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Machine Learning Augmented Prediction for Labor Exploitation Detection in Brazil

Keywords/AMA: machine learning, geospatial analysis, labor exploitation detection, satellite imagery, charcoal production.

Project Overview

Background: Illegal charcoal production in Brazil often involves forced labor. The remote locations and frequent movement of these sites make detection difficult, but satellite imagery offers a promising solution.

Goal: Develop machine learning models to improve the manual identification of suspected charcoal production sites from satellite imagery, enhancing both accuracy and efficiency.

Data: Utilized a geospatial database with high-frequency satellite imagery of Brazil, including confirmed charcoal sites and multi-level spatiotemporal features.

Methods:

🗺️ Identify and integrate new relevant features into the geospatial database.
🔍 Expand labeled training data through detailed inspection and annotation.
🤖 Iteratively train, test, and refine models using geospatial covariates.

Outcome: Developed a model using 38 geospatial features, achieving a 71.7% F1 score, 65.8% precision, and 78.8% recall. Future improvements could include image feature embeddings and enhanced time-series modeling.

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38 Features

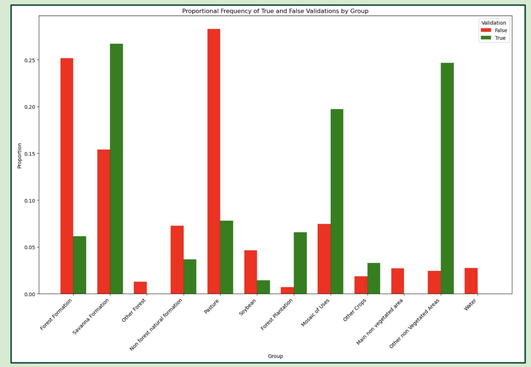
- **14 Distance Variables:** Proximity of sites to key geographical elements
- **3 Density Variables:** Concentration of relevant features around suspected sites
- **12 Land Cover Categories:** Specific land cover group where each site is located
- **9 Survey Variables:** Socioeconomic indicators of regions with suspected sites

Land Cover Feature Insights

Reliable Indicators: Savanna Formation, Other Non-Vegetated Areas, and Mosaic of Uses groups have the highest true positives.

Frequent Misidentifications: Forest Formation and Pasture groups show high false positives.

Unreliable Categories: Other Forest and Water groups have exclusively false positives.



Proportional representation is used to account for the imbalance between false positives and true positives.

Geospatial & Feature Cluster Analysis

Geospatial and feature cluster analyses of charcoal sites were conducted to identify patterns and inform potential improvements in classification methods.