CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE

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An automatic method to determinate the flocculence rate of a galaxy

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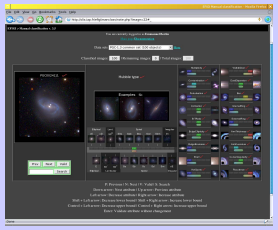
➢Goals

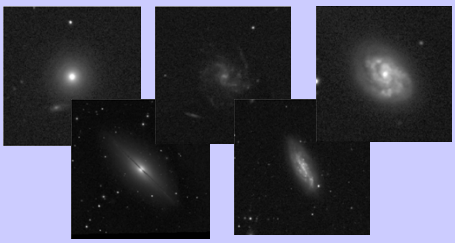
In order to study the evolution of galaxies, astronomers must have tools to classify the huge quantity of images at their disposal. The EFIGI (Extraction de Formes Idealisées de Galaxies en Imagerie, www.efigi.org) is a project directed by the IAP (Institut d'Astrophysique de Paris) as a 3-year ACI (large data-sets) and funded by the French ministry of Research. Astronomers and signal processing engineers seek the best morphological descriptors to analyze the different types of galaxies**.**

The reference dataset contains a subset of the RC3 catalog observed with the Sloan Digital Sky Survey. The morphological information of the 4500 galaxies have been labeled by 9 astronomers with a web service developed at EFIGI. 18 morphological attributes have been chosen among which is flocculence.



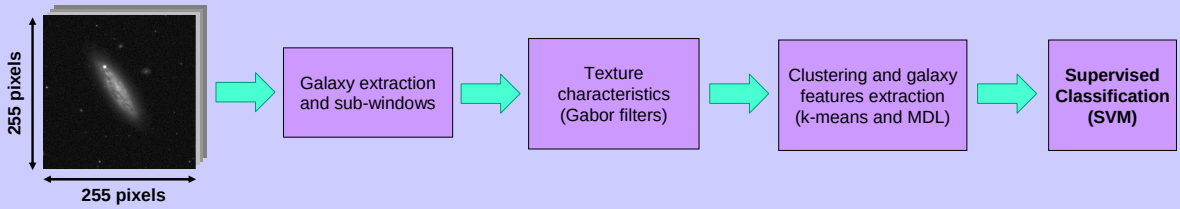
➢Motivations

A lot of parameters are already implemented: form, light description, presence of arms... Another important parameter is the flocculence level of a galaxy. This level, essentially important in some spiral galaxies arms, shows an intense activity in the galaxy's disk, and could explain some galaxies fusions or stellar formation. Some works[1,2] describe it as a relation with concentration, asymmetric parameters or Gini coefficient. We have a base with near 4000 galaxies of which the flocculences levels (from 0 to 4 with integer values) have been manually labeled and homogenized by 9 astronomers.



Some galaxies between not flocculent to very flocculent

➢Methodologies

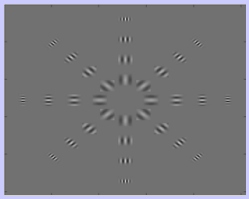


➢Galaxy extraction.

- Pre-processing: all galaxies of our catalog are background-subtracted, resampled, and rescaled to 255x255.
- Sub-windows computation.

➢Bank of filters

- Gabor filters[3]: multiple scales and orientations.
- Relation with the responses of the human receptive cells.



$$H(x,y,u,\theta)=\exp\left(-\frac{1}{2}\left(\frac{x_\theta^2}{\sigma_x^2}+\frac{y_\theta^2}{\sigma_y^2}\right)\right)\cos(2\pi u x_\theta)$$

- Features extractions: mean and standard deviation are used to represent one sub-window m:

$$F_m=(\mu_{00},\sigma_{00},\mu_{01},\sigma_{01},\ldots,\mu_{44},\sigma_{44})$$

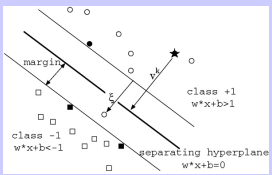
➢Clustering and galaxy features extraction

- Clustering: k-means and Minimum Description Length ⟶ 20 clusters
- Galaxy representation: number of elements of each class

$$H(C_i)=\sum_{k=1}^{n}(F_m\in C_i)$$ (histogram)

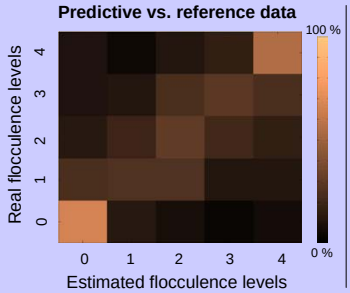
➢Experiments

▪ Supervised learning : Gaussian Support Vector Machine classifier



- 4000 labeled galaxies
- 5 classes
- Classifier one vs. all
- Mean recognition rates using cross-validation

➢Results



▪ Not flocculent vs. flocculent : more than 80 % of success rate

▪Intermediate rate : only 40 % of success rate but when authorizing ± 1 on the flocculence level: 70% of success rate.

Perspectives:

▪Modify statistical Characteristics

▪ Explore data reliability

[1]Roberto G. Abraham , Sidney Van Den Bergh, Preethi Nair. A new approach to galaxy morphology : Analysis of the Sloan Digital Sky Survey early data release. The Astrophysical Journal, 05/2003, Volume 588, Issue 1, pp. 218-229. 18, 28

[2]Christopher J. Conselice. The relationship between stellar light distributions of galaxies and their formation histories, The Astrophysical Journal Supplement Series, 07/2003, Volume 147, Issue 1, pp. 1-28. 18

[3]B.S. Manjunatah, W.Y. Ma. Texture features for browsing and retrieval of image data, IEEE Transactions on pattern analysis and machine intelligence, 1996, vol. 18(8), pp. 837-842. 25