A bird's-eye view on the habitability of exoplanets via statistical learning techniques

Project for the exam: Machine learning, statistical learning, deep learning and artificial intelligence

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"Listen to me again. Just outside the Galaxy are the Magellanic Clouds, where no human ship has ever penetrated. Beyond that are other small galaxies, and not very far away is the giant Andromeda Galaxy, larger than our own. Beyond that are galaxies by the billions. Our own Galaxy has developed only one species of an intelligence great enough to develop a technological society, but what do we know of the other galaxies? Ours may be atypical. In some of the others-perhaps even in all-there may be many competing intelligent species, struggling with each other, and each incomprehensible to us. Perhaps it is their mutual struggle that preoccupies them, but what if, in some galaxy, one species gains domination over the rest and then has time to consider the possibility of penetrating other galaxies" (I.Asimov, Foundation and Earth)

ABSTRACT

Among the different tools that are considered by scholars to challenge the physical science issues, the statistical learning techniques seems to provide a promising approach to challenge them [1]. This approach can be used to tackle, one of the oldest problem of physical sciences: the habitability of exoplanets and the possibility of the presence of life on them [2]. This approach was previously used by scholars [3]: here a group of statistical learning techniques (Decision Tree, Random Forest, Support-vector machines and Quadratic Discriminat analysis) were applied to a selected set of 500 planets. The performances of the different methods were also compared and using the confusion matrix and the ROC curve.

CONTENTS

1 INTRODUCTION

The possibility of other form of life on other planets represent an issue that involved scientists as well as philosophers from different millennia of documented human history [6]. During the XX century, due to the technological progress, such question moved from a pure speculative approach, as it was previously for Lucretius, Muhammad al-Baqir or Iordanus Brunus, to a more quantitative and scientific method.Furthermore it is interesting to point out that this research was undertaken when the exploration of the Earth was almost completed [7]. The exploration of space, and the investigation of other planets was largely boosted with the use of telescopes that measure the radiation also outside the visible spectrum and later with the space telescopes such as the NASA's Kepler. As requested by all form of life in the Earth an habitable planet needs that liquid water can be present [2, 8, 9]: this feature that strictly depends by the radiation intensity I is bounded to the power radiation (P) produced by the star that host the planet and the respective distance r. Indeed by approximating a star as a point or a perfect sphere, a radiation with a spherical symmetry is produced; thus the integral that gives the power produced P:

$$P = \int \mathbf{I} \cdot d\boldsymbol{A} \tag{1}$$

can be simplified as

$$P = |I| \cdot A_{surf} = 4\pi r^2 \tag{2}$$

and so

$$|I| = \frac{P}{4\pi r^2} \tag{3}$$

Further details about this solution and the formalism by which it is obtained from the Maxwell equations can be found in Ref. [10]

2 R CODE

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