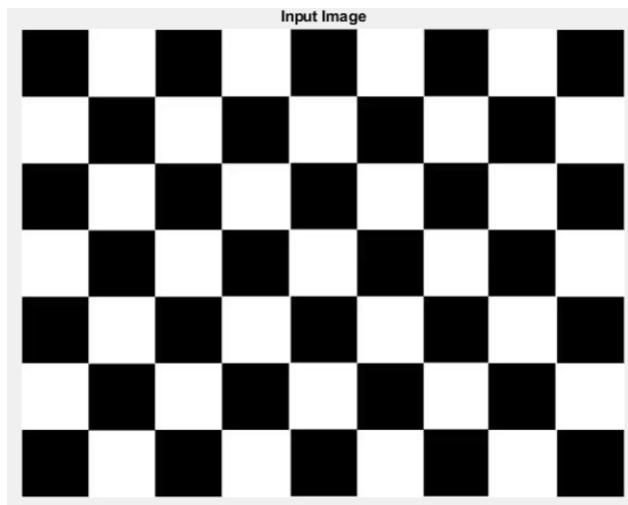


**ECE 415 - Computer Vision I**  
**Name: Pavan Kumar Srikanth Naik**  
**UIN: 669940624**  
**Homework 7**

**Problem 1)**

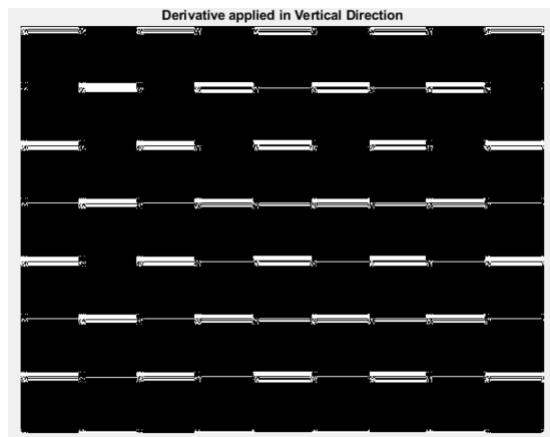
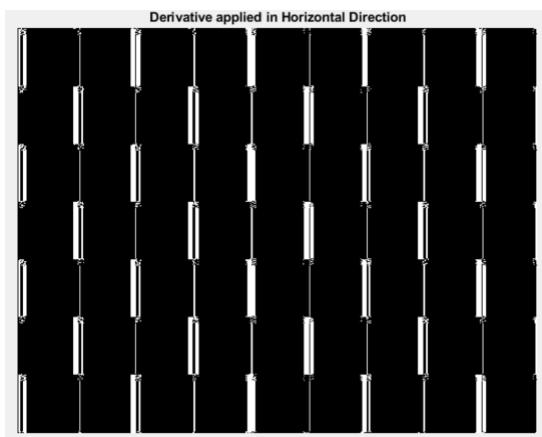
**“Checkerboard.jpg”**

**1). The input image is**

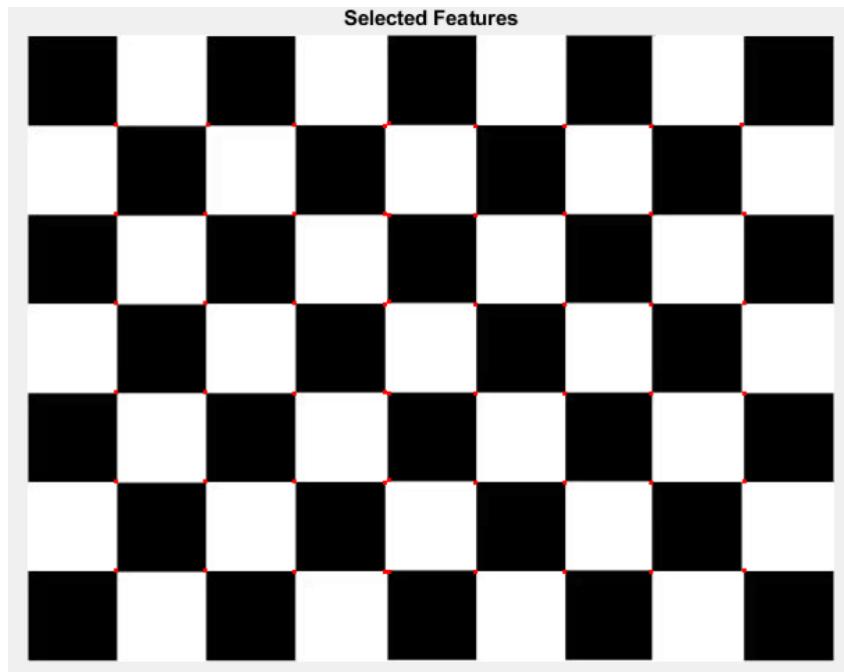


**2. Harris-detector**

**a) The Derivative in x-direction and y-direction**

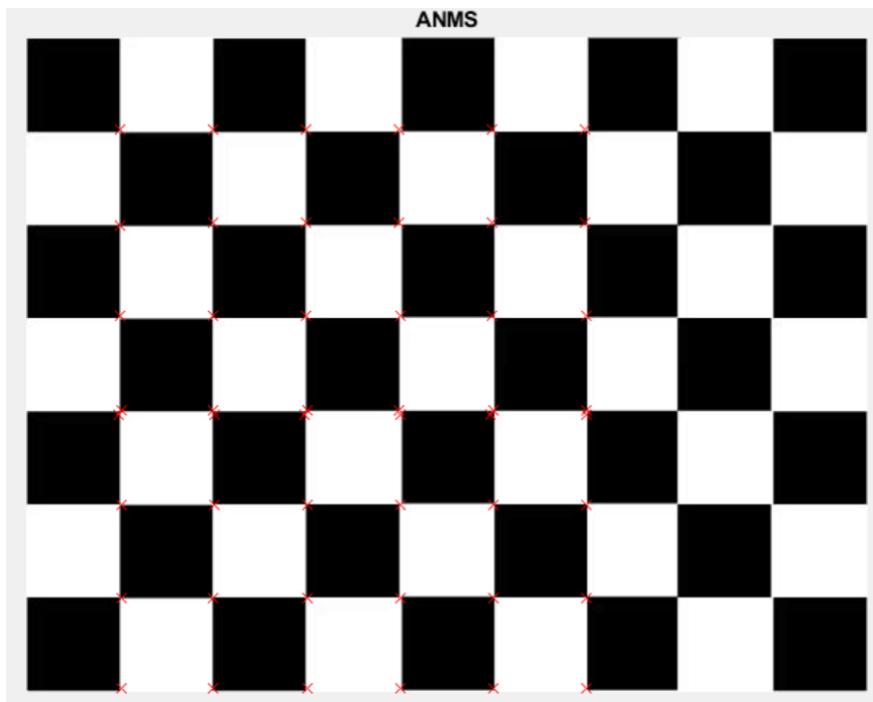


c). The threshold used is **1.610839203431340e+10**. The **48** selected features based on local maximums are



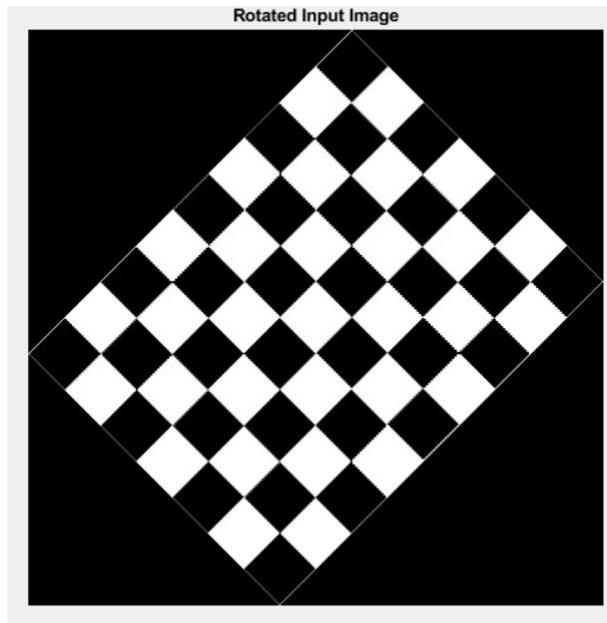
### 3. Adaptive Non-maximal Suppression

b). The image with selected 48 features and its marked locations



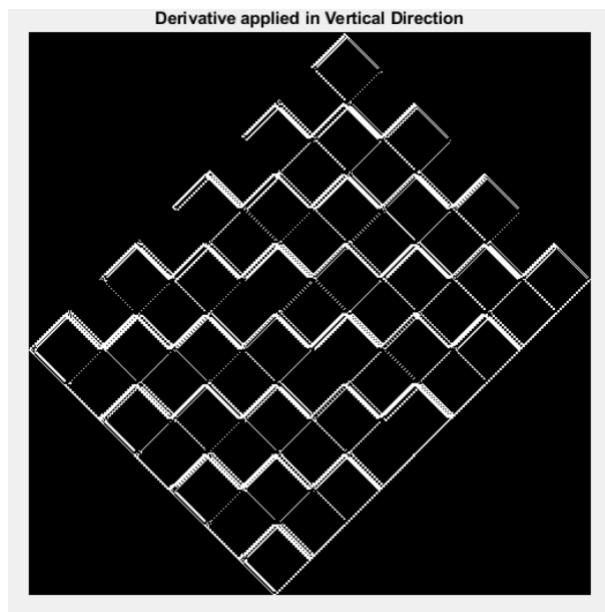
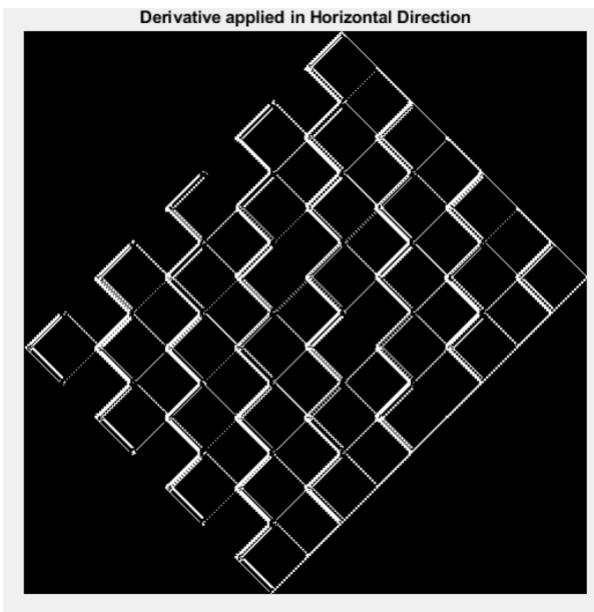
c). Here, we see that compared to harris detector, adaptive filter is more effective as it more spread out whereas in harris detector the points are more concentrated. This is so because adaptive filter takes the highest value in a given radius.

#### 4) Image after 45 degrees rotation

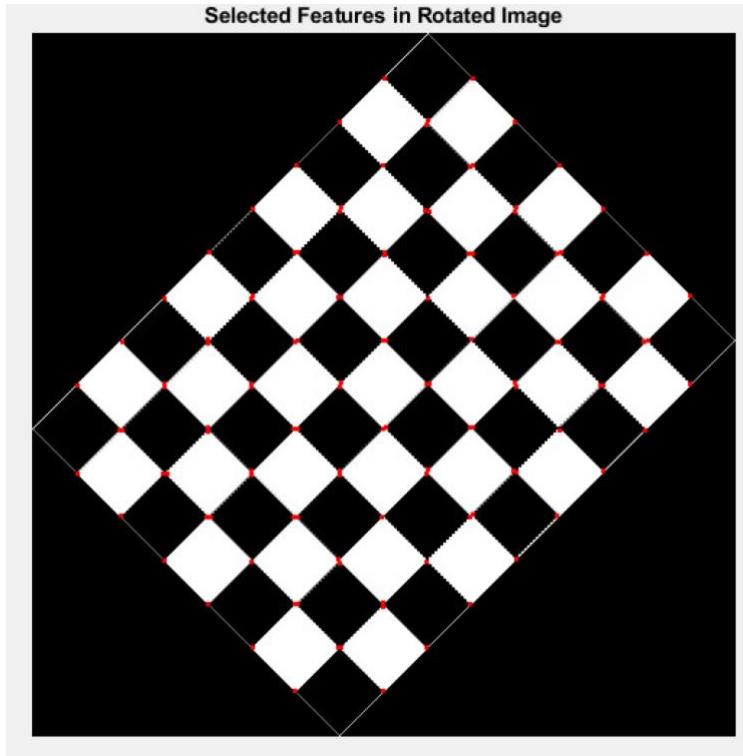


#### 5). Harris-detector

The Derivative in x-direction and y-direction

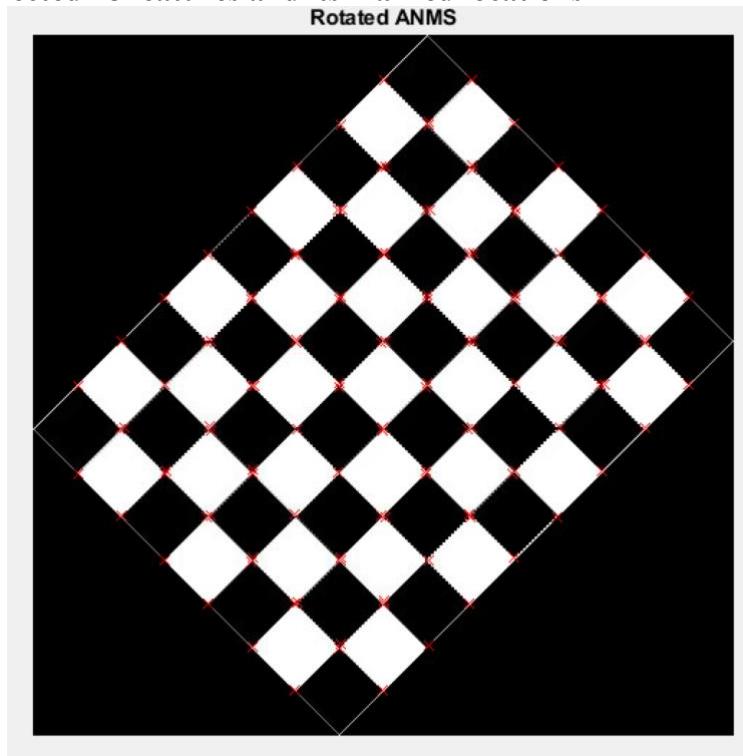


The threshold used is **1.871134005510486e+10**. The 48 selected features based on local maximums are

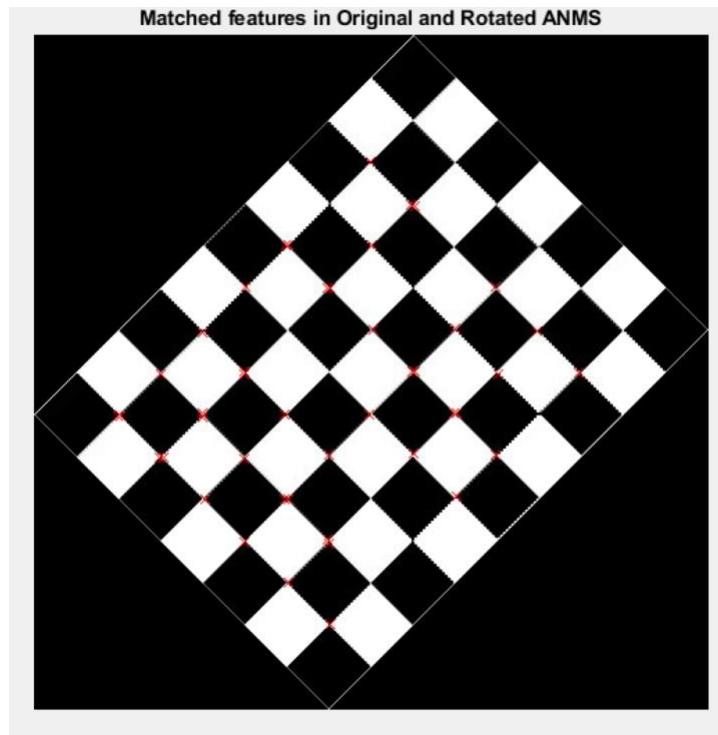


#### Adaptive Non-maximal Suppression

The image with selected 48 features and its marked locations



**6). Only the true positives were matched in the result and there were 450 features exactly matched.**



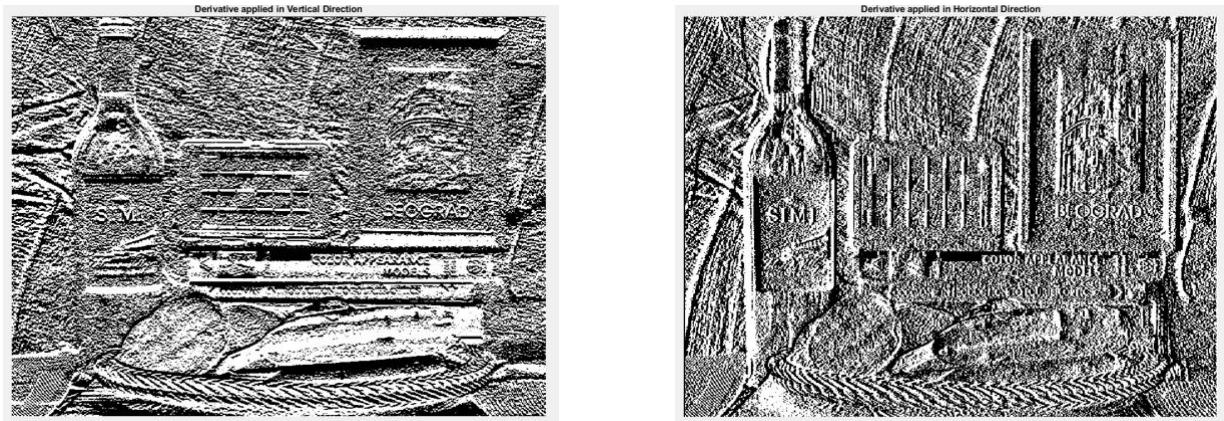
**7). “Image.bmp”**

**The input image is**



## Harris-detector

### a) The Derivative in x-direction and y-direction



c). The threshold used is **2.453512819008502e+09**. The 48 selected features based on local maximums are



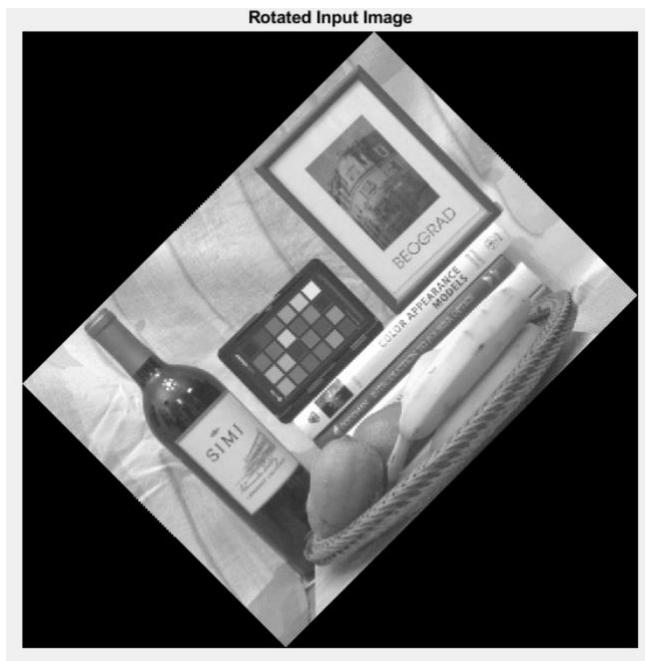
## Adaptive Non-maximal Suppression

b). The image with selected 48 features and its marked locations



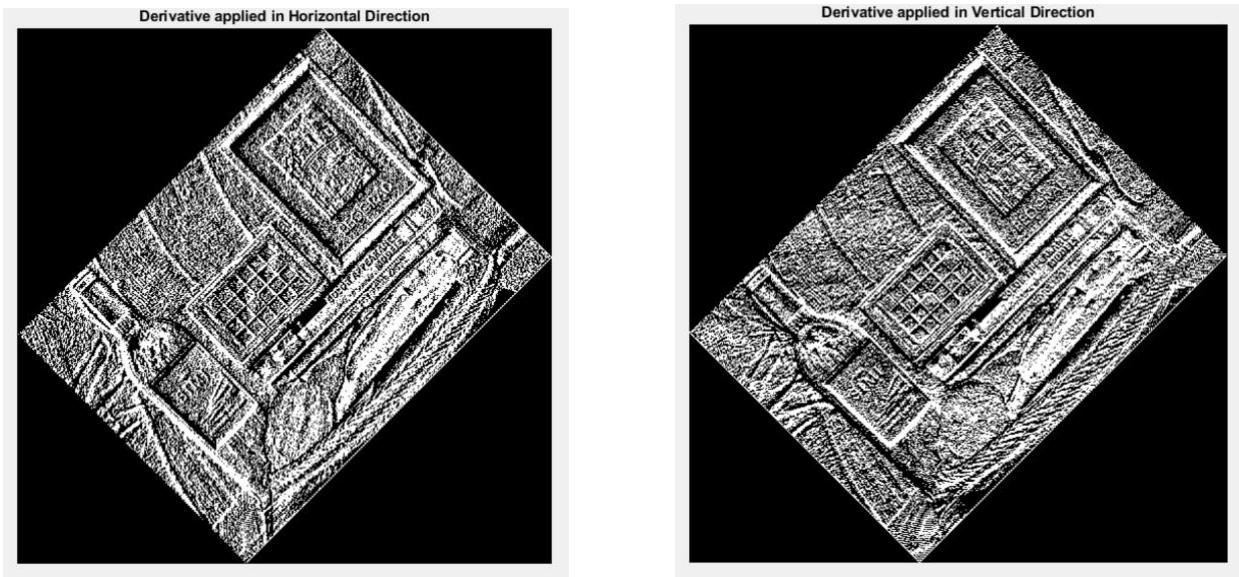
c). Here, we see that compared to harris detector, adaptive filter is more effective as it more spread out whereas in harris detector the points are more concentrated. This is so because adaptive filter takes the highest value in a given radius.

Image after 45 degrees rotation

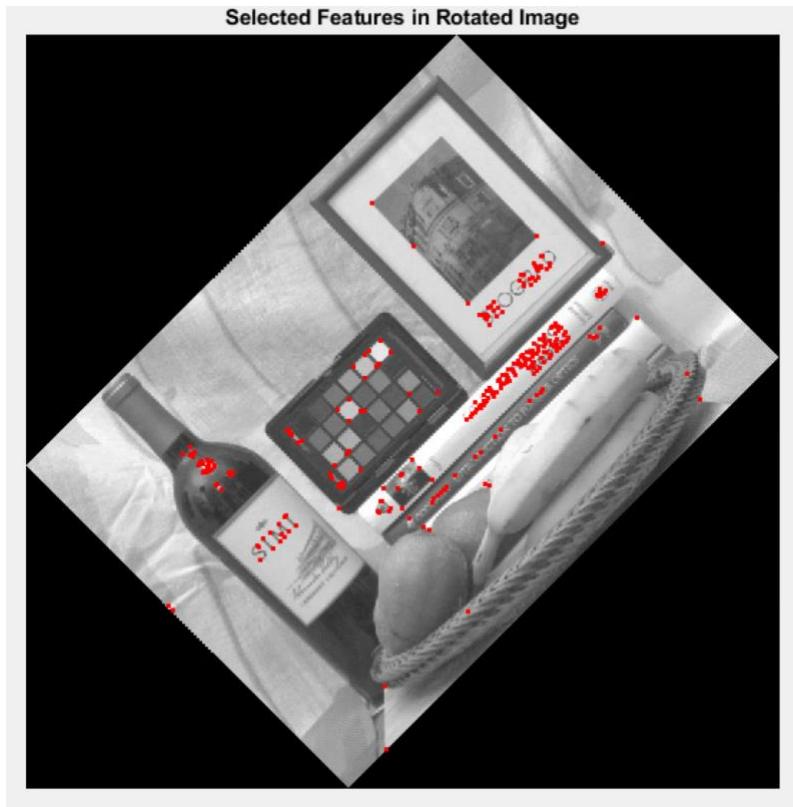


## Harris-detector

The Derivative in x-direction and y-direction



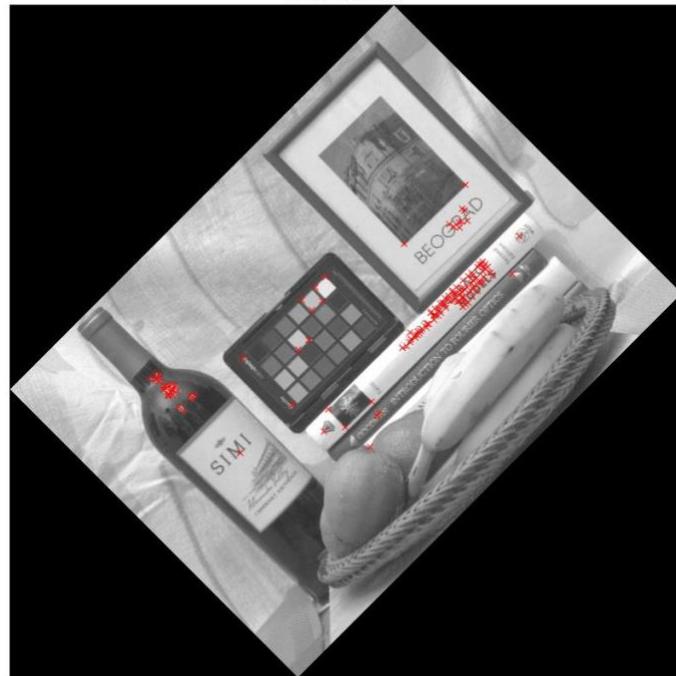
The threshold used is **7.658789916412381e+09**. The 48 selected features based on local maximums are



## Adaptive Non-maximal Suppression

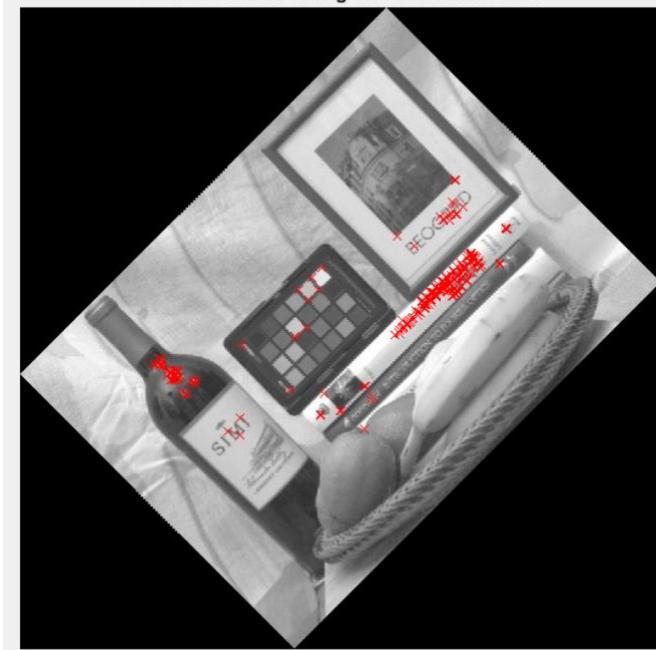
The image with selected 48 features and its marked location

Rotated ANMS



Only the true positives were matched in the result and there were 336 features exactly matched.

Matched features in Original and Rotated ANMS



## Probleme - 2

The neighbourhood elements at pixel (4,6) is

$$\begin{array}{r}
 23 \\
 115 \\
 \hline
 165 \quad 108 \quad \boxed{8} \quad 27 \quad 165 \\
 23 \\
 115
 \end{array}$$

Horizontal derivative kernel:  $\begin{bmatrix} -2 & -1 & 0 & 1 & 2 \end{bmatrix}$

∴ Derivative in x-direction is obtained by filtering the pixel and its neighborhood at (4,6) with horizontal derivative kernel

$$\begin{array}{r} \boxed{165} \boxed{108} \boxed{8} \boxed{127} \boxed{165} \\ \times \quad \boxed{-2} \boxed{-1} \boxed{0} \boxed{1} \boxed{2} \\ \hline = -2 \times 165 - 108 + 0 + 127 + 165 \times 2 \\ = -81 \\ \therefore I_{\alpha}(4,6) = -81 \end{array}$$

Vertical derivative kernel:

-2  
-1  
0  
1  
2

∴ Derivative in y-direction is obtained by filtering the pixel of its neighborhood at  $(4,6)$  with vertical derivative kernel.

$$\therefore I_y(4,6) = 92.$$

The centre of the Gaussian kernel is '1'.

Q).  $\therefore$  Auto-correlation matrix at (4,6) is

$$A = 1 \cdot \begin{bmatrix} (-81)^2 & -81 \cdot 92 \\ -81 \cdot 92 & 92^2 \end{bmatrix}$$

$$A = \begin{bmatrix} 6561 & -7452 \\ -7452 & 8464 \end{bmatrix}$$

6). Magnitude =  $\sqrt{|I_x|^2 + |I_y|^2}$   
=  $\sqrt{6561 + 8464} = 102.57$ .

$$\text{Angle} = \arctan\left(\frac{G_y}{G_x}\right) = \arctan\left(\frac{-81}{92}\right)$$
$$= -41.36^\circ$$
$$= 318.64^\circ$$