

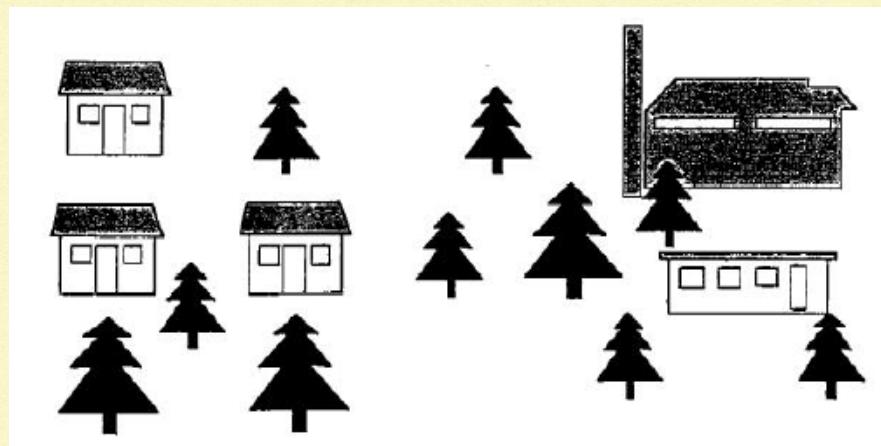
**CZ2003 Tutorial 7 (2020/2021, Semester 1)****Efficient Rendering**

(Note that this tutorial corresponds to the topics in “Module 9” which is for self-study in weeks 6~7. Some topics such as bounding volume might be helpful for lab 4.)

1. Consider a 2D object defined implicitly by

$$\max(1 - (x - 1)^2 - y^2, \min(\min(x - 1, 2 - x, y, 2 - y), -(0.25 - (x - 2)^2 - (y - 2)^2))) \geq 0$$

- (i) Draw a diagram to show the hierarchical representation of the object.  
 (ii) Find the minimum axis-aligned bounding rectangle of the object.
2. With reference to Figure Q2, suggest a database organization for a virtual city containing a factory, an office, houses and trees. The organization should be hierarchical and does not have duplication in the primitive level.

**Figure Q2**

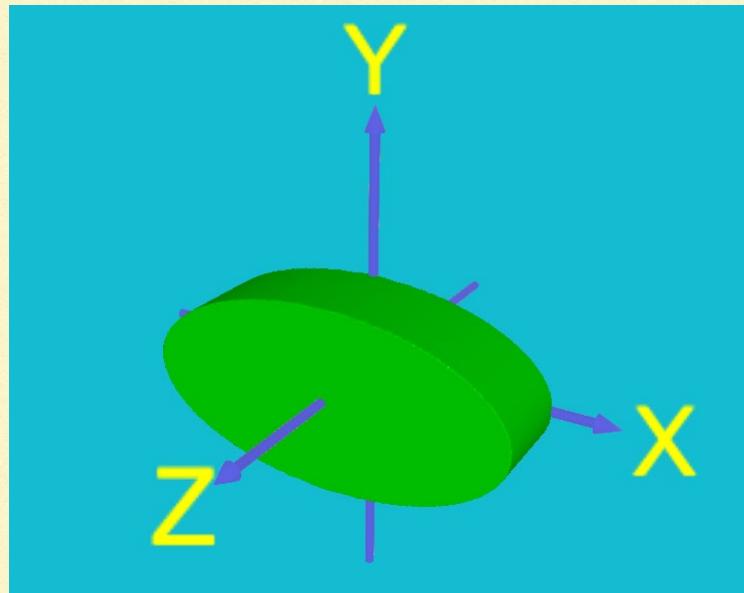
3. Propose how to implement parametrically a continuous level-of-detail for an ellipsoid defined by parametric equations

$$\begin{aligned} x &= 1 + \cos \phi \cos \theta & -\pi/2 \leq \phi \leq \pi/2 \\ y &= 2 + 2 \cos \phi \sin \theta & 0 \leq \theta \leq 2\pi \\ z &= 3 + 3 \sin \phi \end{aligned}$$

4. With reference to Figure Q4, a 3D object is defined implicitly by

$$\min\left(z, \min\left(1-z, 1 - \frac{x^2}{4} - y^2\right)\right) \geq 0$$

- (i) Find the minimum axis-aligned bounding volume of the object.
- (ii) Propose reasonable resolutions for visualizing this object.



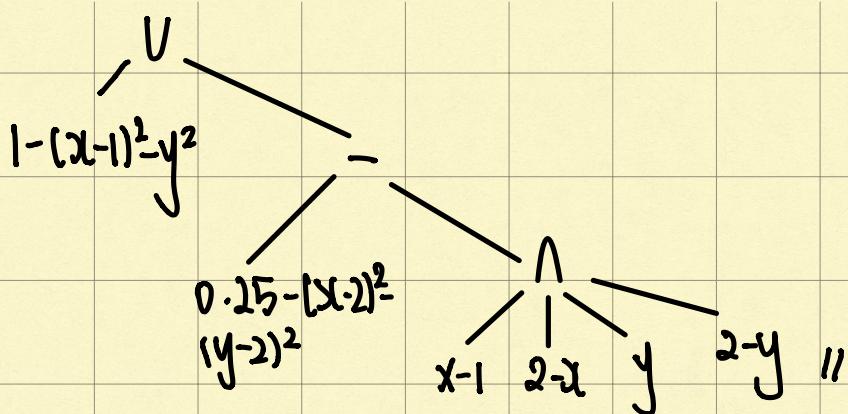
**Figure Q4**

1. Consider a 2D object defined implicitly by

$$\max(1 - (x-1)^2 - y^2, \min(\min(x-1, 2-x, y, 2-y), -(0.25 - (x-2)^2 - (y-2)^2))) \geq 0$$

- (i) Draw a diagram to show the hierarchical representation of the object.  
(ii) Find the minimum axis-aligned bounding rectangle of the object.

(i)



(ii)

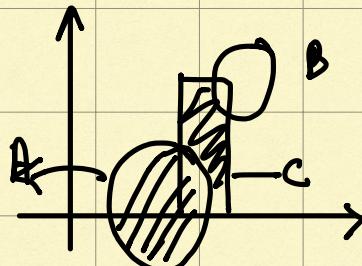
object b/w  $x=0$  and  $x=2$

and also b/w  $y=-1$  and  $y=2$ .

By observations:

$\therefore$  minimum axis-aligned  
bounding rectangle  $(0, -1)$  and  
 $(2, 2)$

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2. With reference to Figure Q2, suggest a database organization for a virtual city containing a factory, an office, houses and trees. The organization should be hierarchical and does not have duplication in the primitive level.

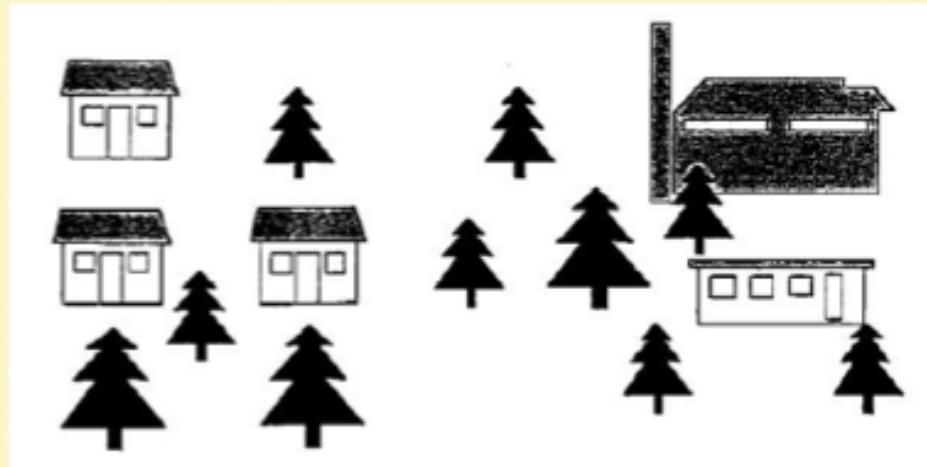
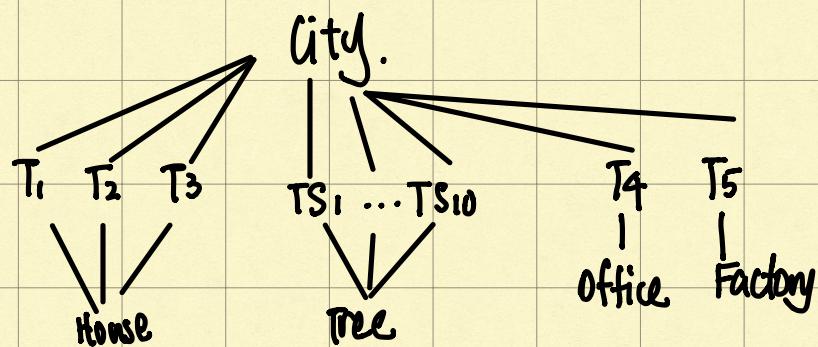


Figure Q2



➢  $T_1, T_2, T_3, T_4$  and  $T_5$  are  
translation transformations

➢  $TS_1 \dots TS_{10}$  are combinations  
of scaling & translation transformations

3. Propose how to implement parametrically a continuous level-of-detail for an ellipsoid defined by parametric equations

$$x = 1 + \cos\phi \cos\theta \quad -\pi/2 \leq \phi \leq \pi/2$$

$$y = 2 + 2 \cos\phi \sin\theta \quad 0 \leq \theta \leq 2\pi$$

$$z = 3 + 3 \sin\phi$$

parametric Eqs:

$$x = 1 + \cos\phi \cos\theta \quad -\frac{\pi}{2} \leq \phi \leq \frac{\pi}{2}$$

$$y = 2 + 2 \cos\phi \sin\theta \quad 0 \leq \theta \leq 2\pi$$

$$z = 3 + 3 \sin\phi$$

$\therefore$  sample  $\phi$  with  $\phi = -\frac{\pi}{2} + f_i d$  and  $f$  with  $f = 0 + f_j d$ ,

where  $f = f(d)$  and  $d$  refers to the distance between the observer to ellipsoid. The lesser  $d$  is, the smaller  $f_j$  should be which results in denser tessellation.

4. With reference to Figure Q4, a 3D object is defined implicitly by

$$\min\left(z, \min\left(1 - z, 1 - \frac{x^2}{4} - y^2\right)\right) \geq 0$$

- (i) Find the minimum axis-aligned bounding volume of the object.  
(ii) Propose reasonable resolutions for visualizing this object.

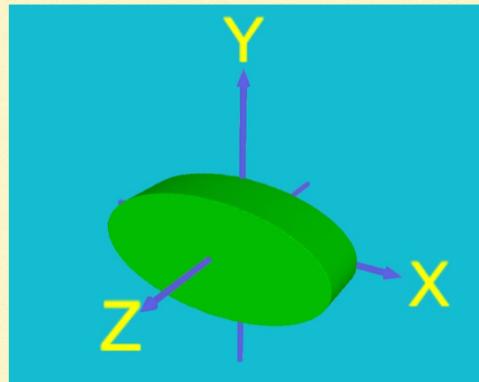


Figure Q4

4(i)

$Z$  coordinate  $\Delta$  from 0 to 1

object in  $X-Y$  plane is ellipse with semi axes of 2 and 1

$\therefore$  center of bounding volume  $(0,0,0.5)$

$\therefore$  lengths of bounding volume can be 4, 2 and 1 along  $X$ ,  $Y$  and  $Z$  direction

4(ii) A reasonable resolution

can be

$[80, 40, 160]$  px.