VIEWS OF THE EARTH

RECENT TRENDS HAVE SHOWN AN OUTSTANDING RISE IN THE IMPORTANCE OF COMPUTER-BASED VISUALISATION IN GEO-SCIENCES. CHRIS HORMANN EXPLAINS HOW PERSISTENCE OF VISION RAYTRACER (POV-RAY) IS BEING USED TO PRODUCE HIGH QUALITY VISUALISATIONS FOR THIS PURPOSE.

FIG. 1: The Zion Canyon in Utah, USA is part of the Grand Staircase structure that consists of layers of sedimental rocks from a long part of earth's history that have been eroded forming various impressive valleys and canyons. Visualisation of geological formations is a convenient application of the techniques presented in this article.

Since the early steps pioneered by flight simulators and other niche products interactive geo-visualisation has become ubiquitous and due to several popular programs available to a wide range of people without requiring in-depth knowledge it became nearly a synonym for both geo-sciences and applied computer graphics. At the same time these techniques have also become an important tool for professionals to understand and interpret complex spatial data and for presenting their findings.

One field where there has not been much progress despite the rapid expansion of the applications of geo-visualisation is the visual quality of the results. For interactive flights through the Grand Canyon based on remotely sensed data we have the choice among several software products. None of them is capable to generate an image for a high-resolution poster with accurate colors though. The techniques to generate such images exist in the repertoire of computer graphics although some adaptation is required for the special demands of spatial data visualisation.

Special challenges

The amount of data necessary to generate a large and detailed view of the earth surface can be very high. Different approaches exist to manage this — the method of choice for rendering the Views of the Earth is raytracing, a technique to generate images by simulating the propagation of light rays that is capable of generating high levels of realism. To cope with the data sizes the

raytracing technique is combined with a direct meshless method for representing the geometry based on elevation data. This reduces the memory requirements for the geometry by a factor of at least 5-10 while avoiding typical mesh artefacts.

For rendering the geometry after mapping the elevation data onto the surface of the earth special care has to be taken for sufficient calculation accuracy. When elevation differences of a meter or less and scales of several thousand kilometers occur in the same image this often becomes a critical factor.

FIG. 2: View of the Nanga Parbat (8125m) in northern Pakistan.

Accurate colors

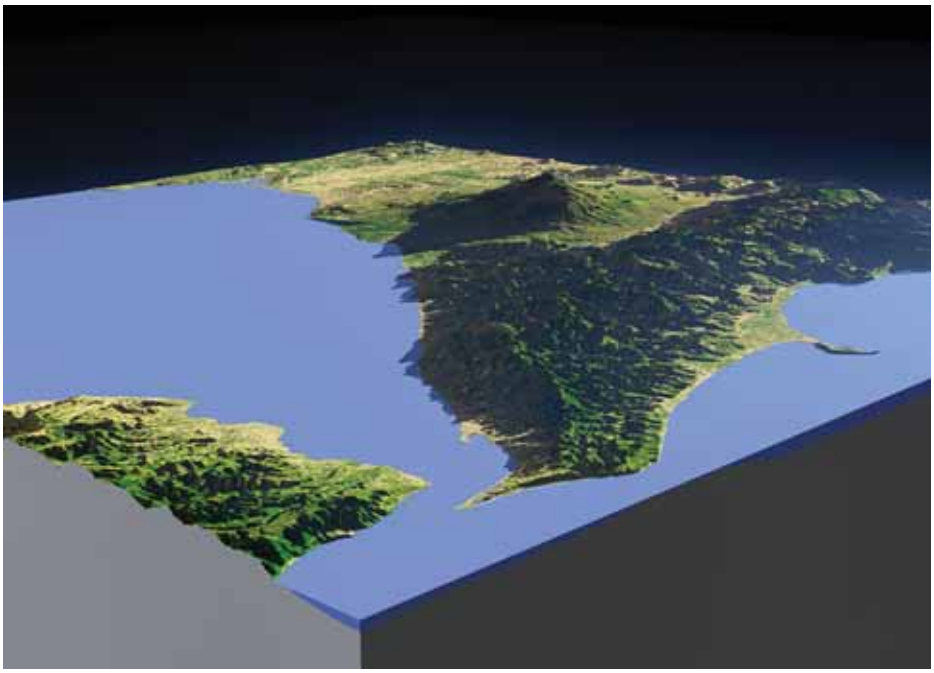
Apart from the geometry the surface coloring is of high importance for realistic earth images. For satellite image analysis data from near infrared sensors is often used in addition to visual range data or even exclusively. Reason for this are that subtle color differences in the visible range are often better articulated in infrared and that the atmosphere is more transparent for infrared than for shorter wavelength light.

For large-scale 3d visualisations false color infrared images are very disadvantageous though. They contradict our empirical knowledge of color and intensity contrasts in nature that we intuitively make use of when viewing an earth image. For an impression of realism and for good perception of a 3d earth render it is therefore fundamentally important to have the surface coloring actually resemble the visual range coloring in reality.

Images require significant processing to be used for the Views of the Earth. This includes clouds masking, compensation for the atmosphere influence and for the illumination at the time the image was taken and finally assembly of different image files. For moderate resolution imagery data products are available that already include at least some of these processing steps. With raising data resolutions this processing become increasingly expensive and usually constitutes most of the data pre-processing work required for generating an image.

Beyond realism

With realism as the primary goal of image



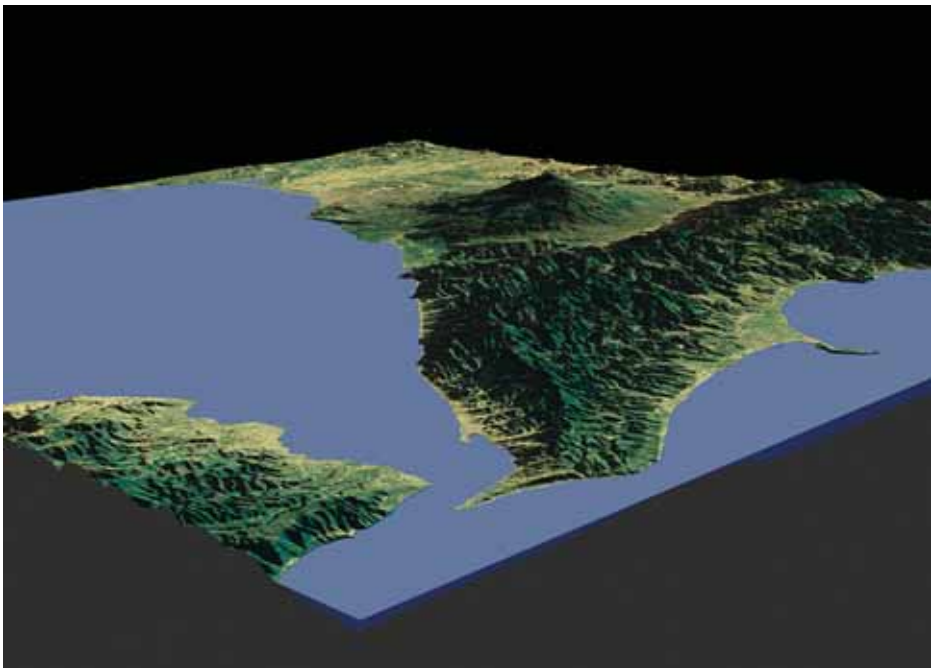


FIG. 3A AND 3B: Comparison of conventional 3d Earth visualisation techniques (above) with the results obtained using the methods described here (below). Both views show the Strait of Messina and the Etna in southern Italy.

creation there would still be a long way to go. In most cases however realism is not an aim per se but a way to improve perception. A realistically rendered earth image is not only pleasing to the eye but also offers a better sense for the actual nature of the earth surface than more basic forms of visualisation. But the primary purpose of a picture usually is the illustration of some earth surface feature. For this artificial images also have a huge advantage compared to space imagery or aerial photographs. Aspects of nature like clouds, fog and dust that hinder the perception of the subject in question can be omitted while maintaining elements of realism helpful to generate a consistent appearance even for the untrained eye.

Raytracing accurately depicts self-shadowing of the relief by default and can be combined with global illumination techniques to obtain more articulated shadows. Reflections can be used to delimitate water surfaces and scattering media is used to support the lighting and improve the sense of depth in the images. All these elements of realism can be fine tuned to emphasize the message of a rendered image (Fig. 2).

The Views of the Earth are rendered with the Persistence of Vision Raytracer (POV-Ray) — a free raytracing program that is both scalable and accurate enough for this purpose. The possibility to extend POV-Ray with custom features make it an ideal choice for novel applications like this.

Data sources

Accurate data is the key to quality images of the earth. As explained the requirements especially for surface color information are high. Even if there is continuous image coverage available for the region to display images taken at different times of the year in regions with strong seasonal variation and persistent cloud cover can make creation of a consistent coloring for the whole area of view very difficult.

Free availability and use of elevation and color data sources are important for large scale visualisations as well. This is the only way to ensure images like these can be created at manageable costs. The Views of the Earth therefore make intensive use of the MODIS, Landsat and SRTM data made available by the NASA and USGS.

Conclusions

Requirements and techniques for generating realistic high-resolution earth images using computer rendering techniques have been outlined. Right now these methods are not sufficiently fast to be used in interactive visualisation but they are well usable for quality still images for both printing and electronic use. The images shown here should give you an idea in what direction geo-visualisation could develop in the next years. More results of applying these techniques to the generation of detailed and accurate earth images can be studied on the Views of the Earth website.

Chris Hormann *is a raytrace specialist. For more information and to see more of his work visit - www.imagico.de*