Astrometry with fish eye lens and orbit determination

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This paper describes a meteor astrometry method for fish-eye lenses and its preliminary results. This work has been done within the framework of the project FRIPON.

1 Introduction

FRIPON (Fireball Recovery and InterPlanetary Observation Network) is a network with 100 cameras which goal is to monitor the French skies in order to find meteorites just after their fall, to track the origin of meteorites and to share this adventure with the public via the "Vigie-Ciel" project. An automated image processing software is currently being developed for FRIPON cameras. This paper is about a new approach of astrometry with fish eye lens.

2 FRIPON pipeline

We can distinguish two parts in the pipeline: the meteor detection part and the trajectory calculation part. Once we made sure that the detection is a meteor, the next step is to compute its trajectory through the atmosphere and its strewn field and orbit. We can split this part of the pipeline into 5 interdependent modules, i.e. astrometry, photometry, trajectory in the atmosphere, orbit and strewn field.

3 Astrometry with fish eye lens

The precision of our trajectories will mainly depend on the accuracy of the astrometry. The very large field of view of our cameras (180°) induces strong distortion that challenges the astrometry process, especially near the horizon. Fortunately, we will have a network of 100 cameras at distant of ~100 km from each other, for which we allow a loss of 10° to 15 ° above the horizon. Several astrometry methods are known. For fish-eye lenses, the methods of Ceplecha (1987) and Borovička et al. (1995) are the best known. We first tried already existing automated solutions like the astrometry software SCAMP[1]. SCAMP software is configurable with standard projections. After several trials with all possible standard projections, we finally had to conclude that it will be difficult to adapt the software for very large fields of view but we did not exclude that solution. We also had a look at documentations provided by opticians[2] and we found out that the mapping function of a fish-eye lens can be expressed as:

$$R = k_1 \times \sin(\frac{i}{k_2})$$

R is the radial distance (between the center of the field and the image point), k_1, k_2 are two parameters that are specific to the lens and *i* is incident angle of the beam (Figure 1).

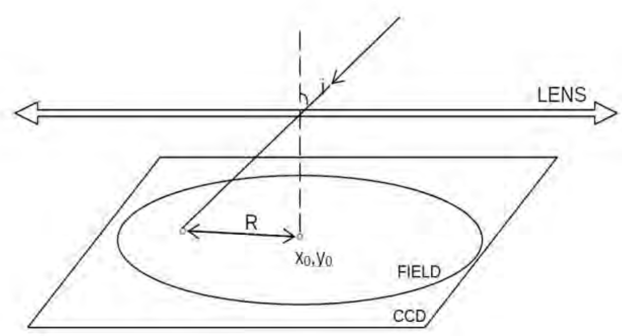

Figure 1 – Illustration of the radial distance

We thought that it would be an interesting way to explore and we started our own camera calibration on an optical

[1] www.astromatic.net/software/scamp (Bertin, 2014).
[2] www.pierretoscani.com/echo_fisheyes (Toscani, 2014).

bench. This gave us a first guess of the distortion parameters. For this model, the parameters to optimize are k_1, k_2, x_0 and y_0 (the center of the field, that differs from the center of the CCD plate), θ (the rotation of the field, because our reference is not perfectly aligned on the North) *and* α, ε (the tilt angles, because the camera is not on a perfect horizontal plane).

4 Preliminary results

At the moment, by only optimizing *k1,k2* and x_0, y_0, we get a fit with an accuracy of 0,4 pixel (Figure 2). We hope that by correcting the rotation of the field and the tilt angles, we will reach 0,1 pixel (around 1 arcmin).

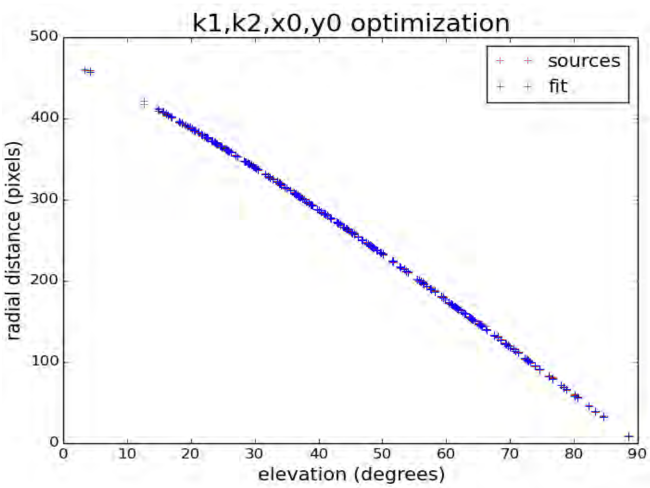

Figure 2 – Extracted sources and fitted function

5 Future improvements

We are currently working on the optimization of the last two parameters: rotation of the field and tilt angles. Once these optimizations are validated, a graphical interface will be developed to make it user-friendly, even for users not familiar with astrometry. The rest of the pipeline is also to be developed.

6 Conclusion

The preliminary results seem promising and we will keep improving them until we get close to the arcmin of accuracy on the astrometry process. Nevertheless, the accuracy we have now is acceptable for a start. We are now planning to start the development of the other modules of the pipeline so that we can have a functional prototype of the whole pipeline by the beginning of 2015.

Acknowledgments

FRIPON project is supported by ANR (Agence Nationale de la Recherche). Thanks to Emmanuel Bertin, Mark Calabretta, Juraj Toth and Jiri Borovicka for discussions and advices about astrometry.

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