SESSION 6: DE-FACING

11:00 am - 11:10 am	Ying Xiao, PhD , University of Pennsylvania
11:10 am - 11:20 am	Christopher Schwarz, PhD , Mayo Clinic *Face Recognition and De-Identification of Research Brain Images with* mri_reface
11:20 am - 11:30 am	Douglas Greve, PhD , MGH/Harvard *MIDEFACE: Minimally Invasive Defacing*
11:30 am - 11:50 am	*Panel Discussion*

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Ying Xiao, Ph.D.

MEDICAL IMAGE DE-FACING AND CLINICAL RESEARCH DATA SHARING

MIDI Workshop, May 23, 2023

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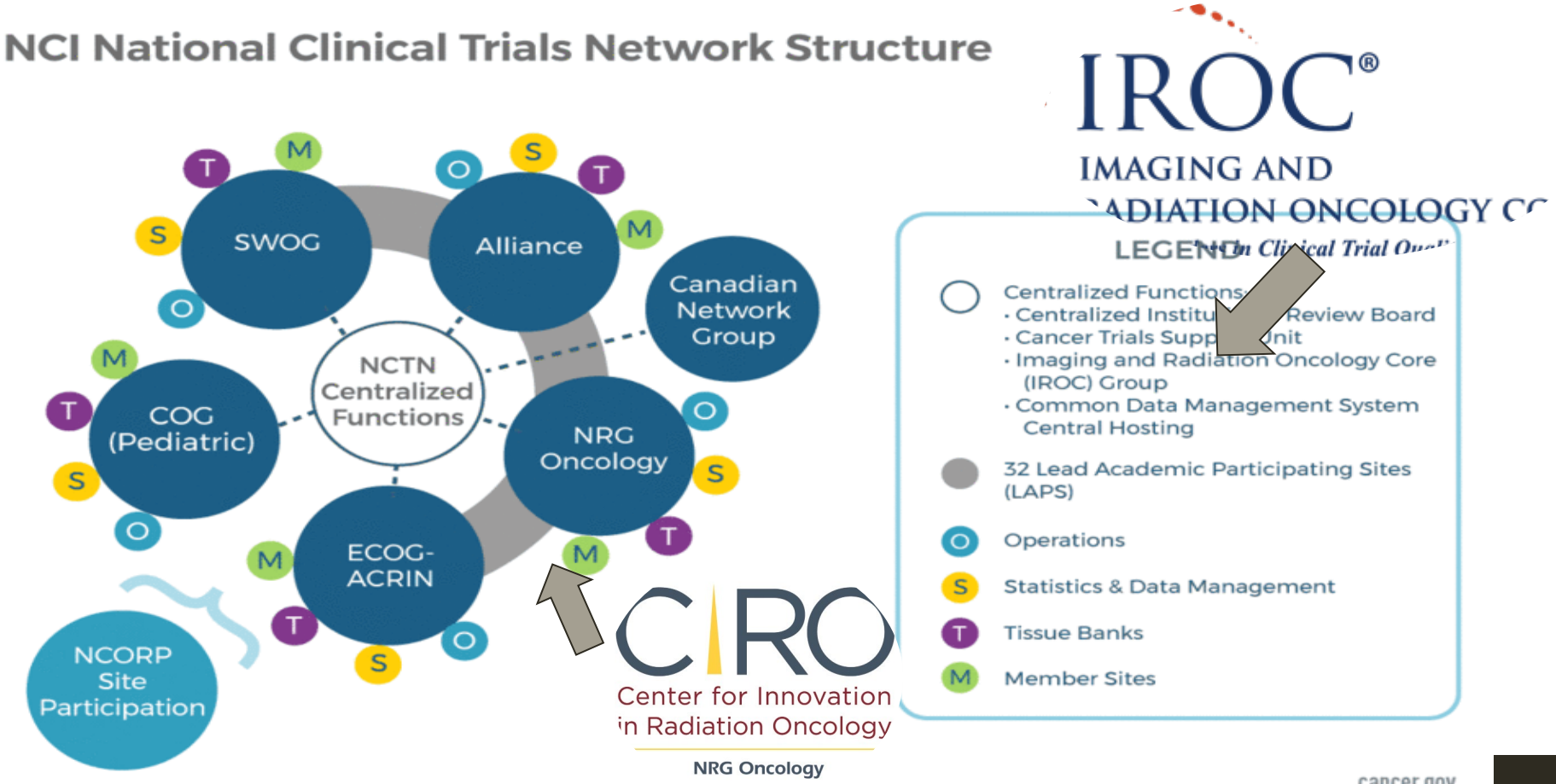
NCTN : NCI'S NATIONAL CLINICAL TRIALS NETWORK



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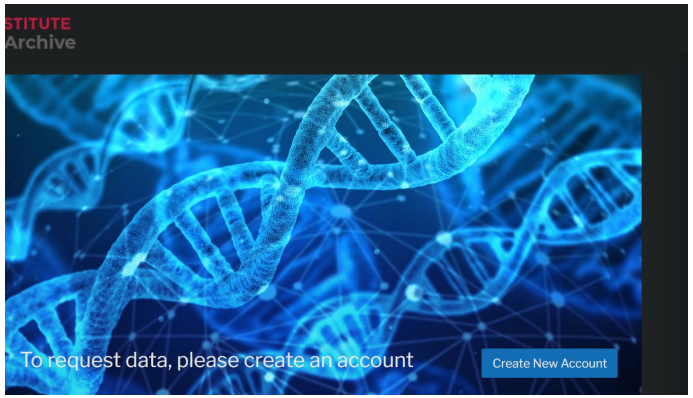

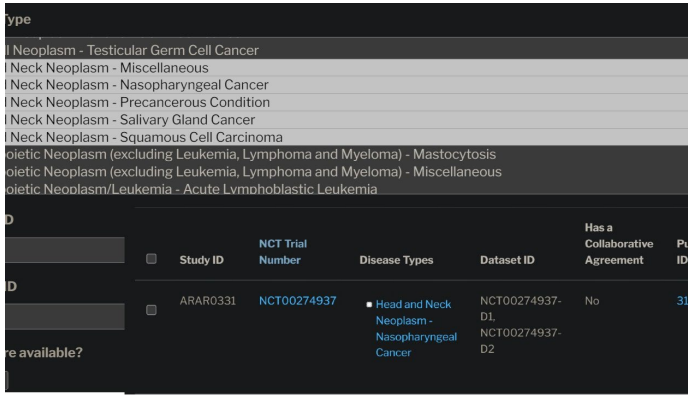

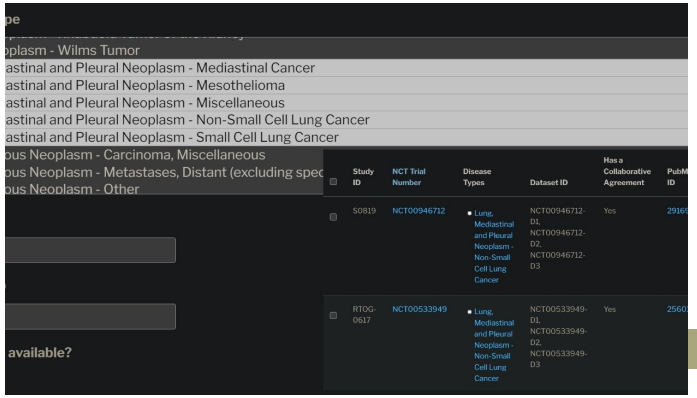

One dataset for H&N
Two datasets with images for Lung

NCTN/NCORP DATA ARCHIVE

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DE-FACING ALGORITHMS

De-facing algorithms are an essential tool for protecting personal privacy in medical images.

Quick-shear: By identifying a plane to divide the head into two parts and remove the part containing facial features.

Biometric_Mask : Remove the front face and ears by defining several rectangular masks.

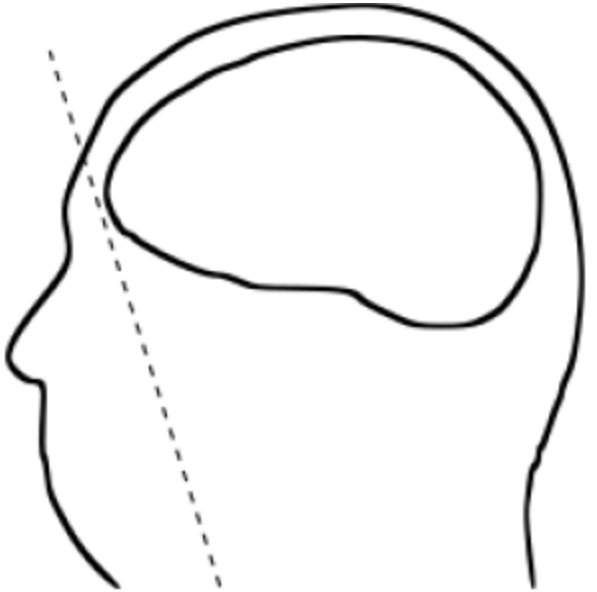
Carina: Generate masks to compensate for facial features by interpolating based on depth for recognition.

MRI_reface: The face and ear regions of each patient were replaced with voxels from a population-average face.

QUICKSHEAR

Offers an image de-identification method that aims to eliminating the need for a manually labeled face atlas and a computationally expensive transform to atlas space.

Identifies a plane that divides the volume into two sections, one containing facial features and another containing the entire brain volume.

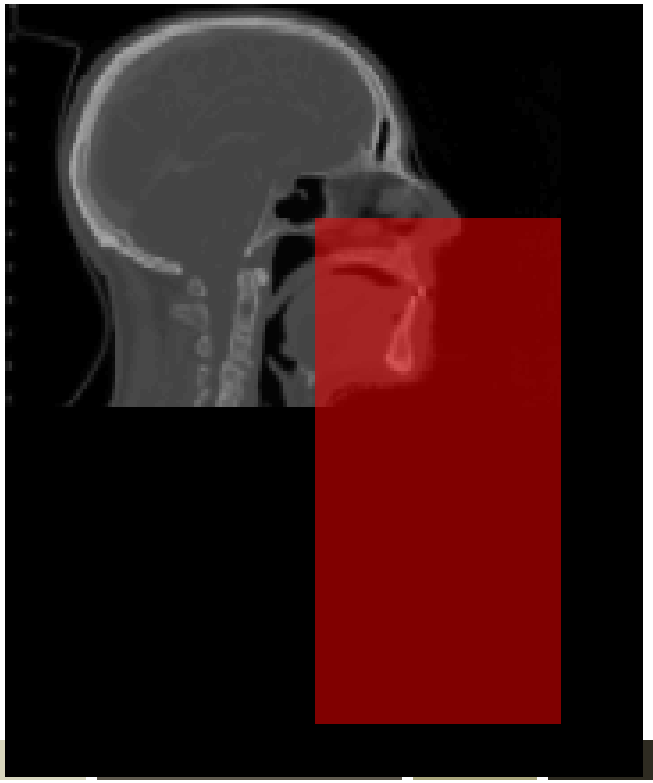


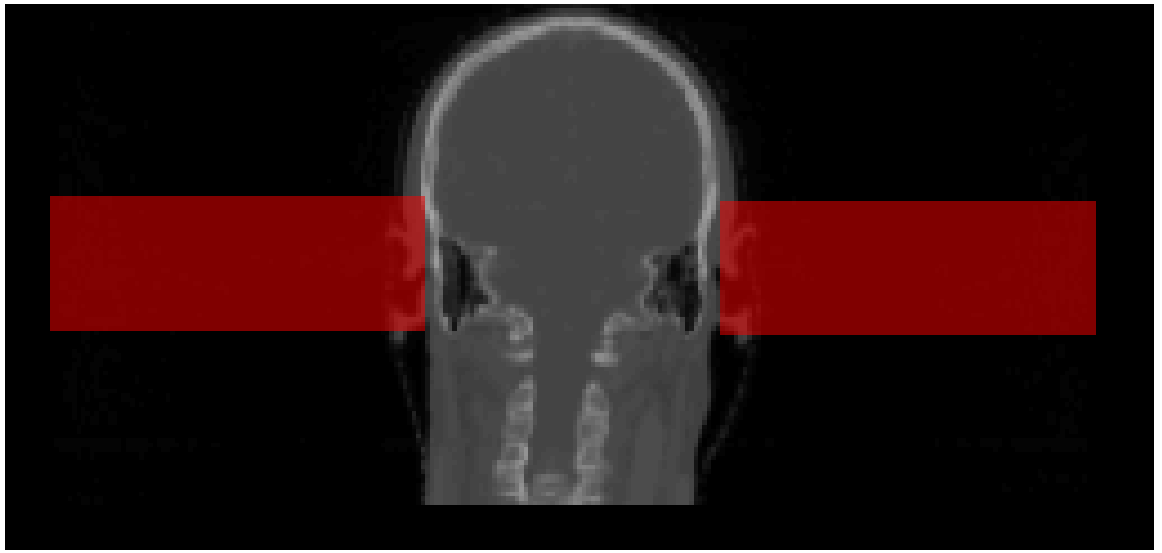
Schimke, Nakeisha, and John Hale. "Quickshear defacing for neuroimages." Proceedings of the 2nd USENIX conference on Health security and privacy. USENIX Association, 2011.

BIOMETRIC_MASK DEFACING

A defacing tool under ichseg R package which aimed to perform preprocessing on computed tomography (CT) scans, including skull stripping

CT-biometric defacing is an aggressive defacing algorithm that cut off the face and ears with a rectangular mask.





MRI_REFACE: INTENSITY NORMALIZATION & ARTIFACT REMOVAL FOR PRIVACY

- Match transformed template and target image intensities
- Swap face and ear voxels with transformed template voxels
- Replace air voxels >10x the mean to eliminate identifiable information (MRI only)
- Preserve brain volume measurements while ensuring privacy

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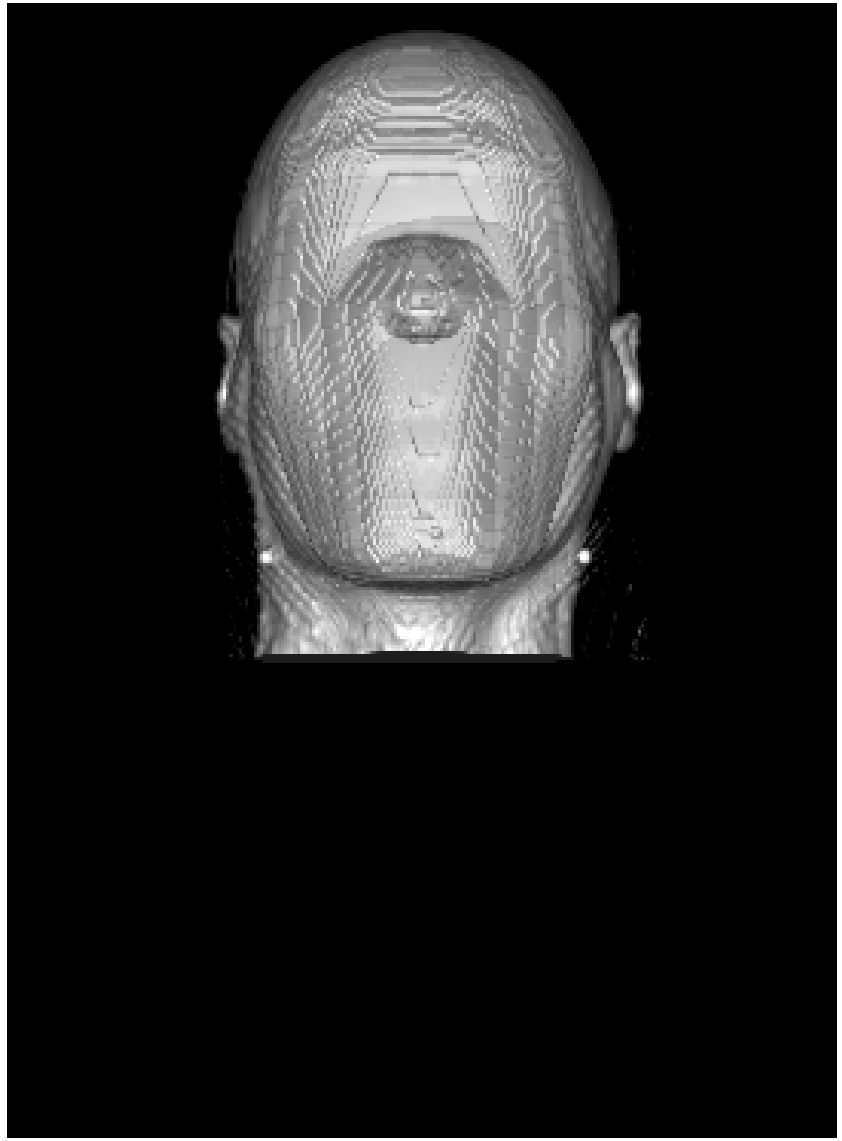
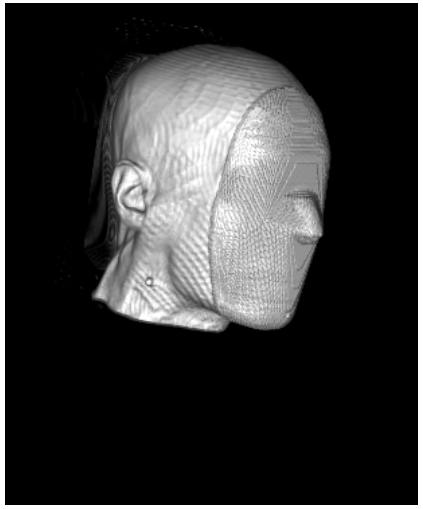
CARINA DEFACING

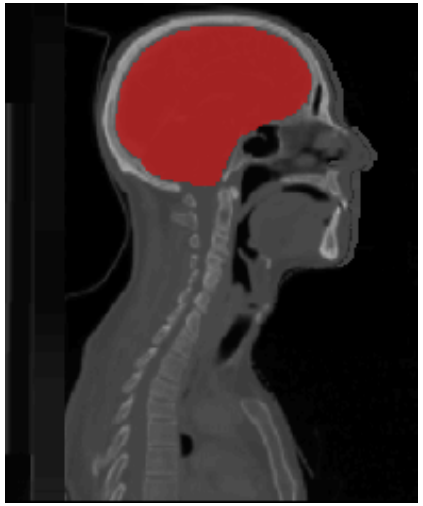
Body segmentation and face detection at first, then generated a "mask" with similar pixel intensities as the face.

By interpolation according to the depth, the mask is generated to compensate the facial features for identification.

Eventually the mask gets applied to the images on the top.







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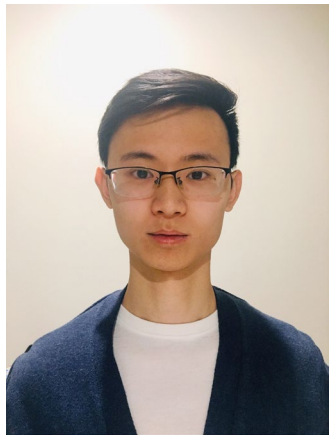
OUR STUDY

Data from The Cancer Imaging Archive (TCIA)

- Brain Data (CT, MRI, RTst, RTDose)
- Head and Neck (CT, PET , RTst, RTDose)



De-facing Tools:

- Quickshear
- Biometric_Mask
- MRI-reface
- Carina

Evaluation

- De-facing performance: Measure the success rate to re-identify the de-faced patient
- Impact on Radiotherapy

Measuring Defacer Success

Measure the success rate to re-identify the de-faced patient

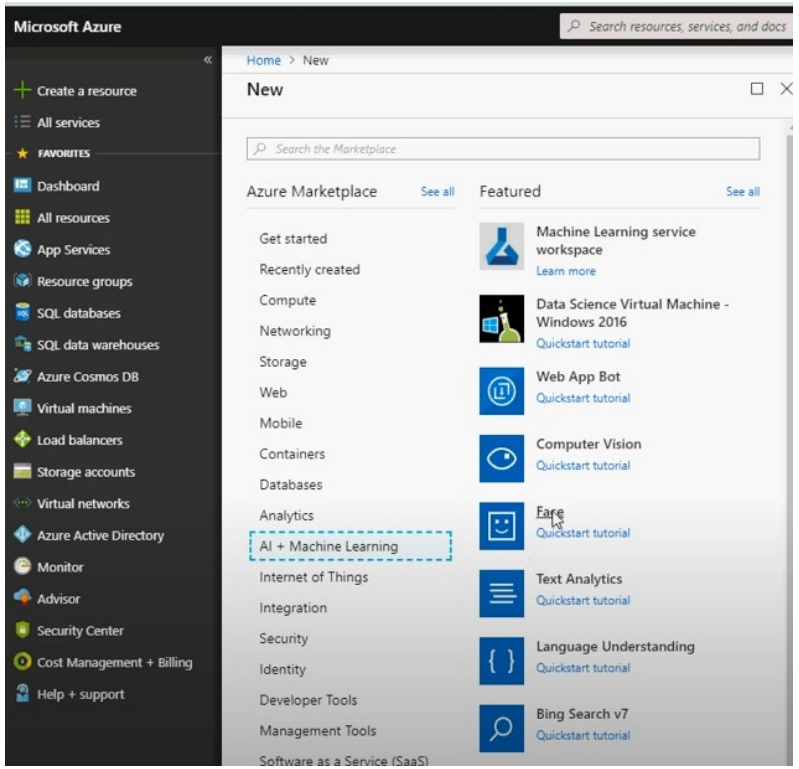
The effects of defacing on radiotherapy

Compare the radiomics features of critical structures between the original and de-faced CT

MICROSOFT AZURE COGNITIVE FACE API

A powerful cloud-based service that provides advanced facial recognition and analysis capabilities.

It allows developers to integrate face detection, recognition, and emotion analysis functionalities into their applications and systems.



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FACE_RECOGNITION

Face recognition library.
https://github.com/ageitgey/face_recognition

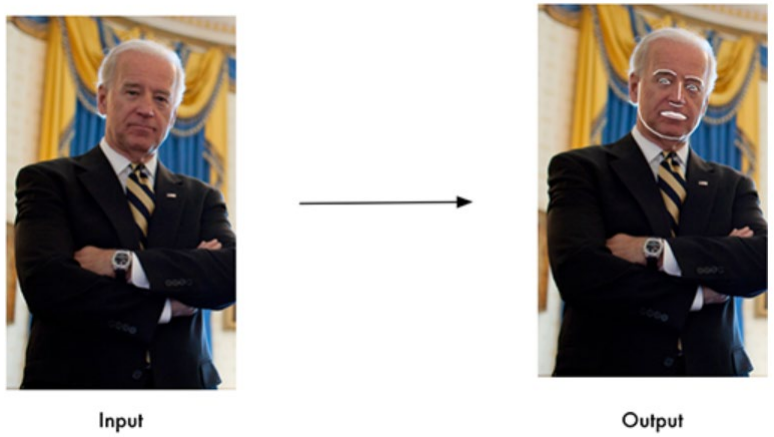
State-of-the-art face recognition built with deep learning and have very high accuracy

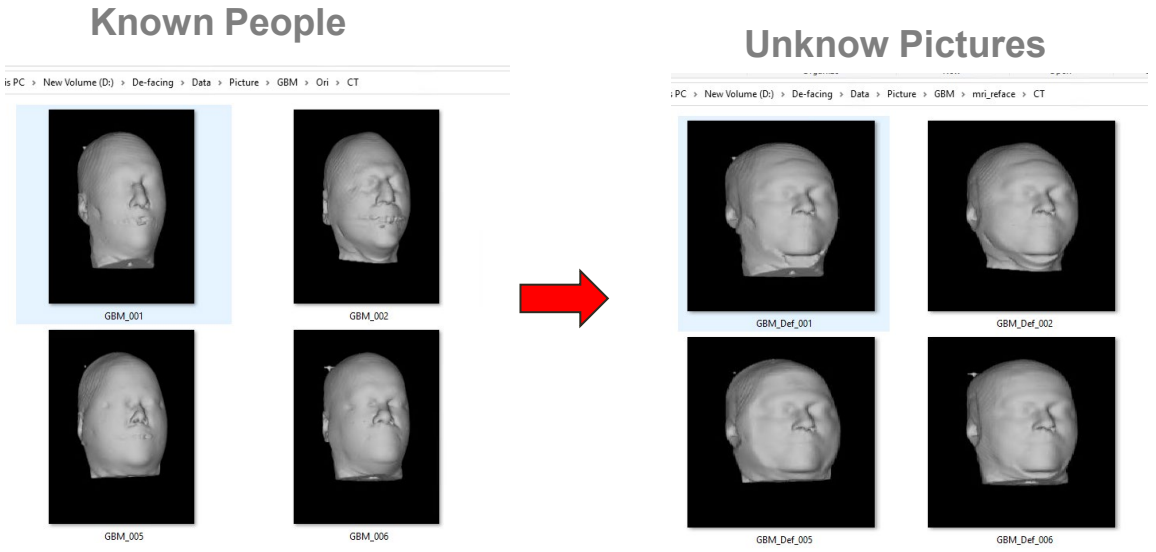
Face detection

Get the locations and outlines of each person's eyes, nose, mouth, and chin.

Face recognition

Face distance 0-1





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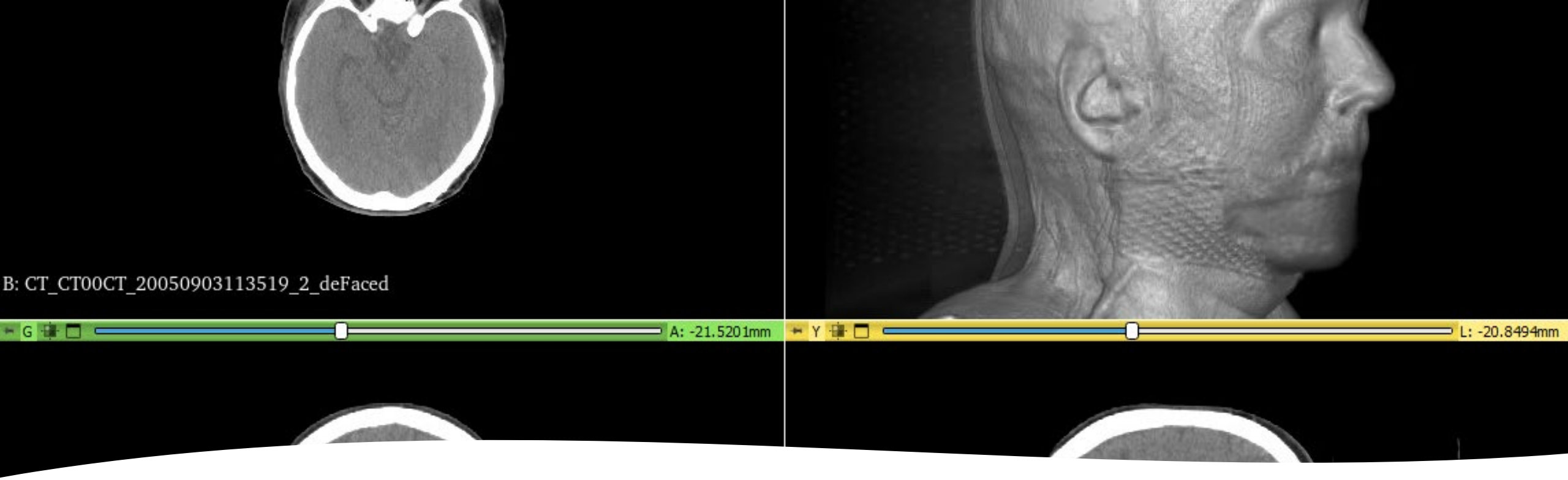

RESULTS – FACIAL RECOGNITION

- 3D slicer to reconstruct images
- Use the reconstructed original image as the know patient group to identify de-faced images
- Tolerance set at 0.3

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FACIAL RECOGNITION

Defacing Method	CT		MRI	
	No. of Cases	Faces detected	No. of Cases	Faces detected
Quickshear	119	0	62	0
Biometric_Mask	102	0	62	0
Mri-reface	119	0	62	0
Carina	103	0	8	0

EVALUATION OF THE EFFECTS OF DEFACING ON RADIOTHERAPY

119 CT Cases

Evaluate structures: Bone-Mandible, Brain, Brainstem, Cavity_Oral, Eye_L/R, OpticChiasm, OpticNrv_L/R, Parotid_L/R

First-order radiomics features of each structure were compared between original and defaced CT images.

- First-order statistics describe the distribution of voxel intensities within the image region defined by the mask through commonly used and basic metrics.

PRELIMINARY RESULTS

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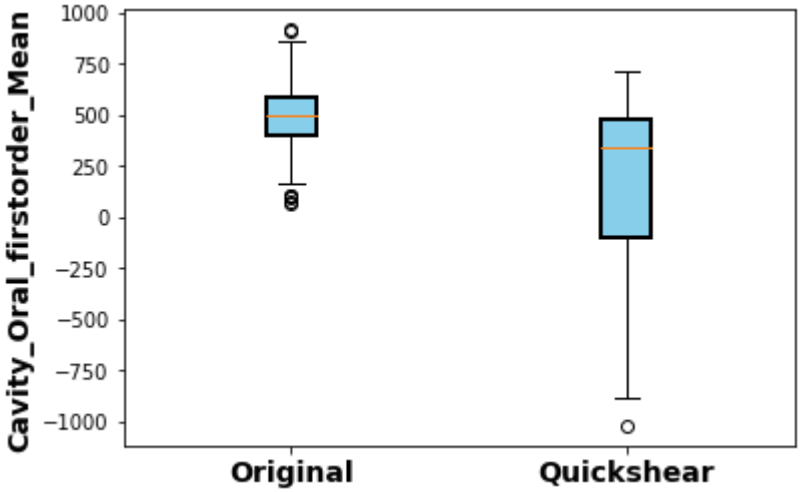
RADIOMICS EVALUATION - QUICKSHEAR

	90Percentile	Energy	Entropy	Kurtosis	Maximum	Median	Range	Skewness	Uniformity	Variance
Bone_Mandible	3.19%	-45.72%	8.24%	-6.65%	6.46%	25.14%	-15.71%	-229.01%	-359.65%	-98.63%
Brain	-1.96%	-211.39%	-0.46%	22.77%	2.17%	-2.13%	-17.29%	187.15%	2.71%	-230.39%
Brainstem	-4.30%	-1038.97%	-9.13%	-4419.94%	-6.46%	-1.98%	-637.22%	6168.16%	7.57%	-2449.34%
Target	-3.04%	-187.16%	-2.76%	-224.40%	-9.04%	-2.17%	-44.83%	9367.15%	2.59%	-173.97%
Cavity_Oral	6.31%	-518.95%	6.02%	-1033.10%	5.37%	-54.57%	-212.57%	910.46%	-15.08%	-316.07%
OpticChiasm	-3.17%	-3099.68%	-4.22%	-1907.52%	9.49%	-8.39%	-672.96%	6347.63%	4.72%	-3630.12%
Eye_L	-2.08%	-3251.90%	-5.71%	-2292.37%	0.73%	-2.62%	-371.91%	-934.78%	6.49%	-3649.96%
Eye_R	-2.29%	-2639.79%	-5.66%	-2420.06%	0.02%	-3.24%	-400.87%	3413.84%	6.47%	-3221.09%
OpticNrv_L	6.31%	-518.95%	6.02%	-1033.10%	5.37%	-54.57%	-212.57%	910.46%	-15.08%	-316.07%
OpticNrv_R	9.74%	-499.77%	7.20%	-1042.97%	10.97%	-34.35%	-205.41%	-782.34%	-16.27%	-320.98%
Parotid_L	-8.00%	-1269.59%	-3.82%	-1285.32%	0.22%	-10.74%	-166.00%	-251.60%	4.74%	-1051.12%
Parotid_R	-9.55%	-1361.84%	-3.85%	-1181.79%	-1.71%	-12.96%	-174.28%	-12319.38%	4.76%	-1106.97%



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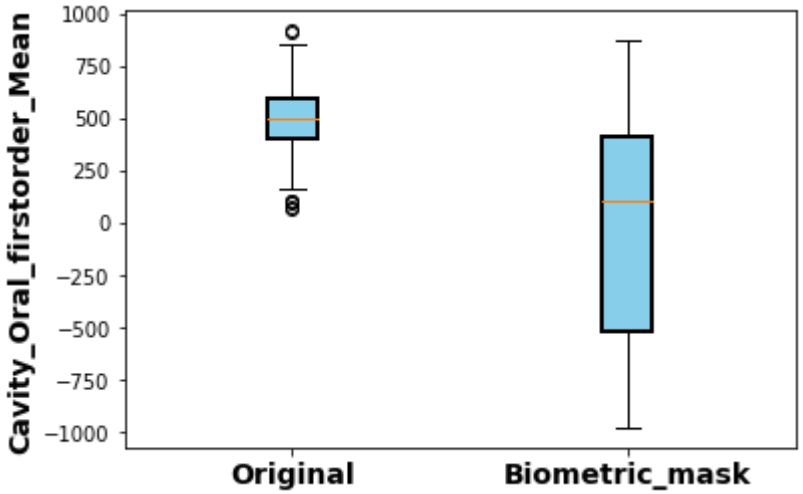
RADIOMICS EVALUATION – BIOMETRIC_MASK

	90Percentile	Energy	Entropy	Kurtosis	Maximum	Median	Range	Skewness	Uniformity	Variance
Bone_Mandible	5.04%	6.17%	10.21%	9.26%	4.51%	34.98%	-16.00%	180.95%	-441.67%	-169.74%
Brain	0.00%	-71.88%	-0.42%	0.92%	0.00%	0.16%	-0.65%	1.42%	0.34%	-118.57%
Brainstem	3.66%	-870.69%	0.10%	-1.01%	0.02%	37.25%	-7.03%	353.50%	-0.59%	-389.98%
Target	-0.31%	-27.79%	-0.57%	-7.18%	-10.36%	-0.14%	-3.84%	17.51%	0.33%	-36.88%
Cavity_Oral	44.09%	-17.60%	21.48%	-46.58%	4.38%	442.17%	1.49%	-10.87%	-385.31%	-2.85%
OpticChiasm	54.36%	3063.18%	1.94%	0.91%	35.38%	90.19%	1.91%	29.24%	2.42%	1.94%
Eye_L	19.21%	-881.98%	0.34%	-100.08%	8.12%	41.73%	-10.42%	77.77%	-1.36%	-15.63%
Eye_R	-0.36%	-182.98%	-1.08%	-21.02%	-2.06%	0.20%	-15.81%	59.86%	0.71%	-509.64%
OpticNrv_L	19.46%	-235.34%	0.98%	0.87%	3.71%	71.64%	0.98%	1.26%	-4.51%	0.98%
OpticNrv_R	18.92%	-285.79%	0.60%	-0.11%	0.61%	66.93%	-1.29%	-1.44%	-2.49%	-23.08%
Parotid_L	4.83%	-719.43%	-3.28%	-315.67%	-0.13%	-3.40%	-54.71%	-215.24%	3.09%	-928.38%
Parotid_R	0.76%	-899.32%	-1.23%	-155.63%	-0.23%	-52.03%	-35.22%	-823.16%	0.85%	-539.02%



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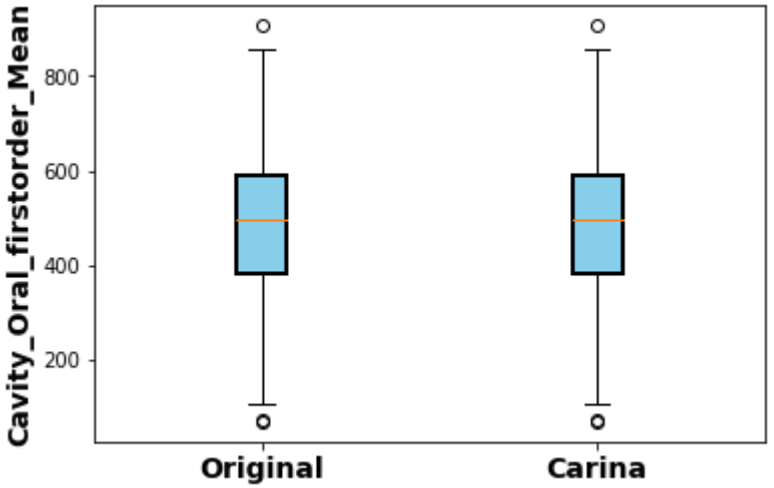
RADIOMICS EVALUATION - CARINA

	90Percentile	Energy	Entropy	Kurtosis	Maximum	Median	Range	Skewness	Uniformity	Variance
Bone_Mandible	0.04%	0.06%	0.00%	-0.02%	0.04%	0.02%	0.02%	-0.10%	-0.02%	0.06%
Brain	0.06%	-0.09%	0.10%	0.17%	0.03%	0.03%	0.00%	0.05%	-0.21%	-0.16%
Brainstem	0.11%	0.14%	0.18%	-0.10%	0.13%	0.00%	-0.03%	-3.38%	-0.21%	0.37%
Target	-0.44%	-31.13%	-0.50%	-43.15%	-16.79%	-0.31%	-6.66%	107.15%	0.03%	-37.44%
Cavity_Oral	0.05%	0.10%	0.04%	-0.13%	-0.12%	0.07%	0.00%	-0.25%	-0.20%	0.16%
OpticChiasm	-0.26%	-0.49%	-0.06%	0.35%	-0.12%	0.04%	0.06%	0.65%	0.09%	-0.54%
Eye_L	0.30%	0.86%	0.42%	-10.12%	-3.63%	-0.02%	3.09%	0.68%	-0.38%	2.05%
Eye_R	0.21%	0.55%	0.42%	-7.25%	-2.31%	-0.06%	2.54%	52.57%	-0.35%	1.72%
OpticNrv_L	0.00%	0.32%	0.02%	0.63%	-0.02%	0.09%	0.38%	1.51%	-0.03%	0.34%
OpticNrv_R	0.11%	0.20%	0.03%	0.31%	0.06%	0.00%	0.29%	4.56%	-0.06%	0.20%
Parotid_L	0.06%	-0.14%	0.04%	-14.99%	-1.18%	0.00%	-0.86%	10.68%	-0.07%	-0.18%
Parotid_R	0.07%	-0.07%	-0.01%	-5.71%	-0.99%	0.04%	-0.80%	-14.68%	-0.03%	-0.38%



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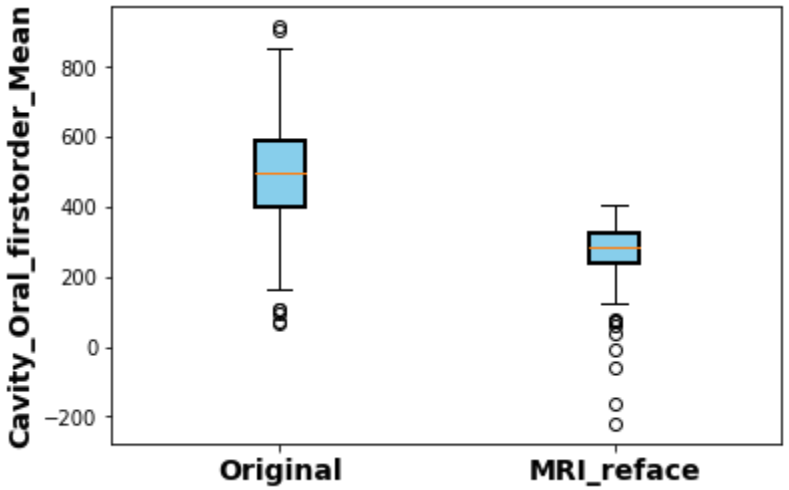
RADIOMICS EVALUATION – MRI-REFACE

	90Percentile	Energy	Entropy	Kurtosis	Maximum	Median	Range	Skewness	Uniformity	Variance
Bone_Mandible	17.50%	51.51%	-0.94%	-6.62%	29.11%	63.15%	16.51%	-322.63%	-6.58%	-31.94%
Brain	0.65%	-17.62%	-0.82%	12.68%	-0.34%	1.12%	0.54%	1.79%	-0.33%	-34.63%
Brainstem	1.64%	3.00%	1.63%	0.81%	1.68%	1.50%	2.13%	42.86%	-1.58%	4.18%
Target	1.47%	-47.87%	0.01%	-31.29%	-11.71%	3.41%	-5.17%	-92.20%	-1.48%	-78.56%
Cavity_Oral	20.22%	41.73%	-2.78%	-5.95%	29.45%	25.29%	30.61%	10.35%	18.37%	39.43%
OpticChiasm	3.08%	9.05%	2.55%	6.40%	8.08%	4.86%	7.59%	94.55%	-2.73%	9.00%
Eye_L	-87.35%	-3553.26%	-60.79%	-279.97%	-168.78%	-37.59%	-291.18%	150.80%	43.15%	-7116.73%
Eye_R	-71.33%	-3835.24%	-61.55%	-266.50%	-147.66%	-21.59%	-289.43%	793.18%	43.86%	-6963.23%
OpticNrv_L	2.95%	-54.18%	-3.47%	-57.19%	-41.43%	170.58%	-25.92%	-247.69%	5.72%	-68.44%
OpticNrv_R	5.36%	-13.44%	-4.13%	-12.93%	-12.22%	134.97%	-8.51%	5.04%	8.10%	-25.62%
Parotid_L	5.20%	-253.01%	-3.78%	-148.81%	-3.80%	-1.46%	-35.16%	-144.40%	2.55%	-309.27%
Parotid_R	-3.29%	-172.75%	-1.54%	-244.64%	-48.52%	3.04%	-61.72%	-742.33%	-0.57%	-244.46%



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LIMITATIONS AND FUTURE STUDIES

No patients photograph, limited cases and image quality

Apply defacing to CT/MR/PET/RT Dose Matrix

Evaluate other defacing, reconstruction and facial recognition tools

THANK YOU