Using Evolution Strategies for Automatic Extraction of Parameters for Stellar Population Synthesis of Galaxy Spectra from SDSS

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ABSTRACT

In this work we employ Evolution Strategies (ES) to automatically extract a set of physical parameters (ages, metallicities, reddening and contributions) from a sample of galaxy spectra taken from Sloan Digital Sky Survey (SDSS) for stellar populations studies. We pose this parameter extraction as an optimization problem and then solve it using ES. The idea is to reconstruct each galactic spectrum from the sample by means of a linear combination of three different theoretical models of stellar population synthesis. This combination produces a model spectrum that is compared with the original spectrum using a difference function. The goal is to find a model that minimizes this difference, using ES as the algorithm to explore the parameter space.

Categories and Subject Descriptors

J.2 [**Physical Sciences and Engineering**]: Astronomy; G.1.6 [**Numerical Analysis**]: Optimization—*Global Optimization*

General Terms

Algorithms, Experimentation, Performance

Keywords

Global optimization, Fitting of spectra

1. INTRODUCTION

In this paper we introduce a novel application of ES to a very interesting problem in astronomy: *the fitting of galaxy spectra with models of stellar population synthesis* [1]. In this task there exist a great amount of data available to be analyzed, and need to be performed automatically using reliable and efficient algorithms, because doing it manually is practically impossible.

2. FITTING

The process starts with an observed spectrum $\vec{o}$ from SDSS, which first is passed to a preprocessing module to be normalized. Then we employed our version of ES for this problem, where we first create $\vec{x}_i$ $i = 1, \ldots, \mu$, $\mu = 11$, parent individuals. Then, each $\vec{x}_i$ is passed to a module that produces models $\vec{g}_i$ following the equation: $\vec{g}_i = \sum_{j=1}^{3} c_j s_j(a_j, m_j)(10^{-4r_j k})$, where $s_i(a_i, m_i)$ represents a model of a stellar population from a library for specific age (a_i) and specific metallicity (m_i), $10^{-4r_i k}$ is the reddening term, and c_i is the relative contribution of each population. The next step consists of an iterative process where models are compared with the observed spectrum; if we obtain a good fit, with the fitness function:
$f(\vec{g}_i) = \sum_{\lambda=3800}^{\lambda=8000} |o_\lambda - g_{i,\lambda}| w_\lambda$, we stop the process, otherwise we create $\lambda = 22$ new children individuals using recombination, mutation and *average operator*, and their corresponding models. Finally, we select the μ best individual from $(\mu + \lambda)$ population and return to determine if some model has reached a good match with the observed spectrum.

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Function Evaluations (average)	$f(\mathbf{g})$ (average)	Standard deviation	Success (%)
5005	26.576	12.65	85

Table 1: Results for a set of 100 galactic spectra from SDSS DR2

3. RESULTS

In Table 1 we present the summarized results for a sample of 100 galactic spectra taken from SDSS DR2. We established experimentally a limit of 5005 function evaluations (for a total of 455 generations), and a lower limit of 1 for the fitness function to terminate, where the fitness function is not normalized and 60 is a value for being good enough. The average fitness function value is 26.576, with a standard deviation of 12.65, which means a good fitting for the great majority of the spectra.

4. REFERENCES

[1] R. C. Fernandes, A. Mateus, L. Sodré, G. Stasin'ska, and J. Gomes. Semi-empirical analysis of sloan digital sky survey galaxies - i. spectral synthesis method. *Monthly Notices of the Royal Astronomical Society*, 358(2):363–378, April 2005.