PRESENT STATE OF THE WORK ON AUTOMATIC SPECTRAL CLASSIFICATION AT TARTU

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An automatic spectral classification technique for objective-prism spectra is being developed. The procedure of selecting standard stars is described. The applicability of a linear polynomial regression model for choosing and calibrating the spectral criteria for T_{eff}, M_V, [Fe/H] is demonstrated.

1. INTRODUCTION

Using objective-prism spectra obtained with the 70-cm meniscus telescope at Abastumani Astrophysical Observatory (D=166 A/mm at H_γ) and facilities for registration and processing of astronomical images available at Tartu Astophysical Observatory, we are developing a technique for automatic spectral classification of stars of spectral range F-K. The work has been reported by Malyuto and Pelt (1981, 1982). In the following we describe the current state of the work on automatic spectral classification. Our logical outline is similar to that proposed by West (1973).

2. CHOICE OF STANDARD STARS AND DATA SOURCES FOR THEM

Choosing standard stars we excluded known double and variable stars and tried to avoid unrecognized ones by requiring that the estimates of T_{eff}, M_V, [Fe/H] obtained by means of different methods were in mutual agreement. Main data sources were the catalogues of Strasbourg Stellar Data Center (CDS) 1010, 2007, 2057, 3042, 3052, 3054 and 5074.

Preference was given to stars with highly accurate photoelectric estimates of [Fe/H] in extensive lists by Nissen (1981), Campbell (1978) and Christensen (1976). These stars amount to 50 per cent of the sample. Another main source of the adopted [Fe/H] was Cayrel's catalog (CDS 3054) where results of high dispersion analysis were presented. The adopted T_{eff} values were drawn mainly from two sets

M. Capaccioli (ed.), Astronomy with Schmidt-Type Telescopes, 287–290.

of homogeneous data with high internal accuracy: the photoelectric β-indices for F stars and the V-K or R-I color-indices for G-K stars. The adopted M_V values were mainly obtained either from most accurate trigonometric parallaxes or taken from the extensive list of Wilson (1976).

Judging from the mean errors of the used data the internal accuracy of the adopted T_{eff}, M_V, [Fe/H] values for our standard stars is expected to be about ± 80 K, ± $0^m.7$ and ± 0.15, respectively. To increase the accuracy of M_V for standard stars within 200 pc, we proposed a list for observations of trigonometric parallaxes with the HIPPARCOS Satellite.

The final list of standard stars contains about 150 F-K stars of all luminosity classes and with the [Fe/H] between +0.3 and -2.0. The observations have been performed at Abastumani Observatory in collaboration with Dr G. Jimsheleishvili. Observational material for some stars obtained by earlier investigators, above all by Dr M. Shiukashvili and Dr R. West, was also used. The spectra (totalling about 400) have been digitally recorded on magnetic tape in Tartu. In future we intend to use the PDS machine installed at Tartu Observatory.

3. TRANSFORMATION OF SPECTRAL DATA

The procedure of transformation of spectral data has been described by Malyuto and Pelt (1981,1982). The transformation results in the so called equivalent areas (confined by the continuum, spectral energy distribution and integration limits). Each equivalent area includes one spectral line or a tight group of lines. It has been shown that these quantities and, in particular, their ratios are rather insensitive to the spectral resolution and to the graininess of photographic emulsion.

4. SELECTION OF CRITERIA

We have adopted equivalent area ratios as spectral classification criteria. The number of possible ratios exceeds 1000 per each spectra. Therefore one needs a simple and effective algorithm for selecting the ratios, most sensitive to different physical parameters in order to exploit them subsequently as classification criteria. We have tried to use models of linear polynomial regression for this purpose. The values of T_{eff}, M_V, [Fe/H], their powers and products were treated as predictors, and the measured ratios as response variables.

Because our measurements of equivalent areas are not yet completed, we analysed 10 central depth ratios, measured by Malyuto (1977) in the same spectra for 72 F2-G8 stars, to try applicability of linear regression models. One may expect that in general central depth ratios behave similarly to area ratios. This assumption is supported by comparisions made by Malyuto and Pelt (1981).

TABLE

No.	Identification	R	Partial derivatives with respect to T_{eff}	M_V	[Fe/H]	Type of sensitivity
1	$4300/H_\gamma$	0.94	-9.84	0.04	1.17	T_{eff}, [Fe/H]
2	$4272/H_\gamma$	0.95	-4.10	-0,08	0.60	T_{eff}
3	$4251/H_\gamma$	0.92	-4.46	0.02	0.28	T_{eff}
4	$4226/H_\gamma$	0.95	-3.71	-0.01	0.40	T_{eff}
5	$4200/H_\delta$	0.94	-3.75	0.31	0.38	T_{eff}, M_V
6	$4172/H_\delta$	0.93	-3.74	0.30	0.41	T_{eff}, M_V
7	$4128/H_\delta$	0.92	-2.73	0.24	0.14	T_{eff}, M_V
8	$3883/H_8$	0.90	-3.64	0.14	0.73	T_{eff}, M_V, [Fe/H]
9	$(3871+3860)/2H_8$	0.92	-5.65	0.32	0.95	T_{eff}, M_V, [Fe/H]
10	$(3826+3815)/2H_{10}$	0.90	-2.45	-0.12	0.63	T_{eff}, [Fe/H]

Inspired by the visual appearance of graphs of corresponding relationships, we started with the following model:

$$Y = \beta_0+\beta_1X_1+\beta_2X_2+\beta_3X_3+\beta_{11}X_1^2+\beta_{22}X_2^2+\beta_{33}X_3^2+$$
$$\beta_{111}X_1^3+\beta_{222}X_2^3+\beta_{333}X_3^3+\beta_{12}X_1X_2+\beta_{13}X_1X_3+\beta_{23}X_2X_3. \quad (1)$$

Here Y is the analysed ratio and X_1, X_2, X_3 stand for T_{eff}, M_V, [Fe/H], respectively. Next we tried to simplify the model by gradually excluding supposedly redundant terms beginning with higher degrees. Multiple correlation coefficients R and partial derivatives with respect to T_{eff}, M_V, [Fe/H] at the average values of these parameters were calculated at each step. In Table we present results for the model with 10 predictors (the $\beta_{333}X_3^3$ and $\beta_{23}X_2X_3$ terms of (1) were excluded). The results are very similar to those for the model (1). In the last column we indicate the type of sensitivity of criteria. The physical parameters to which a criterion is most sensitive, according to Malyuto (1977), are indicated. We see that this model is capable for separating those ratios which are sensitive to different sets of physical parameters (the criteria of differing type were chosen on the basis of the corresponding derivatives). Multiple correlation coefficients differ slightly.

5. CLASSIFICATION

If the chosen model of linear polynomial regression is adequate in detail, it may be used not only for selection of criteria , but also for classification. Sets of relations of type (1) for each star may be considered as systems of non-linear equations with respect to T_{eff}, M_V, [Fe/H]. Using the above model (1) without the last term and the criteria listed in the Table, we composed and solved these systems of equations for our 72 standard stars. The method of steepest descent was used to actually find the solutions. The results turned out to be encouraging. From comparision of program results with standard T_{eff}, M_V, [Fe/H] values and taking into account their mean errors indicated in Section 1, we found that our model gives the T_{eff}, M_V, [Fe/H] values with the mean errors ±170 K (±140 K if stars with calculated T_{eff} > 6200 K are excluded), $\pm 0^m.8$ ($\pm 0^m.6$) and ±0.31(±0.18), respectively. Lower accuracy for hotter (F type) stars is due to lower sensitivity of criteria and, possibly, to the inadequacy of the used model in this temperature region.

The detailed version of this paper will be published in a report to be issued by W. Struve Tartu Astrophysical Observatory.

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https://doi.org/10.1017/S025292110010675X Published online by Cambridge University Press