VISUALIZATION IN ASTRONOMY AT GENERAL SCHOOL

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Abstract

This is an International Year of Astronomy (IYA 2009) when we pay great attention to astronomy education. The International Year of Astronomy is a year-long celebration of astronomy, taking place in 2009 to coincide with the 400th anniversary of the first recorded astronomical observations with a telescope by Galileo Galilei.

Author presents a modern approach to teaching astronomy and planetary sciences, centered on visual images and simulations of planetary objects. The basic idea is to take the students to other celestial objects as tourists, and to teach science through the observations of various natural phenomena in these new environments. The power of scientific visualization, through still and dynamic images, makes such a journey an exciting learning experience. The introduction of new technologies (3D animations, virtual reality) greatly enhances the visualization capabilities the teacher can use, allowing him to simulate actual flights over the terrain of other planets and to study them as if observing from a spaceship in orbit. The present article focuses on the study of the Moon, planets, asteroids and Galaxies by means of observations, interpretations, and comparison to planet Earth. Students learn to recognize geological and atmospheric processes, discuss astronomic phenomena, celestial bodies and discover that the same basic physical laws govern all objects in the Solar system and Universe.

Key words: *interactive learning, astronomy, telescope, astronomy education, scientific visualization, virtual reality (VR).*

Introduction

The human eye is a remarkable biological invention, a shining triumph of the process of evolution. Although the human eye was the detector that started us on mankind's exploration of the Universe, it has some shortcomings that ultimately limit that exploration:

1. The eye has limited size and therefore limited light-gathering power.
2. The eye has limited frequency response, since it can only see electromagnetic radiation in the visible wavelengths.
3. The eye distinguishes a new image multiple times a second, so it cannot be used to accumulate light over a long period in order to intensify a faint image.
4. The eye cannot store an image for future reference like a photgraphic plate can.

Astronomers have developed a variety of instruments and techniques to supplement the human eye and to alleviate these shortcomings. As a result, in modern research astronomy, very few observations are made any more by an astronomer looking directly through an optical telescope. Although telescope is the main instrument for astronomers. At scool it is the main instrument for making visual observations of cellestial objects.

Optical telescopes may be divided into two general categories: (1) ***refracting telescopes*** that use lenses to gather and focus light, and (2) ***reflecting telescopes*** that use mirrors to accomplish the same purpose.

Principle of Refraction

The direction of light propagation is changed at the boundary of glass and air by refraction. By designing lenses having the right curvature, this principle can be used to gather and focus light. The following figurē (Figure 1) illustrates the use of a lens to gather and focus light, and the use of two lenses to make a simple refracting telescope.

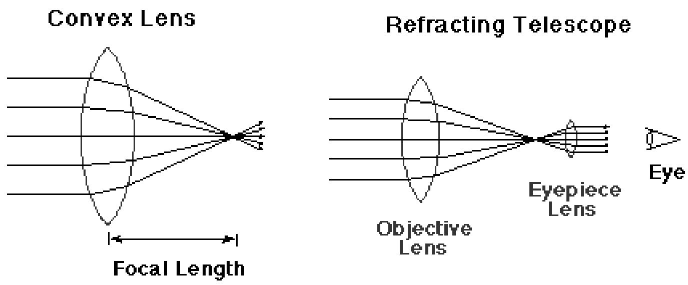


Figure 1. Principle of refraction and the refracting telescope

We can find Internet Java applets which illustrate image formation by a converging_lens and by a diverging lens. These may give everyone some feeling for how such lenses are used to image objects.

We may also use reflection from mirrors to accomplish the same purpose.

The Principle of Reflection

The next figure (Figure 2) illustrates the principle of reflection: the angle of incidence (measured from the perpendicular to the reflecting surface) is equal to the angle of reflection. The right side of the figure illustrates the use of a mirror to make a reflecting telescope.

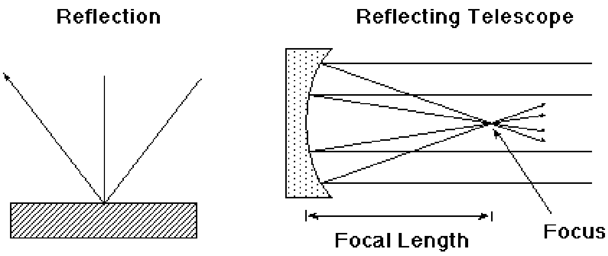


Figure 2. Principle of reflection and the reflecting telescope

We can also find Java applets illustrating the use of a mirror (a diverging or convex mirror in this case) to form an image. For technical reasons, the largest optical telescopes are reflecting rather than refracting telescopes: it is easier to build and support large mirrors of high optical quality than large lenses (Astronomy 162..., 2009).

Some Advantages and Difficulties in Astronomy Education

Astronomy and space science have a strong appeal to children in 9–12 classes. It is a dynamic and exciting science, which is deeply rooted in their everyday life and in the surrounding culture. Teaching astronomy at the primary and secondary school levels is usually a challenge for science teachers, because it contains complex subjects in physics, requires an understanding of three-dimensional geometry and dynamics, and demands (on the student's side) advanced cognitive capabilities. To understand the basic astronomical phenomena such as day and night and the occurrence of seasons, eclipses, phases of the Moon, and the motion of the planets, they must have the capability of visualizing events and objects as these may appear from different perspectives simultaneously. Astronomy teaching is considered difficult also because of the large amount of facts and details it contains and because some of the concepts seem abstract. Teachers are often faced with the dilemma of what topics from the large curriculum to cover in the limited time frame that is usually allocated (Yair, Schur, Mintz, 2003).

Today many interactive sites offer a new virtual environment (VE) which employs a dynamic 3-D models of the Solar system, constellations and other astronomical/physical phenomenon. All this is based on powerful scientific visualization techniques and can be used as an effective aide in astronomy teaching. The learner enters a virtual model of the physical world, journeys through it, zooms in or out as he or she wishes, changes his or her view point, as the virtual world continues to behave and operate in its usual manner. The continual motion of the planets generates day and night, seasons, eclipses, and phases – the topics that are customarily hard to grasp, especially at young age. The visual models allows students for a powerful learning experience, and facilitates the mental construction of three-dimensional space, where objects are varied and different, but share common features and obey the same physical principles. The new possibilities helps to overcome the inherent geocentric view and ensures the transition to a scientific, heliocentric view of the Solar system (Yair, 2001).

Combined with multimedia-based databases, these representations may help students and teachers understand complex abstract astronomical phenomenon, and it is only natural that they are integrated into the science curriculum at scool.

The Use of Visual Sources for Visualization

The use of computer-generated images and of other visual sources of information in present-day scientific research is generally referred to as scientific visualization. Scientific visualization provides a way of observing natural phenomena that, perhaps due to their size, duration, or location, are difficult or impossible to observe directly (Furness, Winn, & Yu, 1997).

In the realm of astronomy, data sent back by the Hubbell Space Telescope (HST) and by other space probes are transformed into images that are enhanced, edited, and analyzed to reveal important new details about our neighbors in space. Astronomers often create video animations to model theories about the creation of the Universe. These scientific visualization tools and techniques are helping scientists to gain a better understanding of how our Solar system formed and how it continues to evolve and change over time.

In modern society astronomy is an integral part of the daily information flux where children are exposed to be. Space shuttle flight, images from the HST and reports from planetary missions appear regularly on television and in publications. The Internet is literally flooded with information on astronomical events and many computer games are situated in outer space and involve some form of planetary or cosmic objects. We can safely assume that if properly designed and used, astronomy teaching can benefit immensely from the powerful attributes of VR.

Usually VR is a medium where a user can operate within a realistic representation of 3-dimensional space, in real time. This can be used to enhance the effectiveness of the learning process. Different models include the Sun, planets, moons, asteroids, and comets, revolving and rotating in their orbits against the constant background of the Milky Way, the stars and constellations (Figure 3). (Yair, 2001).

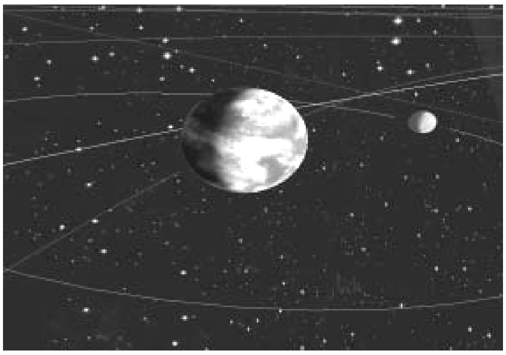


Figure 3. A view of the virtual Solar system. The planet Earth and its Moon can be seen, with planetary orbits displayed. Constellations of (fixed) stars appear in the far background.

Usually user can enter a (virtual) model of the physical world, where the computer mouse becomes like a spaceship that permits a journey through space, to zoom in or out as one wishes, easily changing the view point and perspective. The virtual Solar system continues to behave and operate in its usual manner and the planets rotate and revolve continuously.

The user can also navigate in space, fly above and below the ecliptic plane, approach any object and view it from many angles. The numerical data and orbital parameters, as well as other information, are usually displayed when a specific object is touched. The continual motion of the planets around the only light source in the Solar system (the Sun) naturally generates day and night, seasons, eclipses and phases, which can be easily explored and studied. For example, a confrontation between how things look from a fixed position above the Earth and the view from space (where the Earth revolves around the Sun) should help the students in overcoming the inherent geocentric model. Such models allow a direct study of questions like "what would happen if the Earth rotates faster?", where the results are apparent immediately on the computer screen.

Some Pedagogical Benefits

Journeys through the virtual simulations of the Solar system and the Milky Way help students bridge the gap between the concrete world of nature and the abstract realm of concepts and models.

As students become more familiar in their ability to constructively interact with the VR elements, they should increasingly use these new technologies as a medium for sharing information and discussing ideas and conclusions about science (Figure 4).

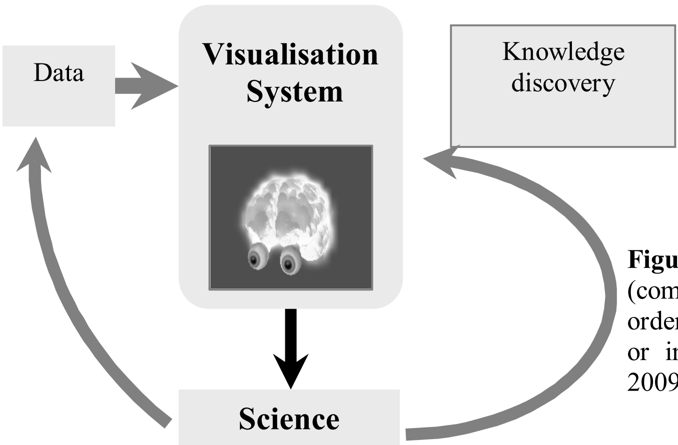


Figure 4. The process of creating (computer-generated) images in order to gain new understanding or insight into data (S2PLOT..., 2009).

As students examine images, animations, manipulate 3-D models, and participate in different virtual simulations, they enhance their understanding of scientific/physical concepts and processes. Students are not simply passive recipients of prepackaged multimedia content. They can use a variety of computerized tools to view, navigate, and analyze a realistic three-dimensional representation of space. Such learning activities provide students with more intuitive understanding of astronomy.

Image-Processing Technique for the Creation of Presentation-Quality Astronomical Images

For many decades astronomical color images have been generated using large-format photographic plates.

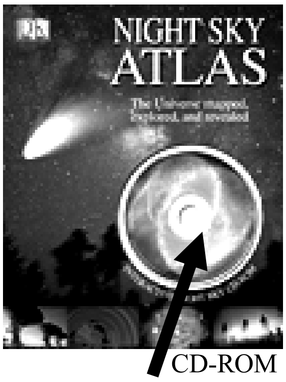
The quality of modern astronomical data, the power of modern computers and the agility of current image-processing software enable the creation of high-quality images in a purely digital form. The combination of these technological advancements has created a new ability to make color astronomical images.

Furthermore, the continuous improvement of imaging capabilities in non-optical windows of the electromagnetic spectrum have enabled the creation of high-quality images at other wavelengths as well. Historically, astronomical images have been made by combining grayscale images taken through red, green and blue optical filters. But often images are now made from datasets that are either outside the optical window or do not match the characteristics of the color-detecting cones in the human eye.

An image which looks properly balanced on one computer monitor may be too dark on another; or the image may look too red when printed on a particular printer. It is anticipated that the image will be used in one or more following ways: The image will be distributed electronically to be viewed on another display device. Or the image will be printed directly to an in-house printer, or it will be sent as a file to be printed on an out-of-house printer. It may be also presented in the classroom on the screen or reproduced by output devices. Each of these scenarios requires that the image must be prepared so that it will look as expected.

In general, one has little understanding of how astronomical images are made. That is why astronomers and image processors often are asked about the authenticity of the representation, with such questions as, "is that what it really looks like?" and, "is this what I would see if I were standing right next to it?"

It is important to generate an image which focuses on the astronomical content and not on the method of data acquisition or image construction (Travis A. Rector, Zoltan G. Levay and Lisa M. Frattare, Jayanne English, Kirk Pu'uohau-Pummill, 2004). On the other hand, very useful for imaging and visualization could be picturesque books or atlases such as Robin Scagell "Night Sky Atlas", London, 2007 (96) with interactive Night Sky CD-ROM (Figure 5). One can take unforgettable interactive journey through the Universe as he/she explores the night sky. There are incredible scenes through pages and a special CD-ROM launch you from the Solar System to the depths of space. It is possible to follow a comet, discover the life cycle of a star, and point stars and constellations. All this can be a thrilling space adventure.

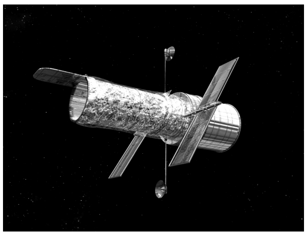


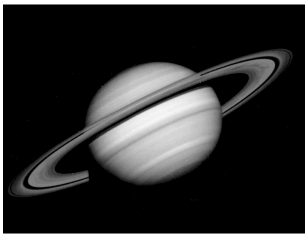
CD-ROM

Figure 5. Revised with a new CD-ROM, this entry in DK's successful series of informative and visually compelling atlases explains how to see and read the night sky at all latitudes for a worldwide audience.
● Stunning photographs, colorful charts and maps throughout
● Features six special acetate pages, and a new CD-ROM with animations (Scagell, 2007).

This CD-ROM have been copied several times by author's students for personal education.
Some example images from Night Sky CD-ROM:


The Leo constellation


The Hubble Space Telescope


Planet Saturn

Summary

The 3D-virtual reality models of the Solar system and other astronomical phenomena holds a substantial didactical advantages that can be used as an effective aide in astronomy teaching. This allows for a powerful learning experience.

Space and astronomy have always captured the human imagination, and children are naturally drawn to space science. Several interactive models enables students to explore space as if flying in their own spaceship. They can decide by themselves where to go, what to watch and from what distance and angle. The user can explore the physical laws governing the Universe by observing planetary motions.

The quality of modern astronomical data, and technologies now available to manipulate them, allows the creation of high-quality images in a purely digital form. The popularity of astronomy depends on the creation of attractive images intended for scientific illustration/visualization. The goal of many of these images is to show what the human eye cannot see.

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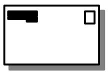

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