DIP - REPORT

Team - ANN (Arya Mihir Singh, Nishant Ravinuthala)

CLASSIFICATION AND SEGMENTATION OF GALAXIES USING MATHEMATICAL MORPHOLOGY

Introduction:

In the domain of image processing, one of the many open challenges that are still of interest are the segmentation and classification of galaxies from multispectral images. This is because of the amorphous nature of galaxies and also because we can get lots of variations of the same galaxy image as galaxies emit radiation of different wavelengths. Thus, we can get multiple images of the same galaxy belonging to different parts of the EM spectrum. We attempt to implement the method inspired by the paper “MATHEMATICAL MORPHOLOGY APPLIED TO THE SEGMENTATION AND CLASSIFICATION OF GALAXIES IN MULTISPECTRAL IMAGES”.

Problem Statement:

1. With technological progress in the field of image acquisition, it is possible for the astronomical community to make use of the massive amounts of data containing numerous new celestial objects.
2. Since galaxies are of special interest to the astronomers, making use for this immense corpus of data, efficiently, is needed.
3. Thus, the problem we are trying to solve is to segment out the galaxies from these images, automatically, and classify them which is still an open problem in the field.

Approaches used till now:

To solve this problem, the approaches till now have used statistical methods. However, besides being computation-intensive they also tend to concentrate on individual pixel values. That is why alternative processing options, such as the MM theory, have been considered.

Our Approach (In brief):
The approach that we plan to use is the MM (mathematical morphology) theory. The main advantage of morphological operators lies in their inherent ability to exploit the spatial relationships of pixels. Moreover, they can also adapt to vectorial strategies in order to process multivariate data. Also, they are computationally efficient.

An overview of the procedure is as follows:

1. The watershed transformation is used to separate out the galaxies from the multispectral galaxy images.
2. Once the segmentation is done, a viewpoint invariant morphological feature that is based on the top-hat operator is used to distinguish elliptical from spiral galaxies.

Detailed Procedure-

The 2 main steps involved are segmentation and classification:

a. Segmentation - Is it done to extract out portions of the galaxy from the image, using some morphological approach. Segmentation is composed of two approaches :

    1.Pre-processing - The morphological operators are applied independently to each channel of the multispectral input. To clean the images and reduce noise, an OCCO (open->close-> close->open) filter has been used.

$$\mathrm{OCCO}_B(f) = \left\lfloor \frac{1}{2}\gamma_B(\phi_B(f)) + \frac{1}{2}\phi_B(\gamma_B(f)) \right\rfloor$$

    2.Watershed Transformation - The presence of a single galaxy, is realized in our case by means of the watershed transformation that segments out the galaxies and puts a boundary around them. Using OCCO we obtain markers which is feeded to our watershed black box, where we do marker controlled watershed.

The morphological operators used here are as follows:

Dilation $\delta_B(f)(x,y) = \bigvee_{(r,s)\in B} f(x-r,y-s), \ (x,y) \in E$

Erosion $\varepsilon_B(f)(x,y) = \bigwedge_{(r,s)\in B} f(x+r,y+s), \ (x,y) \in E$

Opening $\gamma_B(f) = \delta_B(\varepsilon_B(f))$

Closing $\phi_B(f) = \varepsilon_B(\delta_B(f))$

b. Classification - Having obtained the pixels belonging to the galaxy, we try to now use these pixels to classify the galaxy by morphological methods. Certain methods called the spectral methods were used to solve this problem previously but they give less importance to the features that actually caused a distinction which were shape based properties. Morphological approaches will thus be used to incorporate the shape based properties. The classification is done as follows :

1. First the segmented images from both the spectra (in our dataset) all run over by a median filter to remove the noise.
2. A top hat transform is applied to all the images (from each spectra).
3. The result is binarized by considering dark as the zero valued pixels.
4. Then, for each channel, we check the number of connected components, if less than a given threshold, we zero it down, else, we let it remain.
5. Then we count the number of connected components for the image.
6. By trial and error, we arrive at the threshold (of the number of connected components) required to classify the galaxy as elliptical or spherical

Practical problems with this method:

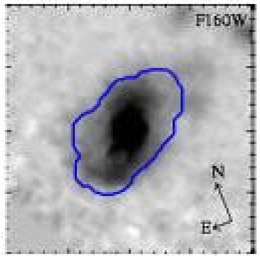
- Since the dataset was not that easily available. We couldn’t run it on many multi spectral galaxy images.
- Of the dataset which was available to us, top hat transform wasn’t able to provide satisfactory results.
- Size of SE to be used for top hat transform was not mentioned in the paper. So a lot of experimentation was required, which couldn’t be done, given our dataset.
- So we came up with another approach.

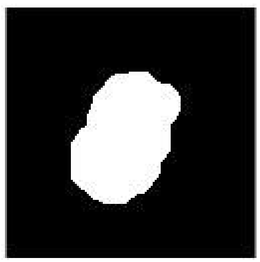
The new approach we came up with is as follows:

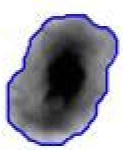
- We used eccentricities of the segmented out galaxies to classify.
- Spiral galaxies will have lesser eccentricities than elliptical galaxies.
- We used bounding boxes of connected components to get the ratio of sides of boxes and thus getting eccentricities.

RESULTS

Elliptical galaxy - 1 (segmented,mask,masked)


F160W
N
E





Spiral Galaxy(segmented,mask,masked)