EPSC Abstracts
Vol. 10, EPSC2015-800, 2015
European Planetary Science Congress 2015

FRIPON, the French fireball network

F. Colas (1), B. Zanda (2,1), S. Bouley (3,1), J. Vaubaillon (1), C. Marmo (3), Y. Audureau (3), M.K. Kwon (1), J.L Rault (7), S. Caminade (6), P. Vernazza (4), J. Gattacceca (5), M.Birlan (1), L. Maquet (1), A. Egal (1), M. Rotaru (8), Y. Gruson-Daniel (1), C. Birnbaum (8), F. Cochard (9), O. Thizy (9).
(1) IMCCE, Observatoire de Paris, Paris, France (colas@imcce.fr), (2) IMPMC, Muséum National d'Histoire Naturelle, Paris, France, (3) GEOPS, Université Paris Sud, Orsay, France, (4) LAM, Institut Pytheas, Marseille, France, (5) CEREGE, Institut Pytheas, Aix en Provence, France, (6) IAS, Université Paris Sud, Orsay, France, (7) International Meteor Organization, Radio Commission, (8) Universciences, Paris, France, (9) Shelhyak Instrument, Le Versoud, France

Abstract

FRIPON (Fireball Recovery and InterPlanetary Observation Network) [4](Colas et al, 2014) was recently founded by ANR (Agence Nationale de la Recherche). Its aim is to connect meteoritical science with asteroidal and cometary science in order to better understand solar system formation and evolution. The main idea is to set up an observation network covering all the French territory to collect a large number of meteorites (one or two per year) with accurate orbits, allowing us to pinpoint possible parent bodies. 100 all-sky cameras will be installed at the end of 2015 forming a dense network with an average distance of 100km between stations. To maximize the accuracy of orbit determination, we will mix our optical data with radar data from the GRAVES beacon received by 25 stations [5](Rault et al, 2015). As both the setting up of the network and the creation of search teams for meteorites will need manpower beyond our small team of professionals, we are developing a citizen science network called Vigie-Ciel [6](Zanda et al, 2015). The public at large will thus be able to simply use our data, participate in search campaigns or even setup their own cameras.

1. Scientific goals

The aim of the project FRIPON is to answer questions that arise about the connections between meteorites and asteroids. It is easy to study a meteorite in the laboratory but we cannot tell where it came from, because its orbit is most of the time unknown. On the other hand, we currently have more than 700,000 asteroid orbits with almost no physical information. However these parameters are crucial for understanding the origin and evolution of the solar system. In recent years the planet migration theory showed that it is possible to find very primitive objects in the main asteroid belt, and that these things may hit the Earth due to Yarkovsky non-gravitational forces. It is therefore essential to know the orbits of the meteorites we find to connect their dynamical history and composition. The main goals of FRIPON are to recover fresh meteorites fallen in France and to compute accurate orbits of fireballs whether or not they are connected with a meteorite.

2. The network

To allow triangulation measurements of fireballs we decided to implement one observatory every 80-100 km. As France has an area of 650 000 km^2, we need about 100 cameras to cover the whole territory.

2.1 Optical network

As with other fireball networks we decided to use fish-eye lenses to cover the whole sky. Our cameras are based on Sony chip ICX445, allowing a good efficiency for low light measurements at night but also a very short exposure time for daytime observations. Compared to older networks mainly based on video analogical devices, the improvements of FRIPON are:

- Digital cameras
- 1.2 megapixel chips
- 10^{-6} sec exposure time for day time
- 30 fps
- GigE Vision protocol
- PoE allowing 100 m single cable

2 Radio network

An optical network is very efficient for measuring fireball geometry, but determination of velocity is less easy with only a few points on fish eye images. However, speed is essential for semi-axis measurement and, therefore, fundamental for pinpointing the origin of fireballs and their possible parent bodies. We will use radar echoes of the

GRAVES beacon dedicated to measuring low altitude satellites [5] (Rault et al, 2015). The beacon is usable all over France, a 200 km spacing being sufficient for radio observatories, so only ¼ of the optical stations will have radio equipment. The goal is to measure relative speed with the Doppler effect.

3. Reduction pipeline

The FRIPON project is open source both for hardware (distribution of the cameras by Shelyak Instruments, though compatible cameras can be used) and software (http://fripon.github.io/freeture/). We developed a pipeline based on GigE Vision cameras, but it will be easy to use other cameras drivers.

3.1 Acquisition

The FreeTure software [1](Audureau et al, 2015) is developed on Linux and Windows. It is nominally written for GigE Vision cameras. Our hardware configuration is: i3 processor, 8Gb of RAM (for image buffering), 32Gb SSD for system installation and 1Tb HDD for data.

3.2 Detection

For detection FreeTure will use the subtraction of two consecutive frames with a detection threshold. It will analyze the pixels detected on several consecutive frames to determine the speed of the object and hence the reality of a meteor observation. As the software stores previous images, it can store images centered on each detection.

3.3 Orbits and strewn fields

Presently, we are using standard two location algorithms. As the FRIPON network will allow multi detection, we will develop in the next months a dedicated method. Our code is based on a robust method [2] (Borovicka, 1990).The orbit is calculated using SPICE Toolkit developed by NAIF-NASA. To start our pipeline we used a standard model [3] (Ceplecha 1987) for dark flight computation and strewn field determination.

3. Conclusion and evolution

At present, the hardware is completely defined and tested. 60 locations are under installation, and we hope to have the whole network set up for the end of 2015. FreeTure source is already distributed on-line and an official release will be available soon, to be fully operational for the end of 2015. One goal of this “open project” is that it can be easily copied, first in Europe to build a network unprecedented in size and eventually worldwide.

Acknowledgements

The FRIPON project is founded by ANR (Agence nationale de la recherche: www.anr.fr). The Vigie-Ciel project is founded by ANRU (Agence Nationale pour la Rénovation Urbaine:www.anru.fr as a part of the 65 millions d’Observateurs project led by Muséum National d'Histoire Naturelle, Paris).

References

[1] Audureau, Y., Marmo, C., Bouley, S., Kwon, M.K., Colas, F., Vaubaillon, J., Birlan, M., Zanda, B., Vernazza, P., Caminade, S., Gattacceca, J.: FreeTure a Free software to capTure meteors for FRIPON, Proceedings of the 2014 International Meteor Conference pp 39-41, IMO, 2015.

[2] Borovicka, J.: The comparison of two methods of determining meteor trajectories from photographs, Astronomical Institutes of Czechoslovakia, Bulletin, 1990.

[3] Ceplecha , Z.: Geometric, dynamic, orbital and photometric data on meteoroids from photographic fireball networks, Astronomical Institutes of Czechoslovakia, Bulletin, 1987.

[4] Colas, F., .Zanda, B., Bouley, S., Vernazza, P., Gattacceca, J., Vaubaillon, J., Marmo, C., Kwon, M.K., Audureau, Y., and Rotaru, M.: FRIPON, a French fireball network for the recovery of both fresh and rare meteorite types, Asteroids, Comets, Meteors 2014

[5] Rault, J.L., Colas, F. and Vaubaillon, J.: Radio set-up design for the FRIPON project, Proceedings of the 2014 International Meteor Conference pp 185-186, IMO, 2015.

[6] Zanda, B., Bouley, S., Colas, F., Marmo, C., Rotaru, M., Lewin, E., Rault, J.L., Maquet, L., Birlan, M., Audureau, Y., Kwon, M.K., Vernazza, P., Gattacceca, J., Julien, J.F., Steanhauser, A., Linares, M., Birnbaum, C., Cochard, F.and Thizy, O.: Vigie-Ciel project, EPSC 2015.