# Joint Class-Affinity Loss Correction for Robust Medical Image Segmentation with Noisy Labels

**Xiaoqing Guo** **Yixuan Yuan**†

City University of Hong Kong

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† Yixuan Yuan is the corresponding author

# Introduction

- **Background:**

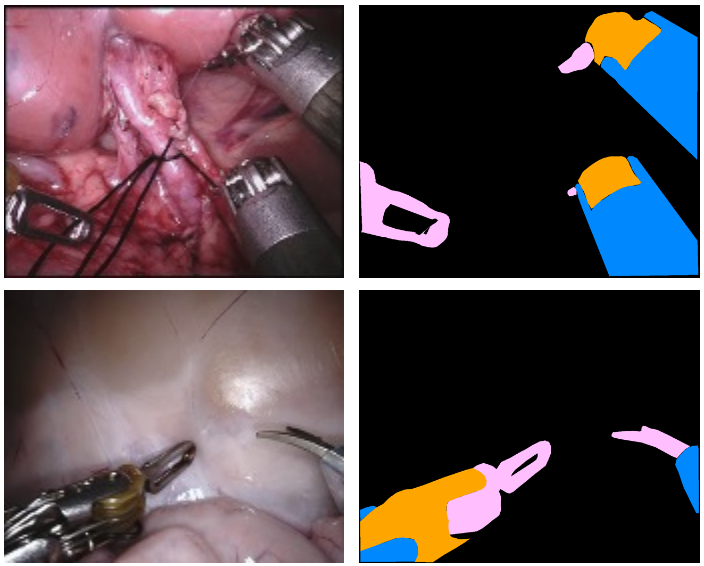

Image Ground truth

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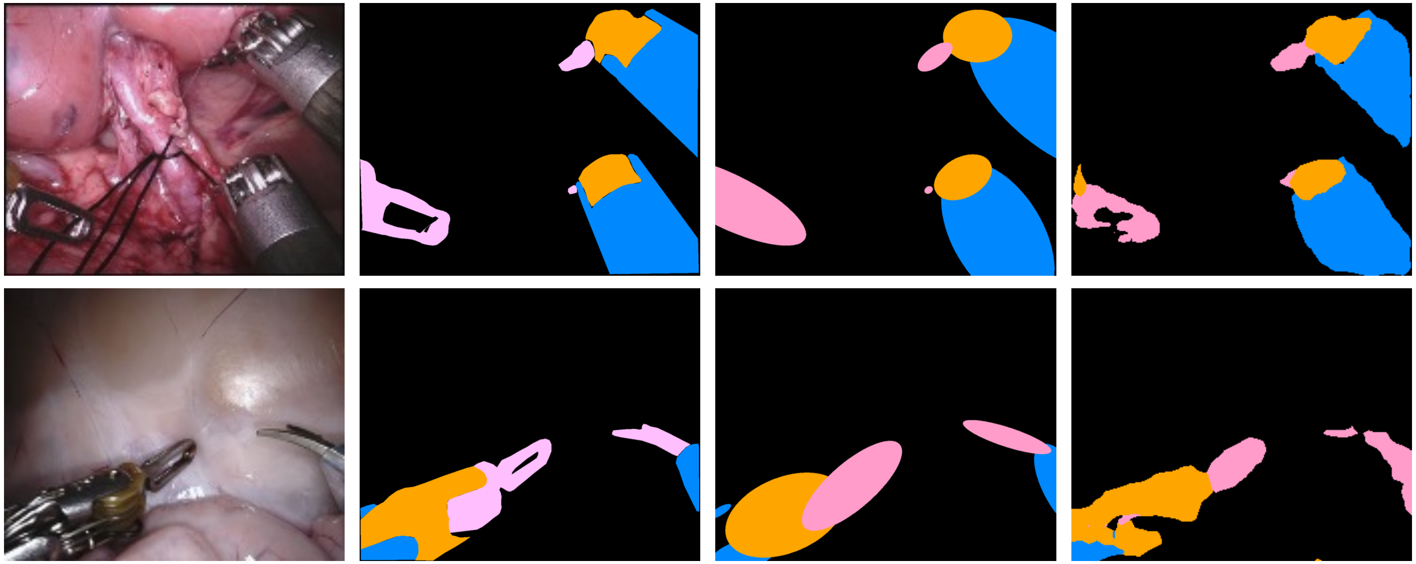

Image | Ground truth | Week label | SFDA label

*SFDA: source-free domain adaptation*

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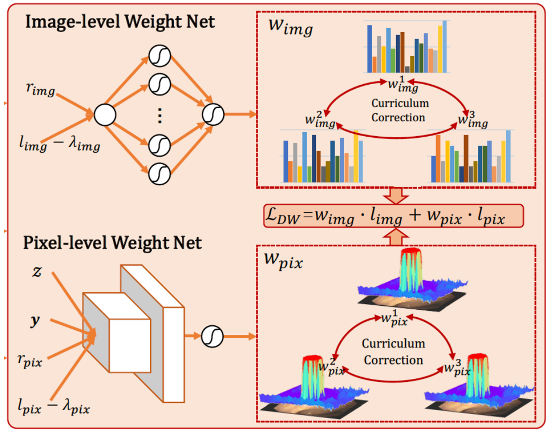


Resampling and reweighting strategy [1]

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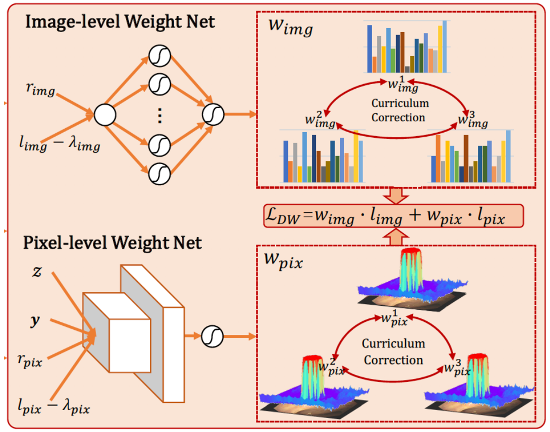


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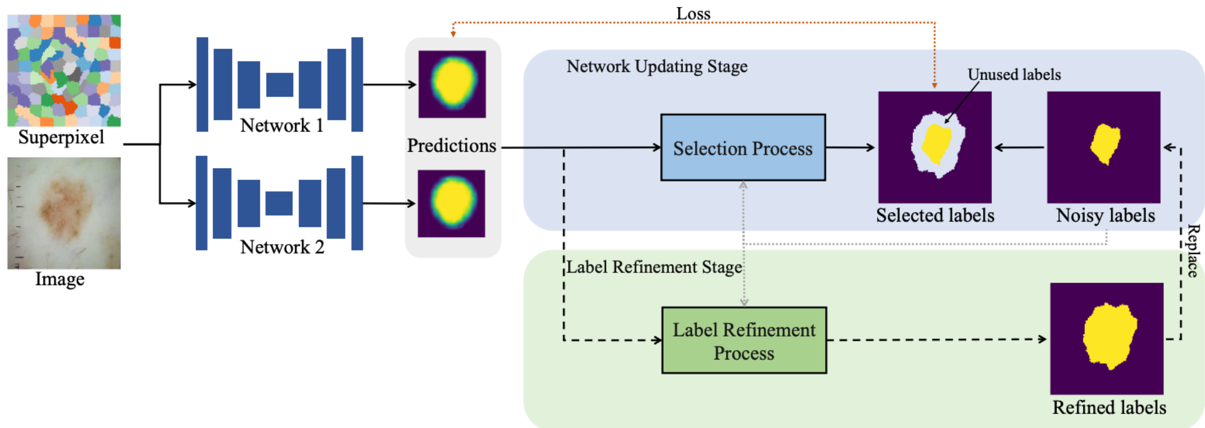


Label Correction [2]

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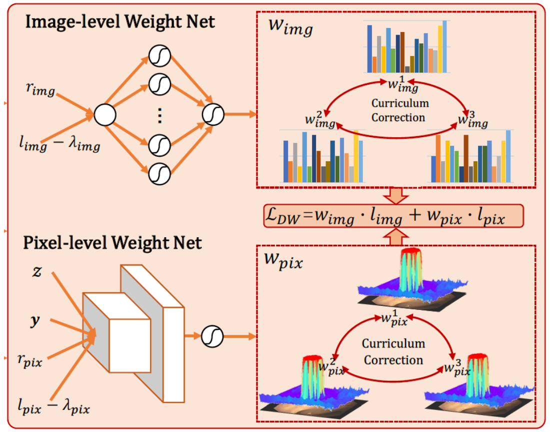


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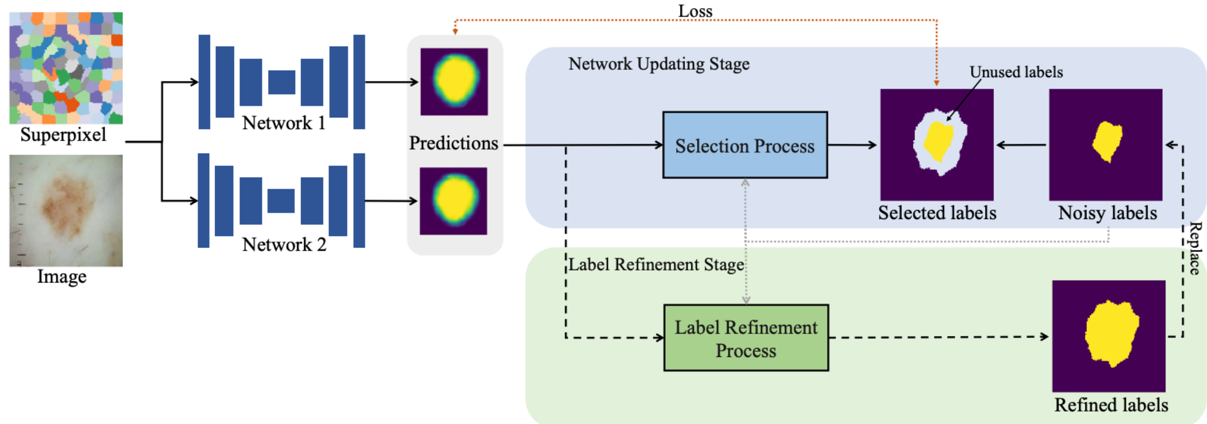


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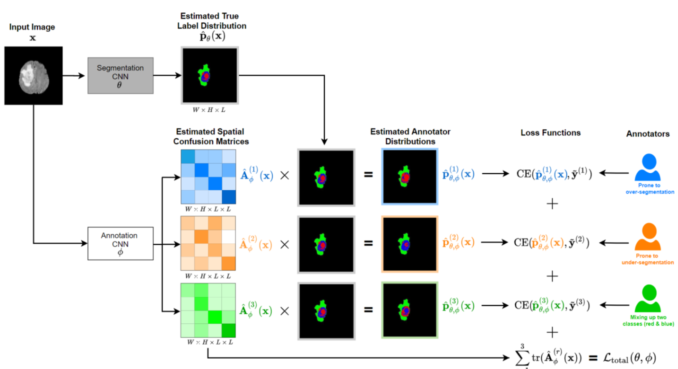
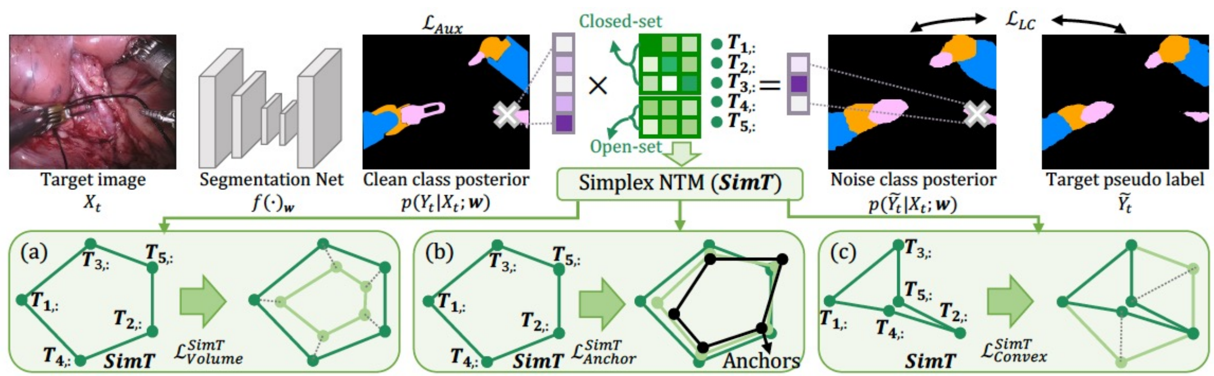



Loss correction w/ confusion matrix [3]




Loss correction w/ noise transition matrix (NTM) [4]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[3] Zhang, L., Tanno, et al., Alexander, D.: Disentangling human error from ground truth in segmentation of medical images. NeurIPS 33, 15750–15762 (2020)
[4] Guo, X., Liu, J., Liu, T., Yuan, Y.: Simt: Handling open-set noise for domain adaptive semantic segmentation. In: CVPR (2022)

# Motivation



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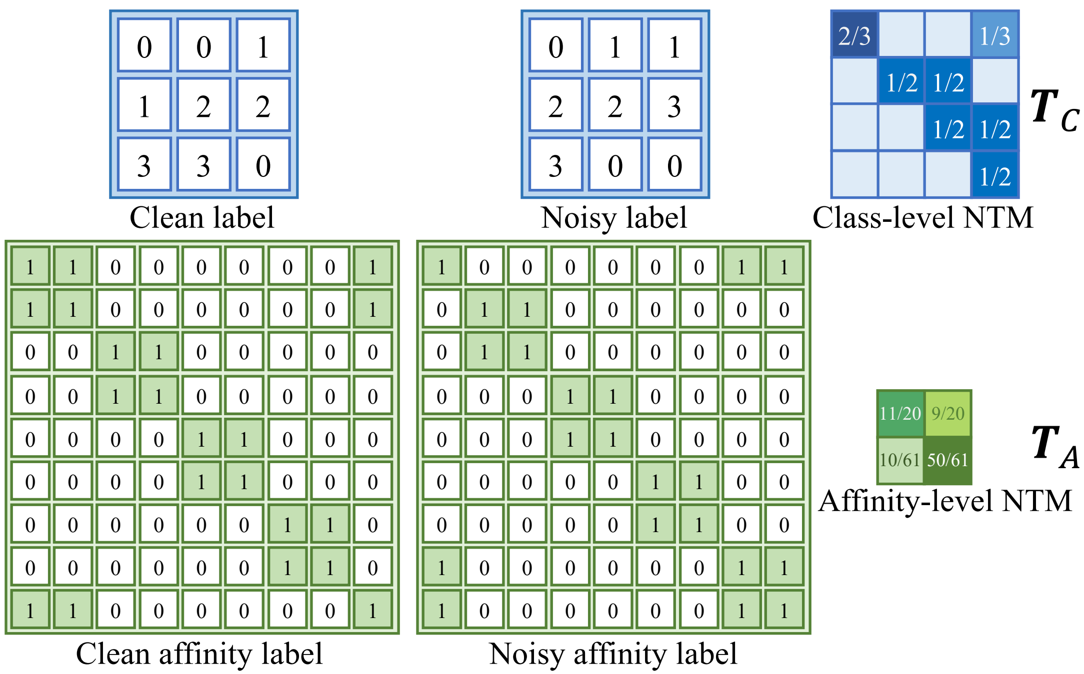
  - The pair-wise manner reduces label noise rate



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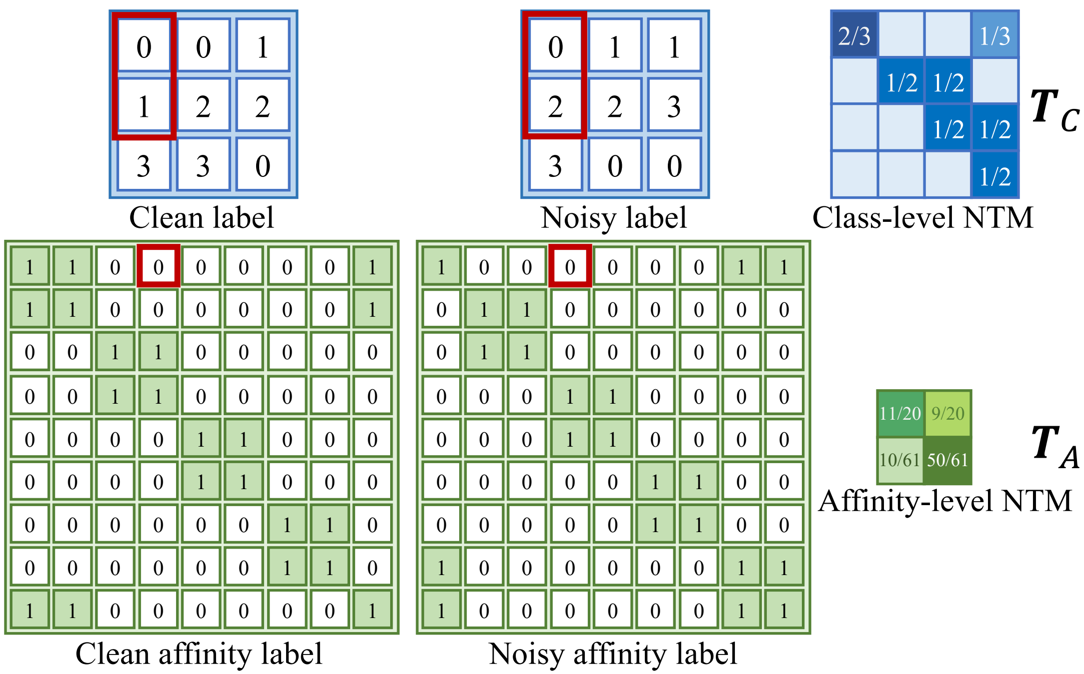

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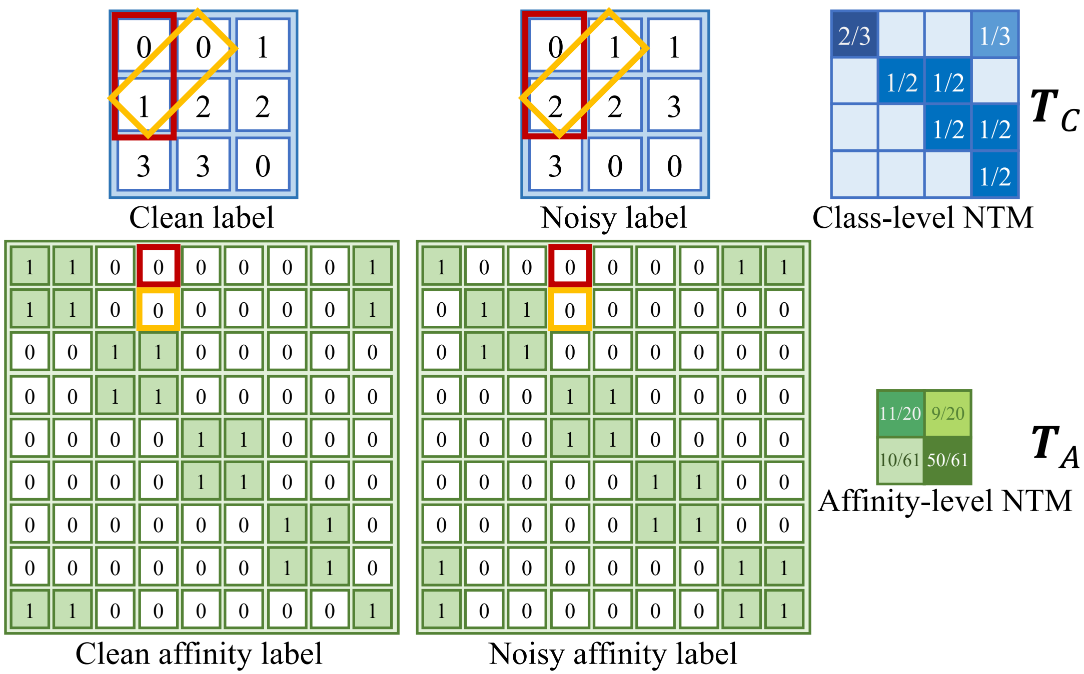

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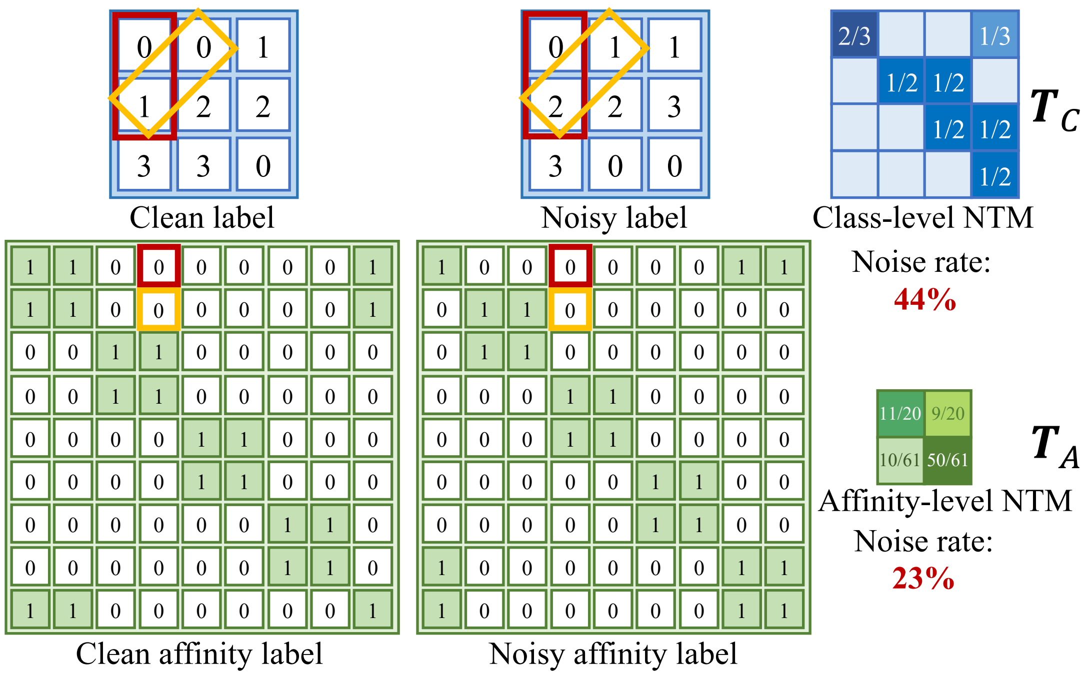

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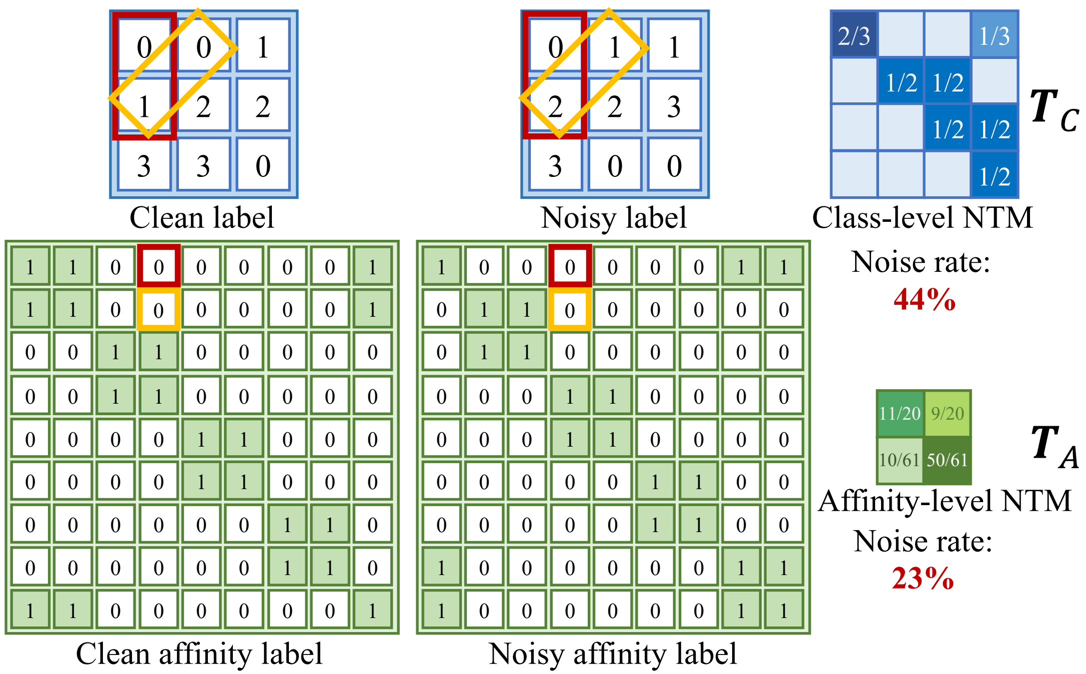


$$T_{C\to A}(0,1) = \frac{\sum_m \left[N_m \sum_n T_C(m,n)\right]^2 - \sum_m (N_m)^2 \|T_C\|_2^2}{\sum_m \left[N_m (\sum_m N_m - N_m)\right]},$$

$$T_{C\to A}(0,0) = 1 - T_{C\to A}(0,1),$$

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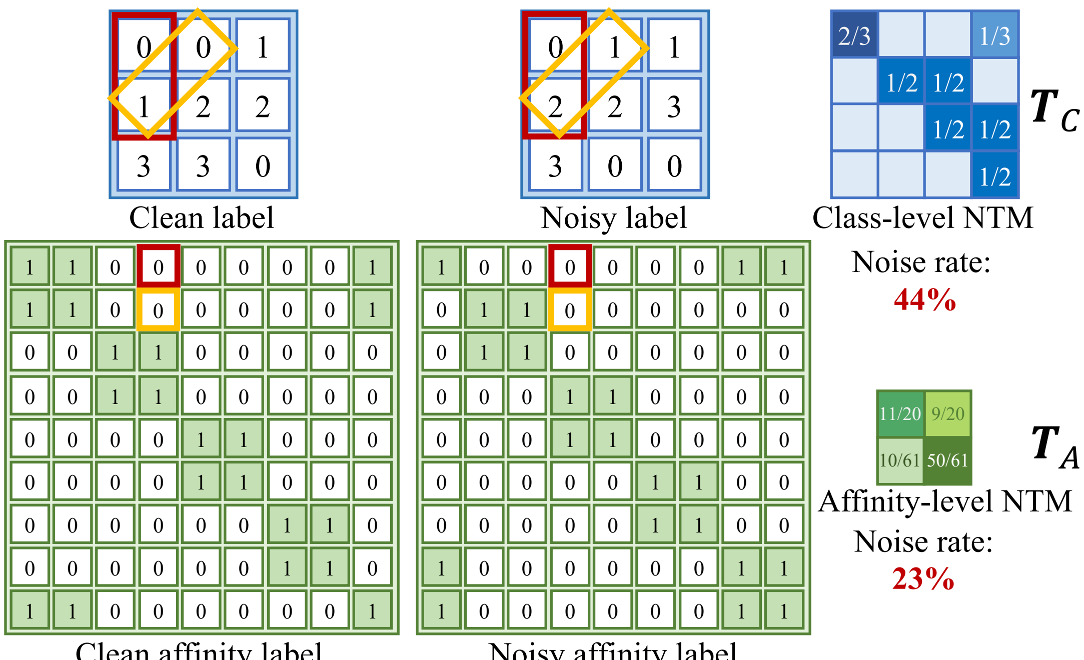


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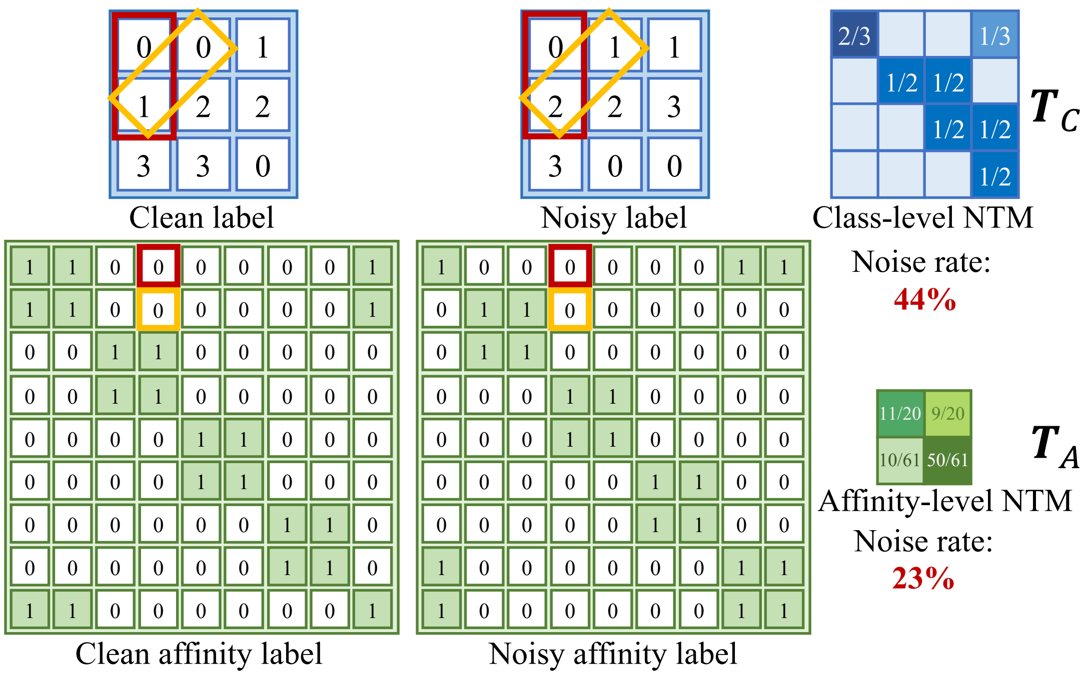
  - The pair-wise manner reduces label noise rate
  - Unify the pixel-wise and pair-wise manners
  - The first effort in exploiting the affinity relation between pixels within an image for noisy mitigation

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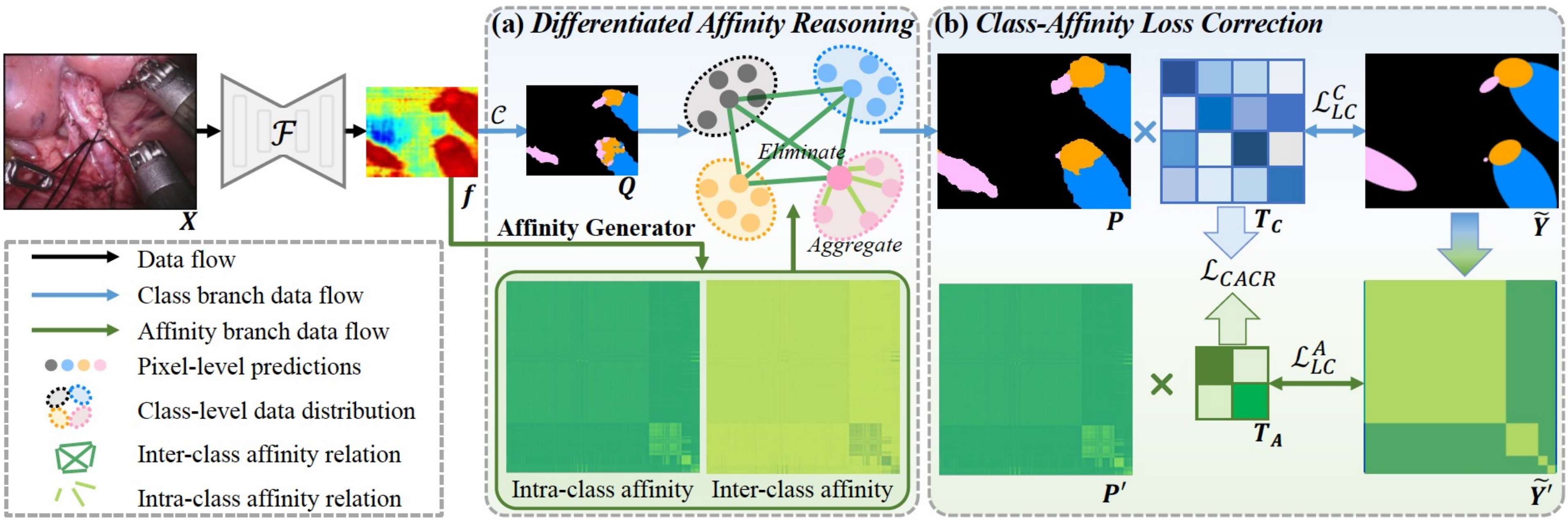
- **Our approach: Joint Class-Affinity Loss Correction (JCAS)**
  - Pixel-wise supervision signal derived from class label preserves semantics
  - Pair-wise supervision signal derived from affinity label reduces noise rate

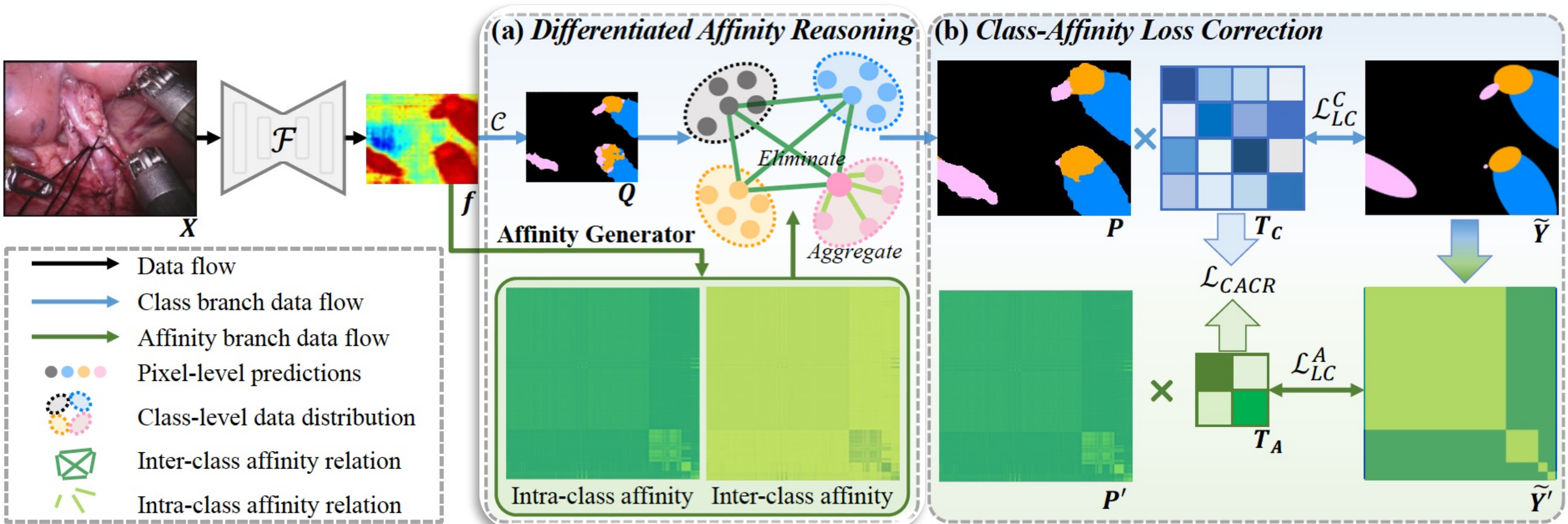


# Method



- **Our approach: Joint Class-Affinity Loss Correction (JCAS)**
  - Pixel-wise supervision signal derived from class label preserves semantics
  - Pair-wise supervision signal derived from affinity label reduces noise rate
  - Differentiated affinity reasoning (DAR) module

$$\boldsymbol{P}_{intra}(k_1) = \boldsymbol{P}(k_1) + \sum_{k_2}^{n} \boldsymbol{P}'(k_1, k_2)\boldsymbol{Q}(k_2); \boldsymbol{P}_{inter}(k_1) = \boldsymbol{P}(k_1) - \sum_{k_2}^{n} \boldsymbol{P}'_{re}(k_1, k_2)\boldsymbol{Q}(k_2)$$



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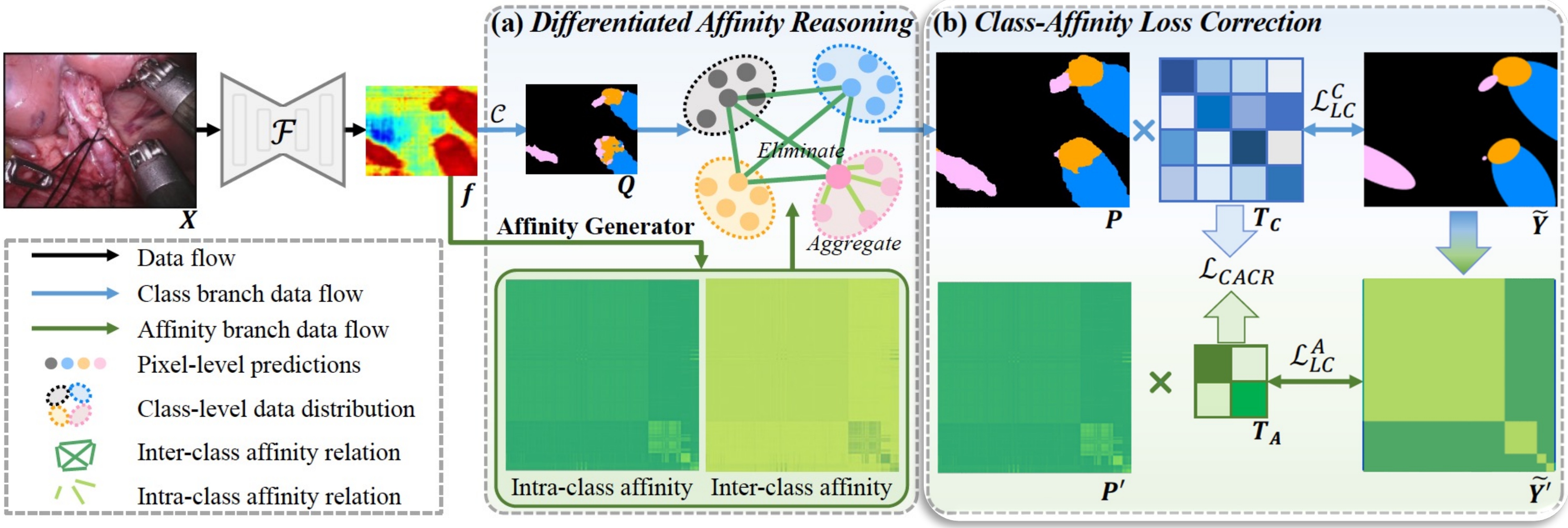
  - Class-affinity loss correction (CALC) strategy $\mathcal{L}_{CACR} = \|\boldsymbol{T}_{C\rightarrow A} - \boldsymbol{T}_A\|_2$

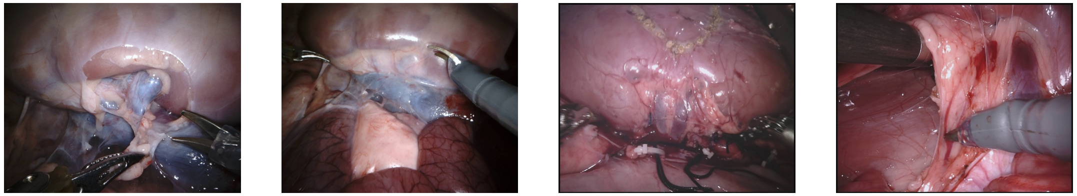


# Experiment



- **Datasets**:
  - Endovis18: 2235 images (1639 training images & 596 test images)

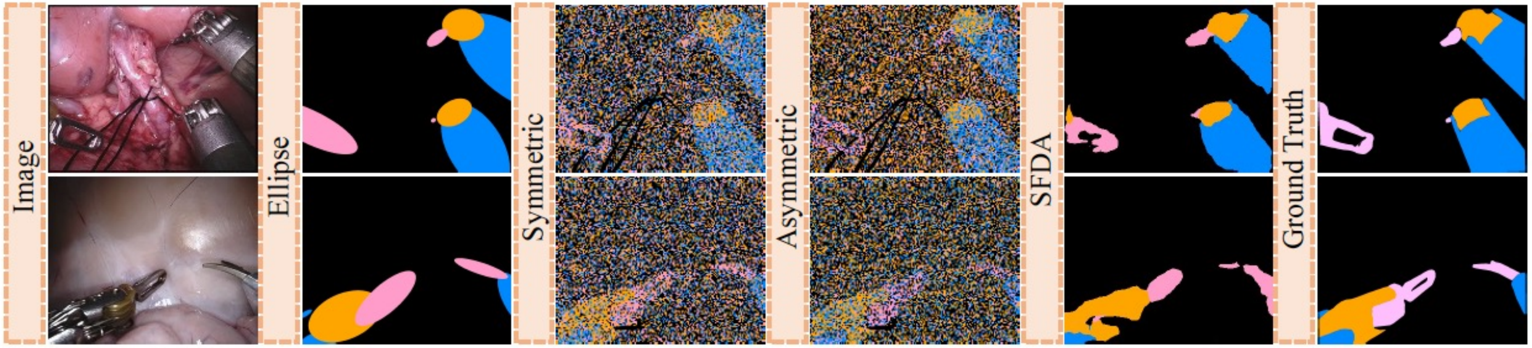
    3 instrument part classes (shaft, wrist and clasper classes)



  - Noise patterns:

    synthetic label noise (elipse, symmetric and asymmetric noises)

    real-world label noise (noisy pseudo labels in source-free domain adaptation (SFDA))




- **Evaluation metrics**:

  $Dice$, $Jac$ per class

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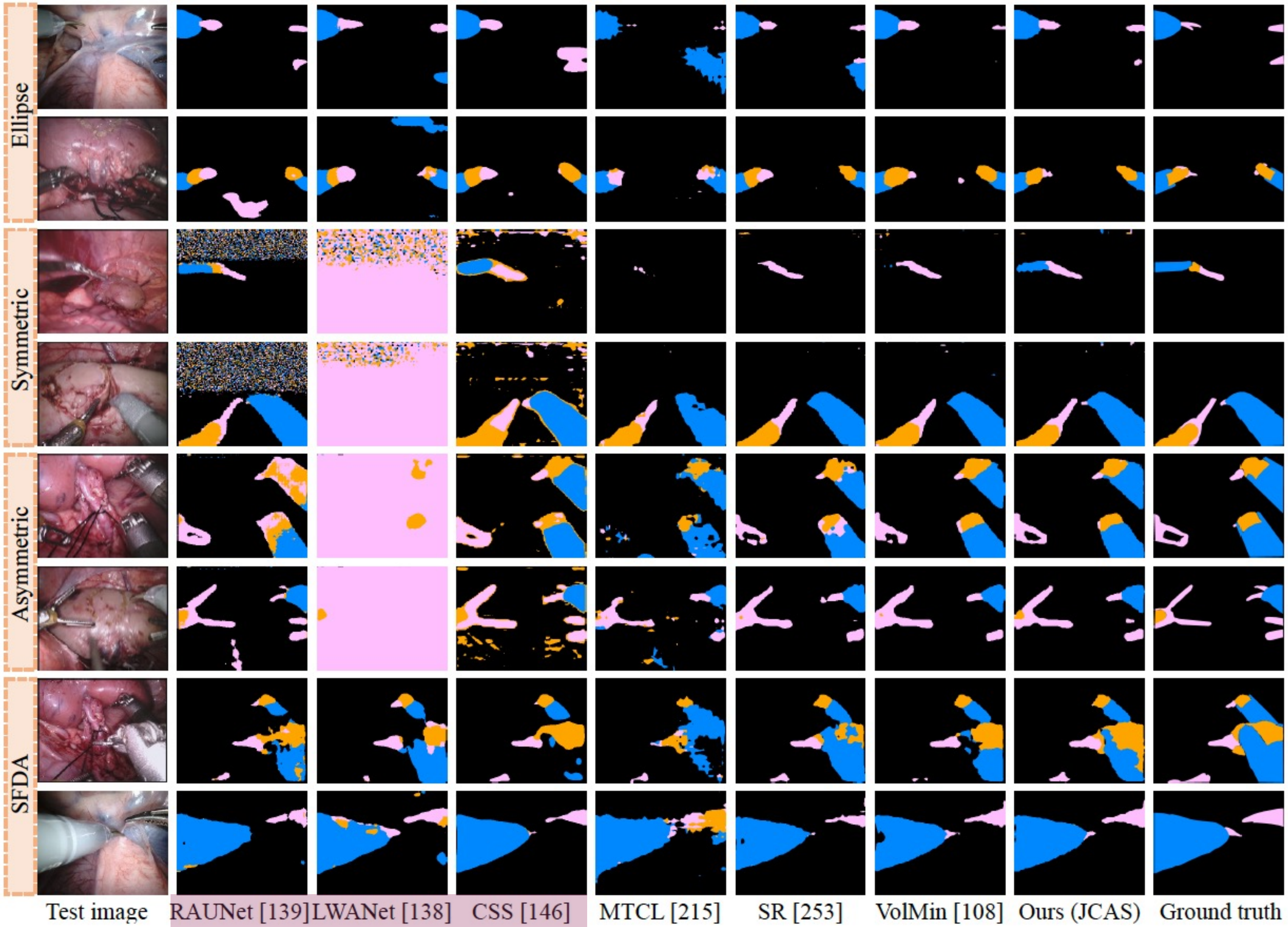
- **Experimental results**
  - Superior to state-of-the-art methods



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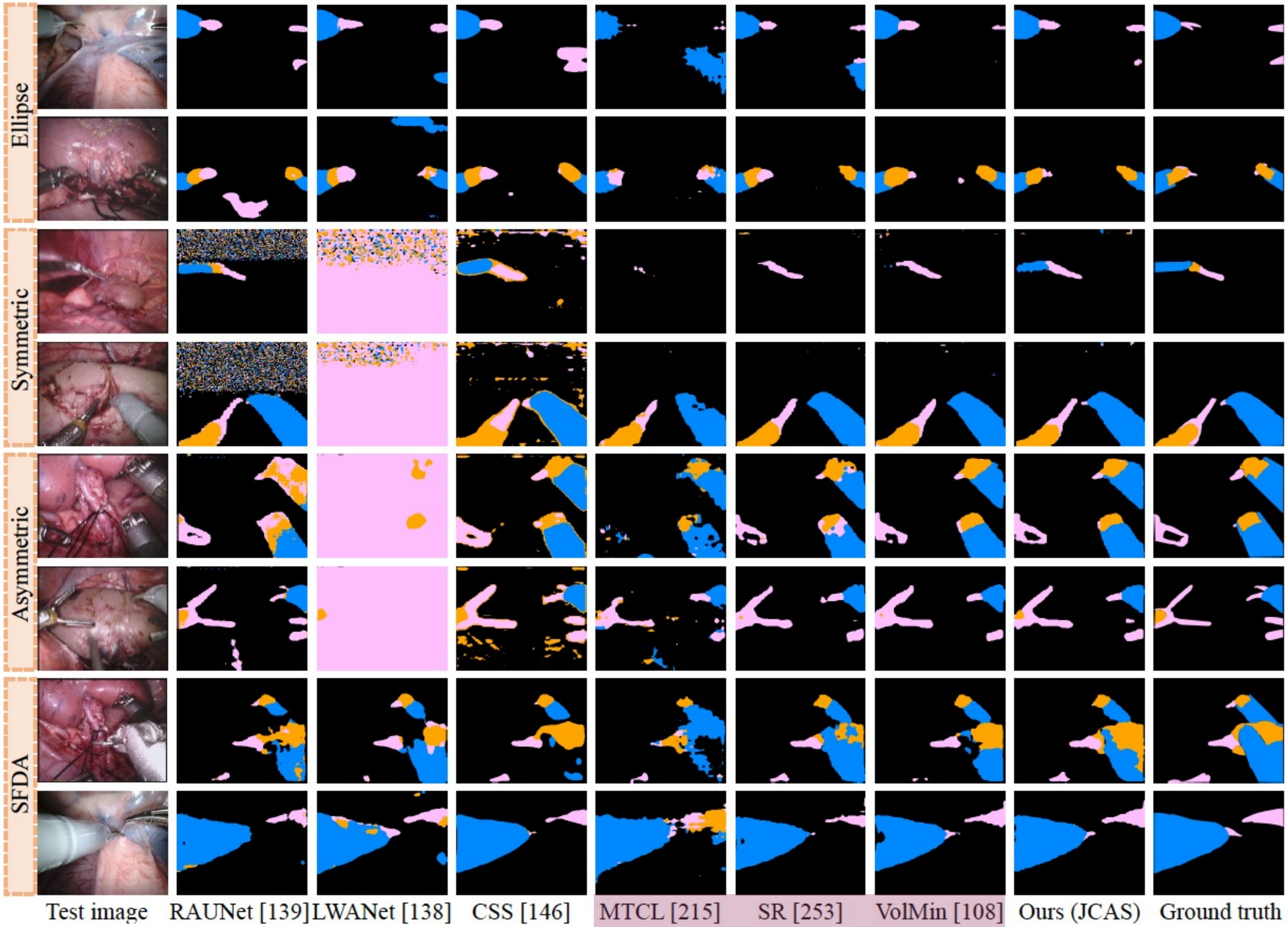


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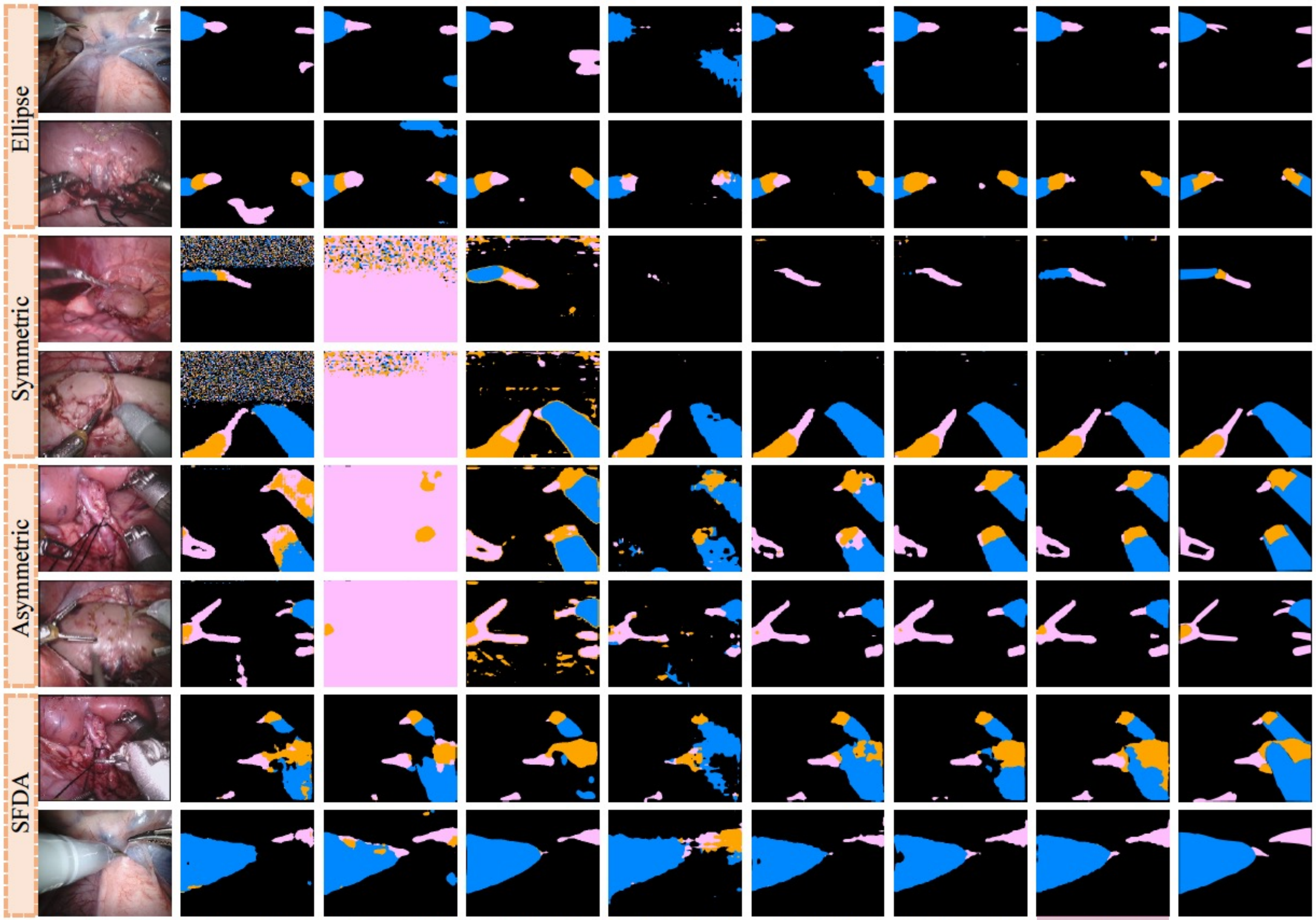


Test image RAUNet [139] LWANet [138] CSS [146] MTCL [215] SR [253] VolMin [108] Ours (JCAS) Ground truth

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# Experiment

- **Experimental results**
  - Ablation study under ellipse label noise

| Method | Shaft | | Wrist | | Clasper | | Average | |
|---|---|---|---|---|---|---|---|---|
| | *Dice (%)* | *Jac (%)* | *Dice (%)* | *Jac (%)* | *Dice (%)* | *Jac (%)* | *Dice (%)* | *Jac (%)* |
| Upper bound | 88.740 | 81.699 | 65.045 | 52.627 | 70.531 | 56.618 | 74.772 | 63.648 |
| Baseline [18] | 79.021 | 68.097 | 42.069 | 29.582 | 55.489 | 40.175 | 58.860 | 45.951 |
| w/ Affinity | 82.158 | 72.339 | 49.128 | 35.455 | 58.933 | 43.594 | 63.406 | 50.463 |
| w/ DAR | 82.698 | 72.992 | 52.207 | 38.442 | 61.544 | 46.027 | 65.483 | 52.487 |
| w/ CALC | 82.973 | 73.126 | 61.885 | 47.527 | 60.416 | 44.821 | 68.425 | 55.158 |
| Ours (JCAS) | **84.683** | 75.378 | **65.599** | **51.623** | 63.871 | 48.356 | **71.384** | **58.452** |

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  - Curve of test $Jac$ vs. epoch with four different types of noise labels

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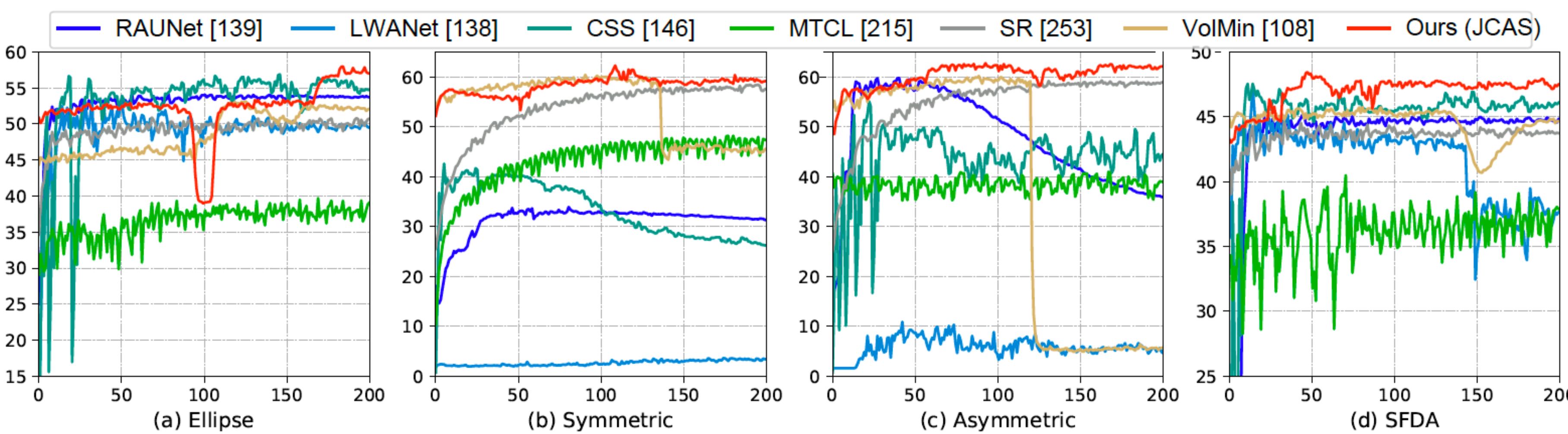


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# Thanks!

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Paper Code