Dürer-style Halftoning

- In work with Y. Pnueli we aimed to do halftoning by attempting to imitate the methods of Engravers.

Halftoning by generating curves that have "local density" controlled by image gray level.

- Solve for the Equal Height Curves of \( H(x,y) \) that obeys

\[
\| \nabla H(x,y) \| = \sqrt{(\frac{\partial H}{\partial x})^2 + (\frac{\partial H}{\partial y})^2} = I(x,y)
\]

A bivariate function whose EHC's are locally "parallel" to have density
Low Gradient

\( H(x, y) \)

EHC's

High Gradient

\( H(x, y) \)

EHC's

Projection in Image Plane

light area \( \alpha \parallel \nabla H \parallel \)

Projection in Image Plane

dark area \( \alpha \parallel \nabla H \parallel \)
We need to solve for the ETC's of $H$ where $\|\nabla H\| = I(x,y)$

The famous EIKONAL EQUATION

In Image Analysis this was done in solving the so-called SHAPE from SHADING problem.

There are very efficient methods to do this based on advanced "Level Set Methods".

The ETC's of $H(x,y)$ are solved by tracking Level Sets of another bivariate function.
Some Results
FIG. 6. A man-made halftone artwork [14].

"Gridless Halftoning: A reincarnation of the old method"

Fig. 1 Traditional copperplate engravings: an enlargement of a modern post stamp (left) and an enlargement of a modern banknote (right).
GRIDLESS HALFTONING

FIG. 1. Early halftoning using a line printer.
FIG. 2. Halftoning with clustered ordered dither.
FIG. 5. Neural network optimized halftoning [18].
FIG. 14. DigiDürer output utilizing edge/segmentation information.
FIG. 18. Gridless halftoning with dot elements.
FIG. 15. DigiDürer output utilizing edge/segmentation information.
FIG. 16. DigiDürer output utilizing edge/segmentation information.
FIG. 25. (Art-Play-1) Image generated using a 3D equidistance curve evolution rule.
FIG. 26. (Art-Play-2) Image generated using a variable terrain 3D equidistance curve evolution rule.
Fig. 9  Examples of color engraving.