DMS are established tools for a variety of applications, e.g., navigation, education, and environmental analysis.

User can interactively:
- explore multi-layered map contents
- customize the visual appearance

Two differently stylized 2D maps of Vienna (Left: Google Earth, Right: OpenStreetMap)

- e.g., 3D photorealistic style to aid exploration of local environments vs. 2D maps for navigation tasks.

### Digital 3D Maps - Characteristics

**Digital 3D Maps (D3DMs)**

- utilize a perspective view,
- are based on generalized data models,
- depict geographical reality in an abstracted, symbolized way, and
- are utilized when spatial relations are of primary relevance.
Digital 3D Maps - Related Work

- Design principles [Häberling et al., 2008] and semiotic model [Jobst, 2008] for D3DMs
- Guidelines for 3D symbols [Petrovic, 2003]
- Generalization/abstraction of 3D virtual city and landscape models [Glander et al., 2011, Kada, 2005]
- Generalized data model and exchange format (CityGML [Kolbe, 2009]).

Digital 3D Maps - Drawbacks

D1 Occlusion
D2 Unlimited number of cartographic scales
Digital 3D Maps - Drawbacks

D3 Visual Clutter
D4 Insufficient use of screen-space

Our Approach - Towards Comprehensible Digital 3D Maps

Combine cartography-oriented visualization (COV) with interactive view-dependent multiperspective views (MPVs).
Comprehensible Digital 3D Maps - Design Aspects

DA1 Decrease of visual complexity by classification, symbolization and abstraction [Häberling et al., 2008, Semmo et al., 2012]

DA2 Decrease of occlusion and visual clutter [Pasewaldt et al., 2011]

DA3 Increase of screen-space utilization [Jobst and Döllner, 2008]

DA4 Increase of user involvement [Reichenbacher, 2007]
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DA4 Increase of user involvement [Reichenbacher, 2007]
Filtering stage converts raw data into primary model
- Primary model contains geometric and semantic geodata
- Primary model organizes geodata and geobjects into:
  - Feature classes (e.g., buildings, green areas, and roads)
  - Multiple Level-of-Detail (LoD) representations per feature class
  - User/Task-specific Regions- and Points-of-Interests
- Mapping stage converts primary model into cartographic model
  - Mapping of 3D geodata to rendering primitives (e.g., colored/textured triangles)
  - Multiple Level-of-Abstraction (LoA) representations are generated per feature class

<table>
<thead>
<tr>
<th>BUILDINGS</th>
<th>VEGETATION / TREES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Photorealistic</td>
<td>Photorealistic</td>
</tr>
<tr>
<td>Texture Abstraction</td>
<td>Impostors</td>
</tr>
<tr>
<td>Texture Edge</td>
<td>Silhouettes</td>
</tr>
<tr>
<td>Enhancement</td>
<td>Generalized</td>
</tr>
<tr>
<td>Footprints /</td>
<td>Signatures</td>
</tr>
<tr>
<td>Colorization</td>
<td>Colorization</td>
</tr>
<tr>
<td>Symbols</td>
<td>Omitted</td>
</tr>
</tbody>
</table>
- Level-of-abstraction is a concept suitable for geometric and visual abstraction

- Cartography-oriented visualization can aid orientation, navigation, and exploration tasks within 3D geovirtual environments

- Parametrized level-of-abstraction can be used for seamless combinations of graphic styles
Multiperspective Views - Configuration

- Shape of the MPV is controlled by a parametric curve $C(t)$
  - $C(t)$ is defined by a set of control points
  - High degree of freedom enables different configurations
  - Map-producer defines multiple MPV-configuration, each associated with the control parameter $\phi$ (e.g., viewing angle)

Multiperspective Views - Configuration Examples

<table>
<thead>
<tr>
<th>Degressive Perspective</th>
<th>Progressive Perspective</th>
<th>Hybrid Perspective</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1" alt="Degressive Perspective" /></td>
<td><img src="image2" alt="Progressive Perspective" /></td>
<td><img src="image3" alt="Hybrid Perspective" /></td>
</tr>
</tbody>
</table>

![Reference Plane](image4)

www.hpi3d.de Pasewaldt et al.
Subdivision of MPV into viewport-zones by minimizing transition zones

- Each viewport-zone depicts geoobjects with one viewing angle
- Eases comparison of geoobjects in one zone and decreases number of cartographic scales

Degressive perspective with (left) and without viewport-zones (right).
Discussion

- Combination of cartography-oriented visualization and multiperspective views is a promising approach for comprehensible D3DMs
  - Implements design aspects for D3DMs
  - Mitigates drawbacks of current D3DMs
- **But:** User study is required to proof its effectiveness

Conclusions

- Concept offers multiple options to adjust the graphic style of a D3DM to tasks and contexts
  - May serve as framework for more elaborate research on D3DMs
  - Map-producer must define a set of feasible configurations to hide complexity from the user
- View-dependent interpolation of different graphic styles reduces configuration overhead during map-usage
- User can be involved in the map-production process by integrating location-knowledge (e.g., retrieved from Google+ Local™)
Thank You For Your Attention

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