**Deep Learning-Based Change Detection of Forest, Water, Barren Land, and Human Activity**

There have been many studies that use deep learning techniques to monitor land use [1], forest coverage [2], and desertification [3]. Previous studies have also used deep learning-based change detection to monitor urban forest cover change [4]. This study aims to perform change detection of forest, water, barren land, and human activity by using deeply supervised image fusion network (DSIFN) [5] to create change maps and Deeplabv3 model fine-tuned for image segmentation [6].

**Keywords:** deep learning; transfer learning; forest cover change detection; river change detection; barren land detection; very high resolution (VHR); DeepLabv3+; deeply supervised image fusion network (DSIFN); desertification

**Expected output**

* Change map of a region based on pre- and post-change VHR satellite image of region.
* Grayscale segmented 2D map of an urban region, based VHR satellite image, classes include forest, water, barren land, and human activity (buildings, roads, agriculture).

**Potential use**

* Forest conservation:
  + Monitoring.
  + Intervention impact analysis.
* Urban planning:
  + City growth.
* Desertification identification:
  + Monitoring.
  + Intervention impact analysis.

**Datasets**

* LoveDA <https://github.com/Junjue-Wang/LoveDA> [7]
* Change Detection Dataset <https://drive.google.com/file/d/1GX656JqqOyBi_Ef0w65kDGVto-nHrNs9> [8]

**Unexplored Datasets**

* Sourcing from Google Earth Engine GEE <https://earthengine.google.com/>

**Data Preparation**

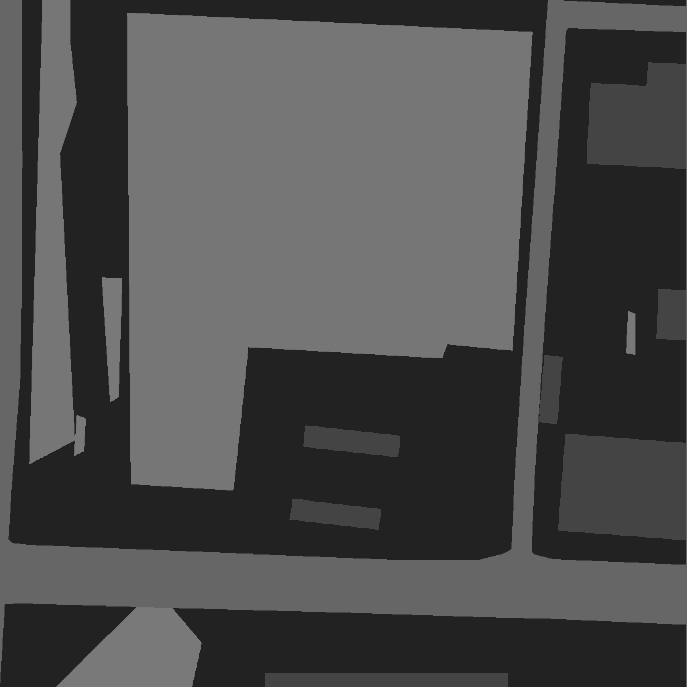
1. LoveDA [7]

Category labels: background – 1, building – 2, road – 3, water – 4, barren – 5, forest – 6, agriculture – 7. And the no-data regions were assigned 0 which should be ignored. The provided data loader will help you construct your pipeline.

Original image and mask:

An aerial view of a construction site

Description automatically generated



Merged labels:

* Forest: 6 -> 1 (Bright Green)
* Water: 4 -> 2 (Bright Blue)
* Barren land: 5 -> 3 (Bright Orange)
* Human activity: 2, 3, 7 -> 4 (Bright Magenta)
* Background: 1 -> 5 (Gray)
* No-data: 0 -> 0 (Black)

Image ‘1366’ from train dataset:

A map of a city

Description automatically generated A colorful squares and rectangles

Description automatically generated

Image ‘3520’ from validation dataset:

A map of a city

Description automatically generatedA map of different colors

Description automatically generated

Processed dataset: <https://drive.google.com/drive/folders/1AX5DdNeSseyn3rN89jYoNEznxX7QCUgH?usp=sharing>

1. Change Detection Dataset (CDD) [8]

Image ‘19’ from Real/subset/train. From left to right, A-B-OUT.

Aerial view of a neighborhood

Description automatically generated A car parked next to a road

Description automatically generated A black and white map

Description automatically generated

**Transfer learning**

1. DeepLabv3+ [6,9]

Using model weights from PyTorch [Deeplabv3-ResNet-101](https://pytorch.org/hub/pytorch_vision_deeplabv3_resnet101/). Trained fro 20 epochs, on LoveDA [7].

1. VGG16

No additional fitting is done. Model up to pool5 is used for feature extraction [10].

**Deeply Supervised Image Fusion Network (DSIFN)** Trained for 50 epochs on CDD [8].

Trained model: <https://drive.google.com/file/d/1FvhzXGa9grV2fcWcrTcKyfRg9HVwf81y/view?usp=sharing>

**Generated Change Maps**

A collage of images of a road

Description automatically generated

**Validation**

On validation set (2998 samples), model achieved mean F1 score of 0.65466. This might be due to limited training time and variation in training dataset. Variation in training dataset can be increased with the use of transforms in PyTorch.

**Generated Urban Activity Segmentation**

**Reference**

[1] M. S. Boori, M. Netzband, K. Choudhary, and V. Voženílek, “Monitoring and modeling of urban sprawl through remote sensing and GIS in Kuala Lumpur, Malaysia,” Ecological Processes, vol. 4, no. 1, Nov. 2015, doi: <https://doi.org/10.1186/s13717-015-0040-2>.

[2] Z. Li, B. Chen, S. Wu, M. Su, J. M. Chen, and B. Xu, “Deep learning for urban land use category classification: A review and experimental assessment,” Remote Sensing of Environment, vol. 311, pp. 114290–114290, Jul. 2024, doi: <https://doi.org/10.1016/j.rse.2024.114290>.

[3] Arslan Berdyyev, Y. A. Al-Masnay, Mukhiddin Juliev, and Jilili Abuduwaili, “Desertification Monitoring Using Machine Learning Techniques with Multiple Indicators Derived from Sentinel-2 in Turkmenistan,” Remote Sensing, vol. 16, no. 23, pp. 4525–4525, Dec. 2024, doi: <https://doi.org/10.3390/rs16234525>.

[4] A. Javed, T. Kim, C. Lee, J. Oh, and Y. Han, “Deep Learning-Based Detection of Urban Forest Cover Change along with Overall Urban Changes Using Very-High-Resolution Satellite Images,” Remote Sensing, vol. 15, no. 17, pp. 4285–4285, Aug. 2023, doi: <https://doi.org/10.3390/rs15174285>.

[5] C. Zhang et al., “A deeply supervised image fusion network for change detection in high resolution bi-temporal remote sensing images,” ISPRS Journal of Photogrammetry and Remote Sensing, vol. 166, pp. 183–200, Aug. 2020, doi: <https://doi.org/10.1016/j.isprsjprs.2020.06.003>.

[6] L.-C. Chen, G. Papandreou, F. Schroff, and H. Adam, “Rethinking Atrous Convolution for Semantic Image Segmentation,” arxiv.org, Jun. 2017, Available: https://arxiv.org/abs/1706.05587

[7] J. Wang, Z. Zheng, A. Ma, X. Lu, and Y. Zhong, “LoveDA: A Remote Sensing Land-Cover Dataset for Domain Adaptive Semantic Segmentation,” Proceedings of the Neural Information Processing Systems Track on Datasets and Benchmarks, Oct. 2021, Available: <https://www.researchgate.net/publication/355390292_LoveDA_A_Remote_Sensing_Land-Cover_Dataset_for_Domain_Adaptive_Semantic_Segmentation>

[8] M. A. Lebedev, Y. V. Vizilter, O. V. Vygolov, V. A. Knyaz, and A. Y. Rubis, “CHANGE DETECTION IN REMOTE SENSING IMAGES USING CONDITIONAL ADVERSARIAL NETWORKS,” The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, vol. XLII–2, pp. 565–571, May 2018, doi: <https://doi.org/10.5194/isprs-archives-xlii-2-565-2018>.

[9] M. S. Minhas, “Transfer Learning for Semantic Segmentation using PyTorch DeepLab v3,” GitHub.com/msminhas93, 12-Sep-2019. [Online]. Available: <https://github.com/msminhas93/DeepLabv3FineTuning>.

[10] K. Simonyan and A. Zisserman, “Very Deep Convolutional Networks for Large-Scale Image Recognition,” arXiv.org, Apr. 10, 2015. https://arxiv.org/abs/1409.1556

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