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# TopDiG: Class-agnostic Topological Directional Graph Extraction from Remote Sensing Images


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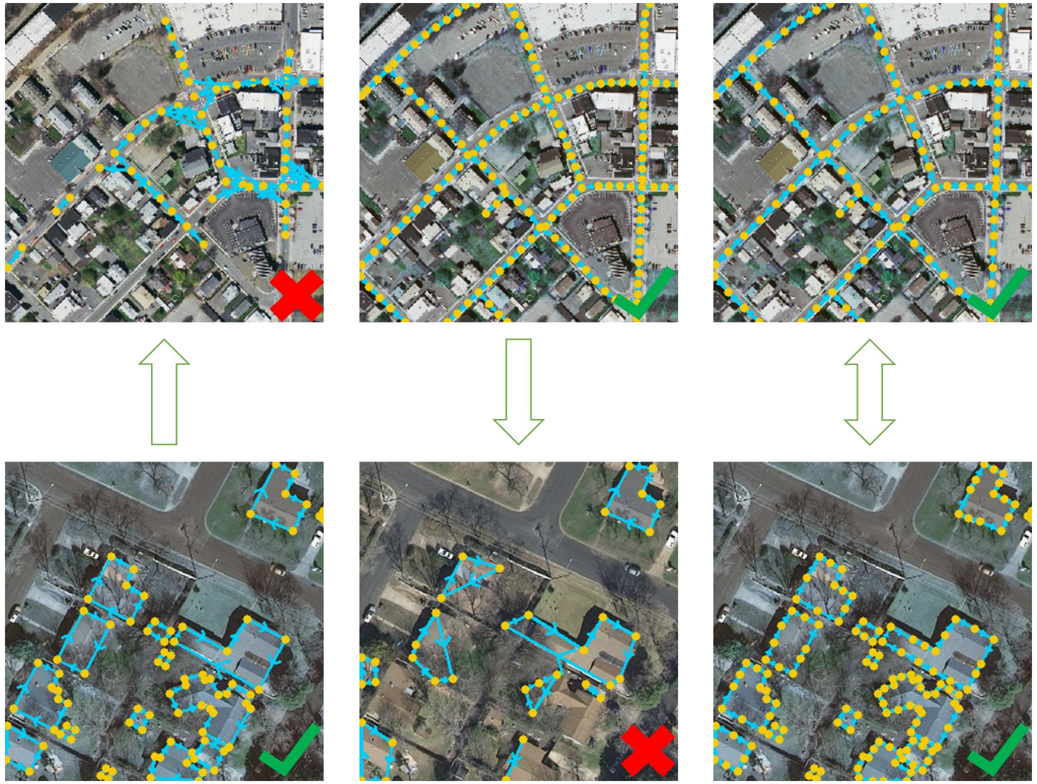
## Challenges:

- Most existing vector extraction works **focus on a specific target** and are **fragile to category variety;**
- Especially Line- and polygon-shape objects are very **different in topological structure.**

## Contributions:

- We propose an innovative **class-agnostic** model **TopDiG**, to directly extract topological directional graphs from remote sensing images **regardless of target types.**
- We design topology-concentrated **node detector** to extract nodes and corresponding features **for both line- and polygon-shape targets**.
- We conduct **dynamic graph supervision** strategy to **facilitate inference in practice .**



(a)PolyWorld (b)Enhanced iCurb (c)Ours

TopDiG can extract vector topology of both line- and polygon-shape objects

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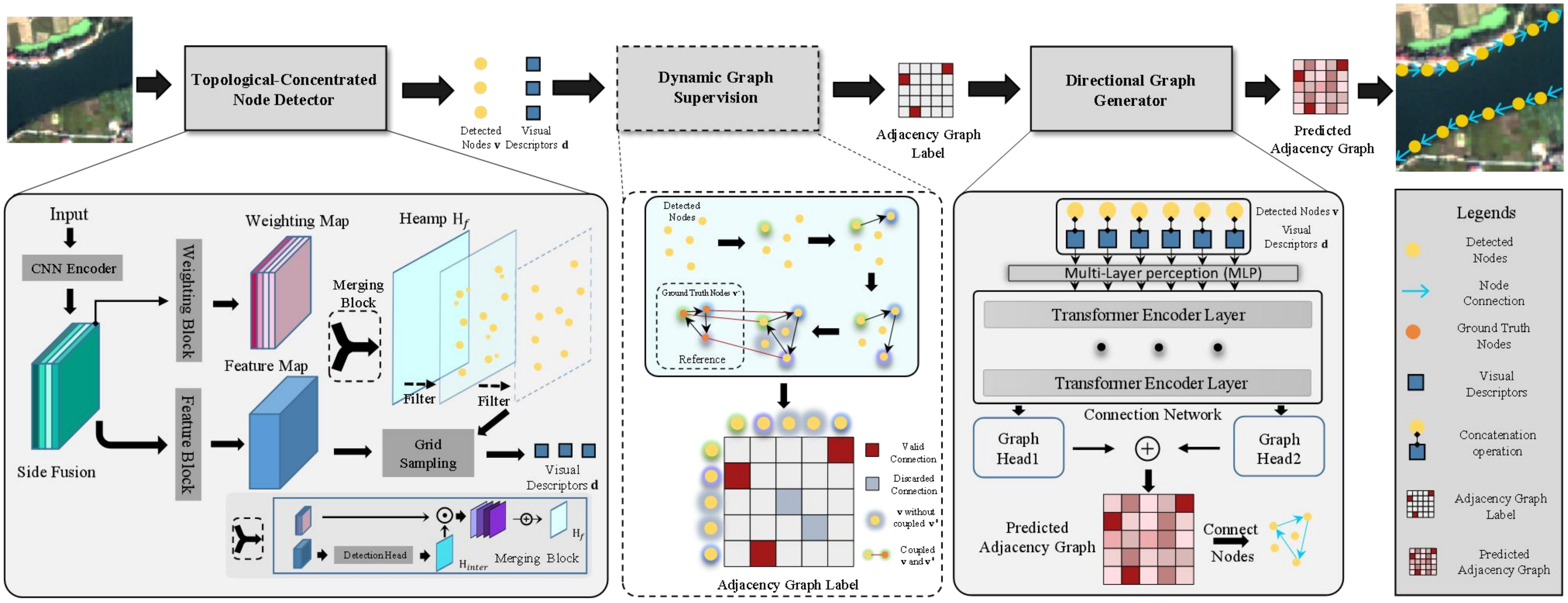
**TopDiG** formulates diverse vector topological structures **as directional graphs** and works by sequentially predicting target **nodes and their connections.**

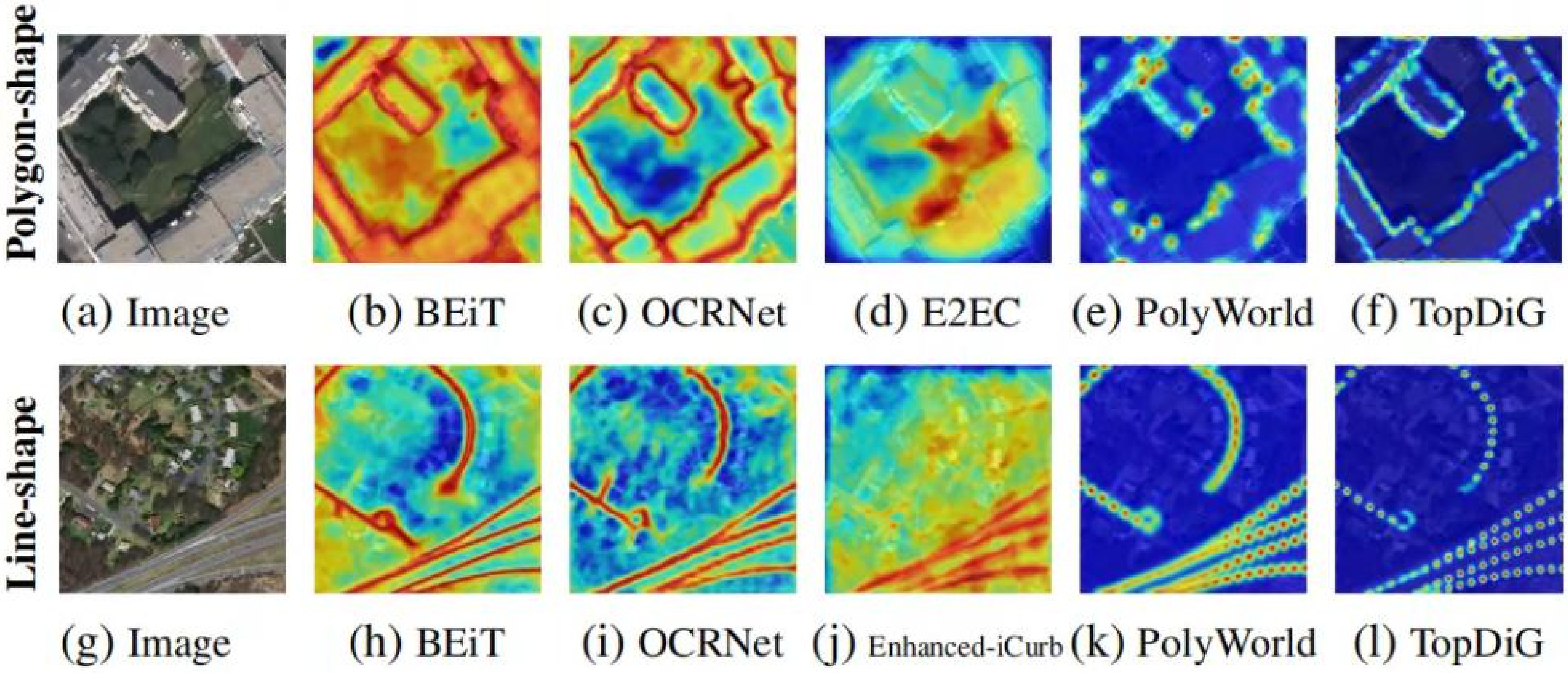



(a) TCND (b) DGS (c) DiG generator

The pipeline of TopDiG

**Topology-Concentrated Node detector(TCND):**

- In satellite and aerial images, line shape objects can be seen as edges
- TCND minimizes sematic contexts and concentrates on low-level geometric features to achieve category independency




Visual comparison of attentive maps for a few methods

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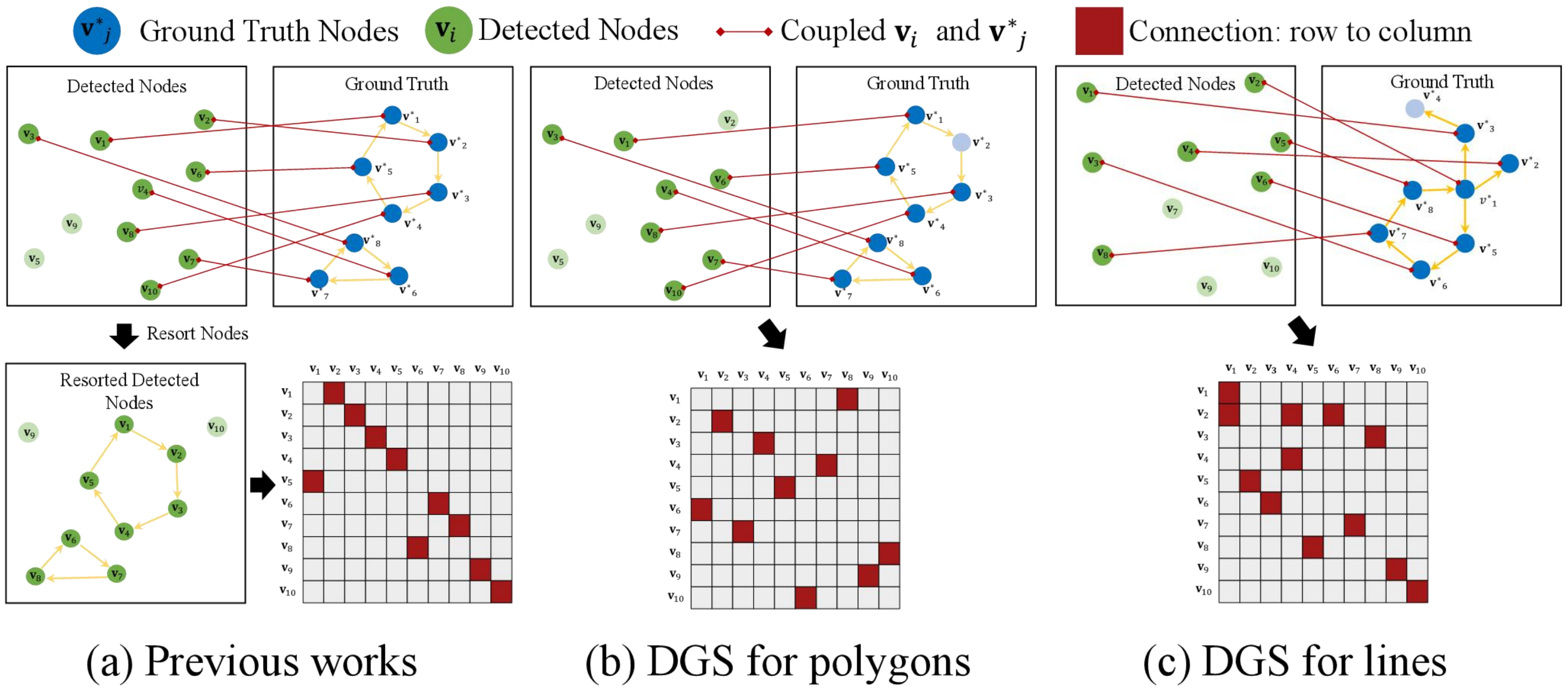
## Dynamic Graph Supervision(DGS):

- Dynamically generates adjacency matrix labels according to real-time unordered predict nodes in each training

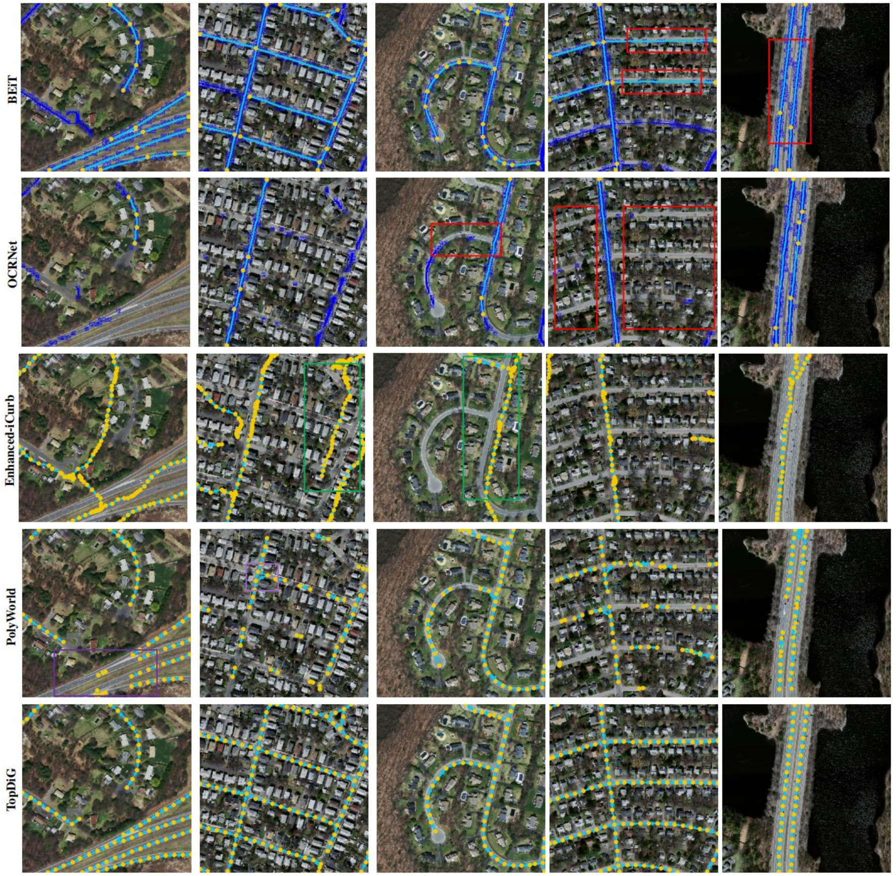



Visual comparison of the adjacency matrix label generation by previous works and DGS

## Visual comparison:

- TopDiG performs better in topology quality and completeness, especially in concave/hierarchical polygon contours and parallel/crossing line object centerlines

Comparison in **Inria** dataset


Comparison in **Massachusetts** dataset

## Quantitative comparison:

- TopDiG obtains competitive scores in pixel-wise metrics
- TopDiG achieve state-of-the-art performance in topology-wise metrics

| Dataset | Method | Pixel-wise Metrics $PA^{mask}\uparrow$ | $F1^{mask}\uparrow$ | $mIoU^{mask}\uparrow$ | Topology-wise Metrics $PA^{topo}\uparrow$ | $F1^{topo}\uparrow$ | $mIoU^{topo}\uparrow$ | $APLS\uparrow$ |
|---|---|---|---|---|---|---|---|---|
| **Inria** [20] | DeepLabV3 | 94.94 | 91.93 | 85.45 | 93.20 | 76.77 | 66.48 | 40.48 |
| | E2EC | 88.46 | 70.85 | 63.64 | 92.69 | 65.83 | 58.61 | 39.46 |
| | PolyWorld | 90.82 | 83.54 | 73.41 | 92.92 | 73.60 | 63.47 | 40.03 |
| | Ours | 94.70 | 91.32 | 84.56 | 93.88 | 78.47 | 68.39 | 48.09 |
| **CrowdAI** [20] | DeepLabV3 | 97.08 | 95.74 | 91.92 | 94.82 | 83.49 | 74.06 | 48.07 |
| | E2EC | 95.62 | 92.11 | 86.72 | 93.70 | 78.67 | 69.13 | 36.05 |
| | PolyWorld | 93.67 | 90.29 | 82.89 | 93.21 | 77.71 | 67.43 | 51.73 |
| | Ours | 96.45 | 94.77 | 90.23 | 94.51 | 82.20 | 72.51 | 59.61 |
| **GID** [27] | DeepLabV3 | 99.05 | 97.34 | 94.92 | 99.23 | 79.27 | 70.55 | 80.14 |
| | E2EC | 98.85 | 76.03 | 69.68 | 99.16 | 73.90 | 66.32 | 76.17 |
| | PolyWorld | 98.07 | 90.05 | 85.66 | 99.17 | 73.65 | 66.04 | 75.84 |
| | Ours | 99.17 | 96.52 | 93.94 | 99.39 | 82.56 | 74.51 | 85.24 |
| **GF2** [37] | DeepLabV3 | 99.24 | 98.14 | 96.40 | 99.11 | 79.46 | 70.70 | 77.90 |
| | E2EC | 99.25 | 81.29 | 75.37 | 99.01 | 75.96 | 67.83 | 74.34 |
| | PolyWorld | 98.55 | 94.68 | 91.10 | 98.98 | 75.51 | 67.20 | 73.63 |
| | Ours | 99.40 | 98.20 | 96.56 | 99.28 | 83.57 | 75.28 | 81.31 |
| **Massachusetts** [19] | DeepLabV3 | - | - | - | 95.75 | 77.94 | 68.30 | 51.40 |
| | PolyWorld | - | - | - | 94.28 | 76.56 | 66.59 | 47.74 |
| | Ours | - | - | - | 95.16 | 80.33 | 70.66 | 64.60 |

Quantitative comparison of TopDiG with segmentation-based, contour-based and graph generation methods