Multi-resolution Technique Examples

Multi-Resolution Visualization

Motivation

- Limited computational resources

Example: Internet-Based Server 3D applications using progressive meshes [Hop96]
Multi-Resolution Visualization

Motivation

- Restricted cognitive resources of human viewers

Example: A graph that contains 87,931 vertices and 87,930 edges [GKN04]

More Examples

- Check several examples in multiple disciplines
  - Image processing
  - 3-D surface rendering
  - Volume rendering
  - Flow visualization

- **Background:** Video-On-Demand services
  - Allow users to tailor video playback quality
  - Provide VCR operations such as fast-forward
- **Challenges:**
  - Storing multiple copies of a video in different resolutions wastes space
  - VCR may cause additional I/O, network bandwidth and system buffer

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**Multi-resolution technique used:** *sub-band coding*

![Sub-band decomposition diagram](image)

An example of sub-band decomposition
Paper 1: Efficient Support for Interactive Service in Multiresolution VOD Systems
(K. Law, J. Lui, and L. Golubchik. 1999)

- **Features**
  - Limited I/O and network resources are motivations.
  - Data needs to be pre-processed.
  - Users can control the resolution.
  - The more details, the better.
  - High resolution = Low resolution + difference

- **Feature preservation from a higher resolution to a lower one:**
  - Reserve low frequency spectrum
  - Filter out high frequency spectrum

- **Resolution control:**
  - VCR
  - Playback quality setting
Paper 2: Efficient Compression and Rendering of Multi-Resolution Meshes
(Z. Karni, A. Bogomjakov, and C. Gotsman. 2002)

- Background: Internet-based server 3D applications
  - Require fast transmission of a geometric model
  - Require fast rendering at the client
- Challenge:
  - A large high resolution model may not be transmitted to the client on time.

- Multi-resolution technique used: *progressive mesh coding*
  - Reconstruct a rough resolution of the mesh using a small number of bits received
  - Gradually refine the mesh as more bits arrived
Paper 2: Efficient Compression and Rendering of Multi-Resolution Meshes (Z. Karni, A. Bogomjakov, and C. Gotsman. 2002)
Features
- Limited I/O and network resources are motivations.
- Data needs to be pre-processed.
- Level Of Detail (LOD) can be changed locally (within sub-region).
- Users has no LOD control other than stopping the refinement.
- Resolution change gradually. No surprise for users.

Feature preservation from a higher resolution to a lower one:
- Adjacent vertices in a special sequence are collapsed into their centroid.

Resolution control:
- A user can stop the refinement when the mesh is good enough.
Background: time-critical applications
- Example: virtual surgery
- Precise rendering time control is crucial

Challenges:
- Rendering may not be fast enough for large volume dataset. So hierarchical rendering is used to trade off between quality and speed
- How to select proper LOD at run time?

Solution: Automatic LOD selection
- Control frame rate precisely
- Control time distribution among different sub-regions

Pre-processing: Hierarchical volume structure
- The entire volume is divided into subvolumes.
- Multiple resolutions are created for each subvolume.
- Each subvolume is assigned an importance value.
Run-time LOD selection:

- Subvolumes are rendering one by one.
- Available rendering time is distributed among subvolumes to be rendered according to their importance values.
- Rendering time for each LOD is predicted from statistic of previous rendering.
- For each subvolume, a LOD whose predicted rendering time is closest to the assigned time is selected.

(a) Without importance parameter
(b) Use opacity as importance parameter – More time to render less transparent areas
(c) Full resolution display

(a) Without importance parameter
(b) Use view distance and projection areas as importance parameters

Features
- Motivated by limited computational resource.
- Data needs to be pre-processed.
- Different regions can have different LODs.
- Regions of users' interest are displayed in more detail.
- Precise time control mechanism
- Pre-load different LODs as texture objects

- Feature preservation from a higher resolution to a lower one:
  - A lower resolution is generated by averaging adjacent voxels in the higher resolution.
- Resolution control:
  - Importance values
  - User preferred frame rate


- Motivation:
  High level details often clutter a 2-D flow display
- Approach: wavelet multi-resolution display

Original display  Display with reduced resolution  Resolution is further reduced
Solution: a multi-resolution model for 2-D flow display
- Lower resolutions eliminate high order details while reserves major trends
- Resolution can be changed locally
- Zoom in and out can be combined with LOD changes
Paper 4: Wavelets over Curvilinear Grids

Features
- Motivated by the clutter problem.
- Data needs to be pre-processed.
- Different regions can have different LODs.
- Users can interactively change LODs.
- High resolution = Low resolution + difference
- Zooming
Paper 4: Wavelets over Curvilinear Grids

- Feature preservation from a higher resolution to a lower one:
  - A lower resolution is abstracted from a higher resolution using wavelet decomposition functions.
- Resolution control:
  - LODs of different regions can be set manually.

Hints

- Motivation of MRV:
  - Limited computational resources
    - Network, processing resource, storage
  - Restricted cognitive resources of human viewers
  - Different cases
    - The more detailed, the better
    - Less detail is preferred
  - Other reason:
    - Privacy