Genetic Algorithm based image enhancement for Astroinformatics

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***Abstract-* We review the current state of Genetic Algorithms in image enhancement problems in Astroinformatics. Genetic Algorithm is related to biological background, in sense that it follows Darwin theory of natural evolution "the survival of the fittest". In this theory Sir Charles Darwin implies that one individual who is fit among the population will survive and reproduce to next generation. The genetic algorithm is first proposed by John Holland in 1975. In genetic algorithms first of all we will understand some terminologies to get insight of the process. Main terms are gene, chromosome, individual, population. Gene is smallest unit of information carrying capacity. Individual is a set of genes carrying information and further set of individuals is population.**

***Keywords:* Astroinformatics, Genetic Algorithm.**

I. INTRODUCTION

Solving the real life problems are always a great challenge for researchers. Although there are many real problems to solve but more or less they are focused on optimizing the solution. Optimizing is of various types for instance code optimization, combinatorial optimization, mathematical optimization etc. In this paper we are trying to understand how genetic algorithm provides solution for Astroinformatics. Genetic algorithm is a part of soft computing a branch of computer science that deals with exploring the search space and select the best solution. Genetic algorithm is a subset of evolutionary computation that is a group of algorithms.

New modes of discovery are enabled by the growth of data and computational resources in the sciences. This cyber infrastructure includes databases, virtual observatories (distributed data), high-performance computing (clusters and peta scale machines), distributed computing (Grid, Cloud), intelligent search and discovery tools, and innovative visualization environments [1].

II. GENETIC ALGORITHM

The term Genetic Algorithm was used by John Holland at very first [3] Genetic Algorithms (GAs) are basically the natural selection process invented by Charles Darwin where it takes input and computes an output where multiple solutions might be taken. The GAs is designed to simulate processes in natural system necessary for evolution. GA performs efficient search in global spaces to get an optimal solution. GA is more effective in the contrast enhancement and produce image with natural contrast. A Genetic Algorithm provides the systematic random search. Genetic Algorithms provide a simple and almost generic method to solve complex optimization problems.

A genetic algorithm is a derivative-free and stochastic optimization method. A Genetic Algorithm needs less prior information about the problems to be solved than the conventional optimization schemes, such as the steepest descent method, which often require the derivative of the objective functions. Based on individual fitness value, genetic algorithm uses the operators such as reproduction, crossover and mutation to get the next generation that may contain chromosomes providing better fitnesses [2].

Basically in Genetic Algorithm the new child or chromosome obtained is made up of combination of features of their parents. So genetic algorithm is applied on any image to get the new enhanced image which is much better than the original one that contains features of parents. Image enhancement techniques are used to improve image quality or extract the fine details in the degraded images. Most existing color image enhancement techniques usually have three weaknesses: (1) color image enhancement applied in the RGB (red, green, blue) color space is inappropriate for the human visual system; (2) the uniform distribution constraint employed is not suitable for human visual perception; (3) they are not robust, i.e., one technique is usually suitable for one type of degradations only.[1] GA has the ability to determine optimal number of regions of a segmentation result or to choose some features such as the size of the analysis window or some heuristic thresholds. Genetic Algorithm works well for many practical problems. However, in complex design, simple GA may converge extremely slowly or it may fail, due to convergence to an unacceptable local optimum. Considerable research efforts have been made to improve GA. Some of these improvements are mentioned in[4]. The two parameters of genetic algorithm are crossover and mutation. Crossover

Crossover is a genetic parameter which will combines two chromosomes (can also be called as parents) to produce a new chromosome (also called as offspring). The result of crossover will give the new chromosome may be better than both of the parents if it takes the best characteristics from each of the parents. Crossover occurs during evolution according to a user-definable crossover probability. The new offspring will have some properties from one parent and some properties from other parent.

Example, suppose parent1 is **11**0010**11** and parent2 is 11**0111**11 and after performing the crossover we will get the output which contains some part of parent1 and other from parent2 i.e.

11011111. 110010**11** + 11**0111**11 = **11011111**

III. MUTATION

Mutation can be takes place after the crossover gets performed. This is to prevent falling all solutions in population into a local optimum of solved problem. The mutation depends on the encoding as well as the crossover. For example when we are encoding permutations, mutation could be exchanging two genes. Mutation changes the new offspring randomly. For binary encoding we can switch a few randomly chosen bits from 1 to 0 or from 0 to 1. Mutation can then be following

- ✓ Original offspring 1- 110**1**111010011110
- ✓ Mutated offspring 1- 110**0**111010011110
- ✓ Original offspring 2- 110110*0*100110*11*0
- ✓ Mutated offspring 2- 110110*1*100110*11*0

Following is the Simple Genetic Algorithm which includes GA operators.[5]

```
function GeneticAlgo()
{Initialize population;
  Calculate fitness function;
 While (fitness value!= termination criteria)
    {Selection;
      Crossover;
     Mutation;
     Calculate fitness function; }
```

IV. IMAGE ENHANCEMENT

Image Enhancement technique is use to convert the original image into the better image. The input image can be from any image capturing device. There are various methods which can enhance the original image without losing its original good properties. Digital image enhancement techniques provide a multitude of choices for improving the visual quality of images. Appropriate choice of such techniques is greatly influenced by the imaging modality, task at hand and viewing conditions. This paper will provide an overview of underlying concepts, along with algorithms commonly used for image enhancement. The aim is just to enhance the properties of original image for the better output. The main purpose of image enhancement is to modify various image attributes to make the original image more suitable for any given task and for a specific observer. For this to achieve we can modify one or more attributes of the particular image. The attributes that are selected and are modified are specific to a given task. Edges are basic features of an image, which carry valuable information, useful in image analysis object classification. Therefore edge enhancement has been topic of fruitful research in recent years. Making use of a *global* method for image enhancement, that is incapable of adapting to the local spatial content in the image. In these cases a *local* procedure that enhances differently in different areas of the image is recommendable. And requirement for user interaction, as each image, treated as an individual in the population, should be rated subjectively by a human interpreter [6] The following figure shows that the original image can be converted into the better image using the image enhancement technique.

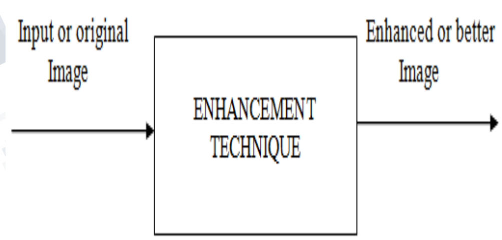

Fig1. Image Enhancement.

V. ASTRONOMICAL IMAGES

Images of astronomical objects are usually taken with electronic detectors such as a CCD (Charge Coupled Device). Similar detectors are found in normal digital cameras. Telescope images are nearly always greyscale, but nevertheless contain some colour information. An astronomical image may be taken through a colour filter. Different detectors and telescopes also usually have different sensitivities to different colours (wavelengths).

A. Filters

A telescope such as the NASA/ESA Hubble Space Telescope typically has a fixed number of well-defined filters. A filter list for Hubble's WFPC2 (Wide Field and Planetary Camera 2) camera is seen below.

Name	Type	Wheel	Slot	Notes	In WF/PC-1?	$\overline{\lambda}$(Å)	$\Delta\overline{\lambda}$(Å)	Peak T (%)	Peak λ (Å)
F122M	A	1	4	H Ly α - Red Leak	Y	1259	224.4	19.3	1240
F130LP	B	2	1	CaF2 Blocker (zero focus)	N	2681	5568.3	94.5	8852
F160AW	A	1	3	Woods A - redleak from pinholes	N	1471	457.2	10.1	1403
F160BW	A	1	2	Woods B	N	1446	457.1	12.1	1400
F165LP	B	2	2	Suprasil Blocker (zero focus)	N	3301	5533.2	95.4	5796
F170W	A	8	1	-	N	1666	434.6	30.7	1655
F185W	A	8	2	-	N	1899	297.4	25.9	1849
F218W	A	8	3	Interstellar feature	N	2117	367.9	21.1	2092
F255W	A	8	4	-	N	2545	408.2	14.8	2489
F300W	A	9	4	Wide U	N	2892	727.6	50.8	2760
F336W	A	3	1	WFPC2 U, Strömgren *u*	Y	3317	370.5	82.6	3447
F343N	A	5	1	Ne V	N	3427	23.5	9.3	3432
F375N	A	5	2	[OII] 3727 RS	Y	3732	24.4	19.5	3736
F380W	A	9	1	-	N	3912	694.8	65.0	3980
F390N	A	5	3	CN	N	3888	45.0	36.5	3886
F410M	A	3	2	Strömgren *v*	N	4086	147.0	70.4	4097
F437N	A	5	4	[OIII]	Y	4369	25.2	52.0	4368
F439W	A	4	4	WFPC2 B	Y	4283	464.4	68.2	4176
F450W	A	10	4	Wide B	N	4410	925.1	91.4	5060
F467M	A	3	3	Strömgren *b*	N	4663	166.4	75.3	4728
F469N	A	6	1	He II	Y	4694	25.0	52.4	4697
F487N	A	6	2	H β	Y	4865	25.9	58.6	4862
F502N	A	6	3	[OIII]	Y	5012	26.9	63.7	5008
F547M	A	3	4	Strömgren y (but wider)	Y	5446	486.6	91.3	5360
F555W	A	9	2	WFPC2 V	Y	5202	1222.6	94.6	5148
F569W	A	4	2	F555W generally preferred[a]	Y	5524	965.7	94.2	5310
F588N	A	6	4	He I & Na I (NaD)	Y	5893	49.0	91.4	5894
F606W	A	10	2	Wide V	Y	5767	1579.0	96.7	6186
F622W	A	9	3	-	Y	6131	935.4	95.6	6034
F631N	A	7	1	[OI]	Y	6306	30.9	85.7	6301
F656N	A	7	2	Hα	Y	6564	21.5	77.8	6562
F658N	A	7	3	[NII]	Y	6591	28.5	79.7	6591
F673N	A	7	4	[SII]	Y	6732	47.2	87.0	6732
F675W	A	4	3	WFPC2 R	Y	6714	889.5	97.3	6780
F702W	A	10	3	Wide R	Y	6940	1480.6	97.1	6538
F785LP	A	2	3	F814W generally preferred[a]	Y	9283	2096.1	91.7	9959
F791W	A	4	1	F814W generally preferred[a]	Y	7969	1304.6	95.9	8082
F814W	A	10	1	WFPC2 I	Y	8203	1758.0	94.8	8387
F850LP	A	2	4	-	Y	9650	1672.4	89.2	10028
F953N	A	1	1	[SIII]	N	9546	52.5	95.6	9528
F1042M	A	11	2	-	Y	10437	611.0	81.6	10139

Filters can either be broad-band (**W**ide) or narrow-band (**N**arrow). A broad-band filter lets a wide range of colours through, for instance the entire green or red area of the spectrum. A narrow-band filter typically only lets a small wavelength span through, thus effectively restricting the transmitted radiation to that coming from a given atomic transition, allowing astronomers to investigate individual atomic processes in the object.

A filename such as 502nmos.fits indicates that the filter used has a peak at 502 nm.

Figure 2: Example of an image constructed from narrow-band exposures. Since the narrow-band exposures probe individual atomic transitions the result is an image that has very 'sharp' features.

Galaxies are often studied through broad-band filters as they allow more light to get through. Also the processes in a galaxy are more 'mixed' or complicated, result from the outputs of billions of stars and so narrow-band filters give less 'specific' information about the processes there.

Figure 3 : "A broad-band image of the "Hyperactive galaxy NGC 7673".

When processing raw science images one of the biggest problems is that, to a large degree, you are 'creating' the image and this means a colossal freedom within a huge parameter space. There are literally thousands of sliders, numbers, dials, curves etc. to twist and turn.

Speaking of right and wrong, there really are no wrong or right images. There are some fundamental scientific principles that should normally be observed, but the rest is a matter of aesthetics — taste. Chromatic ordering of the exposures is one of the important scientific principles.

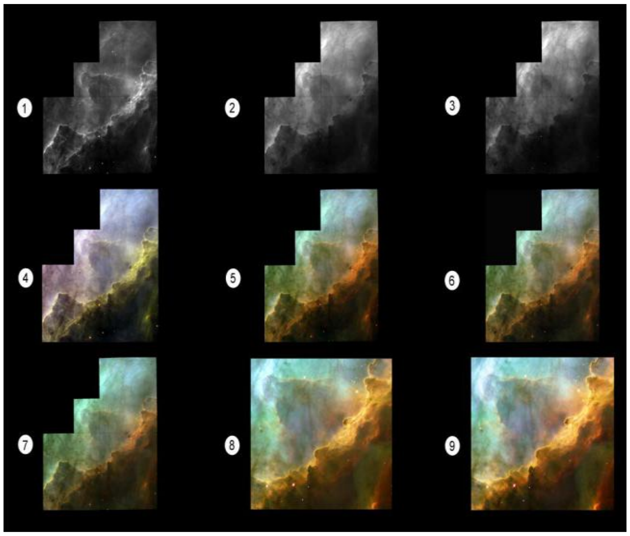

Figure 4: Sequences in the production of a Hubble Space Telescope image of Messier 17. First the individual exposure (taken through three different filters): 1. 673n (Sulphur) shown in red in the final image), 2. 656n (hydrogen, green), 3. 502n (oxygen, blue), 4. First colour composite attempt, 5. Improving, 6. Improving, 7. Improving, 8. Adjusting the composition and then 9. Final colour and contrast adjustments for the final image.

B. Image Enhancement Using Genetic Algorithm

The function GeneticAlgo () can be applied to work on the image for enhancement. The main steps in solving a problem using GAs are [6]:

- Initializing the population of possible solutions .
- Calculation of an evaluation i.e. fitness function that plays the role of the environment, rating solution in terms of their `fitness' .
- Definition of genetic operators (selection, crossover, mutation) that alter the composition of children during reproduction.
- Establishing values for the parameters (population size, probabilities of applying genetic operators) that the genetic algorithm uses .

VI. CONCLUSION

Genetic Algorithm has many advantages in obtaining the optimized solution in image processing. It was proved to be the most powerful optimization technique in a large space. Various tasks from basic image contrast and level of detail enhancement, to complex filters and deformable models parameters are solved using this paradigm. The algorithm allows to perform robust search without trapping in local extremes. Genetic algorithm allows to perform robust search for finding the global optimum. The result of the optimization depends on the chromosome encoding scheme and involvement of genetic operators as well as on the fitness function. However the quality of image segmentation can be improved by selecting the parameters in an optimized way. Image enhancement is the improvement of digital image quality, without knowledge about the source of degradation.[8]

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