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CoLiTecVS – a new tool for an automated reduction of photometric observations

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Abstract. The capabilities of telescopes allow us to make the plotting of light curves a routine task. This one shifts the main attention of an astronomer from the plotting to research. To achieve this goal, we developed a new tool for automated reduction of photometric observations, which includes the computational method for the brightness assessment of the investigated and comparison stars; brightness equalization of astronomical images using an inverse median filter; light curve plotting and its processing using different tools.

Key words: stars: variables – Techniques: photometric, image processing

1. Introduction

CoLiTec application was originally developed for automated detection of objects with nonzero apparent motion (Savanevych et al., 2015). Recently, we have started the major update with the goal to use it in the variable stars research as the tool for automated reduction of CCD images. The new version is called CoLiTecVS[1]. It allows the astronomer to create the light curve of an investigated variable star without manual-data handling between processing steps.

2. CoLiTecVS workflow for the automatic data reduction

CoLiTecVS has the following work-flow: forming the series of frames with the investigated variable star; brightness equalization of frames using master-frames and an inverse median filter; preliminary segmentation of objects on images; estimation of objects brightness and equatorial coordinates; frames identification;

[1] http://www.neoastrosoft.com/colitecvs_en/

automatic selection of the reference stars in the frame; brightness assessment of the investigated star using the developed computational method; preparing the task-file with selected comparison stars; processing of the photometric observations; light curve creation of the investigated variable star. Created light curves can be viewed and analyzed using the specific modules of the CoLiTecVS - PlotViewer or the Virtual Observatory (ViViO).

3. LookSky – the auxiliary tool

To create the task file corresponding to the investigated target on the given telescope the user has to use the additional software called LookSky. Its capabilities are as follows:

- Viewing opened series of frames.
- Selecting investigated target and comparison stars.
- Preparing a task-file for plotting the light curve. It will be used in the future in every reduction of the given target.

The process can be greatly automated using the AAVSO[2] chart for the given target. In one click the software finds the corresponding AAVSO chart, selects the comparison stars in the field of view and take the coordinates and brightness values from the photometry table.

4. Testing on real images

We have performed several tests to ensure the reliability of produced data. We have analyzed archival images taken at the Astronomical Observatory on Kolonica Saddle with several instruments. First, we investigated the possible influence of non-linearity of median filtering on the photometry results. We didn't find measurable influence. Contrary to the background brightness equalization,the inverse median filter usually provides better results than the classical flat-field calibration. Detailed analysis of the inverse median filtering can be found in Dubovský et al. (2017).

The photometry of constant stars obtained by CoLiTecVS was compared with values obtained by the conventional reduction process, i. e. calibration and photometry were performed with C-Munipack[3] software and subsequently the ensemble photometry using MCV software (Kim et al., 2004). We have performed many comparisons with different instruments in different star fields. More than 100 time series were reduced. The typical result is shown in Table 1. The meaning of the methods is as follows: C-Munipack_diff means single differential photometry with C-Munipack software, one comparison star; C-Munipack

[2] http://www.aavso.org

[3] http://c-munipack.sourceforge.net/

Table 1. The mean values and standard deviations of the selected stars measurements in the field of view of cataclysimic variable MASTER OT J174305.70+231107.8

Method	Mean value	Standard deviation
C-Munipack_diff	1.3935	0.0118
C-Munipack + MCV	1.3935	0.0067
CoLiTecVS	1.3939	0.0078
CoLiTecVS + MCV	1.3941	0.0070

+ MCV means ensemble photometry, instrumental magnitudes provided by C-Munipack reduced by MCV software; CoLiTecVS means ensemble photometry, fully automated output of CoLiTecVS; CoLiTecVS + MCV means ensemble photometry, instrumental magnitudes provided by CoLiTecVS reduced by MCV software.

The disadvantage of a single comparison star (C-Munipack_diff method) is clearly visible. The scatter is caused by the parabolic trend connected with extinction. The rest of the light curves are practically equal. So the CoLiTecVS can replace the conventional reduction process with the same precision and accuracy. If the user doesn't trust the automatic process completely, one has still got the option to take instrumental output of CoLiTecVS and play with MCV.

5. Conclusion

A new tool for automated reduction of photometric observations was developed. It includes the computational method for the brightness assessment of the investigated star, comparisons stars and light curve creation. The proposed method of the inverse median filter application can be used for calibration of astronomical images without negative influence on the results of the photometry. Nowadays CoLiTecVS is regularly used for data reduction at the Astronomical Observatory on Kolonica Saddle.

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