Integrating EO with Official Statistics using Machine Learning in Mexico
(Work in progress)
March 10, 2020

INEGI
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UNECE Machine Learning Project

This is one of the pilot projects in the Machine Learning Project of the UNECE High-Level Group on Modernization of Official Statistics.
UNECE Machine Learning Project

Objectives

• Investigate and demonstrate the value added of ML in the production of official statistics, where "value added" is increase in relevance, better overall quality or reduction in costs.
• Advance the capability of national statistical organisations to use ML in the production of official statistics.
• Enhance collaboration between statistical organisations in the development and application of ML.
Imagery Pipeline

In order to have a road map.
We build an abstract machine learning pipeline for Imagery

Based on:

IBM CRISP-DM
Cross Industry Standard Process for Data Mining &
Microsoft Data Science lifecycle
Pilot Project
Establish the problem to be solved

Monitor the growth of urban locations of Mexico, which would generate a more timely input for:

- Cartography update
- Estimation of the population in non-census years
- Related with:
  - SDG Indicator 11.3.1: Ratio of land consumption rate to population growth rate
  - SDG Indicator 15.3.1: Proportion of land that is degraded over total land area
Identify satellite data to address the problem

In our case, the data to monitor the growth of cities can be Landsat images (NASA & USGS):

- They are open data.
- There is a constant record since the 70s, although they are available from 1985 to date.
- The spatial resolution of Landsat images is 30 meters.
- Temporal resolution is 16 days and 8 days with combined satellites.
- Spectral resolution, in this pilot project we use 6 spectral bands
- All the data we use is Analysis Ready Data (ARD)
- We take advantage that we have just built the Mexican Geospatial Data Cube, with all this information.
Translate the problem into statistical problem

We define that is a classification problem:

- Unit of analysis: 1km x 1km squares covering the whole country: 1’975,719
- 2 classes were designated:
  - Urban
  - Non-Urban
Obtain ground-truth data

Obtain layers of geographical information:

- Georeferenced Population Census 2010 (Block Level Aggregation)
- Georeferenced Economic Census (Economic Unit Level)
Obtain ground-truth data

Build the polygons (1 km – 1 km)

1’ 975, 719 Polygons
Obtain ground-truth data

Assign Labels

Georeferenced Census Results (Population and Economic) Intersected with the 1km national grid 1km by 1km regions
Obtain satellite imagery data

- 32 TB of Images in external discs.
- 90 TB decompressed
- March 4, 2019
- The images are ARD, Analysis Ready Data.
- In essence ARD means that the pixels of the entire time series are aligned and comparable.
Obtain satellite imagery data

- 36 Years
Obtain satellite imagery data
• 2010 same year of the Census

Australian Government
Geoscience Australia

Use the ODC to generate annual summaries

2,737,273,075 pixels – 35 Gb
National Cloud-Free Mosaic
Comparador de Geomedianas
Integrate ground-truth data with satellite data

2010 National Cloud-Free Mosaic
33 x 33 pixels
30 meters of resolution

2010 Labeled Grid
1 km x 1 km

Labeled Multispectral Image Patch
From national grid with the urban and non-urban labels, a random sample of 40,000 elements was taken: 20,000 for each class. Then, image patches were extracted from the cloud-free mosaic. Resulting in 40,000 images labeled, each one with 33 pixels x 33 pixels, with 6 spectral bands (or layers).
Define features and generate a dataset to be used for analysis

- Feature Engineering

- Calculate Spectral Indices for each pixel in the patch
- Central pixel values
  - Spectral Features

- Calculate 7 statistical measures
- 12 GLCM Matrices
  - Calculate 7 statistical measures
  - 6 Statistical properties for each GLCM calculated
  - Calculate histogram
  - Calculate 7 statistical measures
  - GLCM Statistical Features
  - GLCM Histogram Features

- LBP Filter
  - Calculate histogram
  - 12 GLCM Matrices
  - 6 Statistical properties for each GLCM calculated
  - Calculate 7 statistical measures
  - LBP Histogram Features
  - LBP-GLCM Plain Features
  - LBP-GLCM Statistical Features
  - LBP-GLCM Histogram Features

- 40 Gabor Filters
  - Calculate 7 statistical measures
  - Gabor Features

30,000 tagged regions
1km x 1km
33 pixels x 33 pixels x 6 Bands

4,305 rows in a data matrix
40,000 rows in a data matrix
Models tried

Two different models were tested, an Extra Trees model also known as Extremely Randomized Trees and a LeNet Convolutional Neural Network.
Results

The evaluation with training data was performed 10-fold cross-validation, for both methods.

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Extra Trees

LeNET

Detailed results
Next Steps
## Next Steps

- Finish other iteration, no later than one 2 months.
- The grid is also an important innovation and is evolving, it is likely that we will have a new version very soon and we should update the classification.
- Apply the model to un-labelled years, for example 2019 first semester.
- Validate a sample of the un-labelled year, requesting support for the area of visual interpretation of the geography division, to have a measure of product quality.
- Hold more meetings with the area of sociodemographic statistics, involve them in the exercise to improve the potential benefit in the population estimate.
- Hold meetings with the cartographic update area, to receive feedback.
GRACIAS!

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