JOHNS HOPKINS
WHITING SCHOOL
of ENGINEERING

LUSTGARTEN
FOUNDATION
PANCREATIC CANCER RESEARCH

BodyMaps

Personalized 3D Atlas of Human Body

Zongwei Zhou, PhD
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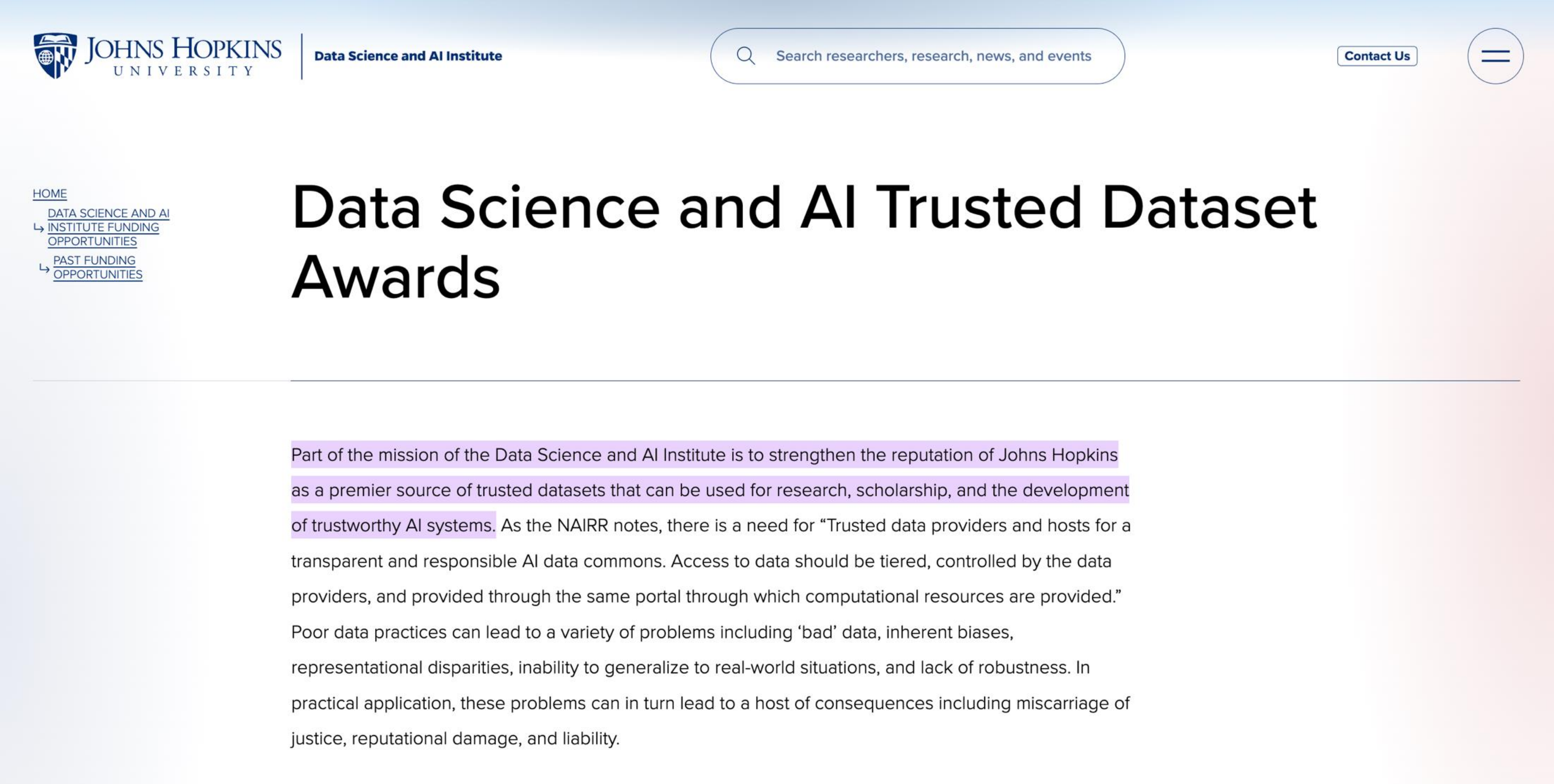

Data Science and AI Trusted Dataset Awards

Part of the mission of the Data Science and AI Institute is to strengthen the reputation of Johns Hopkins as a premier source of trusted datasets that can be used for research, scholarship, and the development of trustworthy AI systems. As the NAIRR notes, there is a need for “Trusted data providers and hosts for a transparent and responsible AI data commons. Access to data should be tiered, controlled by the data providers, and provided through the same portal through which computational resources are provided.” Poor data practices can lead to a variety of problems including ‘bad’ data, inherent biases, representational disparities, inability to generalize to real-world situations, and lack of robustness. In practical application, these problems can in turn lead to a host of consequences including miscarriage of justice, reputational damage, and liability.

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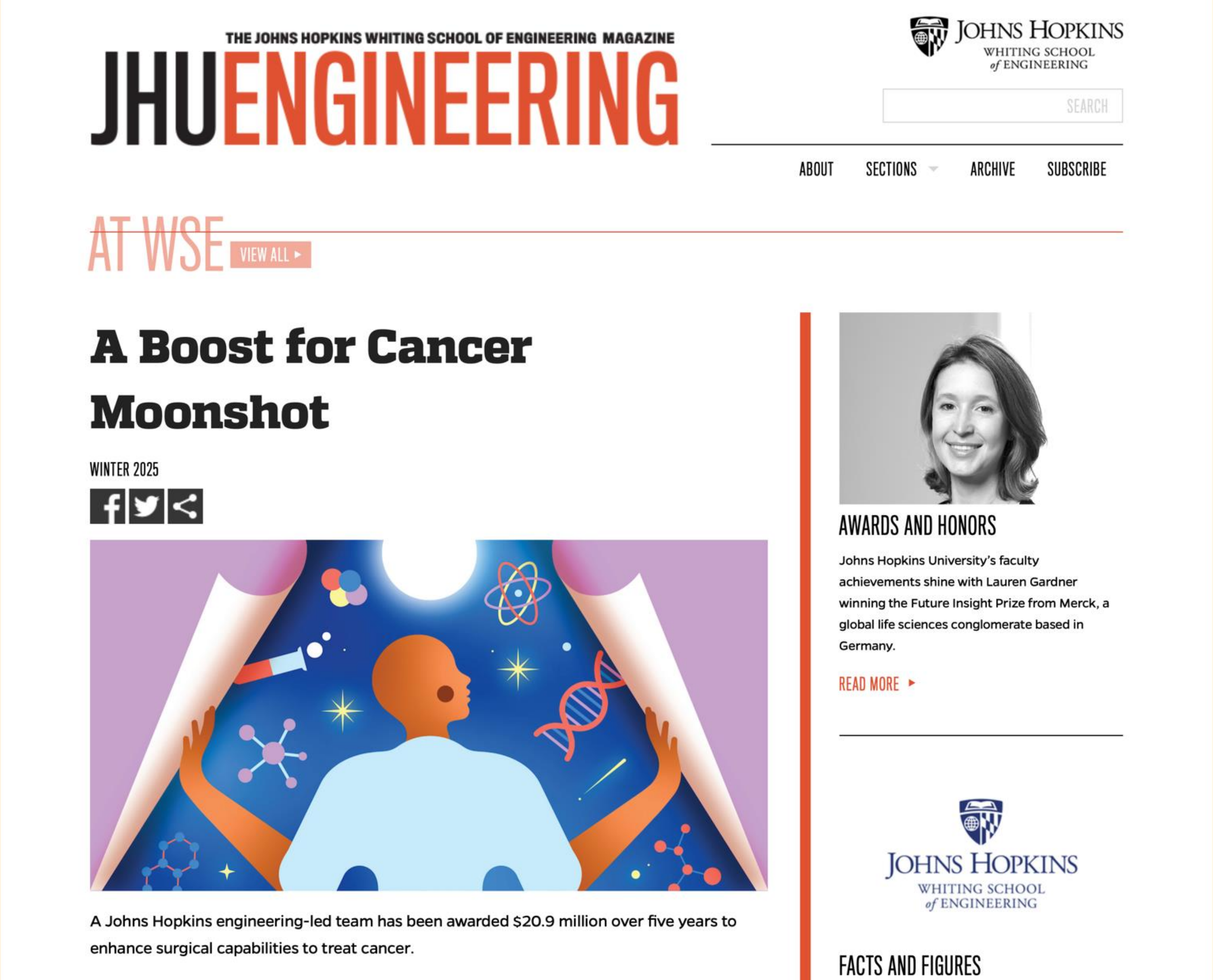

A Boost for Cancer Moonshot

WINTER 2025

A Johns Hopkins engineering-led team has been awarded $20.9 million over five years to enhance surgical capabilities to treat cancer.

AWARDS AND HONORS

Johns Hopkins University's faculty achievements shine with Lauren Gardner winning the Future Insight Prize from Merck, a global life sciences conglomerate based in Germany.

FACTS AND FIGURES

The BodyMaps Project

- **AI-Integrated Annotation**
  - **ScaleMAI Platform**
    - Anatomical Segmentation
  - **Synthetic Data Engine**
    - Multi-lesion Segmentation
- **AI-Assisted Cancer Moonshot**
  - **Lesion Detection**
    - Human-level Detection
  - **Cancer Diagnosis**
    - Super-human Classification
  - **Treatment Planning**
    - Tumor Staging
- **AI-Trusted Benchmark**
  - **Foundation Models**
    - Supervised Pre-Trained Models
  - **Universal Models**
    - Generalists vs. Specialists

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Code, Dataset, & Model:
`https://www.zongweiz.com/dataset`

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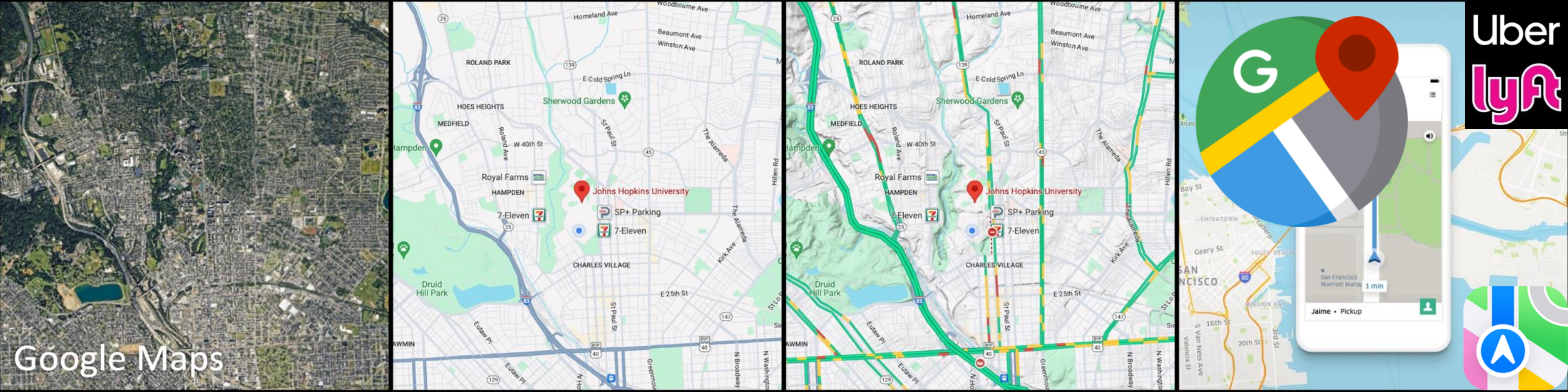
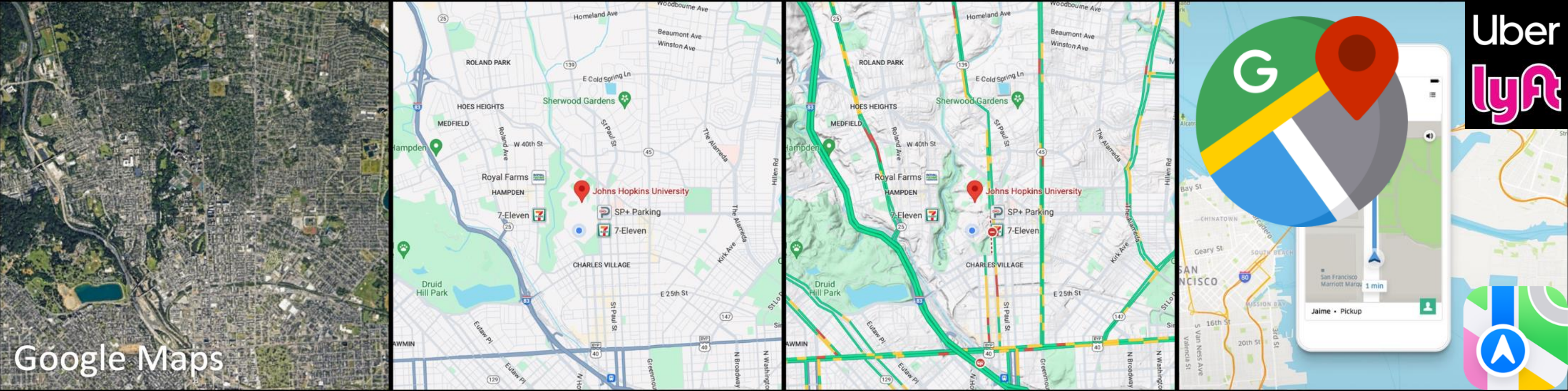


Data → Information → Knowledge → Application



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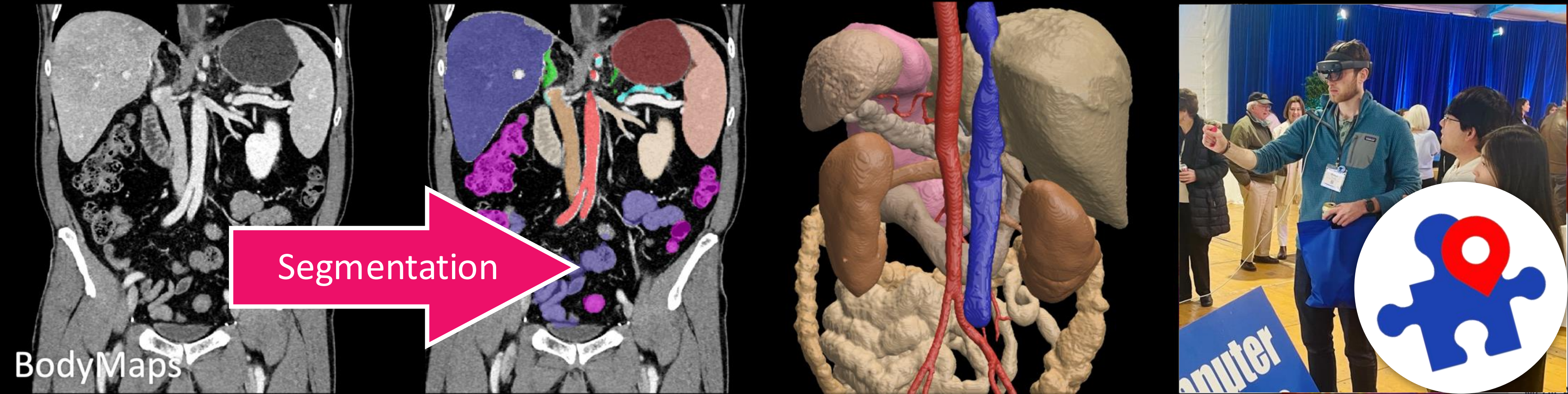
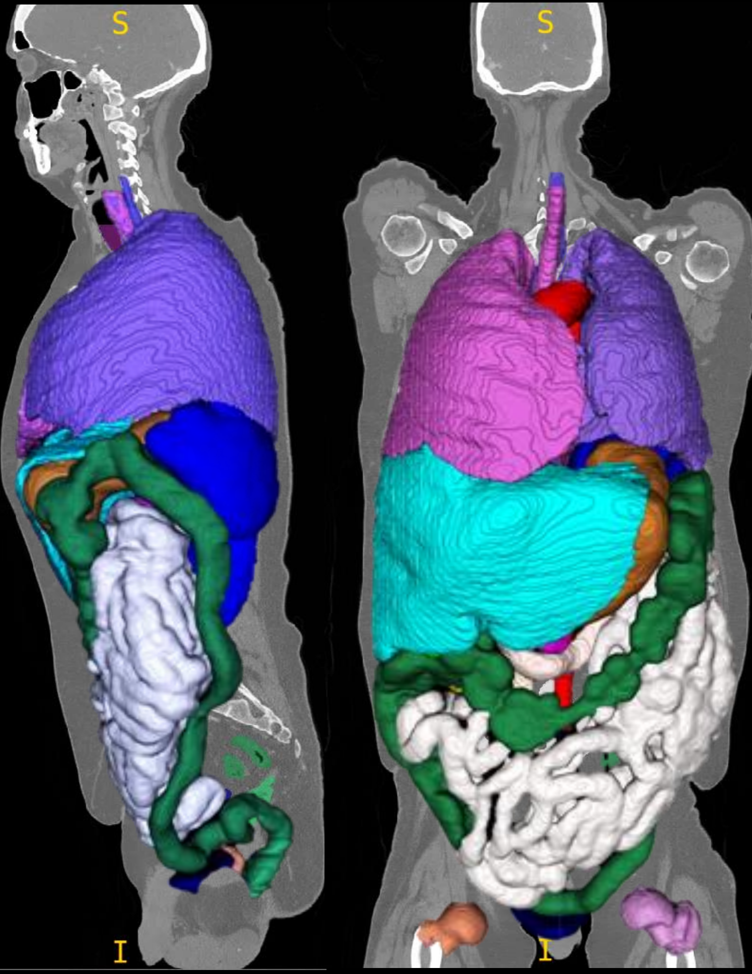
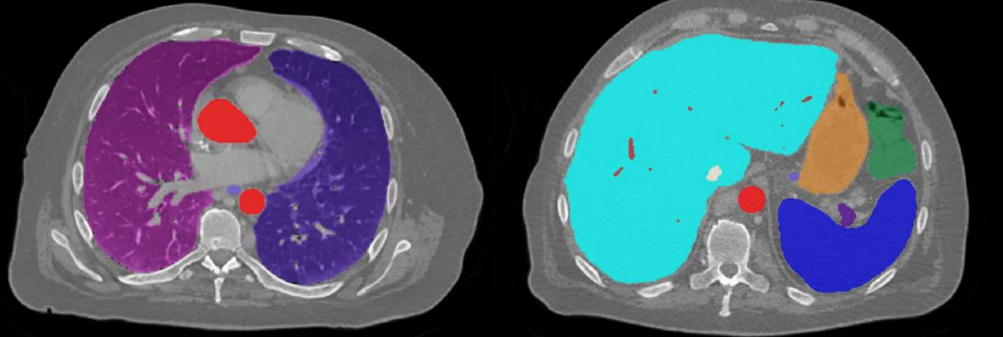
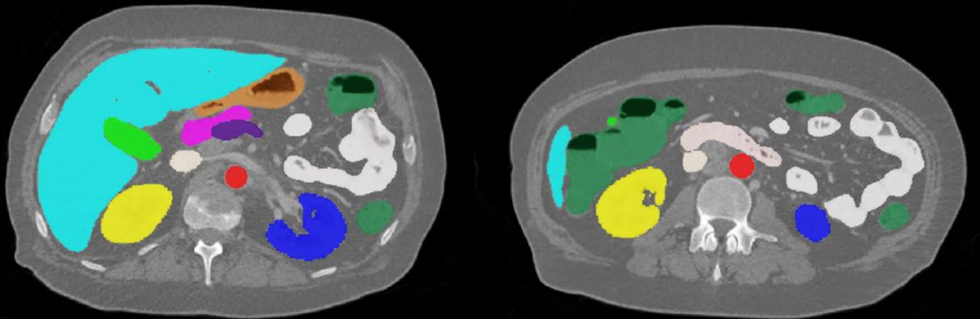






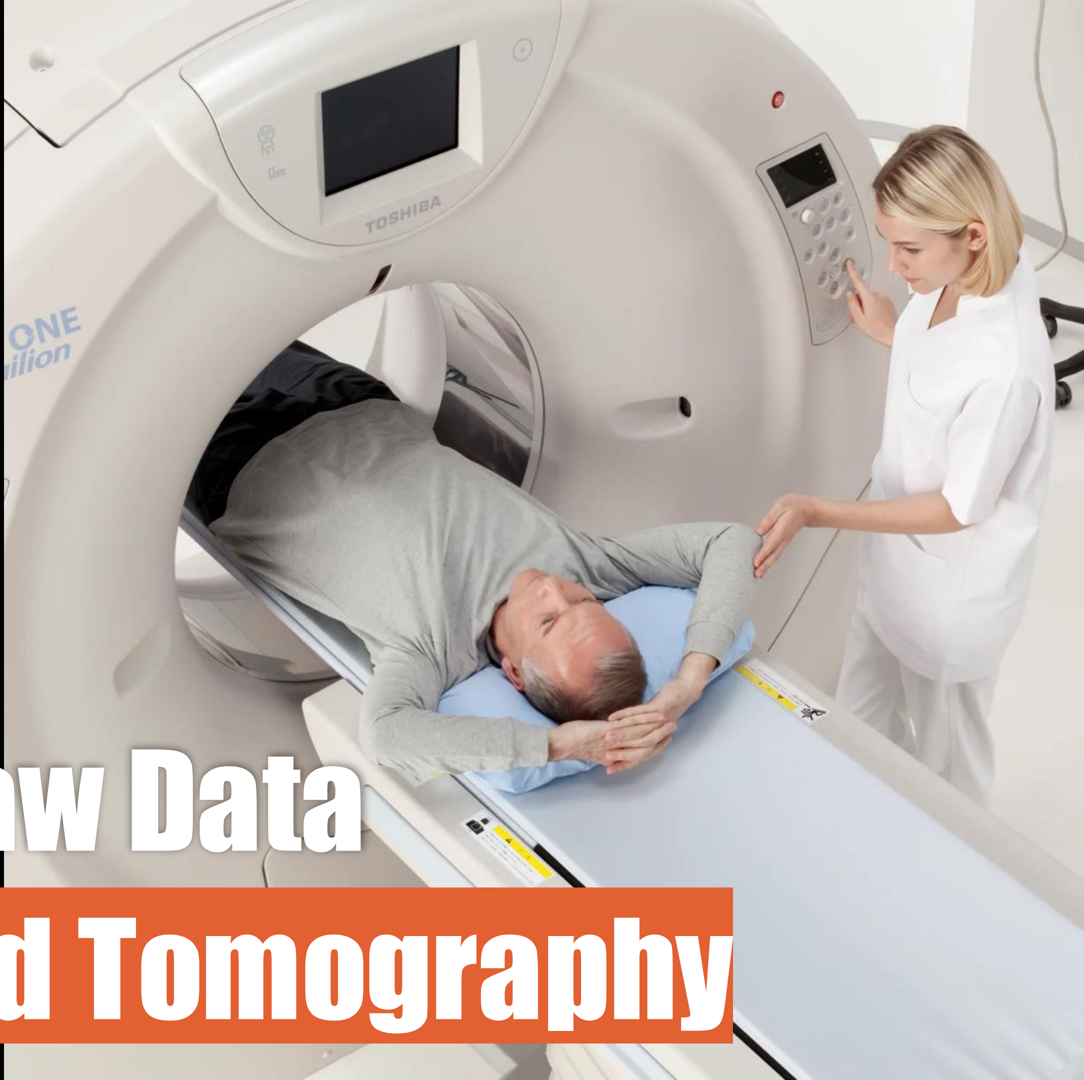
Google Maps Earth
We Map Human Body



The **Visible Human Project** is an effort to create a detailed data set of cross-sectional photographs of the human body, in order to facilitate anatomy visualization applications.

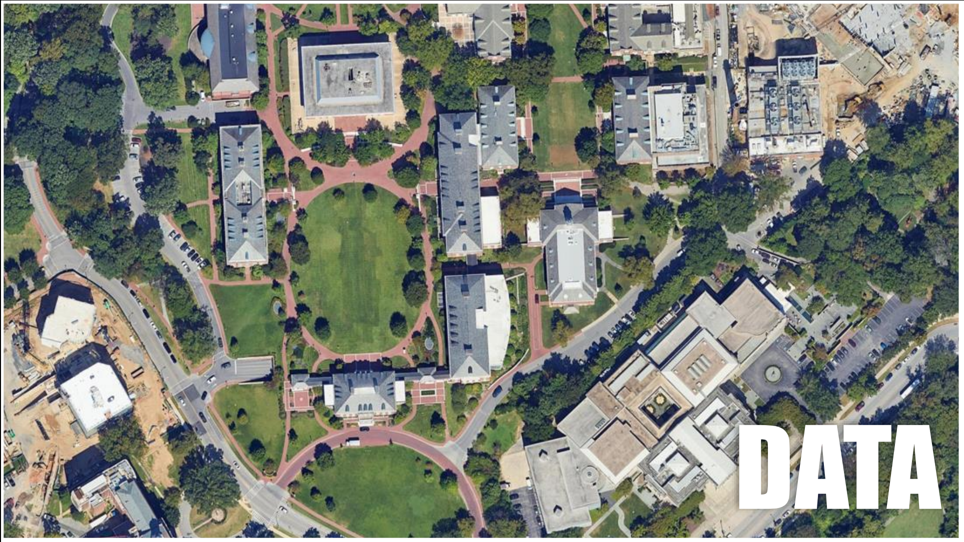
Wikipedia

Photo by Visual Human Project

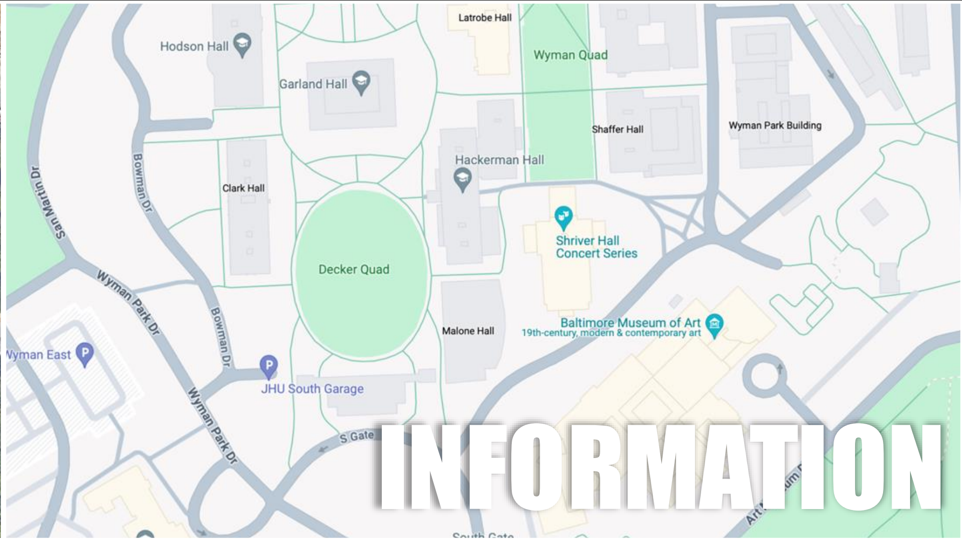


Raw Data

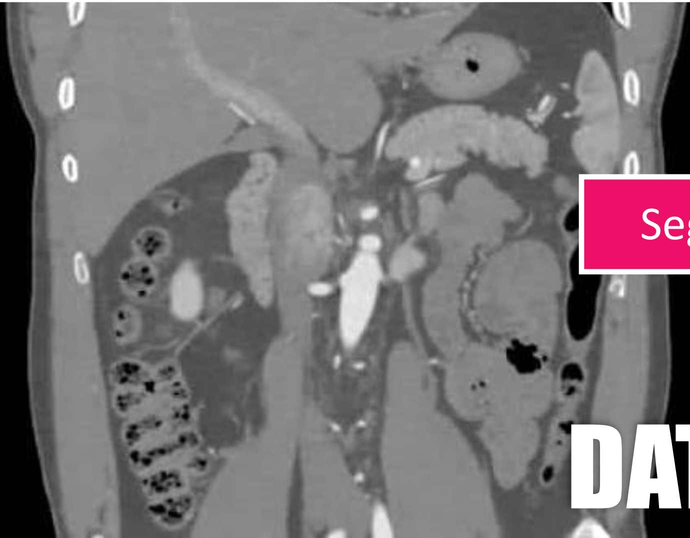
Computed Tomography



DATA



INFORMATION

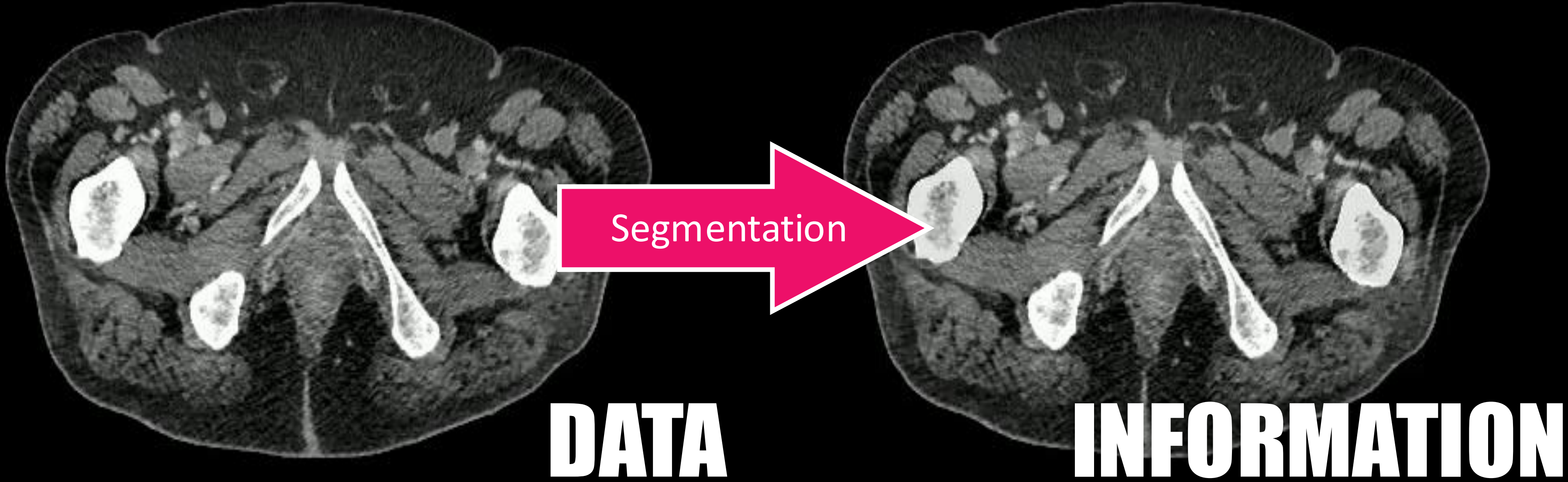


DATA

Segmentation

INFORMATION

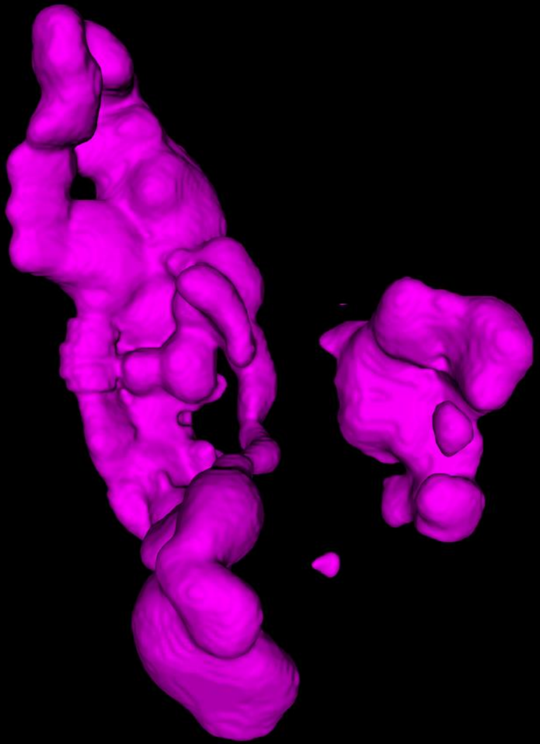
Take a radiologist 30~60 minutes to annotate a structure



Segmentation

DATA

INFORMATION



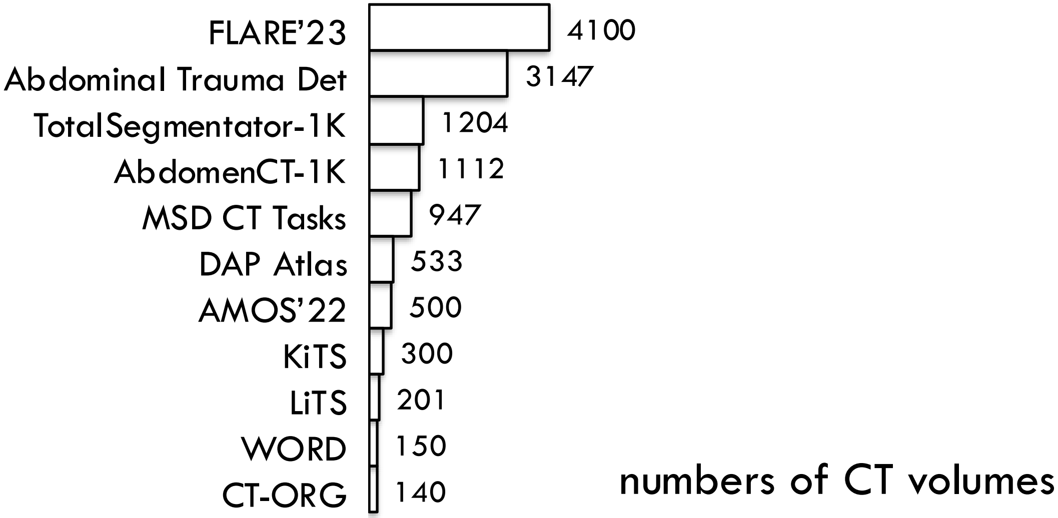
annotated colon in **TotalSegmentator**

“The colon contour should include entire wall and lumen of cecum, appendix, ascending colon, transverse colon, descending colon and sigmoid colon **continuously**, as well as any colon lesions. **Adjacent structures** such as small intestine, surrounding fat, mesentery, and omentum should be excluded. The boundary between the ileum and colon is defined by the ileocecal valve. The boundary between the rectum and sigmoid colon is defined by the sigmoid take-off.”

— **Annotation standard**
for the colon

annotated colon in **AbdomenAtlas**

Publicly available abdominal CT datasets



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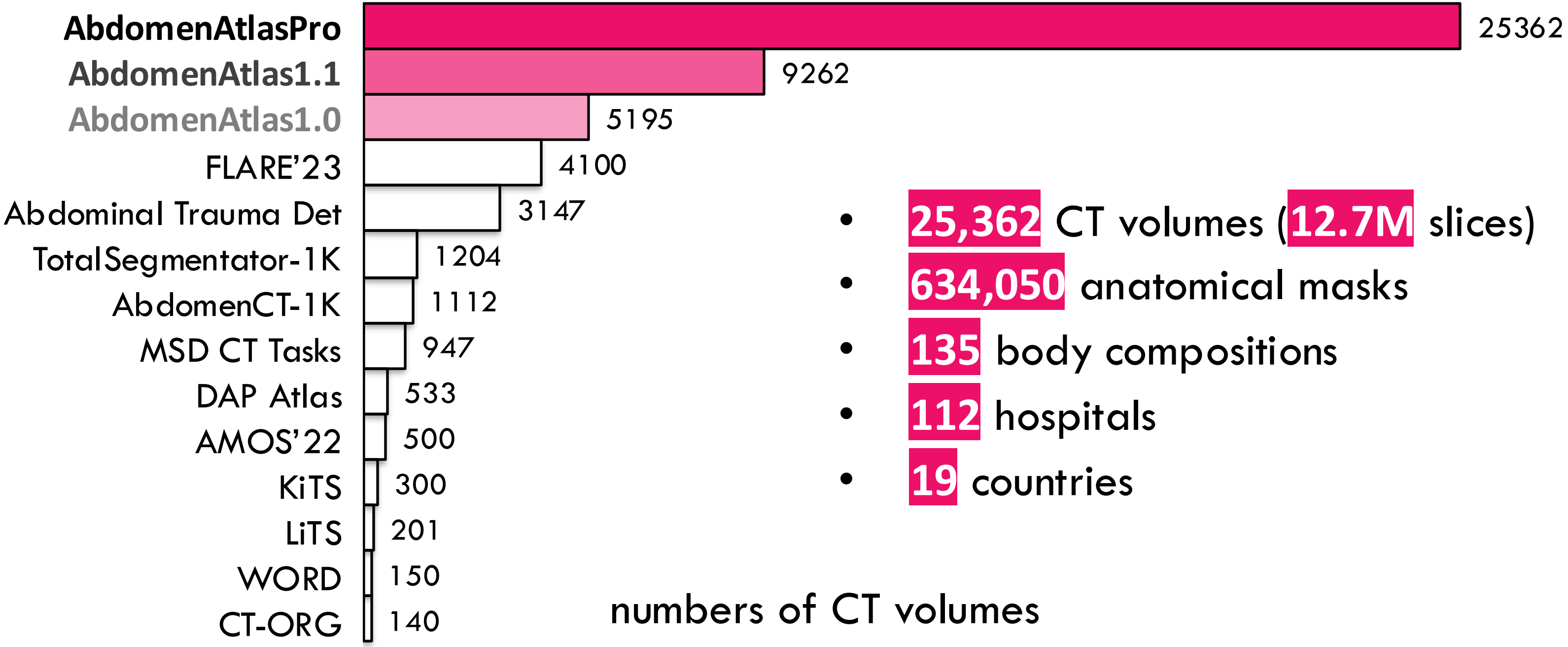
Code, Dataset, & Model:
https://www.zongweiz.com/dataset

AbdomenAtlasPro = 25K CT Volumes + 600K 3D Masks

AbdomenAtlas1.1 = 9K CT Volumes + 225K 3D Masks

AbdomenAtlas1.0 = 5K CT Volumes + 45K 3D Masks



- **25,362** CT volumes (**12.7M** slices)
- **634,050** anatomical masks
- **135** body compositions
- **112** hospitals
- **19** countries

numbers of CT volumes

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136 anatomical structures: adrenal gland left · adrenal gland right · airway · aorta · atrial appendage left · autochthon left · autochthon right · bladder · bone · brachiocephalic trunk · brachiocephalic vein left · brachiocephalic vein right · brain · clavicula left · clavicula right · celiac trunk · colon · common bile duct · common carotid artery left · common carotid artery right · costal cartilages · duodenum · esophagus · femur left · femur right · gall bladder · gluteus maximus left · gluteus maximus right · gluteus medius left · gluteus medius right · gluteus minimus left · gluteus minimus right · heart · hepatic vessel · hip left · hip right · humerus left · humerus right · iliac artery left · iliac artery right · iliac vena left · iliac vena right · iliopsoas left · iliopsoas right · intestine · kidney left · kidney right · liver · liver segment 1 · liver segment 2 · liver segment 3 · liver segment 4 · liver segment 5 · liver segment 6 · liver segment 7 · liver segment 8 · lung left · lung lower left lobe · lung lower right lobe · lung middle right lobe · lung right · lung upper left lobe · lung upper right lobe · pancreas · pancreas body · pancreas head · pancreas tail · pancreatic duct · portal vein and splenic vein · postcava · prostate · pulmonary vein · rectum · rib left 1 · rib left 10 · rib left 11 · rib left 12 · rib left 2 · rib left 3 · rib left 4 · rib left 5 · rib left 6 · rib left 7 · rib left 8 · rib left 9 · rib right 1 · rib right 10 · rib right 11 · rib right 12 · rib right 2 · rib right 3 · rib right 4 · rib right 5 · rib right 6 · rib right 7 · rib right 8 · rib right 9 · sacrum · scapula left · scapula right · skull · spleen · spinal cord · sternum · stomach · subclavian artery left · subclavian artery right · superior mesenteric artery · superior vena cava · thyroid gland · trachea · veins · vertebrae C1 · vertebrae C2 · vertebrae C3 · vertebrae C4 · vertebrae C5 · vertebrae C6 · vertebrae C7 · vertebrae L1 · vertebrae L2 · vertebrae L3 · vertebrae L4 · vertebrae L5 · vertebrae S1 · vertebrae T1 · vertebrae T10 · vertebrae T11 · vertebrae T12 · vertebrae T2 · vertebrae T3 · vertebrae T4 · vertebrae T5 · vertebrae T6 · vertebrae T7 · vertebrae T8 · vertebrae T9

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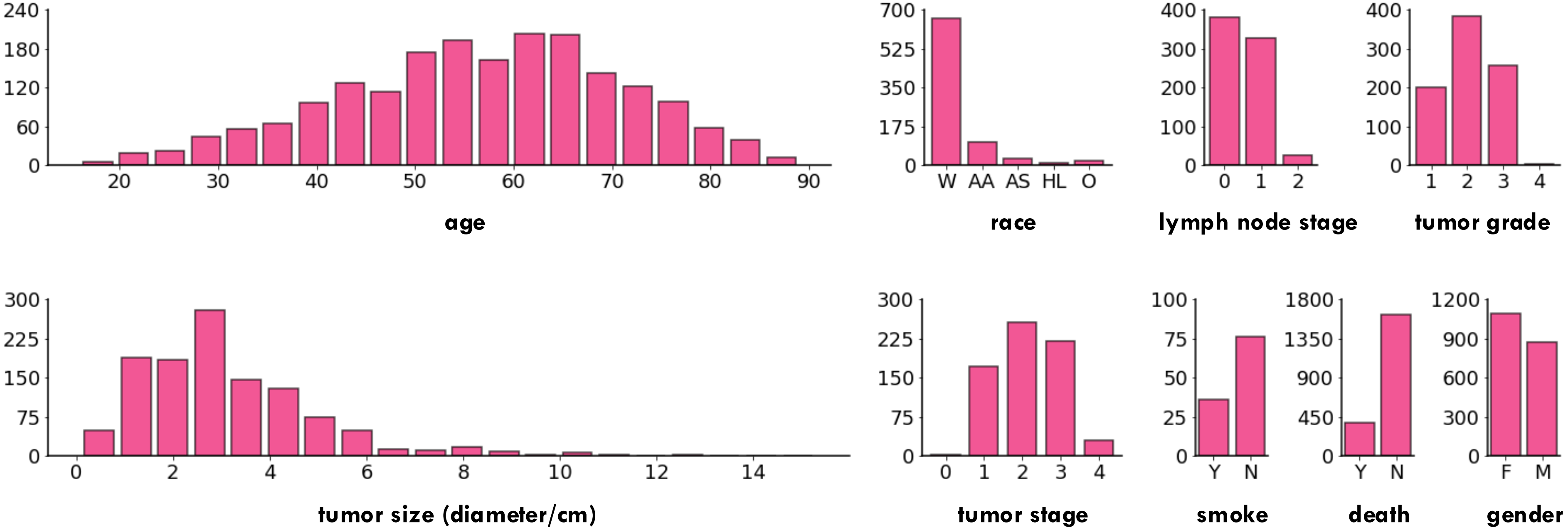

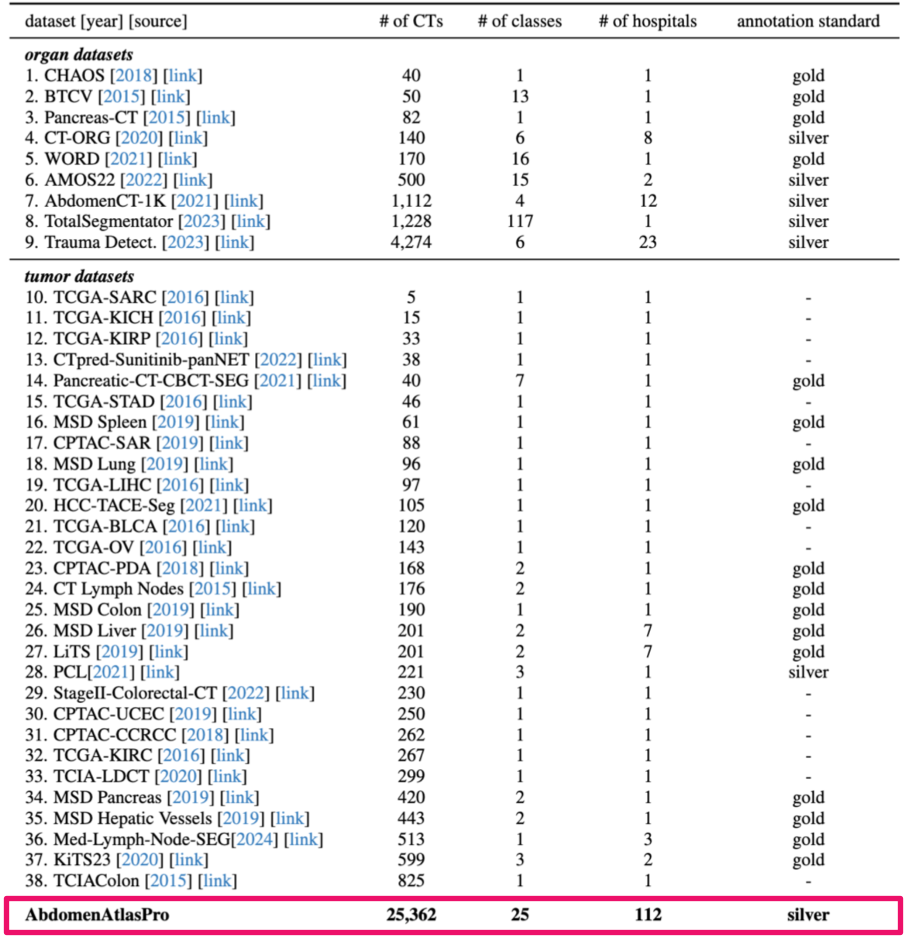

dataset [year] [source]	# of CTs	# of classes	# of hospitals	annotation standard
organ datasets				
1. CHAOS [2018] [link]	40	1	1	gold
2. BTCV [2015] [link]	50	13	1	gold
3. Pancreas-CT [2015] [link]	82	1	1	gold
4. CT-ORG [2020] [link]	140	6	8	silver
5. WORD [2021] [link]	170	16	1	gold
6. AMOS22 [2022] [link]	500	15	2	silver
7. AbdomenCT-1K [2021] [link]	1,112	4	12	silver
8. TotalSegmentator [2023] [link]	1,228	117	1	silver
9. Trauma Detect. [2023] [link]	4,274	6	23	silver
tumor datasets				
10. TCGA-SARC [2016] [link]	5	1	1	-
11. TCGA-KICH [2016] [link]	15	1	1	-
12. TCGA-KIRP [2016] [link]	33	1	1	-
13. CTpred-Sunitinib-panNET [2022] [link]	38	1	1	-
14. Pancreatic-CT-CBCT-SEG [2021] [link]	40	7	1	gold
15. TCGA-STAD [2016] [link]	46	1	1	-
16. MSD Spleen [2019] [link]	61	1	1	gold
17. CPTAC-SAR [2019] [link]	88	1	1	-
18. MSD Lung [2019] [link]	96	1	1	gold
19. TCGA-LIHC [2016] [link]	97	1	1	-
20. HCC-TACE-Seg [2021] [link]	105	1	1	gold
21. TCGA-BLCA [2016] [link]	120	1	1	-
22. TCGA-OV [2016] [link]	143	1	1	-
23. CPTAC-PDA [2018] [link]	168	2	1	gold
24. CT Lymph Nodes [2015] [link]	176	2	1	gold
25. MSD Colon [2019] [link]	190	1	1	gold
26. MSD Liver [2019] [link]	201	2	7	gold
27. LiTS [2019] [link]	201	2	7	gold
28. PCL[2021] [link]	221	3	1	silver
29. StageII-Colorectal-CT [2022] [link]	230	1	1	-
30. CPTAC-UCEC [2019] [link]	250	1	1	-
31. CPTAC-CCRCC [2018] [link]	262	1	1	-
32. TCGA-KIRC [2016] [link]	267	1	1	-
33. TCIA-LDCT [2020] [link]	299	1	1	-
34. MSD Pancreas [2019] [link]	420	2	1	gold
35. MSD Hepatic Vessels [2019] [link]	443	2	1	gold
36. Med-Lymph-Node-SEG[2024] [link]	513	1	3	gold
37. KiTS23 [2020] [link]	599	3	2	gold
38. TCIAColon [2015] [link]	825	1	1	-
AbdomenAtlasPro	**25,362**	**25**	**112**	**silver**

“How long does it take to annotate
25K CT volumes
600K 3D masks?”

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dataset [year] [source]	# of CTs	# of classes	# o	
organ datasets				
1. CHAOS [201		1		
2. BTCV [2		13		
3. Pancr		1		
4. CT-		6		
5. W				
6.				
19.				
20. I				
21. TC		1		
22. TCGA		1		
23. CPTAC-		2		
24. CT Lymph No		2		
25. MSD Colon [2019] [li	190	1		
26. MSD Liver [2019] [link]	201	2		
27. LiTS [2019] [link]	201	2		
28. PCL[2021] [link]	221	3		
29. StageII-Colorectal-CT [2022] [link]	230	1		
30. CPTAC-UCEC [2019] [link]	250	1		
31. CPTAC-CCRCC [2018] [link]	262	1		
32. TCGA-KIRC [2016] [link]	267	1		
33. TCIA-LDCT [2020] [link]	299	1		
34. MSD Pancreas [2019] [link]	420	2		
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38. TCIAColon [2015] [link]	825	1		
AbdomenAtlasPro	**25,362**	**25**	**112**	**silver**

1790-2024

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- **ScaleMAI Platform**
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- **Synthetic Data Engine**
  - Multi-lesion Segmentation

AI-Assisted Cancer Moonshot

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  - Human-level Detection
- **Cancer Diagnosis**
  - Super-human Classification
- **Treatment Planning**
  - Tumor Staging

AI-Trusted Benchmark

- **Universal Models**
  - Generalists vs. Specialists
- **Foundation Models**
  - Supervised Pre-Trained Models

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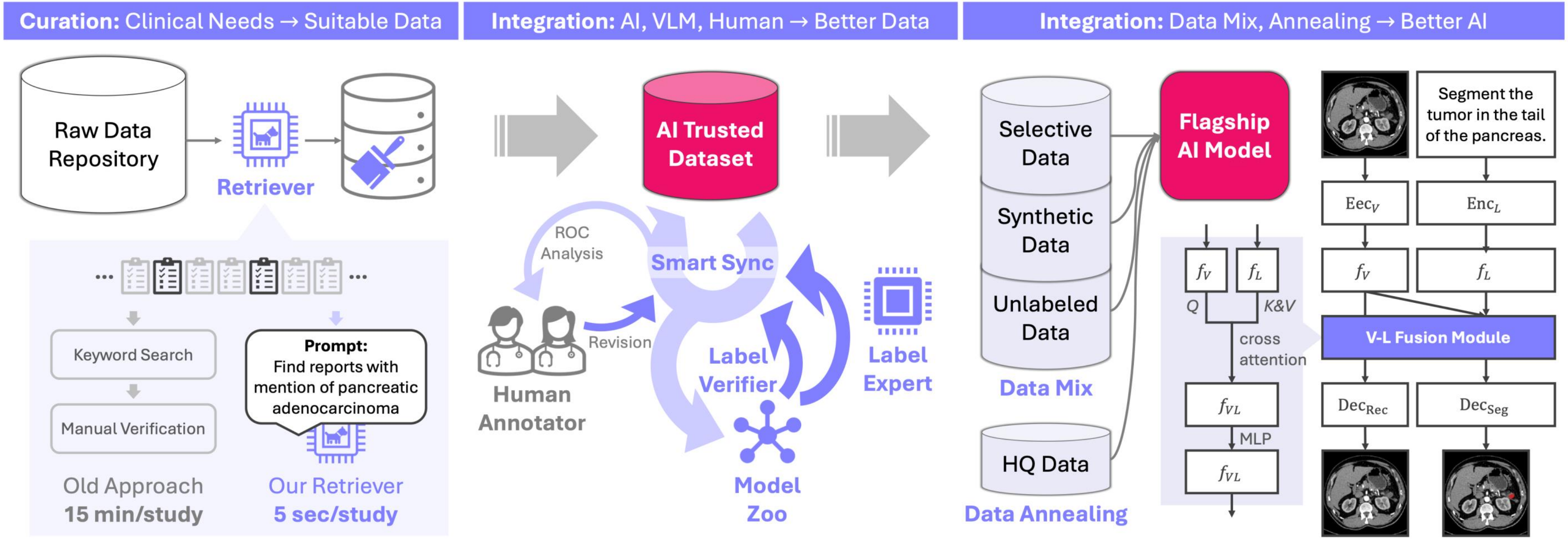
ScaleMAI – Accelerating the Development of Trusted Datasets and AI Models



Curation: Clinical Needs → Suitable Data

Integration: AI, VLM, Human → Better Data

Integration: Data Mix, Annealing → Better AI

Raw Data Repository

Retriever

… …

Keyword Search

Manual Verification

Old Approach
15 min/study

Prompt:
Find reports with mention of pancreatic adenocarcinoma

Our Retriever
5 sec/study

AI Trusted Dataset

ROC Analysis

Smart Sync

Revision

Human Annotator

Label Verifier

Label Expert

Model Zoo

Selective Data

Synthetic Data

Unlabeled Data

Data Mix

HQ Data

Data Annealing

Flagship AI Model

f_V

f_L

Q

K&V

cross attention

f_{VL}

MLP

f_{VL}

Segment the tumor in the tail of the pancreas.

Eec_V

Enc_L

f_V

f_L

V-L Fusion Module

$\mathrm{Dec}_{\mathrm{Rec}}$

$\mathrm{Dec}_{\mathrm{Seg}}$

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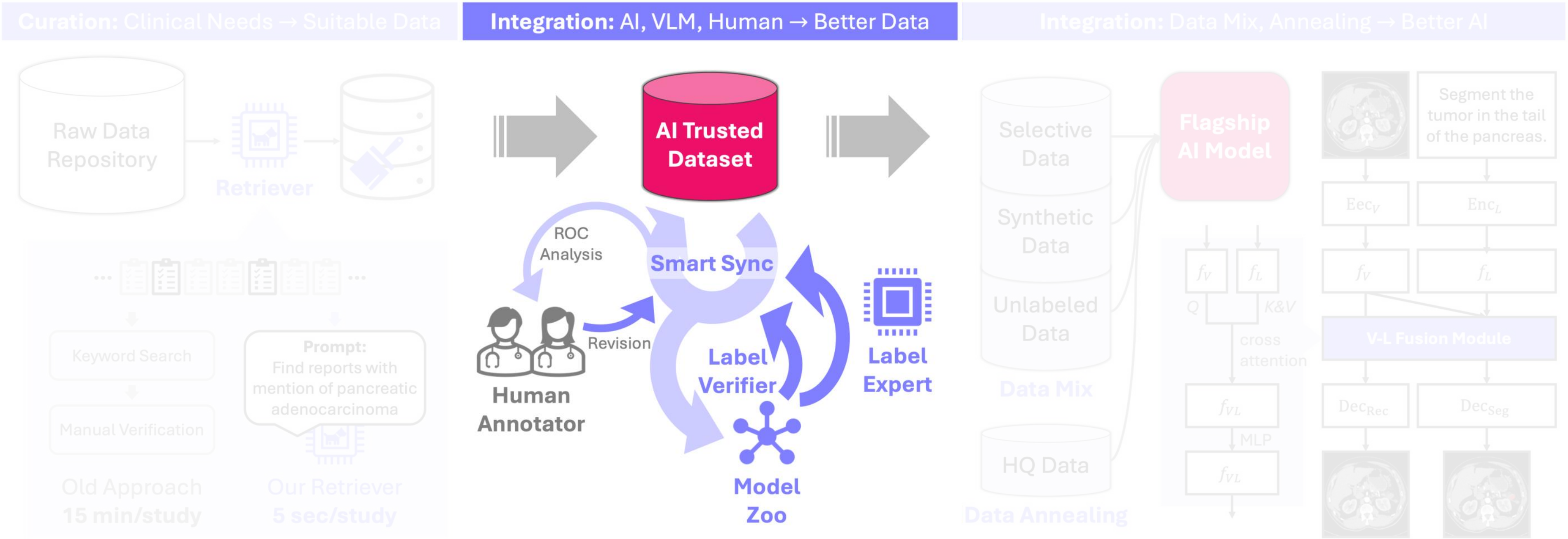

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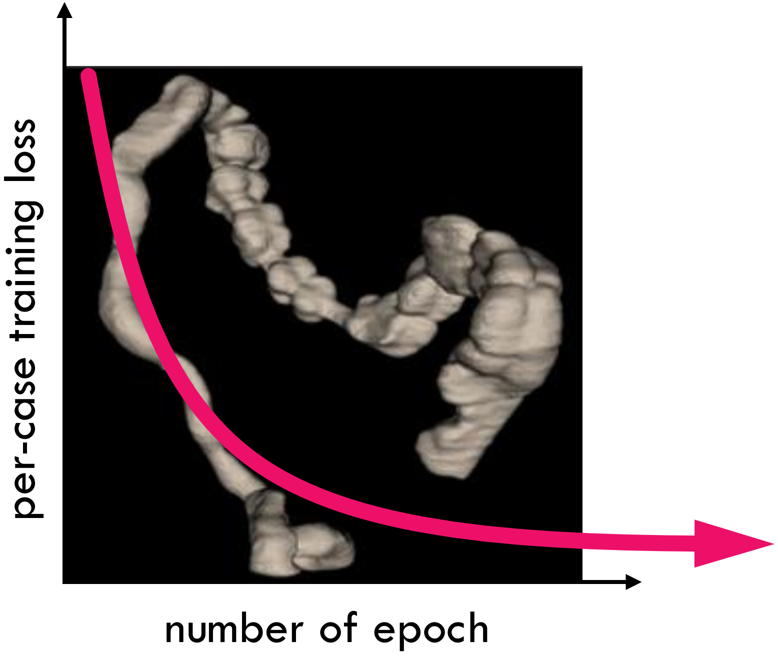
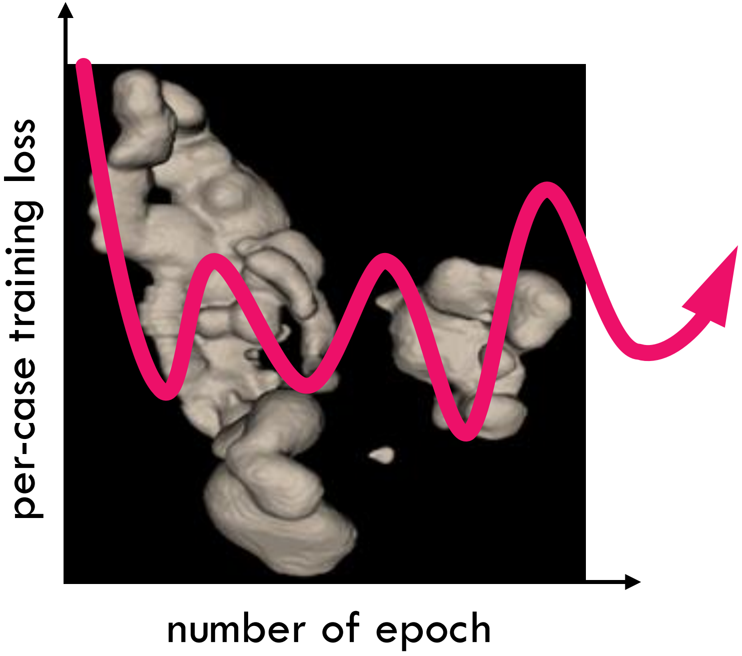
Label Verifier

left: well-annotated training data



right: poorly-annotated training data



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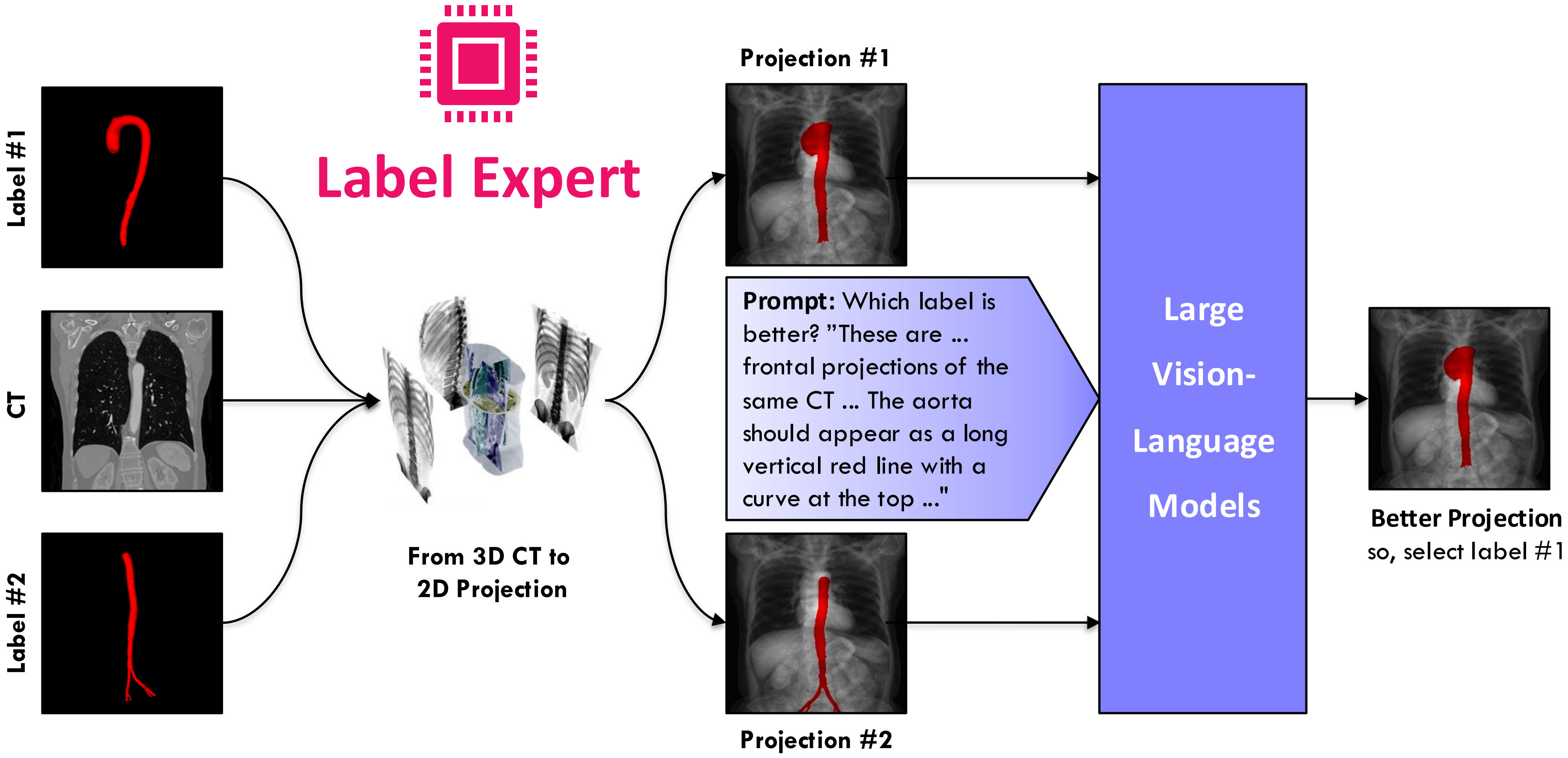
Label Expert



Label #1

CT

Label #2

From 3D CT to 2D Projection

Projection #1

Prompt: Which label is better? "These are ... frontal projections of the same CT ... The aorta should appear as a long vertical red line with a curve at the top ..."

Projection #2

Large Vision-Language Models

Better Projection
so, select label #1

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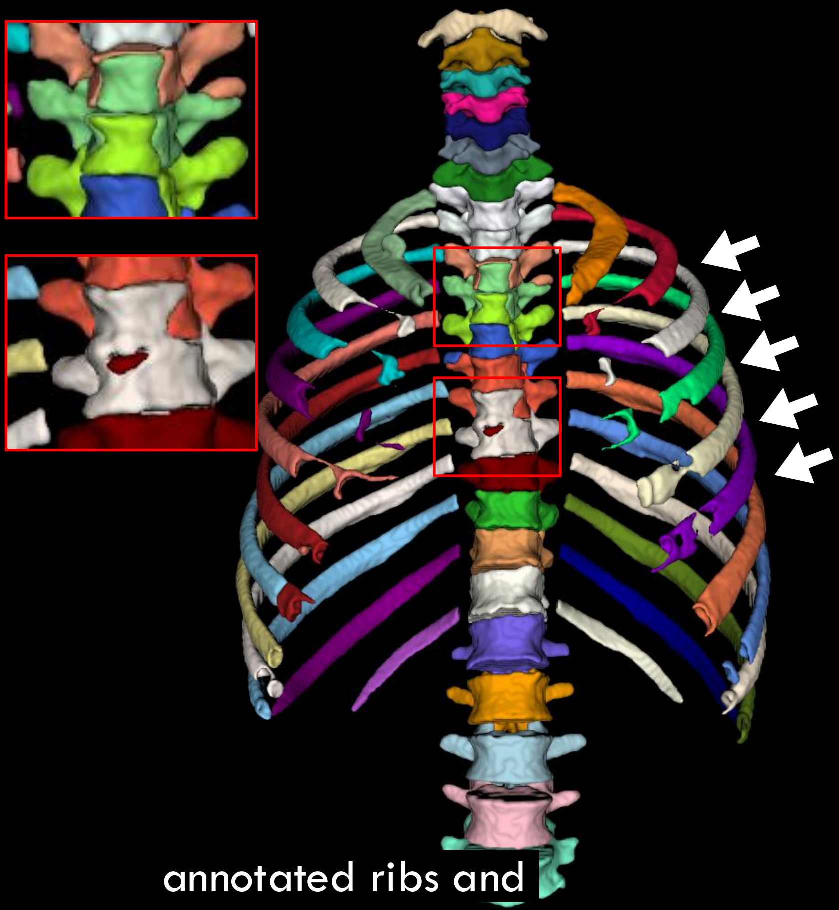
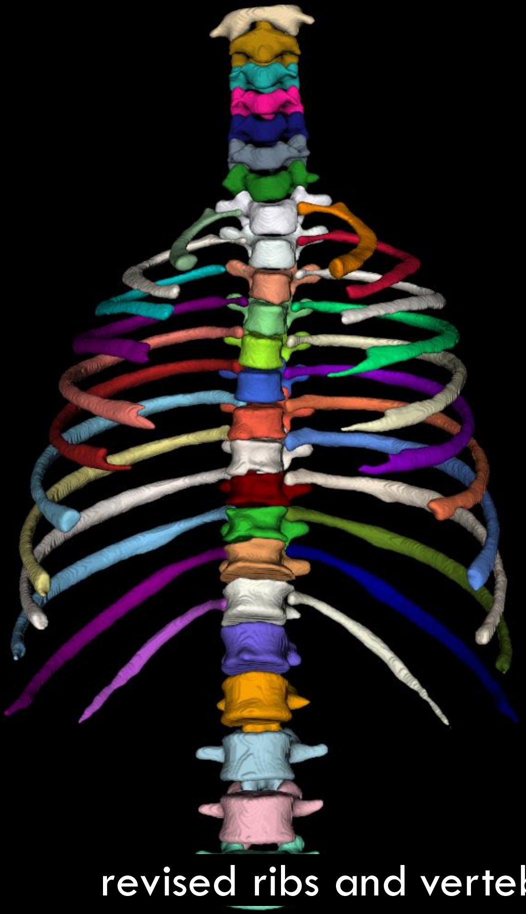
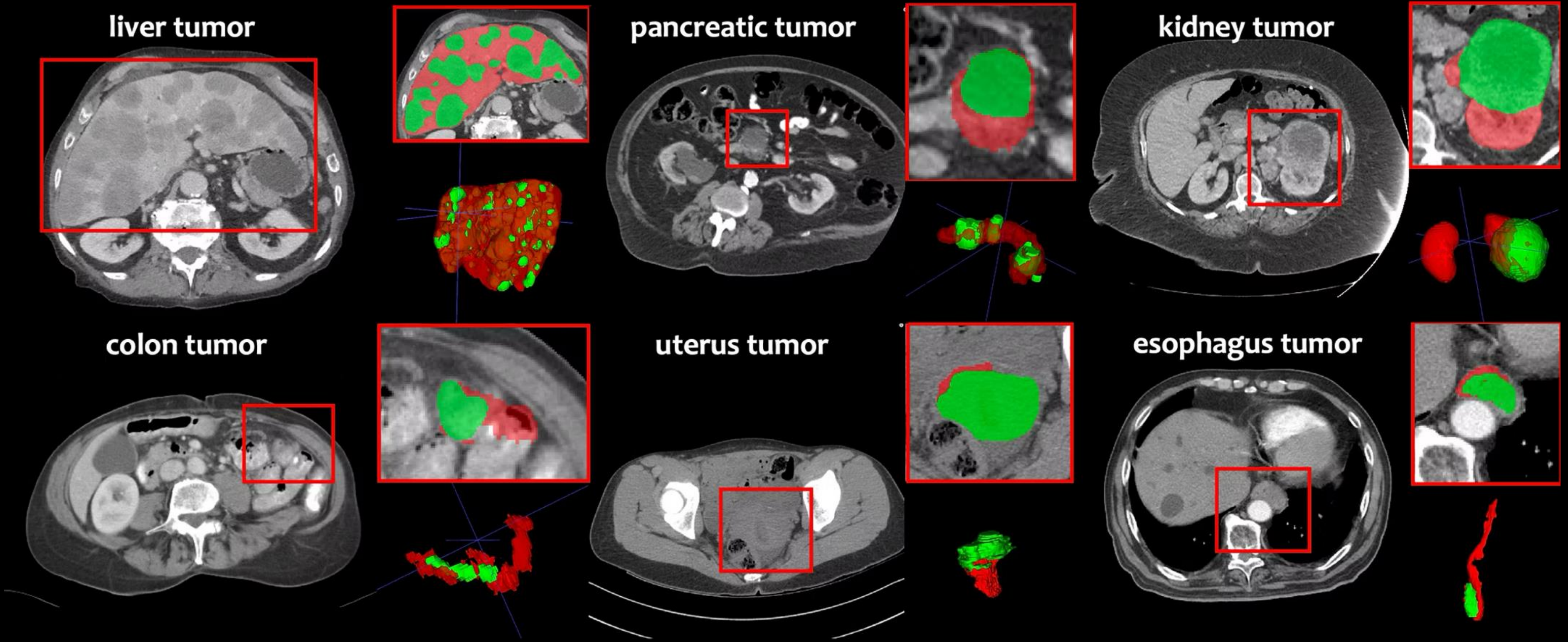


annotated ribs and vertebrae in **TotalSegmentator**



revised ribs and vertebrae in **AbdomenAtlas**



liver tumor

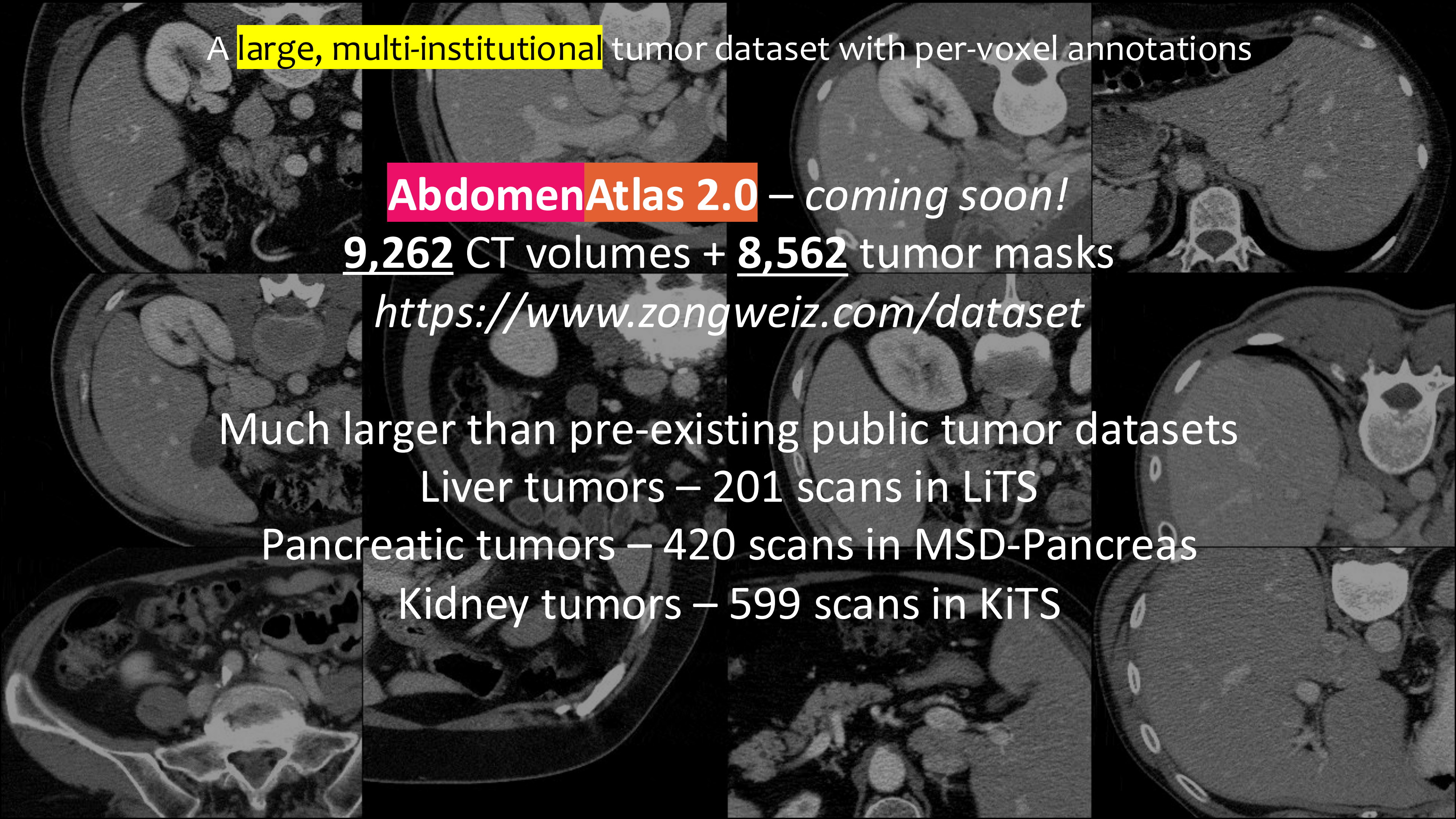
pancreatic tumor

kidney tumor

colon tumor

uterus tumor

esophagus tumor



A large, multi-institutional tumor dataset with per-voxel annotations

AbdomenAtlas 2.0 – *coming soon!*

9,262 CT volumes + **8,562** tumor masks

https://www.zongweiz.com/dataset

Much larger than pre-existing public tumor datasets

Liver tumors – 201 scans in LiTS

Pancreatic tumors – 420 scans in MSD-Pancreas

Kidney tumors – 599 scans in KiTS

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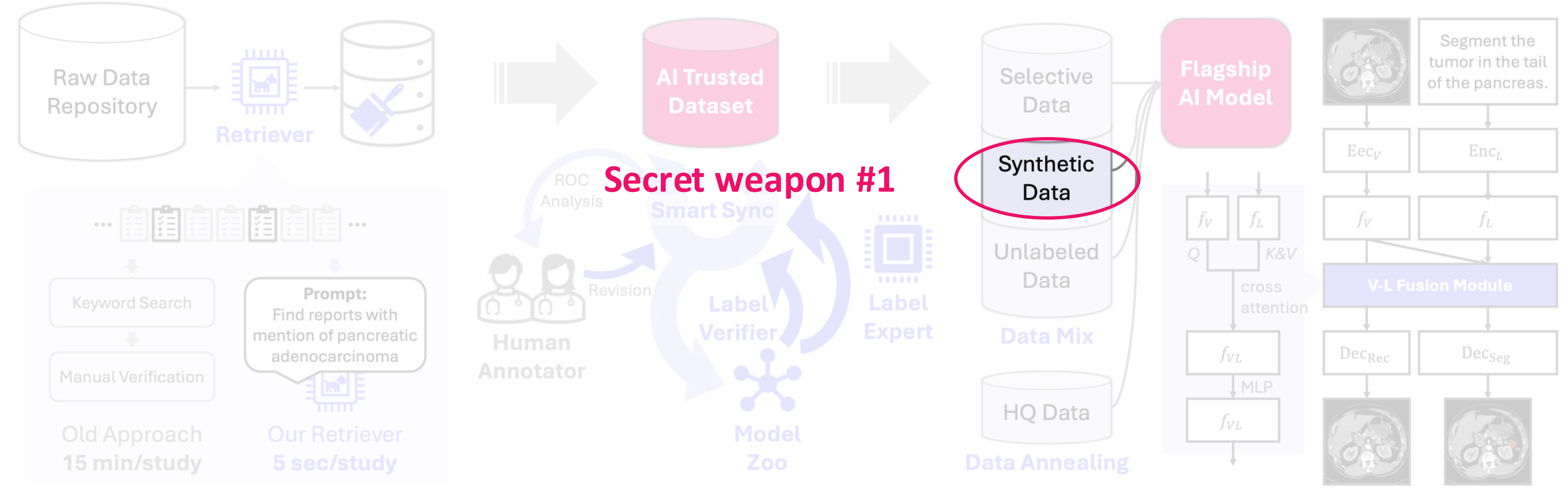

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Data Mix

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Data Annealing

Flagship AI Model

Secret weapon #1

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MidJourney

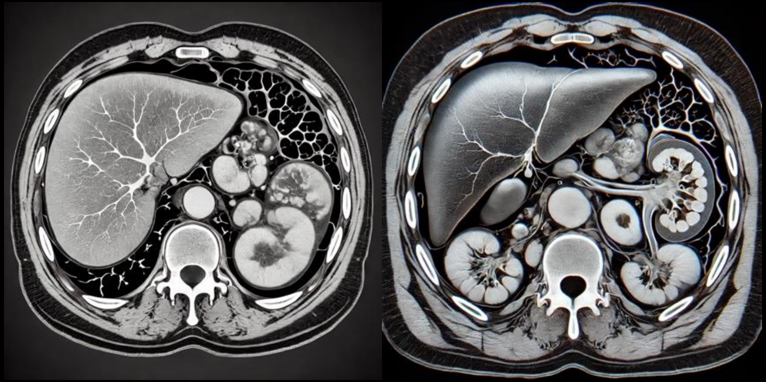
An astronaut riding a horse.

GPT-4o (OpenAI)

An astronaut riding a horse.

Synthetic data are a promising way forward.

- ✓ Cheap & perfect labeled
- ✓ No privacy issue
- ✓ Enormous training data

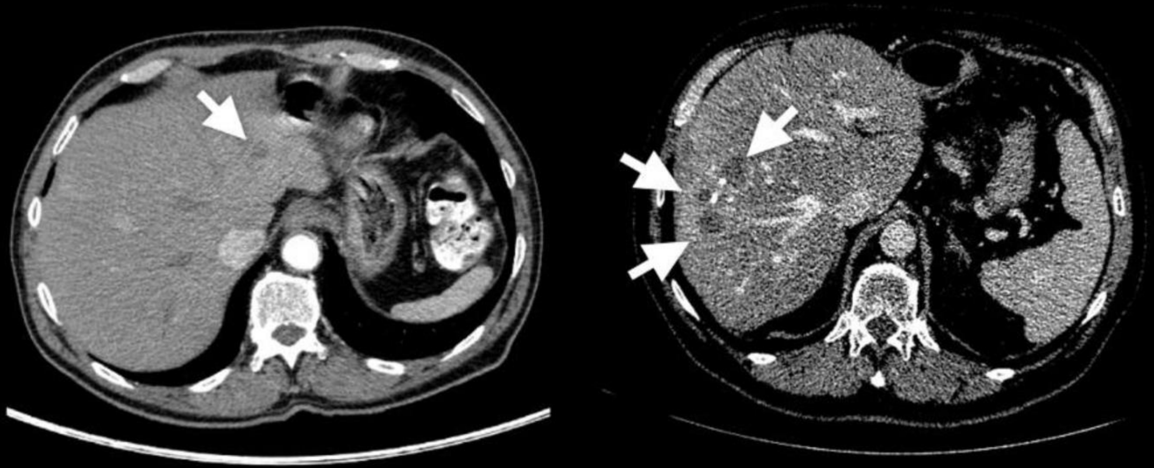


GPT-4o (OpenAI)

Left: A 2D axial view of CT with liver tumors.
Right: A 2D axial view of CT without liver tumor.

GPT-4o (OpenAI)

Left: A 2D axial view of CT with pancreatic tumors.
Right: A 2D axial view of CT without pancreatic tumor.



ARTIFICIAL INTELLIGENCE

JOHNS HOPKINS RESEARCHERS CREATE ARTIFICIAL TUMORS TO HELP AI DETECT EARLY-STAGE CANCER

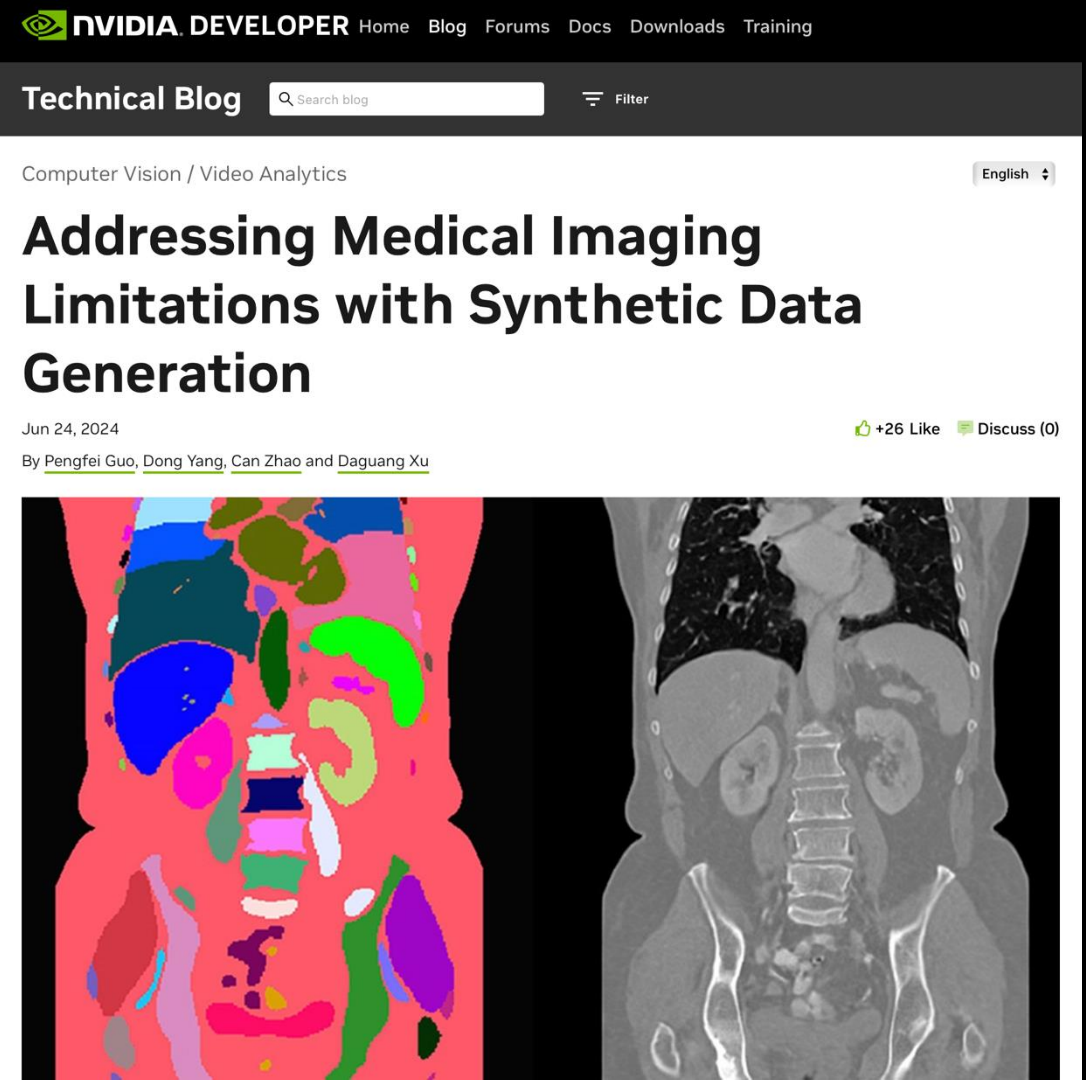
The Hopkins-led team demonstrated that an AI model trained solely on synthetic tumor data works as well as models trained on real tumors

Synthetic data are a promising way forward.

- ✓ Cheap & perfect labeled
- ✓ No privacy issue
- ✓ Enormous training data

(Let's discuss these later)

- ✓ Tougher testing
- ✓ Controllable analysis



Computer Vision / Video Analytics

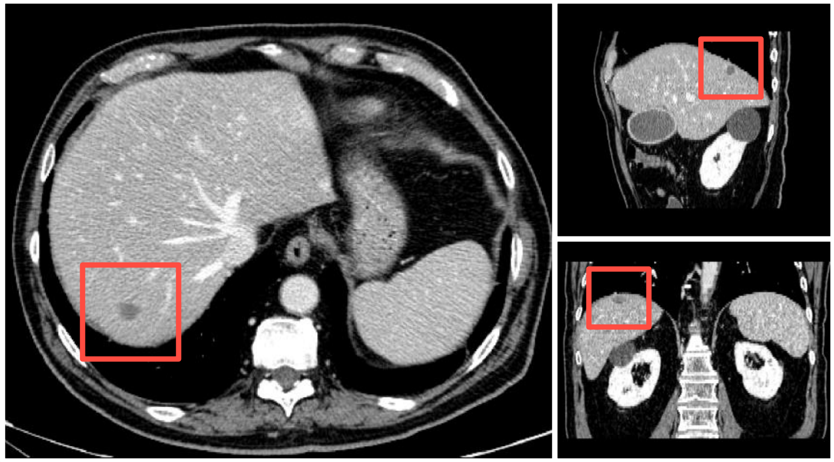
Addressing Medical Imaging Limitations with Synthetic Data Generation

Jun 24, 2024

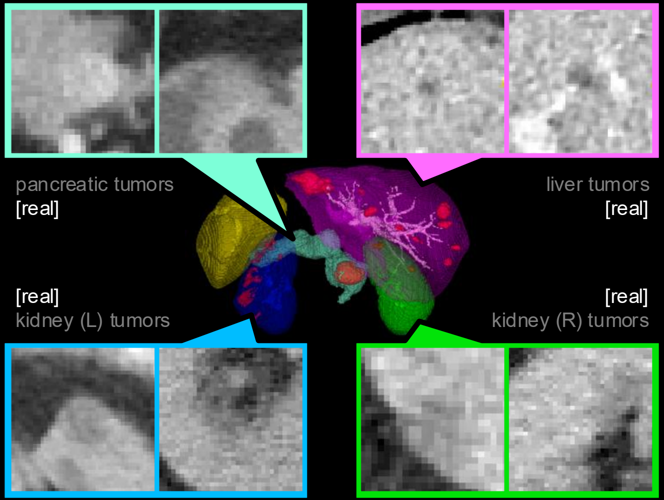
By Pengfei Guo, Dong Yang, Can Zhao and Daguang Xu

Synthetic data are a promising way forward.

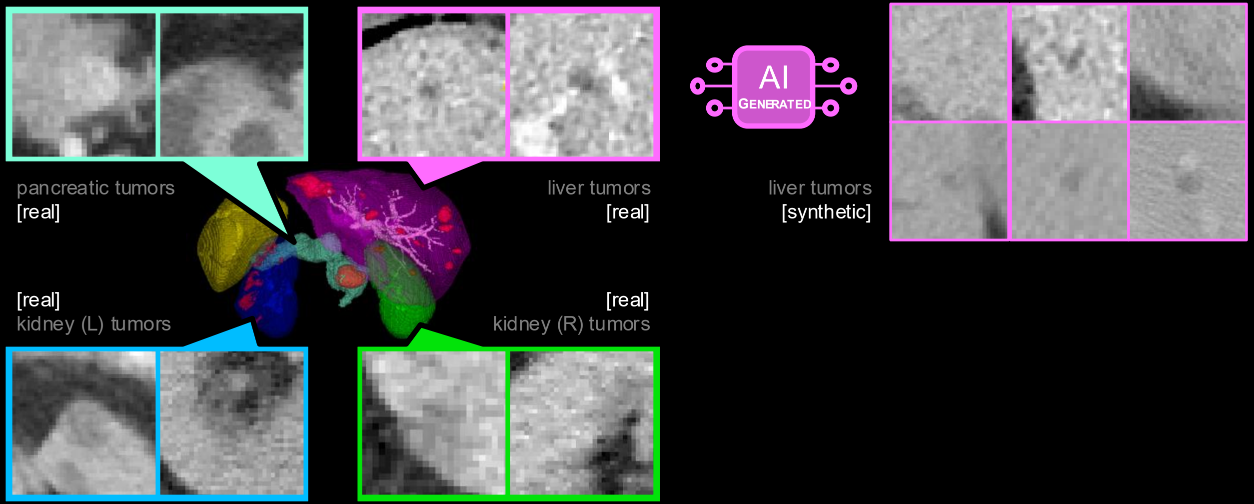
- ✓ Cheap & perfect labeled
- ✓ No privacy issue
- ✓ Enormous training data



Observation: early-stage tumors (< 2cm) often have *similar appearance* in CT images, whether they originate in the liver, pancreas, or kidneys.

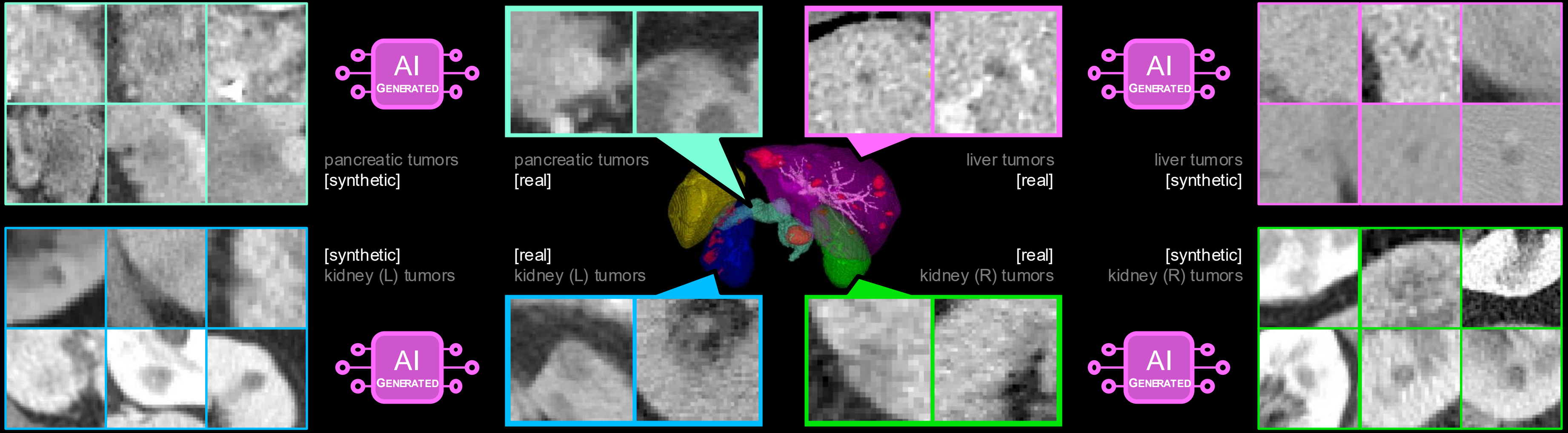


We used a Diffusion Model to “overfit” small tumor appearance across organs



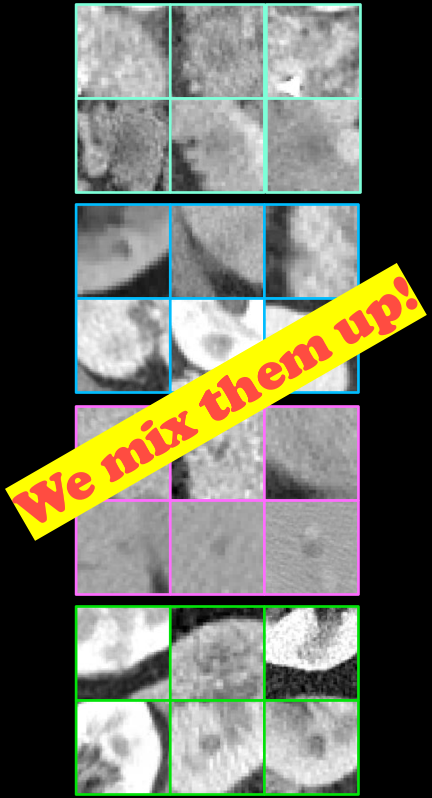
Generative AI models (e.g., diffusion models) trained on **liver tumor** examples

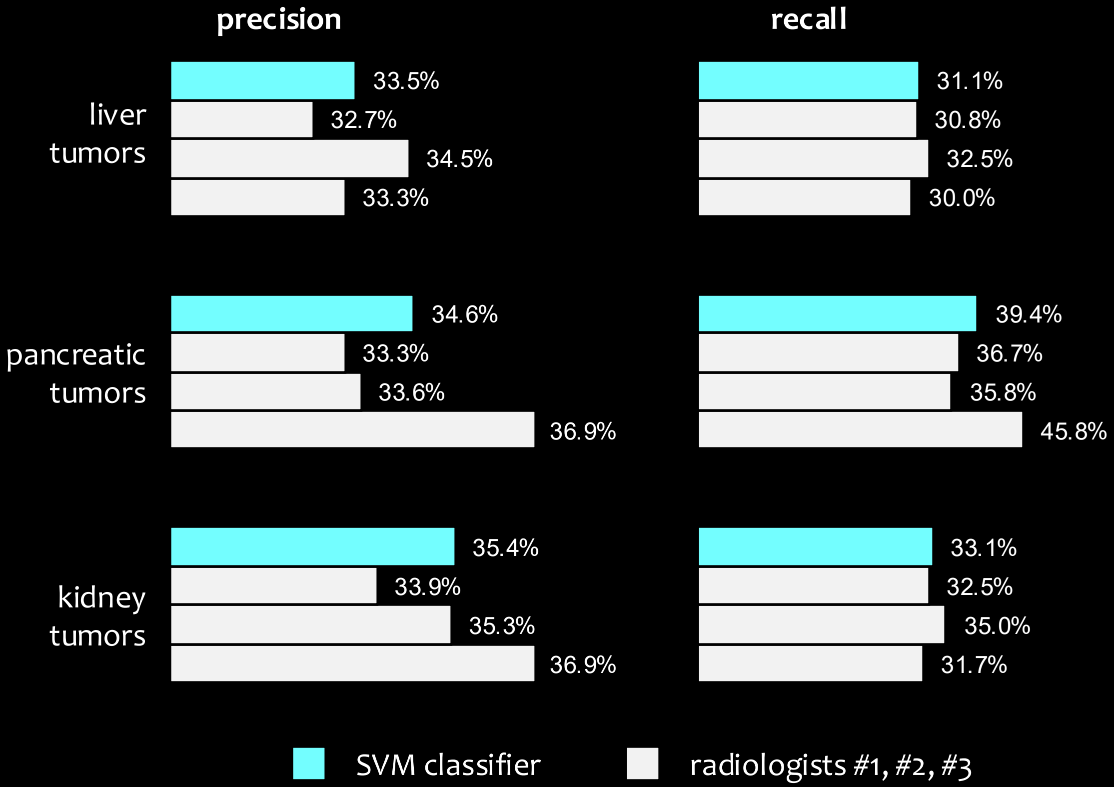
We used a Diffusion Model to "overfit" small tumor appearance across organs



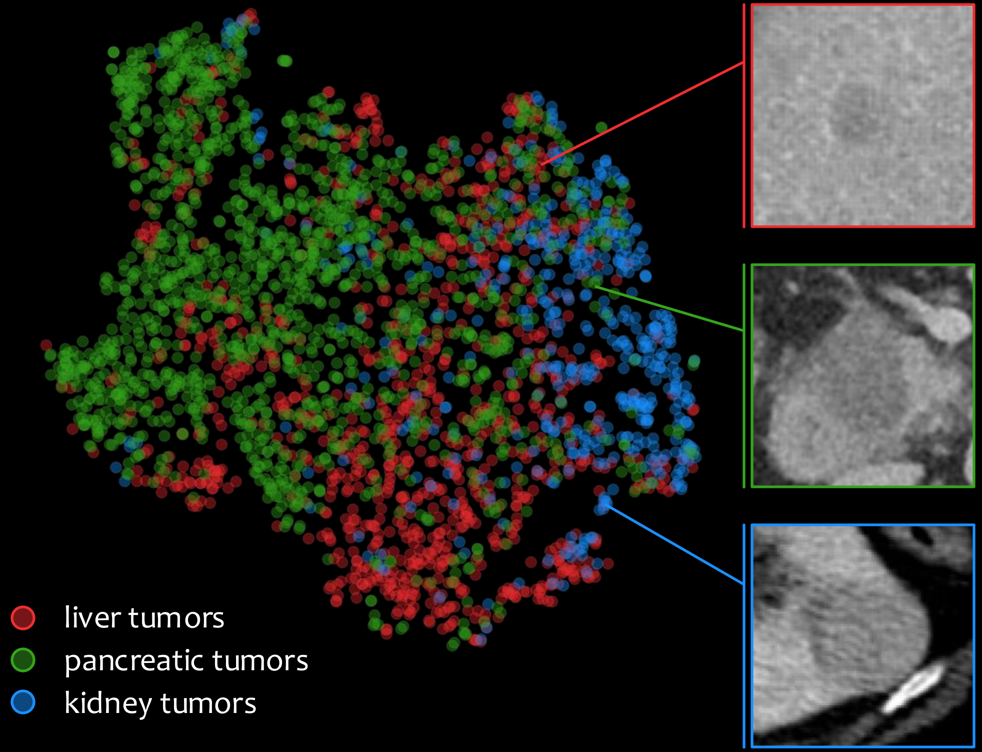
Generative AI models (e.g., diffusion models) trained on **liver tumor** examples

From which organ? Medical professionals / ML models cannot tell





From which organ? Radiomics feature analysis cannot tell



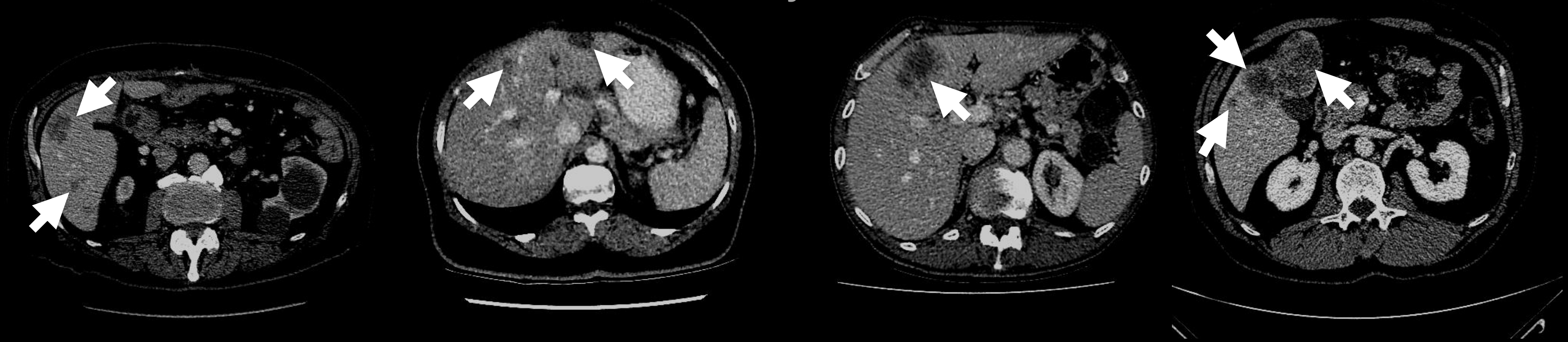
Early hepatocellular carcinoma in the liver presents as a small **hypoattenuating** lesion with a **round** shape in the portal venous phase, attributed to the 'wash-out' effect.

Early pancreatic ductal adenocarcinomas in the head of the pancreas display a **hypoenhancing** lesion with an **oval** shape in the venous phase, resulting from the dense fibroblastic stroma.

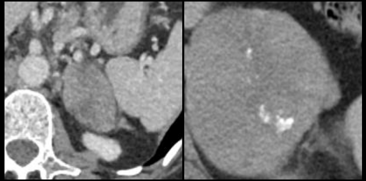
Early renal cell carcinoma in the left kidney manifests as an **oval hypoattenuating** lesion in the nephrographic phase.

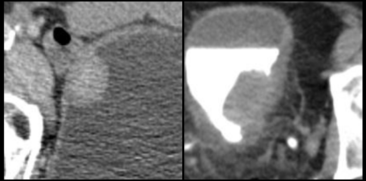
Real or synthetic? Medical professionals cannot tell

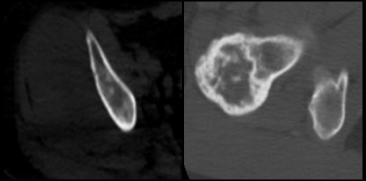
Can you?

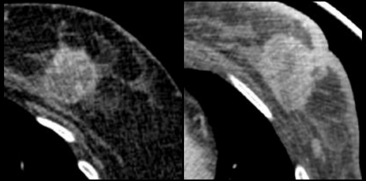


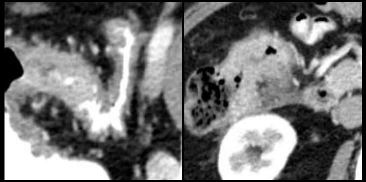
Real or synthetic? Medical professionals cannot tell

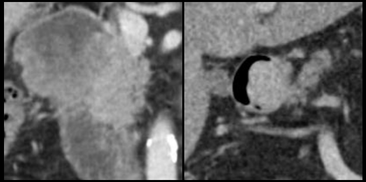

(a) adrenal tumor

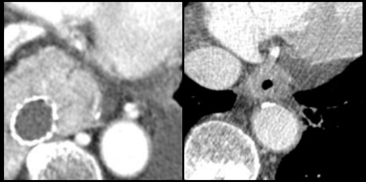

(b) bladder tumor

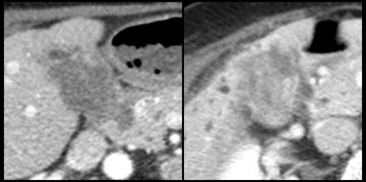

(c) bone tumor

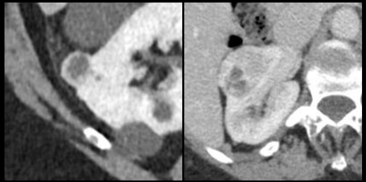

(d) breast tumor

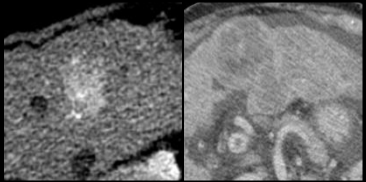

(e) colon tumor

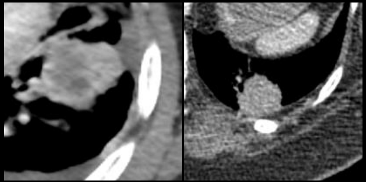

(f) duodenum tumor

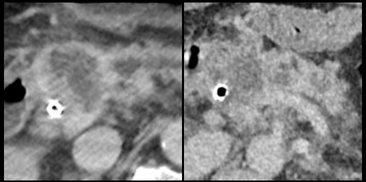

(g) esophagus tumor

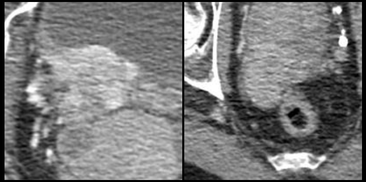

(h) gallbladder tumor

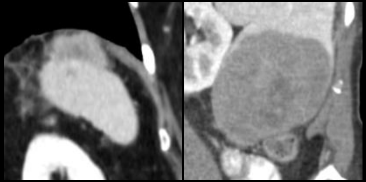

(i) kidney tumor

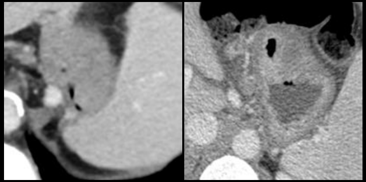

(j) liver tumor

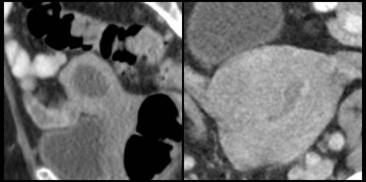

(k) lung tumor


(l) pancreas tumor


(m) prostate tumor


(n) spleen tumor


(o) stomach tumor

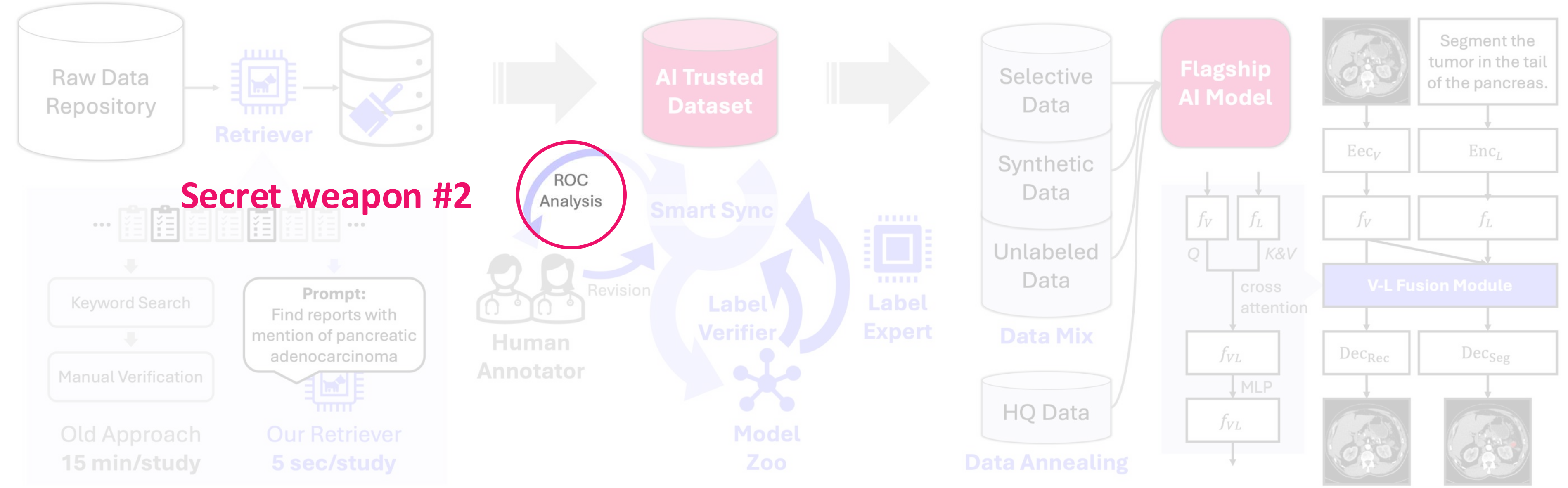

(p) uterus tumor

ScaleMAI – Accelerating the Development of Trusted Datasets and AI Models

Curation: Clinical Needs → Suitable Data

Integration: AI, VLM, Human → Better Data

Integration: Data Mix, Annealing → Better AI



Secret weapon #2

ROC Analysis

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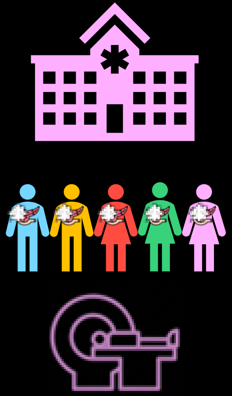
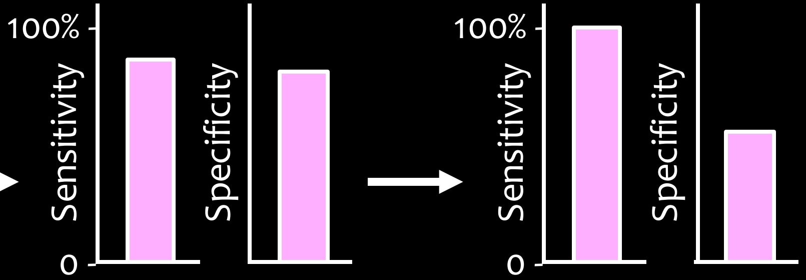
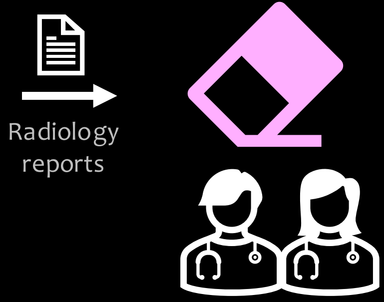
Code, Dataset, & Model:
https://www.zongweiz.com/dataset

Efficient tumor annotation for new hospitals

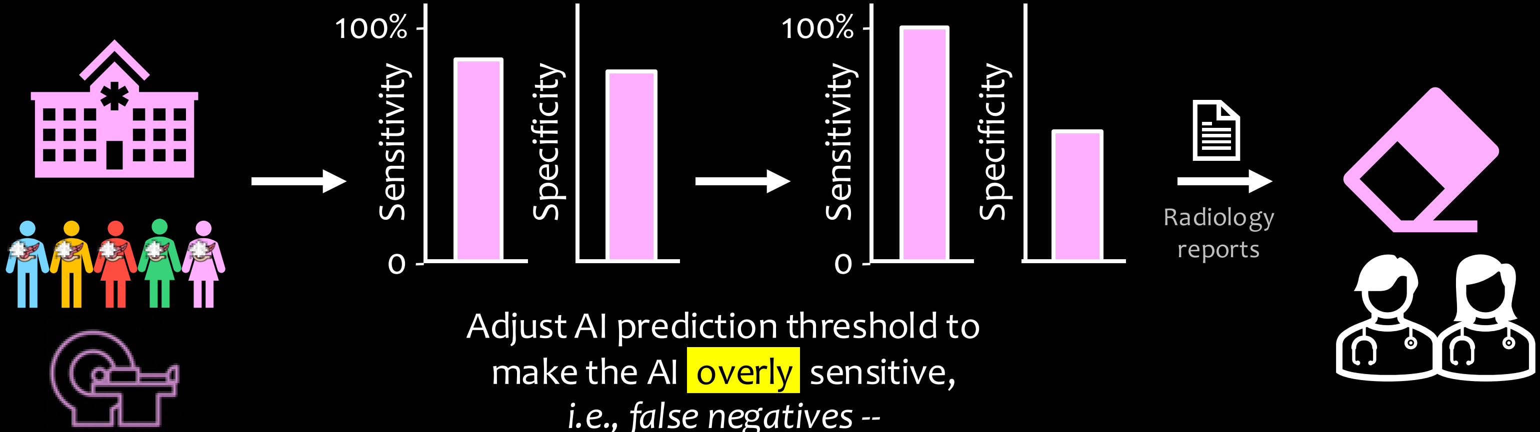






Adjust AI prediction threshold to
make the AI overly sensitive,
i.e., false negatives --
false positives ++

Efficient tumor annotation for new hospitals



Adjust AI prediction threshold to make the AI overly sensitive,
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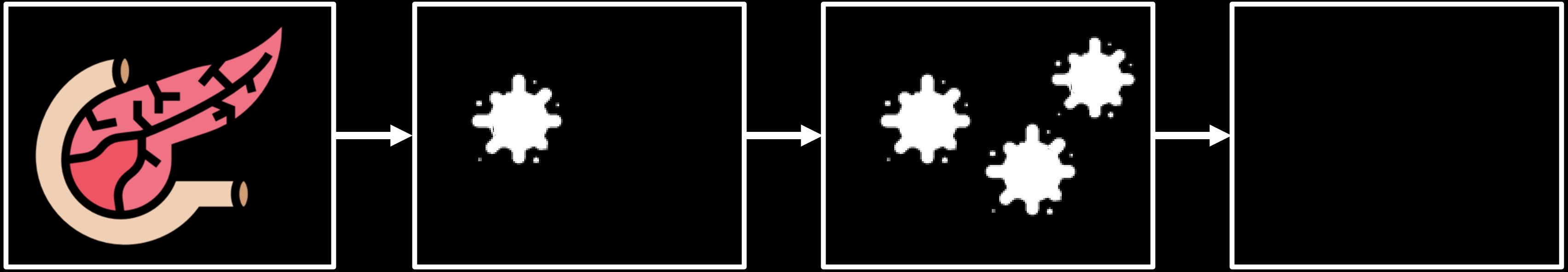
false positives ++



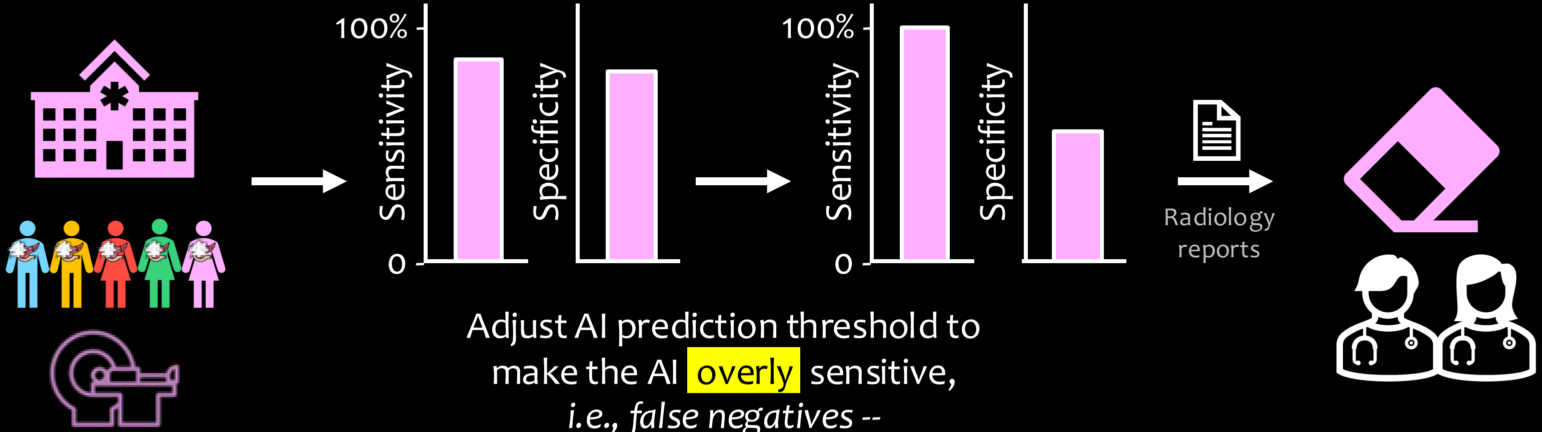
CT scans w/o PDAC

AI predictions

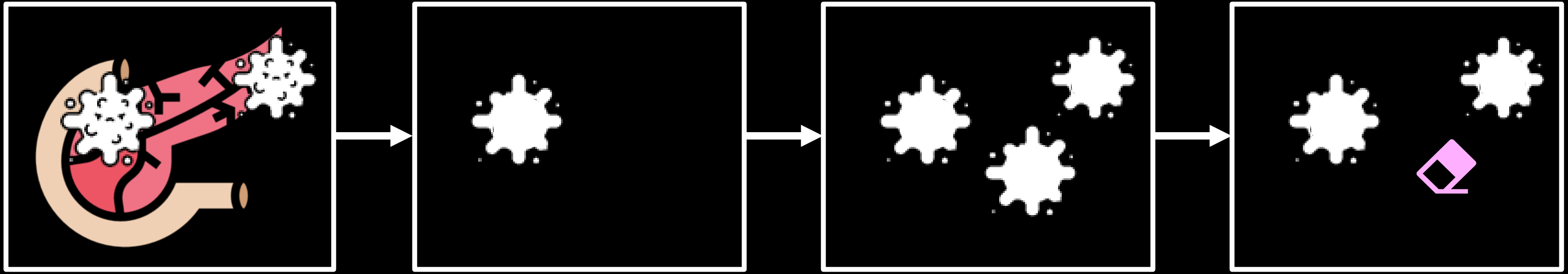
Adjusted predictions

False positive removal (automatic)

Efficient tumor annotation for new hospitals



Adjust AI prediction threshold to make the AI overly sensitive, *i.e., false negatives --* *false positives ++*



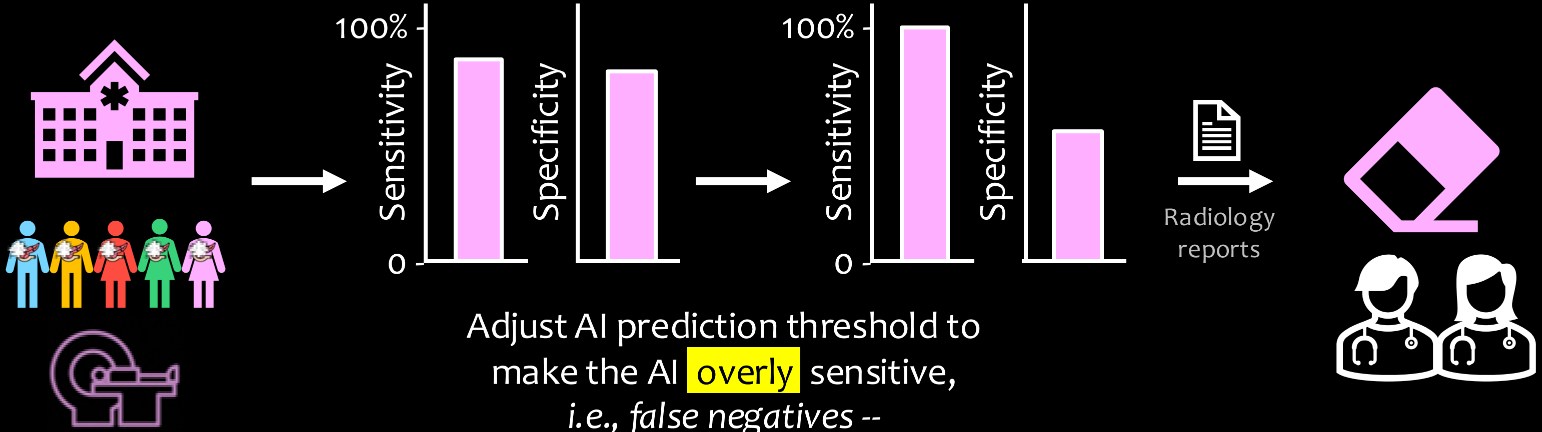
CT scans w/t PDAC

AI predictions

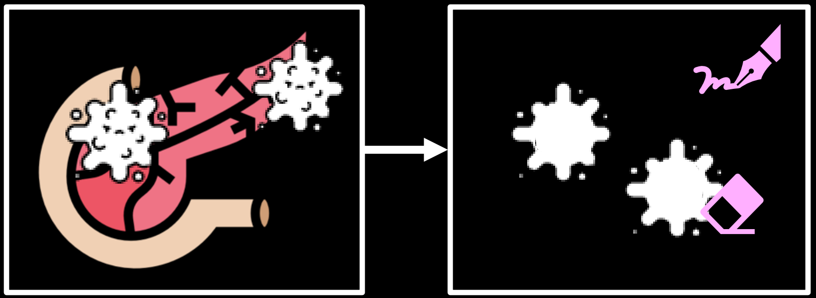
Adjusted predictions

False positive removal (manual)

Efficient tumor annotation for new hospitals



Adjust AI prediction threshold to make the AI overly sensitive,
i.e., false negatives --
false positives ++



CT scans w/t PDAC

AI predictions

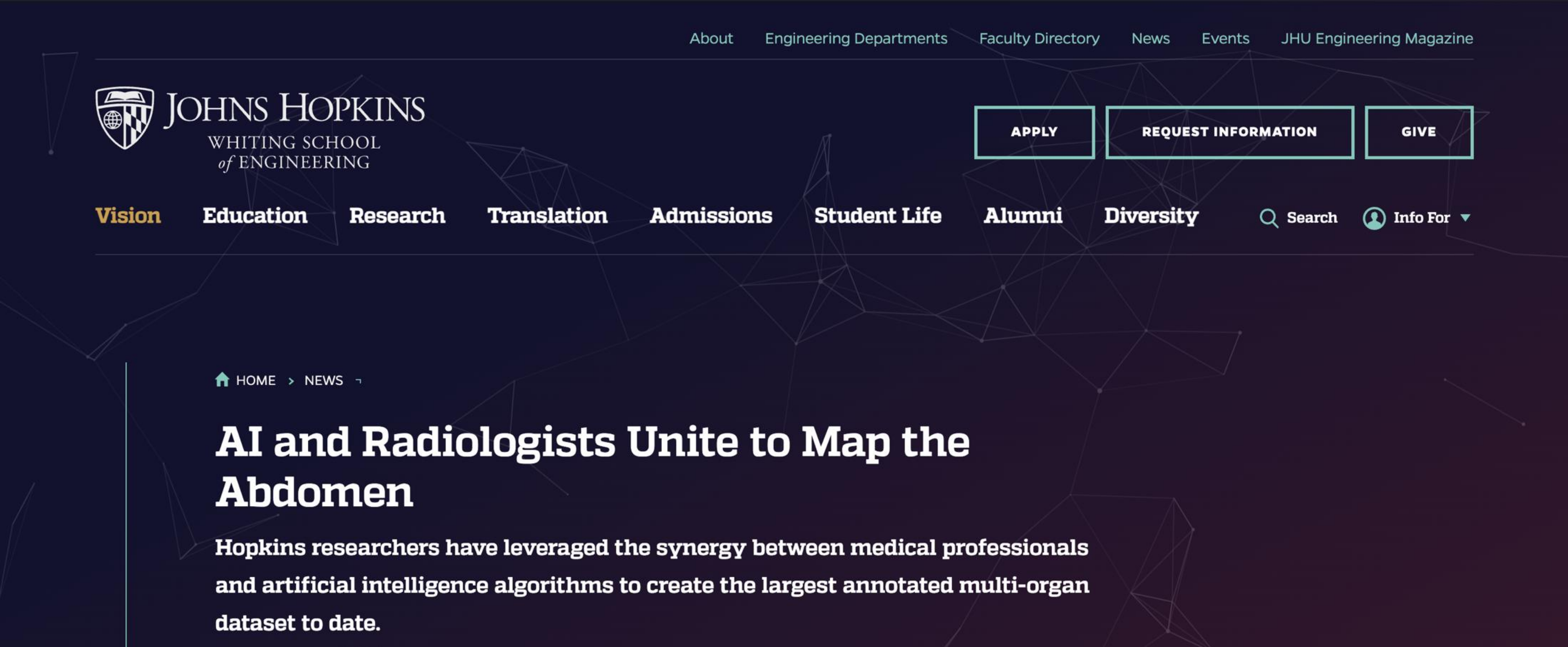
Sensitivity = 99% at 0.6 false positives per patient

4-5 min/tumor: create per-voxel annotation

<5 sec/tumor: remove per-voxel annotation

AI and Radiologists Unite to Map the Abdomen

Hopkins researchers have leveraged the synergy between medical professionals and artificial intelligence algorithms to create the largest annotated multi-organ dataset to date.



AI and Radiologists Unite to Map the Abdomen

Hopkins researchers have leveraged the synergy between medical professionals and artificial intelligence algorithms to create the largest annotated multi-organ dataset to date.

"While a dataset of this size would have taken an experienced human annotator almost 31 years to fully annotate, the team completed this task in only three weeks."

The BodyMaps Project

AI-Integrated Annotation

- **ScaleMAI Platform**
  - Anatomical Segmentation
- **Synthetic Data Engine**
  - Multi-lesion Segmentation

AI-Assisted Cancer Moonshot

- **Lesion Detection**
  - Human-level Detection
- **Cancer Diagnosis**
  - Super-human Classification
- **Treatment Planning**
  - Tumor Staging

AI-Trusted Benchmark

- **Foundation Models**
  - Supervised Pre-Trained Models
- **Universal Models**
  - Generalists vs. Specialists

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Code, Dataset, & Model:
`https://www.zongweiz.com/dataset`

The BodyMaps Project

- AI-Integrated Annotation
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    - Generalists vs. Specialists

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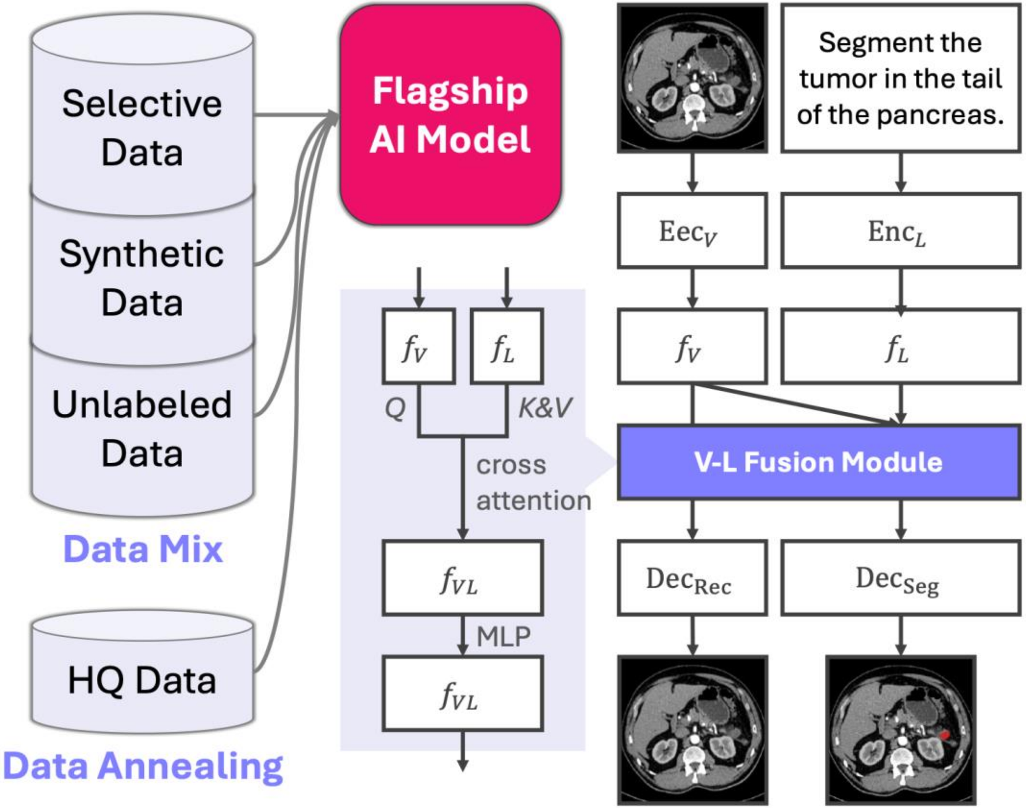
Integration: Data Mix, Annealing → Better AI



Selective Data

Synthetic Data

Unlabeled Data

Data Mix

HQ Data

Data Annealing

Flagship AI Model

f_V f_L

Q $K\&V$

cross attention

f_{VL}

MLP

f_{VL}

Segment the tumor in the tail of the pancreas.

Eec_V Enc_L

f_V f_L

V-L Fusion Module

$\mathrm{Dec}_{\mathrm{Rec}}$ $\mathrm{Dec}_{\mathrm{Seg}}$

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Code, Dataset, & Model:
`https://www.zongweiz.com/dataset`

AbdomenAtlasPro = 25K CT Volumes + 600K 3D Masks

16 tumor pathologies: adrenal gland · bladder · bone · breast · colon · duodenum · esophagus · gallbladder · kidney · liver · lung · pancreas · prostate · spleen · stomach · uterus

136 anatomical structures: adrenal gland left · adrenal gland right · airway · aorta · atrial appendage left · autochthon left · autochthon right · bladder · bone · brachiocephalic trunk · brachiocephalic vein left · brachiocephalic vein right · brain · clavicula left · clavicula right · celiac trunk · colon · common bile duct · common carotid artery left · common carotid artery right · costal cartilages · duodenum · esophagus · femur left · femur right · gall bladder · gluteus maximus left · gluteus maximus right · gluteus medius left · gluteus medius right · gluteus minimus left · gluteus minimus right · heart · hepatic vessel · hip left · hip right · humerus left · humerus right · iliac artery left · iliac artery right · iliac vena left · iliac vena right · iliopsoas left · iliopsoas right · intestine · kidney left · kidney right · liver · liver segment 1 · liver segment 2 · liver segment 3 · liver segment 4 · liver segment 5 · liver segment 6 · liver segment 7 · liver segment 8 · lung left · lung lower left lobe · lung lower right lobe · lung middle right lobe · lung right · lung upper left lobe · lung upper right lobe · pancreas · pancreas body · pancreas head · pancreas tail · pancreatic duct · portal vein and splenic vein · postcava · prostate · pulmonary vein · rectum · rib left 1 · rib left 10 · rib left 11 · rib left 12 · rib left 2 · rib left 3 · rib left 4 · rib left 5 · rib left 6 · rib left 7 · rib left 8 · rib left 9 · rib right 1 · rib right 10 · rib right 11 · rib right 12 · rib right 2 · rib right 3 · rib right 4 · rib right 5 · rib right 6 · rib right 7 · rib right 8 · rib right 9 · sacrum · scapula left · scapula right · skull · spleen · spinal cord · sternum · stomach · subclavian artery left · subclavian artery right · superior mesenteric artery · superior vena cava · thyroid gland · trachea · veins · vertebrae C1 · vertebrae C2 · vertebrae C3 · vertebrae C4 · vertebrae C5 · vertebrae C6 · vertebrae C7 · vertebrae L1 · vertebrae L2 · vertebrae L3 · vertebrae L4 · vertebrae L5 · vertebrae S1 · vertebrae T1 · vertebrae T10 · vertebrae T11 · vertebrae T12 · vertebrae T2 · vertebrae T3 · vertebrae T4 · vertebrae T5 · vertebrae T6 · vertebrae T7 · vertebrae T8 · vertebrae T9

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Code, Dataset, & Model:
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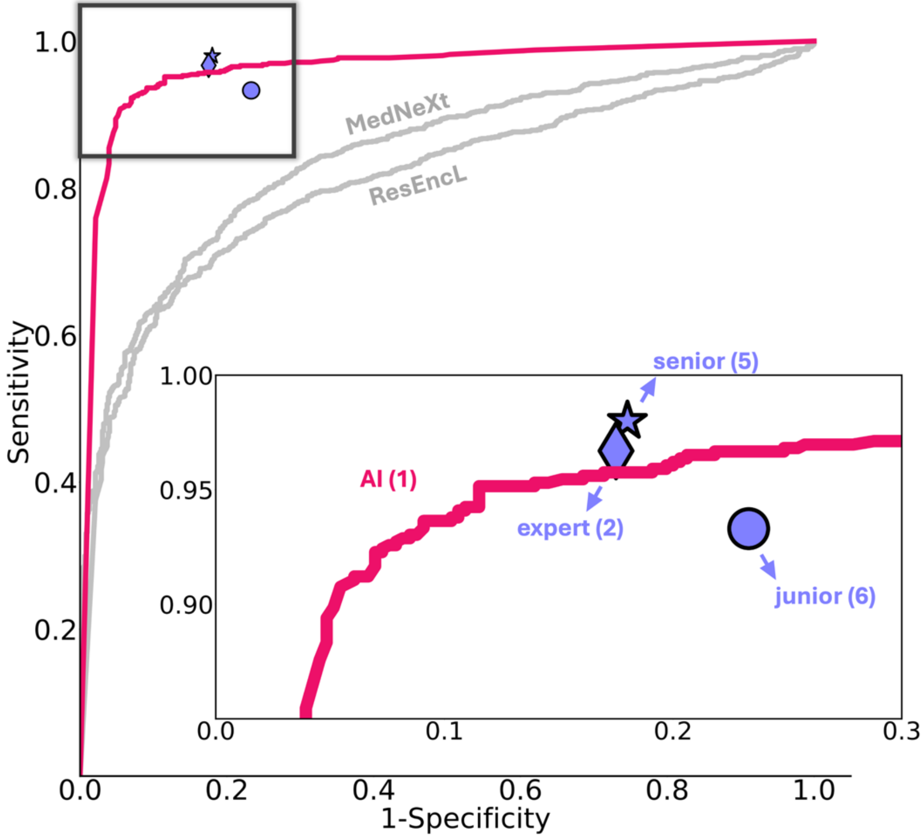
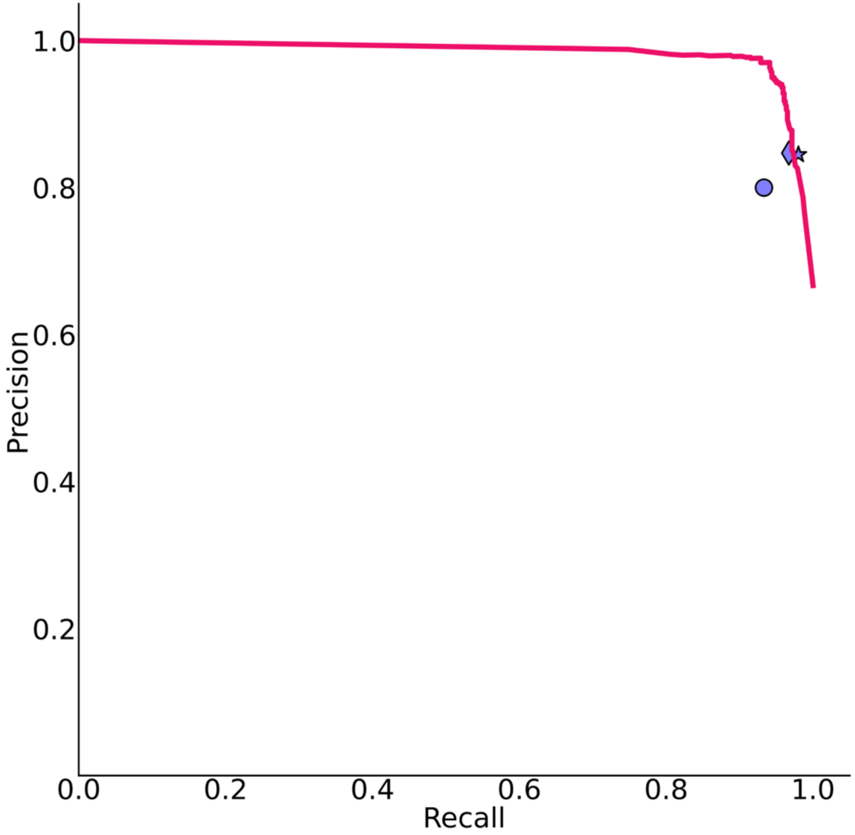
AbdomenAtlasPro → Improved Tumor Detection





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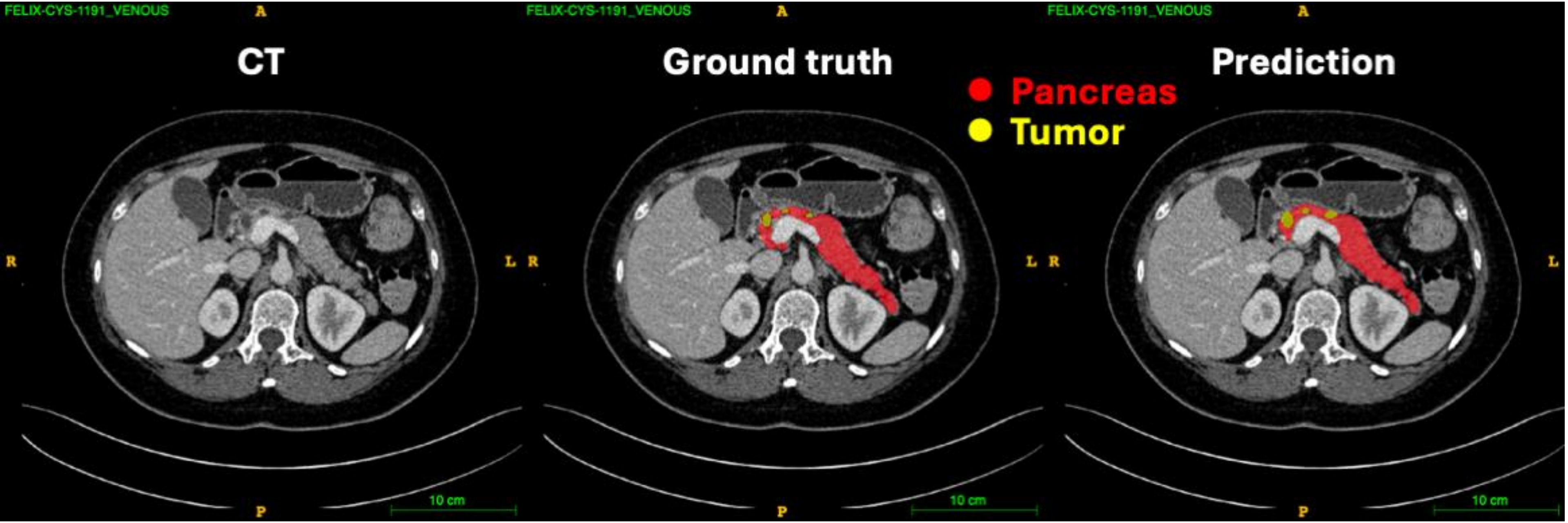
Code, Dataset, & Model:
https://www.zongweiz.com/dataset

AbdomenAtlasPro → Improved Small Tumor Detection



Sensitivity = 89%
Specificity = 93%

Sensitivity = 33~44%
Specificity = 82~96%

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Code, Dataset, & Model:
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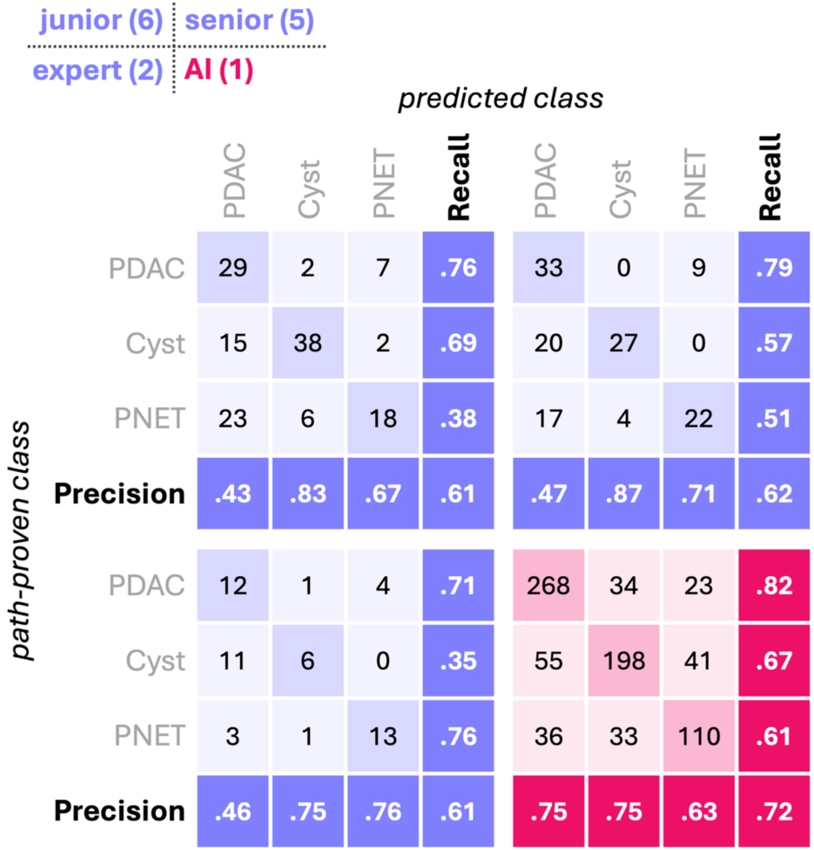
Abdomen**A**tlas**Pro** → Improved Tumor Classification



	junior (6)	senior (5)
	expert (2)	AI (1)

predicted class

path-proven class

	PDAC	Cyst	PNET	**Recall**	PDAC	Cyst	PNET	**Recall**
PDAC	29	2	7	.76	33	0	9	.79
Cyst	15	38	2	.69	20	27	0	.57
PNET	23	6	18	.38	17	4	22	.51
Precision	.43	.83	.67	.61	.47	.87	.71	.62
PDAC	12	1	4	.71	268	34	23	.82
Cyst	11	6	0	.35	55	198	41	.67
PNET	3	1	13	.76	36	33	110	.61
Precision	.46	.75	.76	.61	.75	.75	.63	.72

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Code, Dataset, & Model:
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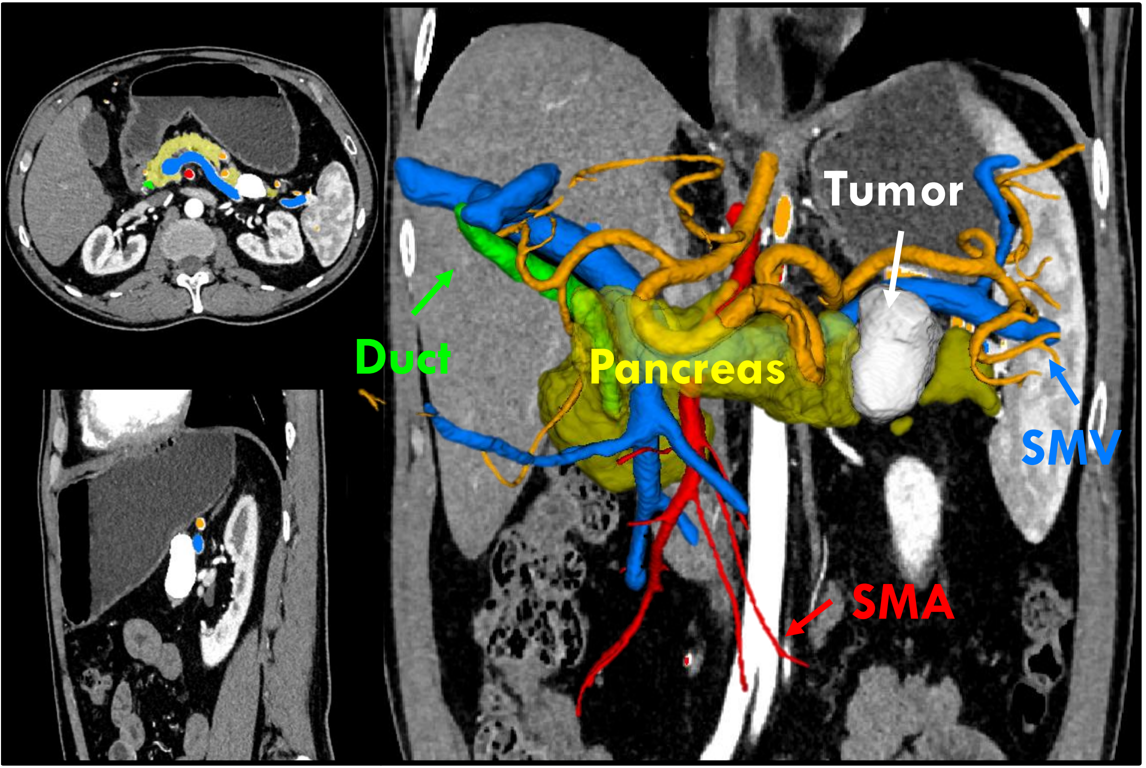
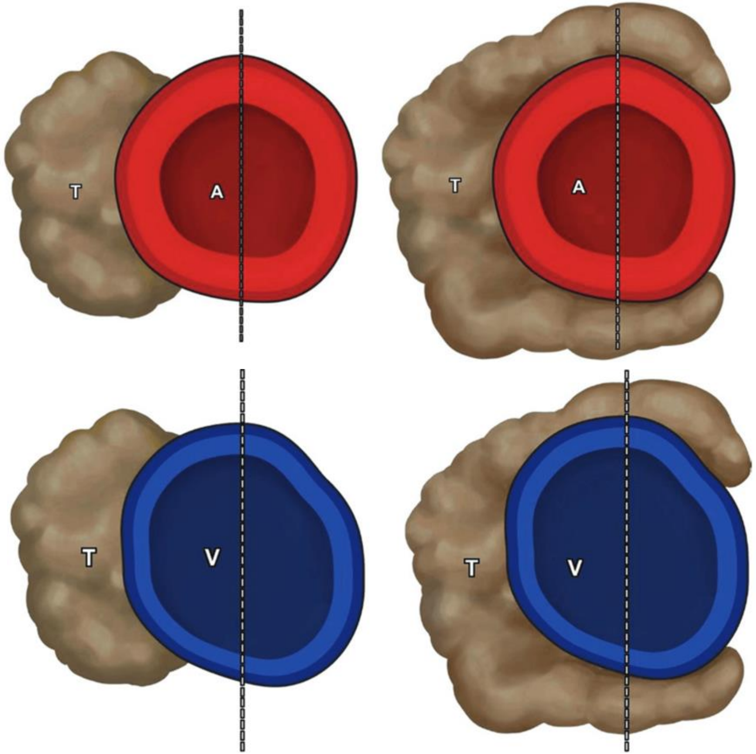
AbdomenAtlasPro → Tumor Resectability Estimation





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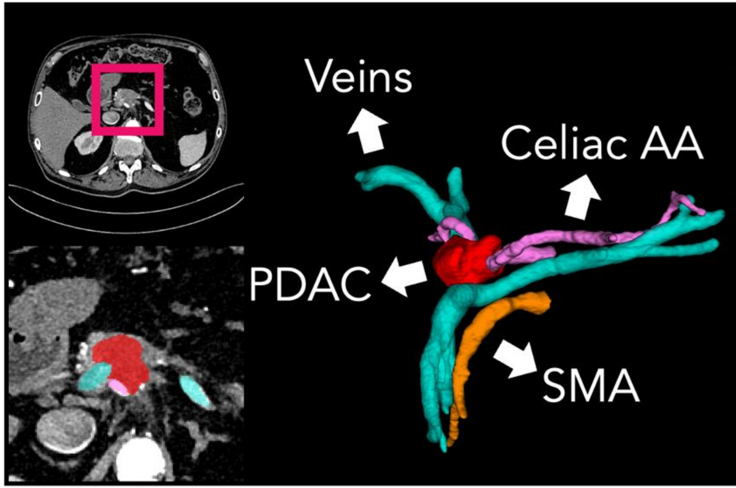
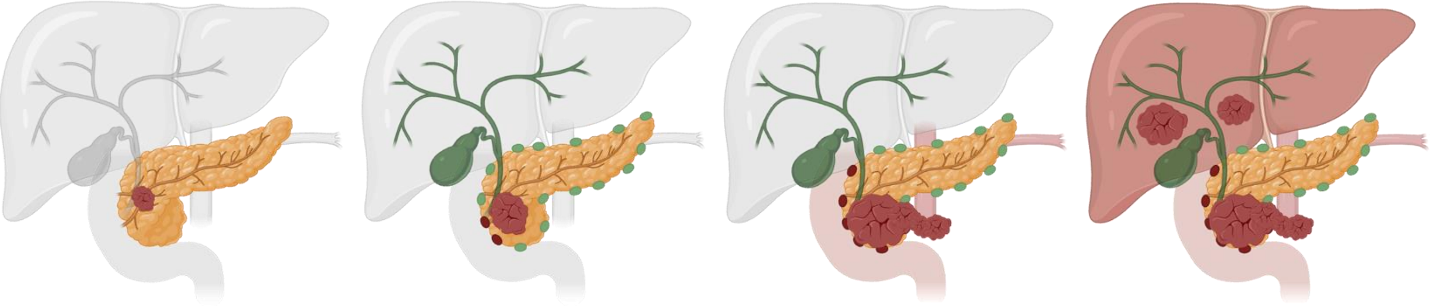
Code, Dataset, & Model:
https://www.zongweiz.com/dataset

AbdomenAtlasPro → Pancreatic Tumor Reporting



Pancreas:
Pancreas is enlarged (volume: 84.6 cm^3).
Mean HU value: 105.7 +/- 33.1.

Pancreas lesions:
Pancreas tumor 1:
Location: pancreas head/body.
Size: 2.9 x 2.2 cm (image 298). Volume: 8.2 cm^3.
Tumor Stage (T stage): T2.
Enhancement relative to pancreas:
Hypoattenuating (HU value is 52.6+/-26.8).



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Code, Dataset, & Model:
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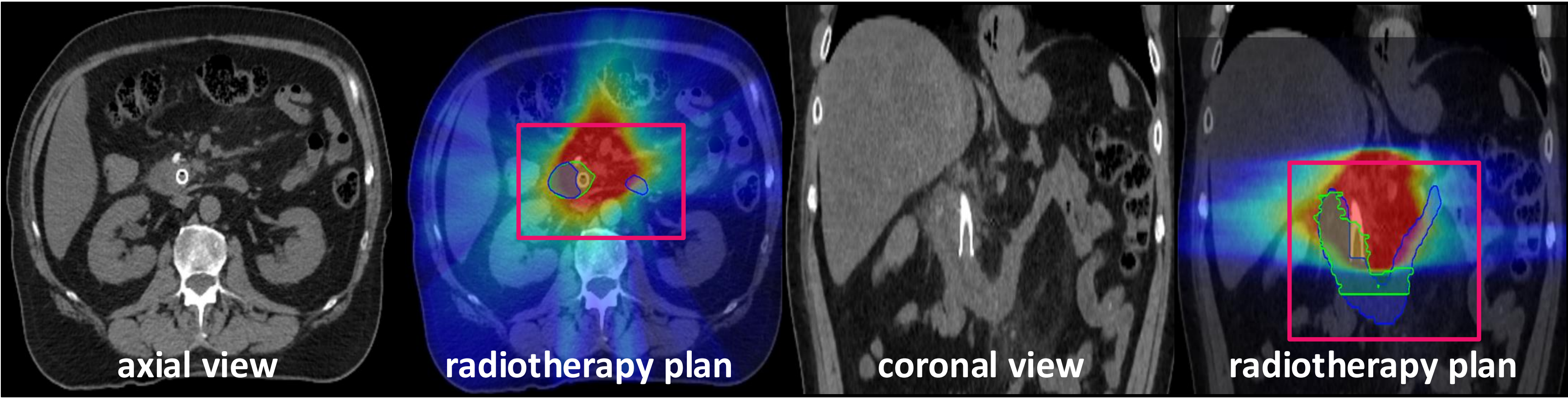
AbdomenAtlasPro → Generalized to Planning CT Scans



E.g., Duodenum Segmentation Planning CT Scans

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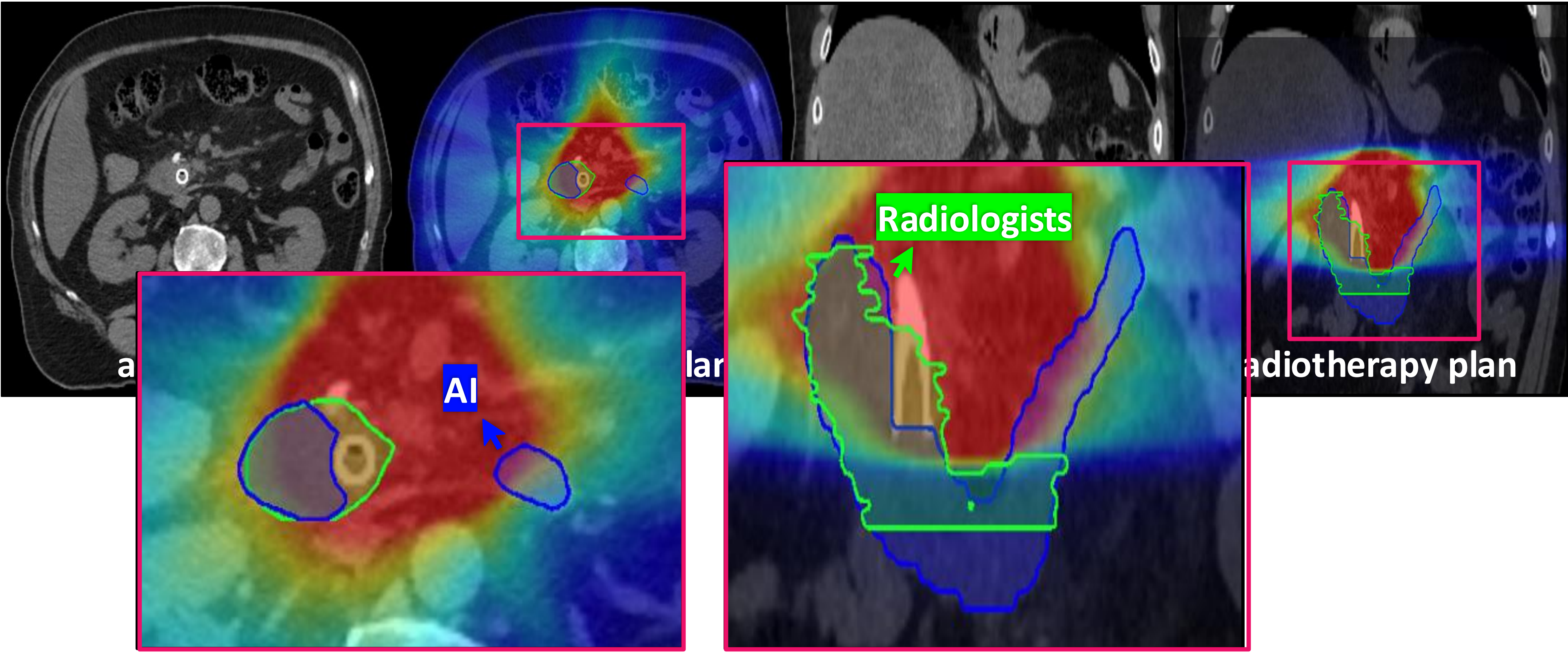
AbdomenAtlasPro → Generalized to Planning CT Scans



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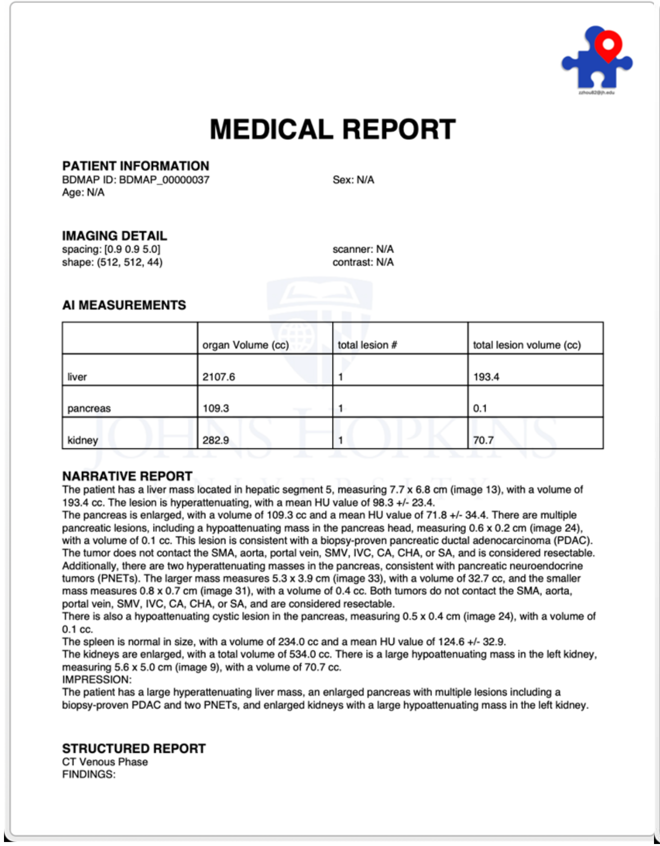
Code, Dataset, & Model:
`https://www.zongweiz.com/dataset`

AbdomenAtlasPro → Automated Report Generation



MEDICAL REPORT

PATIENT INFORMATION
BDMAP ID: BDMAP_00000037
Sex: N/A
Age: N/A

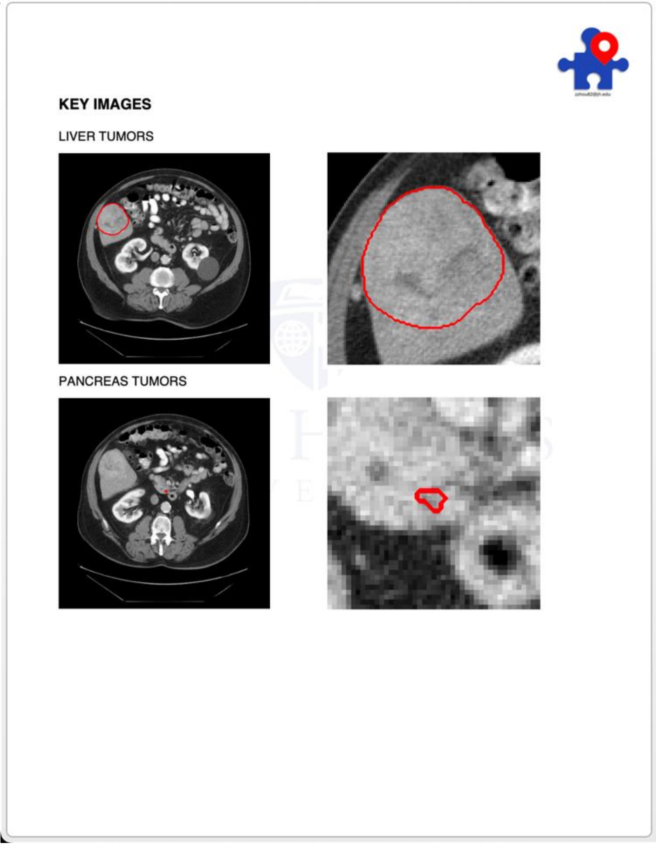
IMAGING DETAIL
spacing: [0.9 0.9 5.0]
scanner: N/A
shape: (512, 512, 44)
contrast: N/A

AI MEASUREMENTS

	organ Volume (cc)	total lesion #	total lesion volume (cc)
liver	2107.6	1	193.4
pancreas	109.3	1	0.1
kidney	282.9	1	70.7

NARRATIVE REPORT
The patient has a liver mass located in hepatic segment 5, measuring 7.7 x 6.8 cm (image 13), with a volume of 193.4 cc. The lesion is hyperattenuating, with a mean HU value of 98.3 +/- 23.4.
The pancreas is enlarged, with a volume of 109.3 cc and a mean HU value of 71.8 +/- 34.4. There are multiple pancreatic lesions, including a hypoattenuating mass in the pancreas head, measuring 0.6 x 0.2 cm (image 24), with a volume of 0.1 cc. This lesion is consistent with a biopsy-proven pancreatic ductal adenocarcinoma (PDAC). The tumor does not contact the SMA, aorta, portal vein, SMV, IVC, CA, CHA, or SA, and is considered resectable. Additionally, there are two hyperattenuating masses in the pancreas, consistent with pancreatic neuroendocrine tumors (PNETs). The larger mass measures 5.3 x 3.9 cm (image 33), with a volume of 32.7 cc, and the smaller mass measures 0.8 x 0.7 cm (image 31), with a volume of 0.4 cc. Both tumors do not contact the SMA, aorta, portal vein, SMV, IVC, CA, CHA, or SA, and are considered resectable.
There is also a hypoattenuating cystic lesion in the pancreas, measuring 0.5 x 0.4 cm (image 24), with a volume of 0.1 cc.
The spleen is normal in size, with a volume of 234.0 cc and a mean HU value of 124.6 +/- 32.9.
The kidneys are enlarged, with a total volume of 534.0 cc. There is a large hypoattenuating mass in the left kidney, measuring 5.6 x 5.0 cm (image 9), with a volume of 70.7 cc.
IMPRESSION:
The patient has a large hyperattenuating liver mass, an enlarged pancreas with multiple lesions including a biopsy-proven PDAC and two PNETs, and enlarged kidneys with a large hypoattenuating mass in the left kidney.

STRUCTURED REPORT
CT Venous Phase
FINDINGS:



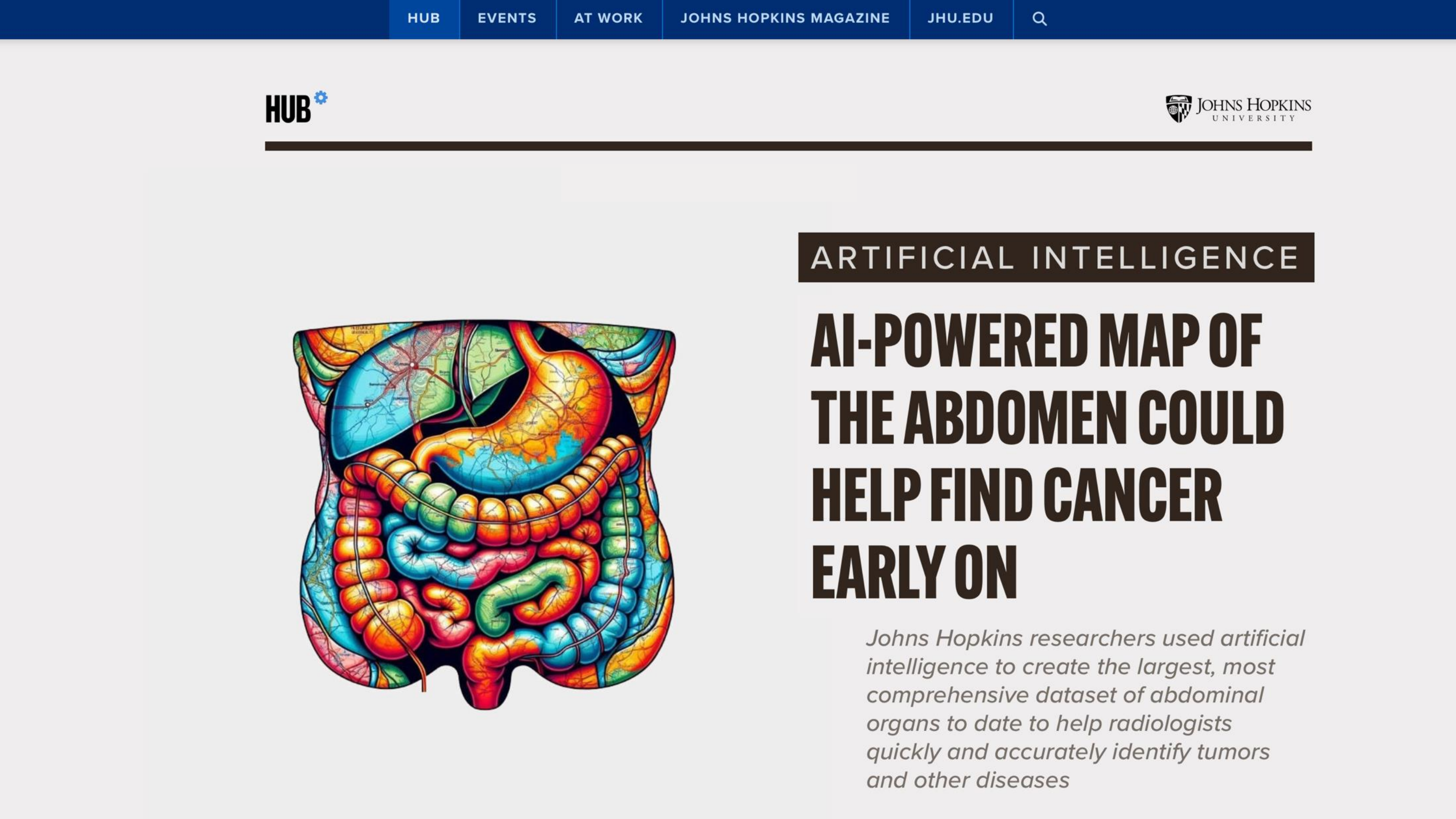
KEY IMAGES

LIVER TUMORS

PANCREAS TUMORS

Zongwei Zhou
zzhou82@jh.edu

Code, Dataset, & Model:
https://www.zongweiz.com/dataset



ARTIFICIAL INTELLIGENCE

AI-POWERED MAP OF THE ABDOMEN COULD HELP FIND CANCER EARLY ON

Johns Hopkins researchers used artificial intelligence to create the largest, most comprehensive dataset of abdominal organs to date to help radiologists quickly and accurately identify tumors and other diseases

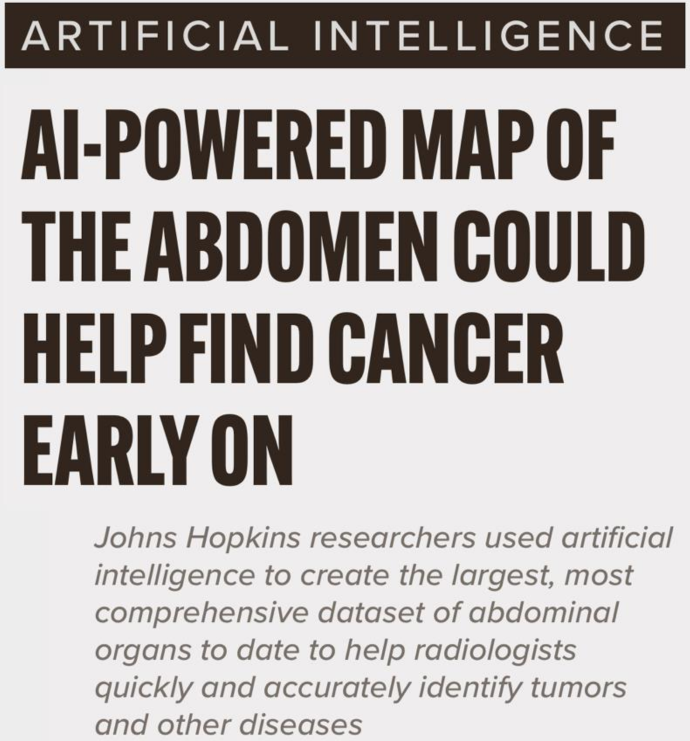
HUB | EVENTS | AT WORK | JOHNS HOPKINS MAGAZINE | JHU.EDU

HUB

JOHNS HOPKINS UNIVERSITY

"Annotating 45,000 CT scans with 6 million anatomical shapes would require an expert radiologist to have started working around 420 BCE—the era of **Hippocrates**—to complete the task by 2025,"

says lead author Zongwei Zhou



ARTIFICIAL INTELLIGENCE

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The BodyMaps Project

AI-Integrated Annotation

- ScaleMAI Platform
  - Anatomical Segmentation
- Synthetic Data Engine
  - Multi-lesion Segmentation

AI-Assisted Cancer Moonshot

- **Lesion Detection**
  - Human-level Detection
- **Cancer Diagnosis**
  - Super-human Classification
- **Treatment Planning**
  - Tumor Staging

AI-Trusted Benchmark

- Foundation Models
  - Supervised Pre-Trained Models
- Universal Models
  - Generalists vs. Specialists

Zongwei Zhou
`zzhou82@jh.edu`

Code, Dataset, & Model:
`https://www.zongweiz.com/dataset`

The BodyMaps Project

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Generalists vs. Specialists

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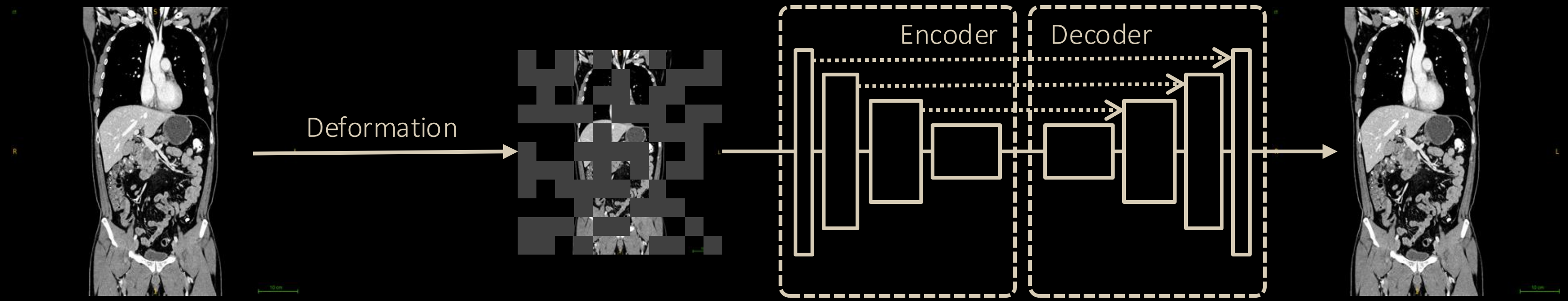


Option 1. Self-supervised pre-training

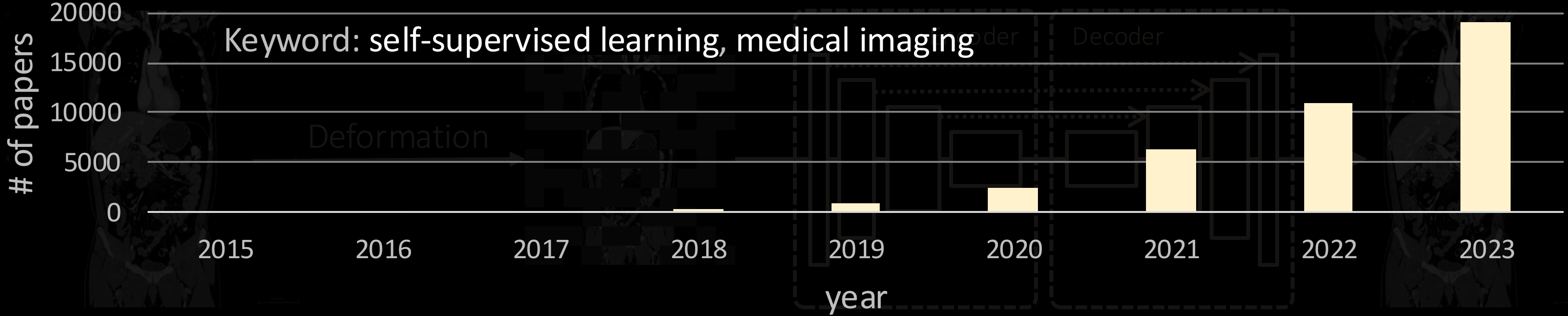
De-noising [Vincent et al., 2010]
Positioning **[Doersch et al., 2015]**
In-painting [Pathak et al., 2016]
Jigsaw [Noroozi and Favaro, 2016]
DeepCluster [Caron et al., 2018]
Restoration [Chen et al., 2019]

Models Genesis
[Zhou et al., MICCAI 2019]
MICCAI Young Scientist Award
MedIA Best Paper Award

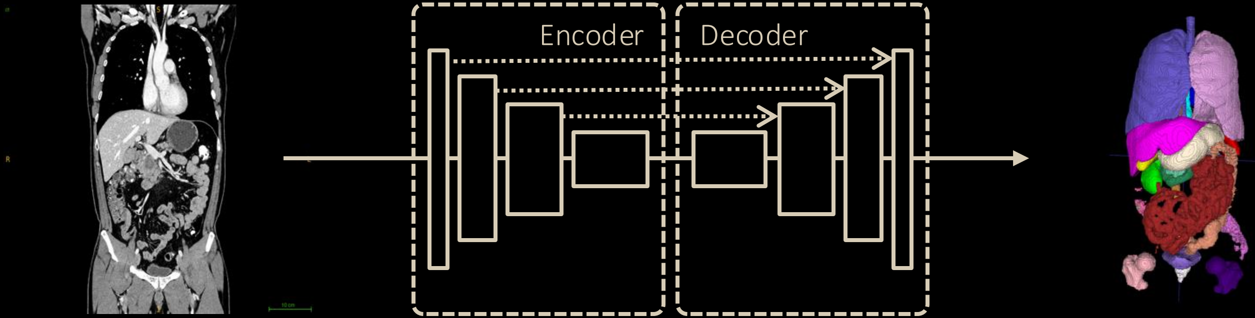
Rubiks Cube
[Zhuang et al., MICCAI 2019]

Swin UNETR
[Tang et al., CVPR 2022]

UniMiSS
[Xie et al., ECCV 2022]



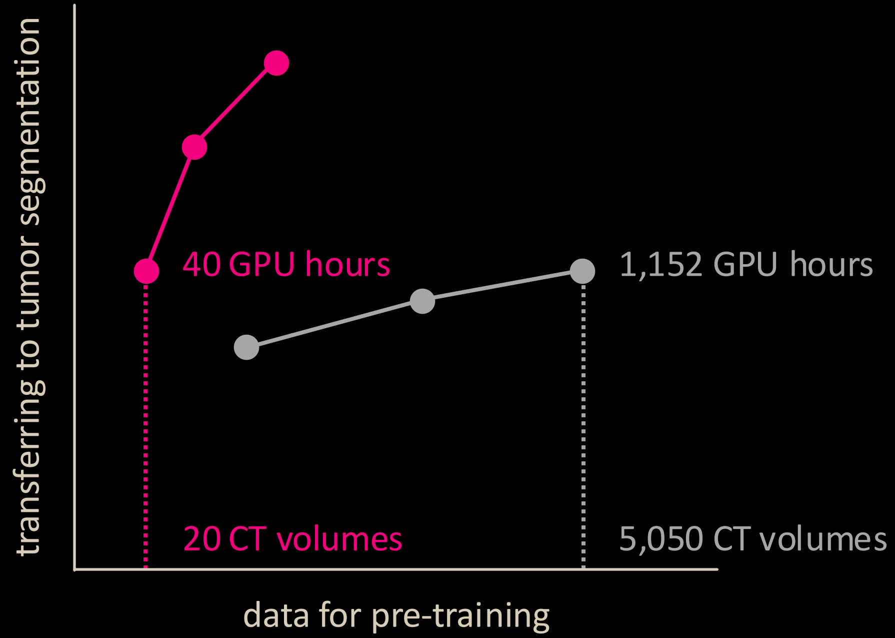
Option 1. Self-supervised pre-training



Option 2. Supervised pre-training

Supervised > **Self-supervised**

data & computation efficiency

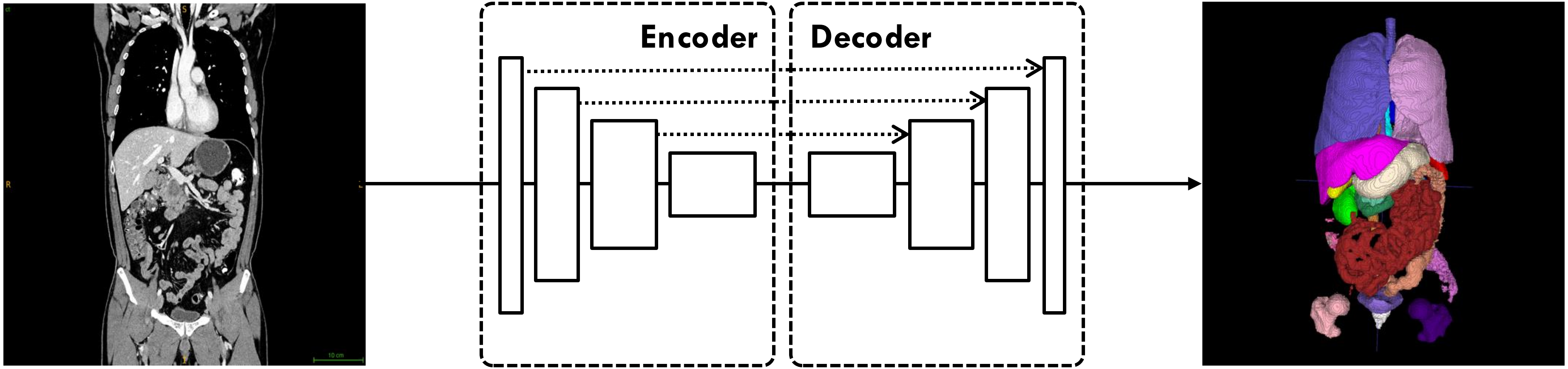


Foundation Models

AI models pre-trained on broad data and can be applied across tasks

Expensive?

“How Well Do Models Pre-Trained on 25K CT Volumes and 600K 3D Masks Transfer to Medical Imaging Tasks?”



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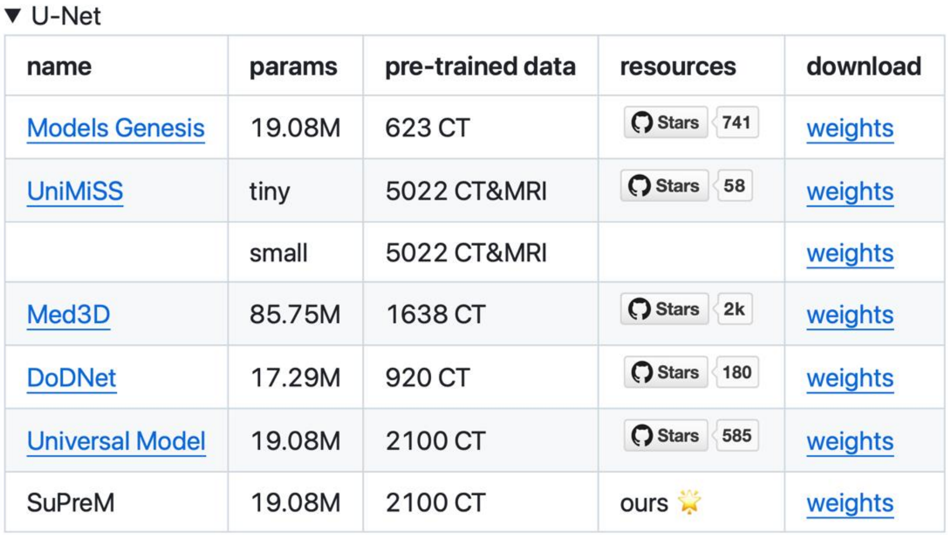
Code, Dataset, & Model:
https://www.zongweiz.com/dataset

Foundation Models

AI pre-trained on broad data and can be applied across tasks

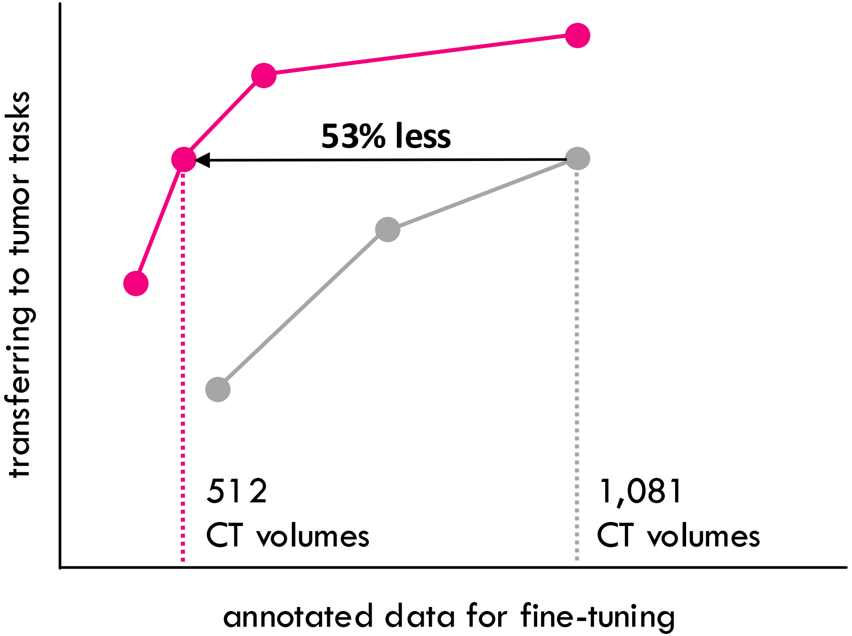


▼ U-Net

name	params	pre-trained data	resources	download
Models Genesis	19.08M	623 CT	Stars 741	weights
UniMiSS	tiny	5022 CT&MRI	Stars 58	weights
	small	5022 CT&MRI		weights
Med3D	85.75M	1638 CT	Stars 2k	weights
DoDNet	17.29M	920 CT	Stars 180	weights
Universal Model	19.08M	2100 CT	Stars 585	weights
SuPreM	19.08M	2100 CT	ours 🌟	weights

Supervised > Self-supervised

annotation & learning efficiency



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Touchstone

@MICCAI @ISBI Challenges

Backbone	Author	Institute	Publication	Backbone	Author	Institute	Publication
U-Net	O. Ronneberger	Uni Freiburg	MICCAI	nnU-Net	Fabian Isensee	DKFZ	Nat. Methods
nnFormer	Hong-Yu Zhou	HKU	TIP	SAT	Ziheng Zhao	SJTU	arXiv
CoTr	Yutong Xie	NPU	MICCAI	Swin UNETR	Ali Hatamizadeh	NVIDIA	MICCAIW
UniverSeg	Victor Ion Butoi	MIT	ICCV	UniSeg	Yiwen Ye	NPU	MICCAI
UNet++	Zongwei Zhou	ASU	TMI	MagicNet	Duowen Chen	ECNU	CVPR
TransUNet	Jieneng Chen	JHU	ICMLW	MedSegDiff	Junde Wu	NUS	AAAI
Swin-Unet	Hu Cao	Huawei	ECCVW	3D UNeXt	Jeya Maria Jose	JHU	MICCAI
DiNTS	Yufan He	JHU	CVPR	……			

So far, 53 groups have confirmed the contribution—we will invite more inventors of **famous backbones** for medical segmentation.

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Code, Dataset, & Model:
`https://www.zongweiz.com/dataset`

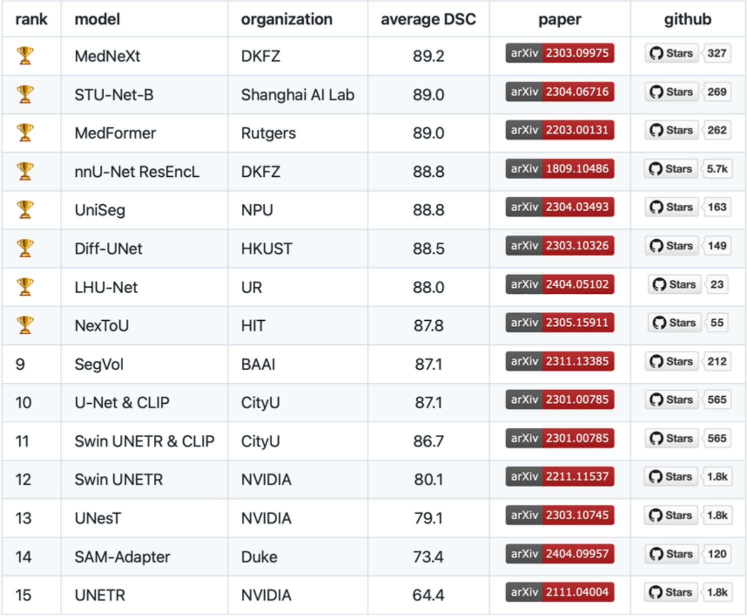
Touchstone Benchmark: Are We on the Right Way for Evaluating AI Algorithms for Medical Segmentation?

Pedro R. A. S. Bassi[1,2,3]* Wenxuan Li[1]* Yucheng Tang[4] Fabian Isensee[5,6]
Zifu Wang[7] Jieneng Chen[1] Yu-Cheng Chou[1] Saikat Roy[5,8] Yannick Kirchhoff[5,8,9]
Maximilian Rokuss[5,8] Ziyan Huang[10] Jin Ye[11] Junjun He[11] Tassilo Wald[5,6]
Constantin Ulrich[5] Michael Baumgartner[5,6] Klaus H. Maier-Hein[5,12] Paul Jaeger[6,13]
Yiwen Ye[14] Yutong Xie[15] Jianpeng Zhang[16] Ziyang Chen[14] Yong Xia[14]
Zhaohu Xing[17] Lei Zhu[17, 18] Yousef Sadegheih[19] Afshin Bozorgpour[19]
Pratibha Kumari[19] Reza Azad[20] Dorit Merhof[19,21] Pengcheng Shi[22]
Ting Ma[22] Yuxin Du[23] Fan Bai[23,24] Tiejun Huang[23,25] Bo Zhao[10,23]
Haonan Wang[18] Xiaomeng Li[18] Hanxue Gu[26] Haoyu Dong[26]
Jichen Yang[26] Maciej A. Mazurowski[26] Saumya Gupta[27] Linshan Wu[18]
Jiaxin Zhuang[18] Hao Chen[28] Holger Roth[4] Daguang Xu[4]
Matthew B. Blaschko[7] Sergio Decherchi[29] Andrea Cavalli[2,29,30]
Alan L. Yuille[1]† Zongwei Zhou[1]†

[1]Department of Computer Science, Johns Hopkins University
[2]Department of Pharmacy and Biotechnology, University of Bologna
[3]Center for Biomolecular Nanotechnologies, Istituto Italiano di Tecnologia
[4]NVIDIA
[5]Division of Medical Image Computing, German Cancer Research Center (DKFZ)
[6]Helmholtz Imaging, German Cancer Research Center (DKFZ)
Full affiliations are given in Appendix F.

`Code, Models & Data: https://github.com/MrGiovanni/Touchstone`

NEURAL INFORMATION PROCESSING SYSTEMS



rank	model	organization	average DSC	paper	github
🏆	MedNeXt	DKFZ	89.2	arXiv 2303.09975	Stars 327
🏆	STU-Net-B	Shanghai AI Lab	89.0	arXiv 2304.06716	Stars 269
🏆	MedFormer	Rutgers	89.0	arXiv 2203.00131	Stars 262
🏆	nnU-Net ResEncL	DKFZ	88.8	arXiv 1809.10486	Stars 5.7k
🏆	UniSeg	NPU	88.8	arXiv 2304.03493	Stars 163
🏆	Diff-UNet	HKUST	88.5	arXiv 2303.10326	Stars 149
🏆	LHU-Net	UR	88.0	arXiv 2404.05102	Stars 23
🏆	NexToU	HIT	87.8	arXiv 2305.15911	Stars 55
9	SegVol	BAAI	87.1	arXiv 2311.13385	Stars 212
10	U-Net & CLIP	CityU	87.1	arXiv 2301.00785	Stars 565
11	Swin UNETR & CLIP	CityU	86.7	arXiv 2301.00785	Stars 565
12	Swin UNETR	NVIDIA	80.1	arXiv 2211.11537	Stars 1.8k
13	UNesT	NVIDIA	79.1	arXiv 2303.10745	Stars 1.8k
14	SAM-Adapter	Duke	73.4	arXiv 2404.09957	Stars 120
15	UNETR	NVIDIA	64.4	arXiv 2111.04004	Stars 1.8k

NVIDIA

UCSF
University of California
San Francisco

NUS
National University
of Singapore

HEIDELBERG
UNIVERSITY
HOSPITAL

ALMA MATER STUDIORUM
UNIVERSITÀ DI BOLOGNA

JOHNS HOPKINS
UNIVERSITY

dkfz.

UNIVERSITY OF
ILLINOIS
URBANA-CHAMPAIGN

上海人工智能实验室
Shanghai Artificial Intelligence Laboratory

北京大學
PEKING UNIVERSITY

THE HONG KONG
UNIVERSITY OF SCIENCE
AND TECHNOLOGY

上海交通大學
SHANGHAI JIAO TONG UNIVERSITY

Duke
UNIVERSITY

香港中文大學
The Chinese University of Hong Kong

Fraunhofer
MEVIS

Stony Brook
University

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HELMHOLTZ
INFORMATION & DATA SCIENCE
SCHOOL FOR HEALTH

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HARBIN INSTITUTE OF TECHNOLOGY, SHENZHEN

西北工業大學
NORTHWESTERN POLYTECHNICAL UNIVERSITY

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UNIVERSITY

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TECNOLOGIA

THE UNIVERSITY
OF ADELAIDE
AUSTRALIA

UNIVERSITÄT
HEIDELBERG
ZUKUNFT
SEIT 1386

BAAI
智源研究院

EPFL
ÉCOLE POLYTECHNIQUE
FÉDÉRALE DE LAUSANNE

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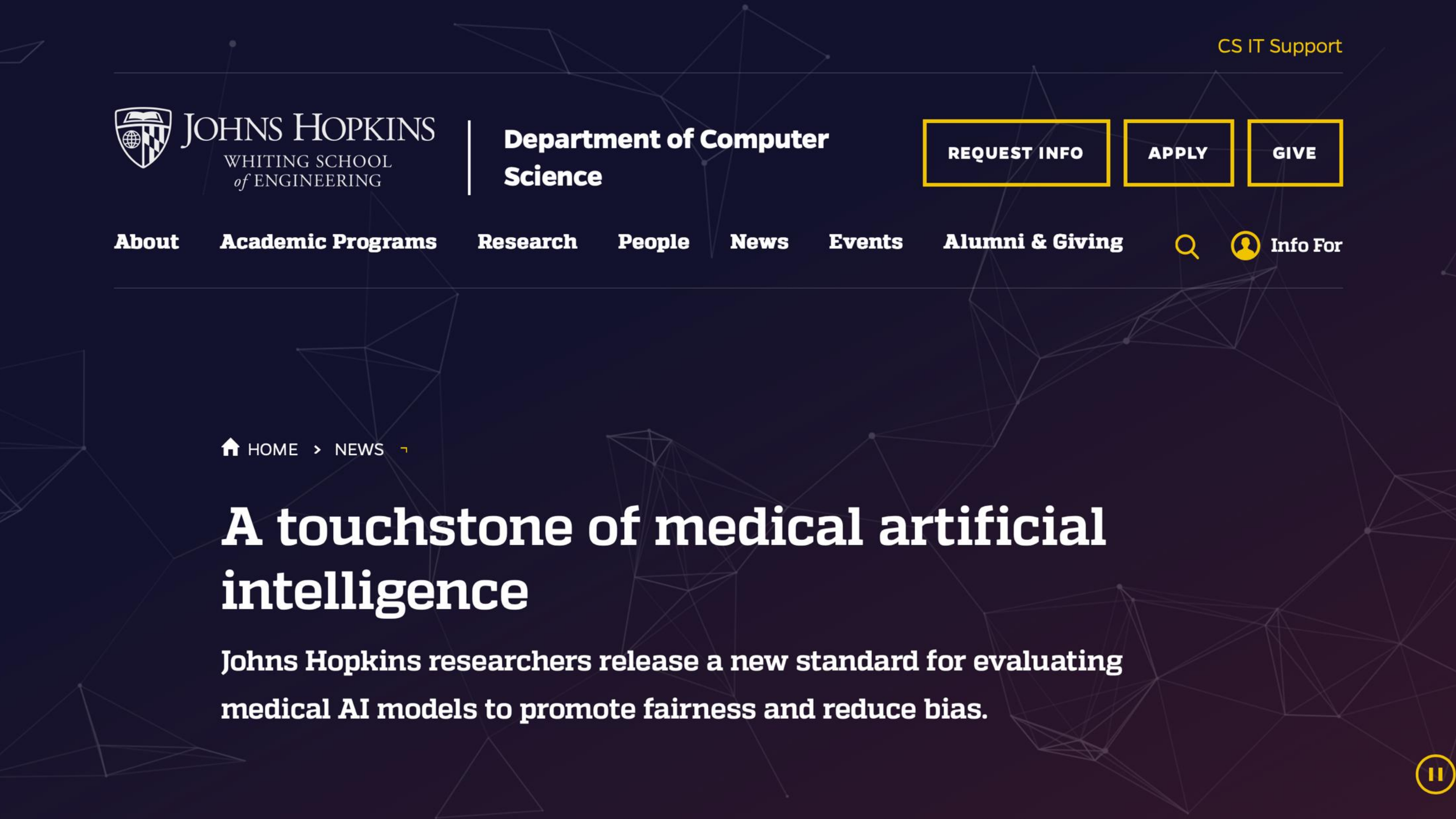
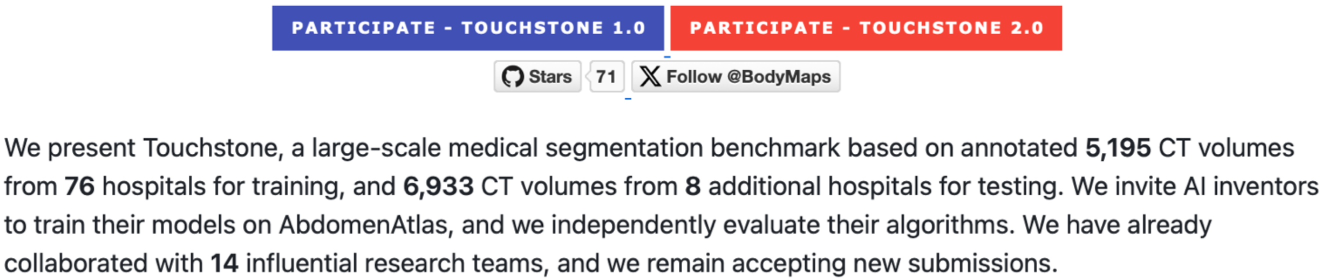
Code, Dataset, & Model:
`https://www.zongweiz.com/dataset`



A touchstone of medical artificial intelligence

Johns Hopkins researchers release a new standard for evaluating medical AI models to promote fairness and reduce bias.

Touchstone Benchmark



We present Touchstone, a large-scale medical segmentation benchmark based on annotated **5,195** CT volumes from **76** hospitals for training, and **6,933** CT volumes from **8** additional hospitals for testing. We invite AI inventors to train their models on AbdomenAtlas, and we independently evaluate their algorithms. We have already collaborated with **14** influential research teams, and we remain accepting new submissions.

The BodyMaps Project

- **AI-Integrated Annotation**
  - **ScaleMAI Platform**
    - Anatomical Segmentation
  - **Synthetic Data Engine**
    - Multi-lesion Segmentation
- **AI-Assisted Cancer Moonshot**
  - **Lesion Detection**
    - Human-level Detection
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    - Super-human Classification
  - **Treatment Planning**
    - Tumor Staging
- **AI-Trusted Benchmark**
  - **Foundation Models**
    - Supervised Pre-Trained Models
  - **Universal Models**
    - Generalists vs. Specialists

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`zzhou82@jh.edu`

Code, Dataset, & Model:
`https://www.zongweiz.com/dataset`

AbdomenAtlasPro = 25K CT Volumes + 600K 3D Masks

AbdomenAtlas1.1 = 9K CT Volumes + 225K 3D Masks

AbdomenAtlas1.0 = 5K CT Volumes + 45K 3D Masks

BodyMaps
36 posts

BodyMaps
@bodymaps317 Follows you

Joined May 2024

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Code, Dataset, & Model:
https://www.zongweiz.com/dataset

AbdomenAtlasPro = 25K CT Volumes + 600K 3D Masks

AbdomenAtlas1.1 = 9K CT Volumes + 225K 3D Masks

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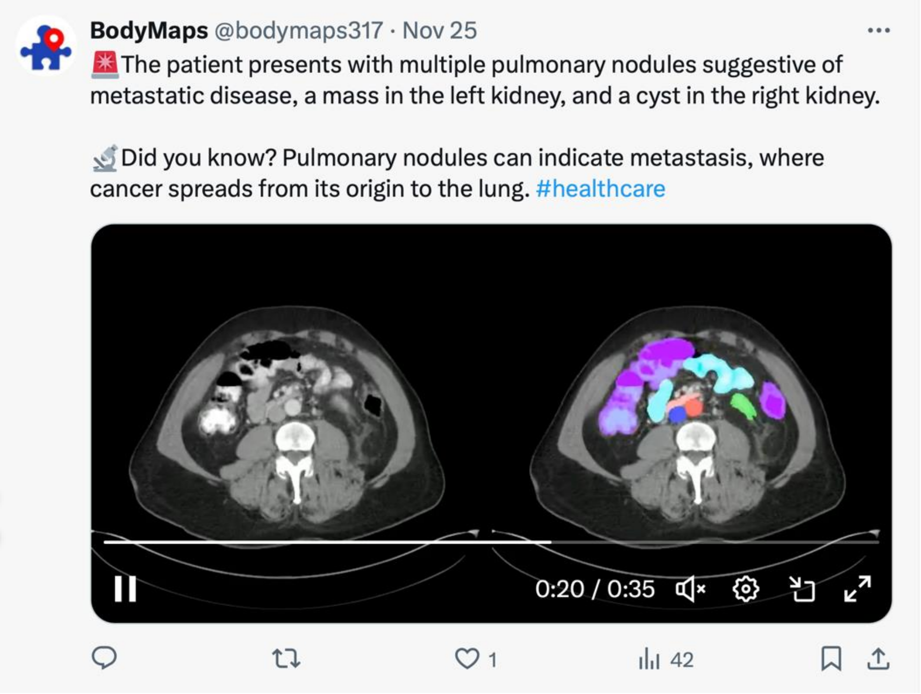

BodyMaps @bodymaps317 · Nov 25

🚨The patient presents with multiple pulmonary nodules suggestive of metastatic disease, a mass in the left kidney, and a cyst in the right kidney.

🔬Did you know? Pulmonary nodules can indicate metastasis, where cancer spreads from its origin to the lung. #healthcare

Zongwei Zhou
`zzhou82@jh.edu`

Code, Dataset, & Model:
`https://www.zongweiz.com/dataset`

Abdomer D Masks

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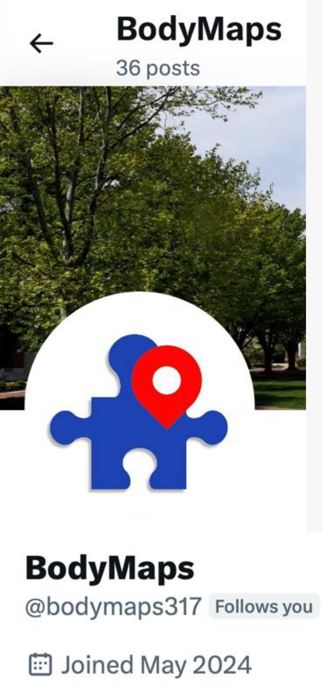

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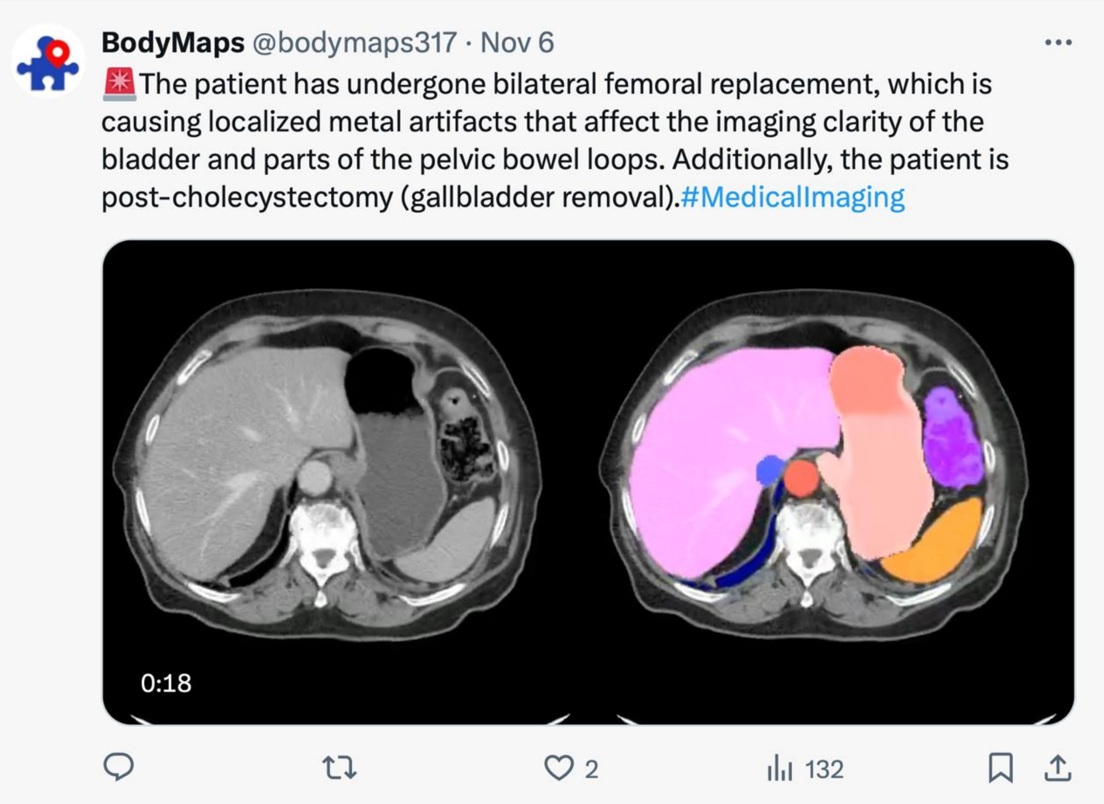
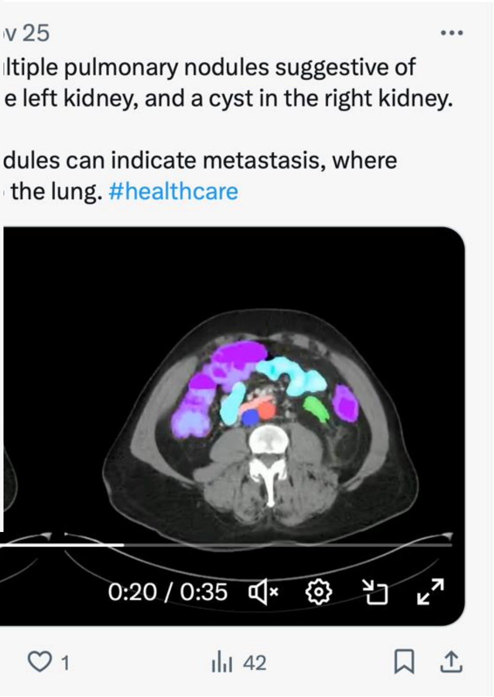


BodyMaps @bodymaps317 · Nov 6

🚨The patient has undergone bilateral femoral replacement, which is causing localized metal artifacts that affect the imaging clarity of the bladder and parts of the pelvic bowel loops. Additionally, the patient is post-cholecystectomy (gallbladder removal).#MedicalImaging



v 25

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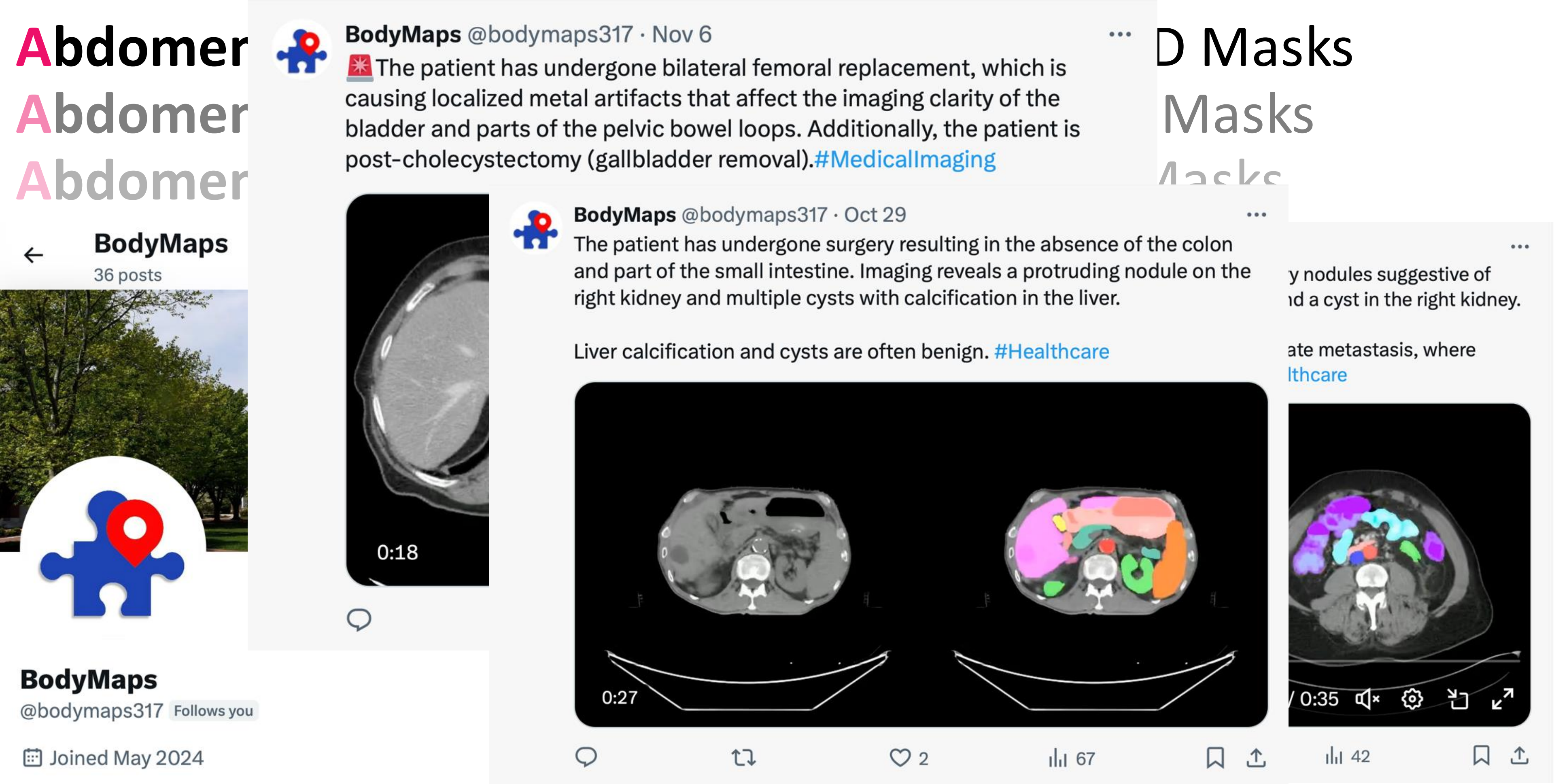
Abdomer D Masks

Abdomer Masks

Abdomer Masks



BodyMaps
36 posts

BodyMaps
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Joined May 2024

BodyMaps @bodymaps317 · Nov 6

🚨The patient has undergone bilateral femoral replacement, which is causing localized metal artifacts that affect the imaging clarity of the bladder and parts of the pelvic bowel loops. Additionally, the patient is post-cholecystectomy (gallbladder removal).#MedicalImaging

BodyMaps @bodymaps317 · Oct 29

The patient has undergone surgery resulting in the absence of the colon and part of the small intestine. Imaging reveals a protruding nodule on the right kidney and multiple cysts with calcification in the liver.

Liver calcification and cysts are often benign. #Healthcare

y nodules suggestive of
nd a cyst in the right kidney.

ate metastasis, where
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Zongwei Zhou
zzhou82@jh.edu

Code, Dataset, & Model:
https://www.zongweiz.com/dataset

Abdomen
Abdomen
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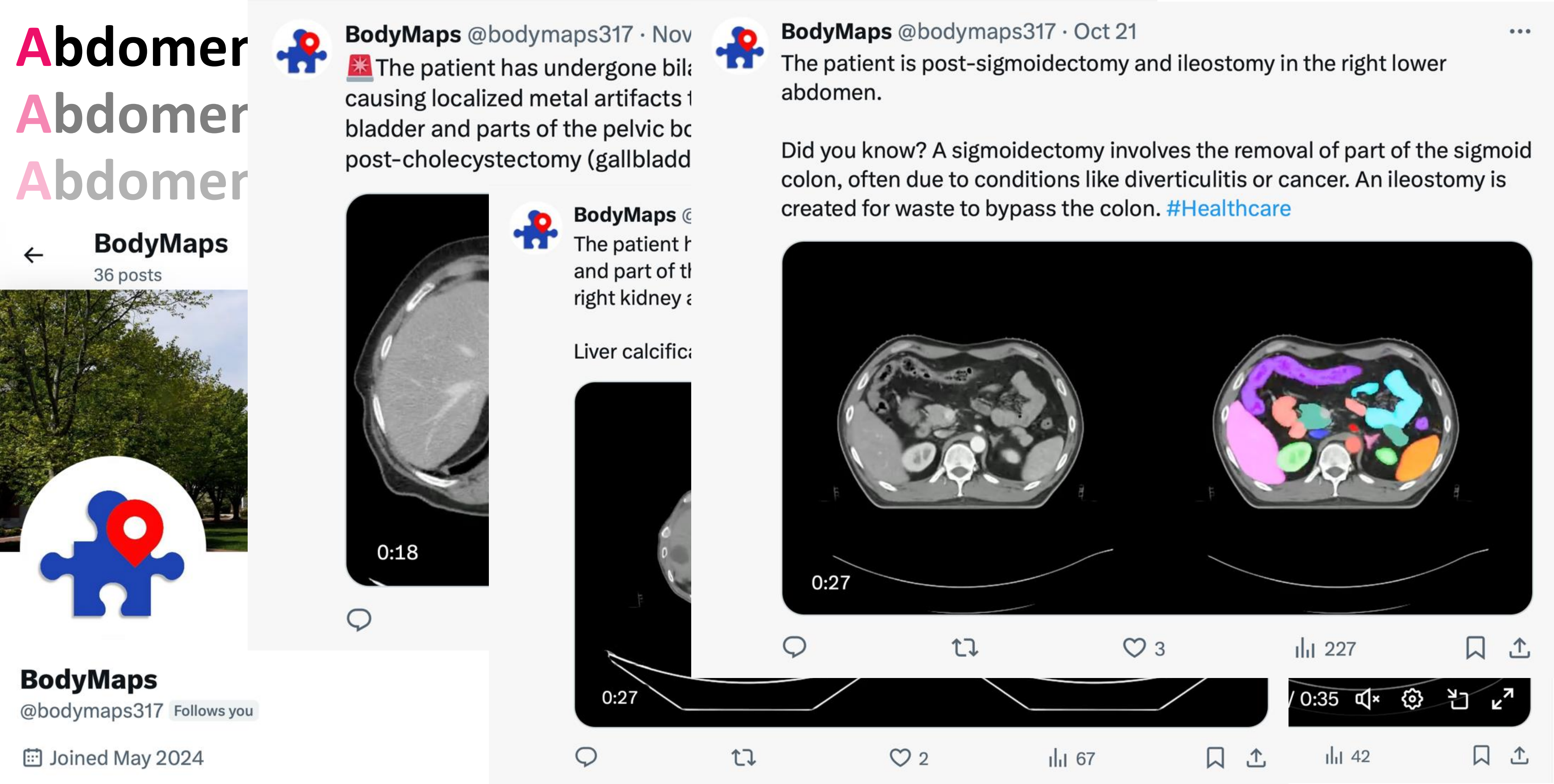

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Joined May 2024

BodyMaps @bodymaps317 · Nov
🚨The patient has undergone bila
causing localized metal artifacts t
bladder and parts of the pelvic bo
post-cholecystectomy (gallbladd

BodyMaps @
The patient h
and part of th
right kidney a

Liver calcifica

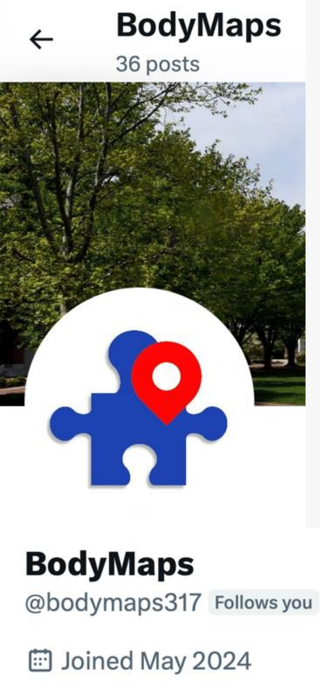
BodyMaps @bodymaps317 · Oct 21
The patient is post-sigmoidectomy and ileostomy in the right lower abdomen.

Did you know? A sigmoidectomy involves the removal of part of the sigmoid colon, often due to conditions like diverticulitis or cancer. An ileostomy is created for waste to bypass the colon. #Healthcare

Zongwei Zhou
zzhou82@jh.edu

Code, Dataset, & Model:
https://www.zongweiz.com/dataset

Abdome
Abdome
Abdome



←

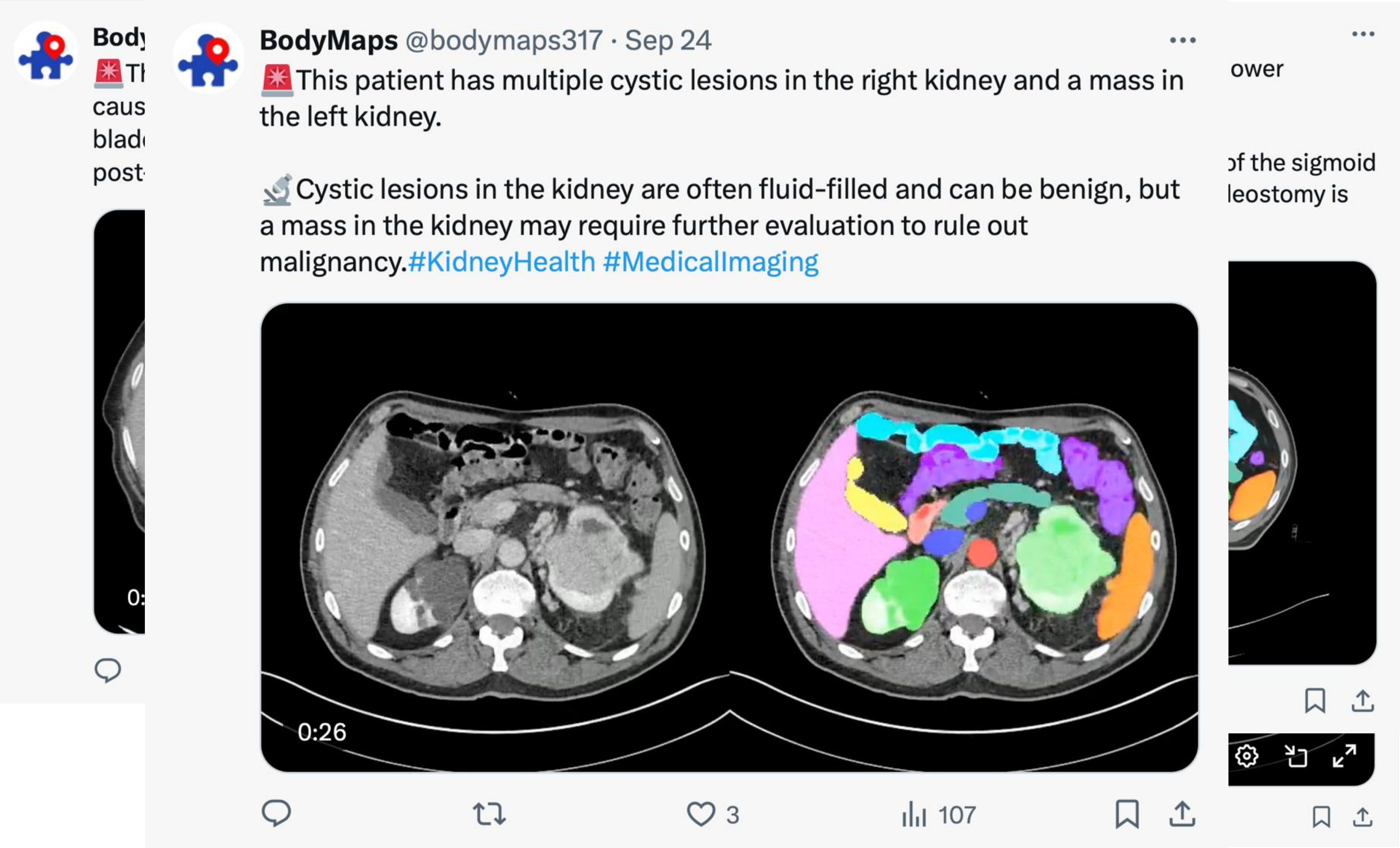
BodyMaps

36 posts

BodyMaps

@bodymaps317 Follows you

Joined May 2024



Body

🚨Th

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BodyMaps @bodymaps317 · Sep 24

🚨This patient has multiple cystic lesions in the right kidney and a mass in the left kidney.

🔬Cystic lesions in the kidney are often fluid-filled and can be benign, but a mass in the kidney may require further evaluation to rule out malignancy.#KidneyHealth #MedicalImaging

0:26

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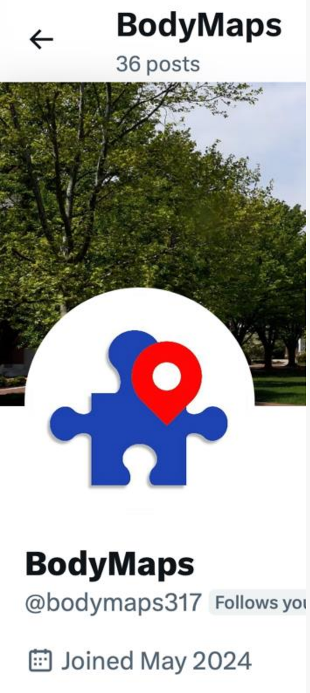


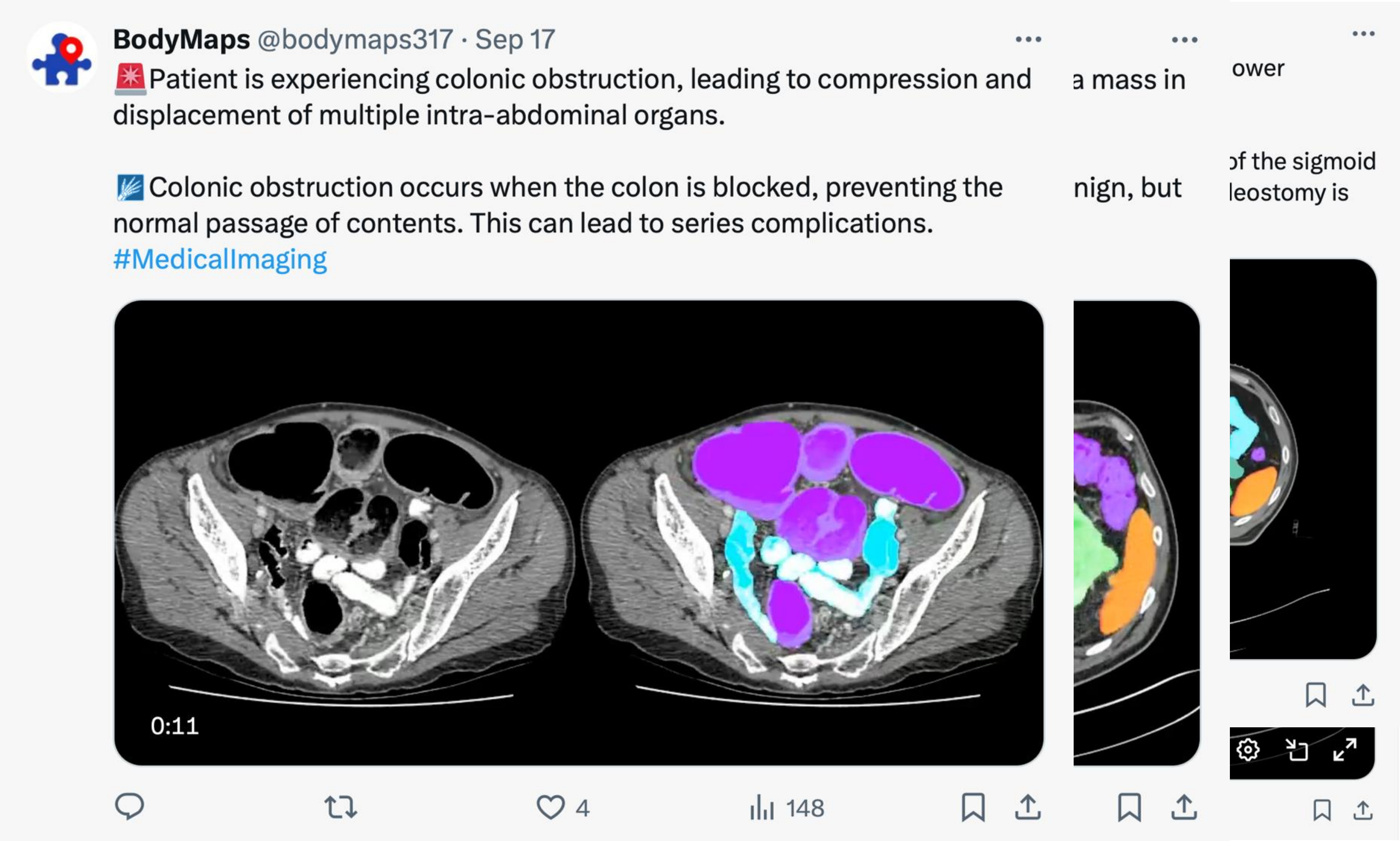
BodyMaps

36 posts

BodyMaps

@bodymaps317 Follows you

Joined May 2024



BodyMaps @bodymaps317 · Sep 17

🚨Patient is experiencing colonic obstruction, leading to compression and displacement of multiple intra-abdominal organs.

🌠Colonic obstruction occurs when the colon is blocked, preventing the normal passage of contents. This can lead to series complications. #MedicalImaging

a mass in

nign, but

ower

of the sigmoid
leostomy is

Zongwei Zhou
`zzhou82@jh.edu`

Code, Dataset, & Model:
`https://www.zongweiz.com/dataset`

Thank you!

Acknowledgement: Wenxuan Li · Pedro R. A. S. Bassi · Qi Chen · Chongyu Qu · Xiaoxi Chen · Kang Wang · Yang Yang · Tiezheng Zhang · Hualin Qiao · Jessica Han · Jie Liu · Yucheng Tang · Yijia Shi · Lihua Gao · Wenlan Zhou · Guiqin Zhang · Damin Li · Yixiao Zhang · Jieneng Chen · Linda Chu · Satomi · Kawamoto · Seyoun Park · Christopher Wolfgang · Ammar Javed · Daniel Fadaei · Shahab Shayesteh · Jefferson Graves · Alejandra Blanco · Eva S. Zinreich · Benedict Kinny-Köster · Kenneth Kinzler · Ralph H. Hruban · Bert Vogelstein · Elliot K. Fishman · Jaimie Patterson · Junfei Xiao · Yongyi Lu · Xinyi Li · Huimiao Chen · Yaoyao Liu · Jianning Li · Yu-Cheng Chou · Angtian Wang · Yixiong Chen · Yuxiang Lai · Jincheng Wang · Huimin Xue · Yining Cao · Haoqi Han · Xiaorui Lin · Yutong Tang · Meihua Li · Yujiu Ma · Jinghui Xu · Jiawei Liu · Zheyuan Zhang