A digital terrain model (DTM) is generally thought of as a height map or digital elevation model (DEM) shaped with one or more co-registered orthoimages or layers. NASA missions have produced enormous DTMs for locations on Earth, Mars, and the Moon using terrain reconstruction techniques with data from Unmanned and other remote sensors. When explored in 3D, these data sets can provide a unique perspective of the subject terrain and take advantage of computational features not available in a 2D setting. However, typically large and complex, they are somewhat underserved due to the lack of dedicated software and documentation.

**Terrain Visualization:** The purpose of DERT is to visualize the results of NASA terrain reconstruction efforts while retaining interactive and responsive to measurement and other data sources. Toward this end, it employs a virtual world implemented with a scene graph and OpenGL. A surface mesh, created from the DEM, is draped with textures created from selected orthoimages. DERT attempts to maintain a balance between visual capabilities and performance while at the same time handling very large terrain data sets. To achieve this, it maintains the virtual world in small parts, some with varying levels of detail. For example, the terrain structure is based on a multi-resolution height image pyramid, mandating that only enough data for the required level of detail is loaded and rendered. This approach was chosen over other terrain rendering techniques (algorithms, for example) because it retains access to actual data, facilitates very large file sizes, preserves interaction responsiveness during collision detection and does not require a high-level shader language.

**Data Preparation:** A composition application called layerfactory converts each DTM layer into an image, and DTM file format include PDS and DTM file, both supported with widely available GIS tools. Image pyramidal tiles are written as PNG format using base64 compression. LayerFactory does not modify the data except for generating lower-resolution files for the preview by averaging the original file. Otherwise, scale and color remain true. Together, all of the layers constitute a Landscape. The DERT website provides examples of creating landscapes using data from a number of sources including MRO, LRO, Mars Express, 3KTM, and LandSat.

**Measurement:** DERT provides several interactive methods for measuring the landscape. The Tape Measure tool performs a point to point measurement of distance, elevation change, slope, and bearing. The Profile tool graphs a profile along a traversed path. Both tools can be used to generate an elevation profile. The linear range of colors are available as well. Below are a variety of tools displayed with Victoria Crater including a radial grid (red), Cartesian grid (green), a path (magenta), a profile (blue), and the tape measure (red). The location of the red line in the profile graph is marked by the green rectangle in the crater. A white surface grid shapes the entire DTM.

**Layers:** DERT permits 7 different co-registered layers to be draped on the terrain surface simultaneously. These layers include orthoimages, color-mapped elevation derivatives, color-mapped orthofields, and camera footprints and viewsheds. Elevation derivatives include elevation, slope, and aspect. Orthofields are single component images that require a color map to visualize. Color maps are loaded from customizable text files and their ranges can be adjusted interactively. Opacity may be adjusted for each layer or distributed so that all layers contribute equally.

**Lighting and Shadows:** DERT simulates two types of interactive lights: solar and artificial. The artificial light is controlled by changing its elevation and azimuth directly whereas the solar light is controlled by time. JPL’s MapTools library is used to determine the position of the Sun relative to the landscape. The color option provides realistic lighting and shadows whereas the artificial light provides the user with complete interactive control of lighting aspects for tools such as tilting. Shadow rendering is implemented with a shadow map technique. The resolution of the shadow map is configured by entering the center and radius of the region to be shadowed.

**Navigation:** DERT uses the ENU coordinate system where the X axis represents East, the Y axis is North, and the Z axis is Up. Navigation is performed by moving the viewport with the mouse including translating along the terrain, pan and tilt rotation around a center point, directly to and from the center point, and viewport camera zoom. An overlay lists navigational field values and a compass point showing the bearing of the viewpoint. The viewpoint is limited to a maximum of 180 degrees to avoid disorientation and a home button returns the viewpoint to the default overlaid position. In addition to mouse navigation, a user may "grab" an object, moving the viewpoint to that object’s vicinity.

**Camera:** This map element simulates a camera placed at a location in the landscape and provides a separate view of the terrain as it would be seen through its lens. The camera can be raised, panned, and tilted. Point the camera at a specified location and obtain the distance to that point. The camera footprint or viewshed may be displayed as a layer. The viewshed is the part of the footprint that is not obscured and will appear in a camera image. It is basically the opposite of a shadow map and is implemented in a similar manner.

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