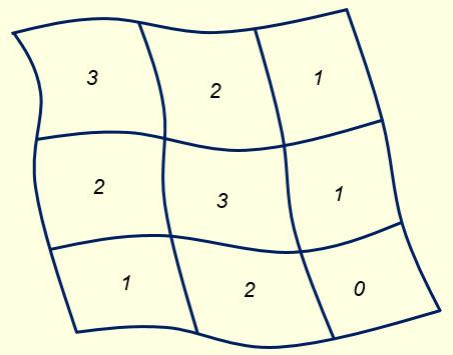
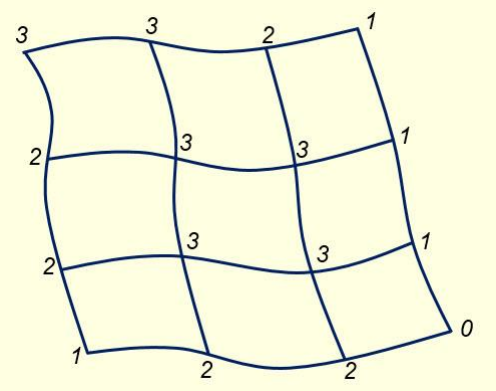
CS633 3D Computer Animation
Solution Set - HW 7 (40 points)
Due: 5/1/2018

1. Given the following control mesh of a Catmull-Clark subdivision surface, the number within each mesh face is the subdivision depth for that mesh face computed using some subdivision depth computation software. Perform adaptive subdivision on the control mesh (see slides 39-45 of the notes: "Special Models for Animationn III") so that the conformity requirement is satisfied (i.e., adjacent mesh faces share the same vertices on their shared edge) (10 points)

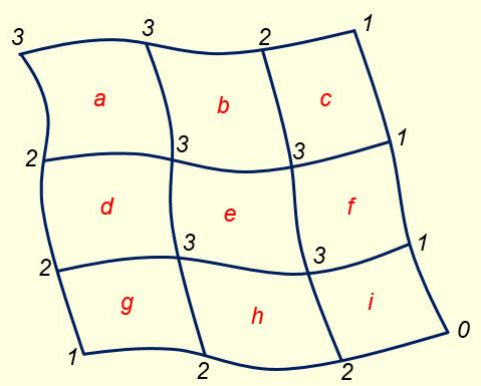


Sol:

First, we generate a label for each vertex of the control mesh, as follows:

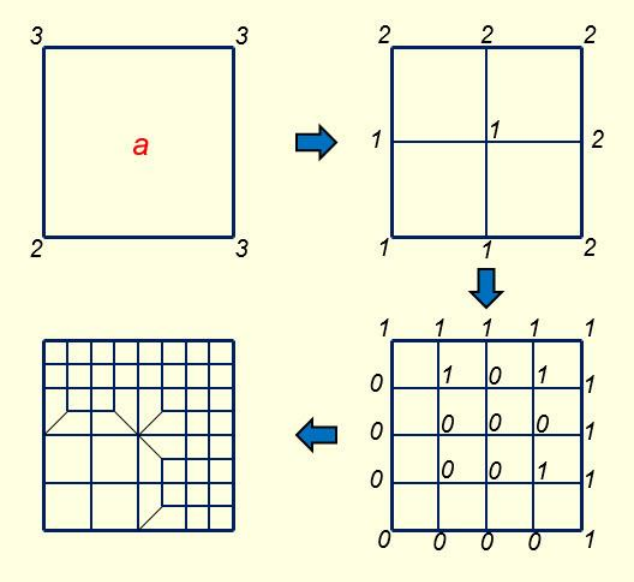


If we name the faces of the control mesh as follows:

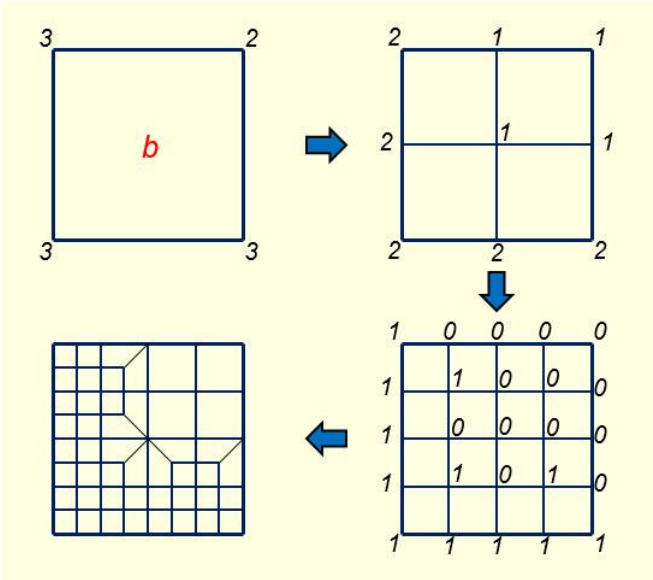


Then by performing a label-driven adaptive subdivision on face a, we get a refined mesh as

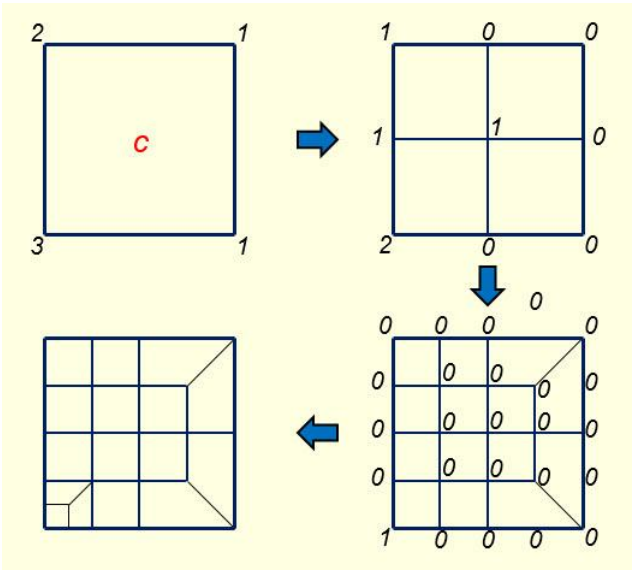
follows. For simplicity, we represent each face as a planar square here.



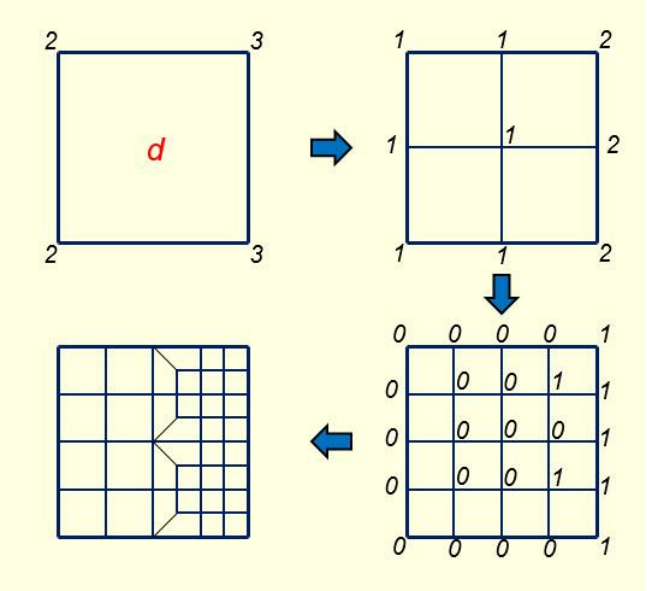
For face b, we have



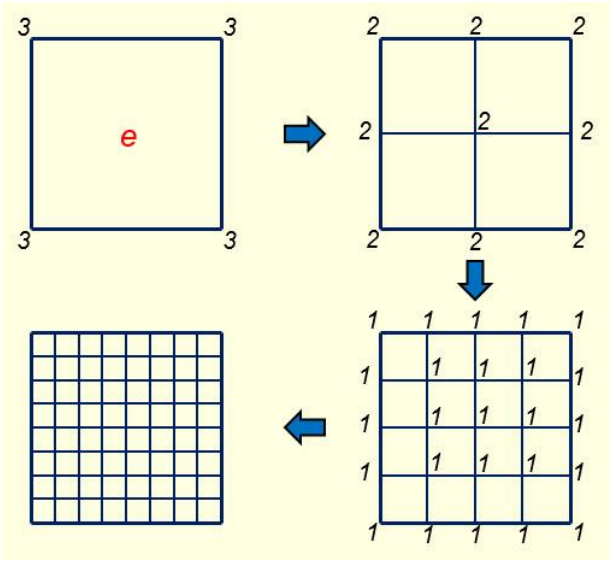
For face c, we have



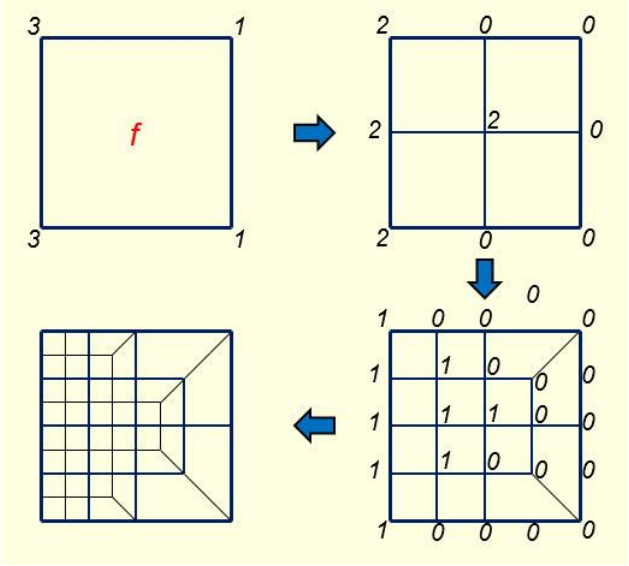
For face d, we have



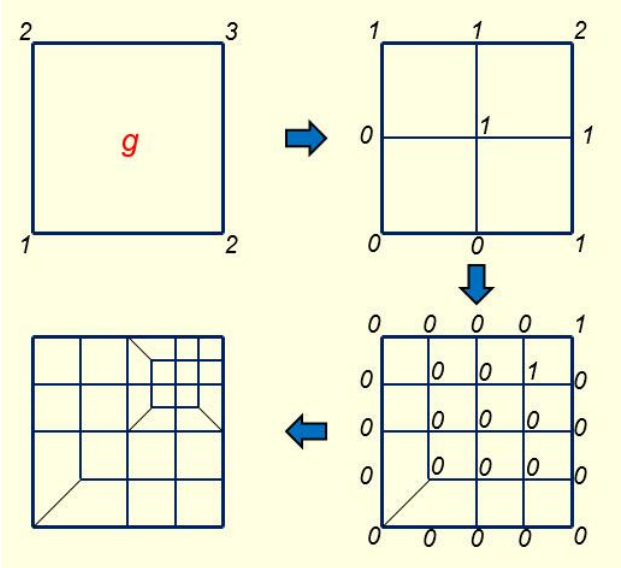
For face e, we have



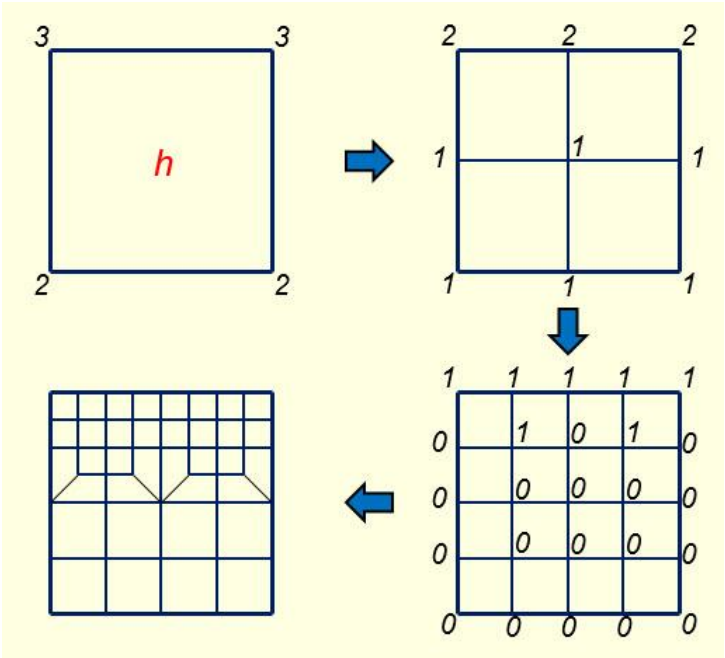
For face f, we have



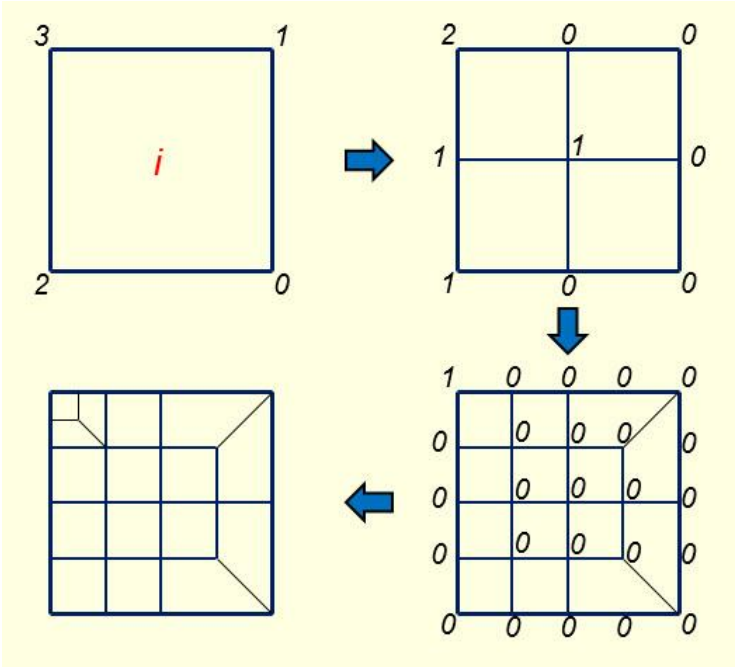
For face g, we have



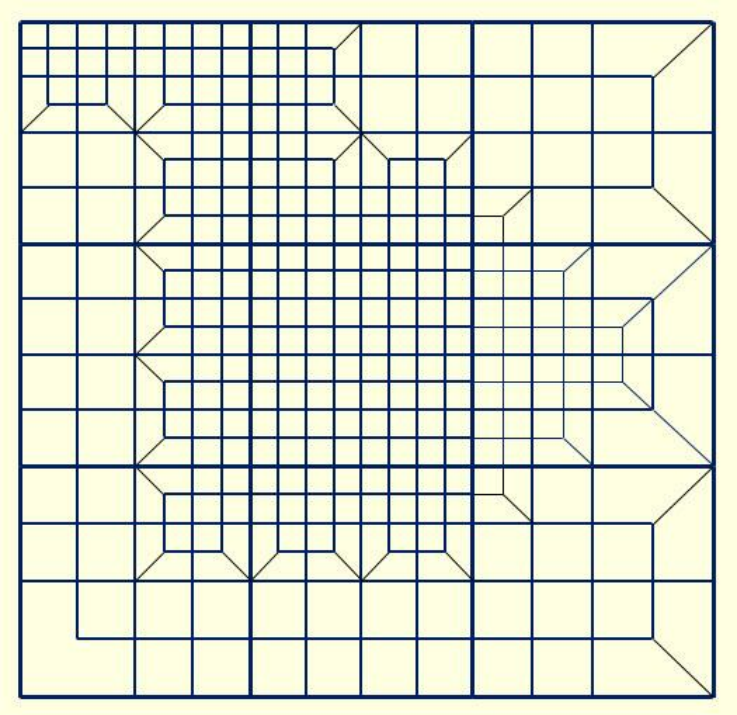
For face h, we have



For face i, we have



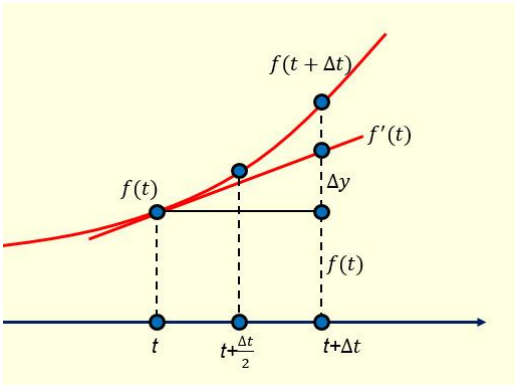
Putting these refined meshes together, we get a refined mesh for the entire control mesh:



2. On slide 14 of the notes: "Physically Based Animation I", the Midpoint Method is introduced as an option to improve the performance of the standard Euler Method (slide 11) when we try to get an estimate for the value of $X(t + \Delta t)$. Why? Justify your answer. (10 points)

Sol:

Consider the case shown in the following figure where the derivative of the function $f(t)$ is an increasing function.

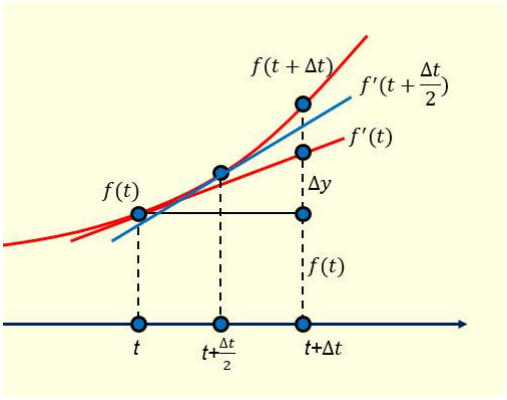


If the values of $f(t)$ and $f'(t)$ are known to us, we can use the Euler method to estimate the value of f at $t + \Delta t$ where Δt is the step size

$$f'(t + \Delta t) \approx f(t) + \Delta y$$
$$= f(t) + \Delta t * f'(t)$$

As can be seen from the above figure, this is not a good approximation of the value of $f(t + \Delta t)$

because there is a big difference between $f(t+\Delta t)$ and $f(t)+\Delta y = f(t)+\Delta t * f'(t)$. Now consider the derivative of f at the midpoint of t and $t+\Delta t$, $t+\frac{\Delta t}{2}$. Note that the slope of $f'(t+\frac{\Delta t}{2})$ is bigger than that of $f'(t)$ (see the blue line in the following figure).

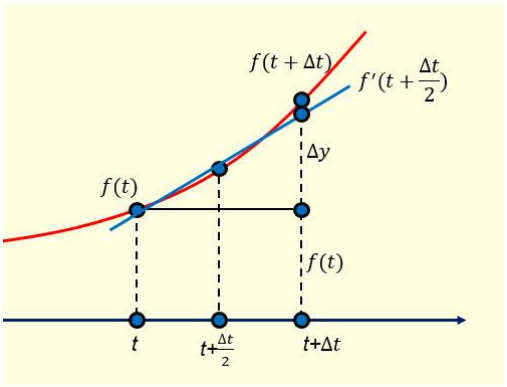


If we use $f'(t+\frac{\Delta t}{2})$, instead of $f'(t)$, to compute Δy as follows (see the following figure):

$$\Delta y = \Delta t * f'(t+\frac{\Delta t}{2})$$

we get a much better estimate of $f(t+\Delta t)$:

$$f(t+\Delta t) \approx f(t)+\Delta y$$
$$= f(t)+\Delta t * f'(t+\frac{\Delta t}{2})$$



The other cases (such as when the derivative of f is a decreasing function) can be considered similarly. This explains why we should use the Midpoint method to improve the performance of the Euler method.

3. A typical particle system's updating loop can be separated into two stages: simulation stage and rendering stage. What would usually be done in the simulation stage and which part is the most critical part of the simulation stage? (10 points)

Sol:

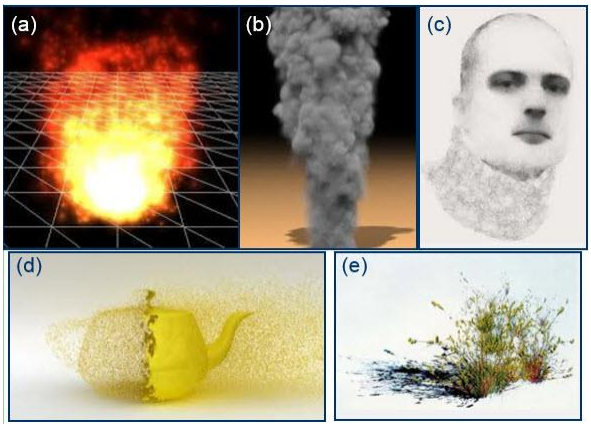
(1) Create new particles in specific positions with initialized parameters

(2) Remove particles that are no longer active and update positions and other characteristics of particles that are still active

(3) Perform interactions between particles and specified objects in the scene (such as collision detection, bouncing operation, …)

The first item is the most critical part because positions and parameters of the particles determine the functions of the particle system.

4. Particle systems can be either animated or static. Please tell in the following cases, which are animated and which are static, or mixed. (10 points)



Sol:

Animated: (a), (b)

Static: (c), (e)

Mixed: (d)