KTH Stockholm
EECS :: CST
Visualization, Autumn 2019, DD2257
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Homework assignment No. 03

Due September 19, 2019

Task 3.1: Marching Cubes **9 P**

Apply the Marching Cubes algorithm for the isovalue $c = 0$ for the cells in Figure 1 by drawing the resulting triangles of the isosurface. Indicate which of the 15 base cases shown in Figure 2 has to be used to set up the triangle connectivity. Mark the faces of the cells that result in ambiguous configurations and solve ambiguities using the *Asymptotic Decider* if necessary.

Task 3.2: Volume Data **4 P**

Given are the scalar values $f_{000}, f_{100}, \ldots, f_{111}$ at the 8 corners of a unit cube. We assume tri-linear interpolation inside the cube. Consider the isosurface $s(x, y, z) = c$ for a certain isovalue c. How many intersections (maximal number) may this surface have with a straight line $\mathbf{p}(t) = \mathbf{p}_0 + t \cdot \mathbf{r}$

(a) for an arbitrary direction vector $\mathbf{r}$. *(2 points)*

(b) for a direction vector $\mathbf{r}$ that is parallel to the x-, y-, or z-axis. *(1 point)*

(c) for a direction vector $\mathbf{r}$ that is perpendicular to the x-, y-, or z-axis. *(1 point)*

Provide a short reasoning for your findings!

Note: Exclude degenerate cases such as the direction vector lying completely inside the isosurface.

Task 3.3: Decider Correctness **4 P**

Given are the scalar values f_{00}, f_{10}, f_{01}, and f_{11} at the corners of a unit square that are interpolated in a bi-linear way. Assume that $f_{00} < c$ and $f_{11} < c$ as well as $f_{01} > c$ and $f_{10} > c$, such that this configuration yields an ambiguous case for the *Marching Squares* algorithm when applied for an isovalue c.

(a) Give the f_{ij} values of a configuration for which the *Midpoint Decider* will fail to solve the ambiguity in the unit square. *(2 points)*

(b) Give the general *formal conditions* for this decider to fail. *(2 points)*

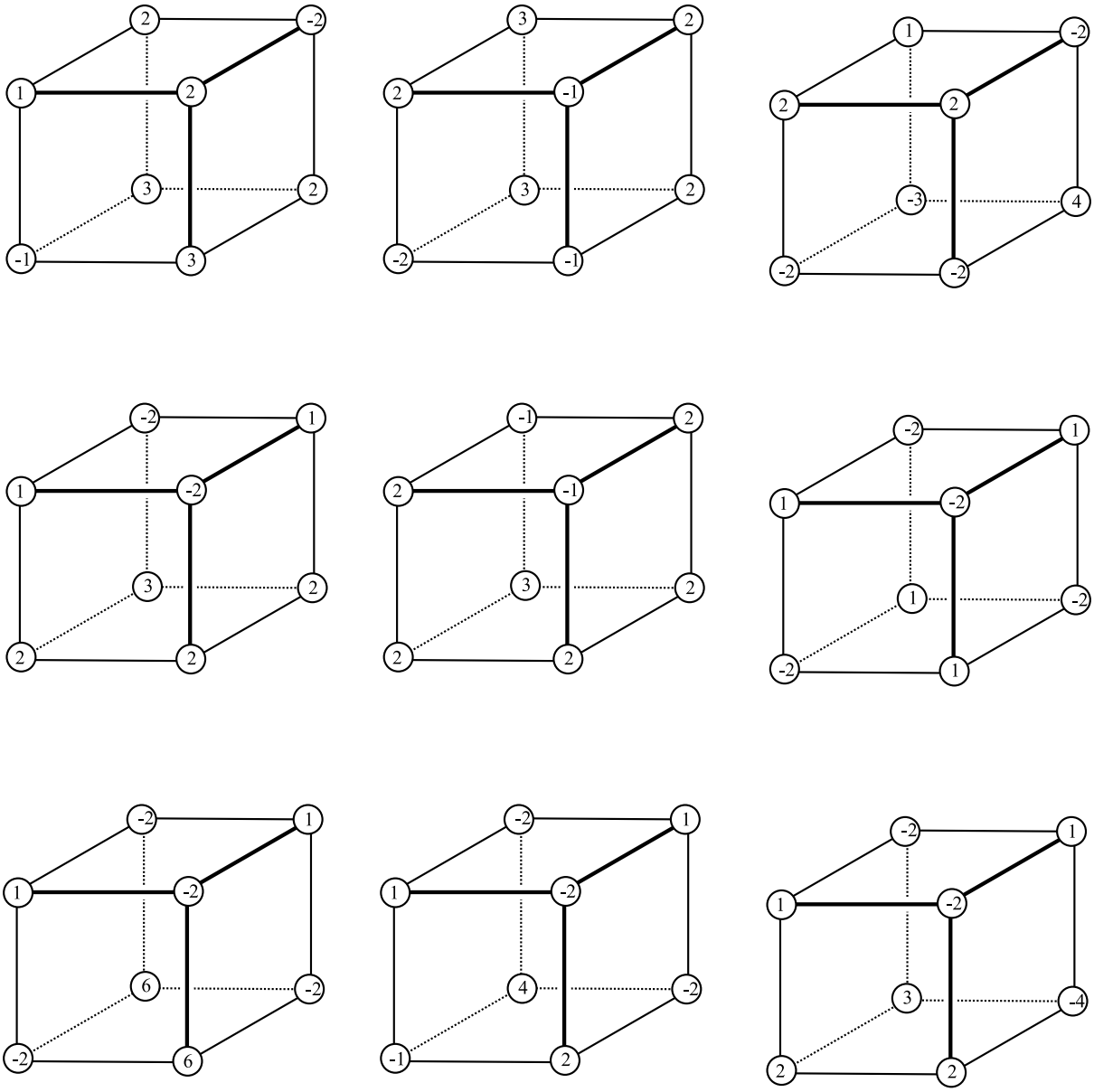

Figure 1: Cells for Task 1.

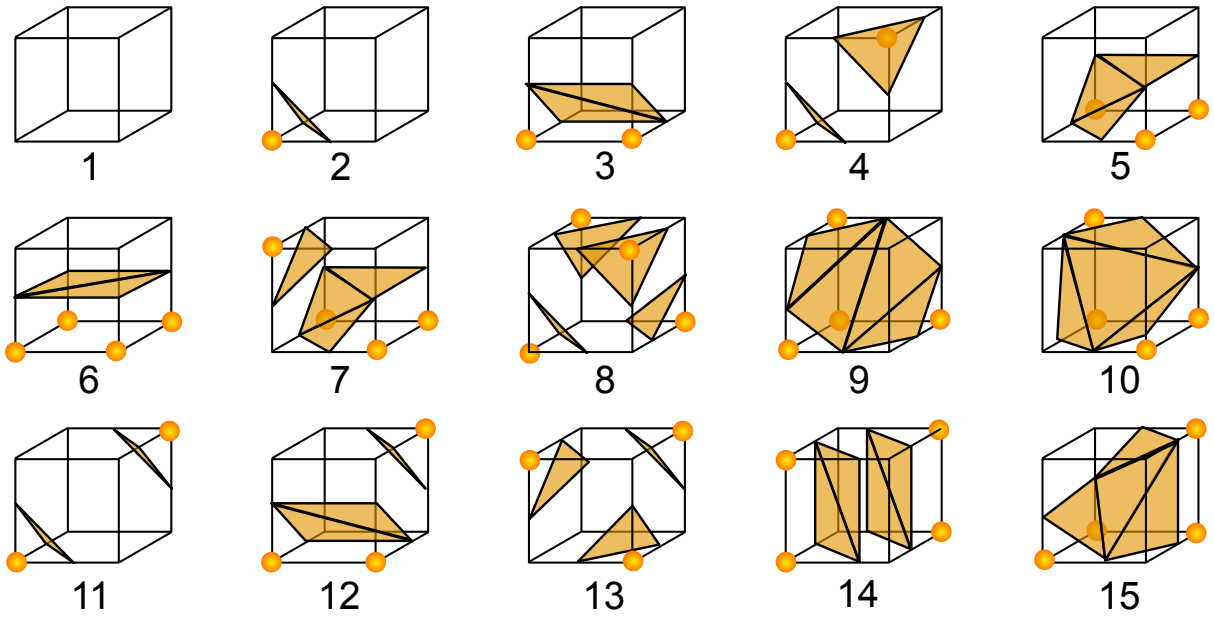

Figure 2: Marching Cubes cases for Task 1.

Task 3.4: Compositing Schemes **9 P**

A ray was shot into a scalar field and collected the following light intensity values C_i and opacity values α_i along its traversal (with increasing depth):

Index i	0	1	2	3	4	5	6	7	8
Intensity C_i	0	2	4	2	8	7	9	5	1
Opacity α_i	$\frac{1}{6}$	$\frac{1}{3}$	$\frac{1}{6}$	$\frac{1}{6}$	$\frac{1}{2}$	$\frac{1}{6}$	$\frac{1}{3}$	$\frac{1}{6}$	$\frac{1}{6}$

For each of the following compositing schemes, compute the resulting value:

(a) *First Hit* with the light intensity value $C = 7$. At which segment $[i, i+1)$ will the first hit occur? *(2 points)*

(b) *Average Intensity. (1 point)*

(c) *Maximum Intensity Projection (MIP). (1 point)*

(d) *Accumulate* with **back-to-front**. *(2 points)*

(e) *Accumulate* with **front-to-back** blending. Can *early ray termination* be applied? (Justify your answer.) If so, at which segment $[i, i+1)$ can blending be stopped? *(3 points)*