

# Halftoning for 3DP

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- **Objective:** Representation of (idealized) *continuous-tone* material composition in a *point-wise* fashion for 3DP in SFF process.
- **Approach:** Employment of the *halftoning technique* from digital image processing and use of *proportional deflection* capability of 3DP machine.
- **Example:**

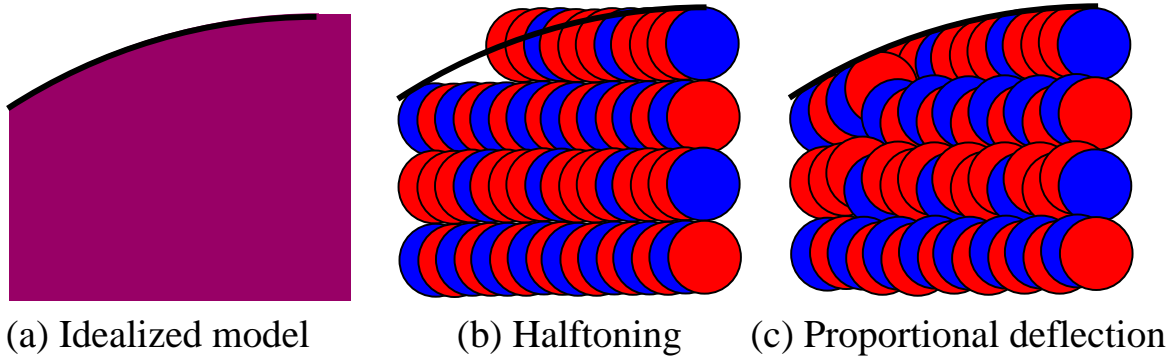


Figure: Conceptual sketch

- **Plans:** Construction of *interfaces* for data exchange, *application/analysis* of various halftoning algorithms, extension to *3D halftoning*.

## Halftone Approximation

Simulation of continuous-tone gray scales for *bilevel* displays and hardcopy devices

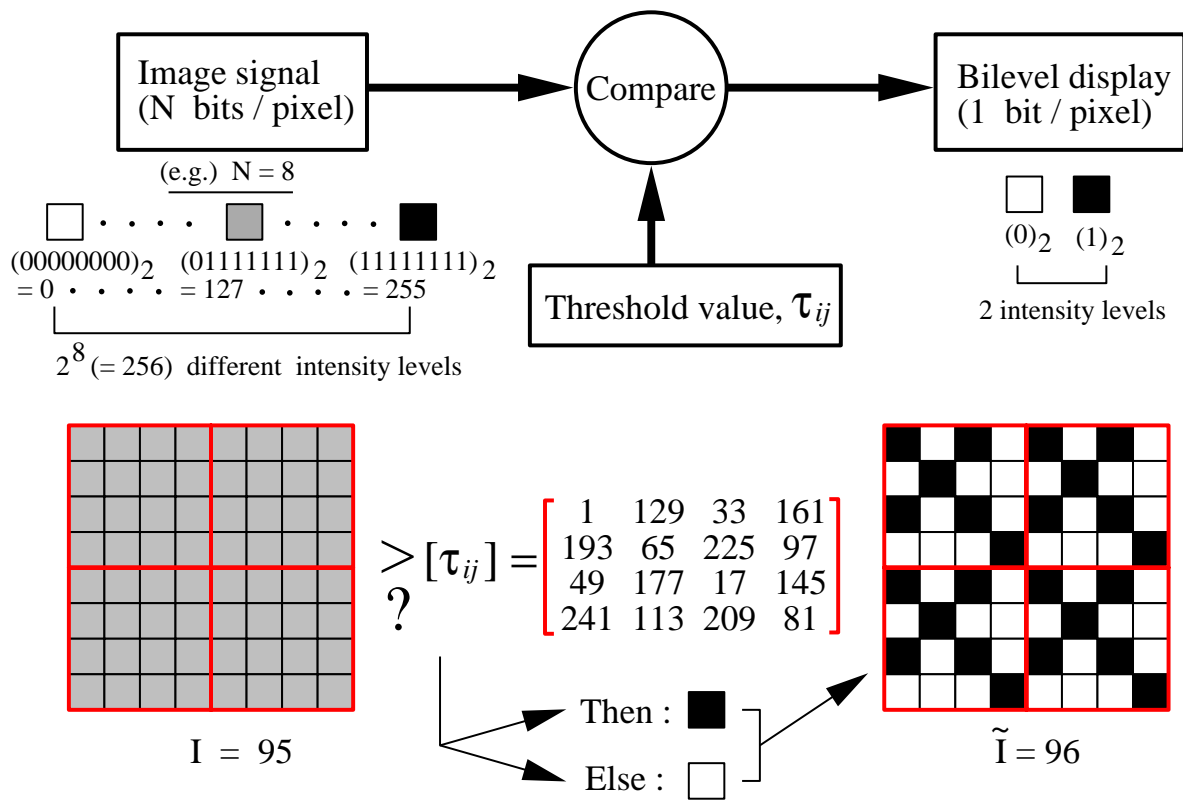
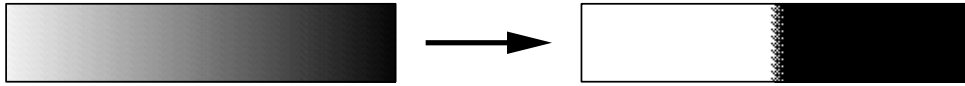


Figure: Basic halftoning process

## Halftoning Algorithms

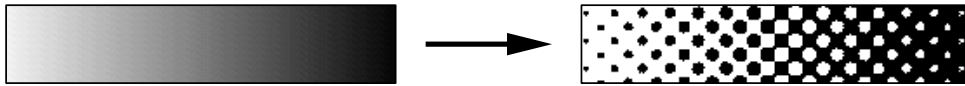
- **Simple fixed thresholding:** Pixel-by-pixel comparison with a *constant* threshold  $\tau_{ij} = \tau$ .



- **Ordered dither approach:** A set of *ordered* threshold values  $\tau_{ij}$  are used.

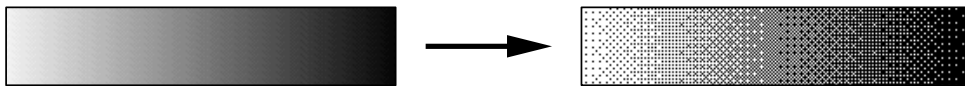
- **Clustered-dot ordered dither:**

- \* On-pixels are *adjacent* to each other.
- \* *Outward growing pattern*.

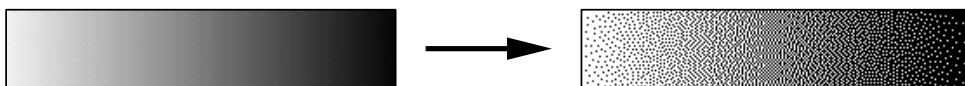


- **Dispersed-dot ordered dither:**

- \* On-pixels are *not necessarily adjacent*.
- \* Yield *high frequency* fidelity.



- **Error diffusion algorithm:** Spread halftone approximation error over neighboring pixels to *minimize the global error*.



## 3D Printing Machine

3DP machine uses *raster scan* and *continuous-jet* printing.

- **Proportional deflection:** The ability of 3DP machine to control the *landing position* of droplets along the long dimension of the PEL.

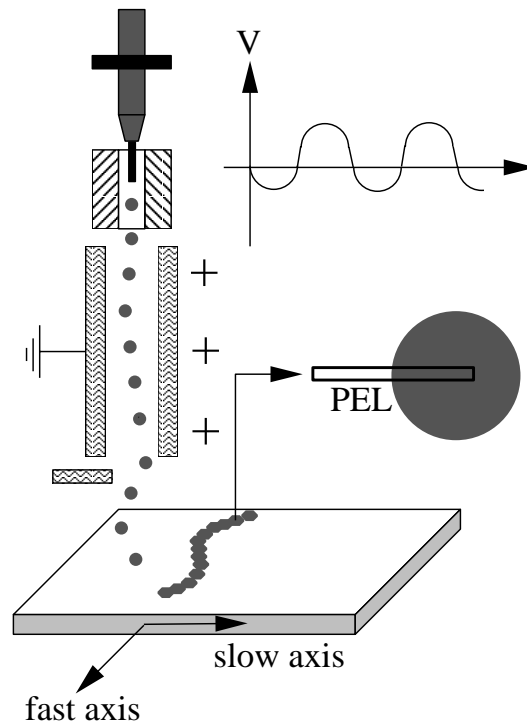
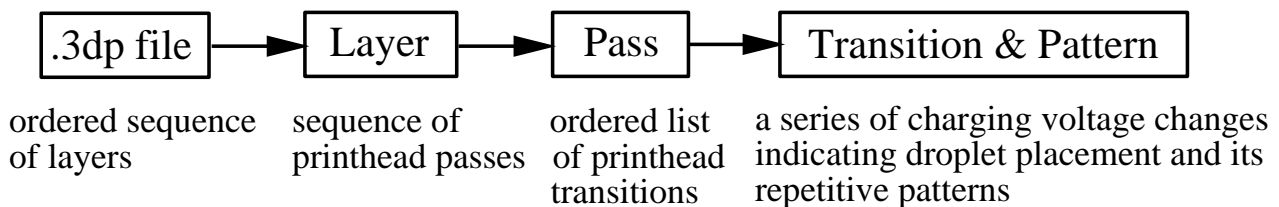


Figure: Continuous-jet printing by use of proportional deflection

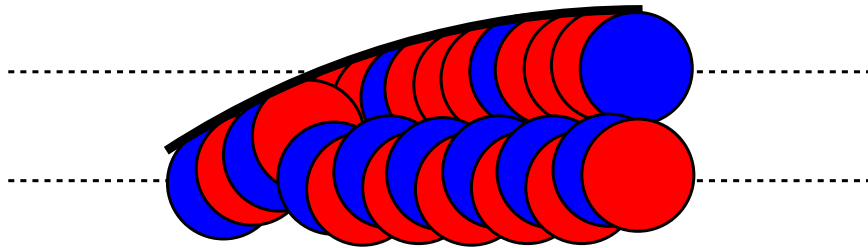
- **3DP data:**



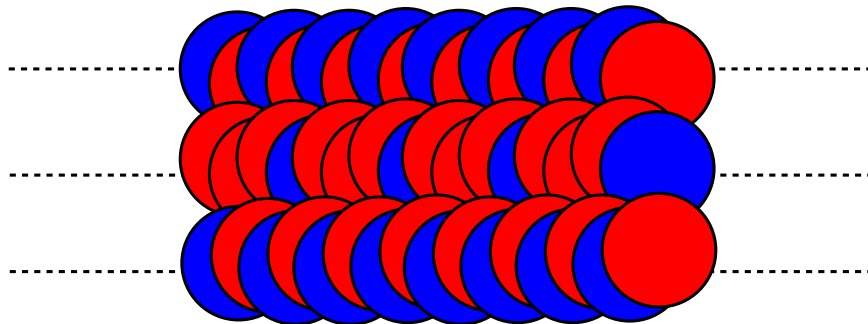
## Surface and Stitching Algorithms

These algorithms are based on the *proportional deflection* capability of 3DP machine.

- **Surface algorithm:** Boundary droplets are steered to land at the edge of the part, thereby creating a *smooth surface*.

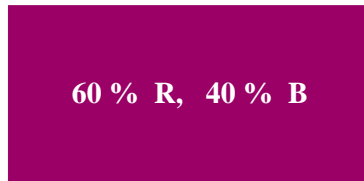


- **Stitching algorithm:** Interior droplets are stitched to maintain *strength* of the part.

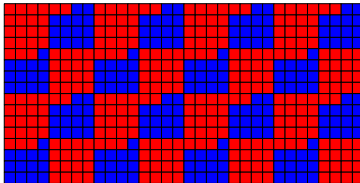
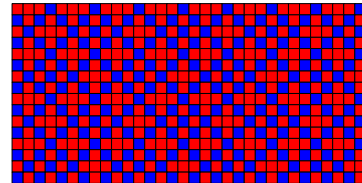


## Other Issues

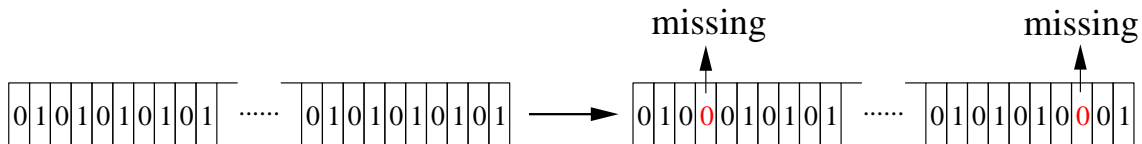
- **Uniformity:** Dither patterns that provide *high frequency* fidelity are desirable to make material distribution locally as *uniform* as possible.



(a) Idealized model

(b) Clustered-dot ordered dither  
( low frequency texture pattern )(c) Dispersed-dot ordered dither  
( high frequency fidelity )

- **Missing droplet-placement:** There is a *higher* possibility of failure in droplet-placement as the *minimum run length* along the fast-axis *diminishes*.

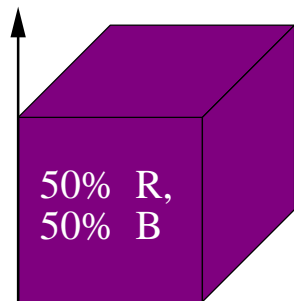


(a) User-specified pattern

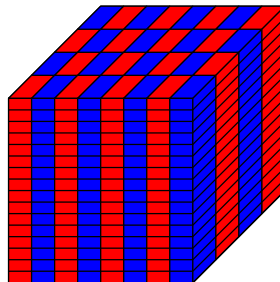
(b) Printed result

- **3D halftoning:** To prevent successive layers being printed with the same patterns so that droplets fall on top of each other when printing a volume of *constant* material intensity.

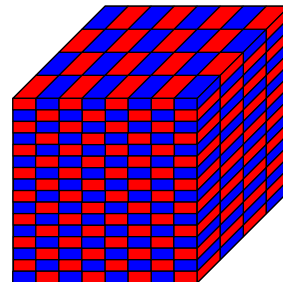
vertical axis



(a) Idealized model



(b) Replication of each layer



(c) Result by 3D halftoning