



Memorial Sloan Kettering
Cancer Center

The Power of Open-Access AI in Clinical and Translational Research

Saad Nadeem

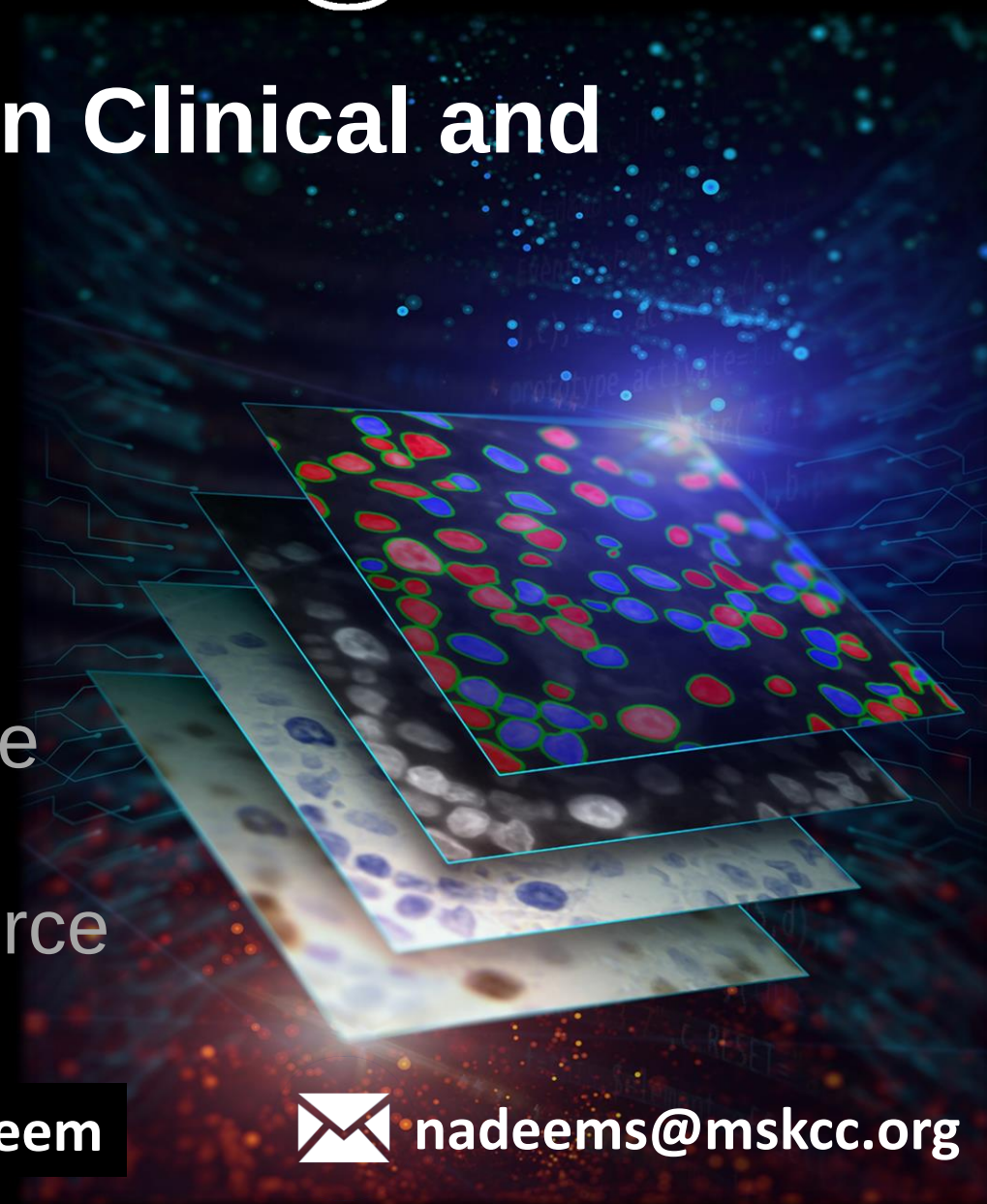
Assistant Attending

Department of Medical Physics

Department of Pathology & Lab Medicine

Service for Predictive Informatics

AI Ethics Committee + Clinical AI Taskforce



<https://nadeemlab.org/>



[/in/sanadeem](https://www.linkedin.com/in/sanadeem)

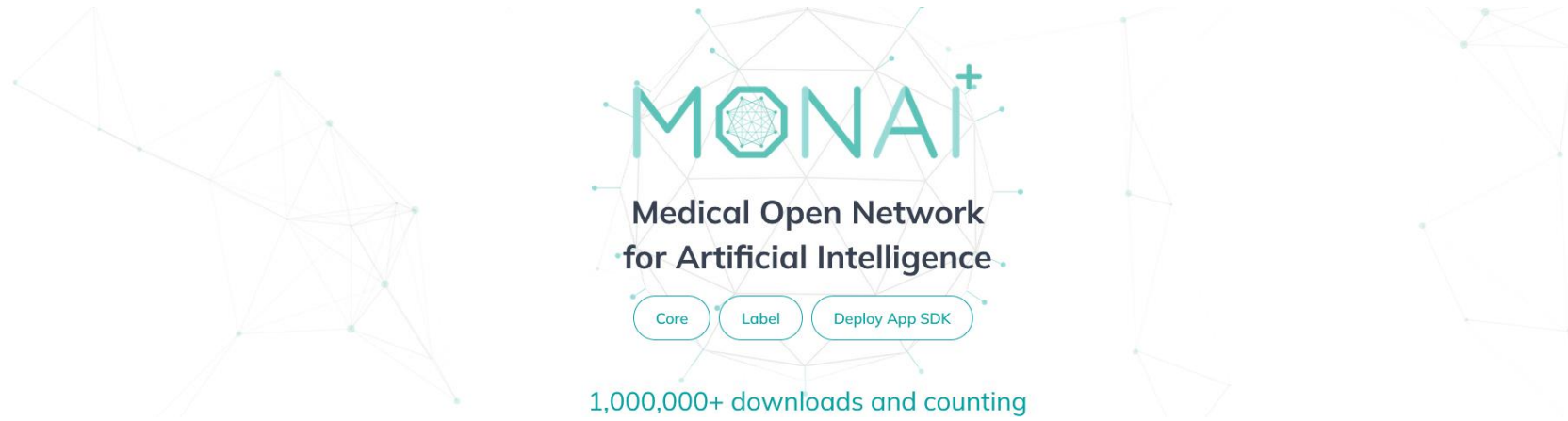


nadeems@mskcc.org



Disclosure

MONAI Advisory Board Member (monai.io/about)



Team



James C Mathews



Joseph Marino



Gunjan Shrivastava



Natalia Martinez



Carlin Liao



Philosophy

“Remember this: You had time to absorb the change. Now you’re introducing it to your colleagues, and although you might be fully on board, they need the time and space to absorb it as well.

You might be comfortable with the change because you helped craft it. Give them that same grace and sense of control – and they’ll come along, just as you did.”

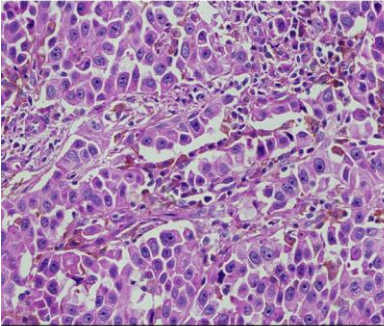
- Jason Fiefer



Pathology

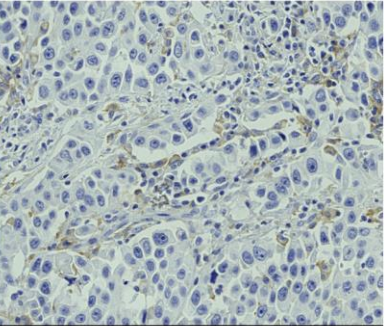
DeepLIIF (deepliif.org)

Hematoxylin-Eosin (H&E)
standard



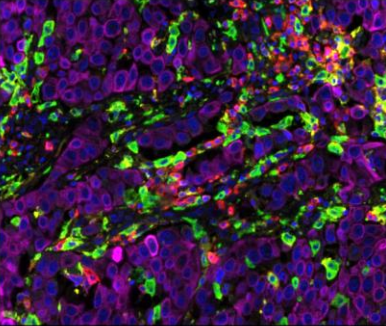
Diagnostic pathology

Immunohistochemistry (IHC)
(single or double chromogen)



Diagnostic pathology

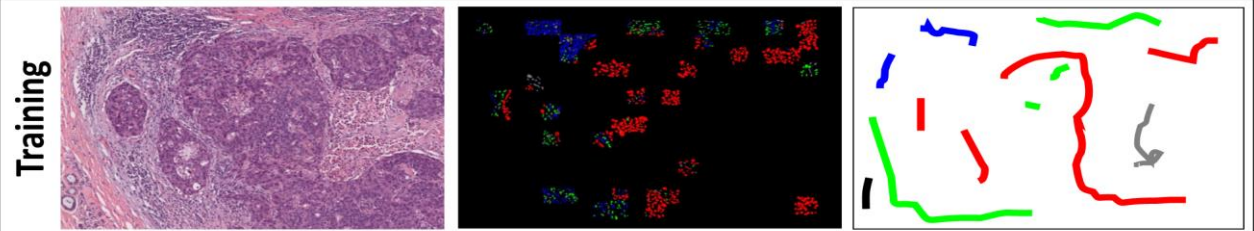
High-Dimensional Imaging
7-30 markers: CellDive, Codex, Vectra



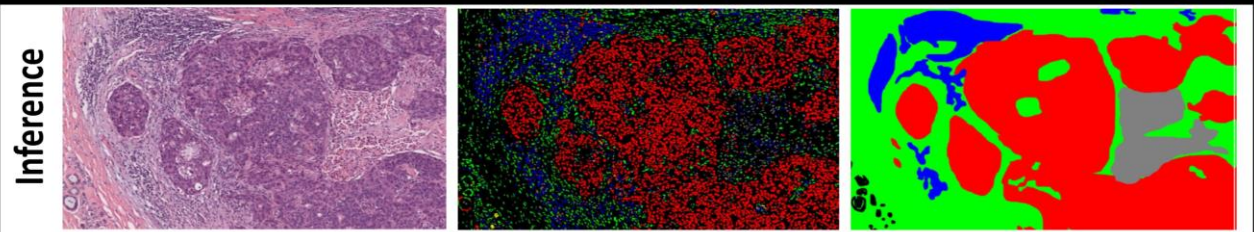
NextGen IHC: R&D

HTCNet

Training



Inference



Spatial Profiling Toolbox (oncopathtk.org)

SPT DASHBOARD
GitHub

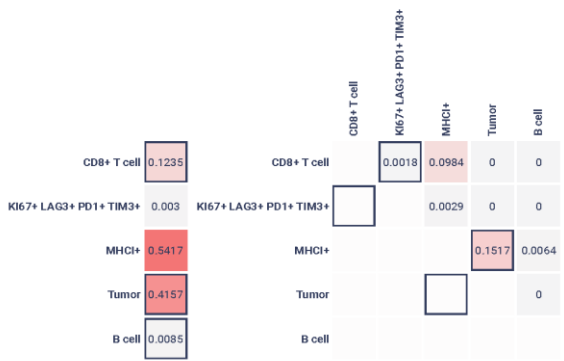
Overview

Select Studies

Analysis

Visualization

Selected stats



The average value of the proximity score for phenotype(s) B cells is 3.59 times higher in cohort 3 than in cohort 1.

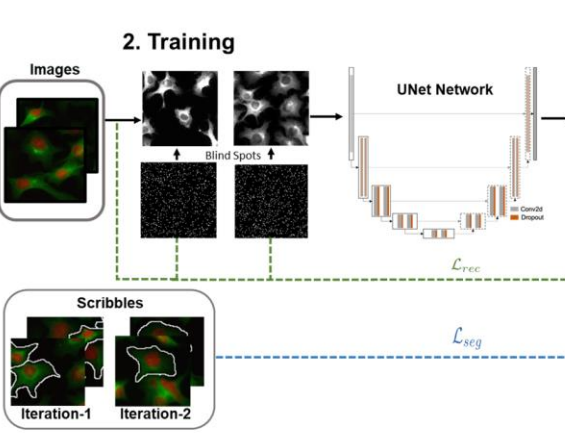
Sample	Cohort	Cells	CD8+ T cell	CD8+ T cell, KI67+ LAG3+ PD1+ TIM3+	MHCI+, Tumor	Tumor	B cell	cell-to-cell proximity
lesion_0_1	1	99168	3225	32	48025	58896	729	Ripley
lesion_0_2	2	186198	7123	339	88672	111620	1668	autocorrelation
lesion_0_3	2	127210	46777	10	0	0	1283	neighborhood enrichment

ImPartial (github.com/nadeemlab/ImPartial)

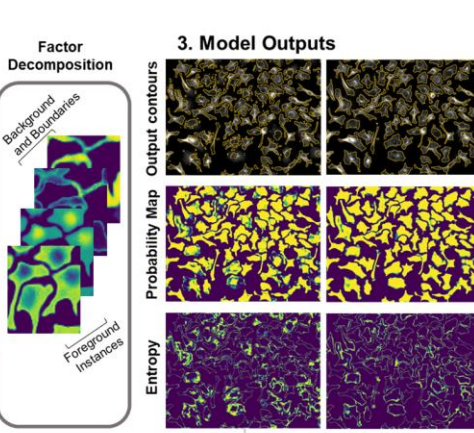
1. Data and Patch Sampler



2. Training



3. Model Outputs

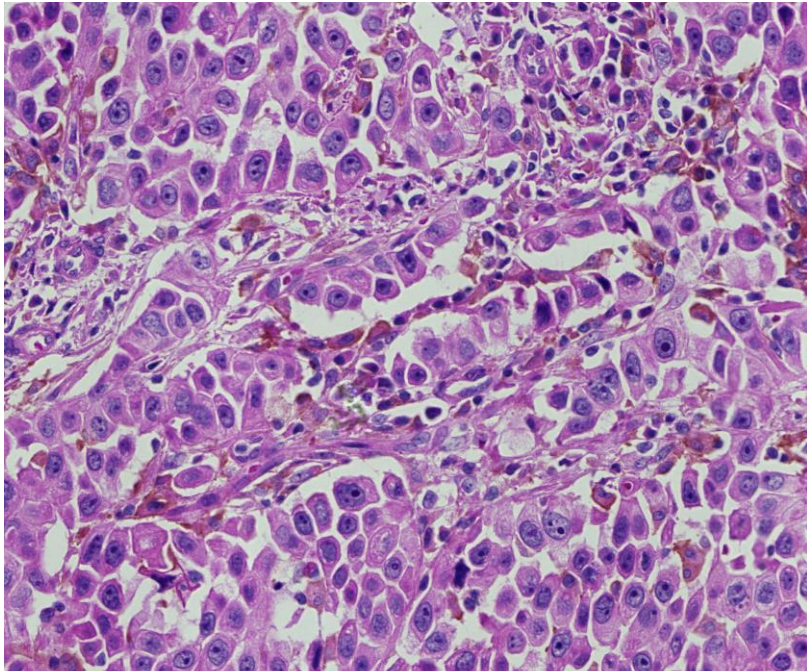


User

Provide additional scribbles to refine model

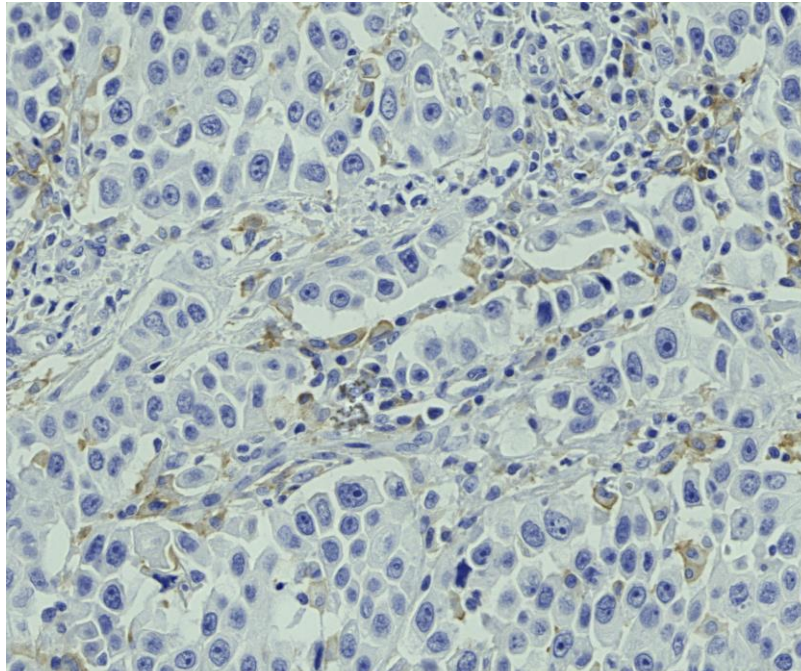
DeepLIF Virtual Multiplex Restaining (deepliif.org)

Hematoxylin-Eosin (H&E)
standard



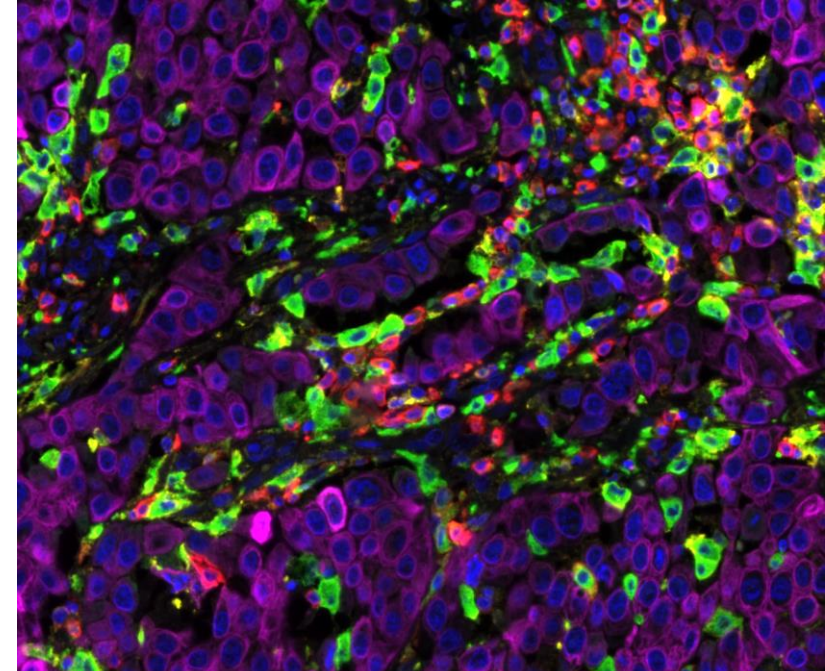
Diagnostic pathology

Immunohistochemistry (IHC)
(single or double chromogen)



Diagnostic pathology

High-Dimensional Imaging
7-30 markers: CellDive, Codex, Vectra



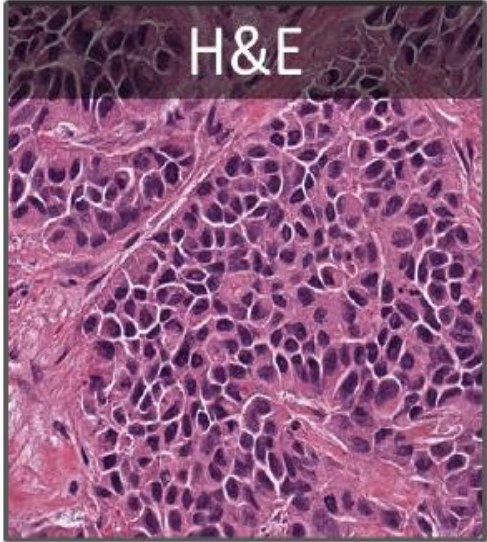
NextGen IHC: R&D

DeepLIIF Virtual Multiplex Restaining (deepliif.org)

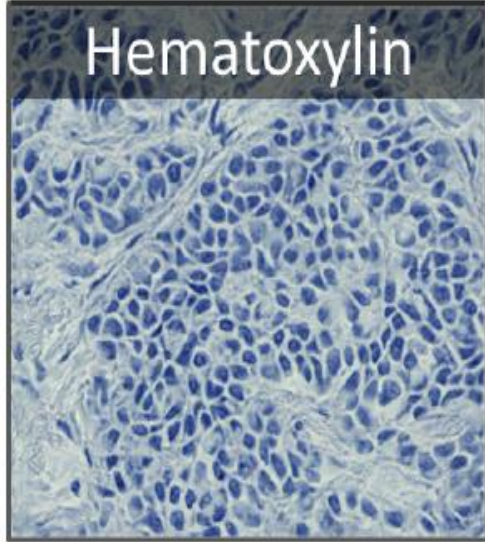
Input

Output

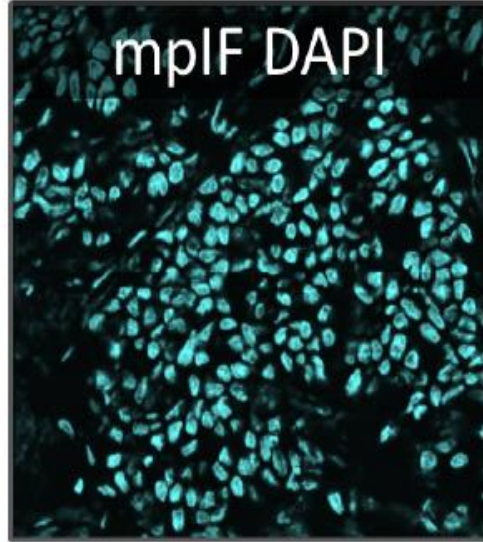
H&E



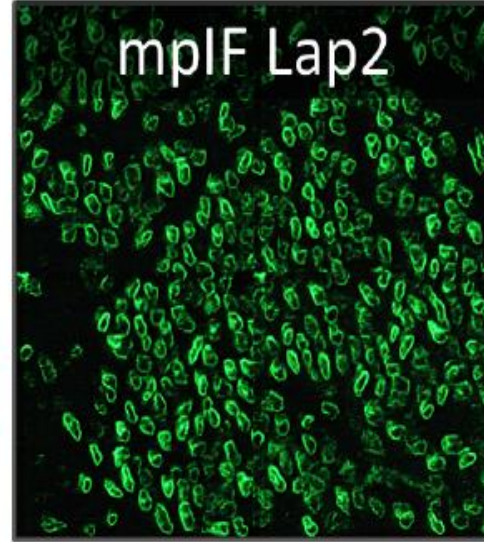
Hematoxylin



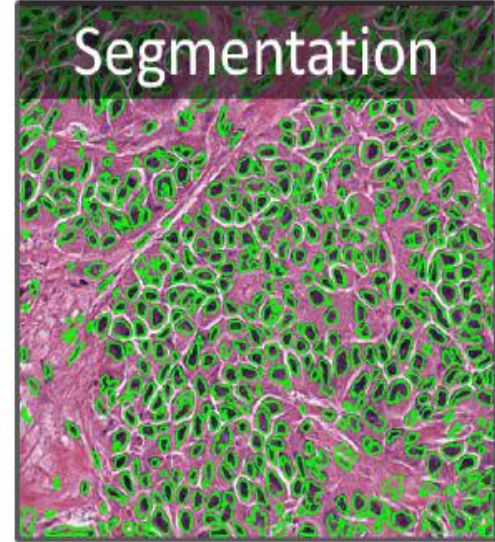
mpIF DAPI



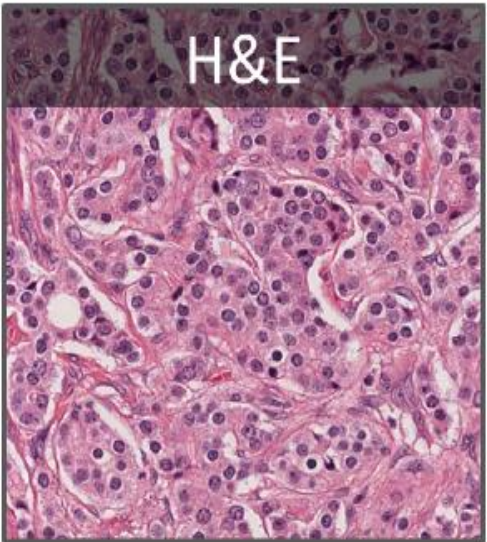
mpIF Lap2



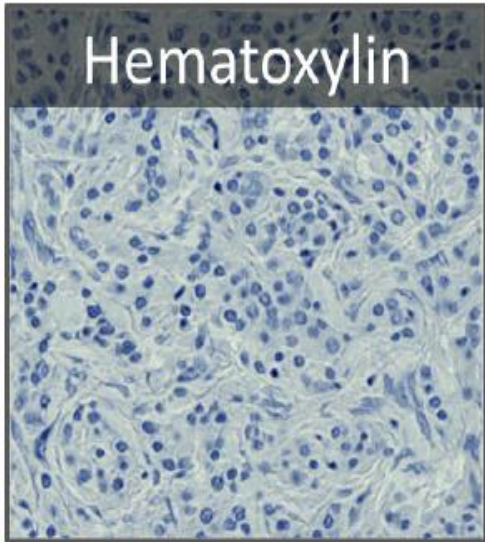
Segmentation



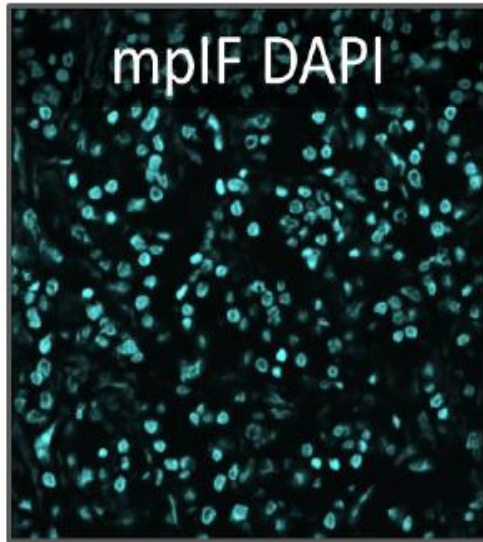
H&E



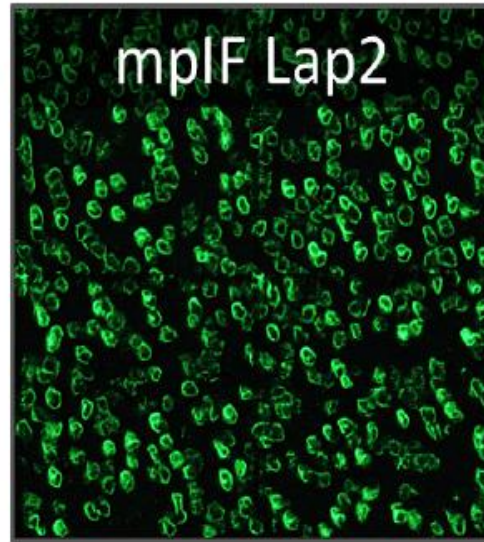
Hematoxylin



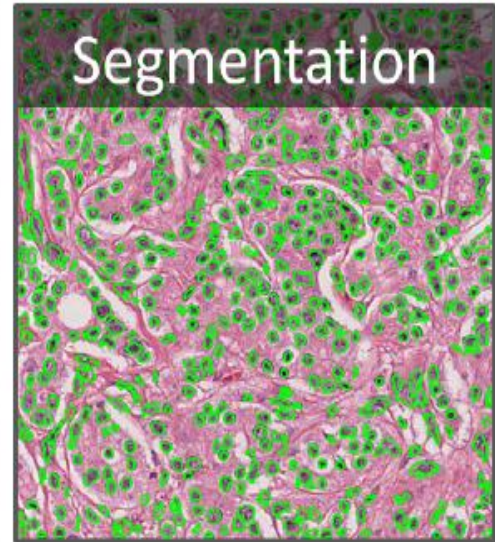
mpIF DAPI



mpIF Lap2

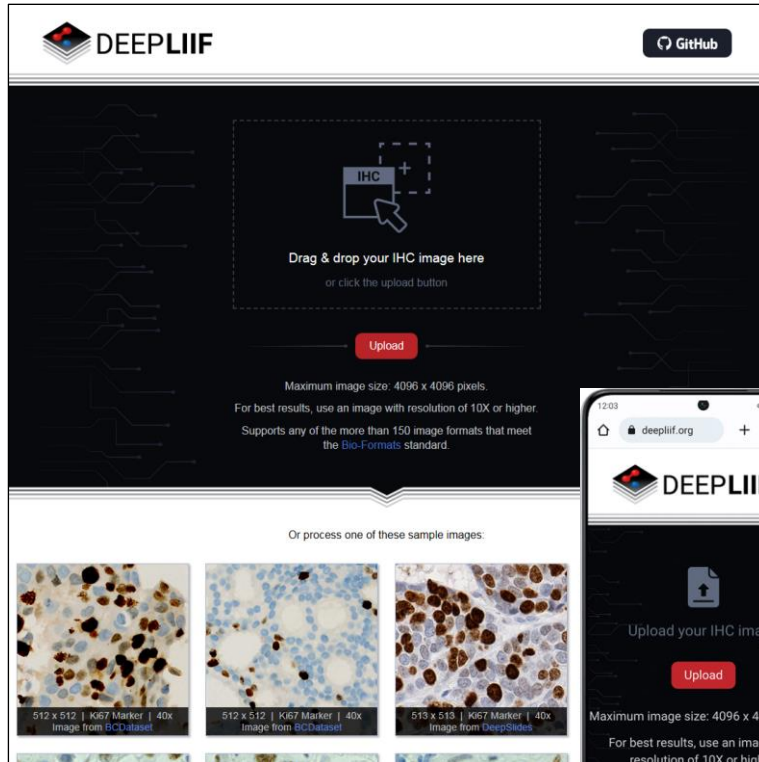


Segmentation





DeepLIIF Progress (<https://deepliif.org>)

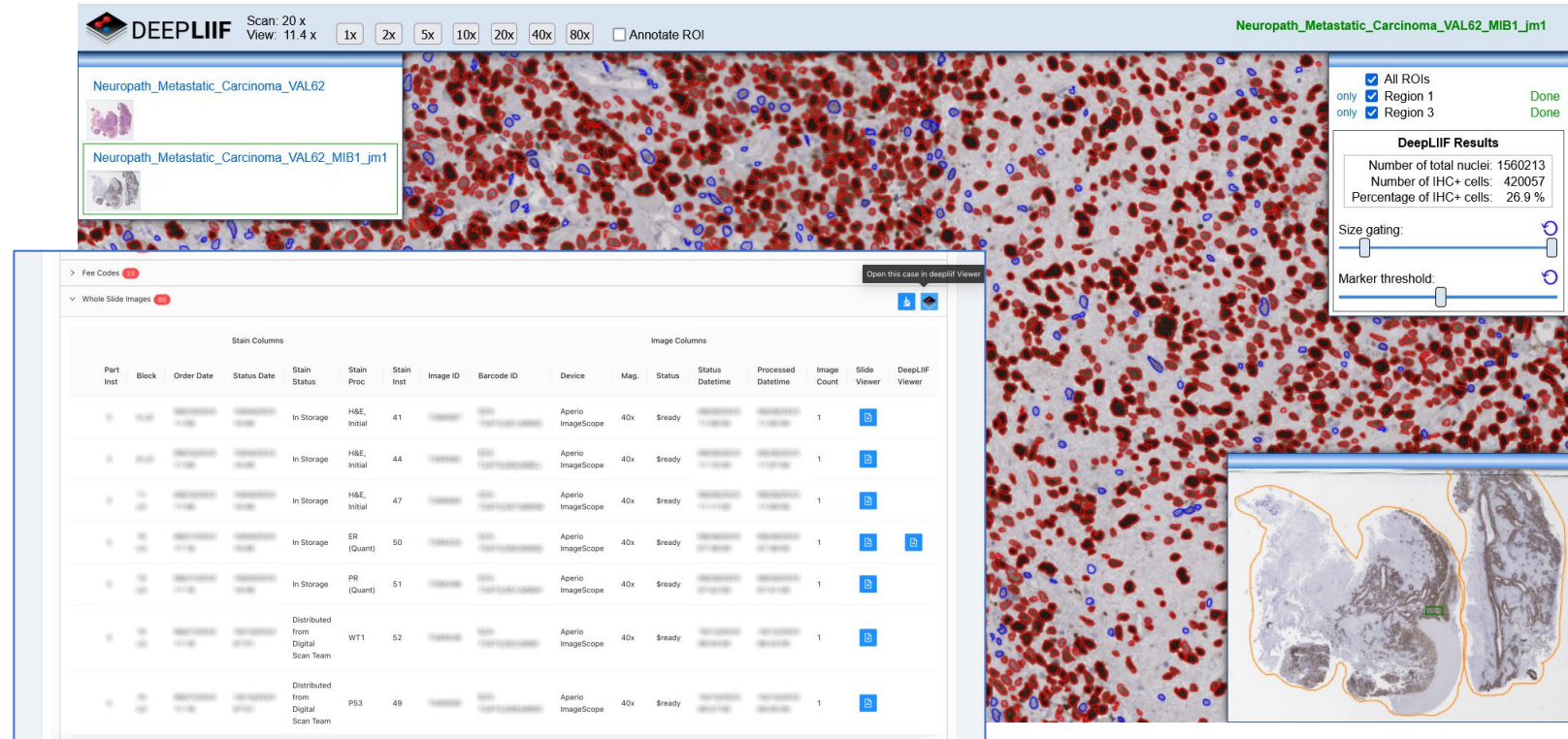


Launched Jan 2022

1,700 sessions every day (17-Oct'23)

Support IHC Ki67, ER, PR, CD3, and CD8

Future support: HER2, PD-L1



DeepLIIF Whole-Slide Image Viewer

Integration with Pathology Dashboard/Worklist

Official launch Sep 1st

Nature Machine Intelligence'22, CVPR'22, MICCAI'23, Histopathology'23

HNSCC

NSCLC

TNBC

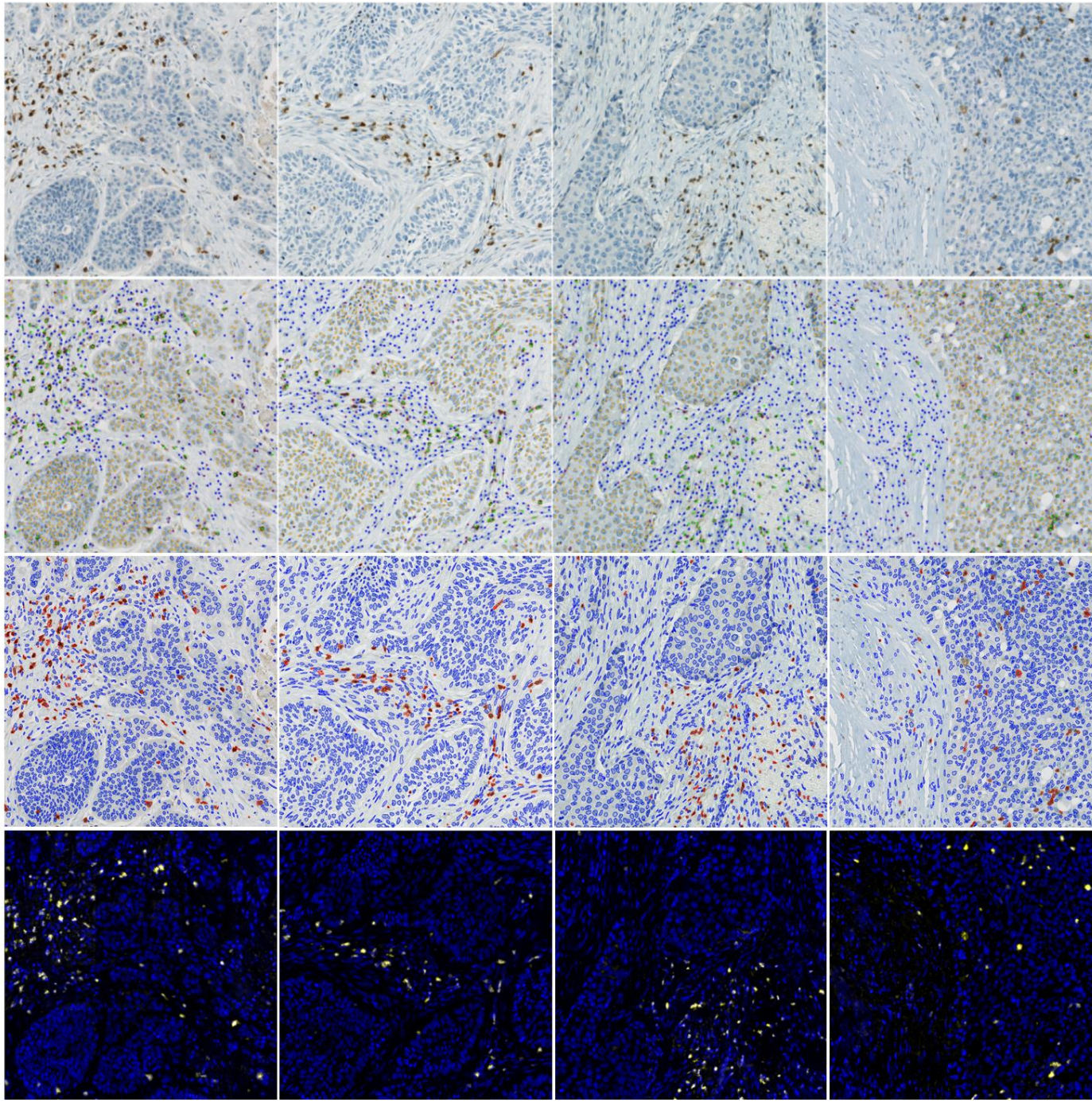
GC

ownstream Studies

Consensus

Ours

Ours



“DeepLIIF out-of-the-box (without being fine-tuned or retrained) outperformed all the models trained on the same samples (DeepLIIF had an average precision of 0.85 on Gastric Cancer [GC], 0.82 Head and Neck Squamous Cell Carcinoma [HNSCC], 0.77 Non small-cell lung cancer [NSCLC], and 0.84 Triple-Negative Breast Cancer [TNBC] vs the best RetinaNet model trained on same samples of 0.72 GC, 0.74 HNSCC, 0.74 NSCLC, and 0.73 TNBC).”

Talat et al. *Histopathology*'23 [Accepted]



DeepLIF Clinical Validation

104 breast cancer patients selected spanning all breast tumor subtypes

IHC Ki67 slides were stained and scanned using 2 FDA-approved clones, **MIB** (*used clinically*) and **30-9**

Pathologist (P1) manually counted Ki67+/- tumor cells for the **baseline score** while pathologists (P2 and P3) performed visual estimation (no manual direct count). Three established commercial tools (Mindpeak, Leica Aperio, 3DHISTECH) and DeepLIF were run on the same slides.

Breast IHC Ki67 [companion diagnostic assay with tumor classified high for \$\geq 20\%\$ and low for \$< 20\%\$ Ki67 expression](#)



DeepLIF Clinical Validation

		Pathologist (P1)	
DeepLIF	MIB	≥ 20	< 20
	≥ 20	32	2
	< 20	0	23

Kappa = 0.928

SE of Kappa = 0.050

95% Confidence Interval: 0.831 to 1.000

		Pathologist (P1)	
DeepLIF	30-9	≥ 20	< 20
	≥ 20	22	0
	< 20	0	35

Kappa = 1.000

SE of Kappa = 0.000

95% Confidence Interval: 1.000 to 1.000



DeepLIF Clinical Validation

DeepLIF is Image Analysis tool 4 (IA4)

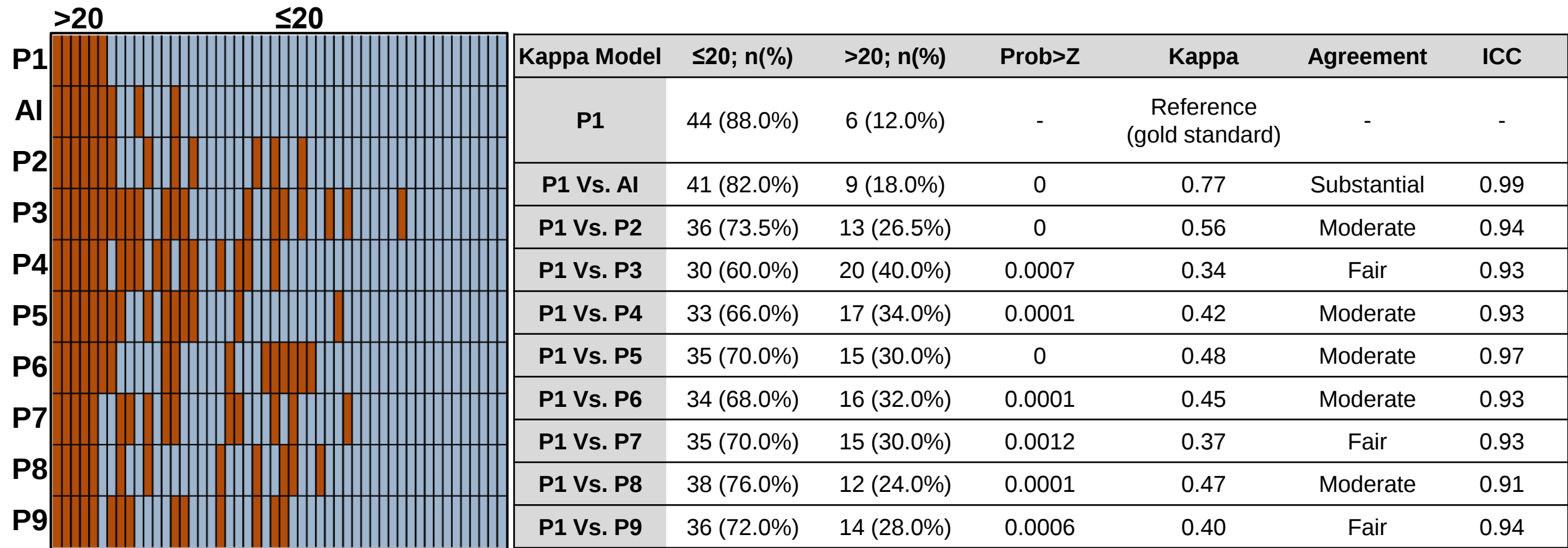
DeepLIF performed better than the expert pathologists, P2 and P3

DeepLIF even performed better than the consensus of expert pathologists, P2 and P3

		P2	P3	IA1	IA2	IA3	IA4
MIB	P1	0.89	0.89	0.856	0.792	0.82	0.928
	P2	X	0.81	0.712	0.856	0.854	0.964
	P3	X	X	0.787	0.755	0.714	0.822
	IA1	X	X	X	0.831	0.709	0.74
	IA2	X	X	X	X	0.662	0.737
	IA3	X	X	X	X	X	0.887
	IA4	X	X	X	X	X	X
30-9	P1	0.778	0.82	0.813	0.761	0.816	1
	P2	X	0.73	0.96	0.741	0.63	0.778
	P3	X	X	0.759	0.781	0.725	0.725
	IA1	X	X	X	0.798	0.664	0.881
	IA2	X	X	X	X	0.681	0.758
	IA3	X	X	X	X	X	0.85
	IA4	X	X	X	X	X	X

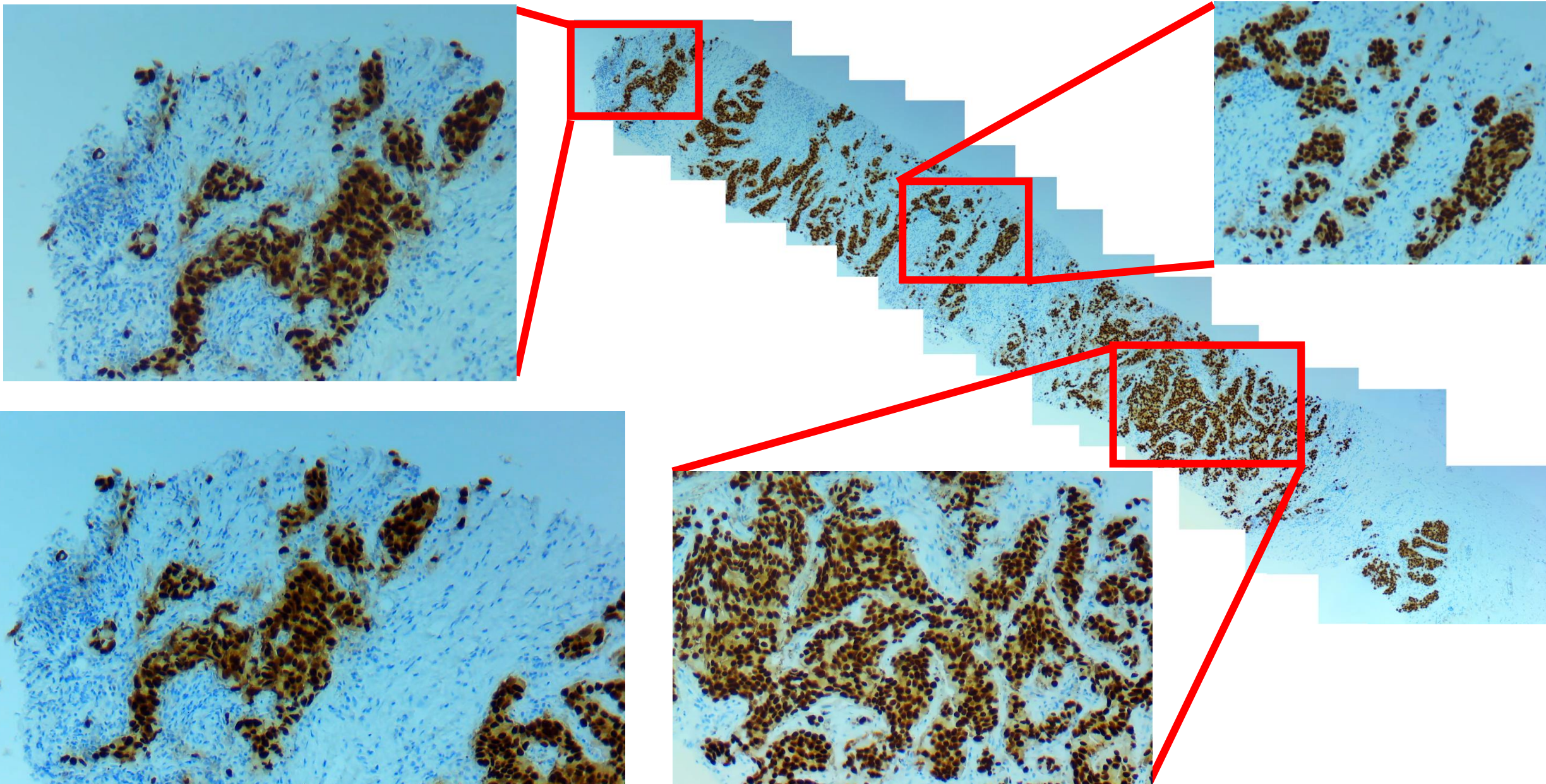


DeepLIF Clinical Validation



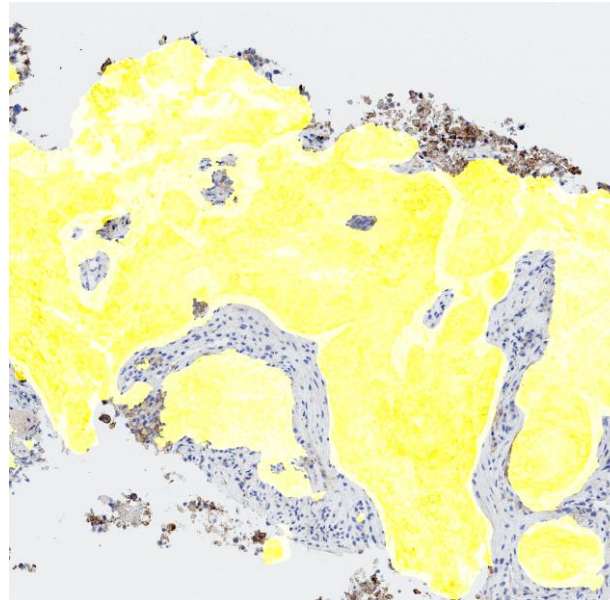
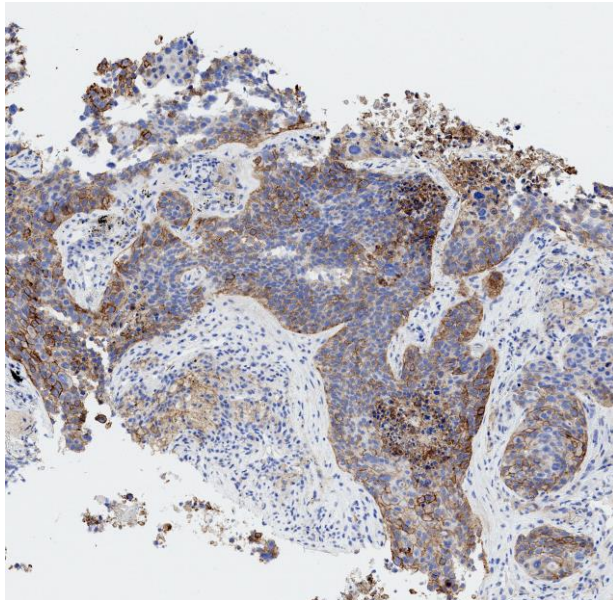
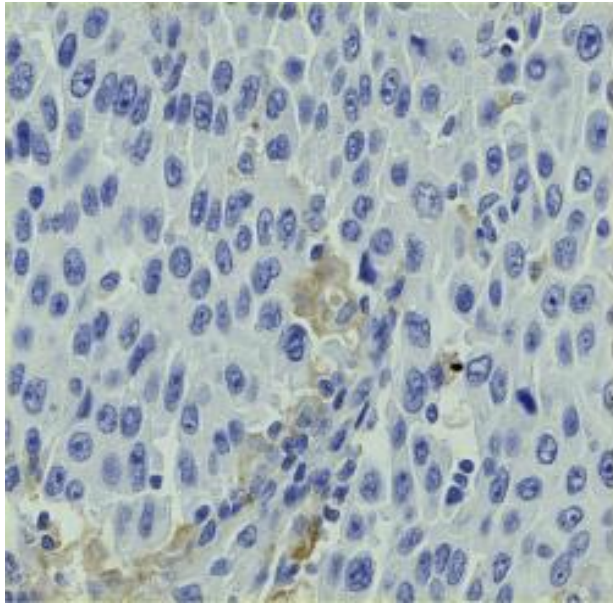


DeepLIF-Stitch (compressed WSI)





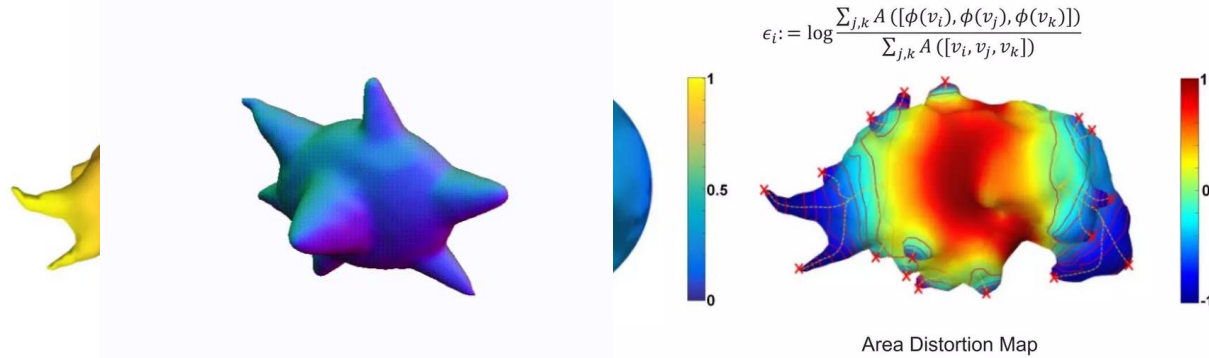
DeepLIIF PD-L1 NSCLC



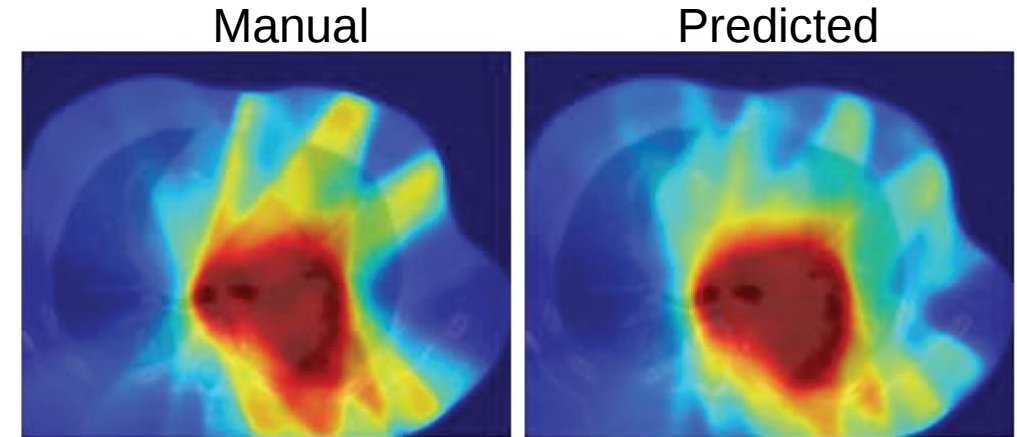


Radiation Oncology

CIR (github.com/nadeemlab/CIR)



DoseRTX(github.com/nadeemlab/DoseRTX)



Dose/DVH Score: 0.77/1.70

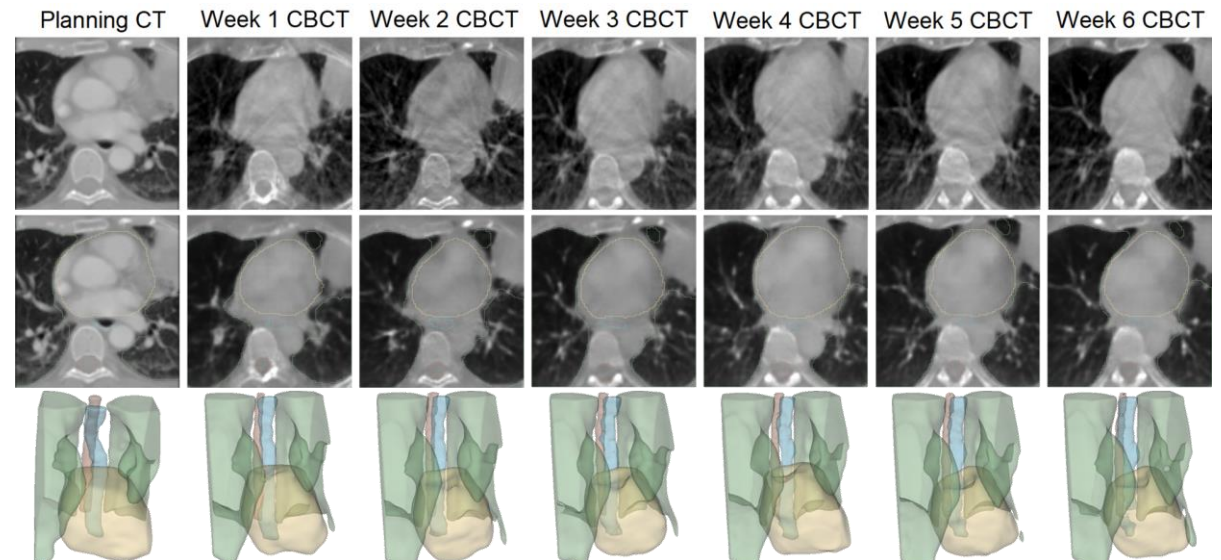
SeqX2Y (github.com/nadeemlab/SeqX2Y)

LUNA Lung Nodule CT Challenge Datasets (Radiology)

RMSim results modulated by random 1D breathing trace

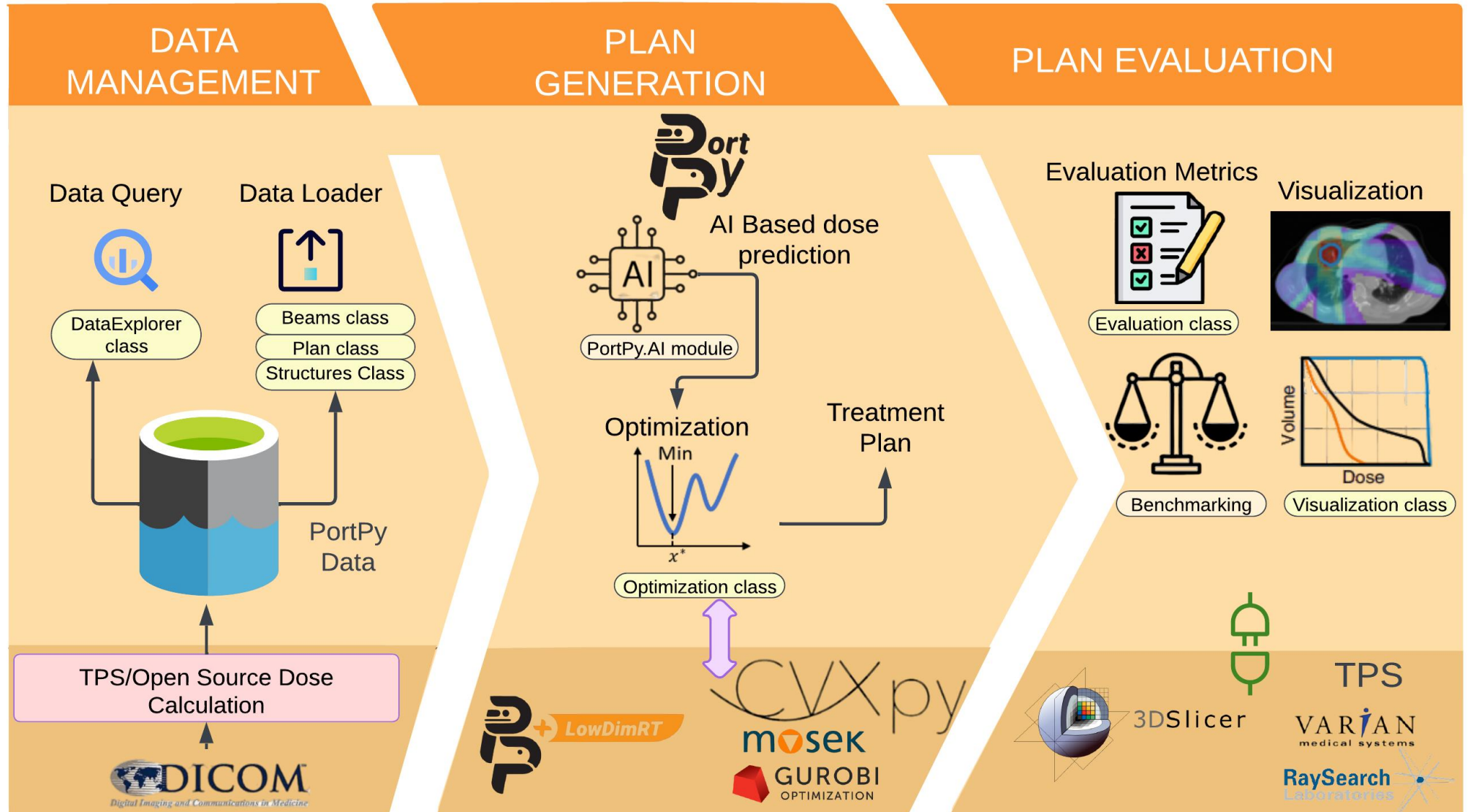


PhysicsArX(github.com/nadeemlab/Physics-ArX)





Planning and Optimization in Radiotherapy Treatment





Realtime Augmented Colonoscopy

Input video

Feature Segmentation
MICCAI'21 (Oral)

Synthetic CT
ISBI'21 (Oral)

Depth Inference
CVPR'20

