A new meteor detection algorithm for shuttered photography

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This paper presents a new meteor detection algorithm used on CCD camera images. We detail some methods used on CCD images but also on other types of images. Then we explain the algorithm which applies image difference and then the Hough transform.

1 Introduction

The meteor detection is decisive information to determine the trajectory of an object. Indeed it helps to know where the object comes from and in the case the corresponding meteorite is found, it allows us to determine the composition of solar system objects. Moreover, the trajectory calculation also allows us to estimate the risks of collision with telecommunication satellites or with the Earth.

The new algorithm presented here was created for the CABERNET (**Ca**mera for **BE**tter **R**esolution **NET**work) project. The aim of this project is to determine precise orbits of meteors by using CCD images taken by 3 cameras during a night. The aim of the algorithm is to reduce the number of false detections obtained by the existing algorithm.

2 Related work

Many scientists worked on meteor detection algorithms because there are different ways to capture meteor images. P. Gural (2008) presents different methods to detect meteors, such as the probabilistic methods, the wavelet transform, the mathematical morphology, the Hough transform and the matched filter.

The probabilistic methods put together predictions of near Earth object's orbits (Babadzhanov et al., 2008), which allow us to determine the associated meteor shower and to detect the meteor. We can also use the Latent Dirichlet Allocation with radio astronomy images (Friedlander et al., 2012), to know the pixel distribution in function of the intensity and allow us to detect the source. Another method (Tzannes et al., 2002), applied on infrared images, consists in computing the temporal mean and the standard deviation of each pixel, and then in applying a band-pass filter and some thresholds including one using ROC curves.

Concerning the methods using a CCD image sensor, we can distinguish two techniques. The first one (Mohanty, 1981) uses the maximum-likelihood ratio detection using a simultaneous estimation of the mean and the covariance of the noise, then simulates the target pattern, before correlating the received data with the target patterns and comparing with the corresponding threshold, to finally print out the positions and paths of the targets when present. The second one (Mojzis et al., 2012) uses a statistical test for the Poisson distribution and the False Discovery Rate (FDR) in multiple hypothesis, for analysis on dark frames. Then the method is applied to detect any object.

On CCD images we can also use the wavelet transform (Thenappan, 2008), for example by using the "À trous" algorithm (Anisimova, 2011) to smooth the object.

Another powerful method is the Hough Transform (Kubickova, 2011 and Trayner et al., 1999), which detects lines in an image. On videos, we can use the Time Hough Transform algorithm to detect the meteors by computing their velocity.

Finally, the matched filter aim is to make an hypothesis on the movement of an object from a velocity vector and a starting point, and then re-center every frame as a function of the model (Gural et al., 2005; Gural, 2008)

The way to do it is:

- Making a patch which contains one or more segments.
- Correlating with the image to determine whether the template is in the image.

These various articles coming from astronomy and computer reviews allowed to choose which methods of image processing to apply.

3 Our method

The algorithm should respect some constraints like:

- Taking FITS image as entry.
- Working on both Windows XP and Windows 7.

- Processing 60000 images in 3 hours.
- Detecting as many meteors as the previous one.

The detection algorithm begins with the difference between two successive images and then applies the Hough transform on the resulting image.

More precisely, we open the FITS image in C language by using the CIFITSIO library. Then we convert the 16 bit image into an 8 bit image to be able to use the OpenCV functions. Indeed this library includes a Hough transform function which processes 8 bit images.

We apply a threshold to reduce the number of the objects (Figure1).

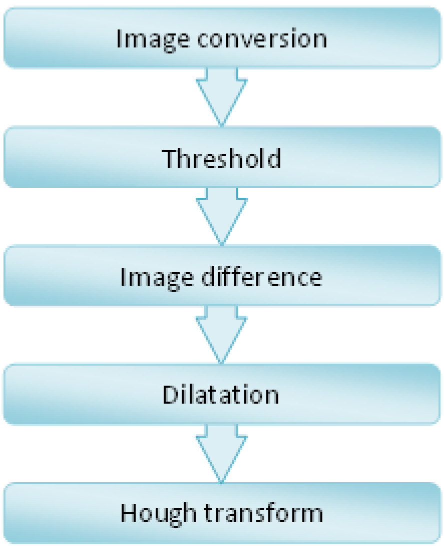

Figure 1 – Diagram of our algorithm.

After these operations we apply an image difference to remove the background. We apply another threshold to keep only our meteor (Figure 2). Then we use a mathematical morphology dilatation to be sure that the Hough Transform will detect our meteor. Finally we apply the Hough Transform.

4 Results

This program gave satisfactory results: all the meteors which had to be detected were detected and we obtained only 2 false detections on the test images database (see also Figure 3).

We have in both cases 100% of images containing meteors detected.

5 Conclusion

The results are more than satisfying, but we could improve the algorithm by using the phase coded disk method or by segregating meteors and satellites in different folders.

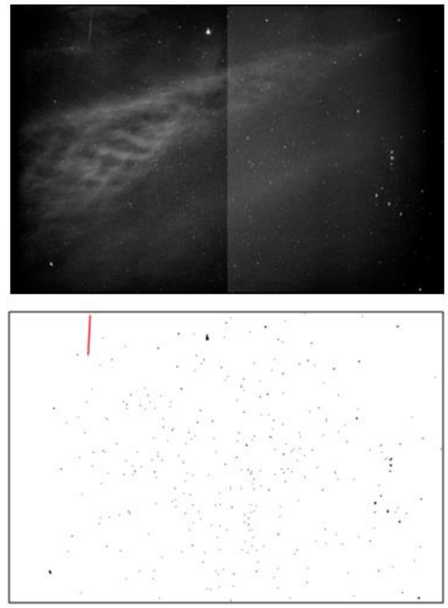

Figure 2 – Upper picture: image with clouds.
Lower picture: image after applying our algorithm.

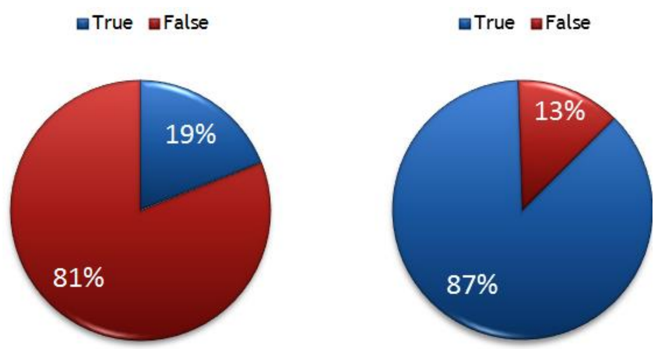

Figure 3 – Left: detections rate with the previous algorithm.
Right: detections rate with the new algorithm.

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