Landslide Trigger Track

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Introduction

Landslides are complex geological phenomena influenced by triggers such as earthquakes and rainfall. This study focuses on enhancing landslide trigger classification models using Topological Data Analysis (TDA) and validating it through Convolutional Neural Networks (CNN). The work encompasses data collection, model development, evaluation, and testing on diverse landslide inventories.

Training Data Overview

Japanese Landslide Inventory

- **Total Polygons:** 26,501
- **Earthquake-induced:** 16,196 (Hokkaido, Iwata, Niigata).
- **Rainfall-induced:** 10,305 (Fukuoka, Kumamoto, Osaka).
- **Data Types:**
  - 2D polygons.
  - 3D data (incorporating Digital Elevation Model (DEM) data for enhanced feature extraction).

Model Descriptions

Model 1: TDA-Based Model

- **Features Extracted:**
  - Persistence diagrams.
  - Statistical summaries such as persistence entropy, various amplitude, and average lifetimes.
- **Classifier:** XG Boost algorithm.

Model 2: CNN-Based Model (Validation Model)

- **Data Augmentation Techniques:** Horizontal/vertical flips, rotations (90 180, 270 degrees).
- **Model Architecture:** Processed polygon data as grayscale images and fine-tuned hyperparameters to optimize performance.

Model Evaluation and Results

Evaluation Metrics

- Test Accuracy.
- Validation Accuracy.

Performance Comparison

Model	Dataset Split	Test Accuracy (%)
TDA	Test (80-10-10)	99.92
CNN	Test (80-10-10)	84.58
TDA	Test (60-20-20)	96.69
CNN	Test (60-20-20)	89.24

Testing on Additional Inventory

- **Greece Inventory** (242 polygons, February 2003):
  - TDA Model: 99.69% accuracy.
  - CNN Model: 88.90% accuracy.

Key Findings

Correlation Heatmaps and Statistical Summaries

- Features such as **persistence entropy**, **number of points**, and **average lifetimes** showed strong correlations for rainfall-triggered landslides.
- Earthquake-triggered landslides exhibited weaker correlations.

Feature Importance (TDA Model)

Feature	Earthquake Mean	Rainfall Mean
Persistence Entropy H1	7.46	5.96
Number of Points H1	192.01	66.61
Amplitude H1 (heat)	743.58	246.56
Average Lifetimes H0	3.23	1.07

Technical Contributions

TDA Model

- Developed visualization tools for landslide polygons.
- Integrated correlation heatmaps and statistical analyses.
- Improved accuracy using the XGBoost algorithm.
- Tested models on additional inventories (e.g., Italy, Greece).

CNN Model

- Enhanced preprocessing with grayscale image visualizations.
- Fine-tuned hyperparameters to optimize performance.
- Expanded testing across diverse inventories.

References

1. Rana, K., Malik, N., & Ozturk, U. (2022). *Landsifier v1.0: A Python library to estimate likely triggers of mapped landslides*. Natural Hazards and Earth System Sciences, 22, 3751–3764. `https://doi.org/10.5194/nhess-22-3751-2022`.
2. Albawi, S., Mohammed, T. A., & Al-Zawi, S. (2017). *Understanding of a convolutional neural network*. IEEE International Conference on Engineering and Technology (ICET). `https://doi.org/10.1109/ICEngTechnol.2017.8308186`.
3. Japan, Greece, and Italy landslide inventories.
4. GitHub Repository: `https://github.com/Snehal-Goyal/TDA-based-Model-for-Landslide-T`

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Conclusion

The proposed models demonstrated strong capabilities in classifying landslide triggers with high accuracy, especially when enhanced with advanced algorithms and hyperparameter tuning. The results underscore the potential for applying these models across domains for pattern recognition in complex datasets.