NANYANG TECHNOLOGICAL UNIVERSITY SINGAPORE

Module 9
Efficient Rendering

Learning Objectives

- Understand hierarchical representations
- Understand two forms of scene organization
- Construct and use bounding volumes
- Design and use level of detail (LOD)

Sources

- Textbook (Chapter 9.3: Fast Rendering of Large Scenes)
- Wiki:
  - http://en.wikipedia.org/wiki/Bounding_volume
  - http://en.wikipedia.org/wiki/Level_of_detail

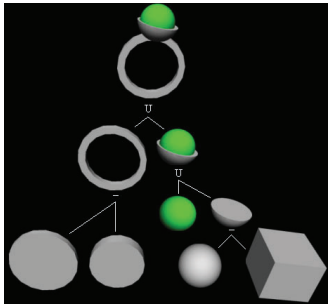
Outline

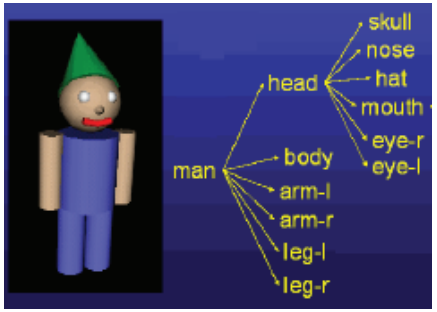
1. Introduction

- In real applications, geometric datasets are usually very complicated. There is possibility to speed up rendering by well-organizing data or appropriately processing data such as
  - Hierarchical representation of models
  - Spatially-based organization of scenes
  - Bounding volumes
  - Level of detail

2. Hierarchical representation

- Hierarchical representation has advantages for modeling, rendering and others.





3. Scene organization

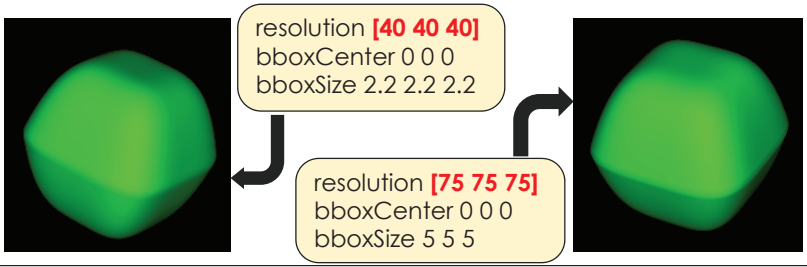
- Logically-partitioned organization: may not be efficient for rendering
- Spatially-partitioned organization: efficient for rendering

4. Bounding volumes

- Using bounding volumes is a simple and effective technique for rendering.
- A few criteria for constructing a bounding volume:
  - The bounding volume should be relatively simple geometrically. This makes the computational cost of geometrical operations with the bounding volume be low.
  - The bounding volume should bound the object tightly. This makes the use of the bounding volume for the object effective.
  - The computational cost of constructing a bounding volume for an object should be low.

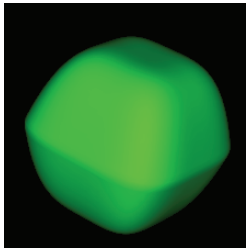
Bounding box in FVRML

- In FVRML, bounding box can be used to speed up the rendering of implicit objects and improve the rendering quality.
- For example, we use FVRML to visualize a shape defined by: $1-|x|-y^4-z^4 \geq 0$.
- To achieve similar rendering quality, we can use a lower resolution with a tight bounding box.

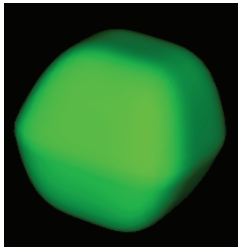


Bounding box in FVRML

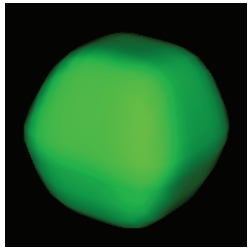
- With the same resolution, tighter bounding box gives better rendering quality.



resolution [40 40 40]
bboxCenter 0 0 0
bboxSize **2.2 2.2 2.2**



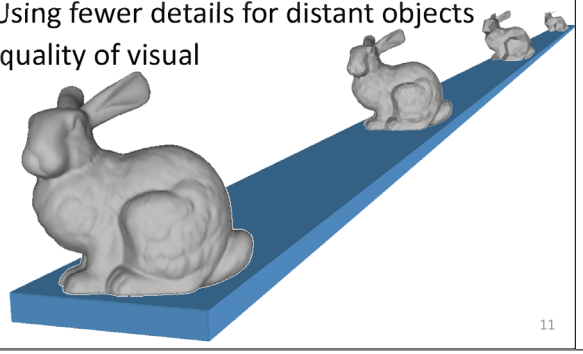
resolution [40 40 40]
bboxCenter 0 0 0
bboxSize **4 4 4**



resolution [40 40 40]
bboxCenter 0 0 0
bboxSize **6 6 6**

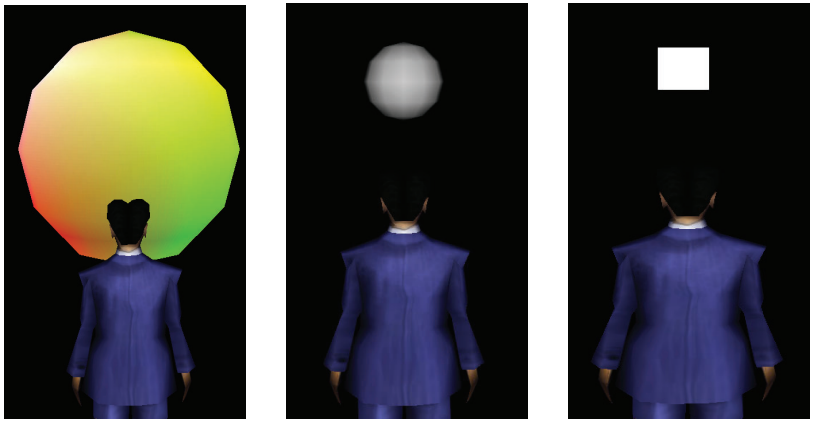
4. Level of detail

- Level of detail (LOD) is an important technique for maintaining interactivity.
  - Basic idea: tradeoff among the fidelity of models, the visual fidelity, and performance
  - Basic observation: Using fewer details for distant objects will not reduce the quality of visual appearance.



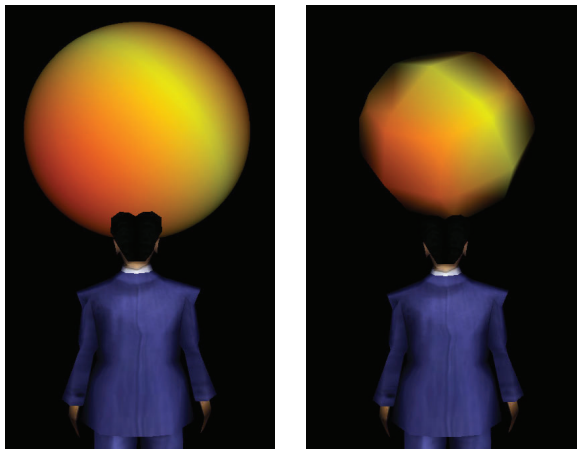
LOD in FVRML

- In VRML, LOD node can specify various levels of detail or complexity in terms of colors and shape.



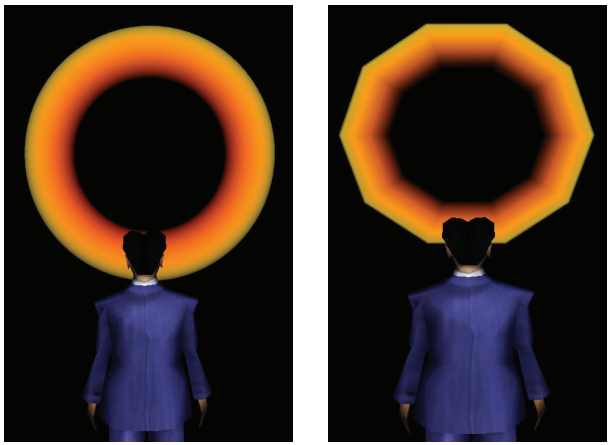
LOD in FVRML

- In FVRML, LODs can be controlled using the resolution for rendering implicit objects.



LOD in FVRML

- In FVRML, LODs can be controlled using the resolution for rendering parametric surfaces.



Outline

Example

Q: Consider a 2D object defined implicitly by

$$f(x, y) = \min(\ \min(1-x^2-y^2,\ -(1-(x/0.7)^2-(y/0.3)^2)),\ y) \geq 0$$

(i) Draw a diagram to show the hierarchical representation of the object.

(ii) Find the minimum axis-aligned bounding rectangle of the object.

Example (cont)

Hints: :

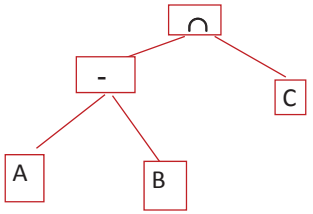
Introduce the following notations:

A: unit disk $1-x^2-y^2 \geq 0$

B: ellipse disk $1-(x/0.7)^2-(y/0.3)^2) \geq 0$

C: half plane $y \geq 0$

One possible diagram could be



min(

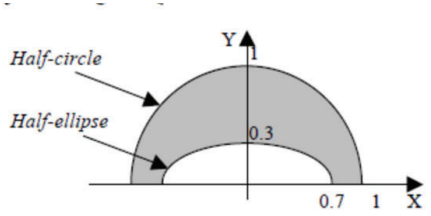
min($1-x^2-y^2$, $-(1-(x/0.7)^2-(y/0.3)^2)$),

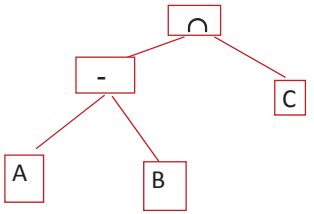
y

) ≥ 0

Example (cont)

Hence the 2D object is the shaded area shown below:





It can be seen that the object is between two vertical lines: x=-1 and x=1, and between two horizontal lines: y=0 and y=1. Thus the minimum axis-aligned bounding rectangle is the one specified by two corners with coordinates (-1,0) and (1,1).

END