Critical Evaluation of 3D Visualization

GEOG 5201 – Spring 2022

Outline

Shepherd, I. D. (2008). Travails in the Third Dimension: A Critical Evaluation of Three Dimensional Geographical Visualization. In: Dodge M, McDerby M, Turner M, editors. *Geographic Visualization: Concepts, Tools and Applications*. Hoboken, NJ, USA: Wiley. pp. 199–222.

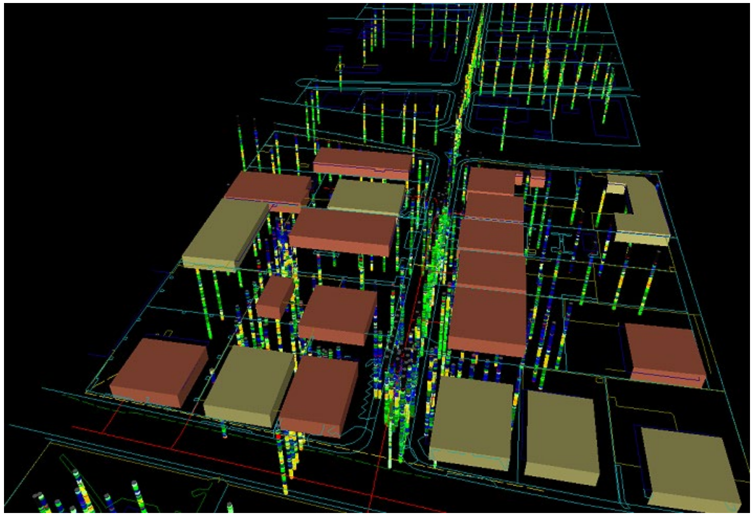
- What is gained by going from 2D to 3D?
- Problems with 3D views (and potential solutions)

What is Gained by Going from 2D to 3D?

- Additional display space
- Displaying additional data variables
- Providing a familiar view of the world
- Resolving the hidden-symbol problem

Additional Display Space

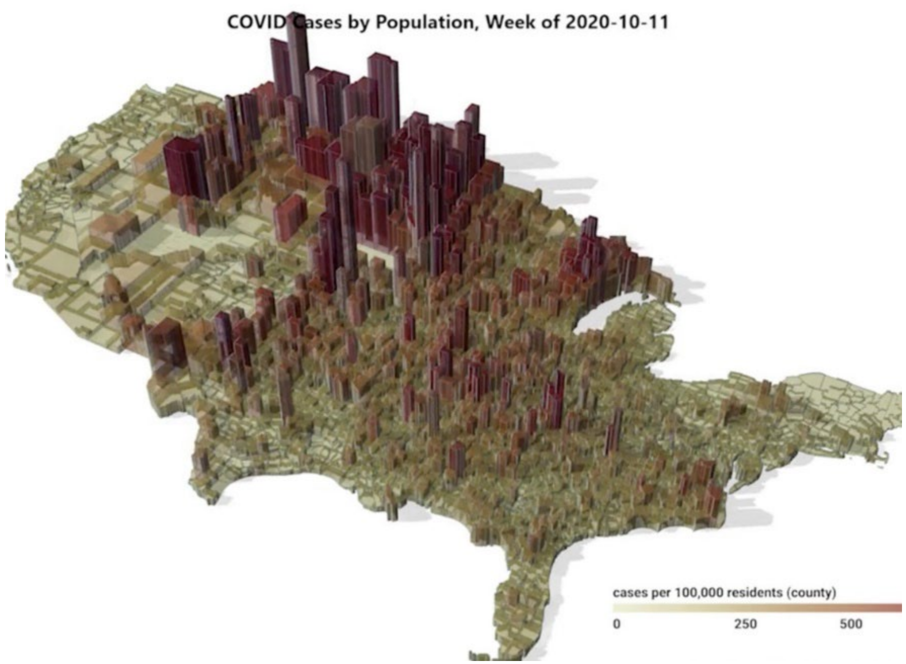
- Allows for a larger number of objects that are reasonably displayed
- Drawback: imposes higher demands for interaction



The multi-colored “straws” display subsurface geologic readings taken every one to five centimeters down to 10 meters below ground surface

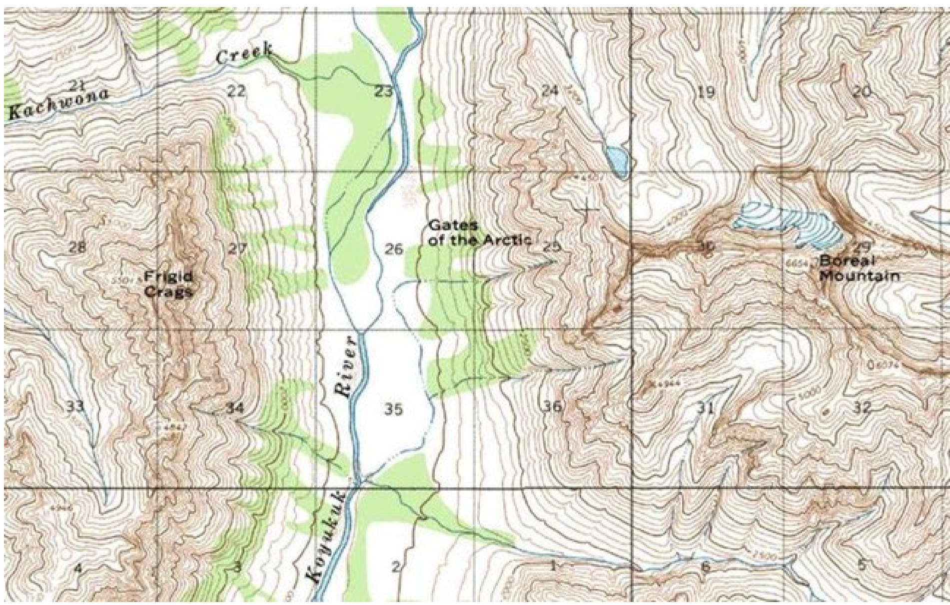
Displaying Additional Data Variables

- Enables at least one additional data variable to be mapped during visualization
  - Example: Prism maps



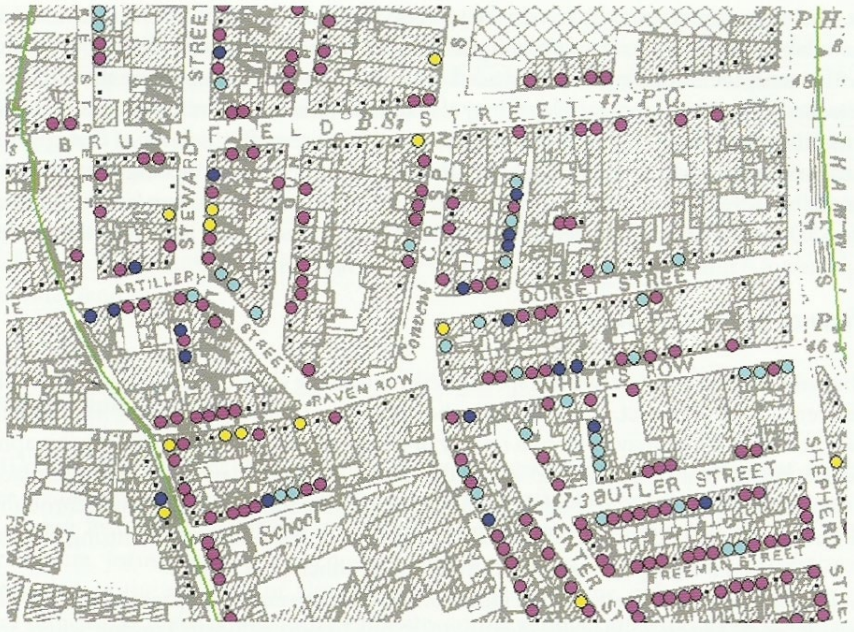
Providing a Familiar View of the World

- Easier to interpret data visualizations in 3D
  - More closely represent the real world
  - Example: terrain visualization



Resolving the Hidden-Symbol Problem

- Use the third display dimension to display stacks at each location
  - Avoid obscurity caused by objects sharing identical locations



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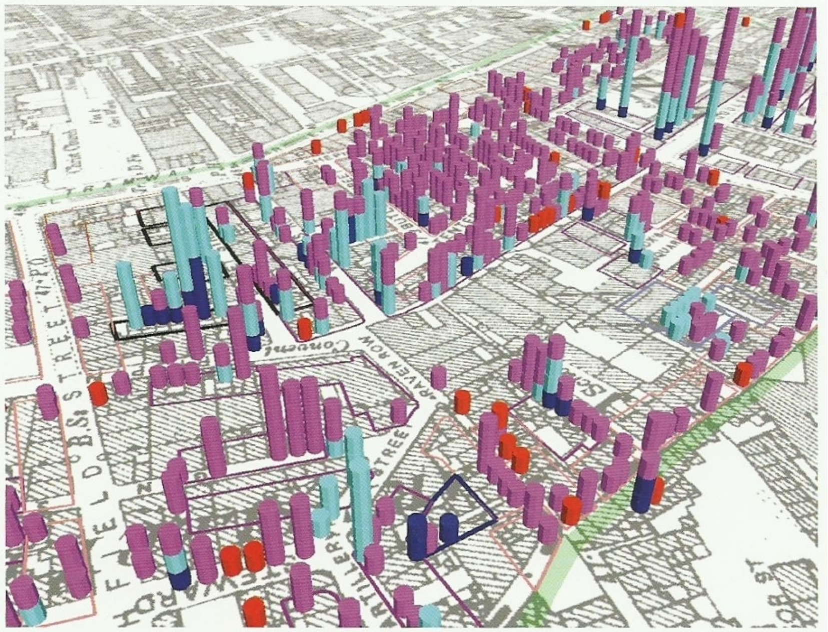


(b)

Question 4-2-1

Find a 2D map from online resources. Discuss the advantages of converting the 2D map to a 3D map. Please also provide a link to the map.

Some Problems with 3D Views

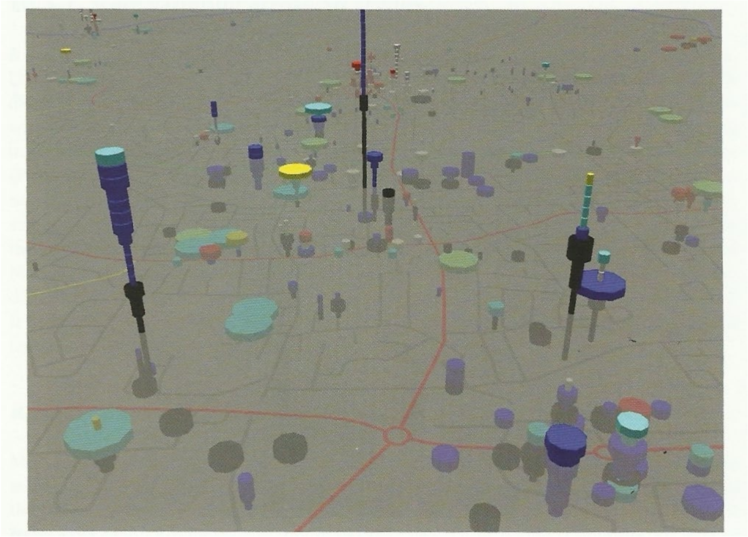
- Scale variation across 3D scenes
- Symbol occlusion within 3D scenes
- Symbol viewpoint dependencies
- Stereo 3D: pretty useful, or just pretty?
- Z-axis contention
- The ‘dimensionality curse’

Scale Variation across 3D Scenes

- Foreshortening effect
  - Visual effect or optical illusion that causes an object or distance to appear shorter than it actually is because it is angled toward the viewer
  - Difficult for users to make effective distance and measurement estimates in 3D visualizations

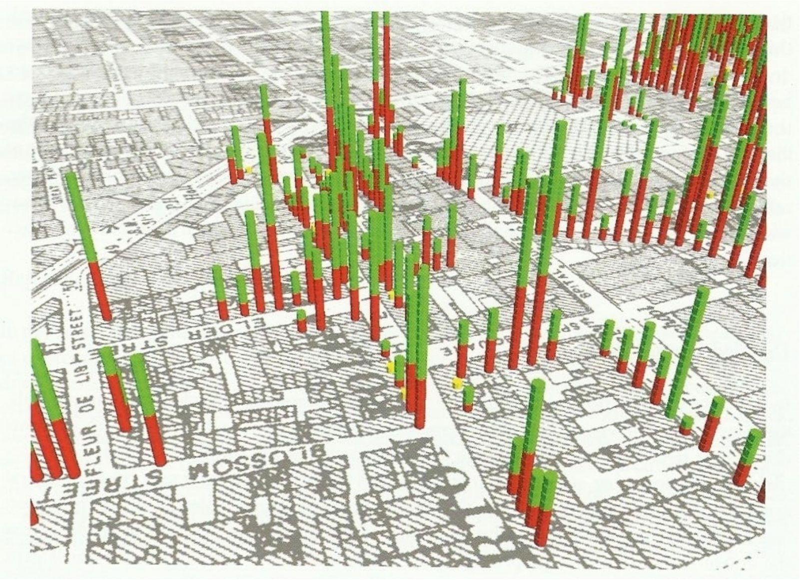
Scale Variation across 3D Scenes: Solutions

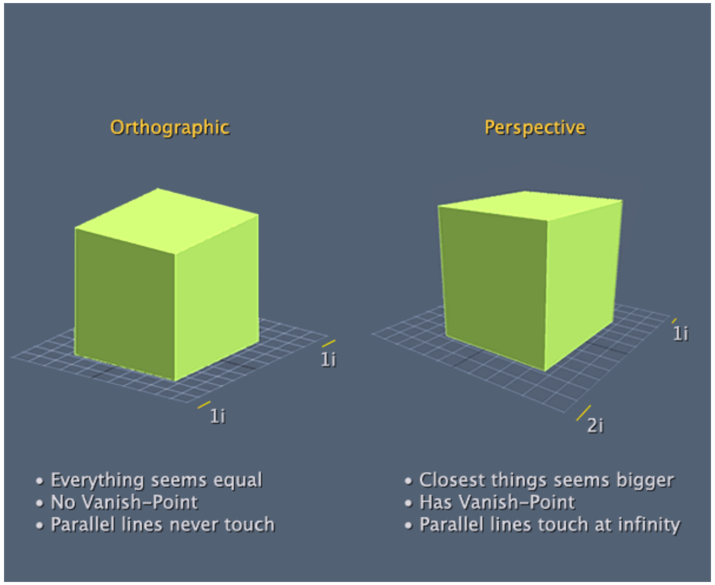
- Reference frames
  - Bounding boxes drawn around objects to provide some sense of scale
- Reference and slicing planes
  - A plane drawn at a specific level within the view, acting as a visual plane of reference for the analyst (e.g., horizontal reference plane)



Scale Variation across 3D Scenes: Solutions

- Divided symbol stacks
  - Small gaps between the symbols in each stack, automatically adjusted to remain proportional to the standard symbol height
- Non-perspective projections
  - Such as using orthogonal projections



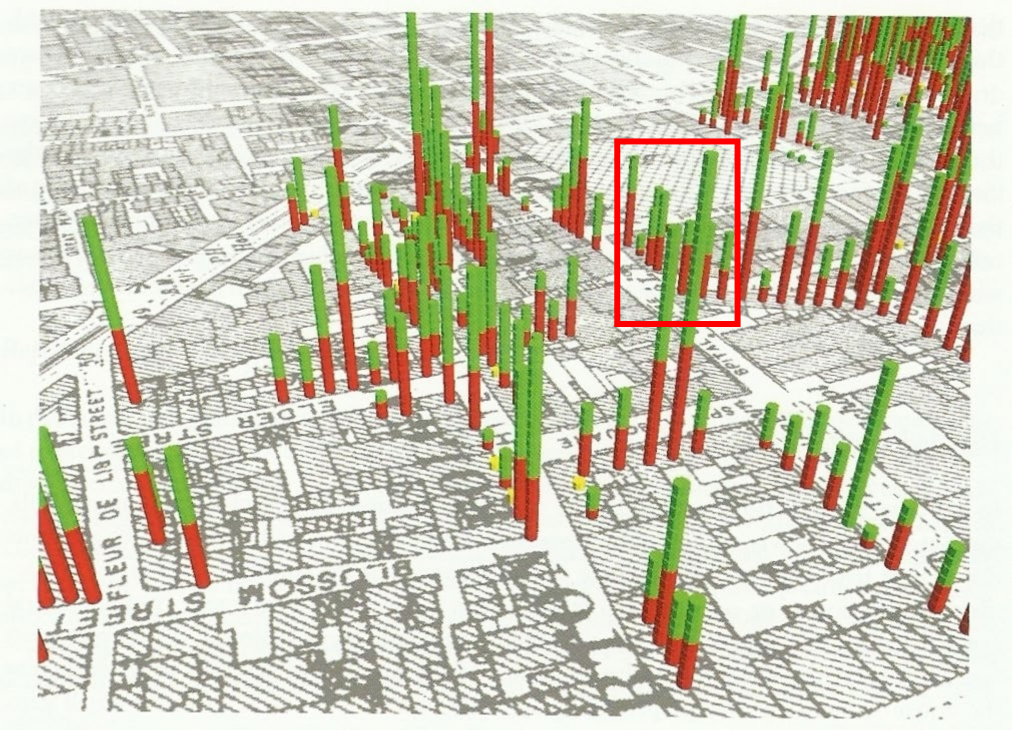


Question 4-2-2

What causes the scale variation across 3D scenes?

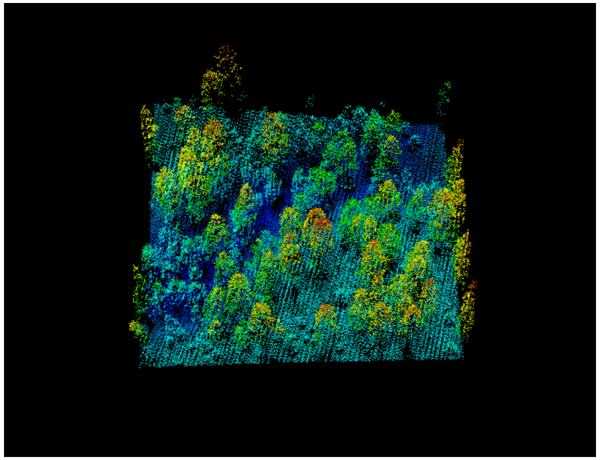
Symbol Occlusion within 3D Scenes

- 3D visualizations still suffer from symbol occlusion
  - Due to the alignment of objects within a scene in relation to the user's viewpoint
  - Though 3D visualizations are used to resolve the problem of hidden symbols in 2D maps



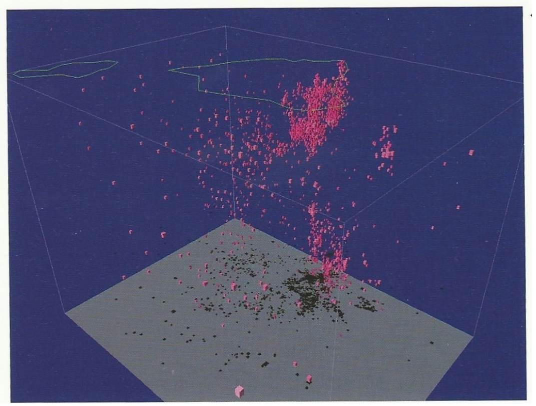
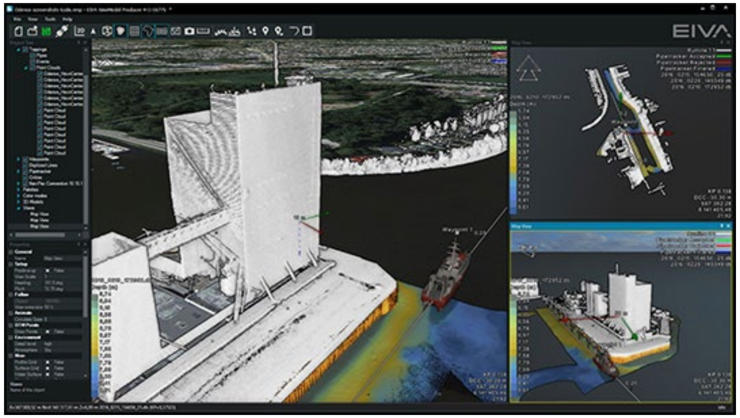
Symbol Occlusion within 3D Scenes: Solutions

- Object culling
  - Remove occluding objects
- Object minimization
  - Reduce the size or height of unimportant objects
- Object displacement
  - Reposition objects to reduce occlusions
- View distortion
  - Distort the geometry of a scene (e.g., fish-eye view)
- Rotation or viewer movement
  - Interactive 3D data visualization



Symbol Occlusion within 3D Scenes: Solutions

- Symbol transparency
  - Draw symbols with reduced opacity
- Symbol shadows
  - Project shadows onto one or more planes of a bounding box surrounding the objects -> spatial distribution
- Multiple linked views
  - Display the virtual world simultaneously as seen from two or more alternative viewpoints in linked views

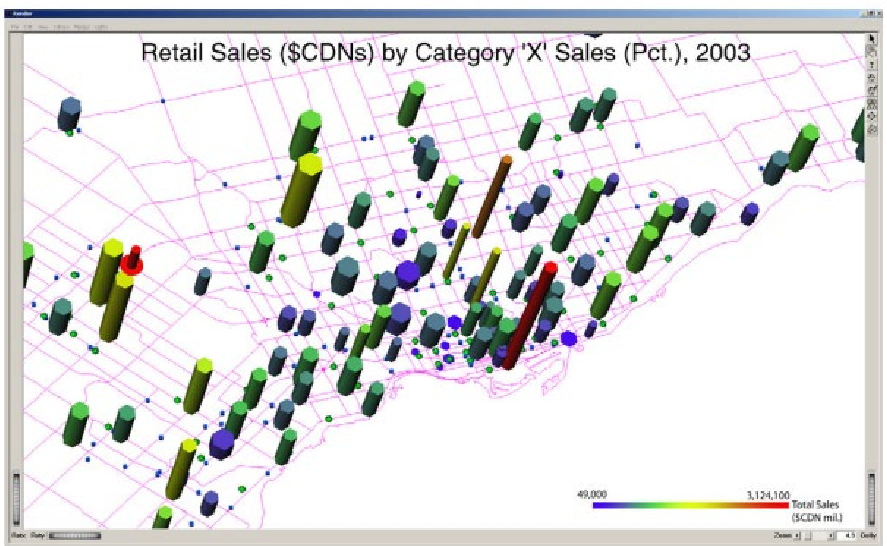




Question 4-2-3

Google Earth is an online platform that renders a 3D representation of Earth based on satellite imagery. Explore Google Earth and explain how it eliminates symbol occlusion.

Symbol Viewpoint Dependencies

- The ability to see a symbol may be dependent upon your viewpoint
  - The perceived dimensions and/or shapes of objects in the scene vary according to their orientation with respect to the viewer
  - Example: 3D bar symbols -- perceived bar widths will not only vary according to the assigned data values, but will also vary with the observer's viewing angle

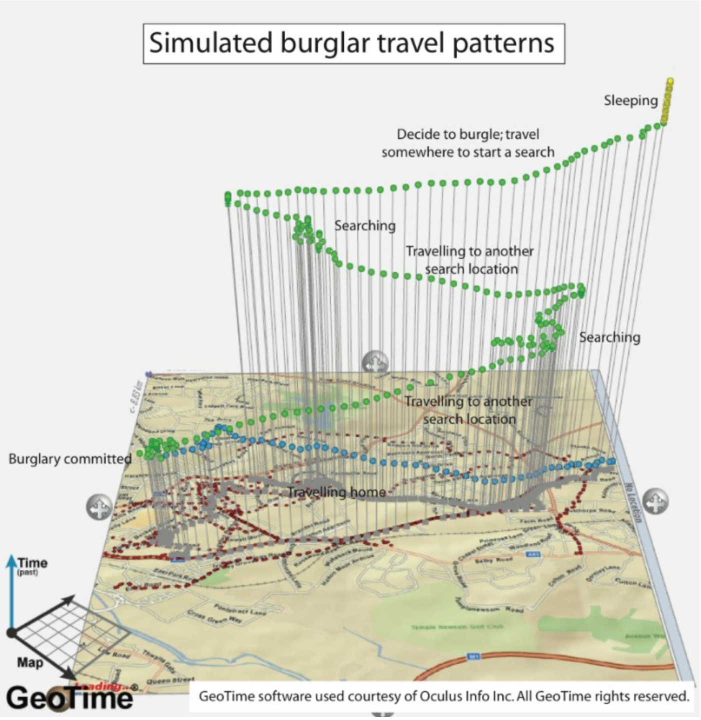


Note: Height and colour of the bars represent total sales, radius of bars represent the percentage sales for category 'x' merchandise. Spheres and cubes show the location of competing firms.

Z-Axis Contention

- Space-time cubes
  - Show how phenomena change over time within geographic space
  - *x* and *y* are reserved for space, and *z* is reserved for time

- Overload where *z* is both spatial height and time
  - Associations between lines and spatial location difficult to determine
  - The space-time cube is already complicated; it may be prohibitively complex if the terrain was also visualized in 3D



Think critically about 3D

- 3D is not always useful for data visualization as it may seem
  - All advantages/benefits have caveats
  - Problems do not have completely satisfactory solutions
- Step back and ask some relatively simple questions
  - Is the visualized scene free from distortion, bias, or other visual error?
  - Are the display methods used appropriate for the task at hand?
  - Would any patterns hidden in the data be more evident if 2D visualization methods were used?
  - Are the visualization techniques being used best suited to the current user?

Think critically about 3D

- Just because it can be done does not mean that it should be done
- Some 3D effects are of questionable analytical value, and 3D is not always better than 2D
- Goals
  - Understand the principles and limitations of 3D visualization
  - Know how to make effective choices in harnessing the power of available tools for your needs