Automatic flood detection from Sentinel-1 data using Deep learning: Demonstration of NASA-ETCI Benchmark datasets.

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November 16, 2022

Abstract

Floods are the most frequent, costliest natural disasters having devastating consequences on people, infrastructure, and the ecosystem. The accurate and rapid mapping of the flooded areas becomes more crucial when floods strike densely populated cities. During flood events near real-time satellite imagery has been proven to be an efficient management tool for disaster management authorities. However one of the challenges is accurate classification and segmentation of flooded water and permanent water. Binary segmentation using the threshold split-based method is commonly used in this regard, however, the generalization ability of this method is limited due to the effects of backscatter, geographical area, and time of image collection. Recent advancements in deep learning algorithms for image segmentation has demonstrated the excellent potential of Convolutional Neural Networks(CNN) for improving flood detection, although there have been limited studies in this domain due to the lack of large scale labeled flood event dataset. In this project, we present a U-net based deep learning approach by leveraging publicly available Sentinel-1 dataset provided jointly by NASA Interagency Implementation and Advanced Concepts Team and IEEE GRSS Earth Science Informatics Technical Committee. Dataset is composed of 66,810 tiles of 256×256 pixels, distributed respectively across the training, validation and test sets and cover flood events from Nebraska, North Alabama, Bangladesh, Red River North and Florence. Specifically we proposed an Unet architecture based convolutional neural network (CNN) with a backbone of EfficientNetb7, trained against the dataset. We then evaluated the performance of the model with multiple training, testing and validation. Two evaluation methods - Intersection over Union (IOU) and F-Score are adopted to evaluate the model performance. During testing, the model achieved the meanIOU score of 75.06% and F-Score of 74.98%. We hope to further improve the performance of the network by performing hyper-parameter tuning and to develop a model which can be used for near-real-time flood mapping.

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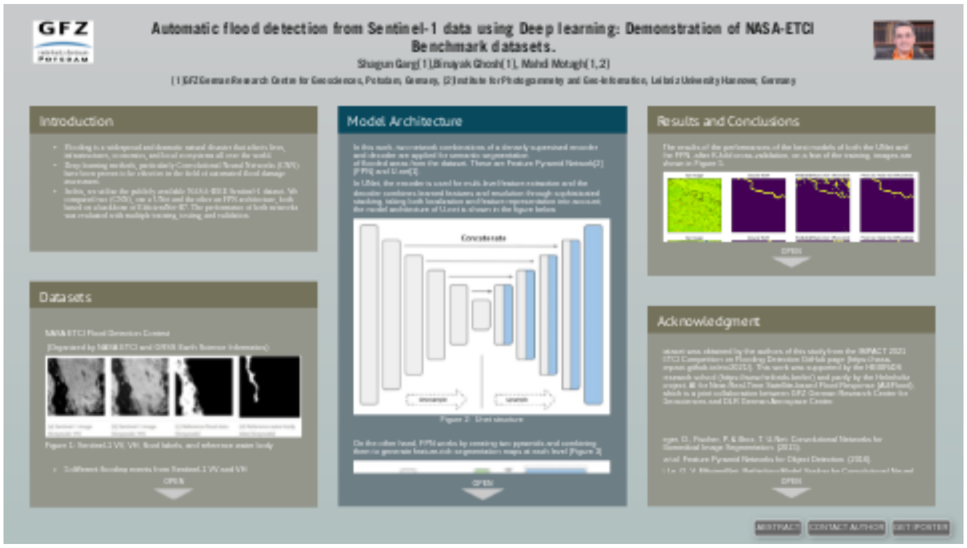

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PRESENTED AT:

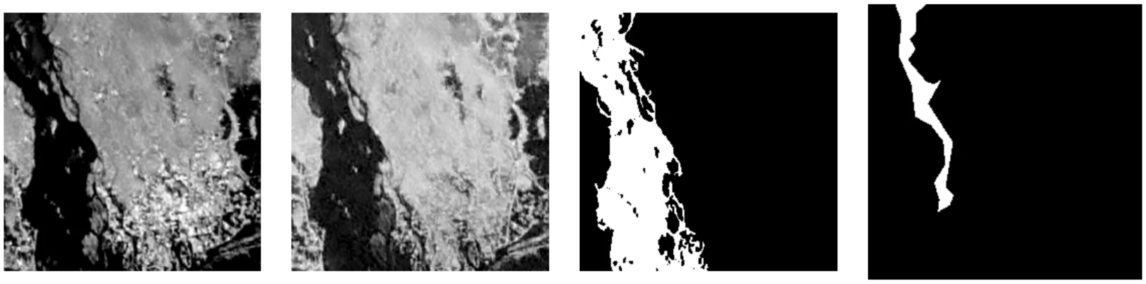
INTRODUCTION

- Flooding is a widespread and dramatic natural disaster that affects lives, infrastructures, economics, and local ecosystems all over the world.
- Deep learning methods, particularly Convolutional Neural Networks (CNN) have been proven to be effective in the field of automated flood damage assessment.
- In this, we utilize the publicly available NASA-IEEE Sentinel-1 dataset. We compared two (CNN), one a UNet and the other an FPN architecture, both based on a backbone of EfficientNet-B7. The performance of both networks was evaluated with multiple training, testing, and validation.

DATASETS

NASA ETCI Flood Detection Contest

(Organized by NASA ETCI and GRSS Earth Science Informatics)



(a) Sentinel-1 image (Grayscale: VV)

(b) Sentinel-1 image (Grayscale: VH)

(c) Reference flood data (Grayscale)

(d) Reference water body data (Grayscale)

Figure 1: Sentinel-1 VV, VH, flood labels, and reference water body

- 5 different flooding events from Sentinel-1 VV and VH
- Interferometric Wide swath mode
- Tile size - 256 x 256 pixel
- Total number of tiles = 56810

MODEL ARCHITECTURE

In this work, two network combinations of a densely supervised encoder and decoder are applied for semantic segmentation
of flooded areas from the dataset. These are Feature Pyramid Network[2] (FPN) and U-net[1].

In UNet, the encoder is used for multi-level feature extraction and the decoder combines learned features and resolution through sophisticated stacking, taking both localization and feature representation into account; the model architecture of U-net is shown in the figure below

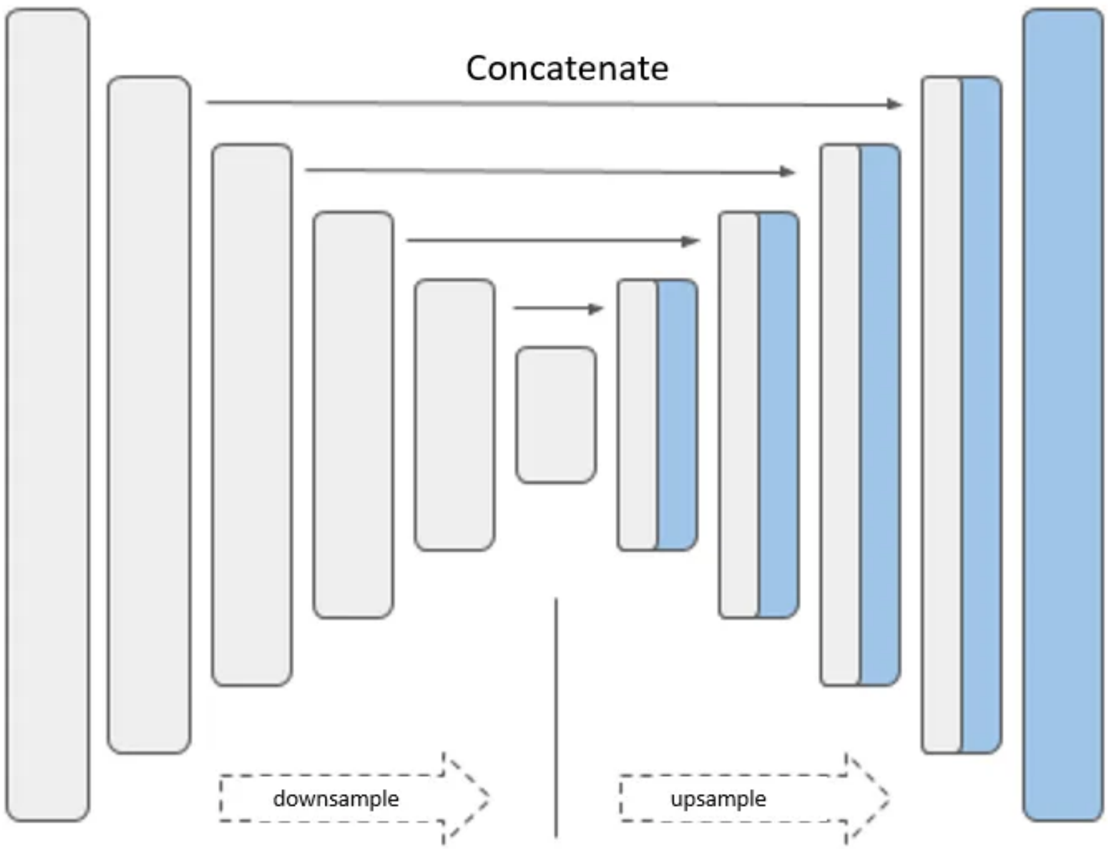


Figure 2: Unet structure

On the other hand, FPN works by creating two pyramids and combining them to generate feature-rich segmentation maps at each level (Figure 3)

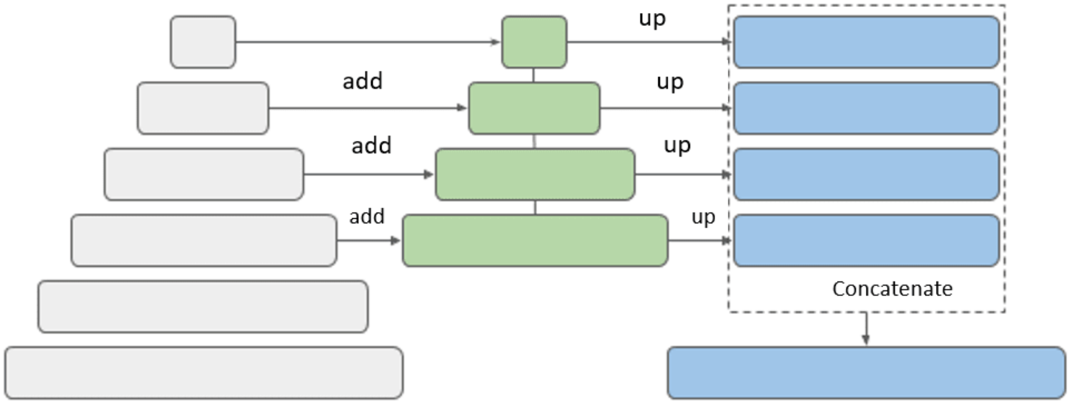


Figure 3: Feature pyramid Structure (FPN) for semantic segmentation

We used EfficientNet B7 [3] (developed by Google in 2019) as the encoder for both models. Efficient net is a baseline framework and is famous for achieving the highest accuracy over ImageNet. B-7 Network architecture is shown below in figure 4.

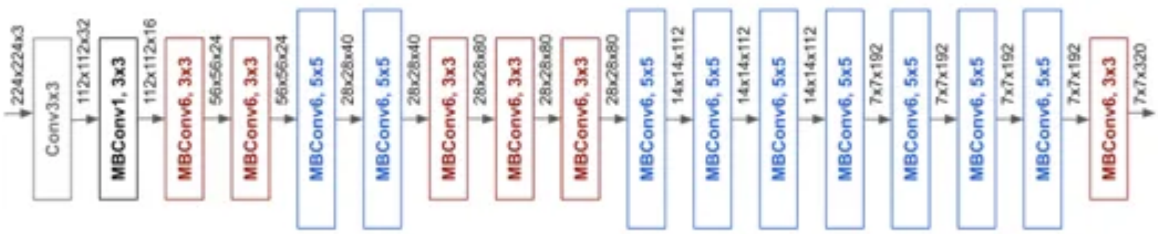


Figure 4: Network architecture of efficient -b7

RESULTS AND CONCLUSIONS

The results of the performances of the best models of both the UNet and the FPN, after K-fold cross-validation, on a few of the training, images are shown in Figure 5.

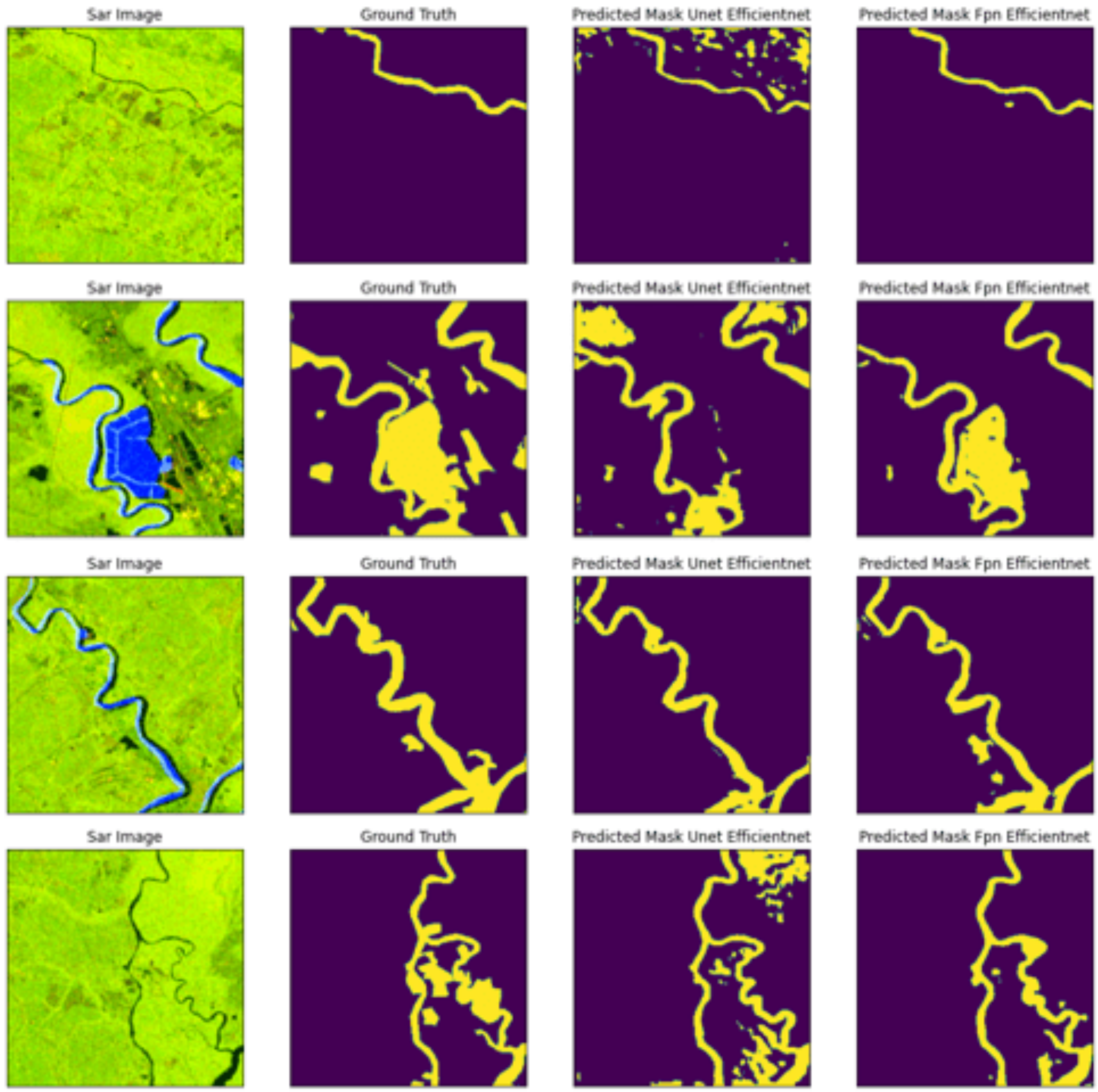


Figure 5: First column: SAR image; second Ground truth as provided by data providers, Third and fourth column are model predictions from Unet and FPN respectively.

Based on the labels from the test data, metrics like precision, recall, F1 score and mean IOU were calculated for both models and the results are depicted in the table below

Performance metric	UNet model	FPN model
Precision	97.2%	97.2%
Recall	95%	97.5%
F1 score	96.1%	97.3%
Mean IOU	75.06%	75.76%

From the results in Table II, it can be seen that both models performed really well in identifying the flood pixels. However, the metrics show that the FPN model outperformed the UNet model to some extent. This may be due to the fact that the FPN model architecture was able to capture the minute details from the three bands much efficiently compared to the UNet.

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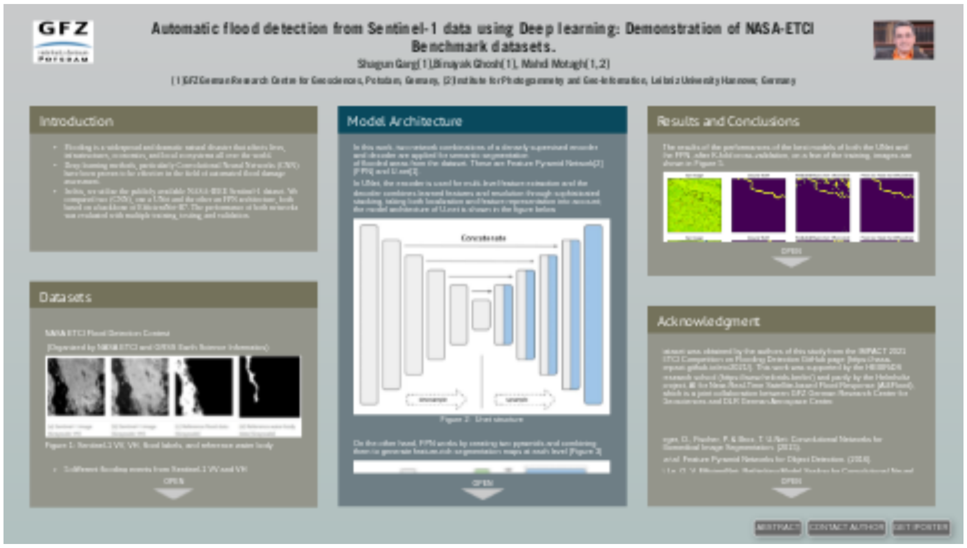

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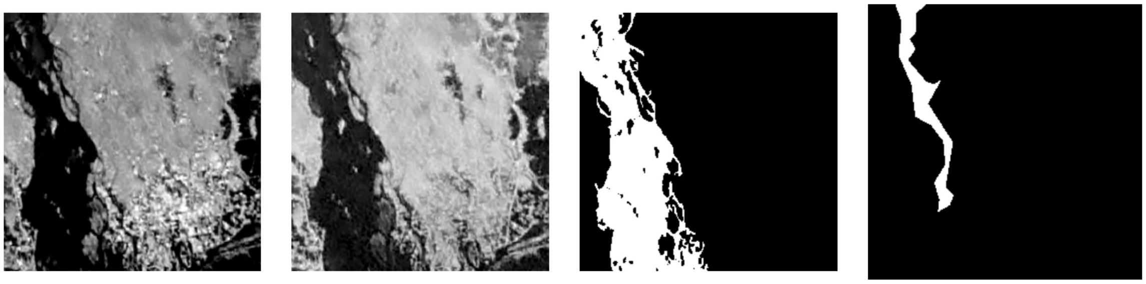

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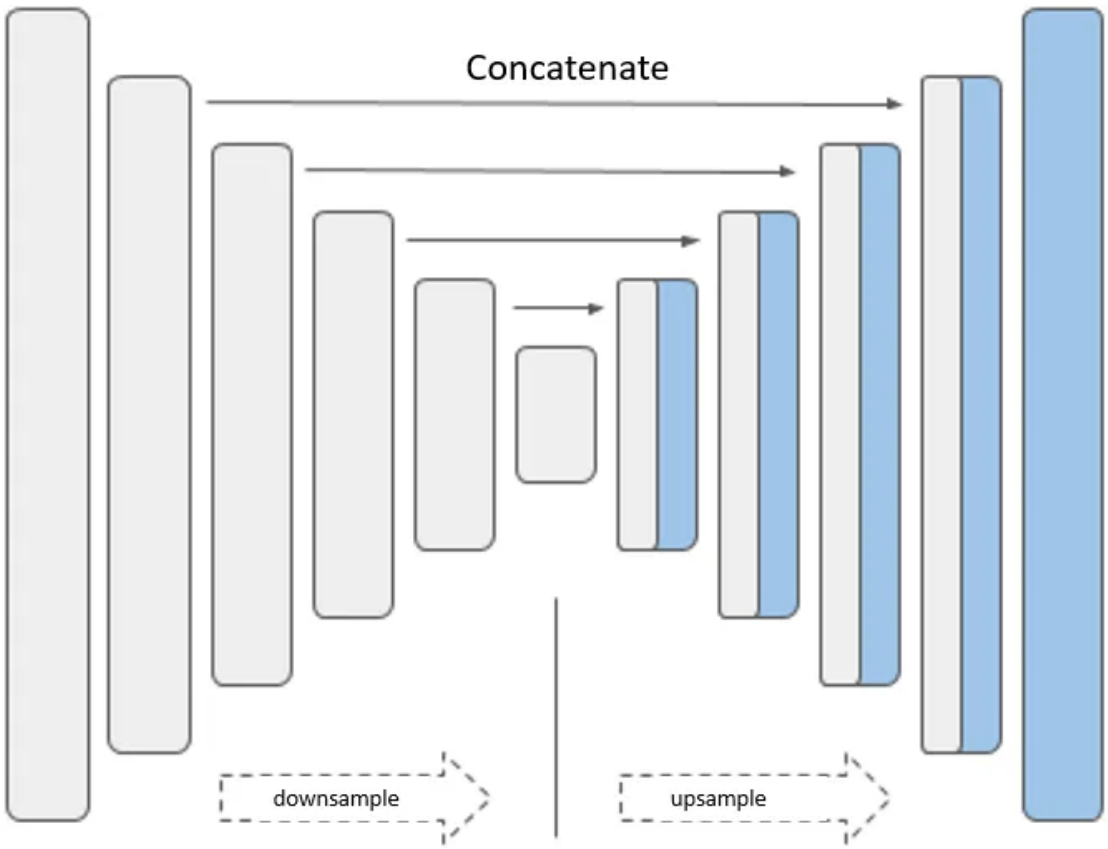

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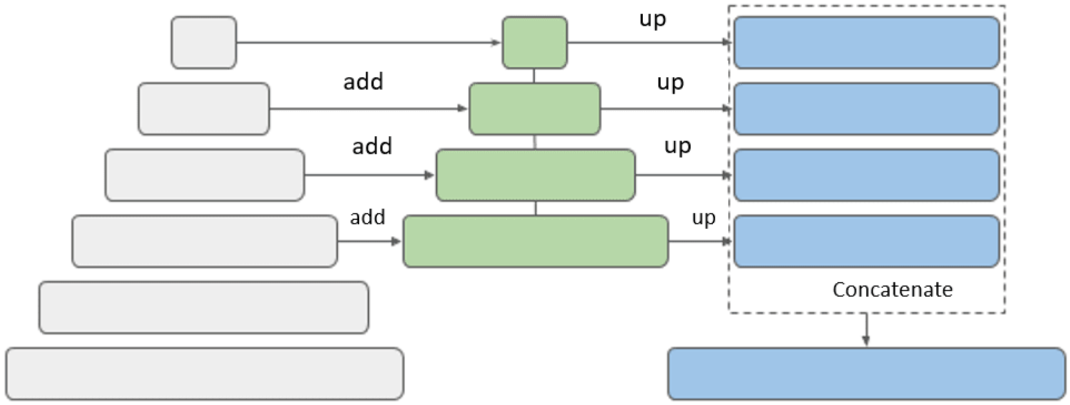

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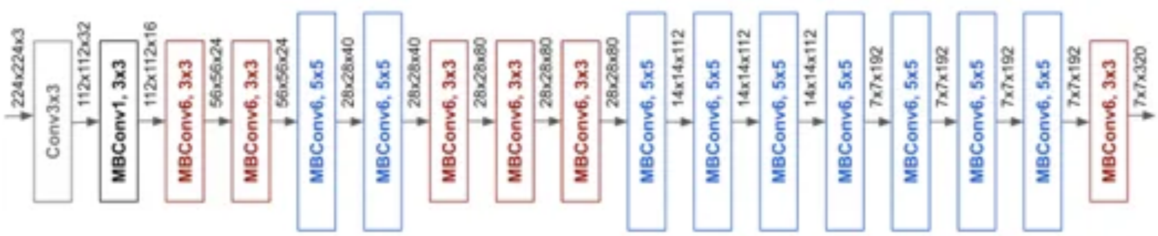

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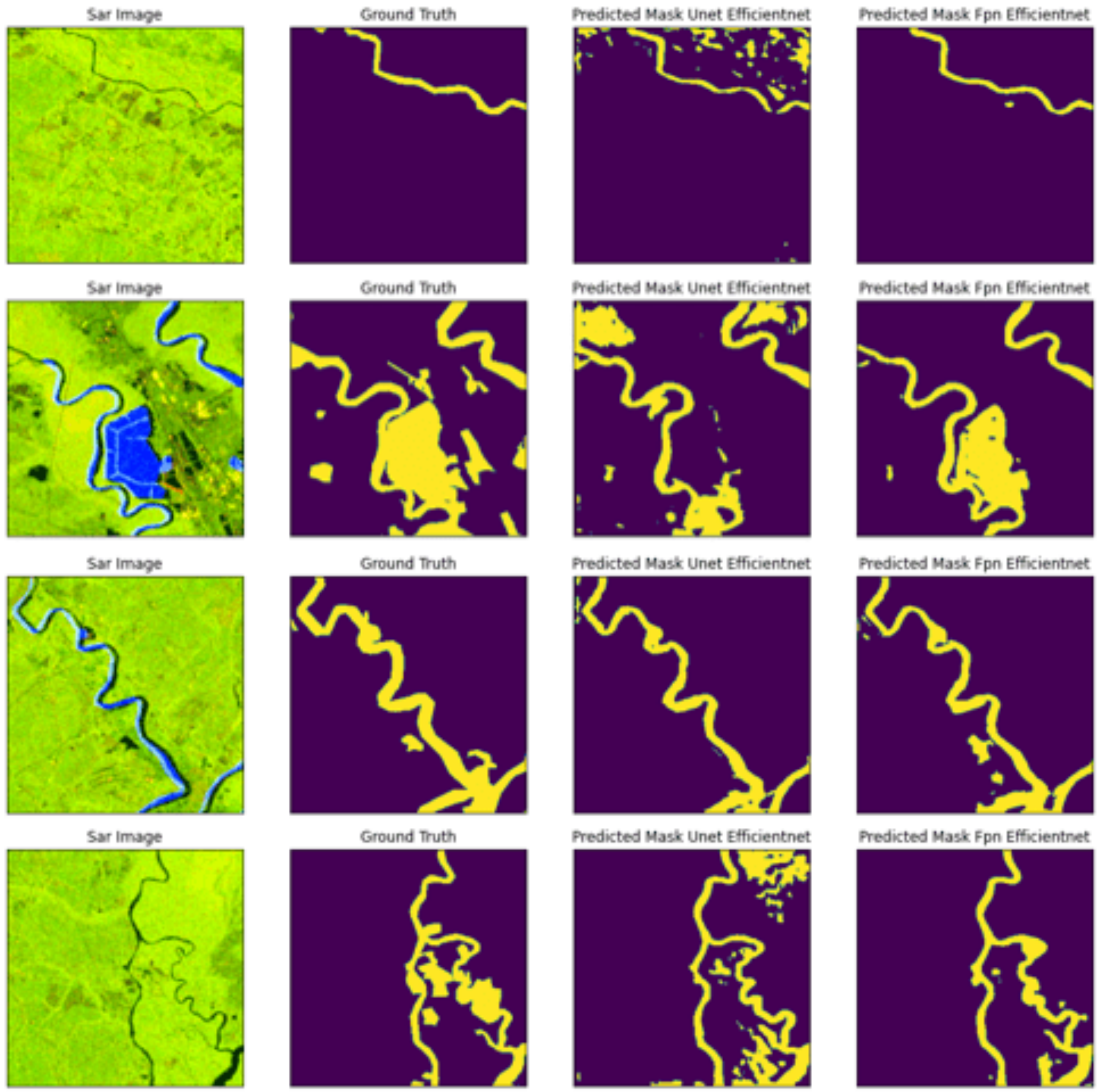

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