Identifying Global Landslides Using Satellite Imagery and Machine Learning in GEE with SLIDT (Satellite Landslide Identification And Detection Tool)

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WHY:
- Climate change ➔ Increased precipitation in some regions ➔ Increased number and impact of landslides
- Optical, Synthetic Aperture Radar (SAR), and Digital Elevation Model (DEM) image processing can be expensive and difficult, thus, there is a need for a free, open-source, easy-to-use tool to monitor mass movements

HOW:
- Use free, pre-processed satellite data to automatically detect landslides through Google Earth Image (GEE)
- Detect drastic changes in vegetation and surface deformation utilizing Sentinel-1 Multispectral Instrument and Sentinel-1 SAR amplitude ground range detected imagery

GOALS:
- Look at four different landslide examples in different climates (arctic, tropical, sub-tropical) and triggers (precipitation, glacial melting, seismic) to analyze global accuracy
- Create a click-and-go tool that can identify global landslides using satellite imagery and machine learning called SLIDT or Satellite Landslide Identification and Detection Tool

Motivation and Objectives

![Preview of SLIDT: Displaying description, instructions, date and geometry input requirements all in one interface](image)

Methodology

Workflow for Optimizing Landslide Change Detection

- **Input:**
  - Insert before and after dates – a range of 1 month (7+ images) is recommended for averaging all images to improve results
  - Assign study area as a geometry layer by uploading shapefiles or drawing polygons in the mapping

- **Optical calculations:**
  - Mask cloudy from Sentinel-2 23m optical data (bands: red, blue, blue, and near infrared (NIR))
  - Calculate Enhanced Vegetation Index (EVI) and EVI Change
    - EVI: [(NIR-R)/(NIR+B+1)]
    - EVI Change: (After EVI) - (Before EVI)

- **SAR calculations:**
  - Mask clouds from Sentinel-2 23m optical data (bands: red, blue, blue, and near infrared (NIR))
  - Calculate Enhanced Vegetation Index (EVI) and EVI Change

- **Machine learning:**
  - Input different combinations of the change ratios into clusterer and identify which performs best
    - Clusterer: K Means
  - Vary the number of training points and clusters for all combinations

- **Masking (Thresholding and DEM):**
  - Calculate curvature using NASA Shuttle Radar Topography Mission 30m Digital Elevation Model
  - Remove flat areas and water from all imagery to reduce false positives since landslides are not probable in these areas [Handwerger, 2022]

- **Accuracy Assessment:**
  - Create a landslide polygons using Google Earth (~15±3m resolution, depending on location)
  - Validation output from machine learning
  - Calculate intersection over union (IoU) of positives & negatives & spatial agreement
  - Compare scores of all

Results

<table>
<thead>
<tr>
<th>Location</th>
<th>Time</th>
<th>Clusters</th>
<th>Training Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chile – Dec. 2017</td>
<td>5 clusters, 12k training points</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Canada – Nov. 2020</td>
<td>5 clusters, 12k training points</td>
<td></td>
<td></td>
</tr>
<tr>
<td>India – Aug. 2020</td>
<td>5 clusters, 12k training points</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Indonesia – Feb. 2022</td>
<td>5 clusters, 12k training points</td>
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</tr>
</tbody>
</table>

Observations

- Including all the change ratios does not necessarily mean better identification
- Adding EVI significantly improves speckle noise caused from SAR (Chile), but in other cases (Canada) it takes away information
- Combining EVI, subtract, ratio, divide, ratio ratio delineates landslides best
- Though Pair 3 shows more connectivity and visually accurate results, there is still many false positives / noise
- Increasing clusters both combines and separates previously distinct classifications
- Different types of noise may be a category and can be further masked
- Landslide origins are labeled differently than landslides body farther away
- Increasing training points changes cluster labels; split several classifications into two

Future Work

- Calculate accuracy scores
- Improve performance and reduce noise
- Finish the click-and-go tool and guide
- Apply automated supervised learning and object-oriented algorithms and compare

References


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