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Norman Joseph, Purdue University

Graduate Student, Computer Graphics Technology, Purdue University

David M Whittinghill, Purdue University, West Lafayette
Kathleen C. Howell, Purdue University, West Lafayette

Professor Howell is the Hsu Lo Professor of Aeronautical and Astronautical Engineering at Purdue University. Besides an active research program in Astrodynamics involving spacecraft mission planning and maneuver design, she teaches Orbital Mechanics and Attitude Dynamics for spacecraft applications.

David William Braun, Purdue University

Work-In-Progress
STEREOSCOPIC VISUALIZATION AS A TOOL FOR TEACHING ASTRONOMY CONCEPTS

Abstract

Since its inception, 3D visualization has continued to become a more broadly adopted tool, finding uses in entertainment, industry, and education. 3D visualization is especially useful when it is used to demonstrate concepts involving the very large – such as astronomy, or the very small – such as nanotechnology. In education, stereo visualization allows students to familiarize themselves with worlds which are otherwise unavailable to experience in real life. The objective of this study is to evaluate the educational benefit of teaching lessons that involve a highly spatially-oriented topic, in this case astronomy, using 3D visualization technology.

We propose to use a stereo visualization system that has been installed in a classroom in order to deploy 3D simulation packages designed for use in classroom instruction. This educational tool is currently being used for two descriptive astronomy courses in the Physics department, and involves visualization of galaxies and the local solar system. These courses are taken by engineering students as well as students from other departments.

We propose a work-in-progress pilot study which will use a 3D visualization tool developed to view the local universe and contains visualizations of the local group of galaxies and our solar system. The visualization tool will use stereographic projection. This interactive simulation will allow a user to navigate through the local group of galaxies, looking at various galaxies in the group, navigating from one galaxy to another and measuring the distance between galaxies. The system will also allow the user to navigate in a visualization of our solar system and view all the planets that revolve around our sun. The objects in this system are rendered to scale in order for students to understand the large variation in sizes of objects found in the universe and to help them comprehend the velocity required to travel through space, the distance between two planets, two stars or even two galaxies.

Upon completion of the application, we will experimentally test whether using stereoscopic visualization results in greater understanding of the core concepts in our study's astronomy lessons.

Index Terms

Virtual Reality, Scientific Visualization, Immersive Visualization Environment.

Introduction

An ongoing challenge for educators is knowing whether students are able to grasp material in which direct experience is impossible. This is especially true in astronomy education. Two-dimensional pictures have been extensively used to explain how the billions of galaxies populate the universe. However it seems more intuitive that, as the world we experience is in three dimensions, teaching spatial concepts would be understood more easily if taught using three-dimensional representations. As a great deal of astronomy pertains to an understanding of the position, size, and velocity of celestial objects, the teaching of astronomy concepts using an immersive 3D visualization is a natural choice.

Our visualization software was developed with the objective of teaching students about the local group of galaxies. We are using stereoscopic projection in an effort to increase students' abilities to grasp the lessons and thus improve their understanding and knowledge. In addition to increasing the students' knowledge of astronomy topics, it is hoped that the more immersive and personal interaction with the content will imprint a deeper, aspirational interest upon the students toward the field of astronomy.

Ultimately we are investigating whether the higher degree of spatial perception and immersion in stereoscopic displays will result in improved learning outcomes relative to traditional and non-stereoscopic approaches to teaching astronomy.

This study is a collaborative initiative from several different departments at the University. The experience gained from this pilot study and the feedback we receive will be used to facilitate the design of a larger final study with a greater number of participants.

Related work

Scientific visualization has been extensively used to facilitate education so as to provide a better way to explain physics concepts[1]. Scientific visualization is defined as, "the use of computer graphics to create visual images that aid in the understanding of complex (often massive) numerical representations of scientific concepts or results"[2](p. 64).

Scientific visualization can certainly be useful in observing natural phenomena which might be difficult or almost impossible to observe in reality[3] as in the case of galactic phenomena and navigation of the universe at high speeds accomplished by using the visualization software developed for this study.

Scientific visualizations can be used in conjunction with immersive virtual reality environments. Immersive virtual reality systems have allowed users to behave in a similar manner as they would behave in a real environment[4] and as such has been used as a valuable tool in education. There is convincing evidence that one can learn from educational VR systems[5].

In astronomy most of the information present is taken from two-dimensional pictures taken by telescopes on earth or by satellites. Thus to visualize the three dimensional world using these two dimensional pictures is often very difficult. In this instance, virtual reality is quite useful as it helps students to visualize this three dimensional world. A great deal of the study of astronomy pertains to the spatial relationships between celestial objects and using virtual reality could help the students understand the relationships that exist between objects in space.

In astronomy education it has often been observed that students have a poor understanding of concepts in astronomy. The article by[6] mentions that as children are growing up, their poor understanding may be caused by incorrect information portrayed in entertainment media like films and television serials. As noted[3], "The private cosmological ideas become deeply rooted beliefs, that are often inconsistent with the accepted scientific view" (p. 294). It is believed that these difficulties in understanding concepts in astronomy could be due to the fact that students need to develop spatial awareness of the three-dimensional objects in space and also consider the movement of these objects from various perspectives[7].

Considering the above issues in understanding astronomy concepts it is important that we consider modifying the instructional medium in order to help provide a better way to explain these spatial relationships. Thus usage of scientific visualization and immersive virtual reality could help provide greater spatial information to students. One of the clear advantages of using such a system for astronomy is that it allows for exploration of the three dimensional structure of the universe[4], in a way which might not be possible in reality.

An interactive virtual reality system is considered useful to explain an astronomy concept to students[8,3]. As such, we have also made the software we have developed for the current study interactive so as to promote self learning by user navigation and discovery.

A good example for the use of such systems in astronomy education is the desktop virtual reality earth motion system (DVREMS) implemented in a classroom[9] to teach elementary school students about concepts in astronomy. The authors did achieve significant results in improvement in test scores while using the system for education. Though the DVREMS system only considered movement relative to the earth, our expectation is that similar significant results will be seen in our study when the astronomical scope has been increased beyond earth to the local group of galaxies.

There have been studies which have shown that misconceptions have also been caused by using a virtual reality system for instruction[10]. We shall follow the advice given by the authors by including guided instructions in the classroom setting where the instructor will help students navigate through the software properly.

Implementation

The goal of this project is to create a stereoscopic application to be used in a classroom setting. Also included, is the installation of the hardware.

The Virtual Galaxy is a scientific visualization of the local group of galaxies and the solar system. It is an interactive stereoscopic application developed using the Vizard Virtual Reality Toolkit[11]. The system is designed to run on a 3D desktop PC / Laptop, a classroom and a cave environment. The navigation mechanism in the application can be controlled using the keyboard and mouse as well as a wand and head tracker system. The application also allows the user to modify the Interpupillary distance (IPD) at runtime thus allowing for adjustments of the distance between the left eye image and right eye image. The system has been developed using Python scripting and the individual galaxy and planet models were developed using 3D Studio MAX.

The images of the galaxies are taken from NASA and Hubble telescope web sites. The hardware in the classroom consists of an active projector with a passive filter so that passive glasses can be used so as to reduce cost.

Currently in its prototype stage, the software currently consists of 27 galaxy models, each of which is scaled to size, distance and location. The galaxies are places according to galactic co-ordinates. The system allows navigation in space with speeds ranging from 10,000 meters per second to 500,000 light-years per second. These speeds are calculated in scale to the system. The application also list information about every object present in the application.

Method

The objective of this study is to see if the use of interactive visualization software along with stereoscopic effect helps students understand the concepts better than traditional classroom material.

Students from a selected class will be chosen at the start of the semester and they will be divided into 3 groups. The first group will be the control group who will undergo classroom instruction using a simple PowerPoint presentation. The second group will receive classroom instruction using the non-stereographic version of the visualization software. The third group will receive classroom instruction using the stereographic version of the visualization software. Figure 1 below shows the students undergoing classroom instruction using the stereoscopic system while wearing the 3D glasses.

Figure 1 – Students in the 3D classroom

The students will first undergo a pretest which will be used to collect bibliographic information about the student and will also assess the level of prior knowledge that student may have about the concepts taught in the course.

Next, the students will undergo classroom instruction. Having three groups use three different instructional mediums will help us see if the stereoscopic effect is improving the student understanding more than just using the visualization software alone, thus testing if it's useful to invest in implementing stereoscopic technology in the classroom.

The students will then give a post test to assess the knowledge level gained by the students while under the different classroom instruction. These test scores will be compared with the pretest scores and the difference in the pretest and posttest scores across the three groups will be tested for significant difference. This assessment will tell us whether students gain any advantage by using the different medium of instruction that an interactive stereographic application provides.

Conclusions and Future work

The study is the result of an initiative at the university where stereoscopic systems has been installed in a campus classroom. This particular classroom is being used for various other courses and we hope to expand the reach of this classroom not only to engineering but also other departments in the future. The current work in this pilot study will form a base for the larger study which will be conducted to assess the effectiveness of installing such a system in a classroom to use for instruction. This pilot study will help us realize any faulty assumptions that were made and see any areas for which we did not adequately prepare. In addition, the study can act as an excellent test bed for revealing any limitations or bugs that may exist in the software.

That we will be checking for statistically significant differences in the change in pretest and posttest scores between the three groups for this particular educational intervention differentiates this study from those currently seen in the existing body of literature. We are attempting to differentiate between traditional lecture material, the use of visualization software alone, and the use of the visualization software with stereoscopic effect. We expect to publish the results of this study as soon as they become available.

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