**Supplementary Materials**

**Toward a standardized methodological framework for developing computer vision models in staging laparoscopy**

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**Supplementary Data 1.** Annotation checklist with definitions.

**Checklist annotations of abdominal structures and peritoneal tumors using Encord**

**Useful info and annotating tips:**

- Annotation will only be performed based on the identification of tumoral lesions and anatomical structures
- Be aware that structures/organs can be absent due to the gender of the patient or prior surgery (e.g., cholecystectomy).
- When you annotate the small bowel, please annotate the mesentery together with it.
- Please use the given abbreviations (e.g., gallbladder, GB).
- Do not modify or add abbreviations.
- Do not submit the video in Encord.
- Try to contour each structure precisely, staying within its borders as accurately as possible.
- Aim to annotate every identifiable structure listed in the checklist for each frame. Do not create frames with partial annotations. However, a frame does not always have to be filled completely with annotations. If a structure is too small or not identifiable, you can leave that space blank. For example, if a frame shows the liver and the stomach, and only a tiny corner of the greater omentum or the bowel appears in the corner, you can omit these structures.
- Choose frames that are different from each other in terms of structure and object presence. Leave at least 20 frames between each annotation unless there is a complete camera switch, where frames are completely different even within 20 frames.
- Try to add frames containing an overview of the abdominal cavity, with fewer objects even when slight blurred if these contain objects from the checklist.
- If in doubt, use the provided label and flag it for review so your supervisor can reassess the annotation.
- If you have any other questions or doubts on this checklist, please contact the team leader.

<u>Note: It is more important to annotate structures precisely than to focus on their location.</u>

N.B: This is a revised checklist: Rectosigmoid and ascites were removed. The small bowel mesentery is annotated together with the small bowel (single class). The uterine tubes are also merged with the uterus. Please annotate these together.

**Important definitions:**

Very often, described and defined anatomical landmarks are not visible during laparoscopy like in open surgery. Therefore, accurate annotation of each structure can be challenging.
Here, some helpful definitions to annotate correctly. Also, some illustrative pictures are included at the end of this document:

1. **Transverse colon:**
    - It runs from the hepatic flexure to the splenic flexure
    - It has a segmented appearance due to a series of sac-like bulges (haustra)
    - It can be covered with small fat accumulations (epiploic appendices)
    - It is connected to the posterior abdominal wall by yellow tissue (mesocolon). Please consider it as part of the colon.
    - In the frame: the liver, falciform ligament and stomach are in the upper side and the greater Omentum in the lower side of frames with different angulations
2. **Greater Omentum:**

- Large yellow curtain of fatty tissue hanging on the transverse colon and greater curvature of the stomach and located in the central region (but can extend towards the flanks and pelvis)
- As it is hanging on the transverse colon (but also covering it) it can be flipped over or laterally in the upper regions by the surgical instrument to expose the transverse colon and the small bowel lying under it (which also must be annotated)
- It can be absent if the patient underwent previous cytoreduction

3. **Right hemidiaphragm:**
    - Anatomically: anterior, posterior and above the right liver lobe
    - In the frame: in the upper side and to the left of the right liver lobe
    - Medial landmark (right side of the frame): the falciform ligament (and its cranial prolongation, the coronary ligament)
    - Lateral landmark (left side of the frame): the curved imprints of the ribs
4. **Left hemidiaphragm:**
    - Anatomically: anterior, posterior and above the left liver lobe
    - In the frame: in the upper side and to the right of the left liver lobe
    - Medial landmark (left side of the frame): the falciform ligament (and its cranial prolongation, the coronary ligament)
    - Lateral landmark (right side of the frame): the curved imprints of the ribs
5. **Falciform ligament**
    - Thin, sickle-shaped, transparent/translucid, or yellow fibrous structure
    - Connects the anterior part of the liver to the ventral wall of the abdomen
    - Divides the right and the left liver lobe
    - It can be absent in case of prior surgery
6. **Lesser Omentum**
    - Yellow fatty tissue that extends from the left liver lobe to the lesser curvature of the stomach (hepato-gastric ligament) and the first part of the duodenum (hepato-duodenal ligament)
    - It is anteriorly covered by the left liver lobe and not always visualized
    - The lesser omentum is annotated together with the greater omentum as a single omentum object. No separate label is created for the lesser omentum.
7. **Left paracolic (abdominal) gutter:**
    - It is the peritoneum lateral to the descending colon, running from the proximal descending colon up to the left iliac fossa
    - Upper landmark: left lower rib arch
    - Lower landmark: the upper border of the left iliac fossa where the abdominal wall deflects down and medially
8. **Descending colon:**
    - It runs from the splenic flexure to the upper border of the left iliac fossa
    - It has a segmented appearance due to a series of sac-like bulges (haustra)
    - It can be covered with small fat accumulations (epiploic appendices)
    - It is connected to the posterior abdominal wall by yellow tissue (mesocolon). Please consider it as part of the colon.
    - In the upper side of the frame, you will see the left paracolic (abdominal) gutter and the descending colon in the lower side
9. **Left pelvic sidewall:**

- Mirror image of the right pelvic sidewall
- Medial landmark (central or in the right side of the frame): lateral umbilical fold under which the origin of the left epigastric vessels (branching from the left iliac vessels)
- Lateral landmark (left side of the frame): left abdominal wall where it deflects down and medially (at the landmark of the sigmoid)
- The left lateral umbilical fold is not always visible but the epigastric vessels or the fold of the peritoneum down into the left lower/iliac fossa (region 5) should always be identifiable

10. **Sigmoid colon:**
    - Often S-shaped
    - It has a segmented appearance due to a series of sac-like bulges (haustra)
    - It can be covered with small fat accumulations (epiploic appendices)
    - It is connected to the posterior abdominal wall by yellow tissue (mesocolon). Please consider it as part of the colon.
    - Annotation landmark is the upper border of the left iliac fossa
    - Due to its variable length, it can extend into the pelvis
    - Frames show both the descending colon and the left abdominal wall deflecting down. This is a landmark for the end of the descending colon and the beginning of the sigmoid colon
11. **Bladder:**
    - This is the peritoneum covering the bladder and can bulge if there is urine in the bladder
    - Supero-lateral landmark: the epigastric vessels covered by the left and right lateral umbilical fold
    - Superior landmark (above in the frame): the transverse vesical fold
    - The bladder is not always clearly identifiable. When the landmarks are unclear, try to delimit the peritoneum by looking at the orientation of the camera. Assuming the camera is placed in a trocar at the midline we will use a frame where the camera is looking down perpendicularly to visualize the bladder.

12. **Peritoneum of the suprapubic region:**
    - Lateral landmark: the lateral umbilical folds
    - Inferior landmark: upper border of the bladder (transverse vesical fold/pubic bone)
    - Superior: origin of the falciform ligament (= level of the umbilicus; often there is a trocar here)
13. **Uterus**
    - Pink pear-shaped organ in the female pelvis
    - Can be absent in case of prior surgery or in male patients
14. **Tubes (or Fallopian tubes)**
    - Paired tubes in the female pelvis
    - Running from the uterus laterally to the ovaries
    - Can be absent in case of prior surgery or in male patients
    - Please annotate this as a part of the uterus
15. **Ovaries**
    - Oval-shaped glands located on either side of the tubes and uterus in the female pelvis
    - Can be absent due to prior surgery or in male patients
16. **Right pelvic sidewall:**
    - Medial landmark (central or in the left side of the frame): lateral umbilical fold under which the origin of the right epigastric vessels (branching from the right iliac vessels)

- Lateral landmark (right side of the frame): right abdominal wall where it deflects down and medially (at the level of the cecum).
- The right lateral umbilical fold is not always visible, but the epigastric vessels or the fold of the peritoneum down into the right lower/iliac fossa (region 7) should always be identifiable

17. **Right paracolic (abdominal) gutter:**
    - Mirror image of the left paracolic (abdominal) gutter
    - It is the peritoneum lateral to the ascending colon, running from the cecum up to the hepatic flexure of the colon (below the lower margin of the liver)
    - Upper landmark: right lower rib arch
    - Lower landmark: the upper border of the right iliac fossa where the abdominal wall deflects medially
18. **Anterior abdominal wall:**
    - It is the parietal peritoneum lining the ventral abdominal wall, visible when the camera faces the abdominal wall rather than intra-abdominal organs.
    - Cranial landmark: Caudal limit of the right and left hemidiaphragms, where the diaphragmatic peritoneum ends and rib impressions can be visible on the peritoneum.
    - Caudal landmark: Inferior boundary corresponds to the end of the suprapubic region as defined in this checklist (transition to the bladder dome and pubic bone region).
    - Lateral landmarks: Inferior epigastric vessels, typically visible running cranio-caudally beneath the peritoneum (often highlighted by the lateral umbilical folds).
19. **Cecum**
    - It is the beginning of the ascending colon
    - It has the shape of a blind pouch, somewhat like a comma
    - It is the origin of the appendix
    - The first haustra (=bulging) of the colon is a landmark for its border
20. **Ascending colon:**
    - It runs from the cecum to the hepatic flexure
    - It has a segmented appearance due to a series of sac-like bulges (haustra)
    - It can be covered with small fat accumulations (epiploic appendices)
    - It is connected to the posterior abdominal wall by yellow tissue (mesocolon). Please consider it as part of the colon.
    - In the upper side of the frame, you will see the right paracolic (abdominal) gutter and the ascending colon in the lower side
21. **Small bowel:** The exact transition between jejunum and ileum is often difficult to identify and not required for this project. Because the camera rotates around a central pivot point, the apparent position of the small bowel loops relative to other structures can change across frames. Annotate all visible small bowel loops as one single object, regardless of jejunum or ileum. Use global localization and visual features as guidance.
    - Usually smaller diameter than the colon
    - No sac-like bulges (haustra)
    - No epiploic appendices (fat tags)
    - Small bowel loops commonly occupy the central abdomen and can extend into left and right upper and lower quadrants, depending on patient position and retraction

- Use surrounding fixed landmarks to orient the field: liver and falciform ligament (cranial), pelvis and bladder dome (caudal), ascending and descending colon with paracolic gutters (lateral)
- Do not include colon when haustra or epiploic appendices are visible
- Do not include omentum or mesocolon when draped over bowel loops

22. **Mesentery of the small bowel:**
    - Large, broad fan-shaped yellow tissue attaching the small intestines to the posterior abdominal wall
    - The small bowel mesentery is annotated together with the small bowel (single class). Do not create a separate mesentery label.
    - When mesentery is visible without clear bowel wall in the same frame, annotate it as part of the small bowel object only if continuity with small bowel loops is evident.

**Annotate each tumoral lesion that is visible and that you can recognize. Again, if in doubt, use the provided label and flag it for review so your supervisor can reassess the annotation.**

**Now annotate structures by filling this checklist:**

**Each video must have annotations for at least these structures:**

- ☐ Greater Omentum **(GO)**
- ☐ Right lobe of the liver **(RL)**
- ☐ Right hemidiaphragm **(RHD)**
- ☐ Left lobe of the liver **(LL)**
- ☐ Falciform ligament **(FL)**
- ☐ Left hemidiaphragm **(LHD)**
- ☐ Stomach **(ST)**
- ☐ Descending or left colon **(DC)**
- ☐ Left paracolic (abdominal) gutter **(LPG)**
- ☐ Left pelvic lateral sidewall **(LPS)**
- ☐ Bladder **(BD)**
- ☐ Suprapubic region **(SPR)**
- ☐ Right pelvic lateral sidewall **(RPS)**
- ☐ Ascending or right colon **(AC)**
- ☐ Right paracolic (abdominal) gutter **(RPG)**
- ☐ Anterior abdominal wall **(AW)**
- ☐ Small bowel **(SB)**
- ☐ Ovaries **(OV)**
- ☐ Uterus **(UT)**
- ☐ Peritoneal metastasis **(PM)**

**These structures are optional (because not always or rarely visible in the videos). If you see it, annotate it please:**

- ☐ Transverse colon **(TC)**
- ☐ Gallbladder **(GB)**
- ☐ Spleen **(SPL)**
- ☐ Sigmoid colon **(SC)**
- ☐ Cecum **(CC)**
- ☐ Appendix **(AP)**

☐ Lesser Omentum (included in GO, do not annotate separately)
☐ Surgical instrument **(SI)**

**Supplementary Table 1. Training configuration and implementation details of the final retained segmentation models**

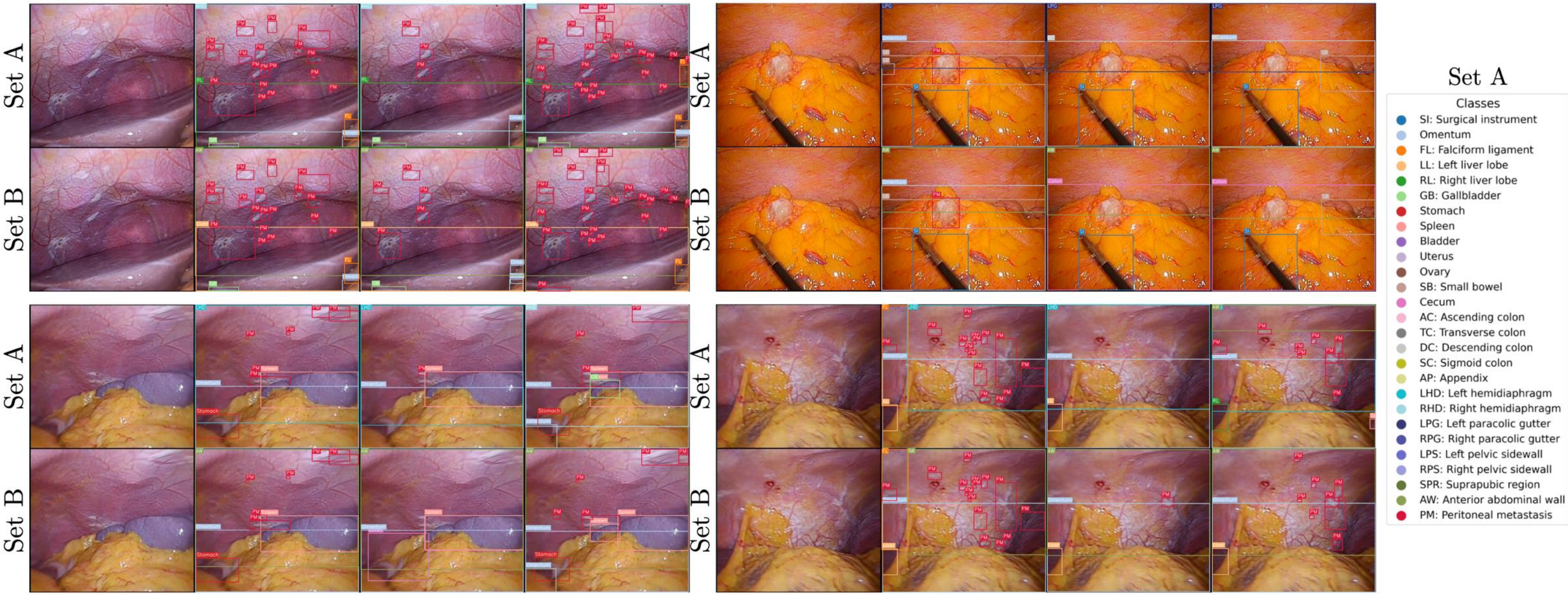
| Model | Classes | Backbone | Pretraining | Optimizer | Learning rate | Weight decay | LR schedule | Batch size | Training resize strategy | Crop size | Inference strategy | Best iteration (validation mIoU peak) | Epoch @ best | Epochs if fully run to 160k |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SegFormer-A | 28 | MiT-B5 | ImageNet-1k | AdamW | $6 \times 10^{-5}$ | 0.01 | Linear warmup (first 1,500 iterations), then PolyLR | 1 | RandomResize anchored at 896 px, ratio range 0.5–2.0, keep_ratio=True | 1024 × 1024 | Resize with keep_ratio to ~896 px on the long side; padded to 1024 × 1024 if needed; sliding-window inference (crop 1024 × 1024, stride 768) | 54,000 | ~41 epochs | ~123 epochs |
| SegFormer-B | 16 | MiT-B5 | ImageNet-1k | AdamW | $6 \times 10^{-5}$ | 0.01 | Linear warmup (first 1,500 iterations), then PolyLR | 2 | RandomResize anchored at 896 px, ratio range 0.5–2.0, keep_ratio=True | 1024 × 1024 | Resize with keep_ratio to ~896 px on the long side; padded to 1024 × 1024 if needed; sliding-window inference (crop 1024 × 1024, stride 768) | 88,000 | ~135 epochs | ~245 epochs |
| Mask2Former-A | 28 | Swin-Large | ImageNet-22k | AdamW | $1 \times 10^{-4}$ | 0.05 | PolyLR, no warmup | 3 | RandomChoiceResize across 16 scales from 320 to 1280 px, keep_ratio=True | 640 × 640 | Resize with keep_ratio to ~640 px on the long | 28,000 | ~64 epochs | ~368 epochs |

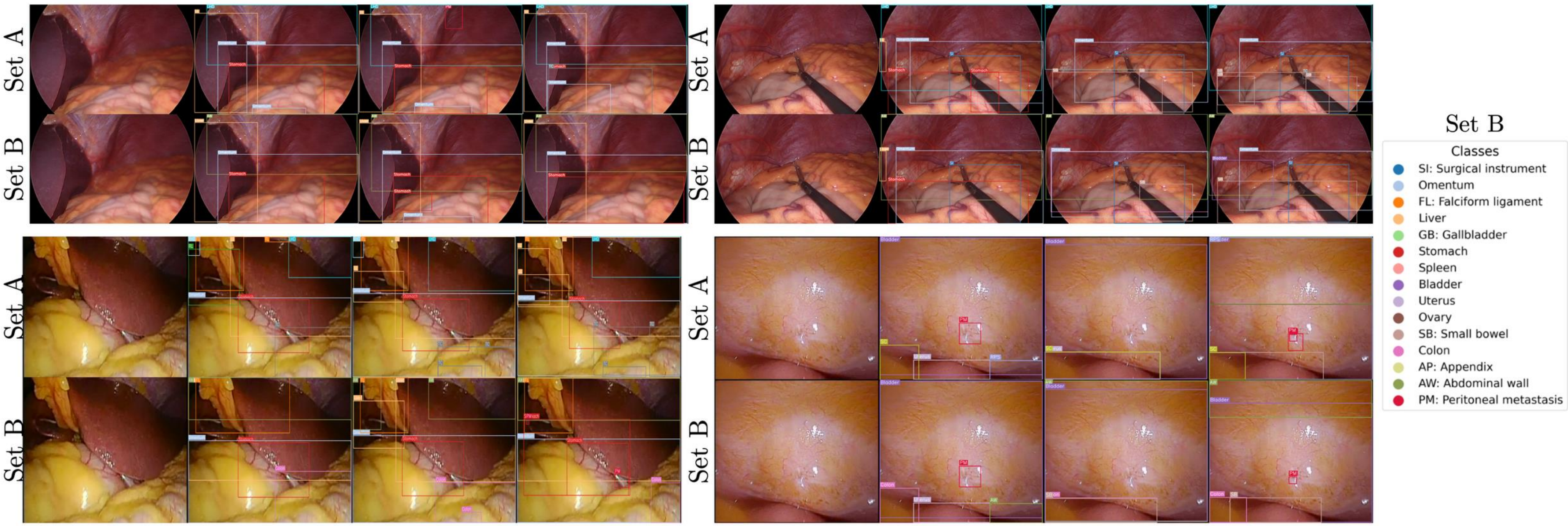
| Model | Classes | Backbone | Pretraining | Optimizer | Learning rate | Weight decay | LR schedule | Batch size | Training resize strategy | Crop size | Inference strategy | Best iteration (validation mIoU peak) | Epoch @ best | Epochs if fully run to 160k |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | side; padded to 640 × 640 if needed; whole-image inference | | | |
| Mask2Former-B | 16 | Swin-Large | ImageNet-22k | AdamW | $1 \times 10^{-4}$ | 0.05 | PolyLR, no warmup | 2 | RandomChoiceResize across 16 scales from 320 to 1280 px, keep_ratio=True | 640 × 640 | Resize with keep_ratio to ~640 px on the long side; padded to 640 × 640 if needed; whole-image inference | 44,000 | ~68 epochs | ~245 epochs |

**Abbreviations:** LR, learning rate; mIoU, mean Intersection over Union.

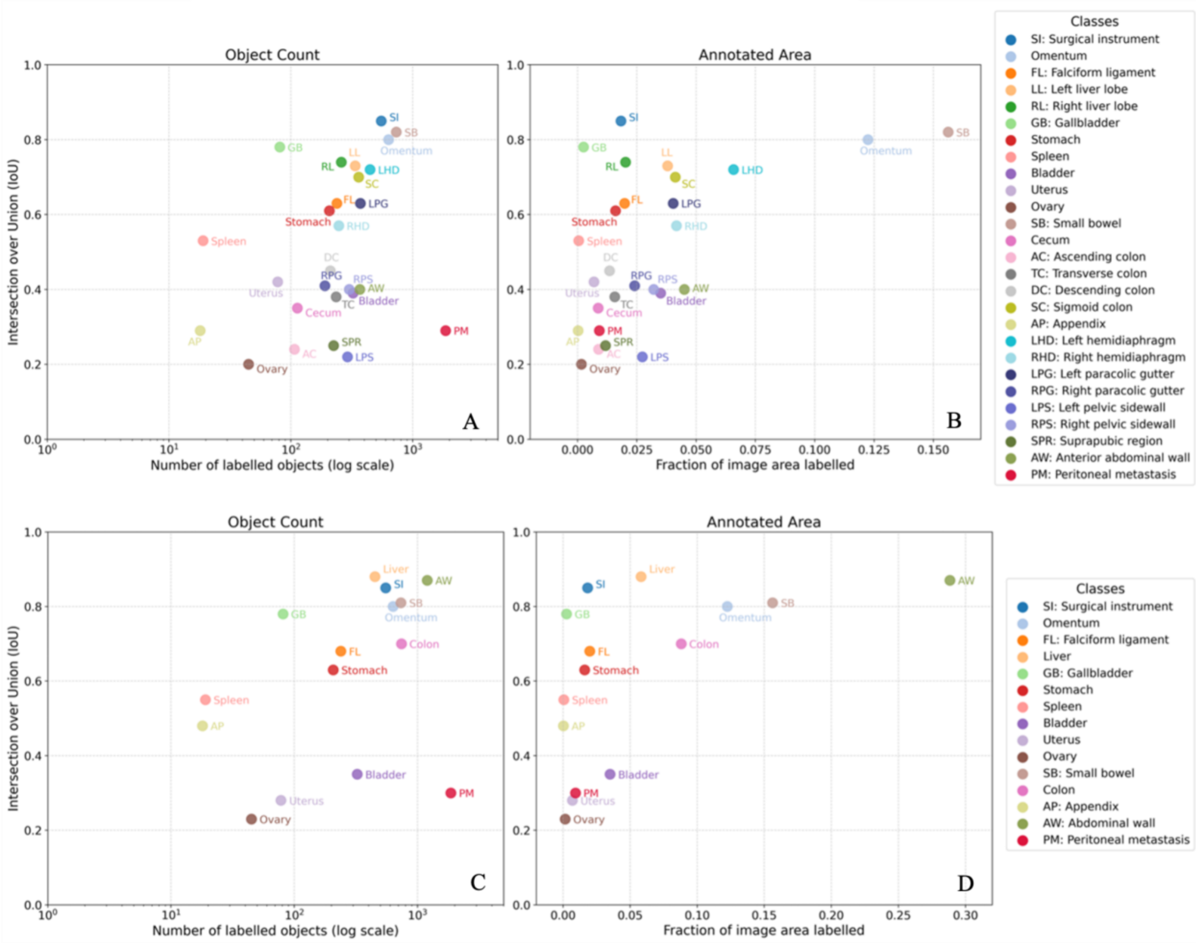
**Note:** All models were trained for a maximum of 160,000 iterations. Best checkpoints were selected based on peak validation mIoU. SegFormer used a decoder-head learning rate multiplier of ×10. Logs indicated use of NVIDIA RTX 3090 GPUs, CUDA 11.2/11.3, PyTorch 1.12.1, and MMEngine 0.10.x. Exact GPU counts and full wall-clock training times could not be consistently reconstructed from the retained logs.

**Supplementary Figure 1. Representative object detection in intraoperative laparoscopic scenes.** From left to right, each example shows the input frame, ground-truth annotation, YOLOv9 prediction, and Co-DETR prediction. The upper row corresponds to Set A and the lower row to Set B.




Set A
Set B
Set A
Set B
Set A
Set B
Set A
Set B
Set B
Classes
SI: Surgical instrument
Omentum
FL: Falciform ligament
Liver
GB: Gallbladder
Stomach
Spleen
Bladder
Uterus
Ovary
SB: Small bowel
Colon
AP: Appendix
AW: Abdominal wall
PM: Peritoneal metastasis

**Supplementary Figure S2. Class-level Intersection over Union in relation to annotation count and annotated area fraction.**




*(A) Set A: IoU versus number of labelled objects. (B) Set A: IoU versus fraction of image area labelled. (C) Set B: IoU versus number of labelled objects. (D) Set B: IoU versus fraction of image area labelled. The x-axis for object count is displayed on a logarithmic scale. Each point represents one annotated class.*

**Supplementary Figure S3.** t-SNE visualization of feature embeddings for SegFormer: A) Set A, B) Set B.