Enhancing Flood Segmentation with Multi-Source Satellite Data: Toward Robust and Generalizable Deep Learning Models

Presented By Batch-C14

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TABLE OF CONTENTS:

Abstract

Floods are among the most destructive natural disasters, with widespread and lasting impacts on society and the environment. Traditional satellite-based flood detection approaches commonly rely on optical imagery, which is limited by cloud cover and a lack of data diversity, often resulting in overfitting and poor generalization. This project proposes a generalizable multi-modal deep learning framework for flood detection in satellite imagery to directly address these challenges.

The proposed system integrates both optical and Synthetic Aperture Radar (SAR) data, enabling reliable flood detection regardless of weather or lighting conditions. By utilizing diverse datasets from multiple satellite sensors and geographic regions—including various flood types—the framework overcomes the constraints of single-source, single-context models. It employs advanced segmentation architectures and incorporates temporal sequence analysis for tracking flood progression when available.

Extensive experiments on heterogeneous datasets demonstrate that the multi-modal approach not only improves detection accuracy in challenging scenarios but also reduces overfitting and enhances the model's ability to generalize across different flood events and regions. This system advances the potential for robust, scalable flood monitoring and supports timely emergency response and disaster management in real-world situations.

Base Paper Analysis : Flood Detection Using Satellite Imagery

Core Objective: Segment flooded regions in satellite images using a modified U-Net deep learning framework.

Key Methodology: Utilizes optical satellite images (RGB + Near-Infrared bands). Employs a U-Net architecture with MobileNetV2 as the encoder for semantic segmentation.

Dataset Used: MediaEval 2017 Satellite Flood Dataset. Composed of 320×320 pixel patches, with manual segmentation masks for flood/non-flood areas.

Model Evaluation:

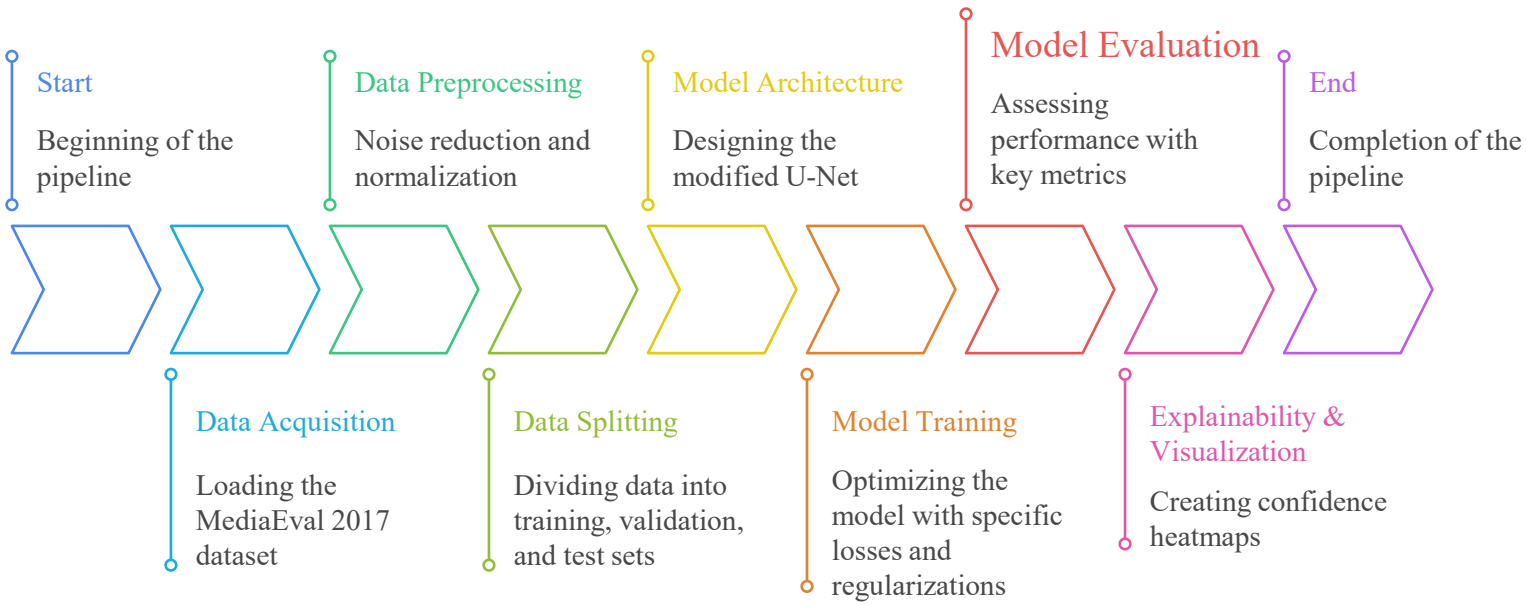
- Metrics: IoU, Dice Coefficient, Precision, Recall, F1-score.
- Visual validation by overlaying predicted masks on images.

Performance & Limitations:

- High accuracy on training data, but significant drop on test/validation sets (overfitting).
- Only optical data—fails under clouds or at night (no SAR usage).
- Limited to a single dataset and region—poor generalization.
- Analyzes only single time points—no temporal (time-series) analysis.

Flood Detection System Development Pipeline

(Existing Functionality)



Problems Identified

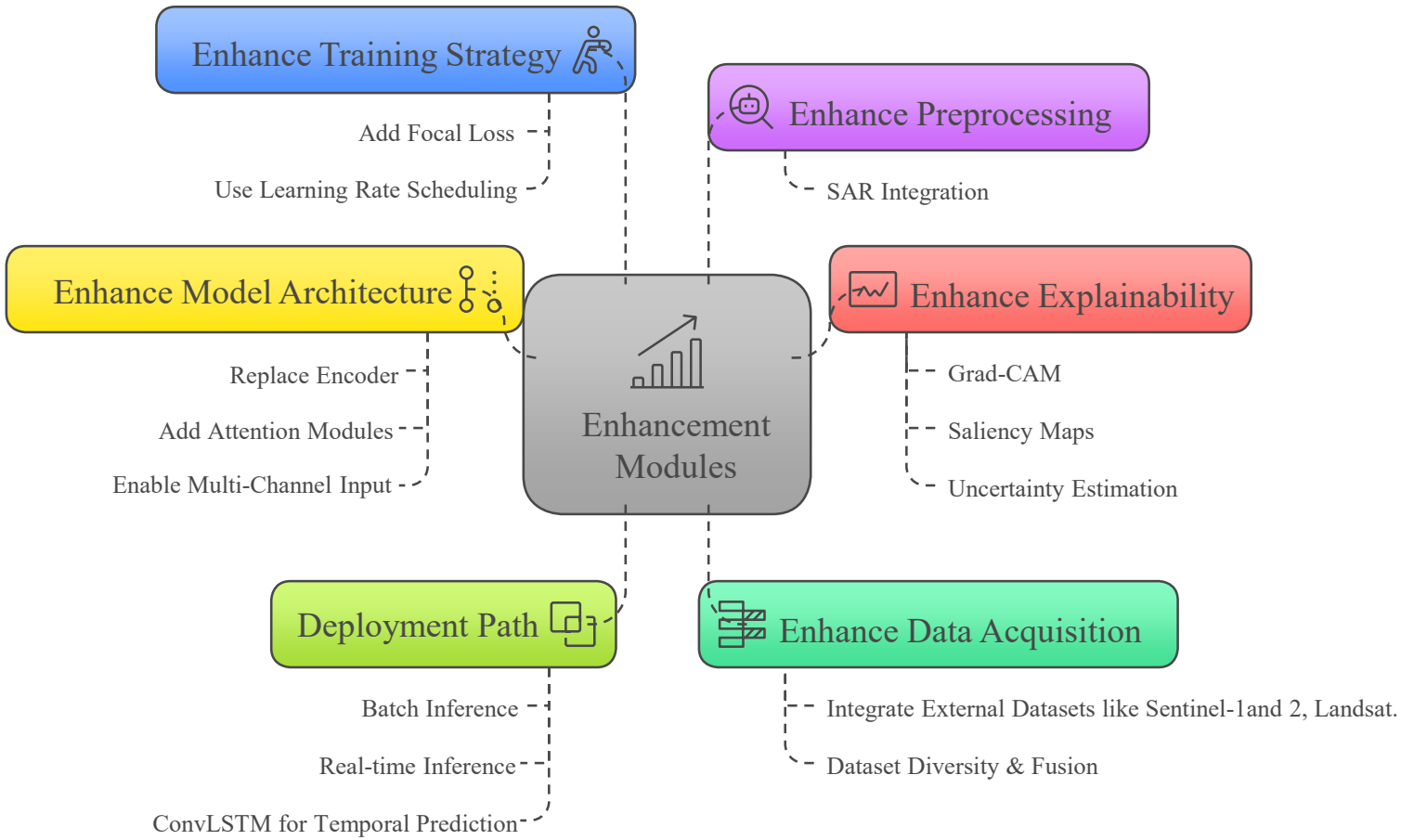
1. Missing SAR (Synthetic Aperture Radar) Data : The model uses only optical satellite images, which are ineffective during cloud cover and at night—common during floods.

2. Overfitting : The model performs extremely well on training data (IoU 99.46%, accuracy 99.41%) but drops on validation/test sets (IoU ~71.5%, accuracy ~68.8%)

3. Lack of Data Diversity: Training is conducted solely on the MediaEval 2017 dataset, with limited representation of geographic regions, flood types (riverine, coastal, urban), or satellite sensor types.

4. Absence of Temporal (Time Series) Analysis: The current system analyzes only static, single-point-in-time images; floods are dynamic events that change rapidly.

Enhancement Modules for Flood Detection Using Deep Learning



References

Base Paper:
M. Divya Sumithra, K. Akhila, P. Adikesava Reddy, N. Swarupa, O. Karthik. “Flood Detection from Satellite Images Using UNet Architecture.” International Research Journal of Modernization in Engineering Technology and Science, Volume 07, Issue 03, March 2025, e-ISSN: 2582-5208.

Dataset Reference:
MediaEval 2017 Multimedia Satellite Task: Flood Detection in Satellite Imagery.
Task organizers: M. Larson et al.
[MediaEval 2017 Satellite Task Challenge Documentation]