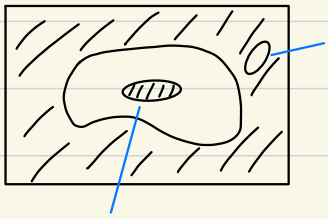
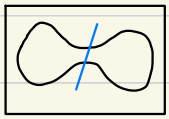
morphological image processing
operate on a binary image (e.g after thresholding)



false positive

false negative

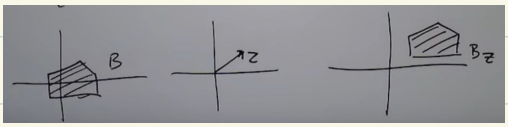


cause 2 objects to appear as 1

morphological operations take a set of pixels —produce—> set of pixels
key element: “structuring element”
a small pixel template that helps produce the new image from the old one
a set of pixels is just a list of (x,y) coordinates (integers)
simple operations on a set B:
Bz: translation of B by a vector z

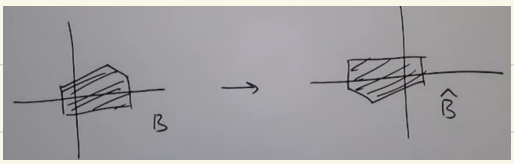
$$\{c \mid c = b + z,\ b \in B\}$$

$$= \{(x+z,\ y+z) \mid (x,y) \in B\}$$



$\hat{B}$ reflection of B

$\{c \mid c = -b,\ b \in B\} = \{(-x,-y) \mid (x,y) \in B\}$



structuring element: small binary array

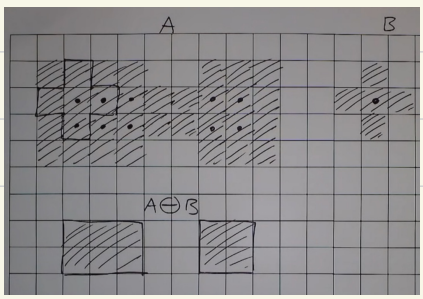
0	1	0
1	1	1
0	1	0

basic operation: erosion

$A \ominus B = \{z \mid B_z \subseteq A\}$

original set — structuring element

set of points z such that strel translate by z fits fully inside A



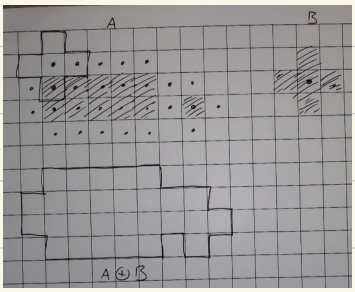
erosion removes thin lines, isolated dots, leaves gross details
“peeling away” layers

$A \ominus B \subseteq A$

dilation: kind of opposite, fatter up

$A \oplus B = \{z \mid \hat{B}_z \cap A \subseteq A\}$

find pixels such that shifted strel has <u>any</u> overlap with A



what we’d like: operator that bridge gaps/fill holes but dont change the overall size of object

<u>opening</u>: $A \circ B = (A \ominus B) \oplus B$
erode, then dilate
break narrow bridges, eliminate thin stucture

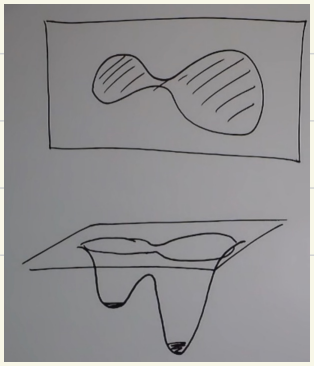
<u>closing</u>: $A \bullet B = (A \oplus B) \ominus B$
dilate, then erode
fuses narrow breaks, eliminates small holes

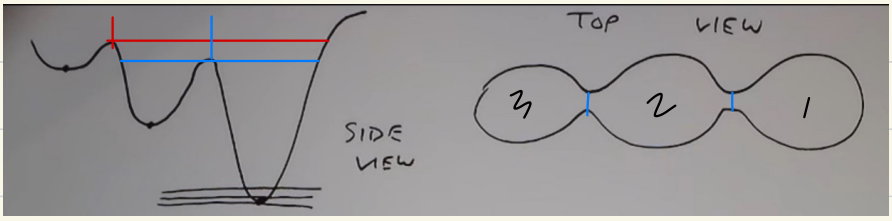
there are many combinations of erosion and dilation,
e.g boundary extraction

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

flood fill/ hole filling

one application is called watershed segmentation: grayscale image, darkish spots on a light BG. think of this as a height map





1) find local minimum
2) imagine punching a hole in each one
3) start rising the water level from the bottom, one kind of unit a time
4) keep track of which points are associated with which minimum
5) at the moment, two basins are about to merge, build a single-pixel wide “dam” to keep them separate