A Proposal of Architecture for the use of Deep Neural Networks in the automated deforestation detection in the Cerrado biome.

The mapping of anthropic areas produced by PRODES-Cerrado is an important dataset for monitoring deforestation in the Cerrado biome. According to an independent validation conducted by LAPIG/UFG, this mapping presents 93.17 ± 0.89% of global accuracy and is in a constant process of improvement, due to the annual accumulation of anthropogenic areas of the biome (Parente et al ., 2020). Given the quality of the data, with high accuracy produced by visual interpretation of satellite images, PRODES-Cerrado has enormous potential to be used as a training sample in supervised machine learning methods. This potential has already been explored for PRODES-Amazônia and presented results with 95% accuracy, in 4 Landsat scenes located in the southeastern state of Pará, using deep neural networks (Maretto et al., 2020). The usage of deep neural networks in satellite data can be considered the state of the art for automatic mappings, surpassing classic techniques such as the Random Forest algorithm, however they demand a high investment in the survey of training samples (Parente et al., 2019).

Assuming that the entire area mapped by PRODES-Cerrado can be used as a training sample, the evaluation of deep neural networks in the Cerrado biome becomes viable and necessary for this project. In this sense, LAPIG developed a research proposal based on the evaluation of a recurrent (i.e. Long Short Term Memory - LSTM) and convolutional (i.e. U-Net - Figure 1) neural networks. In this proposal, LSTM will be able to evaluate all images obtained during the PRODES year (e.g. Jun/2017 to Jun/2018) seeking for disruptions in time series associated with deforestation events. In a complementary way, U-Net will seek spatial patterns and topological relationships that characterize deforestation between two different dates, patterns that are very similar to those evaluated in the interpretation of images carried out by the National Institute for Space Research (INPE).

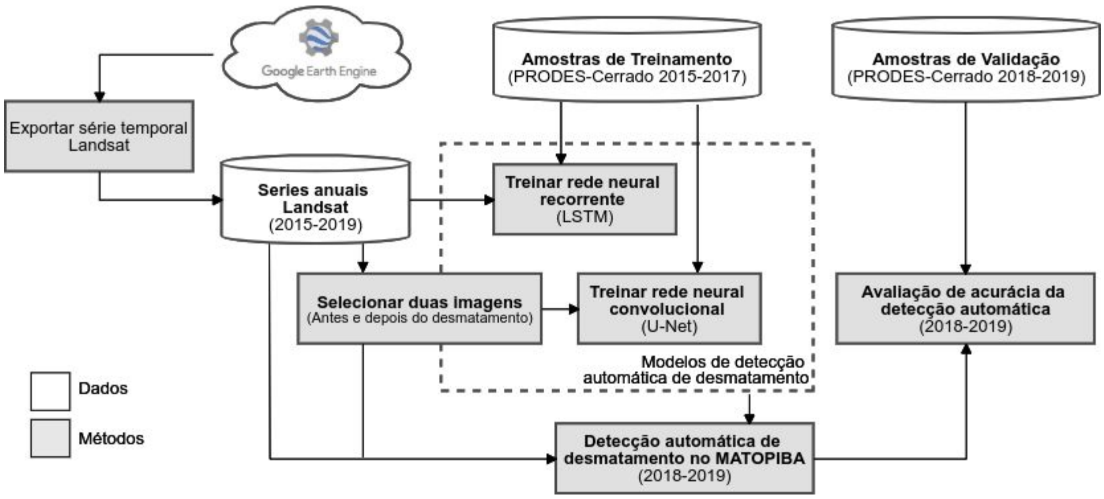

Figure 1. Methodological proposal for the automatic detection of deforestation using deep neural networks.

As PRODES-Cerrado inspects two Landsat images (one before and one after deforestation), all images between the inspection period must be acquired, organized and evaluated by LSTM. Considering the volume of data involved in this process, the method should be implemented with the support of the Google Earth Engine-GEE, a cloud computing platform that possesses all the Landsat collection on the planet and features of data analysis with the ability to export. The export must occur by point-orbit, generating a file per spectral band (Blue, Green, Red, NIR, SWIR-1 and SWIR-2), with the generation dates organized in GeoTiff bands (format supported by GEE), resulting in 6 final files. The quality band (BQA) should also be exported as a separate file, since pixels contaminated by cloud and their shadow will not be filtered/removed from the exported files, in the expectation that LSTM will be able to ignore the values anomalous and noisy spectral time series. U-Net will consider exactly the same images evaluated by PRODES-Cerrado interpreters, equivalent to the first and the last image of the LSTM time series.

As the LSTM training samples are geographic coordinates (points) and the U-Net are polygons, a single and consistent sample design must be used for the two neural networks to obtain results that are comparable to each other. In this sense, we suggest using the strategy defined by Parente et al., 2019, which sampled polygons and points in the same geographic regions, and considered a stratification based on land use and land cover classes. For the PRODES-Cerrado context, deforestation polygons can be classified according to the use and coverage classes of MapBiomas in 1999 (collection 4.1.), The year immediately prior to its base year. As the neural networks will be trained to automatically detect the deforestation event, the amount of training points and polygons must be balanced in 50% of deforestation samples and 50% of non-deforestation samples, however this relationship can be changed after the analysis of results.

The training of neural networks can take place preliminarily with reference to one or two Landsat scenes, however we consider that the ideal study area for this experiment is Matopiba, since this region contains the largest area of remaining vegetation in the biome Cerrado, with varied phytophysiognomies (eg forest, savanna, country) and different classes of land use and occupation. (e.g. soy, cotton, corn, sugarcane, pasture). It is recommended that this evaluation consider samples obtained between 2015 and 2017, which were effectively generated within the scope of the project, to compose the training set, and samples from 2018 and 2019 to compose the validation set, thus evaluating the real capacity of generalization of neural networks and their potential for use in detecting deforestation in future years.

Finally, the LSTM implementation can use the source code available at https://github.com/NexGenMap/dl-time-series, and the implementation of U-Net can occur according to Maretto et al., 2020 or through the source code https://github.com/NexGenMap/dl-semantic-segmentation.

References

Parente L.; Nogueira S.; Baumann L.; Almeida C.; Maurano L.; Affonso A.; Ferreira L. PRODES CERRADO: Monitoring deforestation in a global biodiversity hotspot. Submitted to Remote Sensing Applications: Society and Environment. 2020.

Maretto, R.; Fonseca, L.; Jacobs, N.; Körting, T.; Bendini, H.; Parente, L. Spatio-Temporal Deep Learning Approach to Map Deforestation in Amazon Rainforest. IEEE Geoscience and Remote Sensing Letters, 2020.

Parente, L.; Taquary, E.; Silva, A. P.; Souza, C.; Ferreira, L. Next Generation Mapping: Combining Deep Learning, Cloud Computing, and Big Remote Sensing Data. Remote Sensing, v. 11, n. 23, p. 2881, 2019.