# Laguerre-Gauss Preprocessing:
## Line Profiles as Image Features

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# Introduction

- Reduce an image's feature space.
- Preserve enough information for classification tasks.

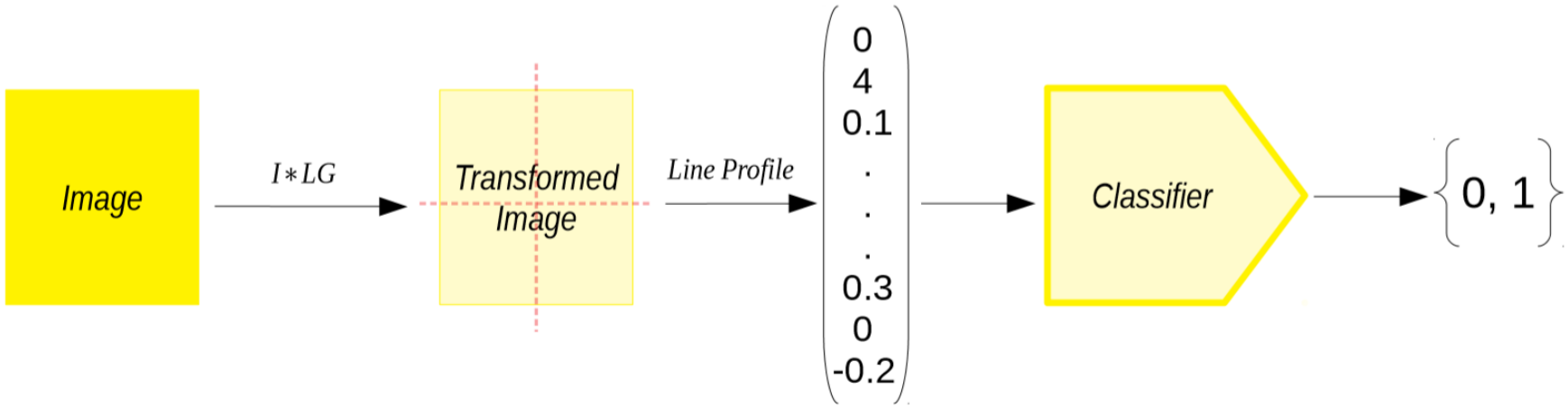


**Figure 1.** Overview of Laguerre-Gauss Preprocessing. A line profile of the image is obtained, which is later used as input to a classifier. Source: Own elaboration.

# Method

- We use Fourier Analysis
  - Laguerre-Gauss Spatial Filter (LGSF) [1]

$$LG(x,y) = (i\pi^2\omega^4)(x+iy)\exp\{-\pi^2\omega^2(x^2+y^2)\} \qquad (1)$$

This Kernel enhances edges and reduces low- and high- frequency noise [1, 2].

# Method

**Algorithm 1:** Laguerre-Gauss Preprocessing

**Data:** image, $\omega$

s $\leftarrow$ `size`(image);

filter $\leftarrow$ `LaguerreGaussFilter`($\omega$, s);

image$_{FT}$ $\leftarrow$ `FourierTransform`(image);

filter$_{FT}$ $\leftarrow$ `FourierTransform`(filter);

convolved $\leftarrow$ image$_{FT}$ $\cdot$ filter$_{FT}$;

shifted $\leftarrow$ `shift`(convolved);

$x$-profile $\leftarrow$ `LineProfile`($shifted, axis = x$);

$y$-profile $\leftarrow$ `LineProfile`($shifted, axis = y$);

**return** $x$-profile, $y$-profile

# Results

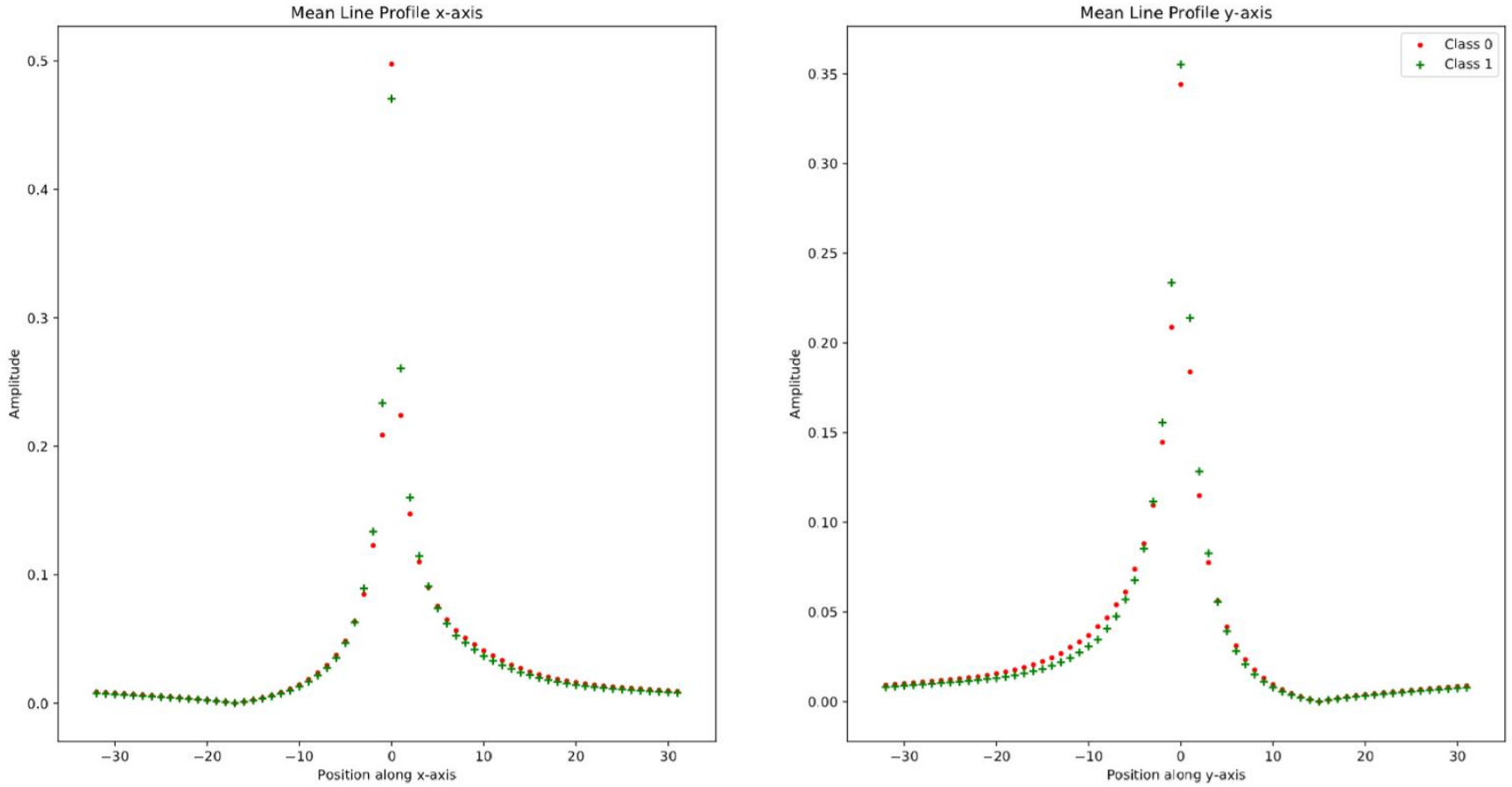


**Figure 2.** Line Profiles obtained using Laguerre-Gauss Preprocessing on a dataset of aerial images. Source: Own elaboration.

# Results

| | | | Train | | Validation | | Test | |
|---|---|---|---|---|---|---|---|---|
| **Model** | **Data** | **Size** | **Accuracy** | **F1** | **Accuracy** | **F1** | **Accuracy** | **F1** |
| kNN | Flattened | 951.2 MB | **0.9257** | 0.93/0.91 | **0.9286** | 0.93/0.91 | **0.9183** | 0.92/0.90 |
| | LP | **30.0 MB** | 0.9030 | 0.91/0.88 | 0.8900 | 0.90/0.86 | 0.9046 | 0.91/0.89 |
| MLP | Flattened | 4.4 MB | 0.5747 | 0.72/0.0 | 0.5720 | 0.72/0.0 | 0.5730 | 0.72/0.0 |
| | LP | **376.4 kB** | **0.8012** | 0.82/0.76 | **0.8116** | 0.83/0.77 | **0.7990** | 0.82/0.76 |

**Table 1.** *Results of Aerial Images classification*. The F1 score is reported for each class in the next order: (0) No object of interest / (1) object of interest. The *Flattened* data type means images whose pixels were transformed to a column vector, which will later be used as input to the model. *LP* data type represents the image features (line profiles) obtained using Laguerre-Gauss Preprocessing.
kNN: k-Nearest Neighbors classifier. MLP: multilayer perceptron.
Source: Own elaboration.

# Discussion

- The introduced methodology can be used to learn a robust image classifier.

- The use of features from the frequency domain might lead to generalization to diverse environments, where it highlights relevant shapes regardless of background noise.

- The LGSF distributes homogeneously and smoothly the intensity in the Fourier spectrum due to its isotropic feature [1, 2]. This resulted in characteristic frequencies that allowed learning relevant shapes within an image.

# Questions?

Code + Paper

https://bit.ly/371OFHY

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# References


- [1] Paniagua, J. G., Quintero, O. L., and Sierra-Sosa, D. Laguerre-gauss filters in reverse time migration image reconstruction. Brazilian Journal of Geophysics, 35(2):81–93, 2018. ISSN 1809-4511. doi: 10.22564/rbgf.v35i2.822. URL https://sbgf.org.br/revista/index.php/rbgf/article/view/822.
- [2] Guo, C.-S., Han, Y.-J., Xu, J.-B., and Ding, J. Radial Hilbert transform with laguerre-gaussian spatial filters. Opt. Lett., 31(10):1394–1396, May 2006. doi: 10.1364/OL.31.001394. URL http://ol.osa.org/abstract.cfm?URI=ol-31-10-1394.