Chapter 24
A Fuzzy Expert System for Star Classification Based on Photometry

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ABSTRACT

*The application of fuzzy systems is emerging in science where experts' knowledge plays a vital role. This paper utilizes the capability of fuzzy set theory for managing uncertainty associated to star classification problem. The fuzzy classifies uses a dataset of stars obtained from Harvard classification. This paper, for the first time, presents fuzzy starts classification based on photometry. For performance evaluation, an ROC analysis was performed. The results reveal a classifier with an accuracy of 83.5% and with the 72% area under the ROC curve. The mean square error (MSE) was ⟦3.77*10⟧^(-5) which reveals superiority of the proposed fuzzy expert system compared to the other classification methods.*

1. INTRODUCTION

In astronomy the stars classification is on the basis of estimations on their receiving light and surface temperature through spectroscopic measurements, which could be done in several ways. Astronomers generally use a combination of two methods: Harvard Classification, and Brox Classification, where the former concerns the surface temperature and the latter deals with the luminosities of the stars (Gray and Corbally, 2009).

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Star Classification in astronomy is made in accordance with the star's spectral properties. The light from a star can be passed through a prism and projected on a screen to see the spectrum. The analysis of rainbow formed on the screen which contains the absorption lines of the spectrum can assist the classification. Each group of lines corresponds to a specific element, and the strength of the lines indicates to some extent the abundance of that element in the star.

The expert systems and all other systems concerning science use the gathered information from star classification to evolve it into language conceivable for a machine. The results in sequence then are in access for the expert to be judged and confirmed. Since there is usually no peculiar algorithm for problems related to the expert systems, and because they are connected to conclusion for achieving a reasonable solution, they necessarily need to use background chaining. That are used because a chain could be simply described on the basis of the kind of the reasoning it has used. In backward chaining the process is done reversely. The main problem is to find the chain that connects the evidence to the hypothesis. The evidence in this subject is the star classes which can be connected to the hypothesis.

STARMIND (Mantegia et. al., 1943) defined a fuzzy set of stars' spectral classification in the MK system. This system was trained on the basis of the obtained table. The properties used in this method were the luminosity of stars and radius scaled by corresponding magnitudes of sun. Graidhard (Mantegia et. al., 2009) used the spectra gathered by telescopes for the classification of the stars. The spectra reveal the types of chemical matters and metals in the stars, so that the expert system can be applied to establish them. Sessa (Giridharet. al., 2006) applied the expert systems for classifications of stars and galaxies while using the fuzzy concepts in his work. He applied seven fuzzy sets normalized for the expected properties. The suggested method contains two stages: in the first step the pre-processing was done, and in the second step the stars and galaxies were resolved from each other using the C-Mean method. Carricaju [5] applied the measurable spectral properties for the systems based on science as the input for the neural networks. He used a hybrid system which contains a number of technologies. In this method signal processing, expert systems, fuzzy systems, and artificial neural networks were combined to gather data and classifying them. Gray in (Carricajo. al., 2003) proposed a method to divide the stars into corresponding classes, making the use of spectroscopy, where the first class contents are those not belonging to the main sequence and the second are those which are one of the seven Harvard classes, from the hottest ones to the coldest. Most of the fuzzy sets are defined on the basis of the MK systems, where the excavated properties were based on star spectra. This method used fuzzy-expert similar to the way that humans classify main starts and non-starts. This study presents a fuzzy classification based on the photometric of the Harvard classes (Hosseini et. al., 2012). The related methods for star classification are presented in Table 1.

In this paper the light from the distant object has been first analyzed to recognize whether the object belongs to the main sequence of stars or not. The input information includes the star's light and its surface temperature. The measurement of the star temperature is indirect, as it is needed to be determined on the basis of information in its light, containing the infrared and ultraviolet light as the invisible part of its receiving light. The stars' spectra are absorptive, in that the observed dark lined are produced as the more or less the black body radiation of the star itself is after passing through its (relatively cold) atmosphere losses some of its wavelengths in part and receives afterward to our detectors on earth. By this way, two important characteristics of the spectrum have been achieve: the blue and the visual parts of the spectrum. The star temperature could be obtained directly by using these two pieces of information. The achieved science then could be embedded into the expert-fuzzy system to specify the class of the star.