Development of a Planisphere Interface Ajax Web System Based on a Constellation Database for Astronomy Education

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Summary

In this study, we build a database specialized for astronomical education. The database consists of the information that planetarium curators have about astronomy and the stars. We suggest that the database should have a structure based on constellations, mirroring the basic way in which humans perceive the night sky. Furthermore, we develop a web system for astronomy education using Ajax. The web system's interface is based on the planisphere, which is the most basic tool for finding stars.

Key words:
astronomy education, ajax, database, constellation

1 Introduction

There are many sites on the Internet about stars and astronomy. Most of these sites are made available to the public by astronomical observatories or universities. Many of their observations, including beautiful images of celestial objects seen with large telescopes, are freely accessible by the public [1,2]. At the same time, for general citizens who look at the night sky and then attempt to find out more about what they see, there is little useful information. This is because information about observed results or celestial objects is not tied to fundamental information about finding objects in the night sky.

In other words, most web sites open to the public that provide knowledge of the stars and celestial objects cover only basic astronomical topics or their own research results. However, they don't mention how to find the stars and celestial objects, interesting information from a general viewpoint, or the location of the researched object in the night sky. So their sites don't have many practical connections with the actual night sky.

Meanwhile, the authors have conducted research about astronomical education through the visualization of astronomical phenomena since 1993. Some examples include "The Collision of Comet Shoemaker-Levy 9 with Jupiter," "The Vanishing Rings of Saturn," "Comet Hale-Bopp," and "Leonid Meteor Shower" [3]. Furthermore, we developed the "Powers of Ten" teaching materials [4].

In the "Powers of Ten," various astronomical phenomena and knowledge were ordered from a spatial viewpoint. We also created an exhibition and a computer graphic movie that illustrated this viewpoint. This showed where interesting celestial objects were in the universe in a hierarchical format. The national astronomical observatory has a similar scheme called the 4D2U project [5]. The purpose of that project places emphasis on more than astronomical education for the visualization of their research data. Therefore, that project isn't comprehensive from the angle of astronomical education. Neither the "Powers of Ten" nor 4D2U can indicate where interesting celestial objects are in the night sky. So far, no comprehensive database or web system has been developed simply from the point of view of being able to look up at the sky and identify objects. There is great potential for the development of these resources for astronomical education.

On the other hand, a wealth of interesting information about the stars and astronomy is shown and explained in an easy-to-understand format at planetariums. The curator, acting as a commentator, selects information that is

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appropriate for the general public. Such content is accumulated as part of the curator's own knowledge. However, only planetarium visitors can currently access such information. Thus, a structure that can disseminate the contents of each curator's knowledge database to the public is desirable. Until now, no systematic database that compiles such information has existed. A project focusing on astronomical observation data and news is being conducted by the National Aeronautics and Space Administration [6]. Furthermore, it can obtain reference results with an ADS system with an XML form-type [7]. However, the stored contents and their structure differ from those of this paper, as we discuss below.

We suggest building a database that consists of the comprehensive information planetarium curators possess on stars and astronomy. Beyond that, we think the database should have a structure based on constellations, which illustrates human cognition about the night sky. In this paper, we use the word "constellation database" to refer to that database.

We also develop a web system that uses this constellation database. The most important aspect of this astronomical education is that after a user visits the web system, they go outside and can find objects in the actual night sky. Thus, we chose the metaphor of the planisphere for the web system interface. The planisphere is the most general and popular tool for finding a star. Using the planisphere, knowledge can be more easily tied to the night sky. A constellation database that has useful knowledge is indispensable in such an educational system.

Additionally, we use Ajax technology to improve the web system's usability. In this paper, we use the phrase "planisphere-type web system" to refer to that web system.

To that end, we built a knowledge database from the perspective of astronomical education and developed a planisphere-type astronomy education web system. Our purpose is to make an interesting web site leading people to the actual night sky.

2 Constellation Database

2.1 Database Requirements

Before building a constellation database, from the perspective of astronomical education, the following points are necessary.

Compatibility:

We need a format for the new astronomical education database that can be used for a long time. Also, the format should offer portability and universality as well. Future improvements and modifications should also be simple.

There are four types of educational projects connected to this database: the planisphere-type web system; a star guide-type web system; a star guide for cellular phones; and the database accumulated knowledge system. Universities, planetariums, schools, and so on are all concerned in these projects.

Internationalization:

The concept of a constellation is a general idea shared by the whole world that was standardized by the International Astronomical Union in 1930 [8]. Thus, if our database structure could be multi-lingual, it would be easy for this concept to be used throughout the world.

Databases using XML [9] are currently attracting a lot of attention. XML has the following features. Using a tag that can be defined freely, XML can structuralize a document. This is suitable for embodying our database structure, which is based on that of a constellation as we discuss below. Also, each element can be changed relatively easily. These characteristics are suitable for many-sided uses in several projects. Because XML uses UTF-8 code, it is possible for data in various languages to be held collectively. Thus, it is easy to ensure internationality.

For these reasons, we chose a text format and applied XML as one of the schemes to meet the above requirement. Items described using XML are stored in the directory structure.

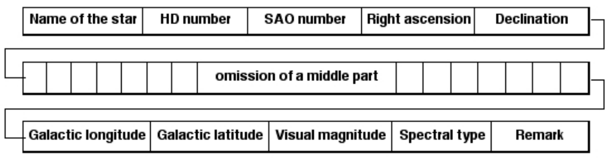

Fig. 1. Conventional star catalogue (BSC5 [10])

2.2 Database Structure and Contents

Figure 1 shows an example of a conventional catalogue of stars. Data are grouped in one table, and they aren't structuralized. The distance to each star can't be perceived with the naked eye or with a telescope in the night sky because it is too far away. There is a custom that shows the position of the star and the celestial object in the virtual two-dimensional polar coordinate space of the celestial sphere. The two axes are right-ascension and declination. Therefore, catalogs of stars and celestial objects are built from the catalog's number or two axes.

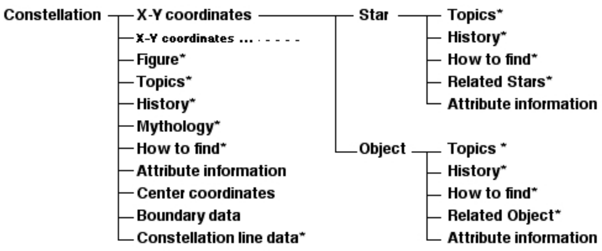

Fig. 2. XML-based constellation database

Such a catalogue is effective when only one celestial object is pin-pointed as a target. This format is easy for astronomy researchers to use. However, it isn't suitable when handling more than one celestial object, such as when working with a constellation.

Another method that shows the position of the star and the celestial object on the celestial sphere is based on constellations. The notion of constellations is much older than indications using coordinates; it originated in Mesopotamia more than 5,000 years ago. The "Almagest," a treatise compiled by astronomer Ptolemy in Greece, is a classic astronomy text in which the explanation of each star is based on the star's position in relation to its constellation. Actually, when we look up at the night sky, it is easier to recognize specific constellations rather than specific coordinates. When expressing the position of a celestial object, constellations are easier for the general public to understand compared with coordinates. Even if a particular constellation can't be found, people can still understand the concept behind it. Furthermore, no database has ever been based on the structure of constellations. So a constellation database's structure itself is a new idea. Such a structure can manage the knowledge that relates to the constellation integratively. Figure 2 shows an example of star information in our constellation database plan. Items are structuralized into an XML-based database. Items that are marked with * are characteristic of this database. When a person looks up at a star, these items are important or may add an interesting point. These items weren't necessarily included in other databases, even though planetarium curators may have had this information. This is only part of a planetarium curator's tacit knowledge. Still, it is crucial to include important knowledge that hasn't been included in any database until now. The database should also be in a format that is easy to introduce to the public on the Internet.

Using the constellation database, it is possible to combine all these elements into one structure. Therefore, in view of a database for general-purpose use in the future, we propose a constellation database that uses XML as a base to be the standard in astronomical education.

Now, in our study group several systems based on this database are being developed in parallel. These are web pages of the encyclopedia of constellations, podcasts of planetarium educators, and a mobile version of the encyclopedia as shown in Fig. 3.

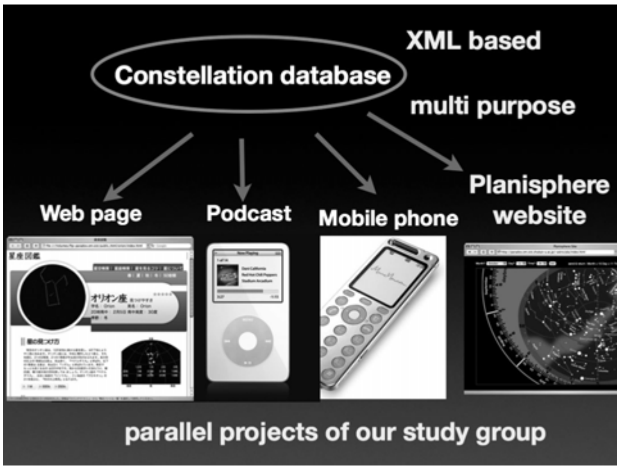

Fig. 3. Systems based on Constellation Database

3 A Planisphere-Interface Ajax Web System

We developed a web system that uses a constellation database. The most important aspect of this system from the perspective of astronomical education is that after a user visits the web, they should look at the actual night sky. In other words, we would like to tie learning by web pages to experience in nature. When a person looks up at the night sky, it is rare that they would have access to their PC outside. Our web system is the same, too. Learning in advance is the purpose of this web system. However, many people will go out to find the stars with a planisphere in their hands.

Planispheres have been an effective tool for astronomical education since the 17th century. A planisphere is tool that finds a star by finding the azimuth and altitude of the star from the observation date and time. Most elementary school students in Japan learn how to use it. In fact, the planisphere is the most popular and general tool for finding specific stars. It is good to choose a tool that people actually use outdoors for the web system's interface. So we applied a planisphere as the interface of our web system. After people learn with a planisphere-type web system, they will go out and look up at the sky with a real planisphere.

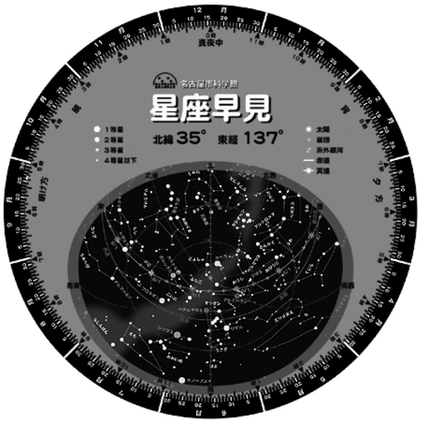

Fig. 4. Planisphere (Nagoya City Science Museum)

Additionally, we use Ajax technology to improve the usability of the web system. Ajax is a generic name for "Asynchronous JavaScript + XML" [11]. Ajax facilitates asynchronous communication between a server and a client. So, Ajax is suitable for scrolling a big image, offering good usability. In our web system, a user can look at the details of a big planisphere image and scroll through it. Additionally, the web system's interface is improved by applying a javascript function. We have already applied XML to our web system database as mentioned above.

Thus, Ajax is the most suitable technology for our web system because it can show content dynamically. Google Earth, Moon, Mars and Sky [12] are good examples of astronomy education systems. The Hubble site has a similar interface [13] that uses Flash technology. However, these examples offer only an actual view of the planet or nebula. Currently, there are no cases that use teaching tools, nor that add extra value using Ajax.

The advantages of adopting the Ajax system are as follows.

User-friendly interface:

Users can rotate the planisphere from any date and time combination. They can display the planisphere on any scale by clicking the Up and Down arrows. They can use the drag operation to find an object easily. They can see the information by clicking the flag at any time. It doesn't require software other than the web browser.

Simple way to get actual sky image:

There are 525,600 date and time combinations. (525,600 patterns = 365 days X 1440 minutes/day) It isn't realistic to prepare all images of the combinations in advance. So our system makes necessary images on demand.

The renewal of the constellation database: The constellation database is updated continuously. So, it is good to download the topics, information, and astronomical phenomena every time.

The communication between the database and the client using Ajax is outlined in Figure 5. As a precondition, the server has an XML-based constellation database. We use the term "detailed data" to mean the database records in this section. Also, the server has another simple database that consists of only the coordinates and classification of the attribute data. This means "where the flag is marked on the planisphere." We use the term "simple index" to name this other simple database.

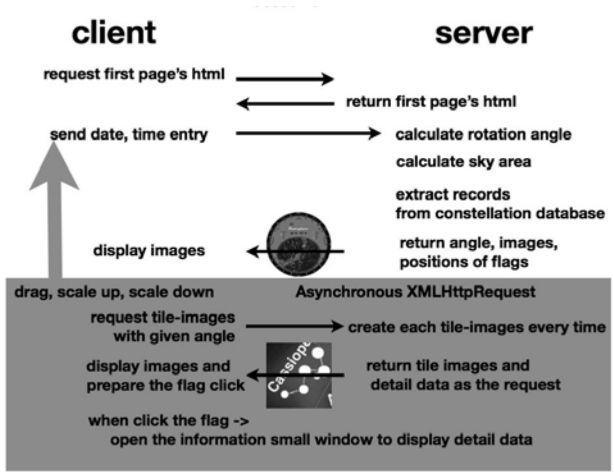

Fig. 5. Process flow

First, the screen is loaded, and the user sets up the date and time. This date and time entry is sent to the server using an asynchronous XMLHttpRequest. Servers generate images that are rotated to fit the date and time entry. Clients get the images as necessary using the asynchronous XMLHttp-Request. At the same time, clients also get a simple index from the server.

Fig. 6. First page of the web system (Japanese version)

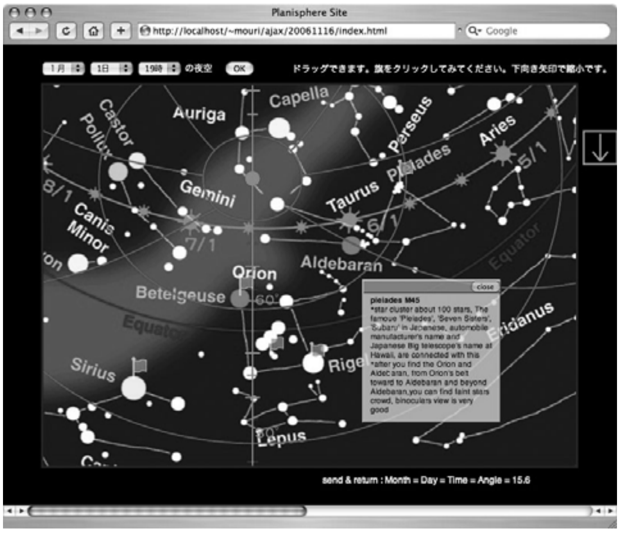

Fig. 7. Detailed images of the planisphere, flags and pop-up window (English version)

Clients send a request and receive images and detailed data in advance, which allows clients t o quickly indicate the detailed data's contents. Users can perform various operations including drag, scale-up, scale-down, and clicking flags on the planisphere interface. When users click the flags, the client indicates detailed data coped with the flag on the planisphere in the most suitable format. A user can study stars, constellations, and celestial objects based on the date and time input into the planisphere.

Users can recognize and memorize the contents of the constellation database by clicking on various places on the planisphere interface web system. Also, the learning content on the system can be memorized and recalled when stars are seen outside with a real planisphere.

4 Conclusion

In this study, we built a knowledge database consisting of the knowledge held by planetarium curators on topics about the stars and astronomy. The structure of the database is based on constellations and mirrors the way humans perceive the night sky. It was very important to include important knowledge that had not been included in databases until now and in a format that was easy to introduce to the public on the Internet.

Furthermore, using Ajax, we developed a web system for astronomy education. The web system's interface was based on the planisphere, which is one of the most basic tools for locating stars. Using a planisphere-type interface, knowledge could be tied to the night sky more easily. Additionally, we used Ajax technology to improve usability of the web system.

We have not yet conducted a strict evaluation verification of this system. Below are several user evaluations. According to evaluations by some planetarium curators, this was the first time for them to see such a database, and they found it very interesting. They stated they would like to use it practically. Astronomy club members evaluated the planisphere-type interface highly. They also stated that it was interesting to see the planisphere on the Internet. Furthermore, they were surprised that information was available there. They found it pleasant that the night sky could be seen with a planisphere. Another member said that it was good to recall the information he had learned in the planetarium and that it was very useful when looking up at an actual starlit sky. There are about 900 members of the astronomy club in our planetarium. We plan to get more evaluations from them and improve our database and system.

In future study, we would like to accumulate more knowledge for the constellation database and to further optimize the structure. Also, we would like to proceed with using this system with more projects. Now, in our study group several systems are being developed in parallel based on this database. These are web pages of the encyclopedia of constellations, podcasts of planetarium educators, and a mobile version of the encyclopedia.

The concept of the constellation is shared by people throughout the world. In terms of the planisphere web system, we would like to expand its applicable areas and make the system accessible to an international audience.

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