OPENING $A \circ B = (A \ominus B) \oplus B$

Erode ~~then~~ dilate.

Break narrow bridges, Eliminate THIN STRUCTURES

Closing $A \bullet B = (A \oplus B) \ominus B$

Dilate, then Erode

fuses Narrow breaks, Eliminates small Holes

MatLab → Look back at circuit diagram

```
im=imread('bwcircuit.tif');
b=strel('disk',1);
```

$$\begin{matrix} 0 & 1 & 0 \\ 1 & 1 & 1 \\ 0 & 1 & 0 \end{matrix}$$

```
out1=imerode(im,b);
```

try

```
b=strel('disk',3);
out2=imopen(im,b);
```

erosion by b, then dilation by b

(12)

```
im=imread('bwtext.tif');
b=strel('square', 2);
out=imclose(im,b);
```
dilation then erosion

→ Area is same but the Gaps are fixed

44:30

binary finger print scan

```
im=imread('bwfinger.tif');
imshow(im)
```

→ Picked white snow
  — between ridges
→ false negative inside actual print

→ erode then dilate → open image

```
b=strel('diamond',1);
```

↳
$$\begin{matrix} 0 & 1 & 0 \\ 1 & 1 & 1 \\ 0 & 1 & 0 \end{matrix}$$

```
out1=im~~erode~~open(im,b);
figure
imshow(out1)
```
→ outside noise is gone

→ We are left with gaps in object
  — want to bridge that Gap

b2 = strel('square', 3)

$$\begin{matrix} 1 & 1 & 1 \\ 1 & 1 & 1 \\ 1 & 1 & 1 \end{matrix}$$

Take result of previous guy then close that with strel b2.

out2 = imclose(out1, b2);

figure
imshow(out2) → Lines are more connected

There are many combinations of erosion and Dilation, e.g.:

Boundary Extraction: Take shape, erode by 1 pixel, subtract thinner shape from original

$$\partial A = A - A \ominus B$$

del shape "Boundary"

52:36

im = imread('lowprofile.tif');
out = imerode(im, strel('disk', 1));

white pixels in original but not in erosion

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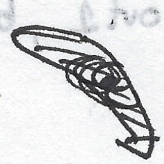
p= xor (im,out);
imshow(p);

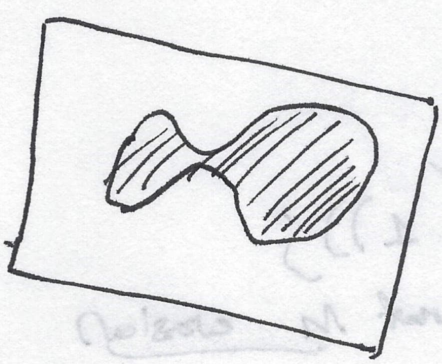
flood fill / Hole fill



dilate the pixel as long as you stay with the Region

doc morphological → list of binary operations
→ process b/w Images
→ version applied to Gray scale Images

ONE Application: Water shed Segmentation



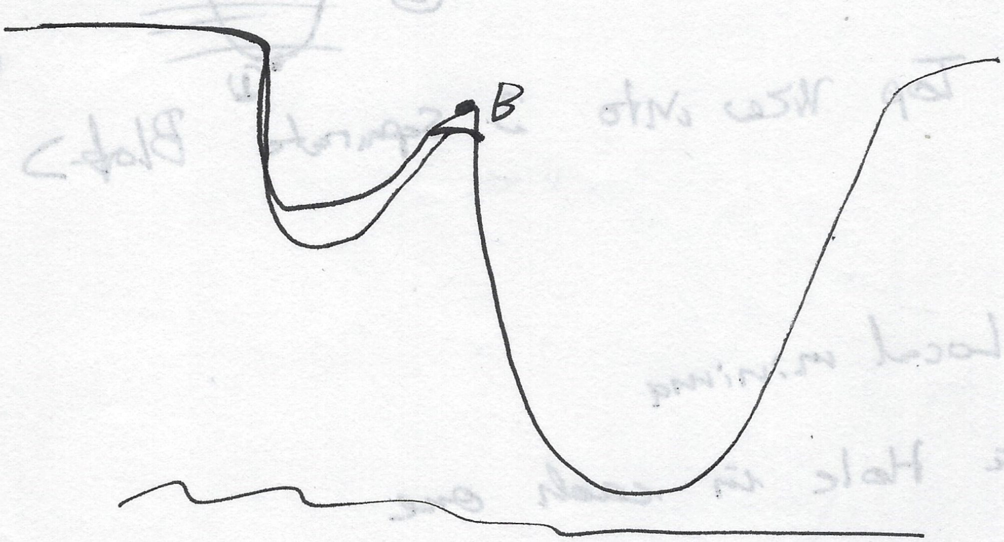
Human sees two objects
GrayScale Image
Darkish spots on a light back Ground

So: Hieght Map

Plot surface at pixel value

Think of this as a Hight map.
Watershed → how water might flow around this 3D surface

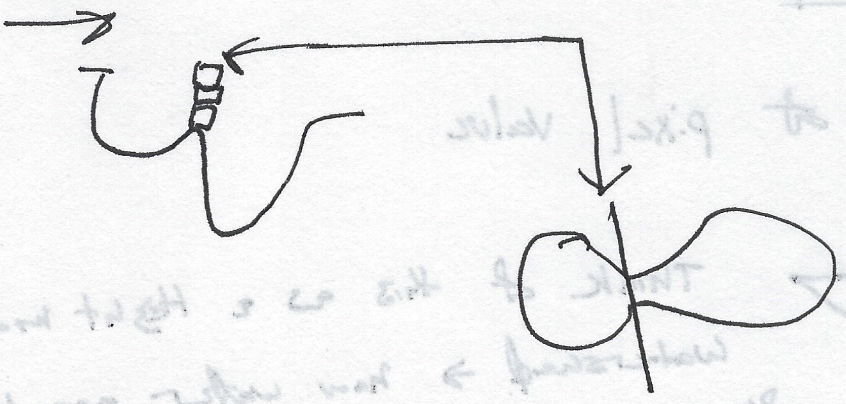
2 Basins where water would collect



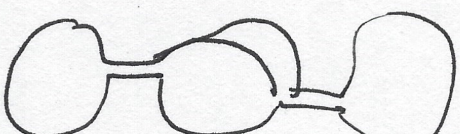
water fills
↳ hits lower ~~Bot~~ Basin first then eventually hits 2nd Basin then reaches a point where water could go into either way.
↓
B

→ Build a dam at that point to keep those two things separate → called Water Shed

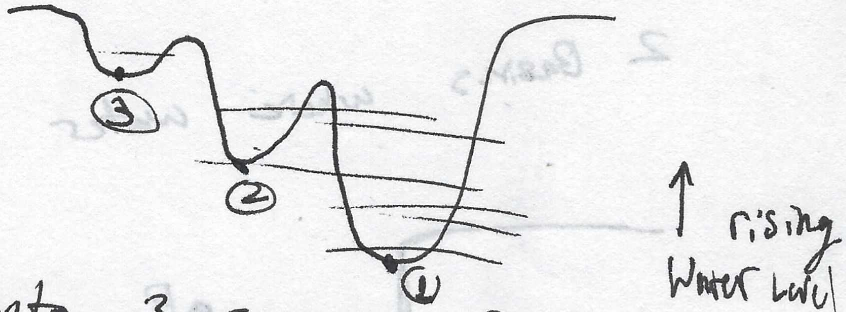
(10) Water shed



Top View



Side View



Segment Top View into 3 Separate Blobs

Rules

1.) find Local minima

2.) Punch a Hole in each one

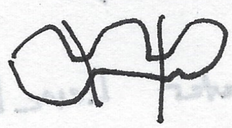
3.) Start rising the water Level from the bottom <u>one</u> unit at a time.

4.) Keep track of which points are associated with each minima.

5.) AT the moment two Basins are about to merge, Build a single-Pixel-wide "DAM" To Keep them separate.

We See, 2 and 1 will be separate after the first dam but not Yet 8 and 2

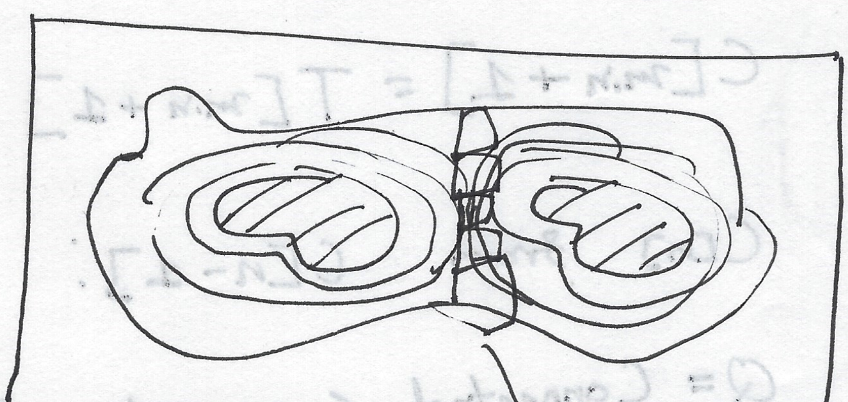
Top View



6.) After water has completely FILLED, DAMS Produce Desired Segmentation.

2D IMPLEMENTATION

1:05:30



Adding water is Like Dilating existing binary image of the basin Locations

Keep building DAM To Keep These Separate.

"FLOOD" AT Time n

$I(x, y) < n$

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Algorithm:

Let $M_1, \ldots M_R$ Be the Coordinates of the Local minima of Some Image $g(x,y)$

min, max Be $\min(g)$, $\max(g)$

Let $T[n] = \{ (x,y) \mid g(x,y) < n \}$

The points below water level n.

$C_n(M_i)$ = Set of Points in Catchment Basin of M_i at Time n.

$$C[n] = \bigcup_{i=1}^{R} C_n(M_i)$$

Initialize $C[\min + 1] = T[\min + 1]$

To compute $C[n]$ from $C[n-1]$:

1) Let Q = Connected Components of $T[n]$

2) For Each $q \in Q$, There are 3 possibilities

THe possibities

a) $q \cap C[n-1] = \emptyset$

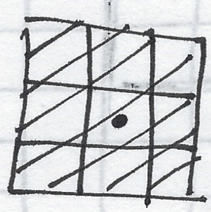
START A NEW BasiN (New minima)

b) $q \cap C[n-1]$ contains one connected component of $C[n-1]$ (Add to BasiN)

c) $q \cap C[n-1]$ contains more than one element of $C[n-1]$ (Build a DAM)

DAM - Building : Based on Morphological operatrons (DiLate)

e.g LeT B = strel



SUCCESSIVELY DiLate Each $C_{n-1}(M_i)$

By B, only consider Points In q

if DiLation would cause merging,

Build a DAM AT That PiXeL

$C[n-1]$