Final Project
Panorama Stitching

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Spring 2020

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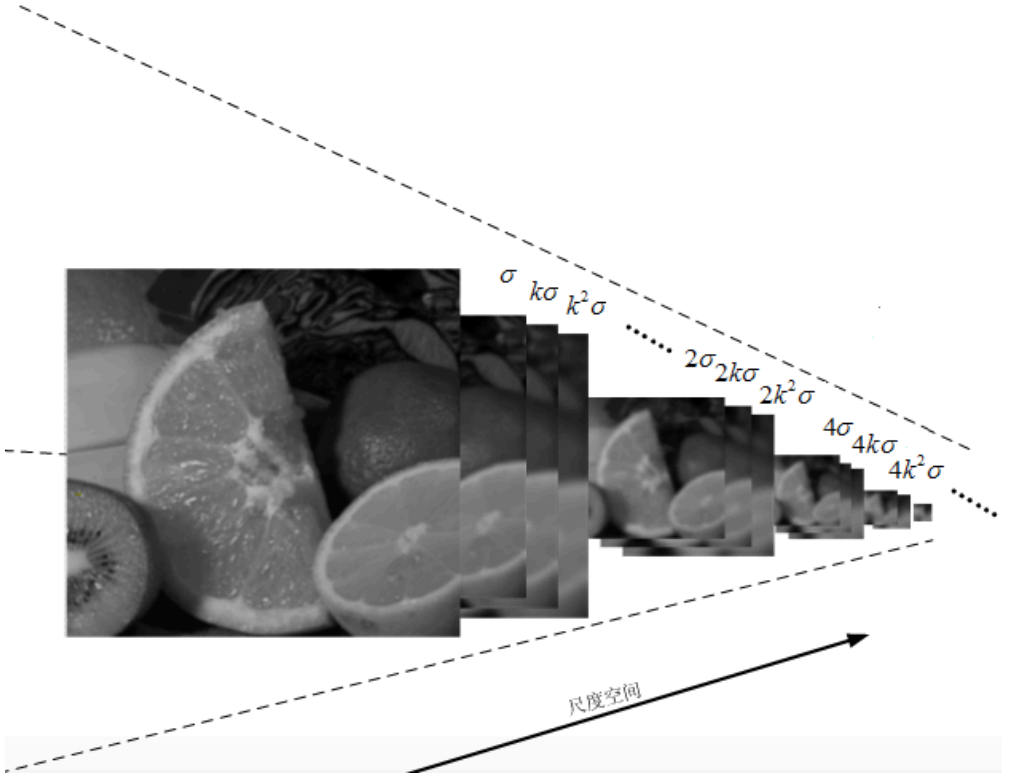
SIFT Basic process

1. Scale Space and Image Pyramids
2. Localizing Extrema
3. Generating Orientations and Descriptors

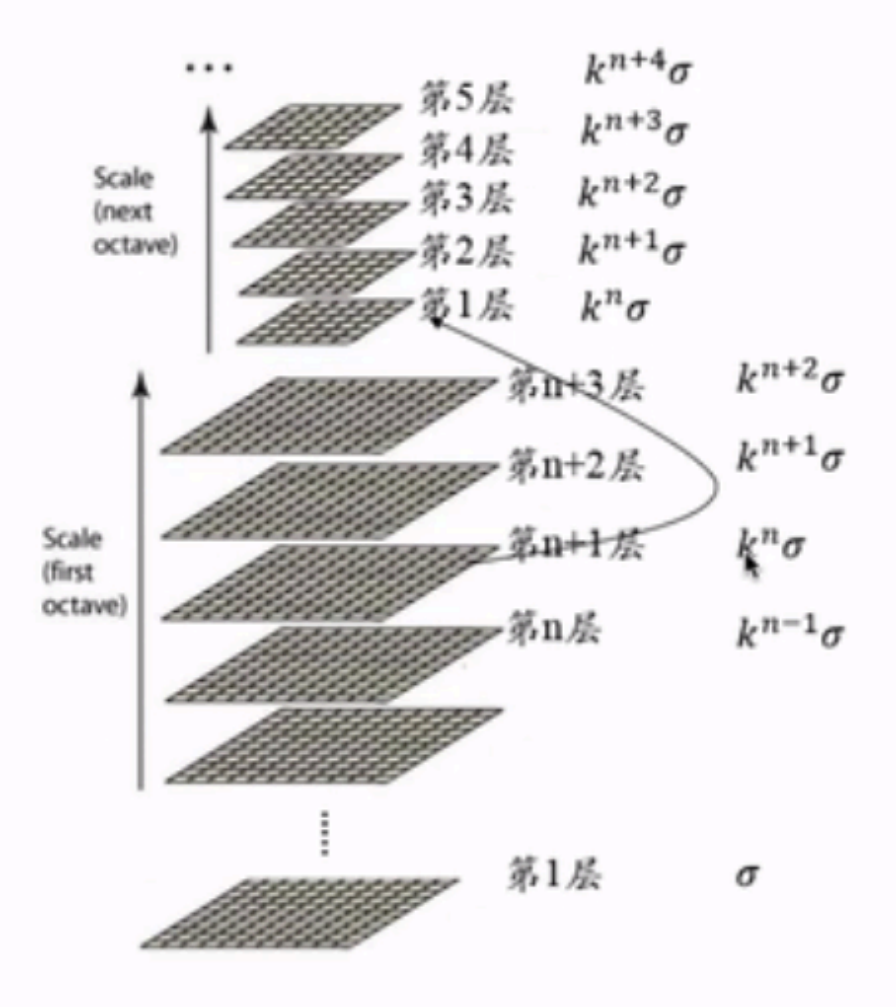
SIFT —— Scale Space & Image Pyramids

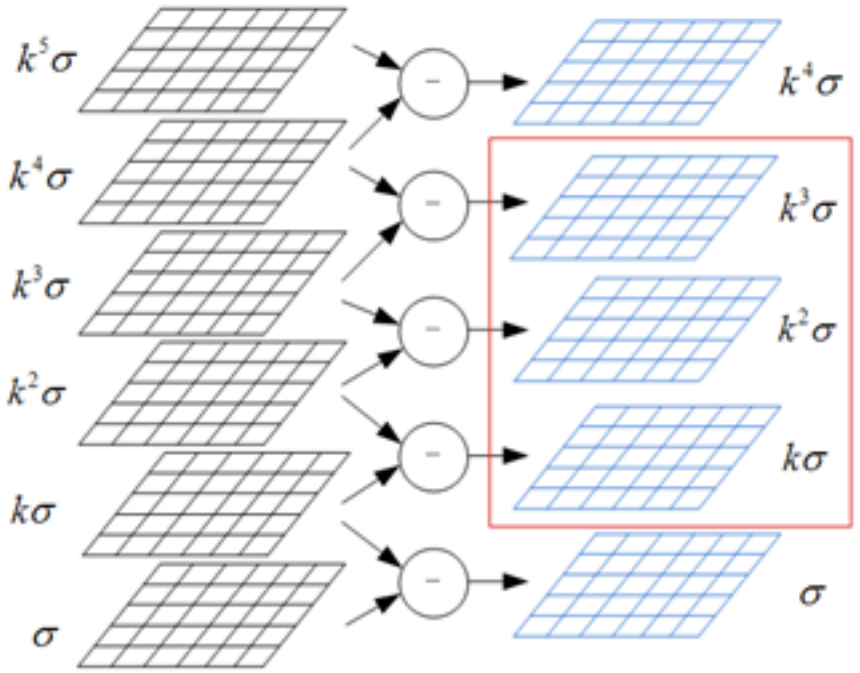
The Gaussian pyramid imitates different scales of the image --"the depth of the image"

The problem solved by the scale space of the image is how to describe the image at all scales.

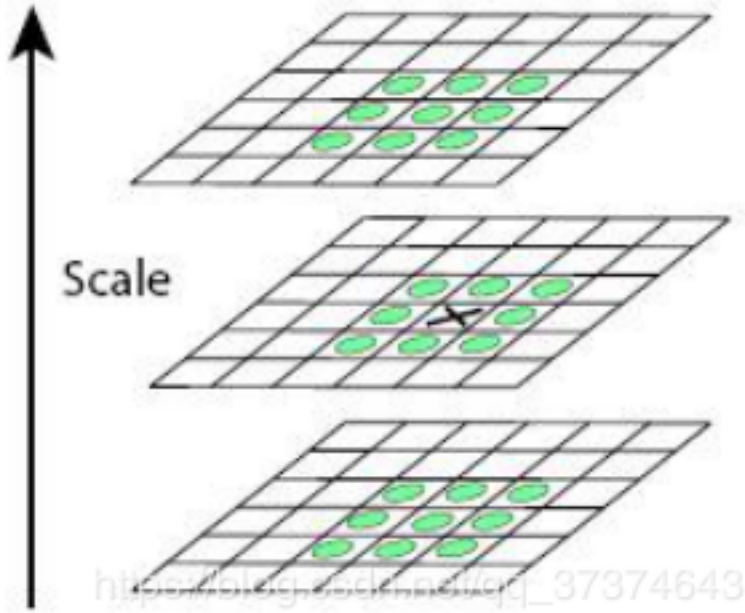


SIFT —— Scale Space & Image Pyramids



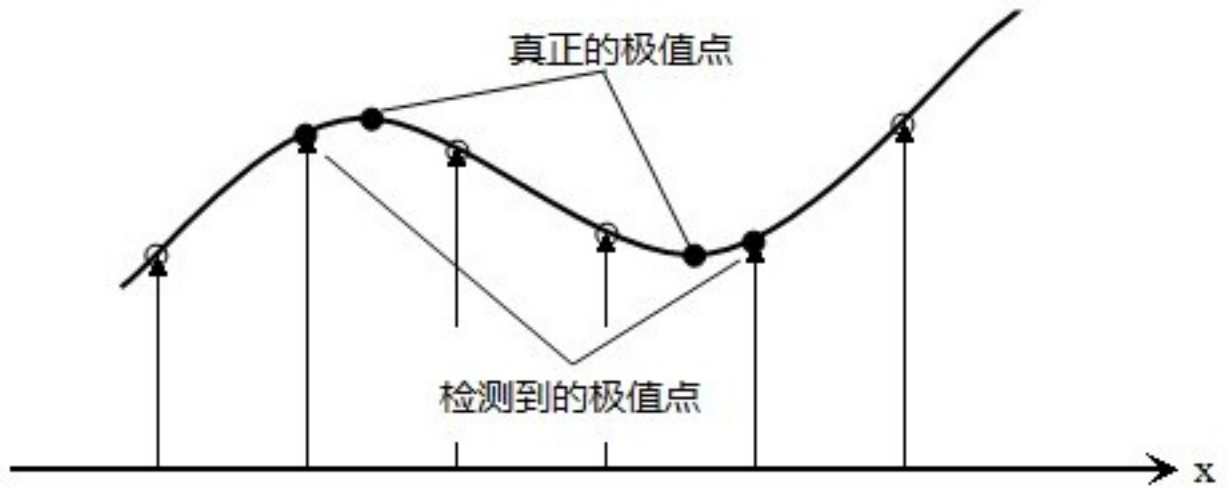


SIFT —— Localizing Extrema



SIFT —— Localizing Extrema

Sub-pixel interpolation

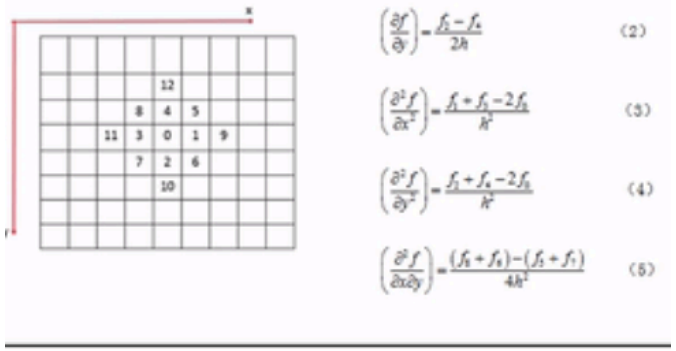


SIFT —— Localizing Extrema

Sub-pixel interpolation

$$D(\Delta x, \Delta y, \Delta\sigma) = D(x, y, \sigma) + \begin{bmatrix} \frac{\partial D}{x} & \frac{\partial D}{y} & \frac{\partial D}{\sigma} \end{bmatrix} \begin{bmatrix} \Delta x \\ \Delta y \\ \Delta\sigma \end{bmatrix} + \frac{1}{2} \begin{bmatrix} \Delta x & \Delta y & \Delta\sigma \end{bmatrix} \begin{bmatrix} \frac{\partial^2 D}{\partial x^2} & \frac{\partial^2 D}{\partial x \partial y} & \frac{\partial^2 D}{\partial x \partial \sigma} \\ \frac{\partial^2 D}{\partial y \partial x} & \frac{\partial^2 D}{\partial y^2} & \frac{\partial^2 D}{\partial y \partial \sigma} \\ \frac{\partial^2 D}{\partial \sigma \partial x} & \frac{\partial^2 D}{\partial \sigma \partial y} & \frac{\partial^2 D}{\partial \sigma^2} \end{bmatrix} \begin{bmatrix} \Delta x \\ \Delta y \\ \Delta\sigma \end{bmatrix}$$

附：有限差分求导法



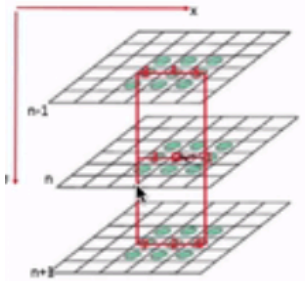
$$\left(\frac{\partial f}{\partial x}\right) = \frac{f_1 - f_3}{2h} \quad (1)$$

$$\left(\frac{\partial f}{\partial y}\right) = \frac{f_2 - f_4}{2h} \quad (2)$$

$$\left(\frac{\partial^2 f}{\partial x^2}\right) = \frac{f_1 + f_3 - 2f_0}{h^2} \quad (3)$$

$$\left(\frac{\partial^2 f}{\partial y^2}\right) = \frac{f_2 + f_4 - 2f_0}{h^2} \quad (4)$$

$$\left(\frac{\partial^2 f}{\partial x \partial y}\right) = \frac{(f_1 + f_4) - (f_2 + f_3)}{4h^2} \quad (5)$$



$$\left(\frac{\partial f}{\partial \sigma}\right) = \frac{f_5 - f_6}{2h} \quad (6)$$

$$\left(\frac{\partial^2 f}{\partial \sigma^2}\right) = \frac{f_5 + f_6 - 2f_0}{h^2} \quad (7)$$

$$\left(\frac{\partial^2 f}{\partial x \partial \sigma}\right) = \frac{(f_1 + f_4) - (f_5 + f_7)}{4h^2} \quad (8)$$

$$D(x) = D + \frac{\partial D^T}{\partial x}\Delta x + \frac{1}{2}\Delta x^T \frac{\partial^2 D^T}{\partial x^2}\Delta x$$

Derivation, substitution, iterative process to get new expression

SIFT —— Localizing Extrema

Edge effect removal

A flat DoG response peak tends to have a larger main curvature across the edge and a smaller main curvature in the direction of the vertical edge.

$$H(x, y) = \begin{bmatrix} D_{xx}(x, y) & D_{xy}(x, y) \\ D_{xy}(x, y) & D_{yy}(x, y) \end{bmatrix}$$

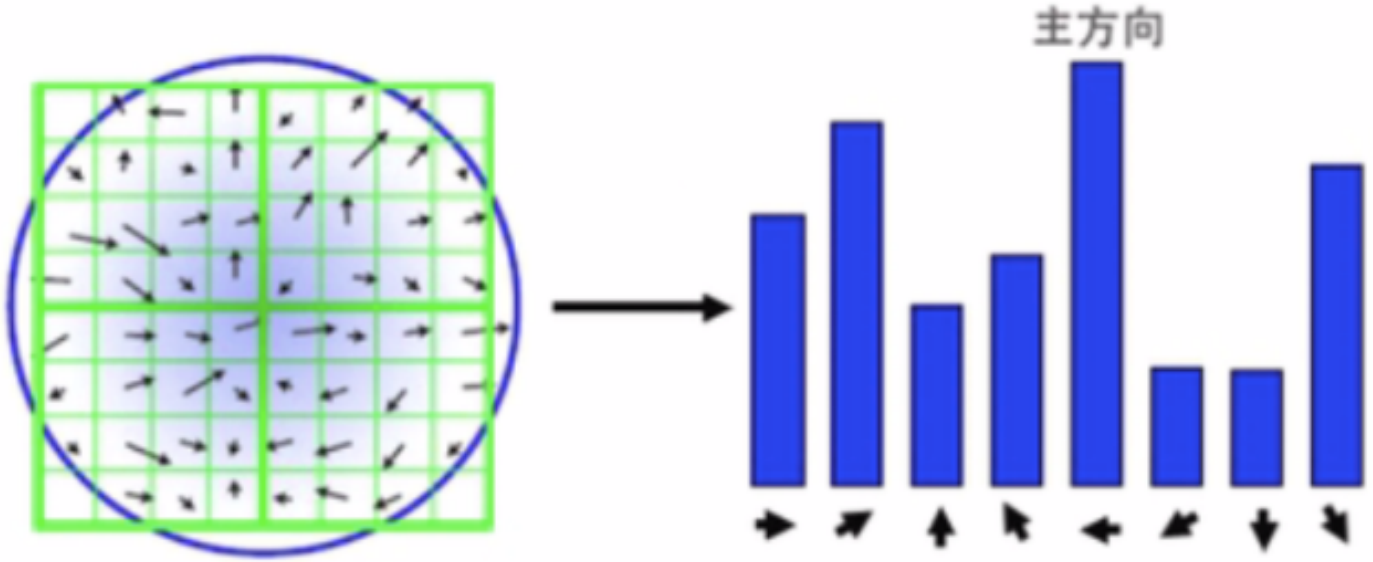
$$Tr(H) = D_{xx} + D_{yy} = \alpha + \beta$$

$$Det(H) = D_{xx}D_{yy} - (D_{xy})^2 = \alpha\beta$$

$$\frac{Tr(H)^2}{Det(H)} = \frac{(\alpha + \beta)^2}{\alpha\beta} = \frac{(\gamma + 1)^2}{\gamma}$$

$$\frac{Tr(H)^2}{Det(H)} < \frac{(\gamma + 1)^2}{\gamma}$$

SIFT —— Generating Orientations & Descriptors



$$m(x,y)=\sqrt{\left(L(x+1,y)-L(x-1,y)\right)^2+\left(L(x,y+1)-L(x,y-1)\right)^2}$$

$$\theta(x,y)=\tan^{-1}\left(\left(L(x,y+1)-L(x,y-1)\right)/\left(L(x+1,y)-L(x-1,y)\right)\right)$$

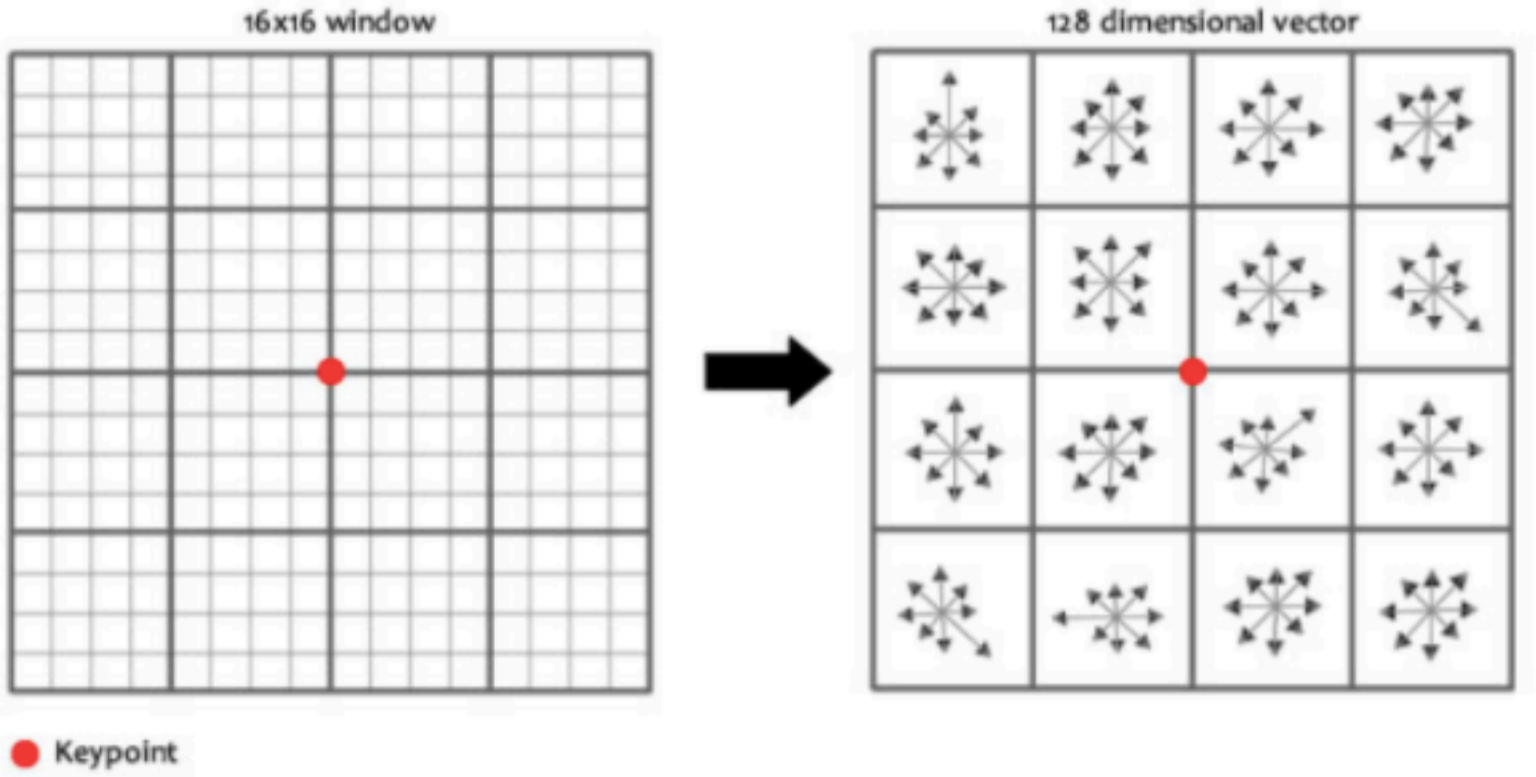
Robustness requirements:

- Secondary direction

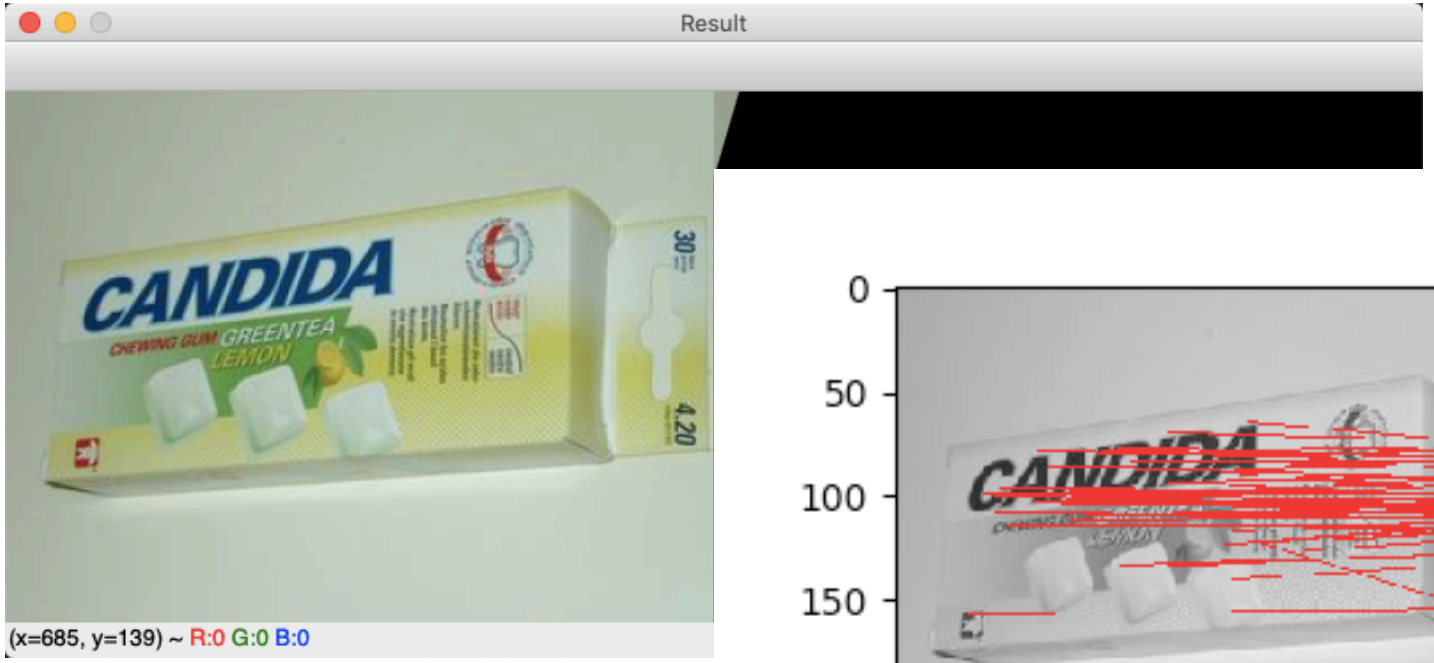
- Smoothing

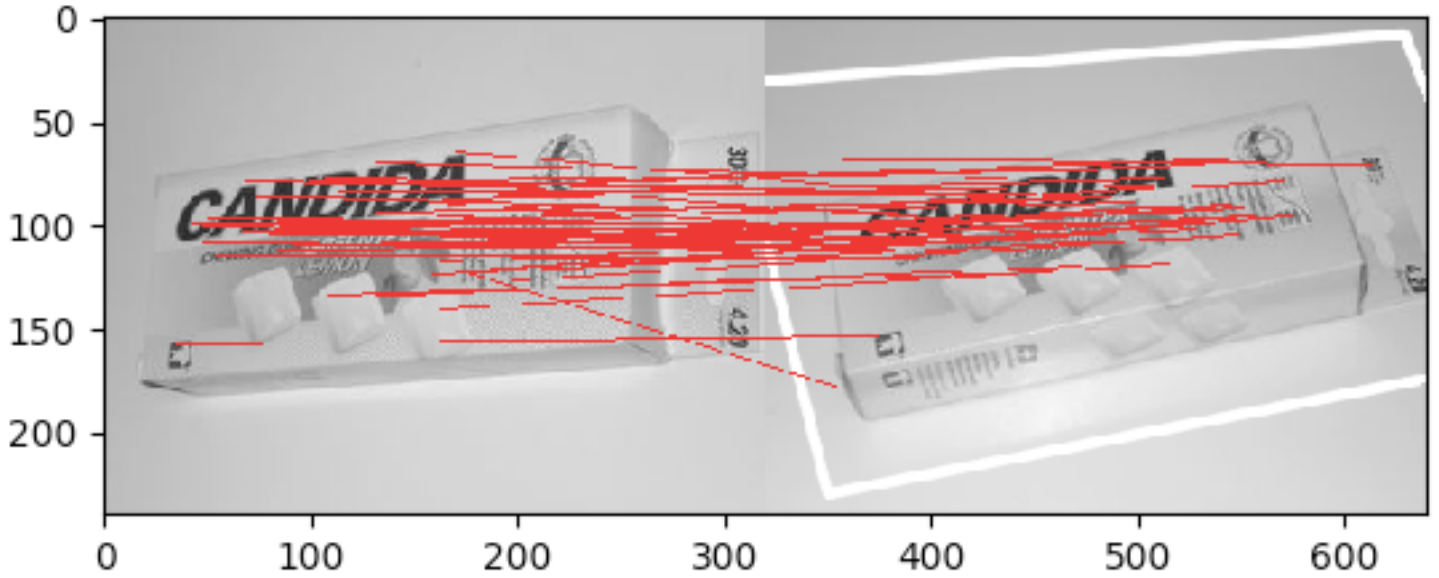
SIFT —— Generating Orientations & Descriptors

对每个关键点使用4 × 4共16个种子点来描述，这样一个关键点就可以产生128维的SIFT特征向量。



SIFT —— Result


Result
CANDIDA
CHEWING GUM GREENTEA LEMON
(x=685, y=139) ~ R:0 G:0 B:0


0
50
100
150
200
0
100
200
300
400
500
600