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Department of Computer Science

Object Detection by Using

Histogram of Oriented Gradients (HOG)

A project submitted to the Council of the College Science for Women at the University of Babylon, which Is part of the requirements for obtaining a bachelor's degree in computer science

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بسم الله الرحمن الرحيم

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صدق الله العلي العظيم

سوره التوبه /ايه ٣٥

Supervisor Certification

I certify that the preparation of this project (description Object using histogram of oriented gradients) was conducted under my supervision in the Department of Computer Science / Faculty of Science for the women’s University of Babylon, which is part of the requirements of the / Bachelor's degree in Computer Science by fourth stage Student(Intesar Raad)

For the year 2021-2022

Supervisor Signature

Name of Supervisor: Zahraa Jabbar Hussein

Scientific Rank: Lecturer

Acknowledgements

All praise be to ALLAH Almighty who enabled me to complete this task successfully and my utmost respect to his last Prophet Mohammad PBUH and the hero of Islam born in the heart of Kaaba Amir AlMo’mineen Al-Imam Ali Ibn Abi Talib.

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Dedication

To Good morals and safety symbols My Parents … taught me that hard work does not take place Except with patience and determination, may God

Bless you

Abstract

This thesis presents an object detection algorithm based on HOG (Histograms of Oriented Gradients) features. object detection is used to describe any object regions from the picture. However, Extract feature descriptor around each interest point as a vector. which can be applied the first step is preprocessing by making resizing for images and after that making gradient images. additionally, The image is divided into small connected areas called cell units. A gradient or edge direction histogram of each pixel in the cell unit is acquired. Combine these histograms to form a feature descriptor. finally, the detected objects can be tested for different RGB, Gray and binary images and give good results.

lines of work

Chapter 1: General introduction

1.1 introduction

1.2 Overall idea

Chapter 2: Theoretical Background

2.1 introduction

2.2Goal & Challenges

2.3 theory

2.4 Histogram of Oriented Gradients

2.5 Feature Descriptor

Chapter 3: Practical Side

Chapter One

General introduction

1.1 Introduction

A histogram of oriented gradients (HOG) is a feature descriptor used to detect objects in computer vision and image processing. The HOG descriptor technique counts occurrences of gradient orientation in localized portions of an image detection on the window, or region of interest (ROI).

- Essentially represents a distribution of intensity fluctuations along different orientations (directions)

1.2 Overall idea

The Histogram of Oriented Gradient (HOG) is a feature that describes the distribution of the spatial directions in every image region. It exploits the thought that local object appearance can be characterized quite well by the distribution of local intensity gradients or edge directions. The basic idea is to divide an image into small spatial regions and, for each region, create a 1-D gradient orientation histogram with the gradient direction (histogram bin selection) and gradient magnitude (histogram bin weight/contribution) information from all the pixels in the region. Those histograms are contrast-normalized using a block-wise pattern and concatenated to obtain the final visual descriptor.

Chapter two

Theoretical Background

2.1 Introduction

Histogram of Oriented Gradients (HOG) is a feature descriptor used in image processing, mainly for object detection. A feature descriptor is a representation of an image or an image patch that simplifies the image by extracting useful information from it.

The principle behind the histogram of oriented gradients descriptor is that local object appearance and shape within an image can be described by the distribution of intensity gradients or edge directions. The x and y derivatives of an image (Gradients) are useful because the magnitude of gradients is large around edges and corners due to abrupt changes in intensity and we know that edges and corners pack in a lot more information about object shape than flat regions. So, the histograms of directions of gradients are used as features in this descriptor.

2.2 Goal & Challenges

Goal:

Detect and localise any an object (people, animal, ball.....) in the images

Challenges:

1- Wide variety of articulated poses

2- Variable appearance and clothing

3- Complex backgrounds

4- Unconstrained illumination

5- Occlusions, different scales

2.3 Theory

The essential thought behind the histogram of oriented gradients descriptor is that local object appearance and shape within an image can be described by the distribution of intensity gradients or edge directions. The image is divided into small connected regions called cells, and for the pixels within each cell, a histogram of gradient directions is compiled. The descriptor is the concatenation of these histograms. For improved accuracy, the local histograms can be contrast-normalized by calculating a measure of the intensity across a larger region of the image, called a block, and then using this value to normalize all cells within the block. This normalization results in better invariance to changes in illumination and shadowing.

The HOG descriptor has a few key advantages over other descriptors. Since it operates on local cells, it is invariant to geometric and photometric transformations, except for object orientation. Such changes would only appear in larger spatial regions. Moreover, as Dalal and Triggs discovered, coarse spatial sampling, fine orientation sampling, and strong local photometric normalization permit pedestrians' individual body movement to be ignored so long as they maintain a roughly upright position. The HOG descriptor is thus particularly suited for human detection in images.

2.4 Histogram of Oriented Gradients

Histogram of Oriented Gradients (HOG) feature-based method is presented in the work for human detection in an image. In this work, the authors have applied these feature descriptions for human detection. This feature counts the incidences of gradient orientation in confined portions of an image.

HOG describes the object in such a way that the same object generates as close as possible to the same feature descriptor when viewed under different conditions such as partial occlusion in this work. These feature descriptors are arranged in feature vectors and used.

2.5 Feature Descriptor

A feature descriptor is a representation of an image or an image patch that simplifies the image by extracting useful information and throwing away extraneous information.

Chapter three

Practical Side

3.1 Introduction

A histogram of Oriented Gradients can be used for object detection in an image. Particularly, they were used for pedestrian detection as explained in the paper "Pedestrian Detection using Histogram of Oriented Gradients" By Dalal and Triggs. The Matlab code computes HOG in a detailed manner as explained in the paper. The descriptor can then be used for training a classifier and for detecting object/non-object regions

3.2 Steps to calculate HOG

1- Input image

2- Preprocessing(resizing) : segment (64*128)

3- Calculate Gradient Images

4- Dividing Grad image into 8*8 cells

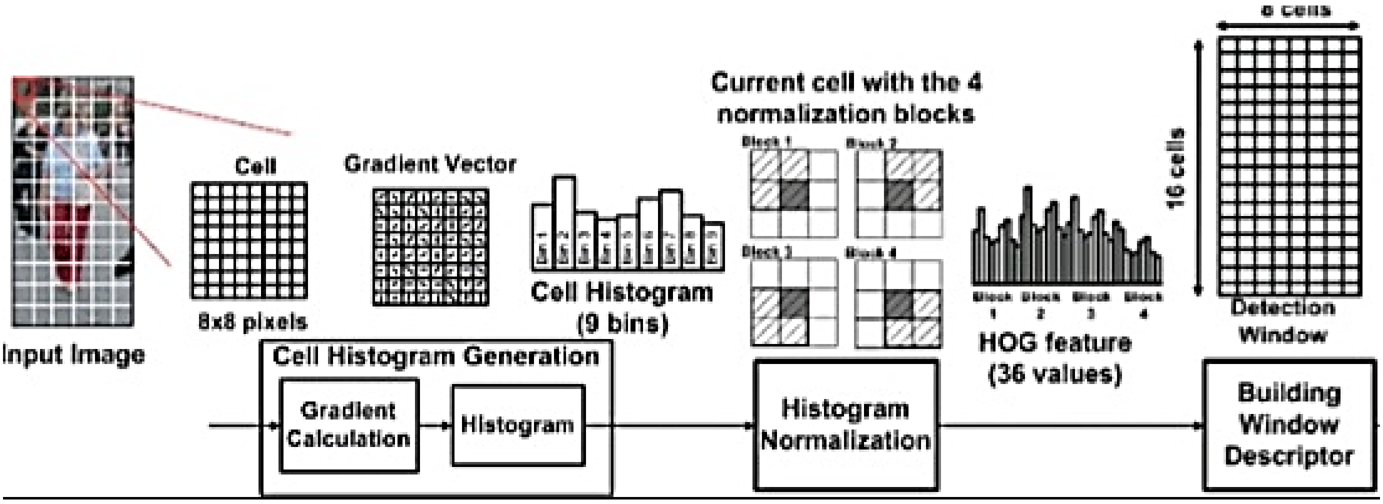
5- Finding histogram Bins for each cell

6- Grouping 2*2 cells to form overlapping Blocks

7- Forming feature vector of each block

8- Feature vectors (Block) Normalization

9- Collect all feature vector to get the HOG fseature.



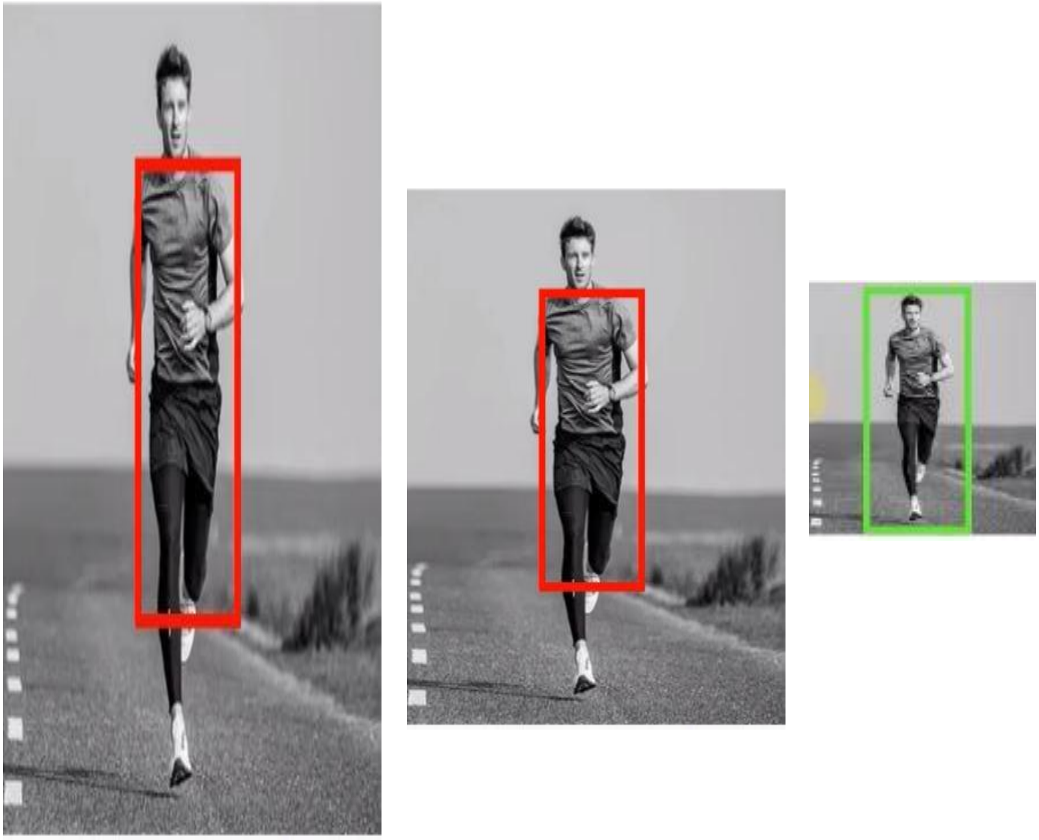
NOW We explain the steps

3.3 Process of Calculating HOG

2.Preprocessing (resizing) : segment (64*128)

- A feature extraction algorithm: converts an image of fixed size to a feature vector of fixed size.
- In the case of pedestrian detection, the HOG feature descriptor is calculated for a 64×128 patch of an image and it returns a vector of size 3780. Notice that the original dimension of this image patch was 64 x 128 x 3 = 24,576 which is reduced to 3780 by the HOG descriptor.

HOG is based on the idea that local object appearance can be effectively described by the distribution (histogram) of edge directions (oriented gradients).



2. Calculate Gradient Images

1- Gradient calculation: Calculate the x and the y gradient images, g_x and g_y from the original image. This can be done by filtering the original image with the following kernels.

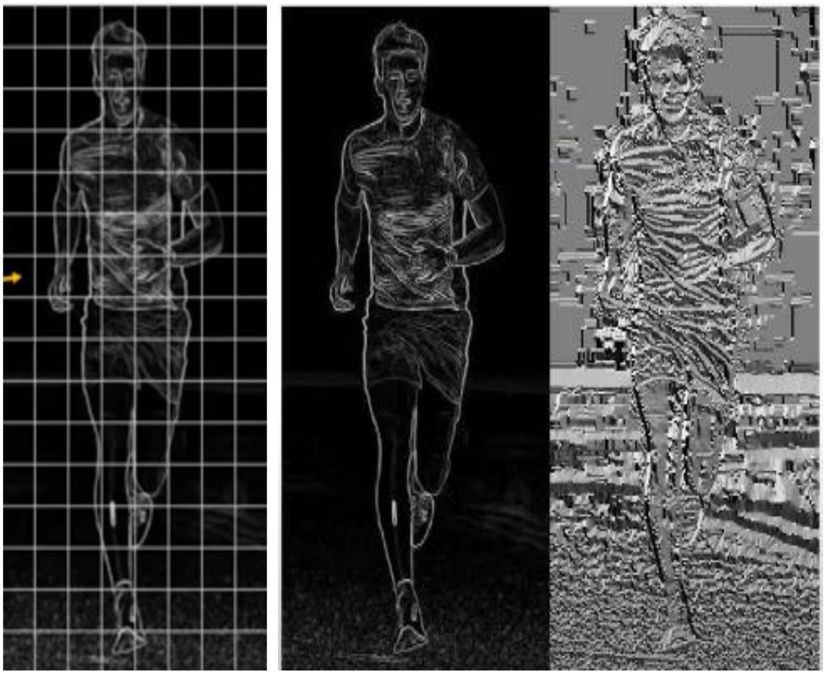
-1	0	1

-1
0
1

2- Using the gradient images g_x and g_y , we can calculate the magnitude and orientation of the gradient using the following equations**.**

$$g = \sqrt{g_x^2 + g_y^2}$$
$$\theta = \arctan \frac{g_y}{g_x}$$

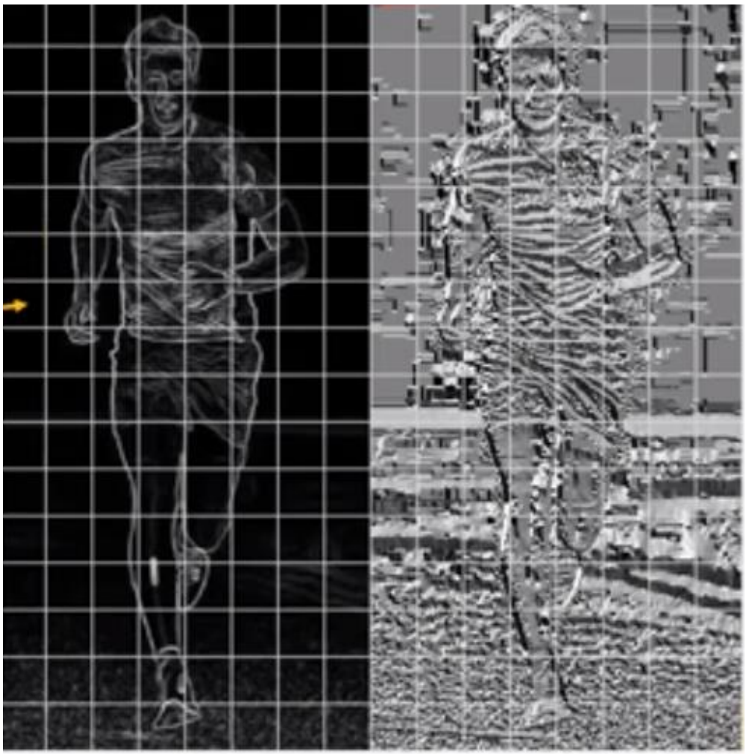
The calculated gradients are “unsigned” and therefore \Theta is in the range 0 to 180



64*128 Magnitude(u) Angle(θ)

4- Dividing Grad image into 8*8 cells

Each cell is of 8x8 pixels



Magnitude (μ) **Angle (θ)**

4- Finding histogram Bins for each cell

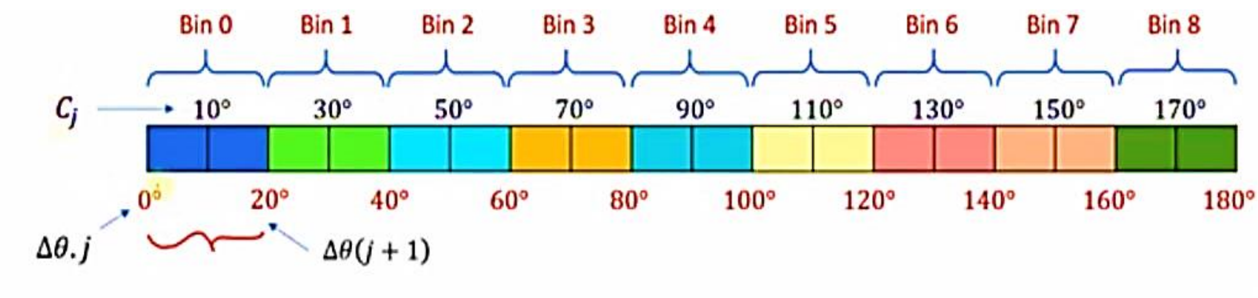
1-Getting 9 point Histogram (Bins)for each cell

2- Number of Bins = 9 (0 to 8) in range = 0° to 180°

3- step size $\Delta\theta = \frac{180^\circ}{9}$= 20°

4- Each j^{th}Bins will have boundaries = [$\Delta\theta$.j , $\Delta\theta$(j+1)]

5- and center of j^{th} Bin, $c_j = [\ \frac{\Delta\theta . j+\Delta\theta(j+1)}{2}]$ = $\Delta\theta$(j+$\frac{1}{2}$)



5- Finding histogram Bins for each cell

Steps:

1-For a given of angle θ

$(obtained\ from\ gradient\ angle\ matrix)$,

- first we find value of (j and j+1)

2- Value of j is calculated by

j = floor ([$\frac{\theta}{\Delta\theta}$ - $\frac{1}{2}$) , where $\Delta = 20^{\circ}$ (is the size of the Bin)

- θ is corresponding with magnitude
- $\theta \rightarrow \mu$ will divider this μ in to the two parts (μ_1, μ_2)
- μ_1= j^{th} and μ_2= j +1

3- values assigned to j^{th} Bin is

$$v_j = \mu[\frac{c_{j+1} - \theta}{\Delta\theta}]$$

4- value assigned to $(j+1)^{th}$ Bins:

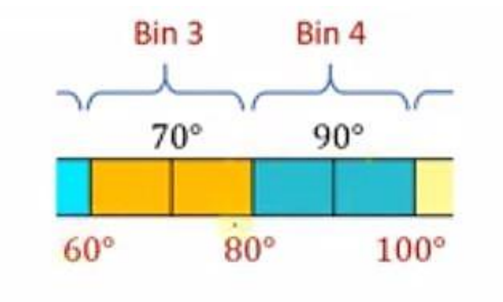
$$v_{j+1} = \mu[\frac{\theta - c_j}{\Delta\theta}]$$

The value assignment to two Bins is actually by Bi-linear interpolation

5- sum of value assigned to two Bins will always be 1

i.e.: $v_j + v_{j+1} = 1$

5- Finding histogram Bins for each cell



Ex 1:

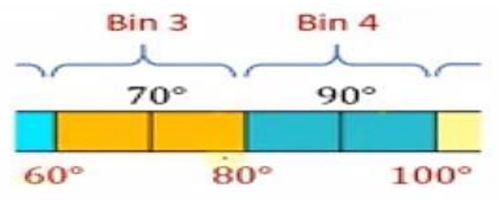
Let $\theta = 77^{\circ}$(closer to Bin 3) and $\mu = 1$

- Value of j = floor ([$\frac{\theta}{\Delta\theta}$ - $\frac{1}{2}$) = floor ([$\frac{77}{20}$ - $\frac{1}{2}$) = Floor (3.35)= 3 (represent Bin 3)
- Values assigned to 3rd Bin is :

$v_j = \mu[\frac{c_{j+1} - \theta}{\Delta\theta}] \rightarrow v_3 = \mu[\frac{c_4 - 77}{20}]$ = 1$[\frac{90-77}{20}]$ = 0.65 (is center Bin 3)

The center of Bin4 is 90.

5- Finding histogram Bins for each cell



- Value assigned to 4th Bin is

$v_{j+1} = \mu[\frac{\theta - c_j}{\Delta\theta}] \rightarrow v_4 = 1[\frac{77 - c_3}{20}]$ = 1$[\frac{77-70}{20}]$ = 0.35 (is center Bin 4)

Sum of value assigned to two Bins will always be 1

i.e. $v_3 + v_4$ = 0.65 + 0.35 = 1

This shows that if θ is mcloser to any Bin, then the orresponding Bin gets more value of μ as compared to next Bin.

6- Making over lapping from cells

Once Histogram (9 Bins) computation is ove for all cells, then 4 cells (in 2× 2) are clubbed together to form a Block.

.This clubbing is done in overlapping manner with stride of 8 pixels

.For all 4 cells in a block, concatenate all 9- point Histogram of each cell to form a 36- point feature vector, let represented as,

fb_i = $[b_1, b_2, b_3, \ \dots \dots .. b_{36}]$

4 cells $\times$ 9 $histogram$ = 36 feature point

8- Feature vectors (Block) Normalization.

Value of fb_i are normalized by L_2 norm as :

$$\mathrm{f}b_i \leftarrow \frac{\mathrm{f}b_i}{\sqrt{\|\mathrm{f}b_i^2\| + \in}}$$

To achieve this normalization, first find :

K= $\sqrt{b_1, b_2, b_3, \ \dots \dots .. b_{36}}$ then,

FB fb_i = $[\frac{b_1}{k}, \frac{b_2}{k}, \frac{b_3}{k} \ldots\ldots\ldots\ldots\ldots \frac{b_{36}}{k}]$

This normalization is done to reduce the effect of changes in contrast between images of the same object.

9- Collecting all feature vectors to get HOG feature

.From each block, a- 36 point feature vector is collected.

In horizontal direction, there are total 7 blocks.

- 7 horizontally
- An 15 vertically
- From each block I get total of 36 point

$$\mathbf{7 \times 15 \times 36 = 3780}$$

3.4 Code of Project:

```
function [feature] =
hog_feature_vector(im)
% The given code finds the HOG feature
vector for any given image. HOG
% feature vector/descriptor can then
be used for the detection of any
% particular object. The Matlab code
provides the exact implementation of
% the formation of HOG feature vector
as detailed in the paper "Pedestrian
% detection using HOG" by Dalal and
Triggs
```

```
% INPUT => im (input image)
% OUTPUT => HOG feature vector for
that particular image


% Example: Running the code
% >>> im = imread('cameraman.tif');
% >>> hog = hog_feature_vector (im);



% Convert RGB iamge to grayscale
if size(im,3)==3
    im=rgb2gray(im);
end
im=double(im);
rows=size(im,1);
cols=size(im,2);
Ix=im; %Basic Matrix assignment
Iy=im; %Basic Matrix assignment
% Gradients in X and Y direction. Iy
is the gradient in X direction and Iy
% is the gradient in Y direction

for i=1:rows-2
    Iy(i,:)=(im(i,:)-im(i+2,:));
end
for i=1:cols-2
    Ix(:,i)=(im(:,i)-im(:,i+2));
end
gauss=fspecial('gaussian',8); %%
Initialized a gaussian filter with
sigma=0.5 * block width.
```

```
angle=atand(Ix./Iy); % Matrix
containing the angles of each edge
gradient
angle=imadd(angle,90); %Angles in
range (0,180)
magnitude=sqrt(Ix.^2 + Iy.^2);
% figure,imshow(uint8(angle));
% figure,imshow(uint8(magnitude));
% Remove redundant pixels in an image.


angle(isnan(angle))=0;
magnitude(isnan(magnitude))=0;
feature=[]; %initialized the feature
vector
% Iterations for Blocks
for i = 0: rows/8 - 2
    for j= 0: cols/8 -2
        %disp([i,j])
mag_patch = magnitude(8*i+1 : 8*i+16 ,
8*j+1 : 8*j+16);

%mag_patch =
imfilter(mag_patch,gauss);
ang_patch = angle(8*i+1 : 8*i+16 ,
8*j+1 : 8*j+16);

        block_feature=[];

        %Iterations for cells in a
block

        for x= 0:1
```

```
              for y= 0:1
       angleA =ang_patch(8*x+1:8*x+8,
8*y+1:8*y+8);

    magA = mag_patch(8*x+1:8*x+8,
8*y+1:8*y+8);
        histr  =zeros(1,9);

      %Iterations for pixels in one cell
                                  for p=1:8

                        for q=1:8
%
                     alpha= angleA(p,q);

 % Binning Process (Bi-Linear
Interpolation)
```

Chapter Four

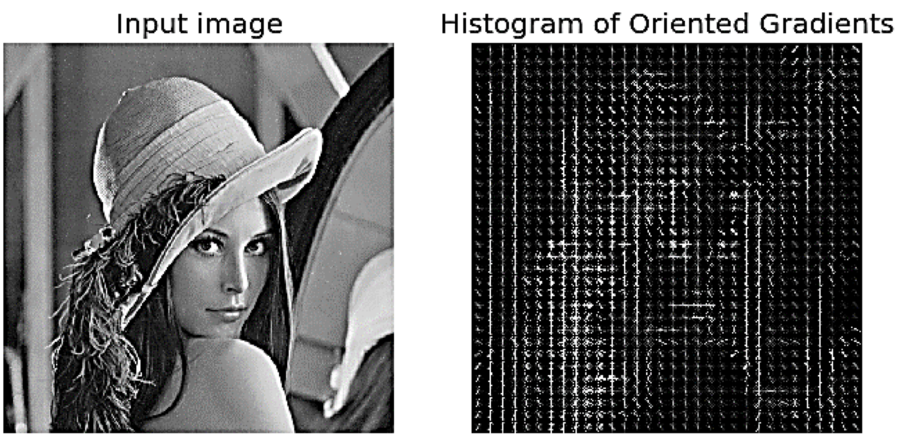
Conclusions & Recommendations

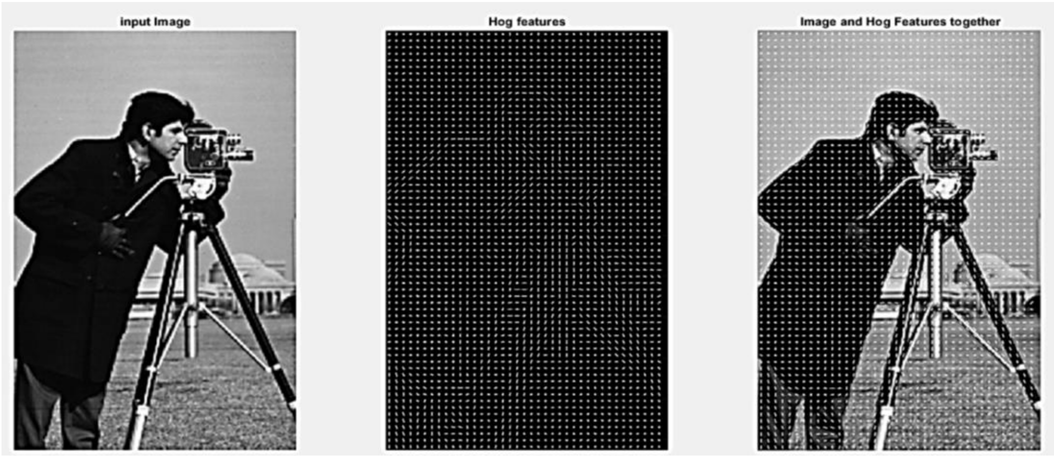
4.1 Introduction

We studied the influence of various descriptor parameters and concluded that fine-scale gradients, fine orientation binning, relatively coarse spatial binning, and high-quality local contrast normalization in overlapping descriptor blocks are all important for good performance. We also introduced a new and more challenging pedestrian database, which is publicly available.

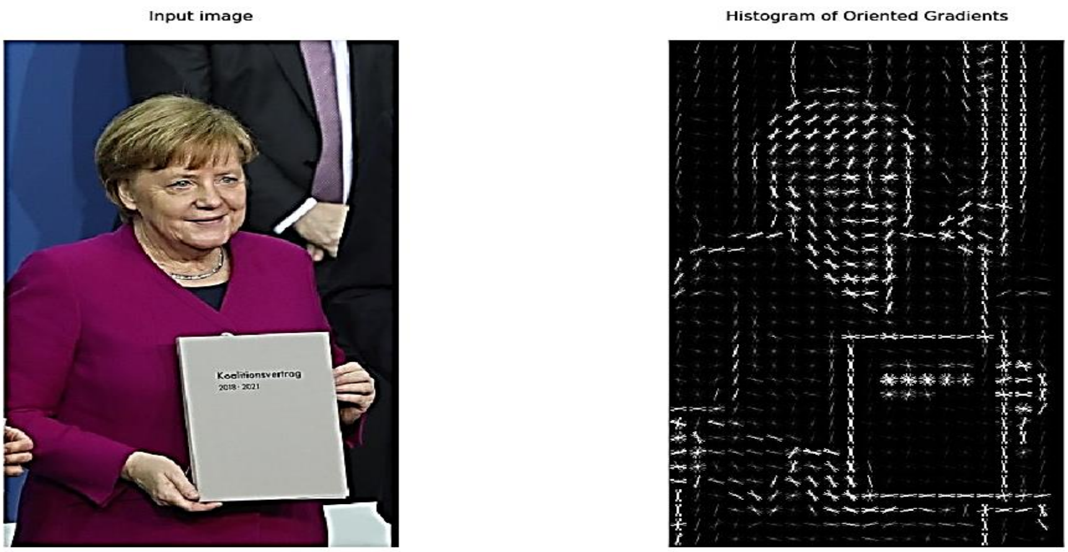
4.2 Discussion

(grey image) to find HOG features

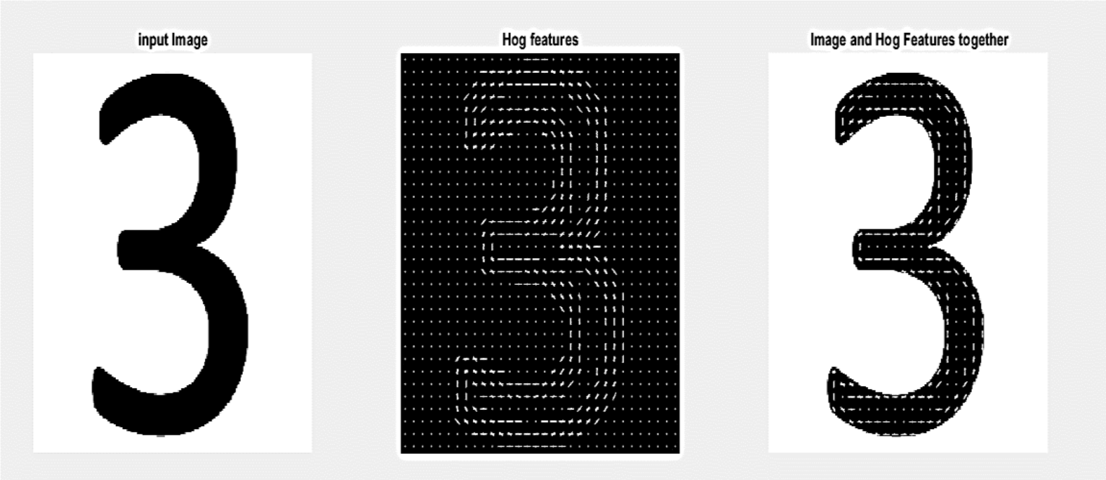




(colour image) to find HOG features



(binary image) to find HOG features


input Image
Hog features
Image and Hog Features together


input Image
Hog features
Image and Hog Features together

References

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