SPICE: A Means for DeterminingObservation Geometry

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Abstract

The "SPICE"[1]system is the NASA Planetary Science Division's method of conveniently packaging, archiving, and subsequently accessing observation geometry needed to understand science data returned from robotic spacecraft. This paper provides an overview of "SPICE"–what it is and how it's used– and then offers a glimpse into how it is being extended to better support the space science community.

1. Introduction

The origin of the phrase "A picture is worth a thousand words" is muddled. But it is clear that the value of a picture returned from a robotic spacecraft exploring our solar system is much enhanced if accompanied by the observation geometry that pertained at the time the picture was taken. The same applies for science data obtained from any kind of instrument on board a spacecraft.

We use the term "observation geometry" to encompass the positions, velocities and orientations of the spacecraft, its observing instruments, and the planet, satellite or other object(s) being observed. Also the various measures of time that tie these geometry items together.

Starting in the late 1980's NASA funded an adjunct to its Planetary Data System to develop a modern, universal and sustainable method for providing researchers with this observation geometry (also referred to as ancillary data). The result is the "SPICE" system, first used on NASA's Galileo mission, and in widespread worldwide use today.

[1]**S**pacecraft, **P**lanet, **I**nstrument, **C**amera-matrix, **E**vents

2. SPICE System Components

Data are an obvious and the most important component of an information system. Within SPICE data are provided in files often known as "kernels." ("*Kernel: the central or most important part of anything.*")

Many information systems supplement the data only with descriptive specifications, leaving it to the user to construct means to read and process the data. But the SPICE user receives a large library of subroutines (also known as procedures, methods or functions) used to read the SPICE kernels and to compute observation geometry parameters based on the kernel data. This software can be viewed as "building blocks": a SPICE user picks a few of those "blocks" useful in constructing her/his own application program that will accomplish whatever is the job at hand. Most of the user's program is constructed from the user's own code, which is implemented based on the user's own knowledge and requirements.

In addition to the data and software, numerous documents, tutorials and programming lessons make up the rest of the SPICE system.

3. SPICE System Characteristics

To be truly useful to and well accepted by the space science community the SPICE system must exhibit key characteristics: the data files and software are portable to all popular platforms; the code is thoroughly tested before being released and is never revised or removed after release; computations are made using high precision methods; the system is extensible to meet new user requirements; extensive user-oriented documentation is provided; all components are freely distributed worldwide; data

are well archived and easily accessible; and, with but a few limitations,user consultation is freely offered.

4. SPICE Applications

By itself, SPICE–a collection of data files and subroutines–cannot accomplish anything useful. But these "building blocks" can be used by researchers to build their own applications useful in interpreting the science data returned from an instrument on any kind of robotic spacecraft. SPICE is also useful in helping a researcher do correlative analysis involving data from two or more instruments, coming from one, two or even more spacecraft. This broad flexibility is yet another important characteristic: it can be easily used with little or no adaptation on any space science mission.

5. SPICE Responsibilities

The human side of SPICE encompasses three primary tasks: system development, flight project operations, and PDS archivemanagement and user support. Development of the SPICE system is the responsibility of the Navigation and Ancillary Information Facility (NAIF), located at NASA's Jet Propulsion Laboratory. Generation of SPICE kernels for NASA and international flights projects using SPICE is the responsibility of the institution managing each particular flight project, or the designee of that institution. Operation of the NAIF Nodeof the Planetary Data System is done by NAIF.

6. SPICE Development Plans

Only available workforce limits the possibilities for extensions and improvements to the SPICE system, and to the SPICE services provided by the PDS' NAIF Node.

With regard to core SPICE development currently underway, key activities are:

- extension of the target body shape model capability, to include both a tessellated plate model and a digital elevation model;
- addition of Java Native Interface as an available method for using SPICE code;
- addition of a web-based "geometry engine" offering quick access to a large assortment of SPICE observation geometry computations using only a web browser.

With regard to the NAIF Node of the Planetary Data System, key activities underway are:

- transition of all SPICE archives from the current "PDS3" standards to the now emerging "PDS4" standards, which should provide users easier and more complete access to NASA's archived data
- revision of SPICE training by breaking the one-size-fits-all class currently offered into beginners and advanced users classes
- outreach to offer SPICE to as broad a community as resources and regulations permit

7. Summary and Conclusions

The SPICE system has slowly but steadily evolved to become an effective toolkit in the hands of scientists worldwide.

Despite a rather full plate of activities outlined above, the NAIF Group is constantly seeking suggestions from the SPICE user community about how to improve the core SPICE system and the NAIF Node operations. To that end, this paper serves as a solicitation for suggestions about improving SPICE and NAIF, as well as for suggestions about where and how SPICE might more broadly serve the worldwide space science community.

All SPICE components and extensive documentation can be obtained from the NAIF website: http://naif.jpl.nasa.gov.

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