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Using Hypermedia as a Interdisciplinary Learning and Exploration Tool: a Case Study of the Development of Solar

by

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Technical Report
15 March 1995

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Introduction

One of the most important issues in education is the format in which information is formally presented to students. Howard Gardner presents stunning evidence of college students who were unable to solve basic problems from a course in which they had received honor grades; the questions were asked in a format different from the one to which they were used [Gardner91]. Gardner has shown a different aspect of the educational crisis, that individuals considered good students by normal standards, do not have a complete grasp of their chosen body of knowledge.

We believe that hypermedia can be used to minimize some these problems. Allowing information to be presented in a myriad of different format, hypermedia empowers educators and teachers to use different approaches to demonstrate a single concept. Another advantage provided by hypermedia is to support linking among many subjects, therefore making it possible to adopt an interdisciplinary approach to building educational applications.

The rest of this article presents Solar, an educational application designed as a hypermedium.

The application

Solar is an educational hypermedia application developed under the Imaginary Museum Project [Sequerra-Breitman94] at the Federal University of Rio de Janeiro. The main goal envisioned for this project is to provide a series of applications concerning different periods in the history of arts and science, to be used in the public school system of Brazil. Another objective is to explore the interdisciplinary aspects of hypermedia, allowing very distinct disciplines, such as history, geography, and foreign languages, to be connected within the same application, thus presenting different perspectives to the reader.

The application's domain is the solar system, at first sight a scientific one, but it also addresses other areas, such as history and religion. The planets are presented in many points of view, through a defined linking strategy, allowing a interdisciplinary approach to this subject. The solar system is presented as the first means found by ancient men to measure time. Based on the cycles of the moon and the sun, planting and harvest times could be calculated, making agriculture possible. Connections are then made to calendars. We present the Jewish lunar calendar together with its specific arithmetic and discuss the changes made to the Julian calendar by Pope Gregory XIII that resulted in our current Gregorian calendar [Boorstin83]. We present Greek mythology, to cover the gods that name the planets of the solar system. We also present short biographies of famous astronomers that discovered the planets during the Renaissance and make a parallel of the Renaissance and Greek periods in History. We address great astronomical discoveries, pointing out that stars have been a great navigational tool for sailors though the ages. Finally, we present a current view of the conquest of space, putting man on the moon, and the political Star Wars. Figure 1 presents a screen snapshot of Solar. Obviously, to support that much connection, we had to devise a strong linking strategy. We built the application using Hiper Autor, a hypermedia authoring method developed and currently at use at the Federal University of Rio de Janeiro. It is based on spiral model [Boehm88] prototyping, and after a series of interaction provides users with a complete specification of the system. For further information on the method, refer to [Sequerra-Breitman93] and [Sequerra-Breitman94].

From an authoring-in-the-large perspective, the application contains three contexts or entities: science, history, and religion. We particularly prefer to view the application as a 3-D container that stores nodes randomly. Each node may contain information on various media formats such as video, still images, written text, voice or animation. Each interaction with the system could be represented as a cross-section of that container, depicting the visited nodes. This point of view is shown in Figure 2.

Building hypermedia systems is always tricky. First of all it is difficult to determine the scope of the application, i.e., what is in and what is out. This is a multidimensional problem, for it has to be solved for all the media, pictures, video, animation, and sound. Therefore, accurately estimating the size of and the effort and time to build the application is almost impossible.

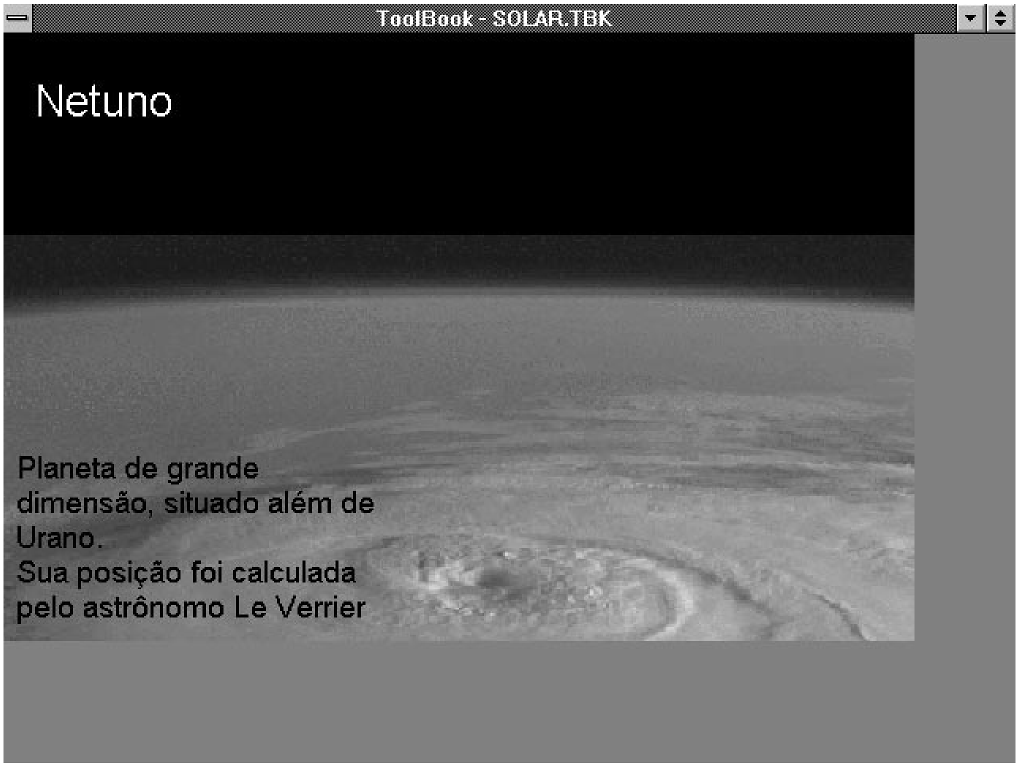


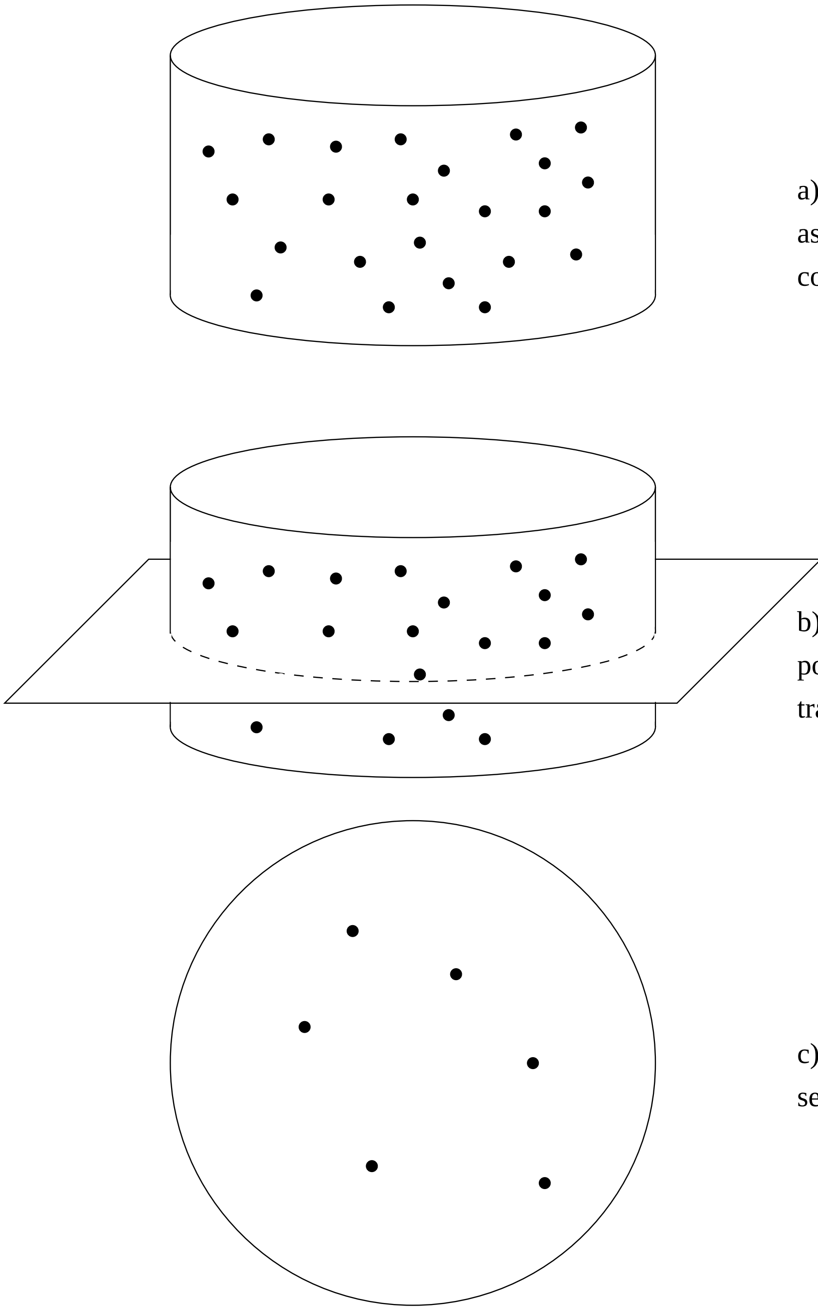
Figure 1: Screen snapshot of Solar depicting the planet Neptune

The time needed for the material to be ready varies and depends on the ability of the people developing it. Compared with software module development the trade-off may not be all that bad. We make very poor estimates of the time to develope a piece of software. Therefore, fortunately, the fact that we cannot predict the time it takes to built a multimedia object, i.e., image, video or sound, does not stand out so much.

There are three options for developing multimedia objects:

- Develop the objects in house—The programmers and analysts develop the digitized version of the objects themselves. Of course, they may not be experts in developing multimedia objects. (They are programmers and, it is hoped, experts in programming languages and techniques.) Therefore, it is possible the team will have to spend a lot of time to learn how to deal with the new tools and techniques to develop multimedia objects. After a while, the team may be able to produce technically acceptable objects, but the artistic quality of their work may leave a bit to be desired. Typically, even the more able of teams using the best of tools will not be able to consistently produce work measuring up to the quality of the media professionals, such as graphic designers, animators, and movie directors. Another aspect to be considered is the high programmer/analyst turnover. The skills needed to develop multimedia objects are not trivial and learning them is time-consuming. In the event of one programmer or analyst leaving the team, the replacing new member may have to devote a lot of time to acquire the skills necessary skill to perform whatever activity was left behind.

- Hiring people to develop the multimedia objects—From the team's point of view, the addition of new people, specially individuals with different backgrounds, will increase the amount of communication necessary among the team members. From the manager's point of view, the degree of complexity is certainly



a) Hypermedium as a whole 3-D container

b) Example of a possible traversing

c) Resulting set of nodes

Figure 2: 3-D view of hypermedium and the projection of one traversing

increased by having a group of people perform a set of activities totally different from the ones regularly performed in the department. Some of these activities are so different that it will difficult to devise a proper management strategy to control them. On the other hand, these difference make the activities relatively independent and may in fact the new activities may generate much less new communication than expected.

Also, additions to the staff may be seen as bad news at a time companies are trying to reduce their payroll. Furthermore, the multimedia objects will have to be generated during a very specific time of the application's development life cycle, which means that unless the company has other multimedia projects, the new staff will have nothing to do during a considerable part of the development of the application. This option is best for a company that has enough multimedia work going on to justify a permanent staff of media experts.

- Outsourcing—Hiring a third party to develop the necessary items for the multimedia application seems to be the most logical solution to the problem for companies doing only occasional multimedia work. It relieves the software manager of the burden of having to control a process of which he or she has very little knowledge, and at the same time, avoids the programmer's and analyst's wasting time in activities other than programming. We must take into account that although having a third party helps to make the cost estimate of the each item more precise (I am assuming that there is a contract that sets the price.), having a third party develop the multimedia objects probably inflates the costs. Another issue to be considered is whether this procedure increases the risks to the project. I personally consider the risk of not finishing a piece of software in time be greater than the risk of complete failure of an inexperienced in-house multimedia group which is turn greater than the all the risks involved in hiring an experienced multimedia company. If the company is known to be reliable, the risks in hiring it as a third party should be minimal. A new trend in the literature suggests quarterization as an effective way to control sub-contracted firms. In this approach, a fourth party is hired to supervise the work done by the third party. This technique can be applied in the case that the multimedia company contracted to develop the necessary objects is uknown.

For Solar, we did most of the multimedia development in house. The video, images, and photographs were created, scanned, and treated by software analysts. The sound was transfered directly from CDs.

The development team was composed of one analyst and three domain experts. To aid the requirements and projects stages we used Hiper Autor, a method developed at UFRJ (Universidade Federal do Rio de Janeiro) to aid in the development of educational multimedia.

We found that using Hiper Autor was not enough to capture all the details of the multimedia objects at the requirements stage. Many a time the team encountered demands as vague as "we want a video of the movement of the planets," or "we want a picture that represents the sun as the king of planets". Such remarks represent very subjective topics and are very difficult to capture in the requirements.

In order to solve this problem a prototype of the system was used during the requirements stage to try to capture the missing details. Prototyping multimedia objects is a very time-consuming activity, because a lot of preparation is required before having objects in a format that allows prototyping. Existing images, i.e., ones that have been captured in some media, require minimal additional preparation. Images on paper have to be scanned and adjusted to the computer screen. Images already in digital format have to be converted to the specific format accepted by the multimedia software package in use for the prototyping and sometimes have to be resized to adjust to the resolution of the monitor used in the prototype. We are not mentioning images that have yet to be created or photographed that have also to pass through all the stages described above. The same problems apply to the prototyping of sounds and video; moreover, it is necessary to identify time spans as well.

In line with the problem described above, there is the fact that domain experts usually have very little experience with graphics design and are generally unaware of the differences between computer-screen based graphics and other media graphics. Printed photographs, for example, may look different when displayed on a computer screen, due to differences in brightness and contrast and the fact that the monitor is back-lit.

The fact that the experts could not anticipate the appearance of the multimedia objects in the screen of the computer had serious consequences to the development of the project. During the requirements elicitation stage graphics and videos that are commonly used for classroom teaching were specified to become part of the application. The material was then digitized and incorporated into a first version of the application. During validation, most of the material was rejected by the experts on the grounds that they did not quite convey the necessary meaning for the application. Videos that were usually presented full screen on the standard scholastic 29-inch (73.66-cm) TV set with resolution (the resolution depends on what system you are using. In Brazil it is Pal-m and the resolution is expressed in lines, not in pixels. This way, the means of comparison is actually the size of the monitor, not the resolution it can reach. In reality the resolution of a computer monitor IS much better than the one from TV sets.) did not look good enough on the smaller computer monitors with resolution 160×120. Pictures that contained large amounts of text were hard to read on the computer monitors. The modifications were so extensive that a second requirements elicitation session was needed. New material had to be specified and sometimes even created. The process had to be restarted practically from the beginning, but this time with a new factor, a growing level of anxiety among the domain experts. Not being able to fully grasp the capabilities of the multimedia system and at the same time being pressed to choose the material to include in the application, the domain experts began choosing an enormous amount of data to be included in the application, more than necessary just to be safe. Later in the project, we understood that this phenomenon was due to the fact that they learned that they could not fully anticipate the appearance of objects on the computer screen. Therefore, they compensated by specifying a large number of objects as a way to force us to prototype all of them. Once these objects were prototyped on to the screen, then and only then would they choose which ones would be suitable.

Obviously, from the analyst's point of view this phenomenon was a disaster, for it consumed many hours of work generating a huge number of multimedia objects, many of which were thrown out in the end. Moreover, the large number of large objects exacerbated the storage and data management problems.

We also noticed that the domain analysts' lack of understanding of the media prevented them from taking a more systematic approach to the authoring of the application. At first most tried to transport to the computer their current classroom notes. Secondly, perceiving that the application was becoming mostly sequential, they began to make links to other topics almost randomly. Inconsistent linking was eliminated by the use of Hiper Autor, but this use was a time consuming effort that we feel could have been minimized if the domain experts had had more experience in authoring multimedia applications.

Perhaps the most interesting feature of hypermedia systems is being able to present information in a non-sequential way, providing a greater degree of freedom to the reader, who is allowed to choose the paths he or she wants to navigate. In that sense, hypermedia systems provide a different approach to presenting information, promoting the exploration and accidental discovery of new things (also referred to as serendipity).

When developing educational multimedia one has to be careful in giving out the right dosages of the freedom and non-linearity that is provided by multimedia. Many a time, the applications being developed refer to some topic that is essentially linear, and cannot be learned in any other way, e.g., a mathematical theory with a specific list of axioms, rules of inference and theorems. Another aspect to consider is that although most of the topics in any multimedia application are related in some way, some connections are clearly more important educationally than others.

In order to make the development of Solar more systematic, we decided against a more free and exploratory environment and created a structure based on templates to present the information. With this approach, we tried to ensure that the educational goals of the application were met, i.e., to show that subjects as different as science, history, geography, and religion are all related. After partitioning the database into several contexts representing the historical, scientific, geographical, and religious aspects of the application's content, the domain experts identified the most important relations to be installed among the contexts. We implemented each of these relations as a guided tour, alluding to a metaphor created by Shneiderman for designing hypermedia [Shneiderman91]. According to Shneiderman, each tour consists of a set of selected nodes that the reader has to visit in a determined order. A tour has an unlimited number of nodes and a single node may be part of more than one tour.

We used templates as a way to discipline the organization of the information on the screen. We observed from previous experiences that the users benefit from a standard interface that facilitates finding information and navigational cues. To make the interdisciplinary aspects of the application more patent to the readers, we established to each context a different background color, so that every time a reader would follow a link to another subject, he or she would have a visual indication of the change.

Of course, the use of templates limited the user interface by making them more predictable, thus excluding all surprises from the application. To regain some beneficial surprise for the user, we inserted some nodes whose visual appearance where completely inconsistent with the templates. The idea of seeding some surprises for the user is based on Jonathan Grudin's idea that if an interface is consistent enough, inconsistencies can be used to focus the user's attention on some important detail. From an educational point of view, presenting different material to students from time to time has net a positive effect, snapping the student out of the apathy induced by long, predictable presentations. We have been careful in determining the right dosage for the number of nodes in order not to create a distraction that could turn the reader's attention permanently from the important contents of the application.

Conclusion

This article discussed the possibility of using hypermedia systems as an interdisciplinary and exploration tool. The article also presented Solar, a hypermedia application developed under the Imaginary Museum Project framework and discussed its contents and goals trying to show the advantages of using a hypermedia approach to deal with an application ranging over so many disciplines.

The author believes that hypermedia can be effectively used in order to minimize the consequences of the so-called education crisis. Supporting the combination of various media, hypermedia allows relations among very different disciplines, otherwise thought independent, within one single application. People do not store their knowledge in different compartments, or classify their problems according to the discipline they are most related to, i.e., as solely a science or a history problem. In this sense, hypermedia can help people to better understand their knowledge as a unique, intertwined, ever changing, ever-changing body of related facts.

The article also presented some possibilities for multimedia products development, discussing the trade-offs involved in each modality Multimedia development is considered a challenging activity because of the many variables involved. Some of these variables are abstract concepts such as personal taste and preferences, making it very difficult to adopt a systematic approach to developing multimedia systems. The article presented the problems that arose during the development of Solar, an educational multimedia application and the solutions applied in order to minimize these problems. It is true that some of the problems presented are specific to this application, but it is believed that the solutions presented in this paper are general enough to be applied to multimedia development in general.

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