
Fig. 1- Screenshot from TerrainView Globe

FROM SPACE TO STREET-LEVEL

WITH SOLUTIONS LIKE GOOGLE EARTH AND NASA WORLDWIND, 3D REAL-TIME VISUALISATION APPLICATIONS HAVE REACHED GLOBAL DIMENSIONS. USERS AROUND THE WORLD CAN NAVIGATE FROM SPACE TO STREET-LEVEL FOR ANY DESIRED POINT ON THE PLANET.

This development has significantly accelerated the next step into the third dimension of the GIS world. ArcGlobe and ArcGIS Explorer from ESRI, TerrainView Globe from ViewTec and Leica Virtual Explorer from Leica Geosystems represent some of the solutions that are currently available on the market. They are able to visualize very large amounts of data from local and remote resources. The data can be 2D like vector data and image data, but also digital terrain models and finally real 3D such as 3D city models.

The type and functionality of today's 3D realtime applications varies depending on which visualization solution is regarded. Whereas Google Earth and NASA Worldwind are designed for displaying Points Of Interest (POI) of various categories and can be downloaded for free (except of premium versions with extended functionality that are not free of charge), ArcGlobe, for example, as a part of the ESRI ArcGIS solution, has a clear focus on GIS applications and analyses.

The growing number of 3D visualization solutions boosts the market for 3D city models. In order to fulfil the market's demands, the Swiss/American CyberCity Group provides 3D data available in various Levels of Detail. These reach from simple untextured cube models to detailed 3D landmarks with high-quality photorealistic textures (Fig. 2).

How are 3D city models and 3D landmarks created?

In order to generate 3D city models, CyberCity applies a semi-automatic feature extraction procedure to derive the 3D roof structure from stereo aerial images or LIDAR data. During the measurement process a particular code is attached to each measured point. This is crucial to interprete the building geometry (basic model, main roof and roof super structures like dormers, chimneys, etc.) correctly for the export into a realtime visualization format later. Once the roof structures are measured, the objects are intersected with the Digital Terrain Model (DTM) in order to generate the walls of the buildings. To obtain a building with planar faces, parallel lines and right angles, the geometry is edited after the intersection process.

For a more realistic appearance, the roofs and facades can be textured using various input data. The spectrum reaches from simple generic texture tiles, which are multiplied in width and height to represent characteristic wall facades, up to textures from digital photos, which are rectified and cleaned before texture mapping.

CyberCity's 3D city models may be complemented with 3D landmarks. These detailed virtual models of significant and famous buildings are of a high level in terms of geometry resolution and texture quality. The objects of interest are scanned using a terrestrial laser scanner. The data of the single scans are registered to a 3D point cloud from which the geometry of the object is derived. As for the other building models, the geometry of the landmarks is edited, too. Depending on the complexity of the object the number of polygons varies between some Hundreds up to about 2500. This makes the landmarks suitable for 3D real-time visualization applications.

For texture mapping of the landmarks, high resolution digital photos are applied. Good texture quality makes the object look photorealistic and may suggest a higher detailed geometry which actually does not exist in the virtual model.

Fig 2

Fig. 2: The complete range of CyberCity's product portfolio. Cube model (left) and photorealistic landmark of Brandenburger Tor in Berlin, Germany (right). © 2005 CyberCity, Harman/Becker.

Fig 3

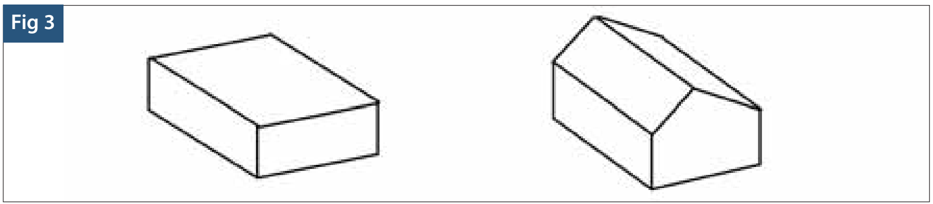

Fig. 3: Different geometry LODs. Left: Cube model. Centre: Main roof. Right: Detailed roof.

Fig 4

Fig. 4: Different texture LODs. Left: Texture resolution 12.5%. Right: Texture resolution 100%.

3D city models in real-time visualization

When combining all the data that are necessary for a 3D visualization project, one ends up very soon with gigabytes or even terabytes of data. To ensure that the user can navigate interactively through the 3D scene, it is crucial that the amount of data to be rendered is reduced in such a way that it can be handled in real-time. Thus, a key technology of 3D real-time visualization is the principle that only the area is displayed in full resolution that is located in the near range of the viewer. The surrounding environment displayed with reduced resolution or not displayed at all. This is represented by a number of different Levels of Detail (LOD).

Initially developed for military simulation systems, complex algorithms compress the terrain and image data (e.g. in the TerraPage format by Terrex) and switch the resolution dynamically between the different LODs as the user navigates through the scene.

The same principle is applicable to 3D city models as well. CyberCity has developed an export interface that exports fully textured 3D city models into the wide-spread MultiGen OpenFlight format (.FLT). Up to 4 different LODs of geometry and texture can be generated. Since the LODs have been defined before by the coding system (basic model, main roof structure, detailed roof structure) the city model can be exported directly without any additional editing/modelling of the geometry (Fig. 3 and Fig. 4).

Optimizing the texture resolution is also very important since the texture memory on the graphics card is limited. For an increased graphics performance, the texture files of the city models are always stored in power of 2 (e.g. 64*64 pixels, 128*512 pixels). Furthermore, the experience with simulation systems shows, that the time for loading the data can be reduced, if the number of textures is reduced. When using 3D city models for web-based real-time visualization, CyberCity generally merges a group of textures to one single texture combining several texture parts.

Examples of 3D city models in ESRI ArcGlobe

Two examples – very different from each other – demonstrate the potential of 3D city models in the GIS world. Being an ESRI business partner, CyberCity has developed an interface that exports a fully textured 3D city model including building attributes (e.g. height, roof area, footprint area, volume, etc.) into an ESRI Personal Geodatabase. These geometric building attributes can be calculated using CyberCity's software CC-Modeler™ and appear in the attribute table when the 3D city model is loaded in ESRI ArcGlobe. Here it can be integrated in a GIS project and analyzed together with other data like DTM, (True-)ortho images and vector data. Urban planning, mobile communication planning, flood protection and volumetric calculations are only a few among a number of applications that are possible in a 3D GIS environment.

The first example is the Austrian city Salzburg, which is famous for its beautiful old town with many historical buildings from the Barock era and the fortress Hohensalzburg.

Covering an area of about 25 km^2, the dataset of Salzburg consists in total about 16'500 buildings from which about 1'500 are measured with detailed roof structures using photogrammetry. The other buildings were generated automatically using footprint polygons from digital cadastral data in combination with the number of floors and a fixed floor height in order to obtain the final building heights.

CyberCity has textured the buildings in the Salzburg dataset using a nearly automatic texture mapping procedure. Oblique aerial images which have been acquired during a helicopter flight campaign served as input data for the texture mapping.

The second example is Los Angeles as one of the largest cities in the United States. CyberCity has generated a fully textured 3D city model of Downtown Los Angeles.

This 3D city model covers about 13 km^2 and contains about 3600 buildings. To increase the visual quality of the dataset in 3D visualization applications, a true ortho photo of the area has been created. Using CyberCity's software CC-Autotex, the textures of the roofs and facades were derived and mapped fully automatic from triangulated aerial images onto the building geometry.

Thanks to the 3D symbology function of ArcGlobe, 3D city models can also be populated with high-quality 3D landmarks.

The trend in the GIS world points clearly in the third spatial dimension. Cities and municipalities find themselves confronted with a changing situation and plan the upgrading of existing 2D cadastral data with 3D information.

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