CMN_ADAPT and CMN_binViewer software

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As the main focus of the Croatian Meteor Network (CMN) shifted from data collection to data analysis, primarily to the discovery of new meteor showers, it became clear that the current data processing pipeline was slow and outdated. In this paper new software for fully automatic data acquisition and processing is presented. Furthermore, a new tool for viewing the data acquired with the CAMS capture and compression software is described and a link is given for free download from the CMN webpage.

1 Introduction

Since late 2009, when the first procedures for automatic CMN data processing were written (Vida et al., 2011), a constant further development of such tools has been ongoing. Although the process of meteor detection, data calibration (astrometry and photometry) and orbit pairing was mostly a matter of running a few automated scripts, data processing was far from real-time. It is evident from the CMN publications of orbit catalogs (Šegon et al., 2012a; Korlević et al., 2013; Croatian Meteor Network, 2013) that in some cases data had still not been fully processed several years after their initial capture. As the main focus of the network shifted from mere data acquisition to data analysis in 2012 and 2013 (Šegon et al., 2014), it became clear that the existing procedures would no longer be sufficient. CMN staff would not have sufficient time to carry out both activities in parallel. Thus it has been decided to develop a new tool that will provide a fully automatic way of data acquisition and processing.

In the second part of the paper a new tool is presented for viewing the files acquired by the CAMS capture, compression and detection software (Jenniskens et al., 2011), and by Skypatrol.

2 Old data processing pipeline summary

Data acquisition

Since the beginning of the Network, Skypatrol software has been used for data acquisition, mostly because of its low minimum system requirements. In the years of the Network's expansion, acquiring a PC with a top-line configuration to be available only for the purpose of meteor capturing proved very difficult. Thus Skypatrol presented a good alternative to other more demanding solutions. With the further development of computer technology and the wider availability of faster computer configurations, CMN could afford more advanced capturing solutions. Replacing Skypatrol was a high-priority task as it had certain drawbacks. After each image had been captured there was a 6 second pause taken up by for internal processing procedures and for the writing of the data to disk. This meant that 10% of all meteors would be missed. For some bright multi-station fireballs it was found that although several stations captured it properly, there would often be one station the fireball happened to coincide with the "6 second time hole". Furthermore, there was no automatic way to start and to stop the capturing process. Automatic scripts which moved the mouse pointer and clicked the start and stop buttons were not very reliable because the Skypatrol window was often minimized and and it could not be automatically restored as the software randomly changed the name of the window. Among other drawbacks, it also could not capture more than two concurrent events.

Meteor detection and image calibration

Meteor detection was done using MTP_MeteorDetector software (Gural et al., 2009) which was run by a script that allowed large volumes of data to be processed at the same time. The detection procedure was very time-consuming, often requiring more than 24 hours of processor time for a few months of data from only one station. The data collected had to be further filtered to remove unwanted detections and to be calibrated with the CMN_AutoCheckFit software in order to perform astrometry and photometry procedures. In cases where

the PC at the station had no internet connection, an additional step of time synchronization needed to be carried out via the CMN_dTcommander software. This compared common events between two stations and calculated the most probable time difference between them for each day.

Orbit estimation

UFOorbit software[1] was used for orbit estimation. It provided an easy to use user interface and a fair visualization of meteor orbits. However, following further research, some of its limitations became apparent. The most obvious one is the assumption of a constant meteor velocity after entering the atmosphere, i.e. it does not take the deceleration of a meteor into account during the orbit calculation.

All orbits obtained by UFOorbit will be compared with orbits computed by the CAMS software application FTP_Coincidence on the same data set in the near future.

3 New Data Processing Pipeline - CMN_ADAPT

CMN_ADAPT (Automatic Data Acquisition and Processing Tool) was developed with all the data handling needs of the Croatian Meteor Network in mind. It provides a fully automatic solution for data capture, meteor detection, astrometry, photometry and data transfer to the central server, allowing for fully processed data to be ready for orbit estimation less than 6 hours after sunrise. Although the full functionality requires an internet connection and a decent computer configuration, these requirements can be considered one of today's standards. A complete compatibility with the previous processing procedures is retained, enabling a seamless use of any old data such as these obtained with CMN_ADAPT software.

Figure 1 – CMN_ADAPT initial setup window.

Initial setup

A special consideration has been given to the ease of setting up the software, as it is sometimes difficult to educate new station operators only via e-mail or by phone. The software is distributed to individual station's computer via a compressed archive. The operator then extracts this to an appropriate location and then runs the

CMN_ADAPT.exe file. The station operator is asked for only two pieces of information: station code and the availability of internet connectivity (*Figure 1*). If the internet connection is available, a configuration file containing all parameters for the specific station is downloaded from the central server and the set up is now complete. If the internet connection is not available, the station operator needs to choose the appropriate configuration file that will have been specifically configured for that particular station and included within the delivered software archive.

During the initial setup some camera parameters such as brightness and contrast can also be adjusted. A configuration window opens and the camera operator can easily adjust the settings to achieve a proper look of the live feed from the camera itself. This step also serves as the last check of a proper hardware setup.

Pre-capturing maintenance

Each time that the software is started, a request is sent to the central server to check for a new software version. If it is available, the software is automatically updated. Before starting a new capturing session, any raw data older than a week is deleted. This prevents accumulation of raw data on the local computer as it would otherwise fill the hard disk in just a few weeks. After the cleanup, the start time and duration of capturing is calculated with regard to the location of the station and the current date.

Capturing and meteor detection

It has been decided to fully replace Skypatrol with a more modern meteor capturing solution. Having considered all available solutions, FTP_CaptureAndDetect by Peter Gural was chosen as the most suitable, as it retains several features from Skypatrol and it has an easily convertible data format, similar to one used by CMN. It also uses video capture via a frame grabber interface that is compatible with all capturing devices currently used by CMN. FTP_CaptureAndDetect is initiated at the calculated start time and the duration of capture is passed to it. Parallel with the capturing thread, the meteor detection thread runs and detects meteors in the captured images. These detections are written to a FTP_detectinfo file.

CMN procedures

When the capturing and detection process has completed, a script to create thumbnails of each captured image is run to provide an easy way to see all events during the night on a single view. It is also necessary to convert the CAMS standard detection information format to the CMN format, in order to apply CMN procedures on the data. For this task a script named CAMS2CMN by Ivica Skokić is implemented in the CMN_ADAPT. Following the conversion, all existing CMN standard procedures are applied on the data. First, detections are filtered using the MTP_filter software in order to eliminate birds, bats, planes and other unwanted detections. Astrometry is performed by running the AutoCheckFit software and photometry is also performed. To make the data compatible again with CAMS standard procedures, the

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[1] http://sonotaco.com/soft/UO2/UO21Manual_EN.pdf (SonotaCo, 2008).

final CMN file, which contains meteor parameters, is converted back into the CAMS standard detection information format.

Archiving and transfer

All files containing detection and astrometrical data are archived to a compressed ZIP file and uploaded to the central server. Such files are often only a few megabytes in size. An archive of compressed raw image files which contain only detected meteors is kept locally and not transferred to the central server as these archives can reach several hundreds of megabytes in size. These files are submitted by the station operators via portable hard drives or DVDs.
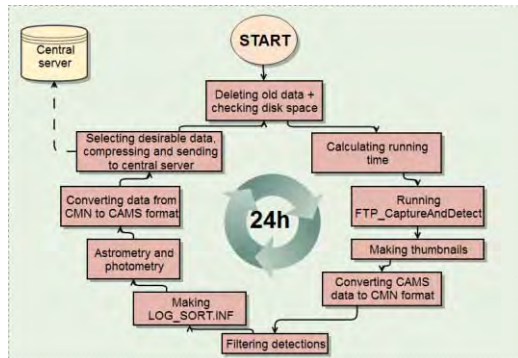

Figure 2 – CMN_ADAPT flowchart.

Orbit estimation

The multi-track coincidence and the orbits procedure is carried out by Peter Gural via the FTP_Coincidence software. The data is downloaded from the CMN central server to his personal computer, the procedure is performed and the processed data is uploaded back to the server. From this point onwards the analysis can be carried out on the orbit data. The possibility of using UFOorbit for orbit estimation is also available, as all output data from the CMN_ADAPT software is fully compatible with it.

4 E-mail alerts and thumbnails

In order to provide some supervision on the current status of the network and an early warning system for fireballs, a daily e-mail report is sent to several CMN members at 22^h00^m local time each day. This task is performed by a script running on the CMN central server. The report contains a list of stations which failed to upload the data that day and a list of detected fireballs. Thumbnail images generated by CMN_ADAPT are added as an attachment. Station operators are immediately contacted to resolve issues at those stations that failed to upload the data so that the issues can be resolved or at least diagnosed via the remote desktop software. Listed fireballs are checked on the thumbnail images, and the thumbnail images themselves are thoroughly examined. If the detected event is determined to be a possible meteorite-dropping fireball, further steps are performed for its analysis.

5 CMN_binViewer software

The use of the new capturing software has highlighted the need for a more advanced solution for viewing captured data. It was decided therefore to develop a new tool for viewing both CAMS standard and Skypatrol standard data. Its goal is to provide an all-around capability for easy data viewing, sorting, saving individual frames and images, making an animation, applying dark and flat frames and correcting image levels. As there are currently numerous networks working with CAMS standard software, CMN_binViewer is given as freeware on the CMN website[2].

Filters

The main advantage of the CMN_binViewer is its filters, special procedures applied to individual images that reveal meteor characteristics which would otherwise be invisible. There are 7 individual filters: Maxpixel image, Colorized image, Detection only, Average frame image, Odd field image, Even field image and Video.

The *Maxpixel image filter* displays the image composed of pixels which had the highest value during the recording period of 256 frames. On the Maxpixel image every recorded meteor should be seen, and thus it is set as the first and the default filter (*Figure 3*).

To get a general idea about the meteor's velocity, without needing to look at the video, the *Colorized filter* is used. It colors intermittent fields with cyan and red color. This is done by deinterlacing the image by odd field duplication. The resulting image is put into the red image channel, and the deinterlaced image by an even field duplication is put into the green and the blue channels. When all channels are viewed simultaneously, the image shows the desired effect. Fast meteors have nicely separated cyan-red detection points, while slow meteors often have detections very close to each other, thus odd field image and even field image are almost indistinguishable from each other. This results in an almost colorless white meteor on the final colorized image.

In Captured mode, the *Detection only filter* subtracts the Average pixel image from the Maxpixel image, and this results in an image which shows only the detection, without background. The resulting image is usually darker than the Maxpixel. This filter is used when the background is very bright, e.g. during Full Moon, to make faint meteors easier to see. In Detected mode, the image is constructed from individual frames of a detection, so that only the particular detection is visible, in cases when there are several detections on a single image.

The *Average pixel image* (Avgpixel in the GUI) depicts the average value of all pixels during the recording period of 256 frames. It shows background features such as background sky brightness, CCD sensor imperfections (hot pixels), stars, the Moon, objects obscuring the field of view, etc. It is used make visible the background conditions when the meteor was recorded.

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[2] http:// cmn.rgn.hr/downloads/downloads.html#binviewer

Odd field image depicts the deinterlaced Maxpixel image by odd row duplication. The method consists of copying odd image rows (from top to bottom) to even rows. This filter is often used to see individual detections of a faster fireball in order to reveal the true nature of the fireball. For brighter events, phenomena such as wakes, trains and trails can be visible between the frames. *Even field image* depicts the deinterlaced Maxpixel image by even row duplication.

Video filter is used for viewing the video of a certain file or a detection. Image modifiers (deinterlacing, levels, dark frame and flat frame) are not applied during a video preview as they require a lot of processor time for each frame of the video. During the video preview the current frame number will be shown at the end of the timestamp (and change rapidly according to the FPS entry). When the viewer is showing a static image, the frame number will simply read "FFF".

Modes

In *Captured mode*, every image in a certain folder is shown in the file list box, whether it has a detection (i.e. meteor) or not. This provides a useful way to check through all images from a certain night. In this mode all filters are available for use. *Video filter* will show a movie from the first to the last frame (0 – 255 for CAMS). The temporal range can be narrowed by specifying a new range for the Start Frame and the End Frame entries. When a GIF animation is generated in this mode, it will also produce an animation 255 frames long. To create an animation showing only the detection, the *Detected mode* is used.

In *Detected mode,* only images with detections are shown. All filters are disabled other than *Detection only filter* which shows the specific event (*Figure 4*). The *Video filter* is also available in this mode, but it will show a movie only from the start to the end of a certain event. This can be used to quickly go through all recorded meteors and see their video clips.

Image calibration and adjustments

CMN_binViewer offers the option of applying two calibration images: *dark frame* and *flat frame*. It can deinterlace the image by blending the odd and even fields. It can also apply levels adjustment. These options are used to enhance the final image. In several filters and in the Detection mode some of these features are disabled, as they would interfere with normal operation. When available, all options can be used to produce a combined effect.

Saving images and animations

It is possible to save an image in BMP or JPG formats while it is being shown on the screen often useful to have a short animation of a certain meteor that can be easily viewed across many platforms. The GIF format has been chosen because of the small final size of an animation, and the compatibility with many current web browsers. This provides easy sharing and viewing of the animations.

6 Conclusion

To fulfill the current needs of the Croatian Meteor Network, two software solutions have been developed. CMN_ADAPT provides an automatic and care-free solution for data capturing, processing and transfer. In addition to the CMN_ADAPT, a server-side script generates a daily e-mail report to alert CMN station operators about camera issues and fireballs. The CMN_binViewer software, developed to view CAMS standard and Skypatrol standard data, provides an easy way to view and manage captured data. CMN_binViewer is freeware and is available to all meteor enthusiasts who are using the mentioned capture software solutions. A detailed user manual is provided with the software to help future users utilize all integrated features.

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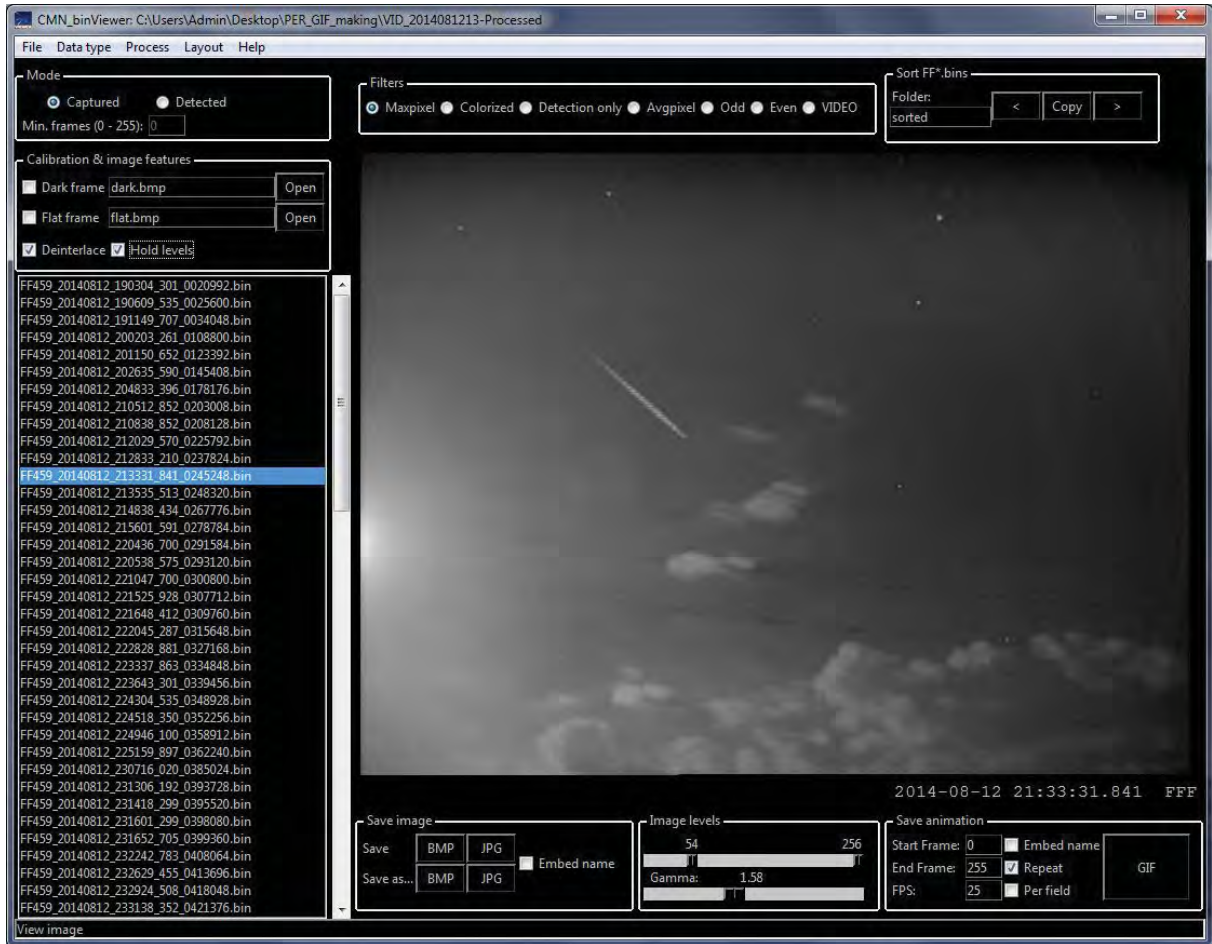
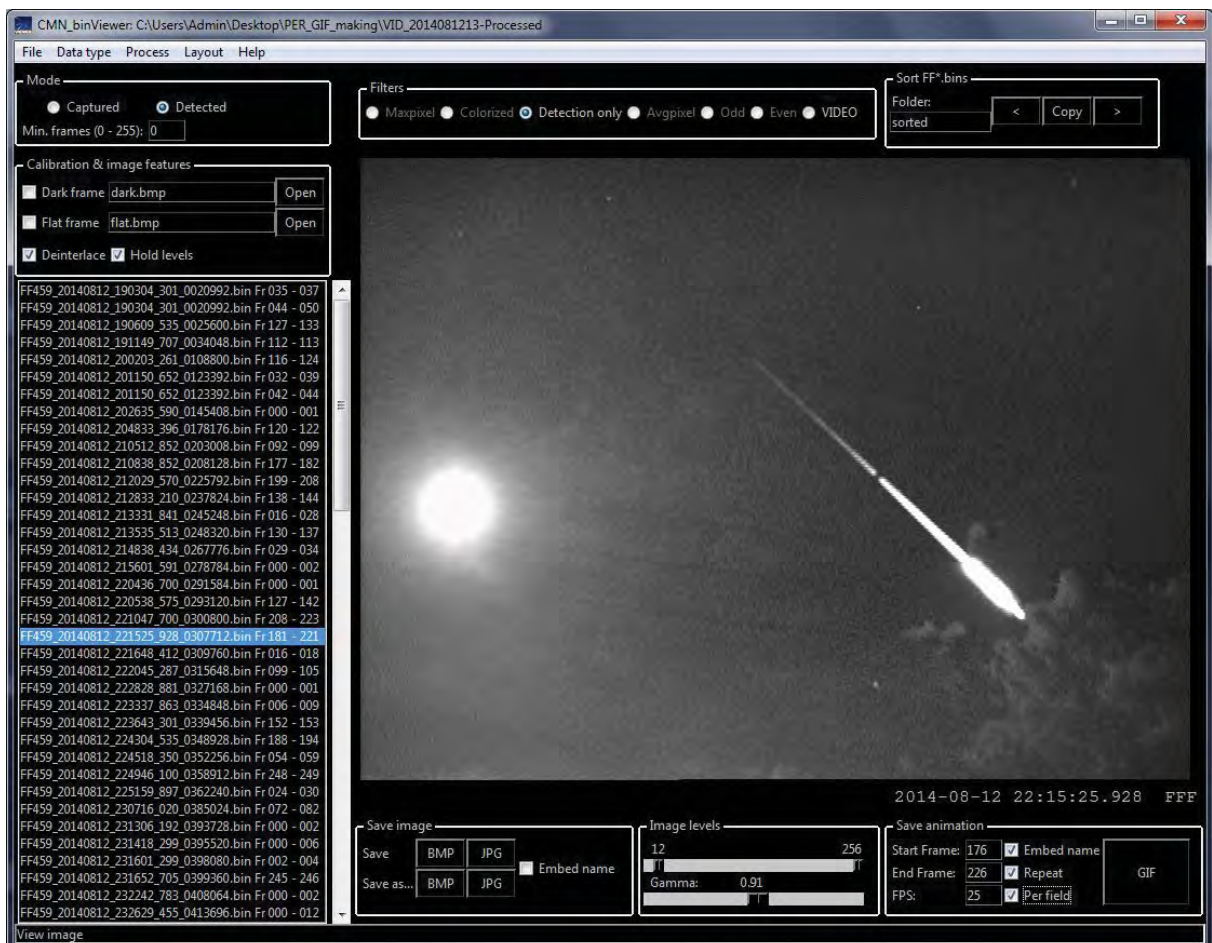*Figure 3* – CMN_binViewer Maxpixel image filter in Captured mode.

Figure 4 – Detection only filter in Detected mode, ready for saving GIF animation.