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# Data analysis software for video meteor observing networks

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## Abstract

The SPanish Meteor Network (SPMN) is performing a continuous monitoring of meteor activity over Spain and neighbouring countries. The huge amount of data obtained by the 25 video observing stations we operate made necessary to develop a new software package for data reduction tasks, including the calculation of orbital parameters. The main characteristics of this software are summarized here.

## 1. Introduction

Since 2006 our network is performing a continuous monitoring of meteor and fireball activity over the Iberian Peninsula and neighboring areas As a result of our effort, a total of 25 meteor observing stations are currently in operation. Most of these employ high-sensitivity black and white CCD video cameras (Watec Co., Japan) endowed with fast aspherical optics. A detailed description of these devices has been given elsewhere [1, 2, 3]. The continuously increasing volume of images obtained from these stations made necessary to develop new software tools in order to perform a fast analysis of our data. In fact, software development has been one of our priorities in the latest years. The main features of our main data reduction package are presented here.

## 2. The data reduction software

For data reduction we have developed a software called Amalthea. This is a MS-Windows compatible package written in C++ programming language. Its main characteristics are described below.

### 2.1 Image and video processing

Amalthea was designed to analyze video files recorded by our high-sensitivity CCD video devices. These images may contain several artefacts that may negatively interfere with data reduction. For this purpose, a wide number of image transformation filters have been implemented in the software. These include, for instance, brightness and contrast enhancement and video deinterlace filters. These transformation procedures enhance the video images before they are used for the astrometric analysis. For instance, our software stacks the frames contained in the video files to increase the number of stars available for the astrometric analysis described below.

### 2.2 Astrometry

For multi-station meteors the software can calculate their atmospheric trajectory, preatmospheric velocity and radiant by using the planes intersection method [4]. For this, the equatorial coordinates along the meteor trail must be provided and these are obtained by performing an astrometric analysis of the video frames. The procedure to obtain meteor and stars positions on our images been described in [5]. To perform the astrometric reduction the user manually clicks on the reference stars that will be considered for the calculation. Then, the user selects which fitting method must be used to convert from plaque coordinates to equatorial coordinates. Then the calculation is performed ant the position of the reference stars is back-calculated by Amalthea in order to establish which is the standard deviation of this calculation. Once we can convert between plaque and equatorial coordinates, plaque coordinates of meteors are specified by the user by clicking on the corresponding positions along the meteor trail. Their equatorial counterparts are then automatically provided by Amalthea.

### 2.3 Orbital parameters

The orbital parameters of the meteor are calculated by Amalthea according to the procedure described in [4]. For this purpose, the values of the preatmospheric velocity, $V_{inf}$, radiant position and meteor apparition time are used, together with the average velocity corresponding to an averaged meteor position along the meteor trail. The procedure implemented in Amalthea has been tested with the Dutch Meteor Society (DMS) orbit calculation software [6] and the MORB software developed by the Ondrejov Observatory [7]. Although the DMS software does not provide any error parameters, we always found that the results provided by this package and Amalthea are very similar, with differences that are very small and within the error bars provided by Amalthea (Tables 1 and 2). However, significant discrepancies were found for the case of the MORB software. When this situation was analyzed in detail, we found that the origin of these is related to a bug in the calculation of the geocentric radiant in the MORB software.

Table 1: Comparison between geocentric radiant position and pre-atmospheric velocities (geocentric, Vg and heliocentric, Vh) calculated for different meteors recorded by the SPMN. Equinox (2000.00).

| SPMN Code | Software | R.A.(º) | DEC.(º) | Vg(km/s) | Vh(km/s) |
|---|---|---|---|---|---|
| **080806** | Amalthea | 46.85±0.051 | 57.29±0.05 | 58.79±0.20 | 40.73±0.20 |
| | DMS | 46.85 | 57.29 | 58.79 | 40.73 |
| | MORB | 46.47±0.13 | 57.070±0.05 | 58.78±0.20 | 41.34±0.18 |
| **210110** | Amalthea | 230.03±0.1 | 66.57±0.03 | 29.80±0.20 | 38.61±0.21 |
| | DMS | 230.10 | 66.54 | 29.79 | 38.59 |
| | MORB | 227.23±0.10 | 67.41±0.03 | 29.79±0.05 | 41.77±0.22 |
| **071106** | Amalthea | 156.51±0.1 | 21.41±0.05 | 70.90±0.20 | 41.76±0.20 |
| | DMS | 156.52 | 21.40 | 70.80 | 41.65 |
| | MORB | 156.20±0.30 | 21.53±0.30 | 70.90±0.20 | 42.20±0.22 |

## 3. Summary and Conclusions

A continuous effort is being made by the Spanish Meteor Network in order to improve and expand our meteor observing stations based on high-sensitivity CCD video devices. Software engineering has been one of our priorities in the latest years and, as a result, a new software package for data reduction has been developed and successfully tested with other existing applications. However, significant discrepancies have been detected with the results provided by Ondrejov's orbits calculation software (MORB). The origin of this discrepancy seems to be a bug in the calculation of the geocentric radiant in the MORB software.

Table 2. Comparison between orbital parameters calculated by Amalthea and the DMS software for different meteors recorded by the SPMN. Equinox (2000.00).

| Software | q(AU) | a(AU) | e | i( ° ) | ω( ° ) | Ω( ° ) |
|---|---|---|---|---|---|---|
| **SPMN Code 080806** | | | | | | |
| **Amalthea** | 0.9482± 0.0003 | 9.65± 1.5 | 0.902± 0.016 | 113.58± 0.15 | 149.82± 0.32 | 139.1491± 0.00003 |
| **DMS** | 0.948 | 9.63 | 0.902 | 113.60 | 149.80 | 139.15 |
| **MORB** | 9.558± 0.001 | 21.36± 7.76 | 0.955± 0.016 | 111.79± 0.15 | 152.87± 0.35 | 139.1481± 0.0003 |
| **SPMN Code 210110** | | | | | | |
| **Amalthea** | 0.9543± 0.0002 | 2.85± 0.02 | 0.665± 0.003 | 48.80± 0.06 | 202.46± 0.08 | 301.615± 0.00002 |
| **DMS** | 0.954 | 2.83 | 0.663 | 48.81 | 202.47 | 301.612 |
| **MORB** | 0.9667± 0.0006 | 15.47± 5.11 | 0.937± 0.020 | 44.92± 0.28 | 195.55± 0.38 | 301.6113± 0.00003 |
| **SPMN Code 071106** | | | | | | |
| **Amalthea** | 0.9774± 0.0003 | 17.31± 5.6 | 0.943± 0.018 | 161.35± 0.09 | 167.74± 0.22 | 236.5034± 0.00003 |
| **DMS** | 0.977 | 16.96 | 0.942 | 161.36 | 167.68 | 236.505 |
| **MORB** | 0.9864±0.0017 | 63.44±8 8.29 | 0.984±0.021 | 156.93± 0.80 | 185.0± 2.3 | 236.50565±0.00007 |

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