AbdomenAtlas 3.0

A Large-Scale Dataset with CT, Masks & Reports

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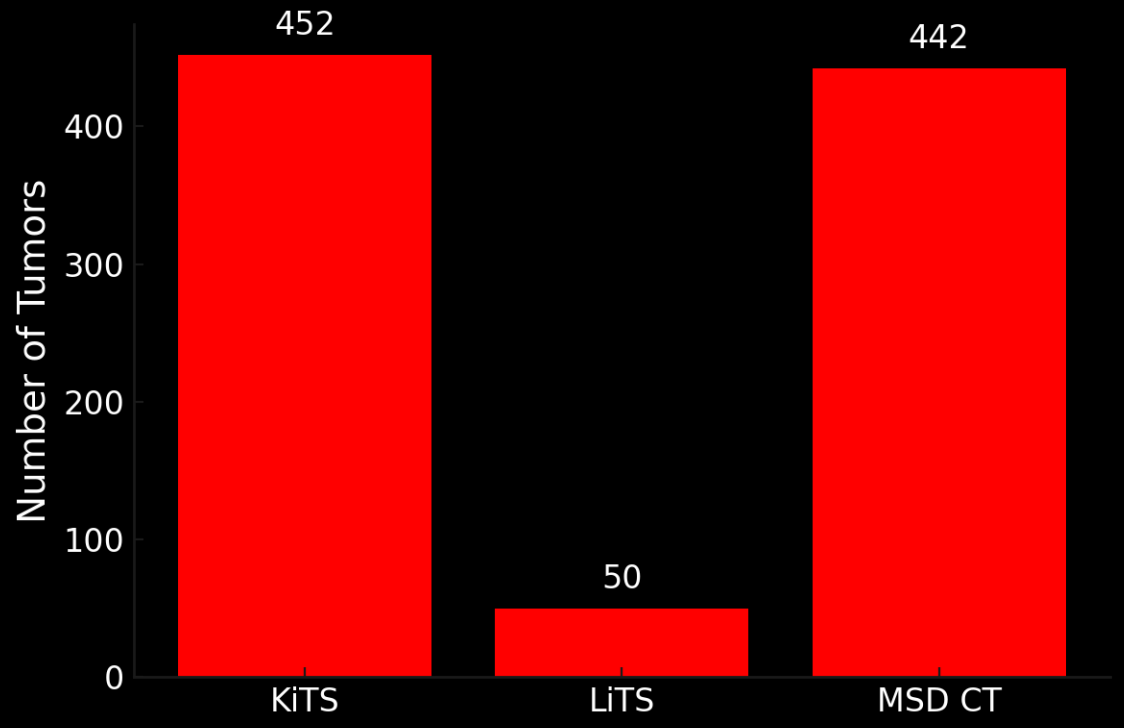
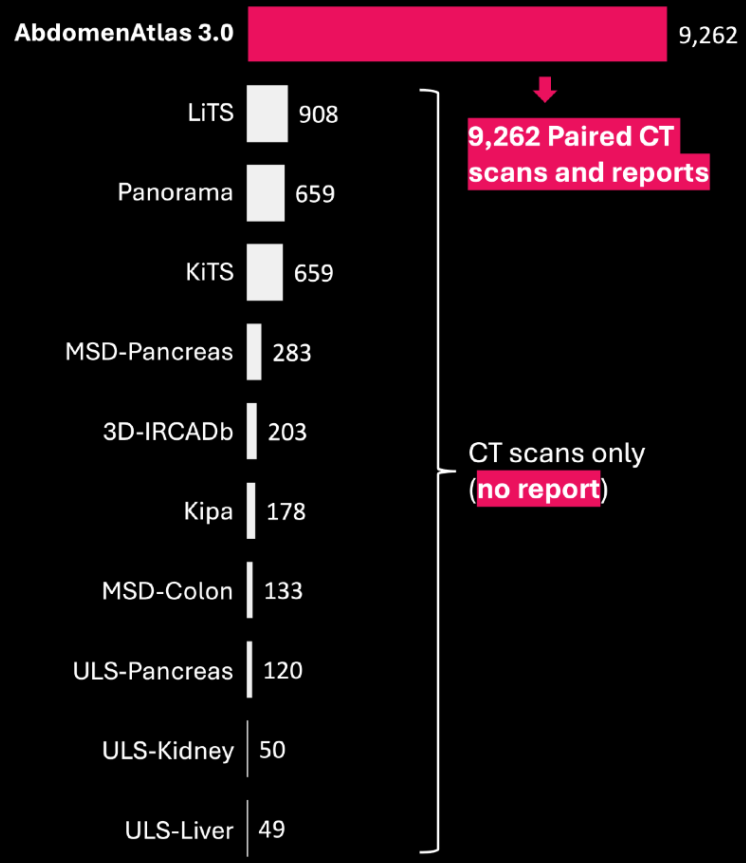
The Data Problem

- Public Abdominal CT datasets: few hundred tumor masks
- Zero reports
- Few VLMs: Merlin (private data) & M3D (jpg/png images & captions from the web)



AbdomenAtlas 3.0
3K Tumor
CTs, Reports, Masks

- 9,262 structured | 9,262 narrative reports | 240 enhanced reports
- 9,262 CT scans from 138 institutions — 1.8 million tokens
- 8,562 tumor instances — 5,262 small tumor (<20mm)
- 3 pancreatic sub-segments — 8 hepatic sub-segments
- per-voxel annotated veins, sma, celiac AA — 4 pancreatic tumor stages



An overview of public tumor datasets

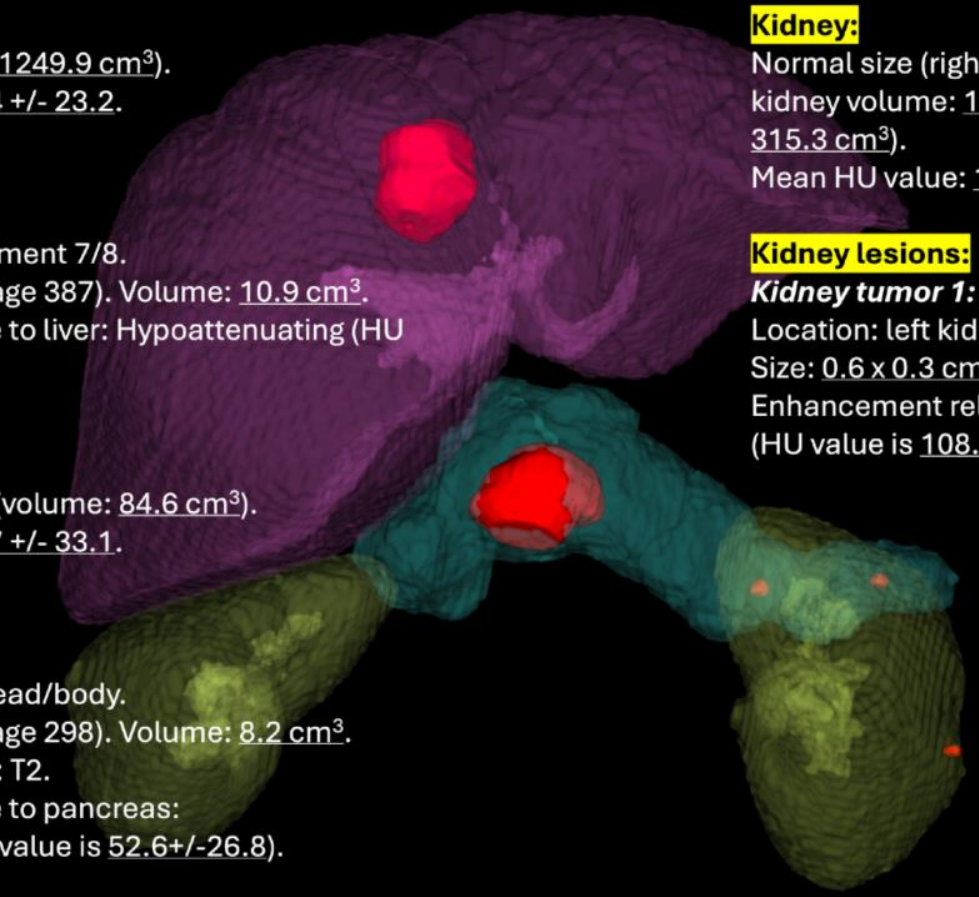
AbdomenAtlas 3.0
Tumor-focused Structured Report

Liver:
Normal size (volume: 1249.9 cm^3).
Mean HU value: 131.4 +/- 23.2.

Liver lesions:
Liver tumor 1:
Location: hepatic segment 7/8.
Size: 3.1 x 2.7 cm (image 387). Volume: 10.9 cm^3.
Enhancement relative to liver: Hypoattenuating (HU value is 58.7+/-29.7).

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).



Kidney:
Normal size (right kidney volume: 148.6 cm^3; left kidney volume: 166.6 cm^3; total kidney volume: 315.3 cm^3).
Mean HU value: 172.9 +/- 57.4.

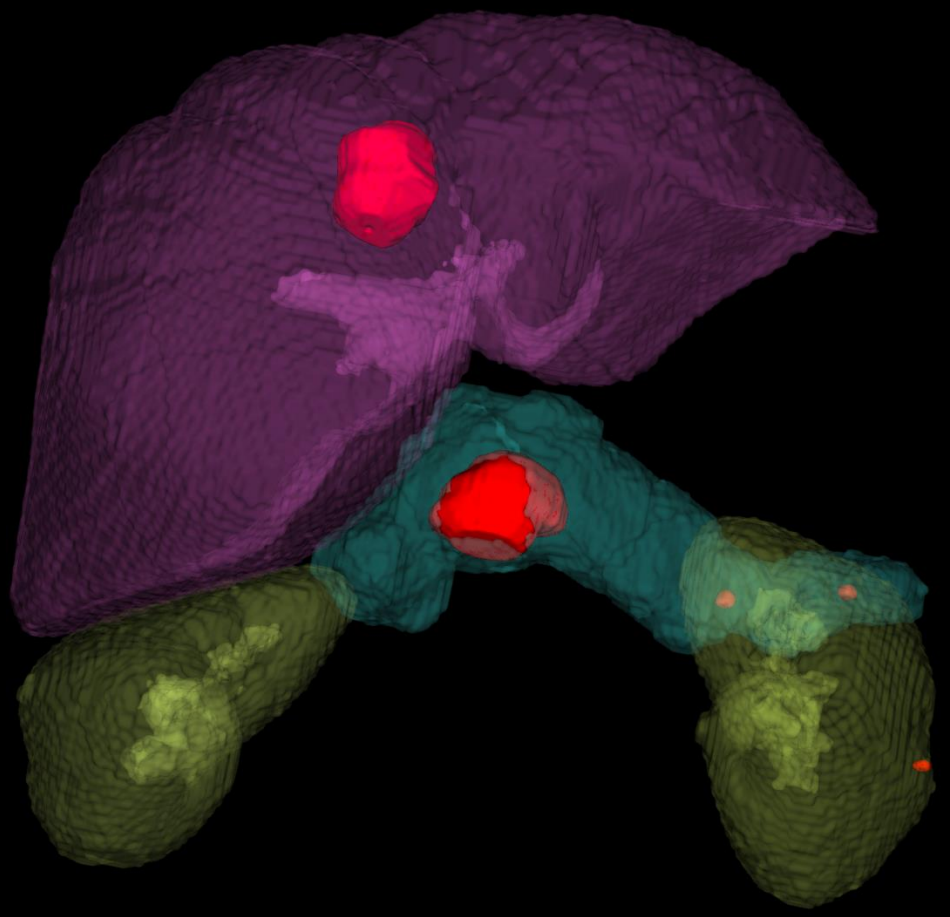
Kidney lesions:
Kidney tumor 1:
Location: left kidney.
Size: 0.6 x 0.3 cm (image 321). Volume: 0.1 cm^3.
Enhancement relative to kidney: Hypoattenuating (HU value is 108.5+/-49.1).

Kidney tumor 2:
Location: left kidney.
Size: 0.5 x 0.4 cm (image 321). Volume: 0.1 cm^3.
Enhancement relative to kidney: Hypoattenuating (HU value is 97.8+/-54.5).

Kidney tumor 3:
Location: left kidney.
Size: 0.6 x 0.4 cm (image 283). Volume: 0.1 cm^3.
Enhancement relative to kidney: Hypoattenuating (HU value is 49.5+/-48.4).

Advantages:
- Standard terminology
- Easy understanding across institutions
- Completeness
- Better medical decisions

AbdomenAtlas 3.0 Narrative Report



Narrative Reports (Section 3.2)

The patient has a hypoattenuating liver mass located in hepatic segments 7 and 8, measuring 3.1 x 2.7 cm (slice 387) with a volume of 10.9 cm^3. The liver itself is of normal size, with a volume of 1249.9 cm^3 and a mean HU value of 131.4 +/- 23.2. The pancreas is enlarged, ...

IMPRESSION:

1. A hypoattenuating liver mass located in hepatic segments 7 and 8, measuring 3.1 x 2.7 cm.
2. A hypoattenuating pancreas mass located in the head and body, measuring 2.9 x 2.2 cm, classified as T2.
3. Multiple small hypoattenuating kidney masses, with the largest one measuring 0.6 x 0.3 cm.

Advantages:

- Adaptation to standard of individual institutions
- Wider applicability

AbdomenAtlas 3.0
Creation: Data & Masks

dataset	CTs	institutions	countries	annotated liver tumors	annotated pancreatic tumors	annotated kidney tumors
FLARE'23 [2022] [link]	4,100	35	1	0 → 376	0 → 34	0 → 763
KiTS'23 [2020] [link]	489	1	1	0 → 1	0	452
LiTS [2019] [link]	131	7	5	50	0	0
TCIA-Pancreas-CT [2015] [link]	42	1	1	0	0	0
CT-ORG [2020] [link]	140	8	6	0 → 41	0	0 → 17
Trauma Det. [2023] [link]	4,714	23	13	0 → 46	0 → 15	0 → 38
BTCV [2015] [link]	47	1	1	0	0	0
CHAOS [2018] [link]	20	1	1	0	0 → 1	0
AbdomenCT-1K [2021] [link]	1,050	12	7	0 → 82	0 → 100	0 → 113
MSD CT Tasks (6) [2021] [link]	945	1	1	251	191	0 → 224
WORD [2021] [link]	120	1	1	0 → 28	0	0 → 26
AMOS [2022] [link]	200	2	1	0 → 54	0 → 3	0 → 41
AbdomenAtlas 3.0 (ours)	**9,262**	**138**	**19**	**301 → 929**	**191 → 344**	**452 → 1,674**

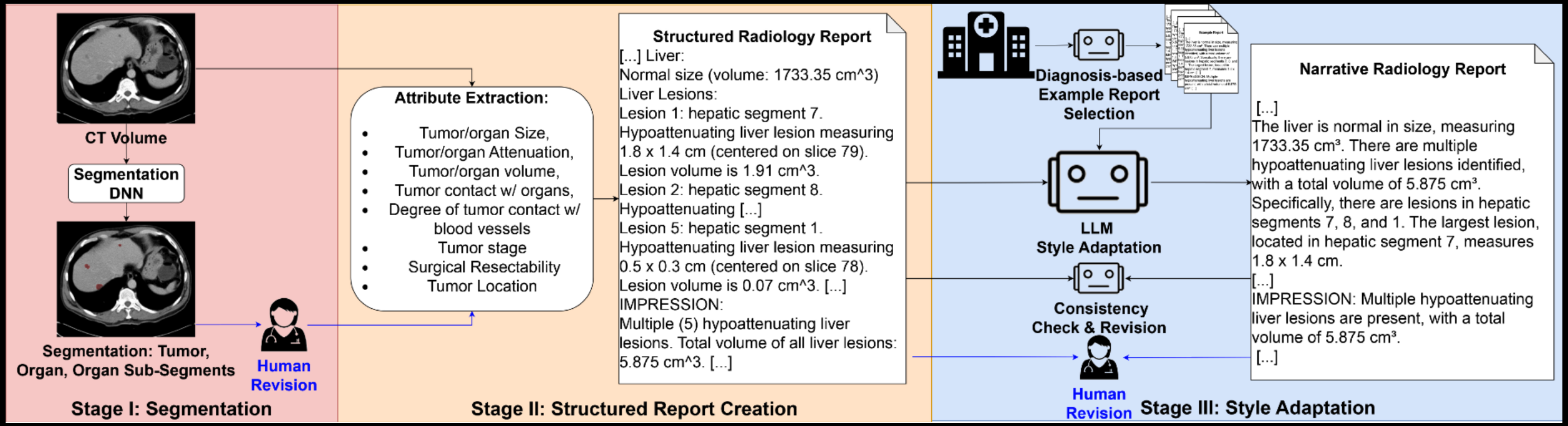
- **3.12x** more tumor annotations
- Public

AbdomenAtlas 3.0
Creation: Data & Masks

dataset	liver sub-segments	pancreas sub-segments	peripancreatic blood vessels[1]	tumor stage	radiology reports	text tokens
FLARE'23 [2022] [link]	✗	✗	✗	✗	0	0
KiTS'23 [2020] [link]	✗	✗	✗	✗	0	0
LiTS [2019] [link]	✔	✗	✗	✗	0	0
TCIA-Pancreas-CT [2015] [link]	✗	✗	✗	✗	0	0
CT-ORG [2020] [link]	✗	✗	✗	✗	0	0
Trauma Det. [2023] [link]	✗	✗	✗	✗	0	0
BTCV [2015] [link]	✗	✗	✗	✗	0	0
CHAOS [2018] [link]	✗	✗	✗	✗	0	0
AbdomenCT-1K [2021] [link]	✗	✗	✗	✗	0	0
MSD CT Tasks (6) [2021] [link]	✗	✗	✗	✗	0	0
WORD [2021] [link]	✗	✗	✗	✗	0	0
AMOS [2022] [link]	✗	✗	✗	✗	0	0
AbdomenAtlas 3.0 (ours)	✔	✔	✔	✔	**18,524**	**1,843,262**

-Uniqueness: pancreas **sub-segments**, PDAC **staging**, **reports**

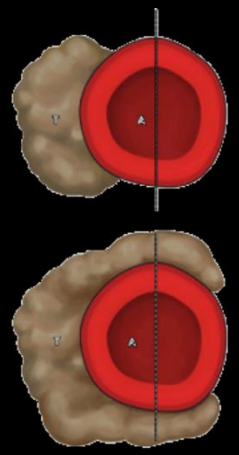
AbdomenAtlas 3.0
Creation: RadGPT

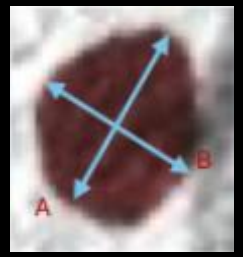


RadGPT: Deterministic Feature Extraction

- Measuring tumors like radiologists
- Staging pancreatic cancer

if `max_contact` for {SMA, CA, CHA} $\geq$ 180 **then**
    Stage = T4
else
    Determine stage by tumor size: T1a $\leq$ 0.5cm, T1b 0.5–1cm, T1c 1–2cm, T2 2–4cm, T3 $>$ 4cm
end if





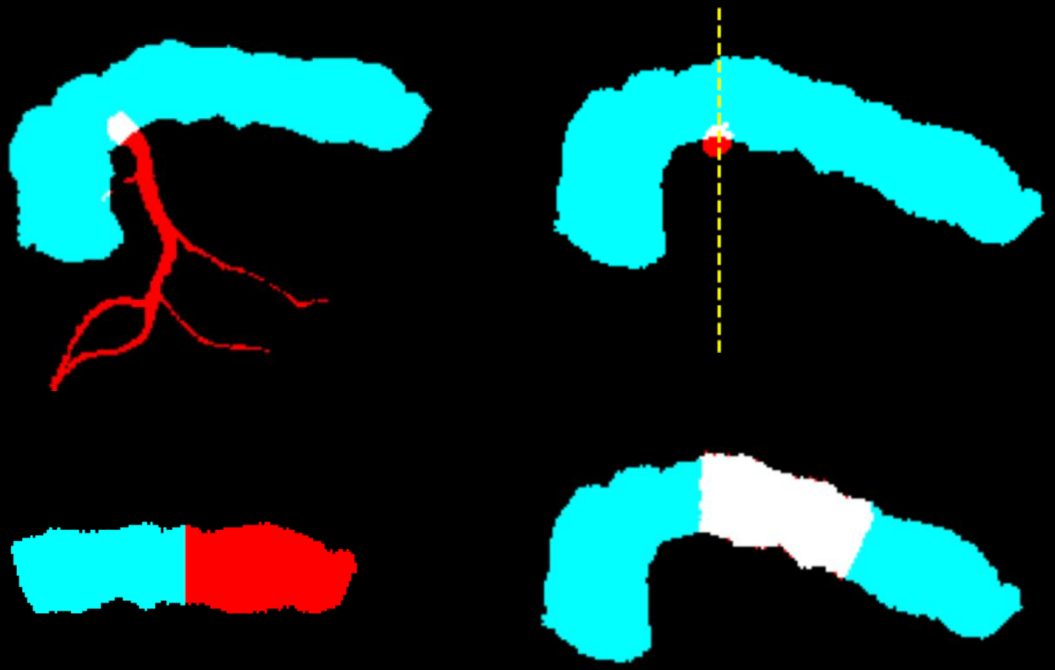
RadGPT: PDAC T Staging

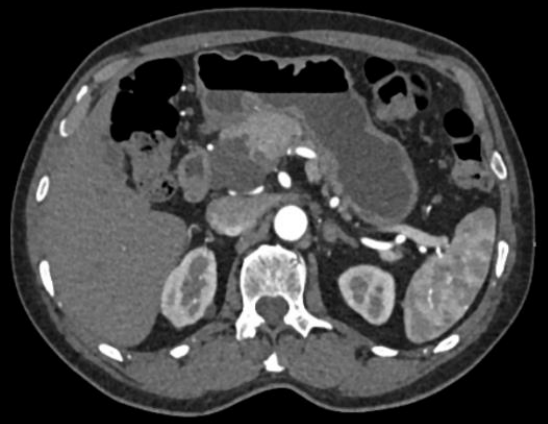
RadGPT Radiology Report

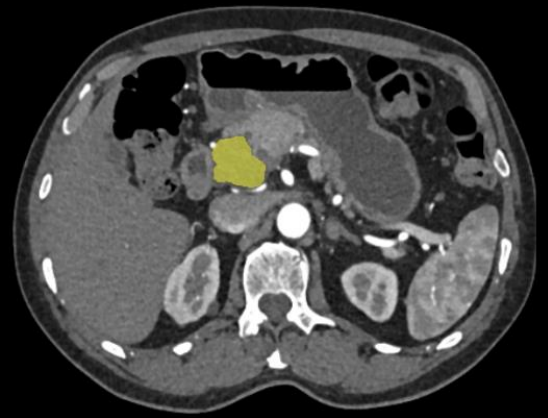
CT Arterial Phase
FINDINGS:
Liver:
Normal size (volume: 1860.0 cm^3).
Mean HU value: 8.6 +/- 28.3.
Pancreas:
Pancreas is enlarged (volume: 94.6 cm^3).
Mean HU value: 64.3 +/- 64.0.
Pancreas lesions:
Pancreas tumor 1: appearance consistent with PDAC.
Location: pancreas head/body.
Size: 5.1 x 3.2 cm (image 348). Volume: 29.0 cm^3.
Enhancement relative to pancreas: Hypoattenuating (HU value is 56.1+/-46.4).
Contact with adjacent organs: duodenum.
Vascular Involvement:
SMA: tumor encasement (360 degree contact with the tumor).
Aorta: tumor contact but not encasement (98 degree contact with the tumor).
Portal vein and SMV: tumor encasement (255 degree contact with the tumor).
IVC: tumor contact but not encasement (56 degree contact with the tumor).
Tumor does not contact: CA, CHA, SA.
Tumor Stage (T stage): T4.
Surgical resectability: unresectable (SMA encasement).
Kidney:
Normal size (right kidney volume: 143.3 cm^3; left kidney volume: 156.8 cm^3; total kidney volume: 300.1 cm^3).
Mean HU value: 139.7 +/- 70.1.
Spleen:
Spleen is enlarged (volume: 327.1 cm^3).
Mean HU value: 118.4 +/- 44.5.
IMPRESSION:
A single large hypoattenuating pancreas (head/body) mass (5.1 x 3.2, cm).
Clinical stage: T4NxMx.
Surgical resectability: unresectable (SMA encasement).

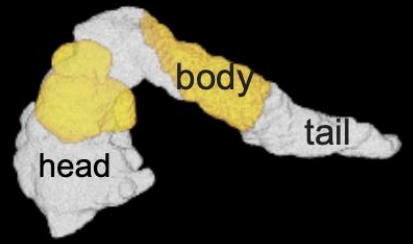
RadGPT: Pancreas Sub-Segments

- Pancreas Sub-segmentation: SMA-based









RadGPT Radiology Report

CT Arterial Phase

FINDINGS:

Liver:

Normal size (volume: 976.0 cm^3).

Mean HU value: 64.3 +/- 25.2.

Pancreas:

Pancreas is enlarged (volume: 89.3 cm^3).

Mean HU value: 109.3 +/- 64.8.

Pancreas lesions:

Pancreas tumor 1: appearance consistent with cyst.

Location: pancreas head.

Size: 3.8 x 2.5 cm (image 232). Volume: 17.4 cm^3.

Enhancement relative to pancreas: Hypoattenuating (HU value is 15.0+/-19.6).

Kidney:

Normal size (right kidney volume: 125.7 cm^3; left kidney volume: 156.2 cm^3; total kidney volume: 281.9 cm^3).

Mean HU value: 135.0 +/- 93.9.

Spleen:

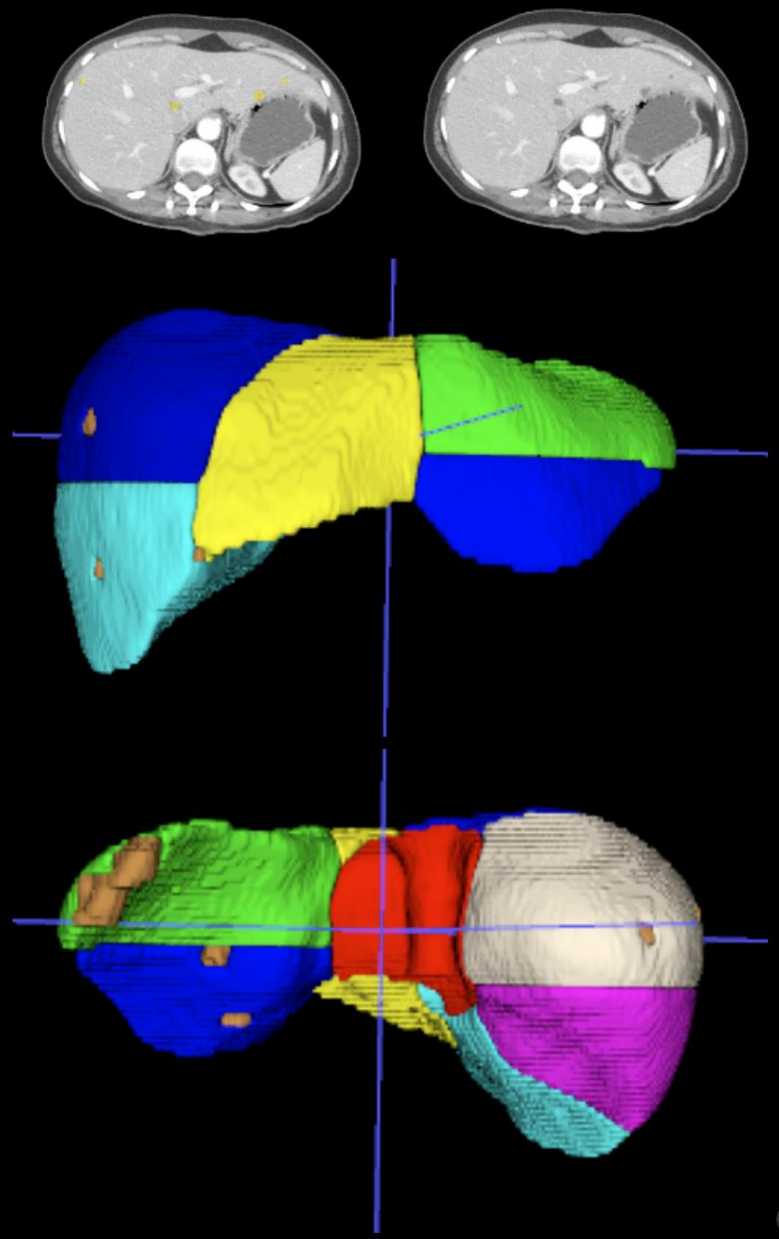
Normal size (volume: 115.2 cm^3).

Mean HU value: 128.8 +/- 43.7.

IMPRESSION:

A single hypoattenuating pancreas (head) mass of cystic appearance (3.8 x 2.5 cm).

RadGPT : Liver Sub-Segments



RadGPT Radiology Report

CT Arterial Phase

FINDINGS:
Liver:
Normal size (volume: 1293.7 cm^3).
Mean HU value: 111.3 +/- 17.4.

Liver lesions:
Liver tumor 1:
Location: hepatic segment 2.
Size: 3.2 x 1.7 cm (image 174). Volume: 8.1 cm^3.
Enhancement relative to liver: Hypoattenuating (HU value is 9.6+/-19.8).

Liver tumor 2:
Location: hepatic segment 8.
Size: 2.5 x 2.0 cm (image 178). Volume: 4.9 cm^3.
Enhancement relative to liver: Hypoattenuating (HU value is 36.3+/-31.3).

Liver tumor 3:
Location: hepatic segment 8.
Size: 1.4 x 0.9 cm (image 170). Volume: 0.7 cm^3.
Enhancement relative to liver: Hypoattenuating (HU value is 58.5+/-28.6).

[...]

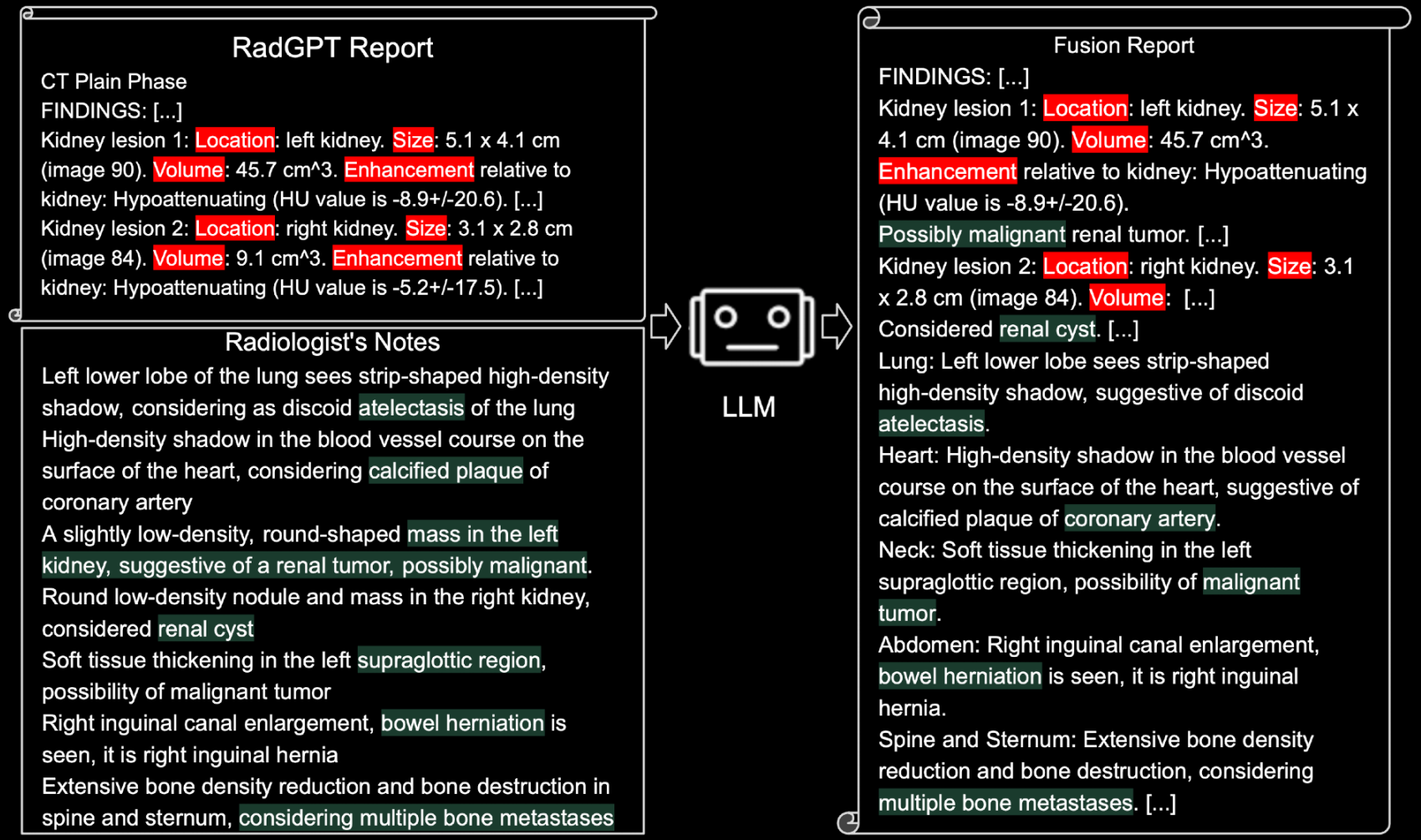
Liver tumor 23:
Location: hepatic segment 4.
Size: 0.5 x 0.4 cm (image 159). Volume: 0.1 cm^3.
Enhancement relative to liver: Hypoattenuating (HU value is 96.4+/-11.8).

Liver tumor 24:
Location: hepatic segment 5.
Size: 0.5 x 0.4 cm (image 156). Volume: 0.1 cm^3.
Enhancement relative to liver: Hypoattenuating (HU value is 97.2+/-16.9).

[...]

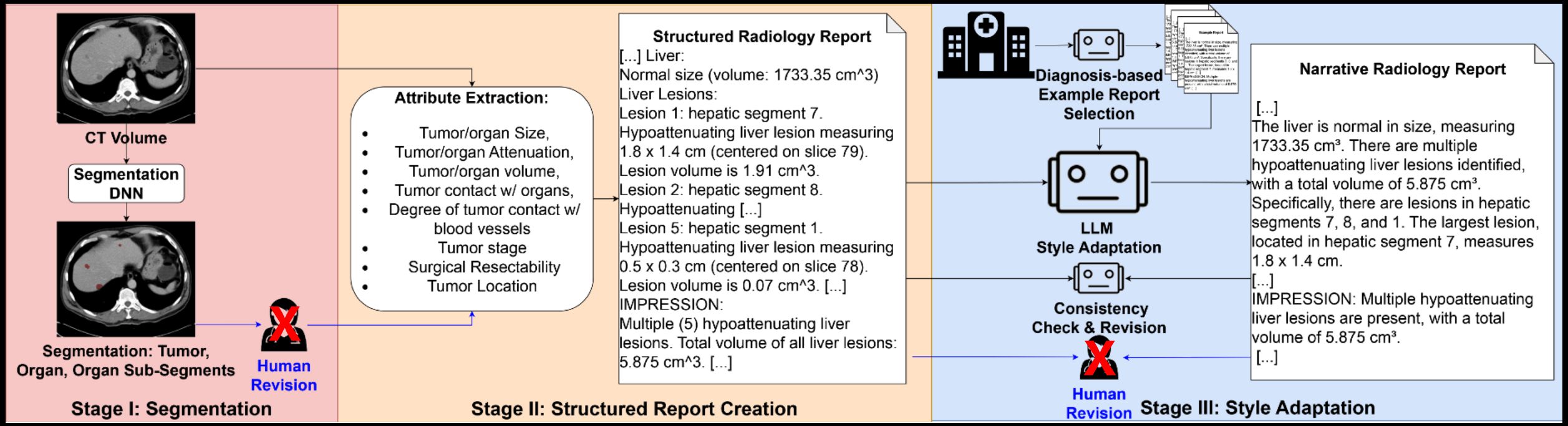
IMPRESSION:
Multiple (24) hypoattenuating liver masses. Largest one (hepatic segment 2) measures 3.2 x 1.7 cm.
Total volume of all liver lesions: 19.4 cm^3.

RadGPT: Enhanced Human Reports



	Measuring Volume	Providing HU	Measuring All Tumors
Human-made	0%	0%	63%
RadGPT (ours)	100%	100%	100%

RadGPT: Fully-automatic Mode



RadGPT : Evaluating VLMs

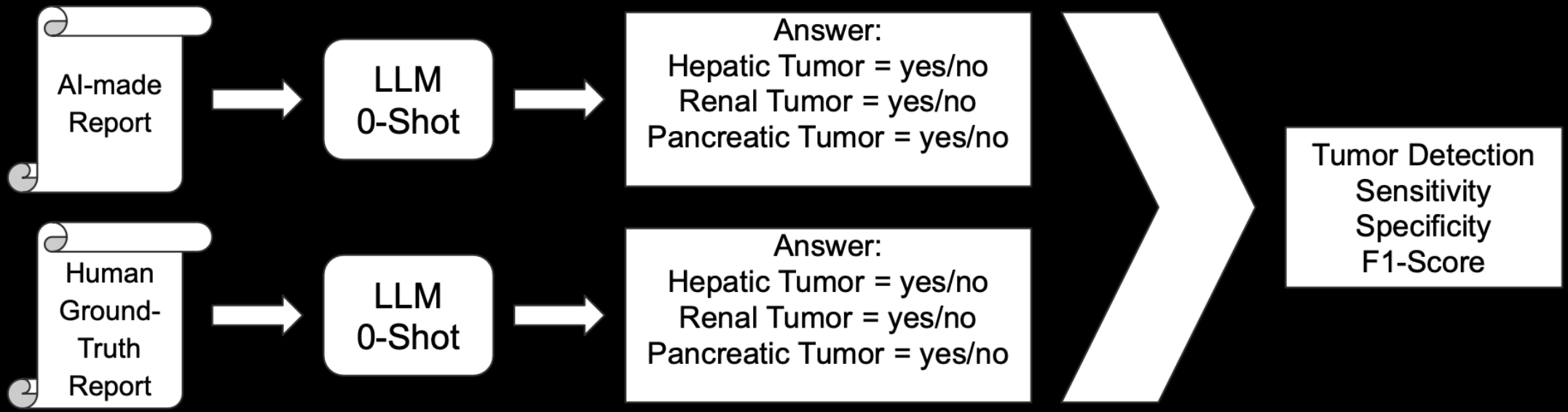
-Usual evaluation of Report Generation: LLM text similarity metrics

Model	BLEU	METEOR	ROUGE-1	ROUGE-2	ROUGE-L	BERT-Score
M3D	0.0000	0.0252	0.0694	0.0100	0.0453	0.4416
CT2Rep	0.0003	0.0443	0.0772	0.0068	0.0525	0.5128
RadGPT-DiffTumor Structured Reports	**0.0098**	0.1099	0.1476	0.0181	0.0888	**0.5489**
RadGPT-DiffTumor Narrative Reports	0.0069	**0.1120**	**0.2467**	**0.0276**	**0.1243**	0.5344

-Proposal:

-LLM Accuracy (0-Shot, N=447): 96%

-prompt!



RadGPT: IID & OOD Evaluation, All SOTA

Internal validation on the test set of AbdomenAtlas 3.0 (IID)

	pancreatic tumor (%)			kidney tumor (%)			liver tumor (%)		
Model	Sen. (≤2 cm)	Sen. (>2 cm)	Spec.	Sen. (≤2 cm)	Sen. (>2 cm)	Spec.	Sen. (≤2 cm)	Sen. (>2 cm)	Spec.
CT-CHAT [19]	**66.7**	51.9	61.2	31.1	32.8	74.2	5.7	3.2	94.7
CT2Rep [20]	0.0	0.0	92.5	36.5	39.3	70.4	35.8	49.2	70.4
M3D [4]	0.0	7.4	97.2	8.1	16.4	84.1	9.4	12.7	86.0
Merlin [8]	33.3	51.9	71.8	28.4	45.9	86.6	30.2	41.3	**95.9**
RadFM [53]	0.0	0.0	**99.9**	3.7	6.3	**95.6**	3.3	5.7	93.9
RadGPT (ours)	**66.7**	**81.5**	93.2	**54.8**	**93.3**	51.8	**39.6**	**96.8**	64.4

External validation on unseen hospitals (OOD)

Model	Sen. (≤2 cm)	Sen. (>2 cm)	Spec.	Sen. (≤2 cm)	Sen. (>2 cm)	Spec.	Sen. (≤2 cm)	Sen. (>2 cm)	Spec.
CT-CHAT [19]	27.5	N/A	73.1	24.3	29.7	74.6	5.2	4.2	94.0
CT2Rep [20]	2.1	N/A	96.7	4.0	10.0	98.0	0.0	0.0	**100.0**
M3D [4]	3.3	N/A	97.9	14.8	13.1	86.3	10.7	17.3	87.3
Merlin [8]	7.5	N/A	**100.0**	8.1	9.2	**100.0**	9.1	19.2	**100.0**
RadFM [53]	0.0	N/A	**100.0**	7.5	6.8	90.9	10.9	11.1	85.0
RadGPT (ours)	**76.9**	N/A	76.6	**92.0**	**97.3**	78.3	**79.6**	**89.4**	73.4

Models and Dataset:
https://github.com/MrGiovanni/RadGPT