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Associativity

consider: is correlation / convolution commutative?

see p. 2

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why? $\underbrace{(w_x * w_y) * f}_{O(M^2N^2)}$

$\underbrace{w_x * (w_y * f)}_{O(MN^2)}$

slides 34-37

When is 2D mask separable?

see p. 3

$f\ [a\ b\ c] \quad w = [d\ e\ f]$

Not commutative

Correlation

$[a\ b\ c] \circ [d\ e\ f]$

$[a\ b\ c]$ $[a\ b\ c]$ $[a\ b\ c]$ $[a\ b\ c]$ $[a\ b\ c]$
def def $[def]$ $[def]$ def

$[af \quad ae+bf \quad ad+be+cf \quad bd+ce \quad cd]$

$[def] \circ [a\ b\ c]$

$[def]$ $[def]$ $[def]$ $[def]$ $[def]$
abc abc $[abc]$ $[abc]$ $[abc]$

$dc \quad db+ec \quad da+eb+fc \quad ea+fb \quad af]$

commutes ✓

conv. $[a\ b\ c] * [d\ e\ f]$

$[a\ b\ c]$ $[a\ b\ c]$ $[a\ b\ c]$ $[a\ b\ c]$ $[a\ b\ c]$
fed ed $[fed]$ $[fed]$ $[fed]$

$ad \quad ae+bd \quad af+be+cd \quad bf+ce \quad cf$

$[def] * [a\ b\ c]$

$[def]$ $[def]$ $[def]$ $[def]$ $[def]$
$[cba]$ cba $[cba]$ $[cba]$ $[cba]$

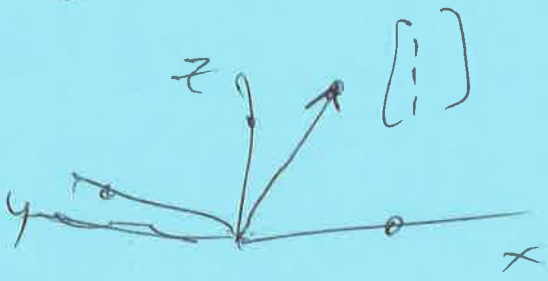
$da \quad db+ea \quad dc+eb+fa \quad ec+fb \quad fc$

W separable:

* if rank W is 1

meaning? all rows or cols are same direction.

e.g., $\begin{bmatrix} \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot \end{bmatrix}$



also, let $\bar{r}_i$ be row i vector, $\bar{c}_i$ be col i vector

then $\forall i,j \; \exists \alpha \; \bar{r}_i = \alpha \bar{r}_j$

$\exists \alpha \; \bar{c}_i = \alpha \bar{c}_j$

* then

1. Find any non-zero value in W, say $w(x,y)$
2. Let $\bar{v} = \bar{c}_y$ and $\bar{w} = \dfrac{\bar{r}_x}{w(x,y)}$

Then $W = \bar{v} * \bar{w}$

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edge

get dx, dy

get mag sqrt

get ori atan2

Hessian

get dx dy

↓ ↓

dxx dxy dyx dyy

* go to each pixel (x,y)
* form $H = \begin{bmatrix} dxx(x,y) & dxy(x,y) \\ dyx(x,y) & dyy(x,y) \end{bmatrix}$

* get eigenvals $[V, D] = eigs(H)$

D(1,1) → channel 1

D(2,2) → channel 2

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LoG

create_im

LoG =
LoG2 =
surf(LoG)
surf(LoG2)
surf(abs(LoG - LoG2))

G5 =
G2 =
surf(G5 - G2)

Lap G

use create_im with LoG
conv2

im =
im(=
[imLapG, im≠c] =
surf(imLapG - -
~~im22 =~~ . . .
combo(mat2gray(imLapG), im≠c)

ZC

~~compute ZC~~ mask
∀ pixel: if 8 neighbors have
neg & pos values → set to 1

median

$\forall$ x,y pixel

get 5x5 window W

compute median of W → output pixel value