Studying the contribution of components and type of spiral galaxy NGC 6946 using digital image processing

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Abstract

NGC 6946 have been observed with BVRI filters, on October 15-18, 2012, with the Newtonian focus of the 1.88m telescope, Kottamia observatory, of the National Research Institute of Astronomy and Geophysics, Egypt (NRIAG), then we combine the BVRI filters to obtain an astronomical image to the spiral galaxy NGC 6946 which is regarded main source of information to discover the components of this galaxy, where galaxies are considered the essential element of the universe. To know the components of NGC 6946, we studied it with the Variable Precision Rough Sets technique to determine the contribution of the Bulge, disk, and arms of NGC 6946 according to different color in the image. From image we can determined the contribution for each component and its percentage, then what is the percentage mean. In this technique a good classified image result and faster time required to done the classification process.

Keywords

Image classification, classification techniques, Spiral Galaxy, NGC 6946.

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دراسة مساهمة مكونات ونوع المجرة الحلزونية NGC 6946 باستخدام معالجة الصور الرقمية

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الخلاصة

تم رصد المجرة NGC 6946 بالفلاتر BVRI، في 15-18 أكتوبر، 2012، بواسطة تلسكوب 1.88م نوع Newtonian في مرصد القطامية التابع للمعهد القومي للبحوث الفلكية و الجيوفيزيقية، مصر(NRIAG)، حيث تم تركيب الفلاتر BVRI للحصول على صورة فلكية للمجرة الحلزونية NGC 6946 والتي تعتبر المصدر الرئيسي للمعلومات لاكتشاف مكونات هذه المجرة، حيث تمثل المجرات العناصر الأساسية للكون، ولمعرفة مكونات NGC 6946 تم دراسة Variable Precision Rough Sets technique لتحديد مساهمة النتوء، القرص، والأذرع الحلزونية للمجرة NGC 6946 وفقا للألوان المختلفة للصورة. ومن الصورة تم تحديد مساهمة كل مكون والنسبة المئوية له. في هذه التقنية حصلنا على صورة تصنيفية جيدة ووقت أسرع لعملية التصنيف.

Introduction

NGC 6946 is a Spiral galaxy with 8.9 mag, was discovered by William Herschel[1] on September 9, 1798. NGC 6946 is a rather nearby spiral galaxy, which at one time was suspected to be an outlying member of the Local Group (see Hubble 1936)[2]. It is highly obscured by interstellar matter of the Milky Way galaxy, as it is quite close to the galactic plane. Located at a distance of 5.9 Mpc, NGC 6946 is a large spiral galaxy seen almost face-on[3], shows a bright central nucleus, the central regions are affected by dust extinction (Elmegreen et al. 1998)[4].

As noted by Sandage (1975)[5], the first step in studying any class of objects is a classification ofthose objects.Classification built around small numbers of shared characteristics can be used forsorting galaxies into fundamental categories, which can then be the basis for further research.From such research, physical relationships between identified classes may emerge, and theserelationships may foster a theoretical interpretation that places the whole class of objects into a broadercontext[6 and reference there in].

Based on previous facts we will use one of the image processing techniques- Variable Precision Rough Sets- for the study of galactic and the percentage of each component, which contributed to the classification of the galaxy NGC 6946, which is classified by de Vaucouleurs et al. 1991[7] as SAB(rs)cd.

Observations

Observations of the spiral galaxy NGC 6946 were obtained on October 15-18, 2012 at the Newtonian focus (f/4.84) of the 1.88 m telescope of Kottamia Astronomical Observatory (KAO), Egypt. The pixel size, scale and total field of view are 13.5 µm, 0.305" pixel-1, and 10×10 arcmin2 respectively. The filters used were a standard BVRI Johnson photometric system. Table 1 gives general information about the galaxy (according to the NED and LEDA catalogs).

Table 1: Basic parameters of studied galaxy.

Type	**SAB(rs)cd**
B_T^o, *mag*	7.78
M_{BT}^o,mag	-20.53
D, *Mpc* (distance)	5.5
d_{25},arcmin minor	9.8
d_{25},arcmin major	11.5
i, deg	18.3
b/a	1
P.A., deg	52
RA(2000)	20 34 52.3
DEC(2000)	+60 09 14

Data reduction

The subsequent reduction of the data was carried out at (NRIAG), using the standard procedures in the [1]IRAF image-reduction Package.

All raw images were over scan corrected, bias subtracted, and flat-fielded using the standard IRAF tasks "quadprocess". The images were flat-fielded using dome images taken in all filters at the end of each night.The sky background level was determined using IMSTAT IRAF task by taking the mean of at least five regions (25×25pixel^2) free of sources. The BVRI images were shown in Fig.1.

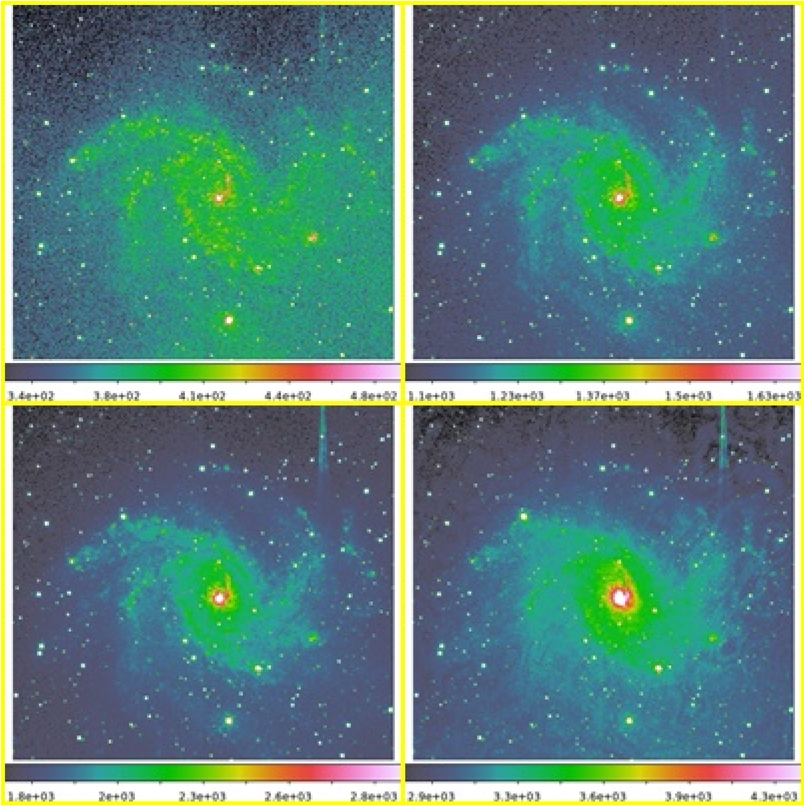

Fig. 1: The BVRI images of NGC 6946 from left to right.

Variable precision rough sets

Rough sets theory is a new mathematical tool in data mining area to deal with vagueness and uncertainty data, which can analyze and deal with various imprecise and incomplete information [8,9]. However, traditional rough sets are very sensitive to even small misclassification errors which restrict its application greatly. Hence, it is necessary to increase the system redundancies. Here, we mainly introduce the Variable Precision Rough Sets (VPRS) model. And VPRS is also taken [8,10].

In conventional rough sets, universe U is known and conclusion is only suitable for objects belonging to U. It is very difficult to satisfy the constrains in practice. To solve the problem, a method must be found to generalize conclusions obtained from sample data to a more wide area. VPRS is proposed by Ziarko[10] to solve the problem.

Let X and Y be non-empty sets in finite field. If there exist x ∈Y for all x ∈X , we call that X ⊆ Y.

It is obviously that no misclassification errors are allowed for in the condition. A new idea is presented in VPRS which give a new measurement method on inclusion relation as follows.

$$c(X,Y) = \begin{cases} 1 - \frac{card(X \cap Y)}{card}(X) if card(X) > 0 \\ 0 \qquad if card(X) = 0 \end{cases} \qquad (1)$$

where card(*) denote cardinal number of sets. C(X,Y) denote degree ofmisclassification set X into Y. That is to say, there are c(X,Y) *100%

elements misclassified. Obviously, X ≤Y when c(X,Y)=0 . Therefore we can give an admissible misclassification error β(0≤β≤.5).According to the definition, there is:

$$Y^{\beta} \supseteq \; X \; if and only if c(X,Y) \leq \beta \quad (2)$$

Suppose that U is universe, R is indiscernibility relation on U.R* ={E1,E2,….En} are partitions of equivalent classes on U.

Β- Lower approximation (β-position region of set X),

$$R_{\beta}X = U\{E \in R^{*}: c(E,X) \leq \beta\} \quad (3)$$

Β-upper approximation (β-negative region of set X)

$$R_{\beta}X = U\{E \in R^{*}: c(E,X) < 1-\beta\} \quad (4)$$

β- Boundary region,

$$BNR_{\beta}X = U\{\, E \in R^{*} : \; \beta < c(E,X) < 1-\beta\} \quad (5)$$

Β-negative region

$$NEGR_{\beta}X = U\{E \in R^{*}: c(E,X) \geq 1-\beta\} \quad (6)$$

Ziarko give a very important definition in VPRS namely quality of classification.

$$\gamma(P,Q,\beta) = card\;(POS(P,Q,\beta))/card\;(U) \quad (7)$$

In which POS(P, Q, β) is a β-position region on part ion Q*
Attribute reduction and optimal set of attribute are the most important conception in rough sets model. VPRS provide us two important criteria [10],

1. $\gamma(P,Q,\beta)=\gamma(RED(P,Q,\beta),Q,\beta)$
2. No attribute can be eliminated from RED (P,Q, β) without affecting the requirement1.There have been many algorithms for attribute reduction. Optimal reduction can be derived from combined minimum cost criterion naturally if it is possible to assign a cost function to attributes. In the absence of attribute cost function, two basic approaches were presented by Ziarko in which optimal reduction can be determined according to the number of attributes and rules [10].

Experimentanalysis

In this workwe was take Astronomy imagethe galaxy NGC 6946 to classified usingVariable Precision Rough Sets Technique, the classified technique was done used Visual Basic language. The classification taken in to threecomponents according to different region which is the bulge and a part of disk of the Pink color,the spiral arms of the blue color, and the spiral arms yellowcolor.

Results and discussion

The NGC 6946 Multiband image in the study consisting (256x256) shown in Fig.2. Fig. 3 the histogram of Multiband image for each band, the histogram shown the Data value and its frequency distribution in original image. Fig. 4 shows the classified image of three classes, in its color are assigned arbitrary, Fig. 5 shows the histogram of a segment of image data may exhibit peaks at the location of classes or clusters. Table 2 shows the statistical properties for each band of Original image. Table 3 shows the number of each class which was calculatedand evaluate the percentage of each cluster.The total percentages for all classes not equal to 100%, perfected, because there are several points is not included in any class of classified image. Therefore; the rate of this study represents the classified points which are included in the classes of classified image.

Fig. 2: Multiband image of NGC 6946.

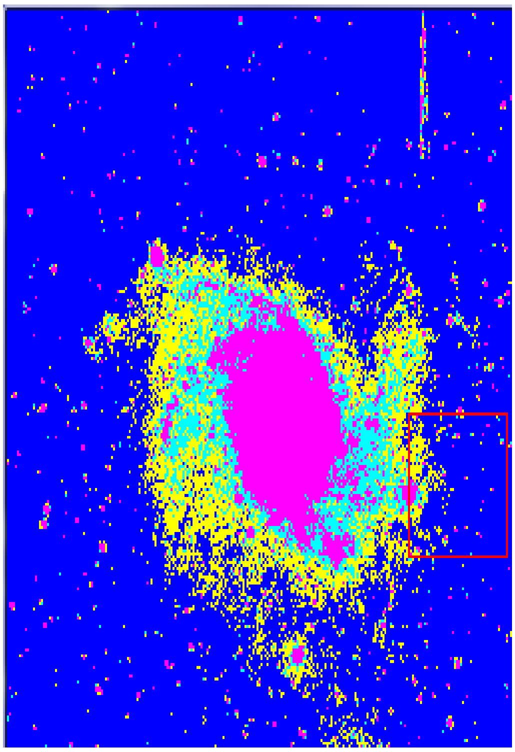

Fig. 4:The classified image of NGC 6946.

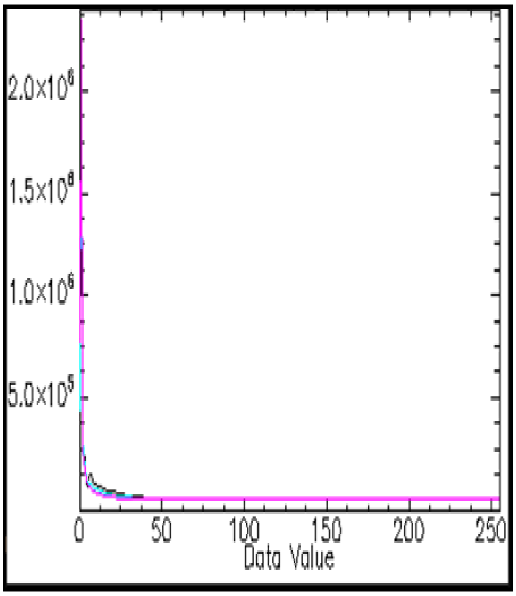

Fig. 3: The histogram (y-axes represented the probability and x-axes represented the intensity) of the original NGC 6946 galaxy (Three bands).

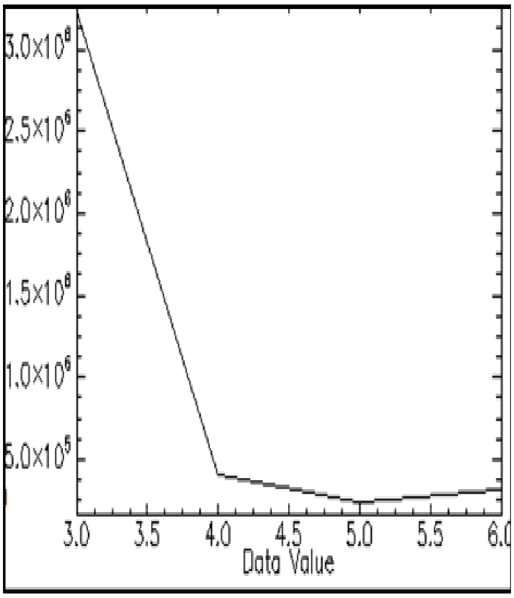

Fig. 5: The histogram (y-axes represented the probability and x-axes represented the intensity) of classified NGC 6946.

Table 2: The statisticalproperties of each band.

Basic stats	Min	Max	Mean	Stdev
Band 1	0	255	10.876	22.346
Band 2	0	255	5.929	17.0735
Band 3	0	255	3.657	10.762

Table 3: The classes and percentage for each one.

*DN	Percentage
1	42.317
2	23.99
3	33.648

Conclusions

Obviously from classified image the following important notes:

1- The percentage of the Bulge and a part of disk of the galaxy is a nearly (42.317) from the total size of the NGC 6946 galaxy.
2- The spiral arms of the galaxy the blue color, is about 23.99 of the galaxy.
3- The spiral arms yellowcolor the percentage of it is33.648.
4- It is evident from the Previous that the galaxy is a disk dominant where the contribution of the bulge is a small in comparison with the disk.
5- The bulge, disk and the arms are the most obvious components of the NGC 6946, but they are not the only one. The galaxy is surrounded by a spherical halo of hot gas, old stars and globular clusters, which is unnoticed here because of the face-on view.

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