CS289 Early Deadline Project Report- Synthetic Astronomical data generation using Stellarium's Remote Control API

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***Abstract*—Python code was developed for the interaction with Stellarium software to achieve the retrieval of accurate information about the locations of various celestial bodies for a given time and place the Earth. A large dataset of such synthetic measurements was then generated using the code, which can be used for the final project.**

***Index Terms*—Astronomy, Stellarium, API, Artificial measurements**

I. Introduction

Throughout the ages, people have always been intrigued by their observations of the night sky, and they were always trying to explain what they were seeing [1]. However, most ancient records of such observations are lost due to various grim historical events, and most of what remains are mere evidence of their theoretical understanding [2]. Today, our modern interpretation of the cosmos allows us to make accurate predictions for thousands of years into the past and future. While numeric simulations can be made, using as few assumptions as our computational resources can allow, it is still sometimes more reasonable to compromise accuracy for simplicity. Fitting simpler models to our available data is one way to achieve this. Using machine learning to train models that can predict the locations of celestial bodies, however, requires the use of large datasets of observations. Our team has written python code that can interact with Stellarium to retrieve synthetic astronomical observations. We then used the code to generate a large dataset of such synthetic observations for the final projects. Stellarium is an open-source free-software planetarium, licensed under the GNU General Public License version 2, available for Linux, Windows, and macOS. All versions use OpenGL to render a realistic projection of the night sky in real-time [3]. With its Remote Control Add-on, it can be automated to update its parameters and retrieve output via HTTP requests. Exploiting that feature, we have gathered synthetic observations of the locations of the planets of the solar system, the Sun and the Moon, as seen from an observer in Athens, Greece, for a period starting from -1500 BC and ending in 2020, taking at least one daily sample for each body of interest.

Our motivation was two-fold. First, to produce a large quantity of accurate and reliable data that teams working on the final project can use to apply machine learning techniques and demonstrate their understanding of the course material. The dataset itself can be used to train machine learning models, to make predictions about all of its fields for a specified time. It was also to provide those teams with a reliable tool to use as-is or tinker to suit their needs (if they need to extract some other quantity from the wide variety of information that Stellarium can produce). In that sense, all teams can benefit from using our code as a starting point to interact with the software if they desire.

II. Method

Stellarium features a remote control plugin that enables the communication to the software via HTTP requests. First, we developed python code, in the form of a jupyter notebook, which uses the remote control feature to interact with the software for the purposes of data retrieval. The jupyter notebook contains a series of functions that allow for changing the current time and location and retrieving a subset of the information that Stellarium outputs for a given celestial body. This functionality can be combined in various creative ways to create datasets of *synthetic observations*. It contains a full usage example, but the other teams are welcome to experiment or alter the code as needed for their particular use case scenario (i.e., retrieving different kinds of information than what we have implemented or have a different list of bodies of interest).

As a usage example, we have gathered synthetic observations of the locations of the planets of the solar system, the Sun and the Moon, as seen from an observer in Athens, Greece, for a period starting from -1500 BC and ending in 2020, taking at least one daily sample for each body of interest.

III. Results

Table I shows a sample of the synthetic dataset collected on Julian date 1,721,059.5 JD.

A small random sample of the data was individually checked for errors, and no errors were found. We also compared the declination of Mars to the quantity we obtained from Paul Schlyter's algorithm for planetary motion, published on [4]. The results are in good agreement, as can be seen in figure 1.

The dataset can be accessed via Google Drive: https://drive.google.com/drive/folders/1IZnVKX3Om4ZEDY2pzeEgPjTnf4gZbiSr?usp=sharing

Our code can be downloaded from our Github page here:, https://github.com/ioannis-vm/CS289_2020_ProjectS_TeamJupyter

IV. Conclusion

In conclusion, the produced dataset can be used to apply machine learning techniques, and the provided code can be used as-is or modified to extract other kinds of information.

TABLE I: Sample of the collected data. Location: Athens GR, Date: January 1, 0000

Body	RA (hour angles)	Dec (decimal degree)	Az (decimal degrees)	Alt (decimal degrees)	Dist (AU)	Dist_Sun (AU)	Constellation
Mercury	18.238839	-24.586722	72.039444	-60.017333	1.407000	0.450	Cap
Venus	15.986550	-17.064000	89.691417	-31.783444	1.132000	0.722	Sgr
Mars	15.108467	-16.711167	96.030444	-19.070333	1.940000	1.537	Oph
Jupiter	10.806239	9.300500	119.165472	44.857694	4.866000	5.435	Vir
Saturn	3.608233	17.906472	272.159389	27.203667	8.239000	8.967	Tau
Uranus	23.551217	-2.279667	294.176028	-32.965833	20.221000	19.934	Psc
Neptune	15.036122	-14.398889	95.198528	-18.892583	30.887000	30.306	Oph
Moon	0.215000	6.749944	294.852528	-17.389778	0.002532	0.985	Ari
Sun	18.773081	-22.736167	57.687694	-65.629694	0.985000	0.000	Cap

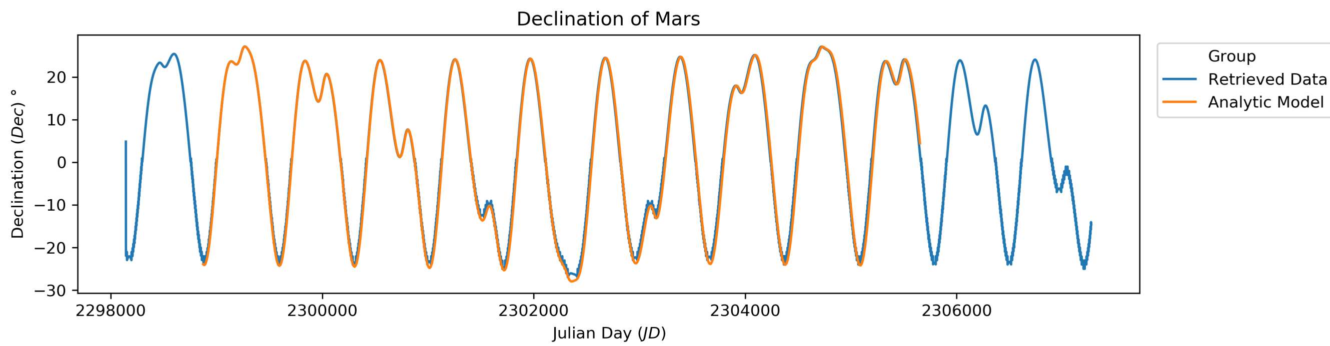

Fig. 1: Comparison of the declination of Mars from the analytical model estimation and the Stellarium data.

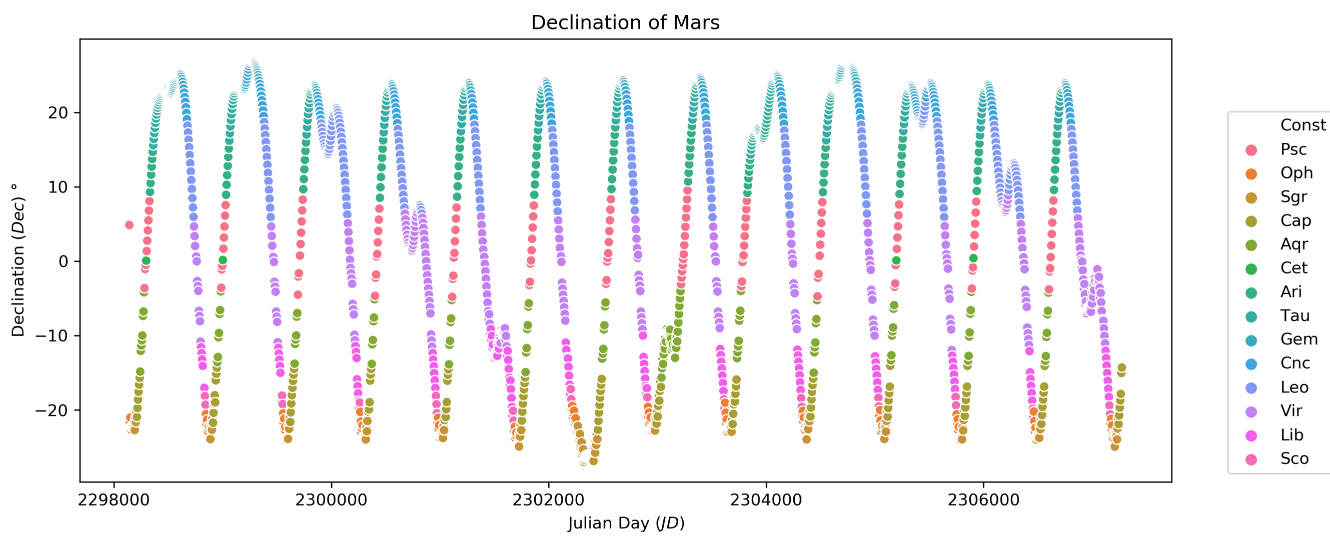

Fig. 2: Declination of Mars. The hue corresponds to its nearest Constellation at that time.

Users should carefully read the instructions provided on the README page of our Github repository.

References

1 Lindberg, D. C., *The beginnings of western science: the European scientific tradition in philosophical, religious, and institutional context, prehistory to A.D. 1450*, 2nd ed. Chicago: University of Chicago Press, 2007, oCLC: ocn156874785.

2 Empereur, J.-Y., "The destruction of the library of alexandria: An archaeological viewpoint," in *What Happened to the Ancient Library of Alexandria?*, El-Abbadi, M., Fathallah, O., and Serageldin, I., Eds. BRILL, pp. 75–88. [Online]. Available: https://brill.com/view/book/edcoll/9789047433026/Bej.9789004165458.i-259_006.xml

3 "http://stellarium.org."

4 Paul, S., "How to compute planetary positions." [Online]. Available: https://stjarnhimlen.se/comp/ppcomp.html