Active learning based semantic segmentation for extraction of minute objects from multispectral satellite images

R Abhishek *(220CS0004)*
Deepak Rathore *(118CS0044)*

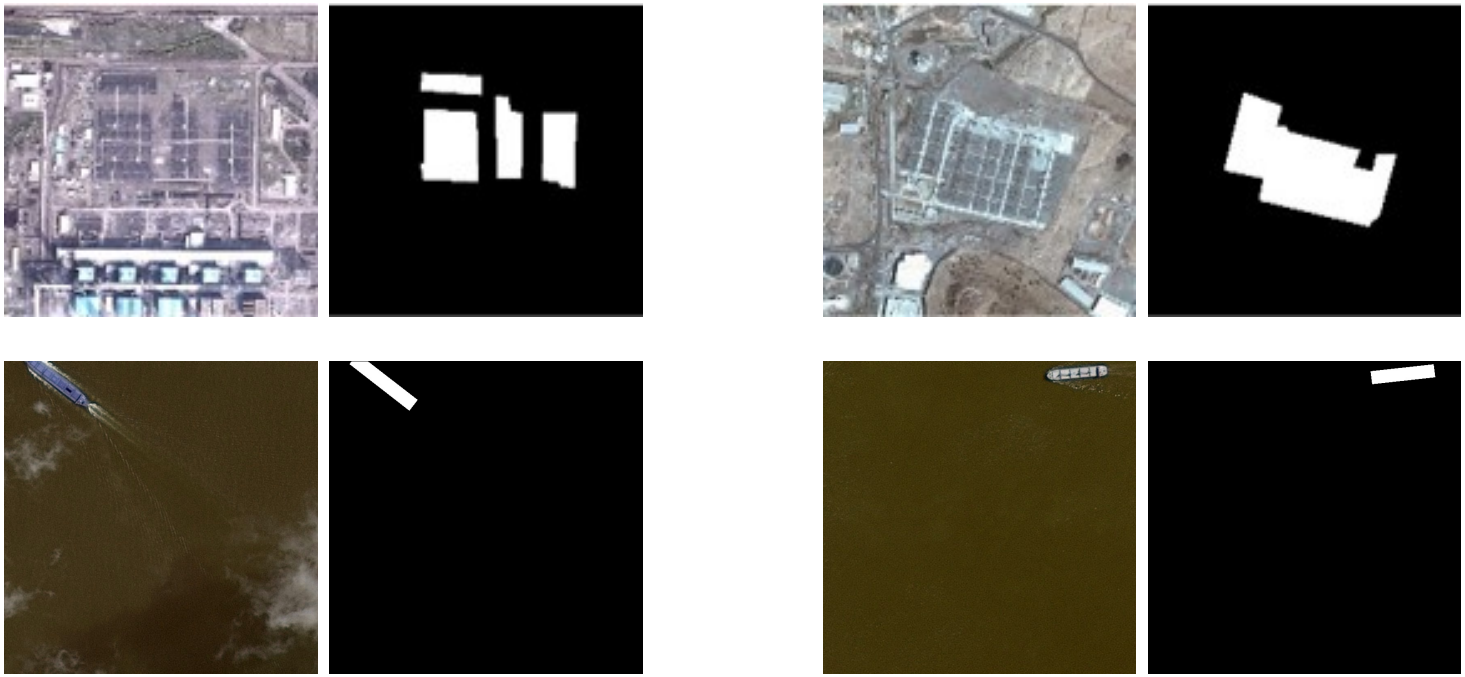
Indian Institute of Information Technology, Design and Manufacturing, Kurnool

Guided by: Dr. Shounak Chakraborty

May 04, 2022

Problem Definition

- Semantic Segmentation on images captured by Unmanned aerial vehicle and satellite images.
- Here in our problem statement we are using multi-spectral images.



Case Study

Case Study 1: Detecting Electrical substations from images captured by the Drones



Case Study 2: Detecting Ships From aerial captured images



Previous Approaches for Semantic Segmentation from aerial captured images

S.No.	Methodology	Scope of Improvisation
1.	A Simple U-Net is used for Medical image segmentation	The Conv blocks could have been a pre trained model rather than a custom conv-U-Net.
2.	A Residual – U-Net is used for nuclei segmentation	Attention gates could have been implemented for better IoU.

S.No.	References
1.	Ronneberger, O., Fischer, P., & Brox, T. (2015, October). U-net: Convolutional networks for biomedical image segmentation. In *International Conference on Medical image computing and computer-assisted intervention* (pp. 234-241). Springer, Cham.
2.	Li, C., Liu, Y., Yin, H., Li, Y., Guo, Q., Zhang, L., & Du, P. (2021, July). Attention Residual U-Net for Building Segmentation in Aerial Images. In *2021 IEEE International Geoscience and Remote Sensing Symposium IGARSS* (pp. 4047-4050). IEEE

Previous Approaches for Semantic Segmentation from aerial captured images

S.No.	Methodology	Scope of Improvisation
3.	An Edge FCN based neural network is used for semantic segmentation	Fails in case of discrete object detection since its totally on edge based.
4.	A PP-link net based approach is used for solving the problem	Attention gates could have been implemented since target based learning is missed out.

S.No.	References
3.	He, C., Li, S., Xiong, D., Fang, P., & Liao, M. (2020). Remote sensing image semantic segmentation based on edge information guidance. *Remote Sensing*, 12(9), 1501.
4.	Wu, M., Zhang, C., Liu, J., Zhou, L., & Li, X. (2019). Towards accurate high resolution satellite image semantic segmentation. *IEEE Access*, 7, 55609-55619.

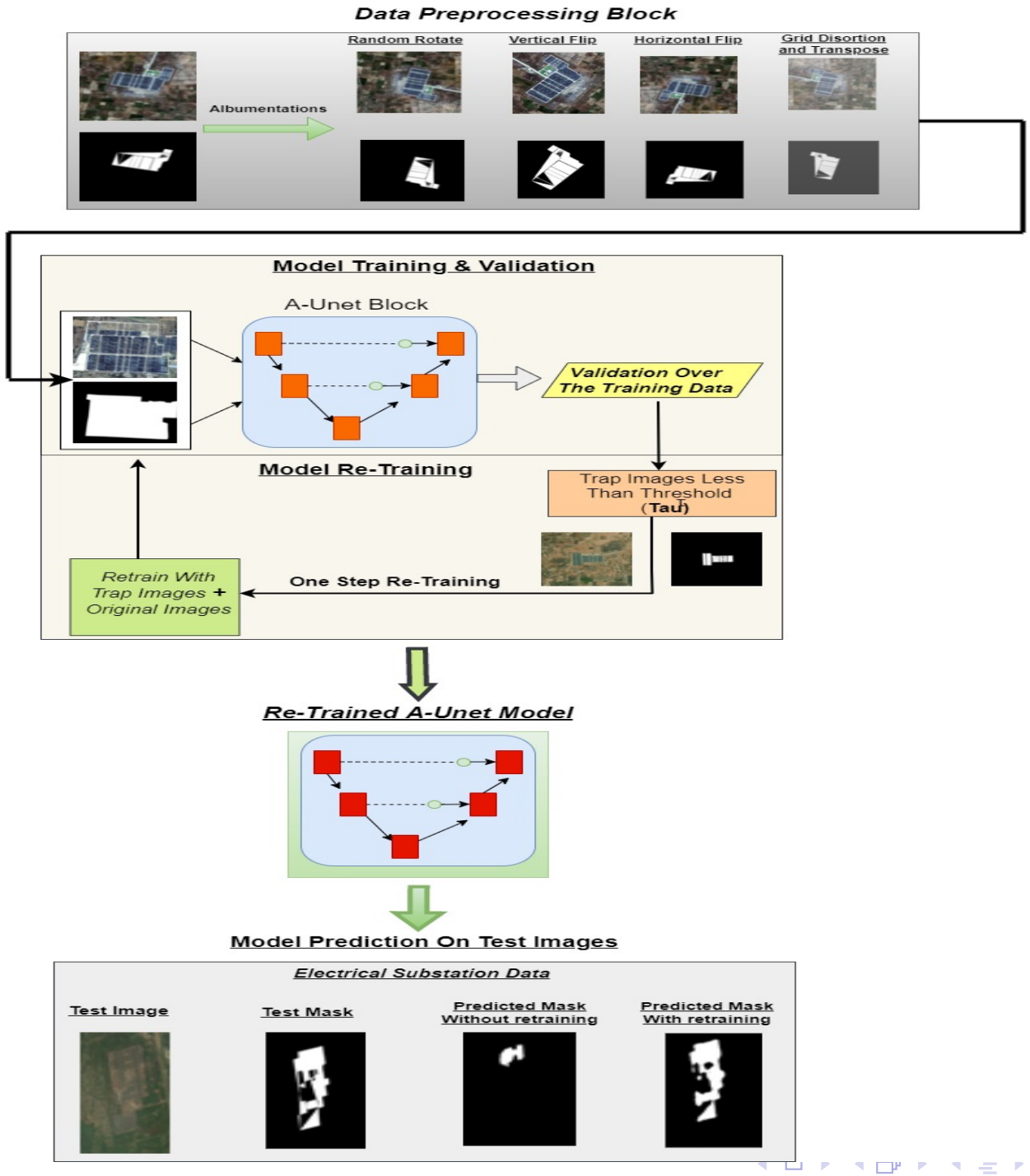
Previous Approaches for Semantic Segmentation from aerial captured images

S.No.	Methodology	Scope of Improvisation
5.	An Attention U-net is used for detecting and segmenting of Buildings from an image captured from an aerial view.	Target based feature extraction is used but backbone convolutional network is dense.
6.	An Attention U-Net model on the images captured by satellite images for Cloud detection.	No scope of semi supervised learning approach applied.

S.No.	References
5.	Li, C., Liu, Y., Yin, H., Li, Y., Guo, Q., Zhang, L., & Du, P. (2021, July). Attention Residual U-Net for Building Segmentation in Aerial Images. In *2021 IEEE International Geoscience and Remote Sensing Symposium IGARSS* (pp. 4047-4050). IEEE.
6.	Guo, Y., Cao, X., Liu, B., & Gao, M. (2020). Cloud detection for satellite imagery using attention-based U-Net convolutional neural network. *Symmetry*, 12(6), 1056.

Proposed Deep Learning Methodology:

- The objective here is to identify minute and discrete objects from the remotely sensed images considered in the case study.
- This objective is attained through using a novel active learning technique which is inculcated along with semi-supervision strategy, using an attention based U-net model with pre-trained back bone of dense-net in every encoder decoder level.
- The experimentation has been carried out into two phases: pre-processing of the images (P) and training of a Attention U-NET architecture to obtain the segmented mask of the electrical substation.


Data Preprocessing Block
Random Rotate
Vertical Flip
Horizontal Flip
Grid Disortion and Transpose
Albumentations
Model Training & Validation
A-Unet Block
Validation Over The Training Data
Model Re-Training
Trap Images Less Than Threshold (Tau)
Retrain With Trap Images + Original Images
One Step Re-Training
Re-Trained A-Unet Model
Model Prediction On Test Images
Electrical Substation Data
Test Image
Test Mask
Predicted Mask Without retraining
Predicted Mask With retraining

Data Pre-processing

Albumentation technique: augmentation techniques to increase the number of images in the training set from 80 to 500 so as to be suitable for deep learning mechanism

- ⋆ Vertical flip : Flip the input vertically around X-axis
- ⋆ Horizontal flip : Flip the input horizontally around Y-axis
- ⋆ Random rotation : Randomly rotate the input by 90 degrees
- ⋆ Grid distortion : Creates grids and adds distortion to the image
- ⋆ Transpose : Transpose the input by swapping rows and columns

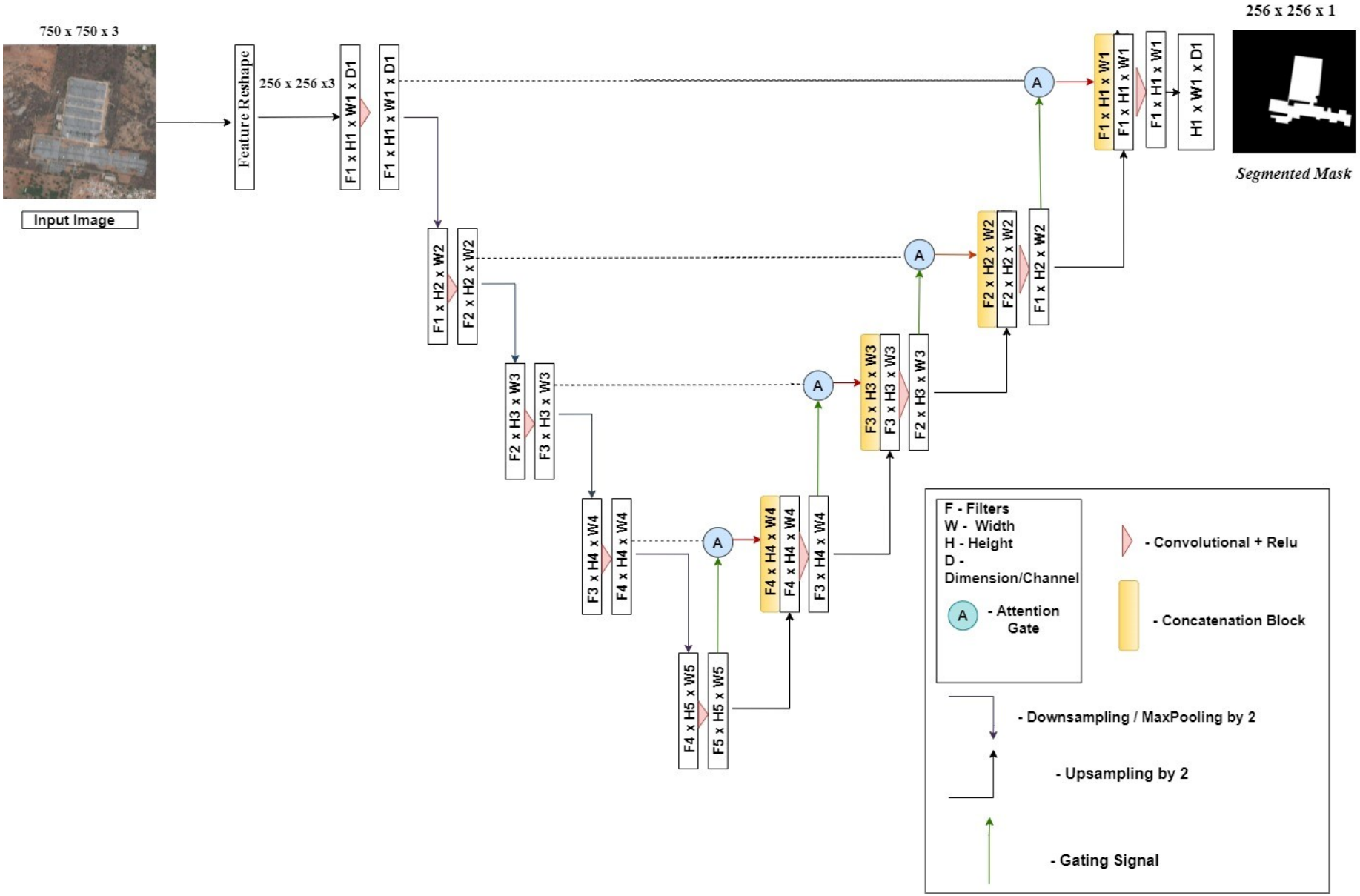
Data Pre-processing

- Reshaping of training images: The images are reshaped from 750x750x3 to 256x256x3.
- Validation split: From the training images 20 percent of the images (i.e., 100) is used for training validation.

Training Images

Validation Images

Model Architecture



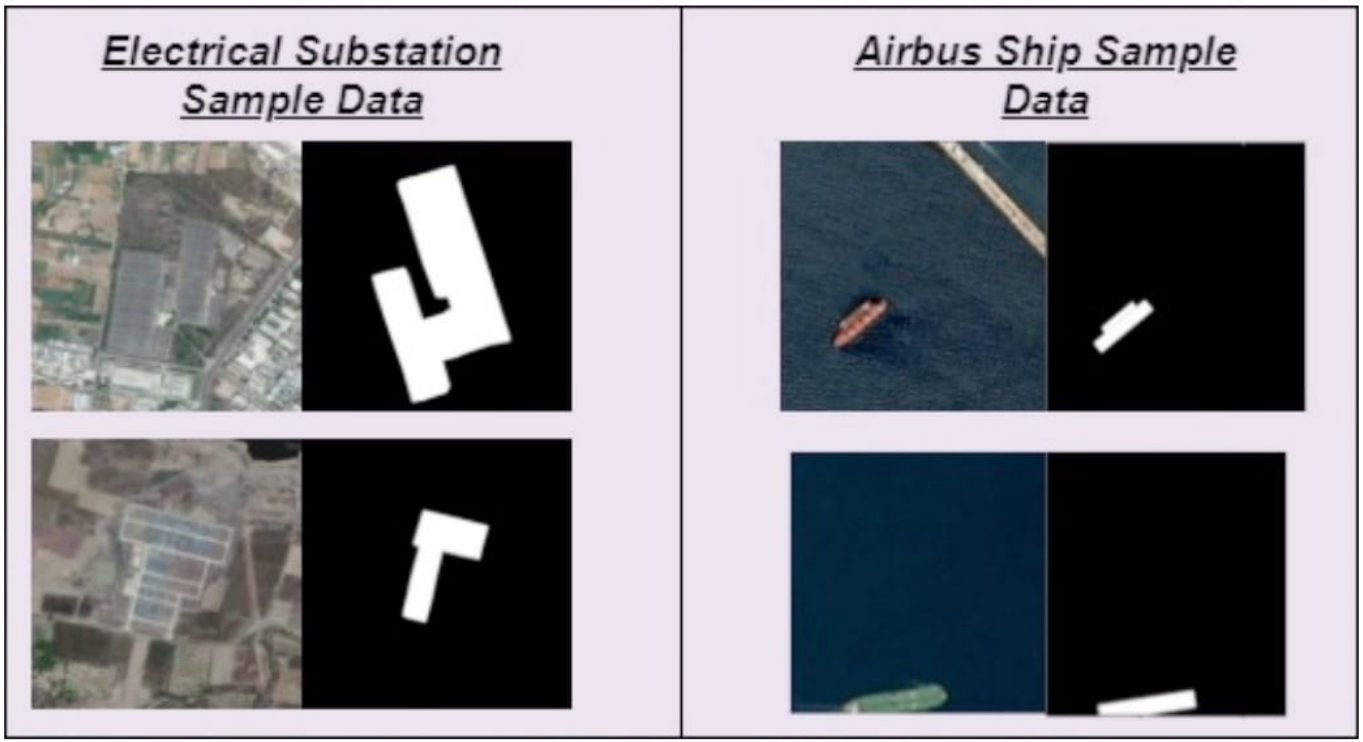
Dataset Used

Electrical Substation Dataset

Provided by: Maharashtra Remote Sensing Application Center & National Remote Sensing Center , Nagpur

Ship Dataset

Provided by: Maritime Surveillance –intelligence-airbusds.com



Substation Dataset Results

Using Attention U-Net Model without Semi-supervision

Total images	Train test ratio	Images in Training set	Images in Testing set	Mean IOU Training	Mean IOU for test set
100	80:20	80 to 500	20	0.93468344	0.82584034
100	50:50	50 to 500	20	0.90358849	0.76686604

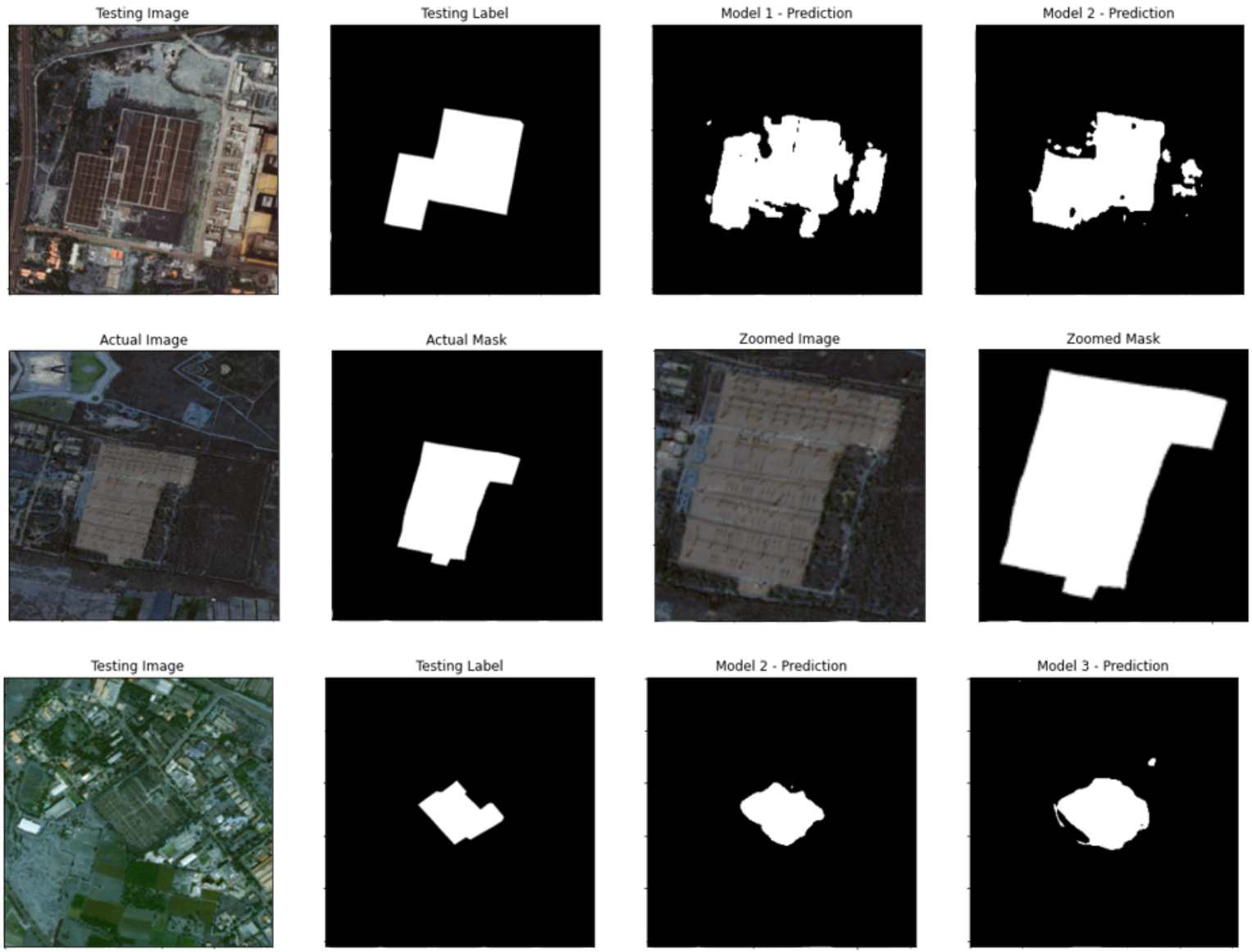
Semi-supervision Model with including images having less IoU

Total images	Train test ratio	Trapped Images	Extra reinforced images	Mean IOU Training	Mean IOU for test set
100	80:20	23	23 to 100	0.94353674	0.8430669
100	50:50	53	53 to 100	0.69933308	0.47903764

Semi-supervision Model with including zoomed images having less IoU

Total images	Train test ratio	Trapped Images	Extra reinforced images	Mean IOU Training	Mean IOU for test set
100	80:20	23	23 to 100	0.90064789	0.64942634
100	50:50	53	53 to 100	0.7452607	0.48823328

Results comparison pre & post retraining



Ship Dataset Results

Using Attention U-Net Model without Semi-supervision

Total images	Train test ratio	Images in Training set	Images in Testing set	Mean IOU Training	Mean IOU for test set
2236	80:20	1788	448	0.84554285	0.6768785
2236	50:50	1118	1118	0.8637305	0.607625

Semi-supervision Model with including images having less IoU

Total images	Train test ratio	Trapped Images	Extra reinforced images	Mean IOU Training	Mean IOU for test set
2236	80:20	190	250	0.84390473	0.76793927
2236	50:50	115	250	0.4869841	0.48726624

Semi-supervision Model with including zoomed images having less IoU

Total images	Train test ratio	Trapped Images	Extra reinforced images	Mean IOU Training	Mean IOU for test set
2236	80:20	190	250	0.8168265	0.7613674
2236	50:50	115	250	0.83933604	0.77072966

Performance Comparison with State of the art models
Proof of concept

Table: Performance (mIoU) of the proposed model (PM)

Datasets	Train-test ratio	Linknet	Hybrid Unet	PP Linknet	Res-UNet	Trapped images	PM with zoom	PM without zoom
Electrical Substation	80-20	0.54	0.61	0.59	0.58	23	**0.650**	**0.843**
	50-50	0.23	0.30	0.20	0.31	53	**0.488**	**0.480**
Ship Dataset	80-20	0.46	0.52	0.51	0.60	190	**0.761**	**0.768**
	70-30	0.43	0.47	0.45	0.57	175	**0.756**	**0.785**
	50-50	0.33	0.35	0.39	43	115	**0.770**	**0.487**

Future Work

- ⋆ Work on self supervised learning for the similar problem statement overcome manual annotation of labelling and to reduce labelling efforts using vision transformers and modality specific data method.
- ⋆ Haze Removal using Dark channel Prior in case working with real time data.
- ⋆ Work on Multi-category object detection and semantic segmentation
- ⋆ Working on semi supervised approach for predicting labels for unlabelled data using Generative adversarial neural network (Gan's) using train set validation approach.

References

[1] Chakraborty, S., & Roy, M. (2018). A neural approach under transfer learning for domain adaptation in land-cover classification using two-level cluster mapping. *Applied Soft Computing*, 64, 508-525.

[2] Li, C., Liu, Y., Yin, H., Li, Y., Guo, Q., Zhang, L., & Du, P. (2021, July). Attention Residual U-Net for Building Segmentation in Aerial Images. In *2021 IEEE International Geoscience and Remote Sensing Symposium IGARSS* (pp. 4047-4050). IEEE.

[3] Alom, M. Z., Yakopcic, C., Taha, T. M., & Asari, V. K. (2018, July). Nuclei segmentation with recurrent residual convolutional neural networks based U-Net (R2U-Net). In *NAECON 2018-IEEE National Aerospace and Electronics Conference* (pp. 228-233). IEEE.

[4] Haroun, F. M. E., Deros, S. N. M., & Din, N. M. (2021). Detection and Monitoring of Power Line Corridor From Satellite Imagery Using Retina Net and K-Mean Clustering. *IEEE Access*, 9, 116720-116730.

References

[5] Guo, Y., Cao, X., Liu, B., Gao, M. (2020). Cloud detection for satellite imagery using attention-based U-Net convolutional neural network. *Symmetry*, 12(6), 1056.

[6] Zhang, Y., Guo, L., Wang, Z., Yu, Y., Liu, X., Xu, F. (2020). Intelligent ship detection in remote sensing images based on multi-layer convolutional feature fusion. *Remote Sensing*, 12(20), 3316.

[7] Ronneberger, O., Fischer, P., Brox, T. (2015, October). U-net: Convolutional networks for biomedical image segmentation. In *International Conference on Medical image computing and computer-assisted intervention* (pp. 234-241). Springer, Cham.

Thank You