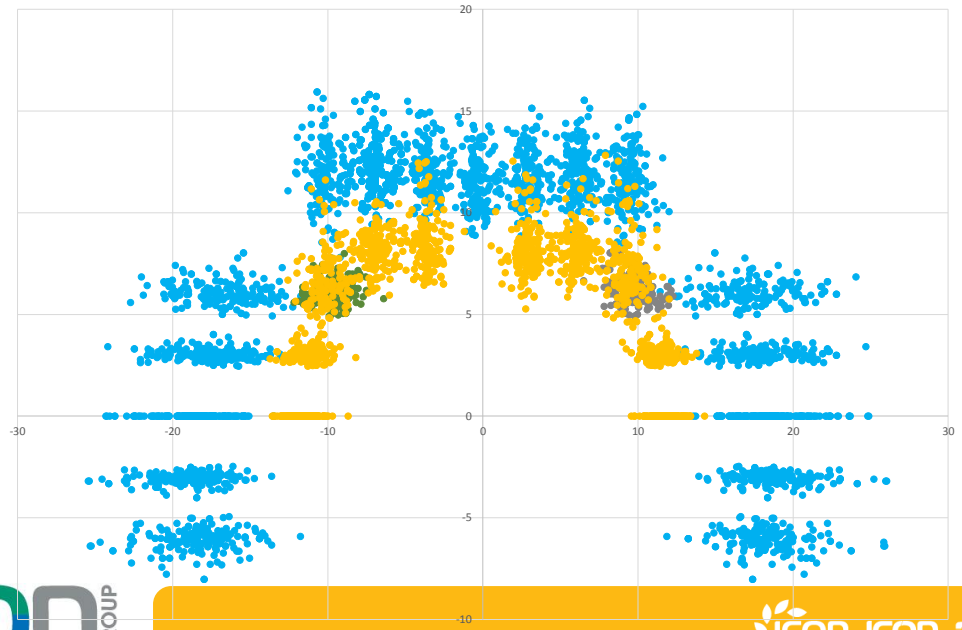
Chest Wall Distributions

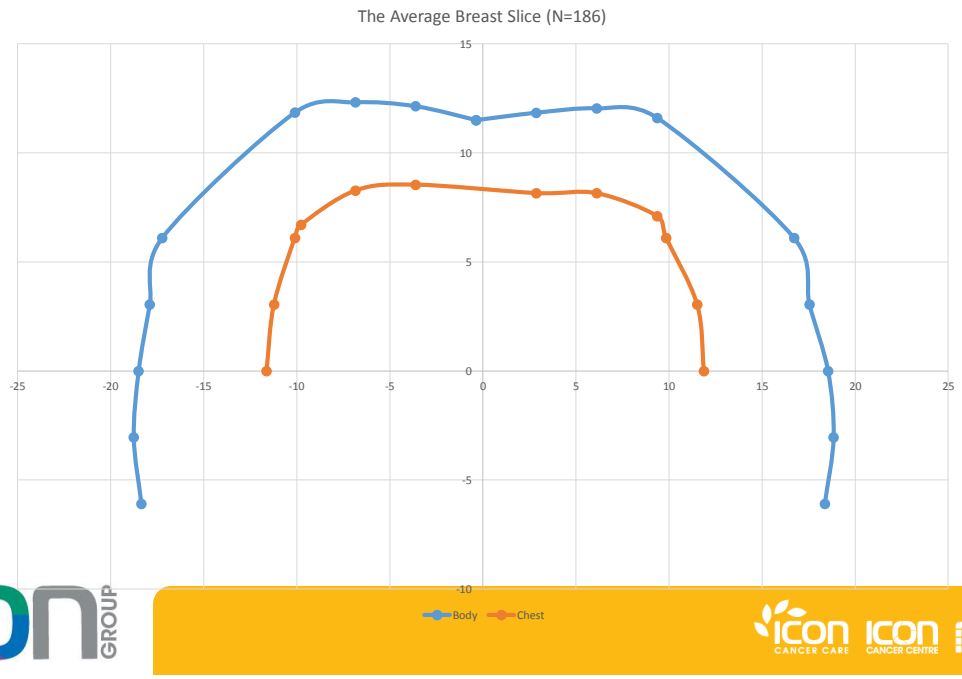


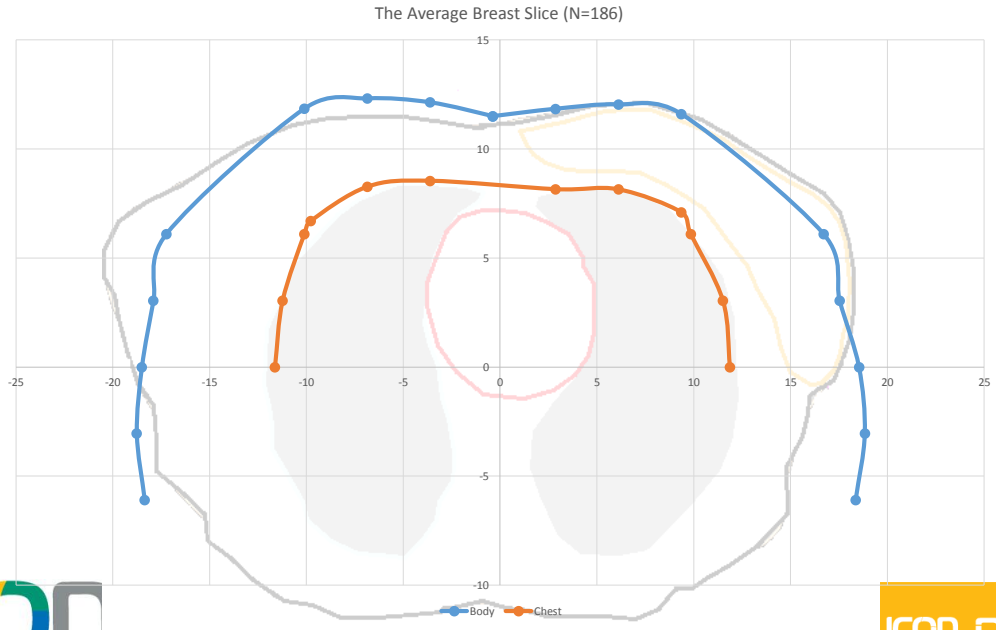


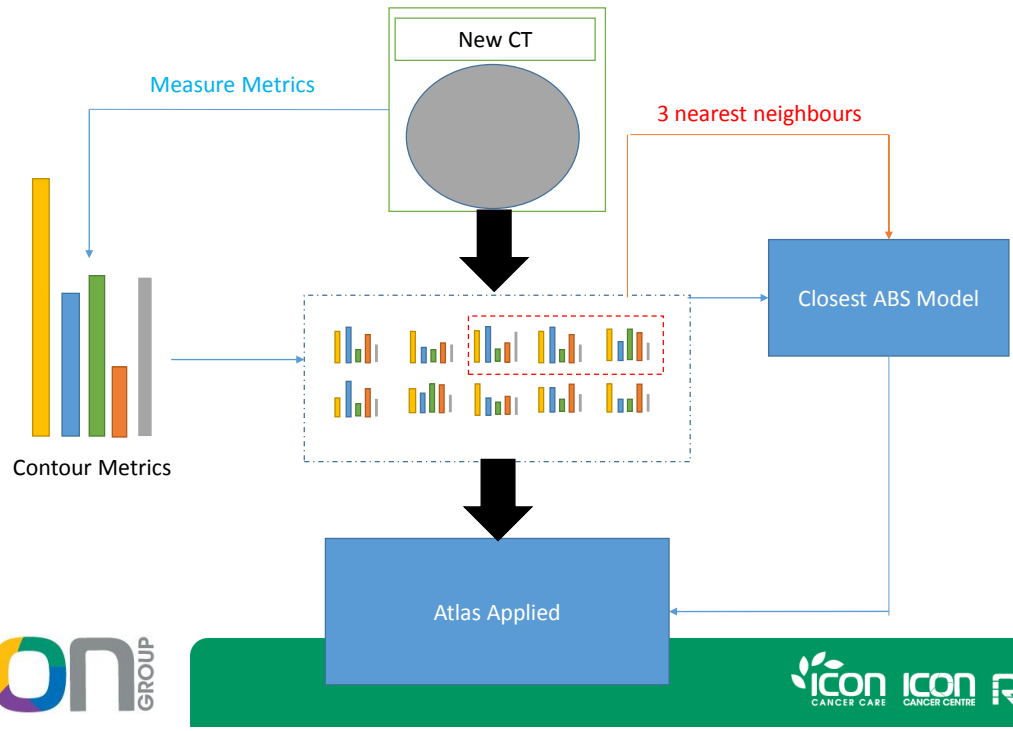
Breast Shape

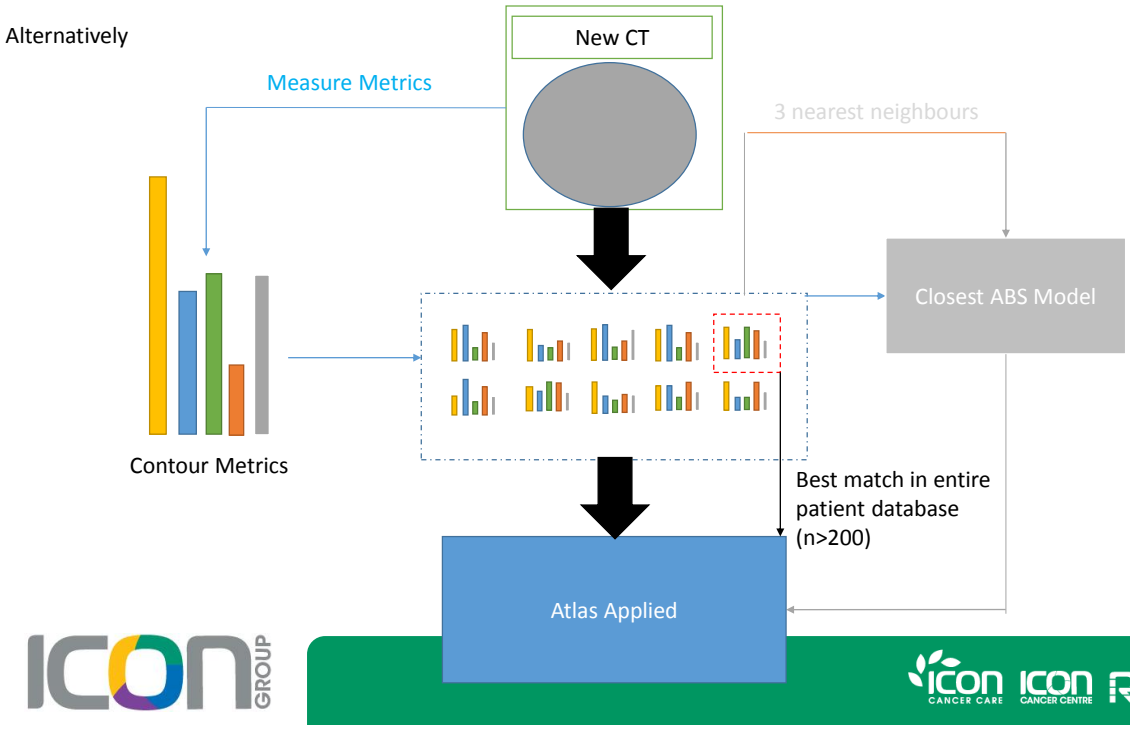



20
15
10
5
0
-5
-10
-30
-20
-10
0
10
20
30

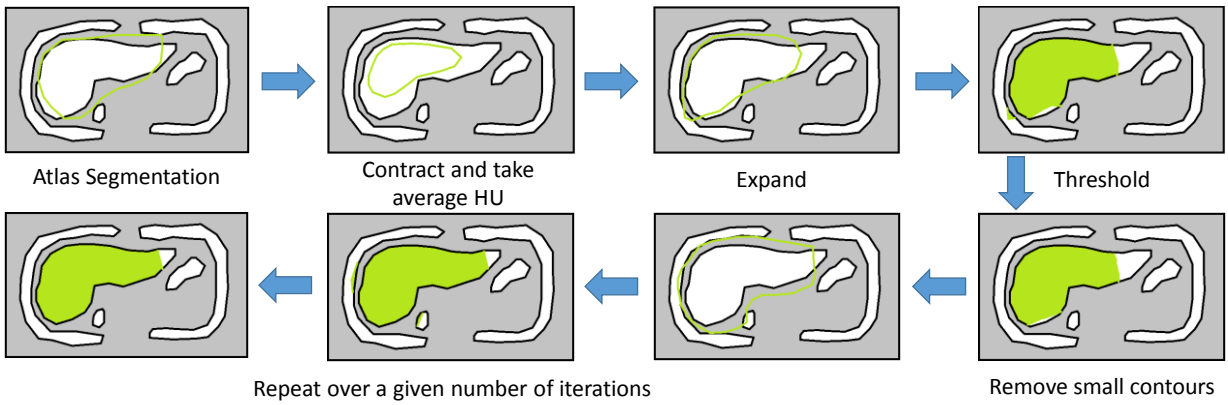

The Average Breast Slice (N=186)
15
10
5
0
-5
-10
-25
-20
-15
-10
-5
0
5
10
15
20
25
Body
Chest

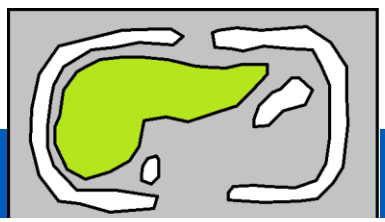

The Average Breast Slice (N=186)
15
10
5
0
-5
-10
-25
-20
-15
-10
-5
0
5
10
15
20
25
Body
Chest


New CT
Measure Metrics
3 nearest neighbours
Closest ABS Model
Contour Metrics
Atlas Applied



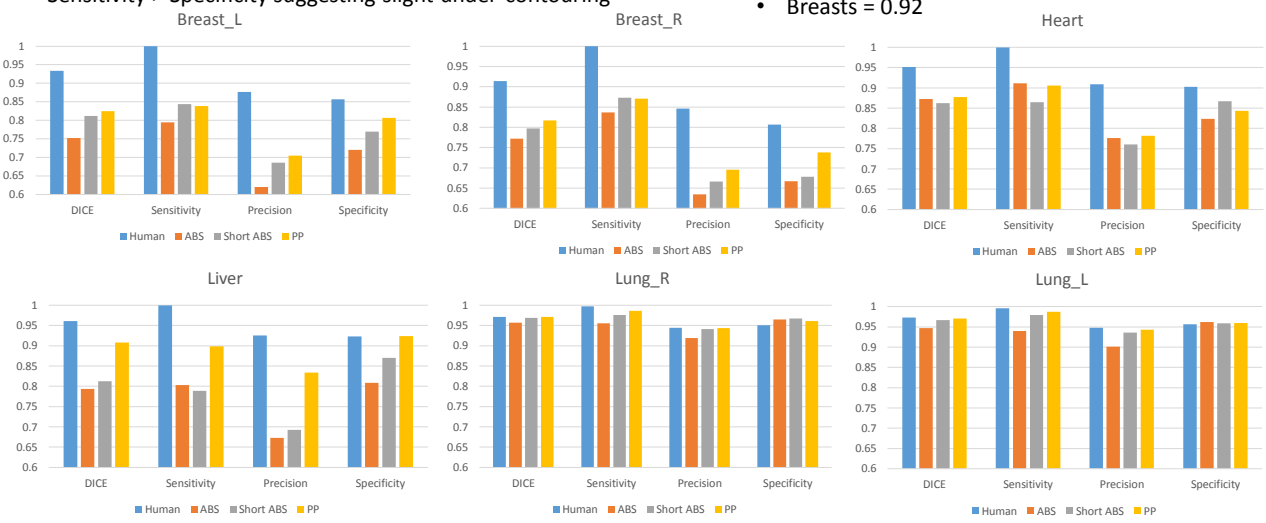
Post-Processing: Iterative Contour Growth





- Improvements from large atlas, to measurement directed atlas, to post processing
- PP- approaching inter-user variations DICE scores
- Sensitivity > Specificity suggesting slight under-contouring

Average Inter-User Variation (DICE)
- Heart = 0.92
- Lungs = 0.97
- Breasts = 0.92

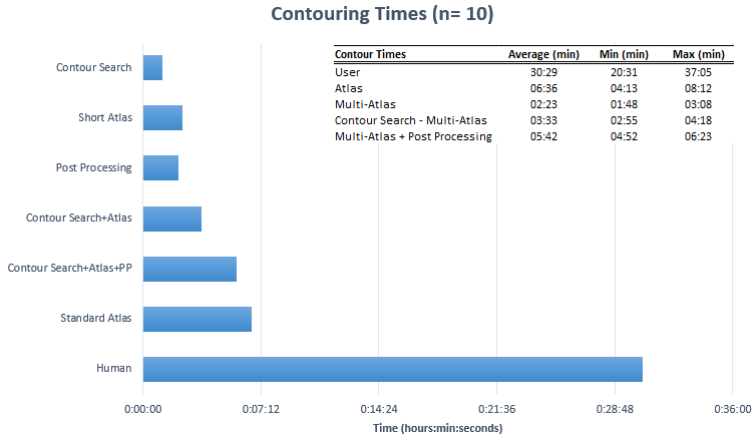


Systematic review

Uncertainties in volume delineation in radiation oncology: A systematic review and recommendations for future studies

Shalini K. Vinod [a,b,c,e], Michael G. Jameson [a,d,e], Myo Min [a,b,d], Lois C. Holloway [a,b,d,e]

Results- Contouring Time

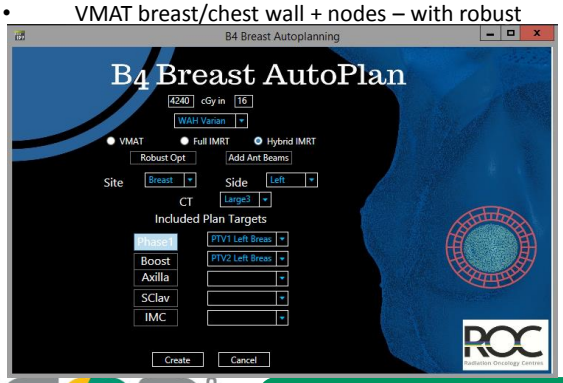


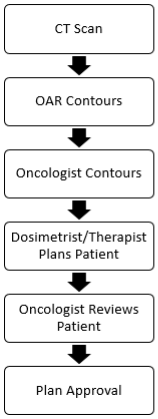
Contour Times	Average (min)	Min (min)	Max (min)
User	30:29	20:31	37:05
Atlas	06:36	04:13	08:12
Multi-Atlas	02:23	01:48	03:08
Contour Search - Multi-Atlas	03:33	02:55	04:18
Multi-Atlas + Post Processing	05:42	04:52	06:23

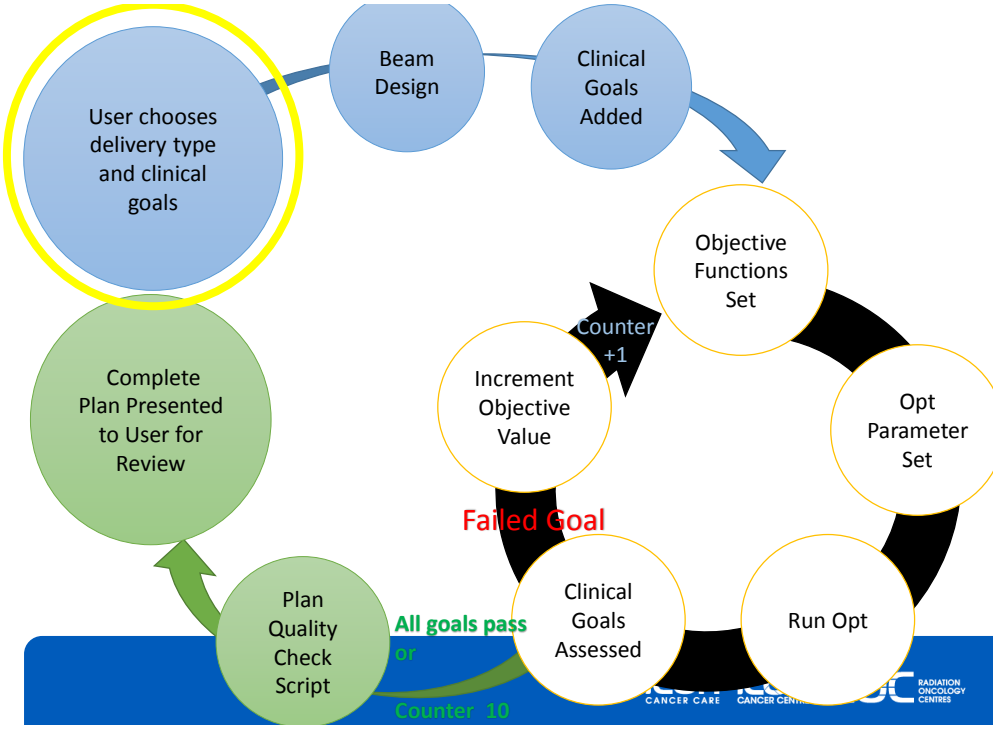
Incorporating a DICOM folder watch code results in auto-contouring performed before staff return from CT simulation
Couch position is set from the couch height DICOM header from the CT image

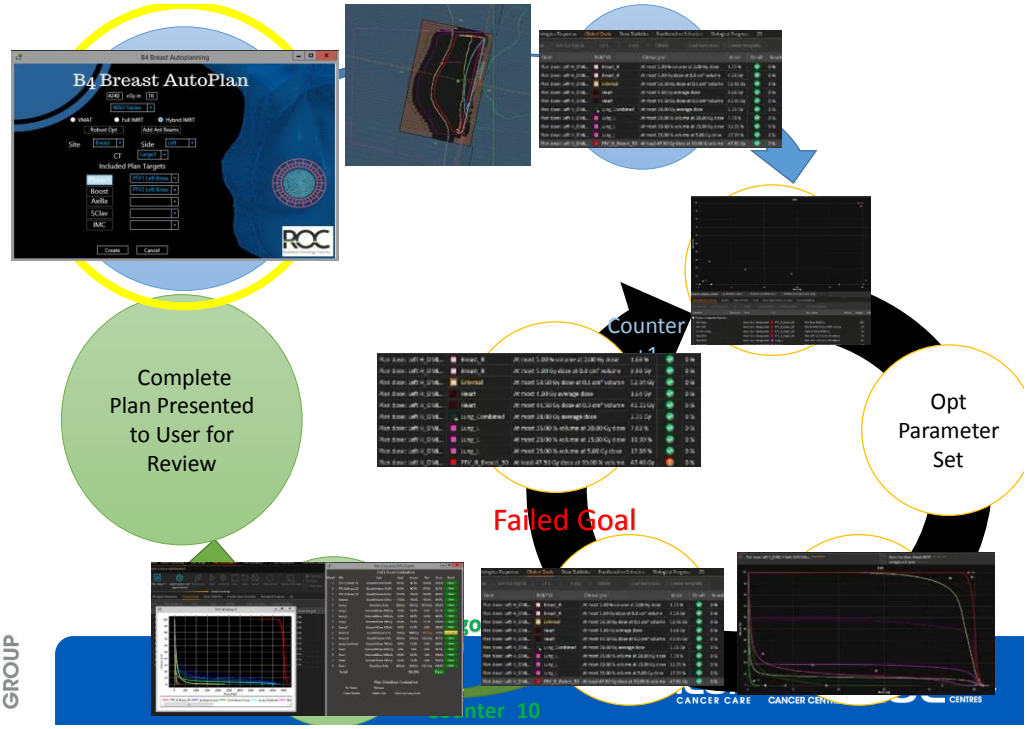
Auto-Planning

- Auto-contour from CT header
- Oncologist reviews and amends auto-contours
- Hybrid IMRT
- VMAT short arc with robust optimisation
- VMAT breast/chest wall + nodes – with robust

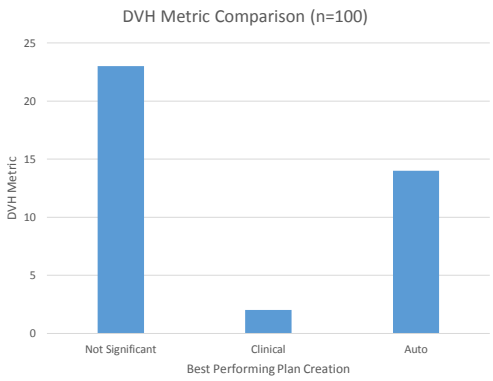








AutoPlan Results



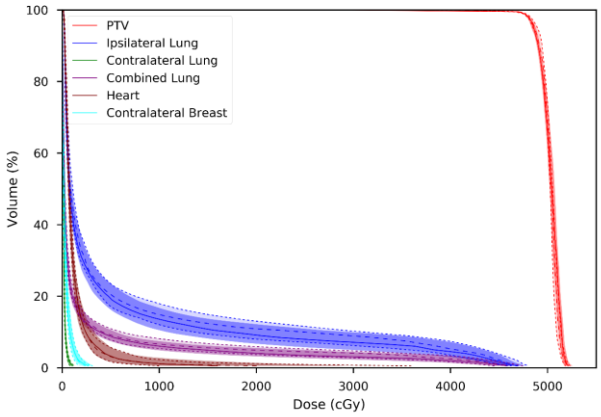
*statistical significance determined as $p < 0.05$

	Per Protocol					
	RTOG		EviQ		London Cancer	
Case Laterality and Target Dose	Clinical	Auto	Clinical	Auto	Clinical	Auto
Left 5000cGy (N = 32)	25	24	23	26	26	25
Right 5000cGy (N = 40)	30	31	30	32	30	33
Left 4240cGy (N = 11)	3	10	9	11	10	11
Right 4240cGy (N = 17)	10	12	9	11	9	11
Percent per Protocol	**68%**	**77%**	**71%**	**80%**	**75%**	**80%**

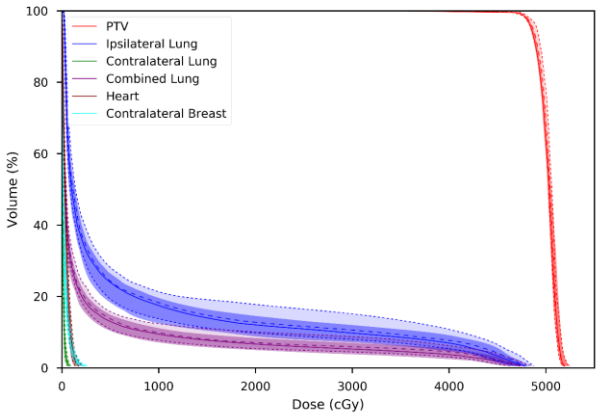
Time Measured (N=10)	Min	Average	St Dev	Max
Automated Plan (minutes:seconds)	04:48	05:31	00:42	06:21
Clinical Dosimetrist Time (minutes:seconds)	21:36	30:37	04:25	41:07
Relative Planning Time (%)	**22%**	**18%**	**16%**	**15%**
Time Saving (minutes)	**17**	**25**	**4**	**35**

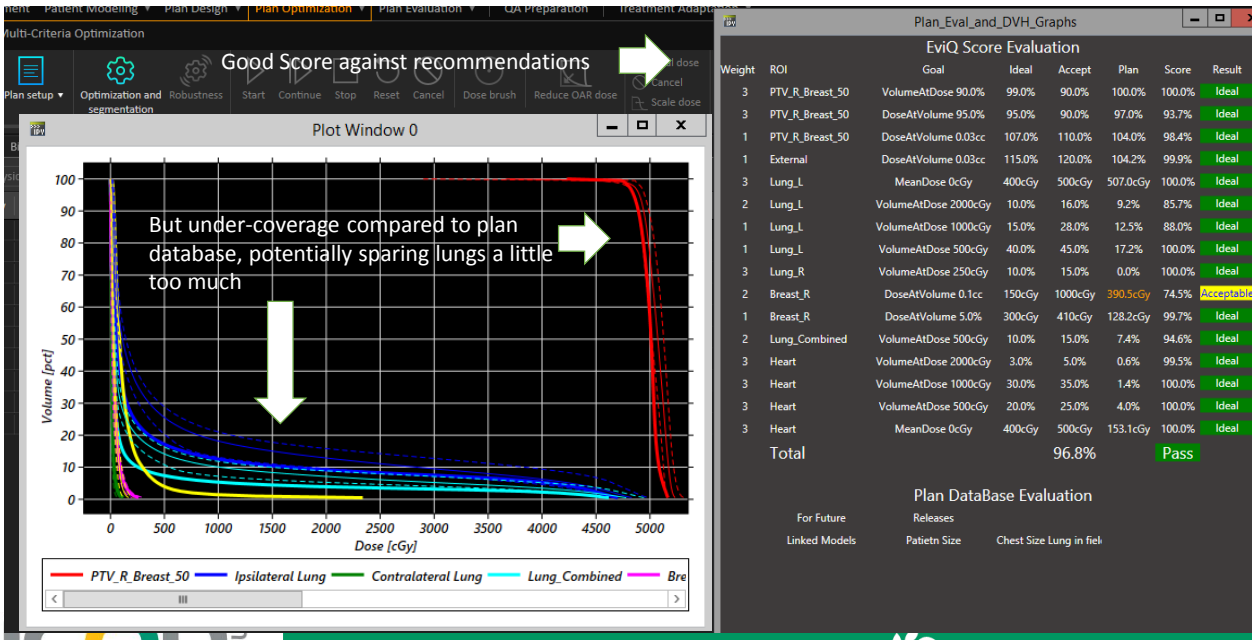
Excluding Physician contouring of boost targets total average processing time approximately 11min

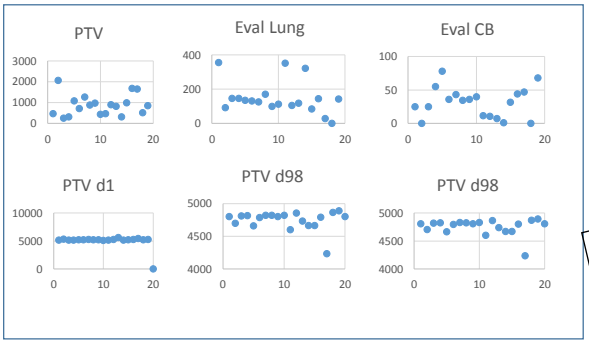
Lt Breast



Rt Breast

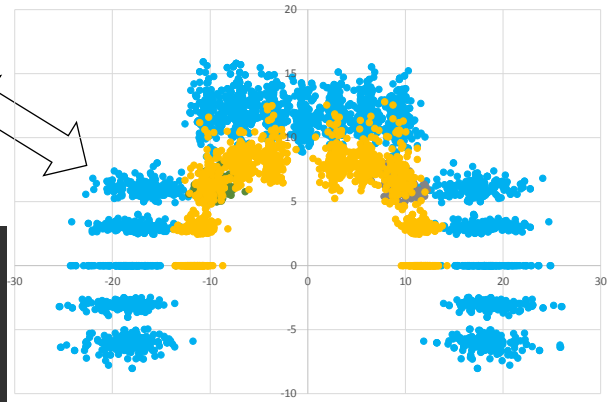


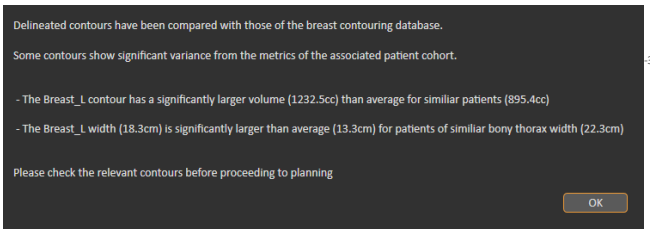




Use of database to QA contours after auto-contouring and to predict both optimisation objectives and expected plan quality

Various machine learning algorithms





Import

Deformation

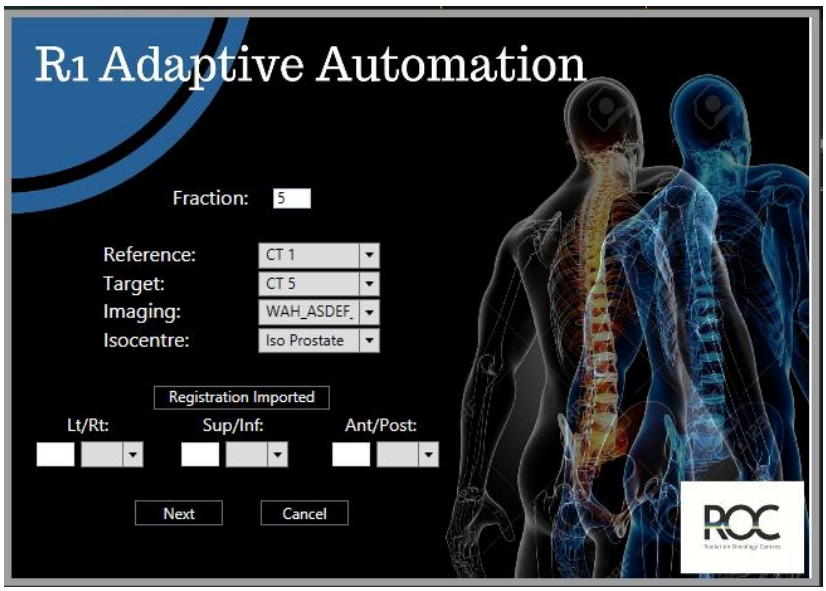
Deformation QA

Contour Propagation

Fraction Calculation

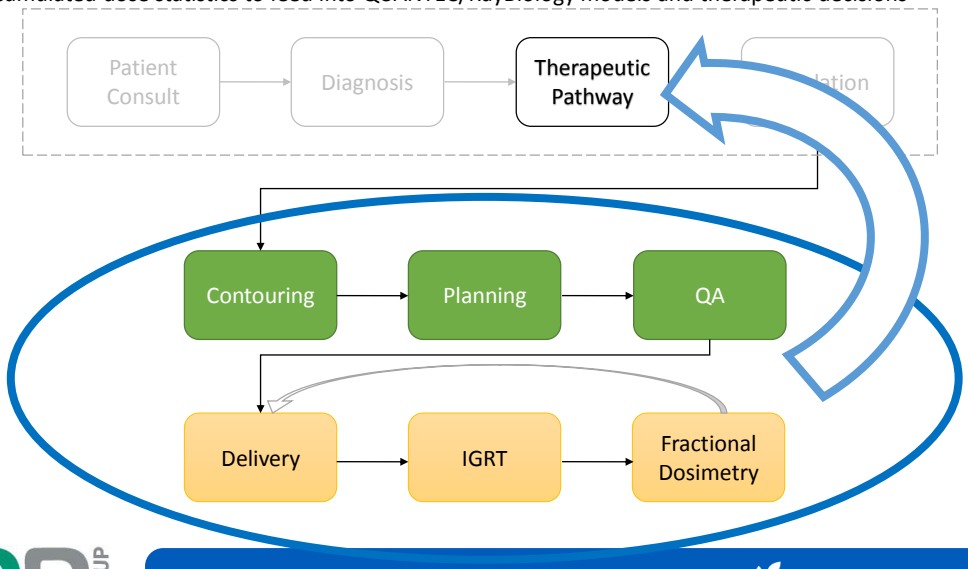
Dose Comparison

Dose Accumulation



< 2 minute total process time

- The automation workflow allows for a technically feasible online adaptive process
- Doctor buy in? Who reviews the deformed CTV on set?
- Eventual accumulated dose statistics to feed into QUANTEC/RayBiology models and therapeutic decisions



Acknowledgments

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- Guilin Liu

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