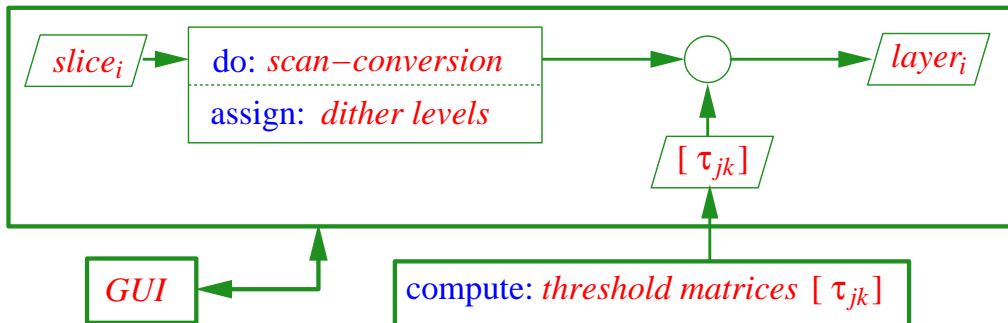


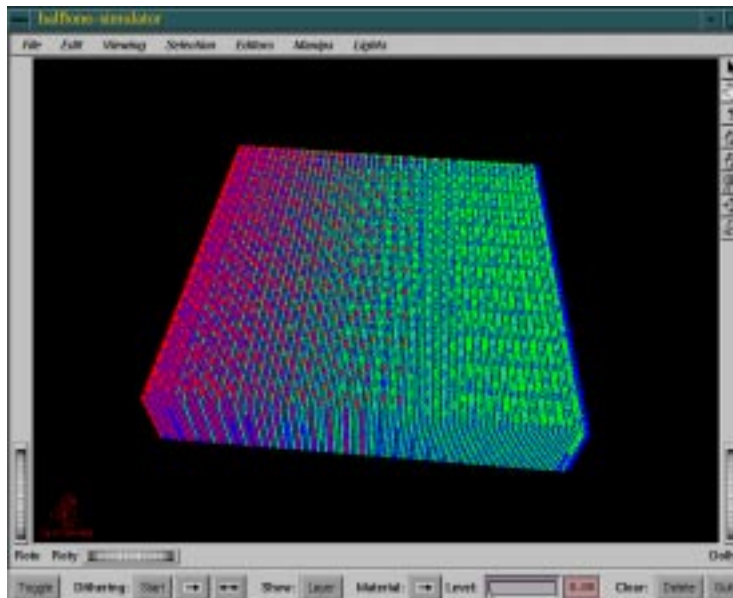
Halftoning for 3DP

Wonjoon Cho, Design Laboratory

- **Objective:** Representation of *continuous-tone* material composition in a *point-wise* fashion for 3DP
- **Approach:**



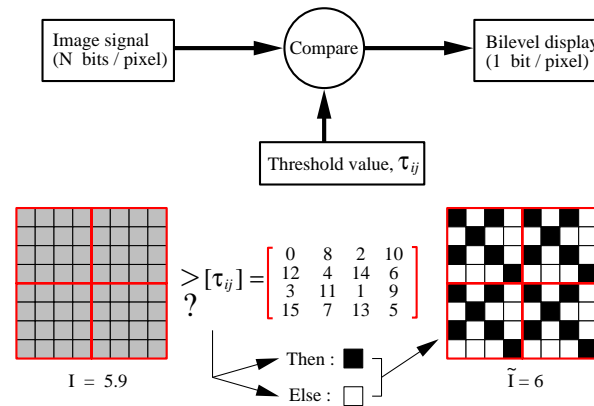
- **Result:** Simulation using *GUI*



- **Plans:** Implementation of a complete workflow

Halftoning for 3DP

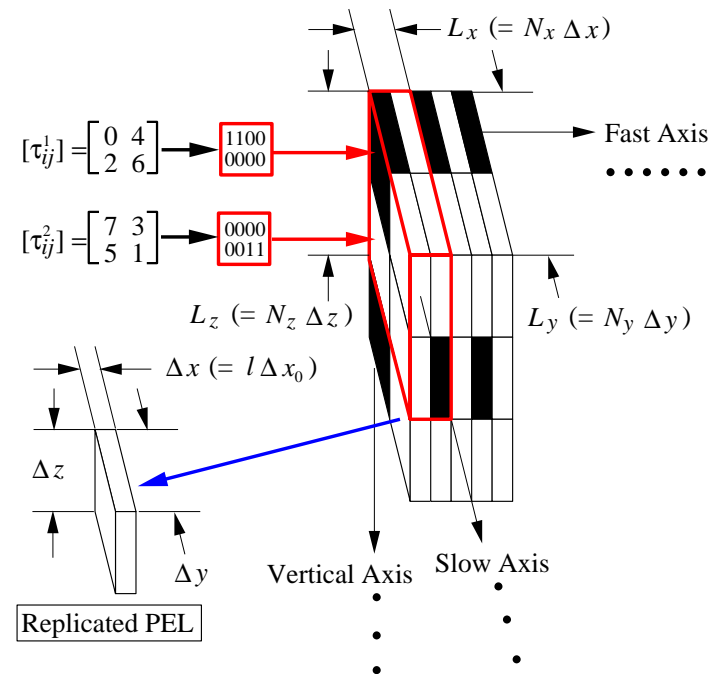
- **Objective:** Representation of *continuous-tone* material composition in a *point-wise* fashion
- **Approach:** Development of a *3D halftoning technique* for 3DP
 - Halftoning in digital image processing:



- **Issues:**
 - Minimization of *low frequency* textures in material composition
 - Minimum *run-length* requirement along the fast-axis
 - *Scan-conversion* and assignment of *dither levels*

Halftoning for 3DP

- Minimum Run-Length (l) Requirement:
 - Replication of each PEL of a halftone cell l -times along the fast-axis
- Construction of Threshold Matrices ($[\tau_{ij}]$):
 - Computation of a *sequence of droplet placement* in l -times replicated PELs of a 3D halftone cell that *minimizes* low frequency textures

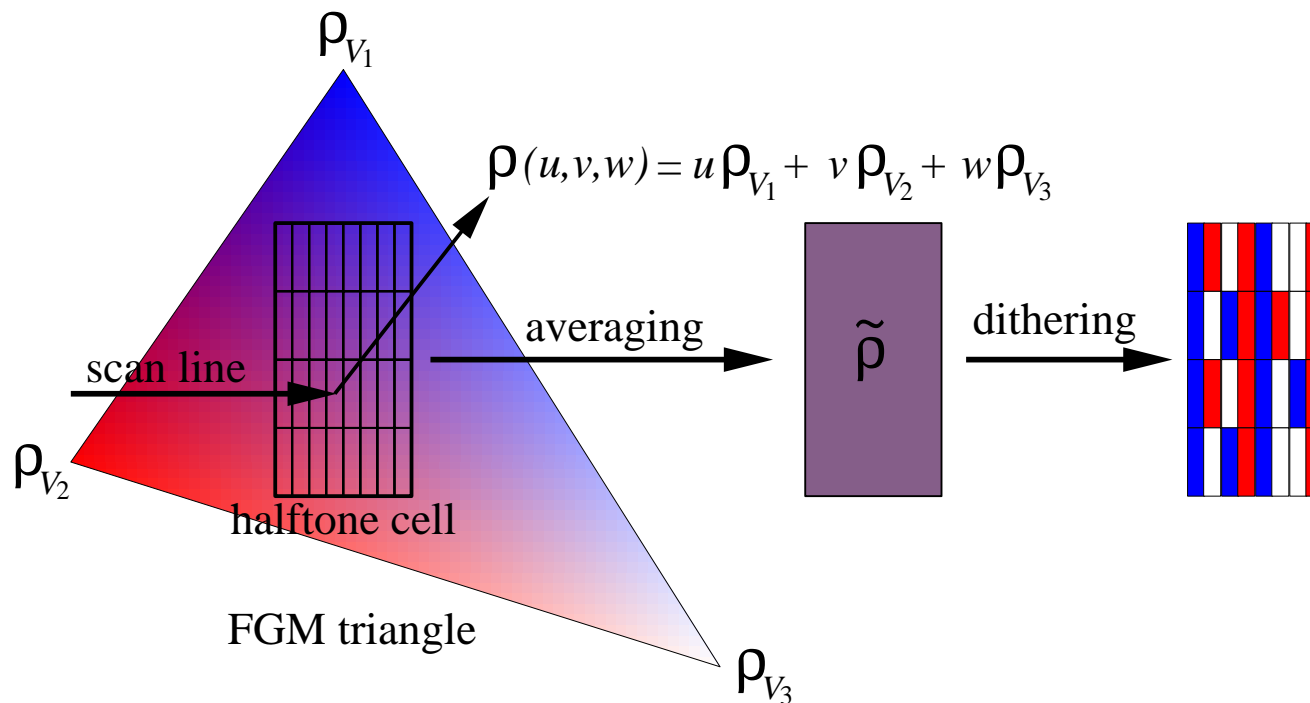


Example: A volume of uniform intensity, level 2

$$(N_x = N_y = N_z = 2, \Delta x_0 = 25\mu, \Delta y = 200\mu, \Delta z = 175\mu, l = 2)$$

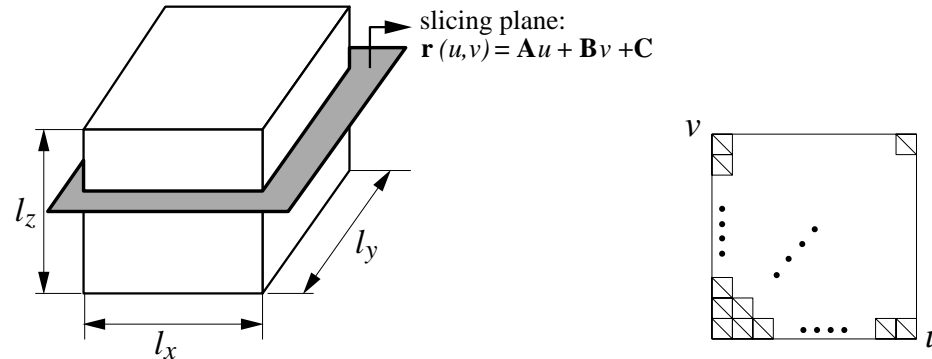
Halftoning for 3DP

- Scan-Conversion and Dithering:



Halftoning for 3DP

Implementation:



- Type of object geometry: cube
- Type of slice meshing: structured/uniform triangular
- Total number of slices (n_z): 58
- Height (l_z): ~ 1 cm.
- PEL geom: $25\mu \times 200\mu$ in the fast/slow axis-direction
- Minimum run length: 2
- Total number of materials: 3
- Dither matrices: 4 by 8

$$\begin{bmatrix} 7 & 23 & 15 & 31 & 3 & 19 & 11 & 27 \\ 1 & 17 & 9 & 25 & 5 & 21 & 13 & 29 \\ 6 & 22 & 14 & 30 & 2 & 18 & 10 & 26 \\ 0 & 16 & 8 & 24 & 4 & 20 & 12 & 28 \end{bmatrix}$$

(a) material #1 (R)

$$\begin{bmatrix} 24 & 8 & 16 & 0 & 28 & 12 & 20 & 4 \\ 30 & 14 & 22 & 6 & 26 & 10 & 18 & 2 \\ 25 & 9 & 17 & 1 & 29 & 13 & 21 & 5 \\ 31 & 15 & 23 & 7 & 27 & 11 & 19 & 3 \end{bmatrix}$$

(b) material #2 (B)

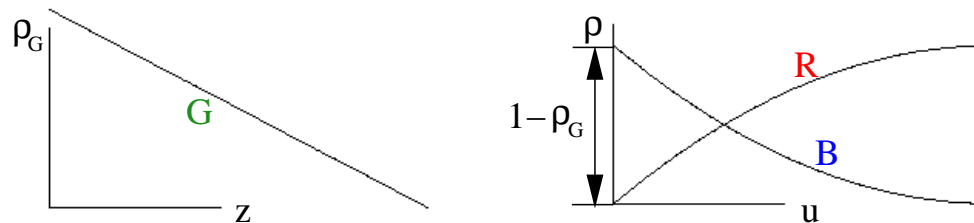
$$\begin{bmatrix} 10 & 18 & 2 & 30 & 14 & 22 & 6 & 26 \\ 13 & 21 & 5 & 25 & 9 & 17 & 1 & 29 \\ 11 & 19 & 3 & 31 & 15 & 23 & 7 & 27 \\ 12 & 20 & 4 & 24 & 8 & 16 & 0 & 28 \end{bmatrix}$$

(c) material #3 (G)

Halftoning for 3DP

Implementation (continued):

- Material composition:



Volume fraction: (a) ρ_G w.r.t. vertical axis (z); (b) ρ_R, ρ_B w.r.t. u for given ρ_G

- Result:

Case	Parameter		CPU (sec) at 180 MHz			File Size (Mbyte)	
	l_x, l_y (cm)	n_u, n_v	Step 1	Step 2	Step 3	IN	OUT
1	1×1	11×11	0.55	17.59	1.51	0.5	0.2
2	1×1	101×101	53.54	29.48	1.76	57	0.2
3	10×10	11×11	0.70	1809	170	0.5	18

(Step 1: reading slice file, 2: scan-conversion, 3: computation of dither levels and writing layers)