ADVANCES IN THE FRAMEWORK OF THE SOUTHWESTERN EUROPE METEOR NETWORK: MACHINE LEARNING APPLIED TO THE STUDY OF METEOR EVENTS.

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Introduction: The Southwestern Europe Meteor Network (SWEMN) is a research project coordinated from the Institute of Astrophysics of Andalusia (IAA-CSIC) with the aim to analyze the Earth's meteoric environment. This network is integrated by researchers from different research centers and universities in Spain. In order to identify and analyze meteors in the Earth's atmosphere, SWEMN develops the Spectroscopy of Meteoroids by means of Robotic Technologies (SMART) survey, which was started and funded by the author of this work in 2006 [1, 2]. This work focuses on one major step recently taken in the framework of SWEMN and SMART. It involves the development of the first comprehensive digital database containing information about bolides and meteors recorded over the Iberian Peninsula and neighboring areas. And also the software tools necessary to exploit this new resource. This new software employs Machine Learning (ML) techniques for several purposes. For instance, to automatically derive key information from the contents of the above-mentioned meteor database.
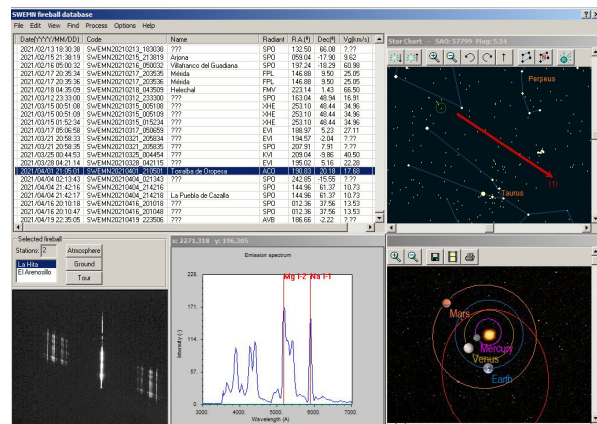

Figure 1. Screenshot of the software interface employed by the SWEMN digital database. In this example the interface shows the orbit, spectrum, fireball, and the star chart viewers.

The new SWEMN meteor database: A key achievement performed in the framework of SWEMN is the development of a digital and interactive database containing meteors recorded and analyzed by the SMART project since this survey was started in 2006 [3]. This includes a new dedicated software developed by the author of this work and called SAMIA to handle and exploit the contents of this database (Figure 1). Before these tools were available, a Microsoft Excel

file was used as a simple database to store information about meteors recorded by our cameras. It contained very basic data: typically, radiant position, radiant name, and peak magnitude. But this system was not comfortable, since in order to recover additional information for a given meteor (e.g., its emission spectrum or its lightcurve, or even the method(s) employed to perform the calculations), the operator had to locate those data manually in the specific storage device where the all of the files recorded and calculated for that particular event were stored. This manual process was very slow, and did not allow to perform automatic or efficient comparisons between the different events included in the Excel file. The new database is the first digital and interactive database ever developed for meteors recorded over the Iberian Peninsula and neighboring areas, and it stores very comprehensive information about these events. Thus, among other data, for each meteor it contains the images taken from different observing stations, its lightcurve and emission spectrum, the calculated atmospheric trajectory and radiant, the orbit of the meteoroid, and other physical properties of the particle.
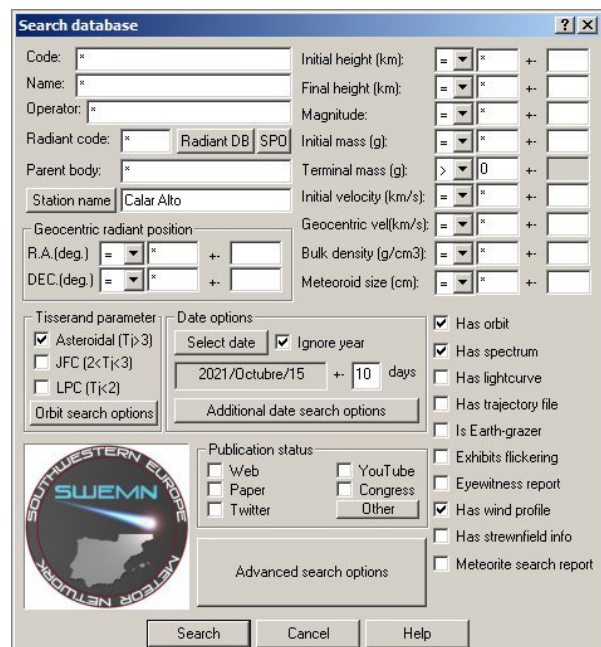

Figure 2. Screenshot of the software interface employed to search information in the SWEMN database.

Figure 2 shows a screenshot of the software module employed by SAMIA to browse information in

the database. Once the user specifies the selected options, the software retrieves a list of meteor events fulfilling the search criteria. That list is displayed by a software interface identical to the one shown in Figure 1. In this way, the user can easily access any data or information stored in the database for a particular event contained in that list.

Application of Machine Learning to Meteor Science: The SAMIA software employs ML methods to obtain useful information from the SWEMN database. These methods are based on Supervised Learning algorithms. In this way, for instance, SAMIA can automatically find likely links between events included in the database. This can be employed for instance to identify new meteor showers, or to provide valuable information about poorly-known meteoroid streams. Other interesting applications are related to the identification of fireball streams, specially those that could be associated with meteorite-producing events or with bright lunar impact flashes.

Dissemination and outreach: In addition to Meteor Science, one of the aims of SWEMN is the dissemination of the most remarkable results obtained by the SMART project, given the interest that bright meteors have for the public. This dissemination, which is also important to promote the interest for Meteor Science, has been performed worldwide by SWEMN and SMART by means of platforms such as YouTube, press releases, and social networks (chiefly, Twitter and Facebook) since SMART was started in 2006. In order to simplify these tasks and to perform them faster, the new software SAMIA has been also designed to automatically prepare the texts describing specific meteor events that should be disseminated through the above-mentioned channels. For instance, by employing ML, SAMIA can automatically write a press release describing the particular circumstances of a given fireball. This dissemination method based on SAMIA has been successfully employed by SWEMN and SMART since the second half of the year 2021. One of the advantages of this new dissemination technique is that the information arrives much faster to the public. In fact, SAMIA can perform this task immediately after the analysis of a given fireball is completed. This is very important to let people know as soon as possible about the nature of bolides that we have recorded or that even they might have witnessed, in order to provide a precise scientific explanation about these events.

Conclusions: In the framework of the SWEMN network, the author has developed a new database to handle the detections performed by the systems employed by the SMART project. This is the first digital and interactive database ever developed for meteors recorded over the Iberian Peninsula and neighboring areas, and it stores very comprehensive information about these events. The software SAMIA has been also developed to handle this new tool. It employs Machine Learning algorithms based on Supervised Learning to automatically obtain important information from the contents of this database. This can be employed for instance to identify new meteor showers, or to provide valuable information about poorly-known meteoroid streams. Other interesting applications are related to the identification of fireball streams, specially those that could be associated with meteorite-producing events or with bright lunar impact flashes. But, in addition, this software also employs these ML methods to disseminate our main results through social networks and press releases. One of the advantages of this new dissemination technique is that the information arrives much faster to the public. This is very important to let people know as soon as possible about the nature of bolides that we have recorded or that even they might have witnessed, in order to provide a precise scientific explanation about these events and to promote the interest for Meteor Science.

References: [1] Madiedo J.M. (2014), Earth, Planets & Space, 66, 70. [2] Madiedo J.M. (2017), Planetary and Space Science, 143, 238. [3] Madiedo J.M. et al. (2021), eMeteorNews, 6, 397.