Interest points detector (Harris).

1 Introduction

The aim of this practical course is to program a interest point detector proposed by Harris and Stephen under Matlab.

Harris Detector

The algorithm of this corner point detector is :

- Vertical and horizontal gradient computation (using a Sobel Filter) : `Ix` et `Iy`
- Computation of the square gradients : $\texttt{Ix}^2$, $\texttt{Iy}^2$ and of the cross-gradient `IxIy`
- windows spatial convolution using a 3×3 gaussian or average kernel :
  Average kernel
  $$\texttt{W} = \frac{1}{9}\begin{pmatrix} 1 & 1 & 1 \\ 1 & 1 & 1 \\ 1 & 1 & 1 \end{pmatrix}$$
  Gaussian kernel
  $$W(i,j) = C \exp\left[-\frac{i^2+j^2}{2.\sigma^2}\right]$$
- Computation of Harris score R map from the Harris Matrix `M` :
  $$\texttt{M} = \texttt{W} * \begin{pmatrix} \texttt{(Ix)}^2 & \texttt{Ixy} \\ \texttt{Ixy} & \texttt{(Iy)}^2 \end{pmatrix} = \begin{pmatrix} \texttt{W} * \texttt{(Ix)}^2 & \texttt{W} * \texttt{Ixy} \\ \texttt{W} * \texttt{Ixy} & \texttt{W} * \texttt{(Iy)}^2 \end{pmatrix}$$
- $\text{Trace}(M) = \lambda_1 + \lambda_2 = M_{1,1} + M_{2,2}$
- $\text{Determinant}(M) = \lambda_1.\lambda_2 = M_{1,1}M_{2,2} - M_{1,2}M_{2,1}$
-
  $$R = \text{Det}(\texttt{M}) - k(\text{Trace}(\texttt{M}))^2$$
  k is a setting parameter (usually $k = 0.04$)
- Harris score R threshold.
- Local Maximun Extraction (A local maximum is defined by a point that has only neighbors with lower values)
- Coodinate extraction of the resulting points

The linear spatial filtering of an image `I` is computed by :

$$\texttt{I}_\texttt{f}(x,y) = \sum_{i=-m}^{m}\sum_{j=-n}^{n} W(i,j).\texttt{I}(x+i, y+j) \tag{1}$$

Questions

1. Write a Matlab function that read an image, compute the Harris Map and display a pseudo-image of this map. Test should be done on images `test1.jpg` and `test2.jpg`. You should use the file `harris.m` that is the core of the function and that povides useful sub-functions to create gaussian kernel and apply a linear spatial filter (`masqn`).
2. Modify the function to extract the interest points from Harris score and superimpose them to the original image. Extracting the interest points from Harris map is achieved by a two steps algorithm : 1) threshold the Map (n% from the max. value) and 2) extract local maximum.

Application to object recognition

The Harris detector, coupled with a descriptor, can be used to extract a sparse description of an object. Therefore, it can be use to solve object recognition problems. You must modify the file `harris.m` to produce a function with input (input image) and one output (set of interest points). Moreover, you have to complete the file `recog.m` in order to :

1. Compute interest points from a input image and a pattern to find,
2. extract descriptors,
3. Compute a distance matrix between the two sets of descriptors
4. Use a greedy algorithm to extract correspondences between the two images.

one function is available for each step.

```
%%%%%%%%%%%%%%%%%%%%%%%%
% script d'exemple matlab
%%%%%%%%%%%%%%%%%%%%%%%%
%
% lecture d'une image
[I,map]=imread('meadownb.jpg');
%%%%%%%%%%%%%%%%%%%%%%%%
% Affichage d'une image
image(I);
% pause il faut appuyer sur une
% touche pour reprendre
pause ;
colormap(gray(256));
%%%%%%%%%%%%%%%%%%%%%%%%
% Convertion de l'image en
% format double afin de la modifier
Id=double(I);
%%%%%%%%%%%%%%%%%%%%%%%%
% Extraction d'une partie de l'image
% des lignes 100 à 300 et
% des colonnes 200 à 400
I3=Id(100:300,200:400);
%%%%%%%%%%%%%%%%%%%%%%%%
% Sauvegarde d'une image
imwrite(uint8(I3),gray(256),'toto.jpg','JPEG');
```

Table 1 – Sample of Matlab script.

```
%%%%%%%%%%
% Exemple de fonction matlab fichier fo.m
% Les parametres d'entree sont a,b,c
% les parametres de sortie sont t1 et t2
%%%%%%%%%%
%%%%%%%%%%
% Prototype
function [t1,t2]=fo(a,b,c)
%
t1=a+b;
t2=b+c;
```

Table 2 – Sample of Matlab function.