UNITED STATES MILITARY ACADEMY
WEST POINT

Are we able to classify burn area during active wildfires?

An Investigation into Utilizing Sentinel-1 SAR and Sentinel-2 Imagery with Deep Learning to Assess Burn Area

CDT Garrett Chrisman
West Point Advisors: COL Starling, MAJ Park, CPT Sustaita
Lockheed Martin Space Advisors: Dr. Lora Koening,
Dr. Lynn Montgomery

MATHEMATICAL SCIENCES

Current Capabilities

- Current wildfire burn area & severity utilizes pre and post-wildfire imagery.

- Sentinel-2 & Landsat predominately utilized for this task
  - Equipped with a Multispectral Imager (MSI)
  - Limitations
    - Affected by smoke, clouds, and day/night variations
    - Passover opportunities during wildfire
- Sentinel-1
  - Equipped with C-band Synthetic Aperture Radar (SAR)
  - Synthetic Aperture Rader
    - Unaffected by the above limitations
    - Unique ability to detect and measure surface roughness and moisture content.

NASA • USGS
LANDSAT NINE
KSC • GSFC • EROS

sentinel-1

sentinel-2

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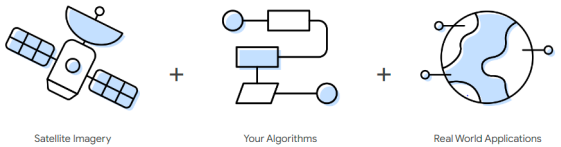
Data Workflow

Satellite Data

- Sentinel 1 SAR & 2 Satellite Imagery
  - Wide array of band imagery
- MTBS – Burn Severity

Google Earth Engine

- A planetary-scale platform for Earth science data & analysis

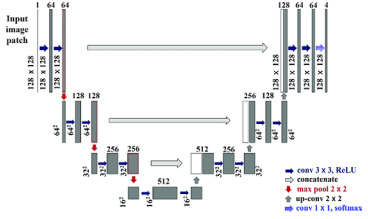


Data Preprocessing

- Resolution
- Gaps in images

CNN

- Semantic Segmentation
- U-Net



Burn Area Classification of Area of Interest

CNN = Convolutional Neural Network

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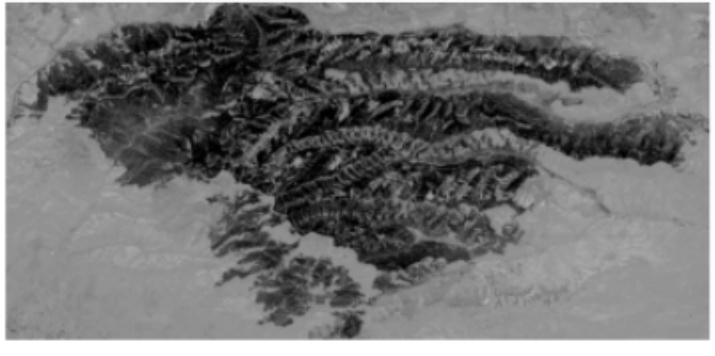
Preprocessing – S2

Sentinel-2

- Pull pre and post images from RGB bands
- Cloud mask applied
- Change in Normalized Difference
  - *NBR (Normalized Burn Ratio) = (NIR − SWIR) / (NIR + SWIR)*
  - NIR: Near Infrared band (B8)
  - SWIR : Short-Wave Infrared band (B12)

7 Fires as Samples
- Pine Gulch
- Grizzly Creek
- Cherry Canyon
- Lake Christ
- Decker
- Silver Creek
- Plateau

DNBR Image: PineGulch



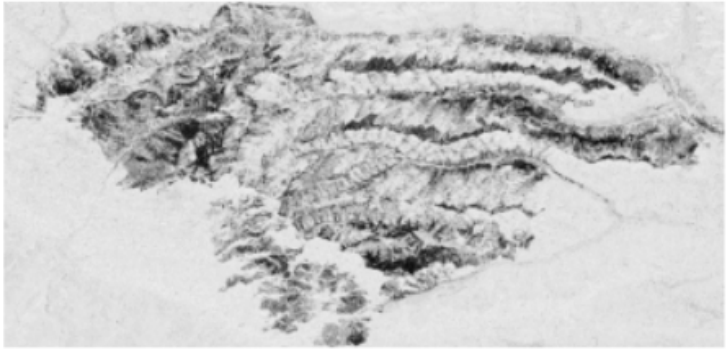
Ground Truth Image: PineGulch

Preprocessing – S1

Sentinel-1

- VH band imagery is collected
- Change in burn ratio
- Enhance changes in ratio
- Normalized image values

DNBR Image

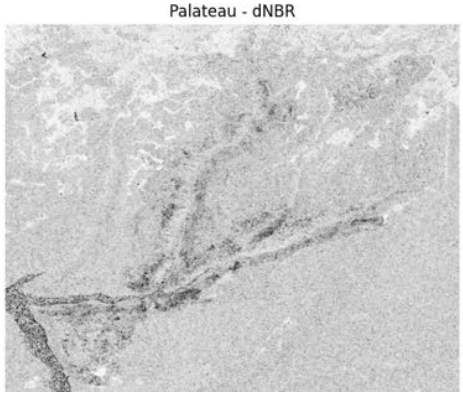


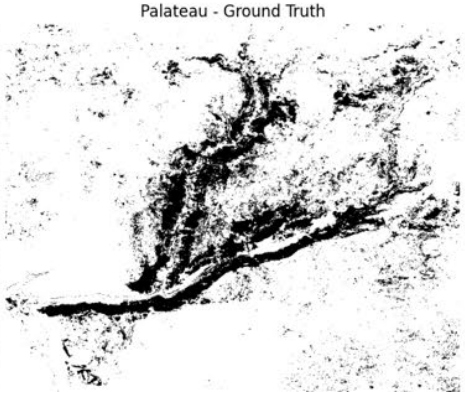
Ground Truth Image

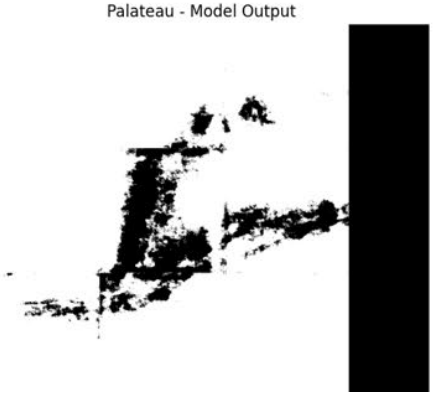
Test Cases

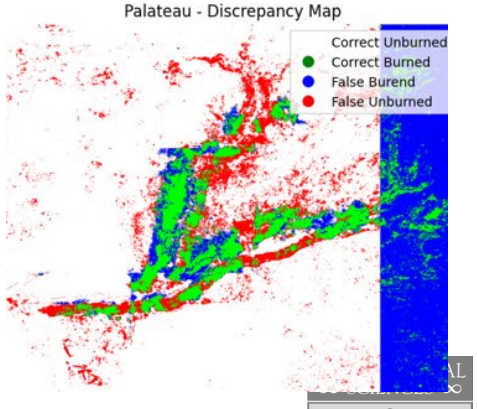
Case 1: Base Case

- Split images into 256x256
- Model trained on 1 fire – Pine Gulch
- Tested against 6 other fires
- Under classifying burned areas





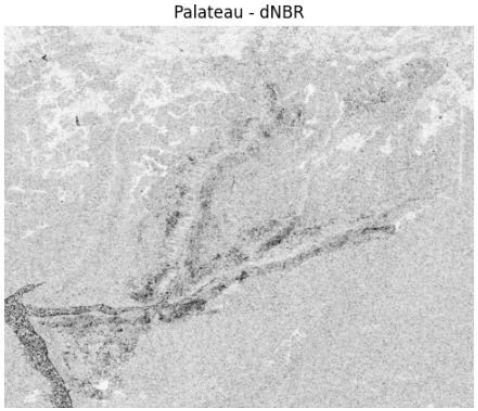


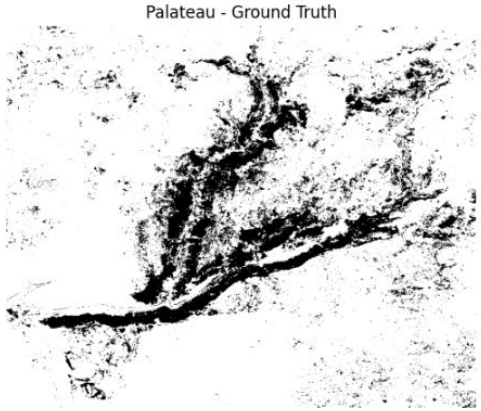


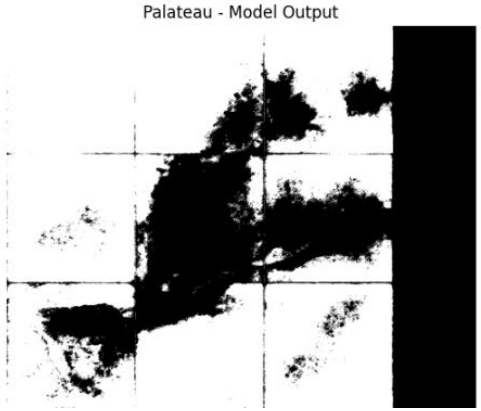
Test Cases

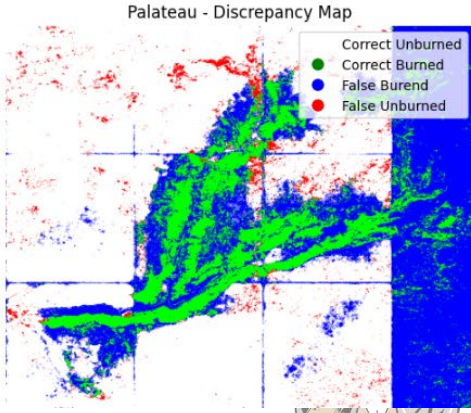
Case 2 & 3: Data Augmentation

- Trained on Pine Gulch and Lake Christ Fires
- Central area region extracted 1280x1280
- Data Augmentation to increase training material and balance burned area groups (mostly burned, partially burned, slightly burned, etc.)
- Performs worse on evaluation metrics due to over classifying area





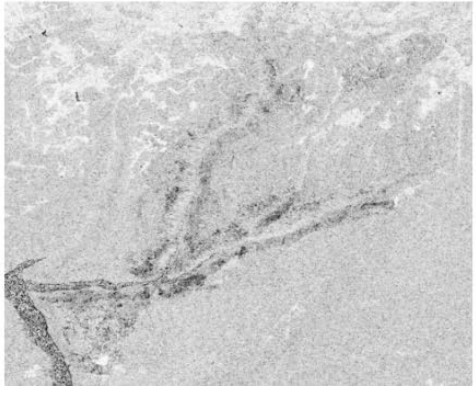


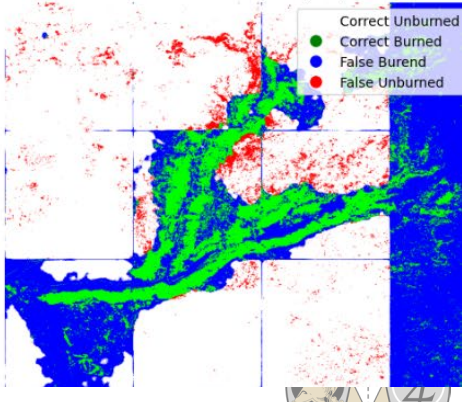


Test Cases

Case 4: Median, Uniform & Gaussian filters

- Different filter methods for ‘Salt and Pepper’ showed varying results of success for different fires. With Median preforming the best on average.
- Filtering also aims to address the shadowing effect of SAR imagery





Further Findings

Ground Truth Images:

Different thresholding worked better or worse depending on the type and location of the fire (SE CO, Mountains, etc.) for both ground truth and CNN output.

Thresholding image output:

- **Threshold Setting:** Set at 0.9 for identifying burned areas.
- **Decision Criterion:** Any prediction below this threshold indicates a burned area.

Future Work:

Case 5: Smoothing

- Explore more complicated methods of 'smoothing functions' to help mitigate this salt and pepper effect such as a separate ML model.

Questions?