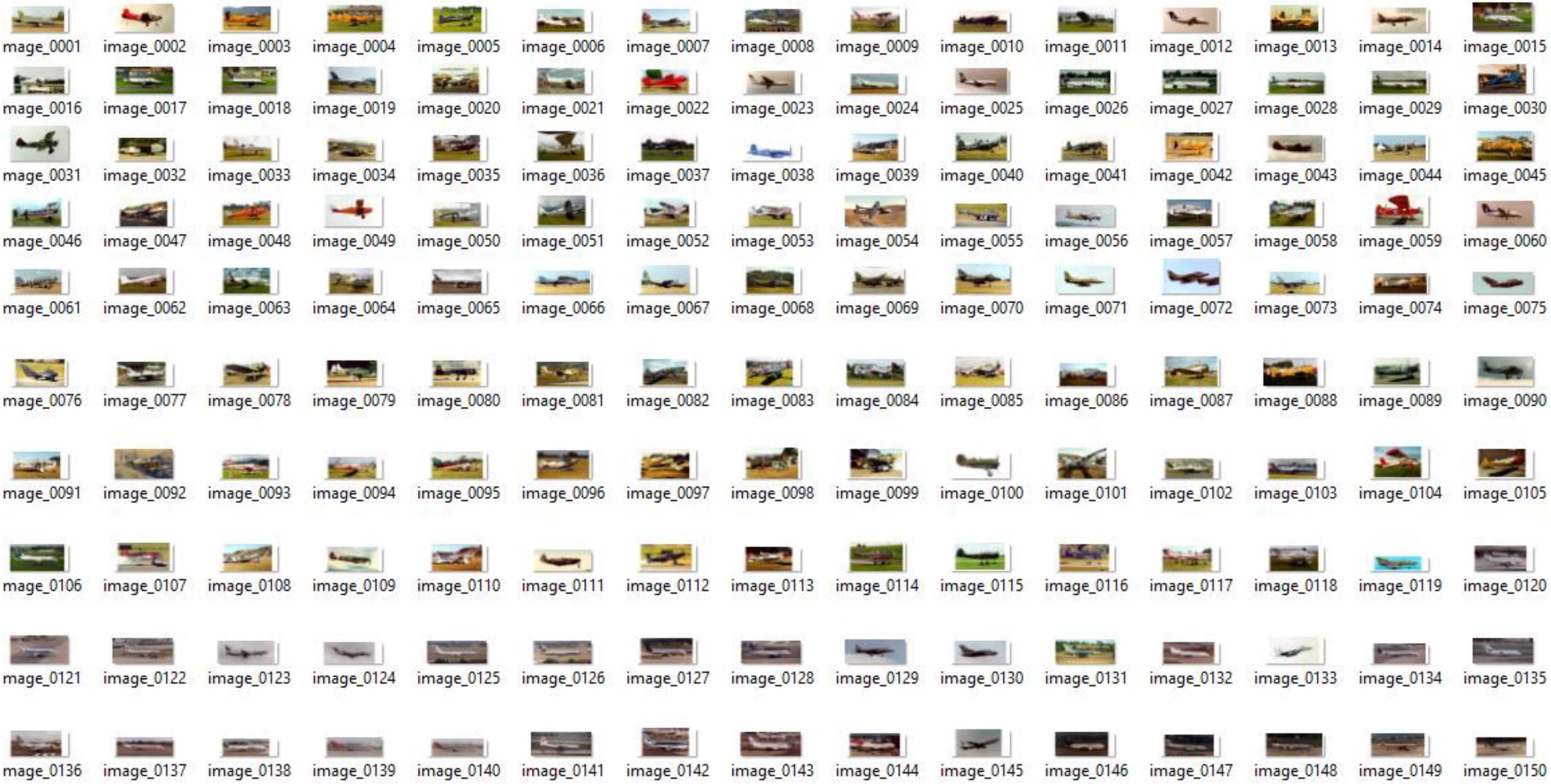
CSE463: Neural Networks

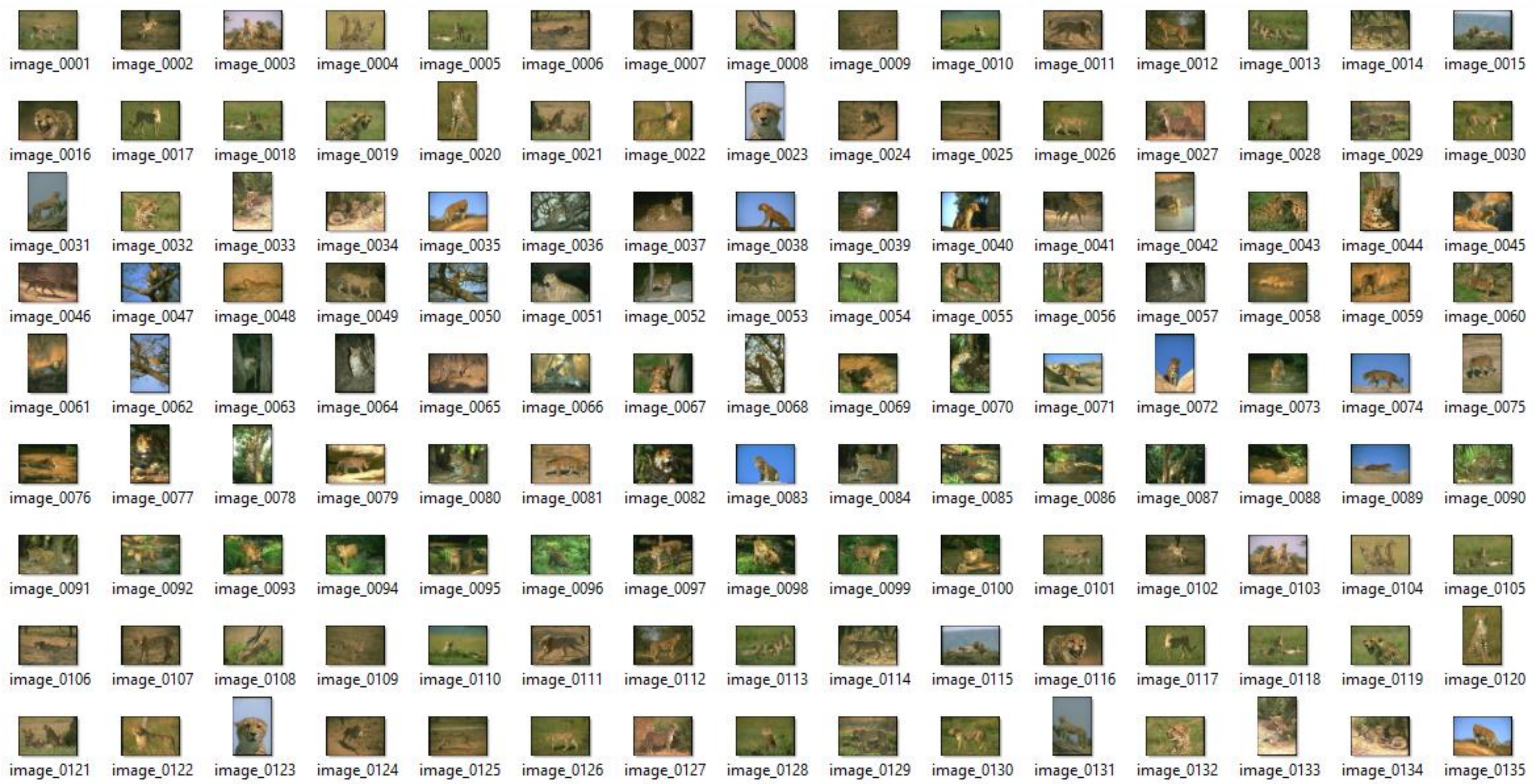
Visual Recognition: Revisit

by:
Hossam Abd El Munim
Computer & Systems Engineering Dept.,
Ain Shams University,
1 El-Sarayat Street, Abbassia, Cairo 11517

Airplane Class



Leopard Class



Motorbikes Class

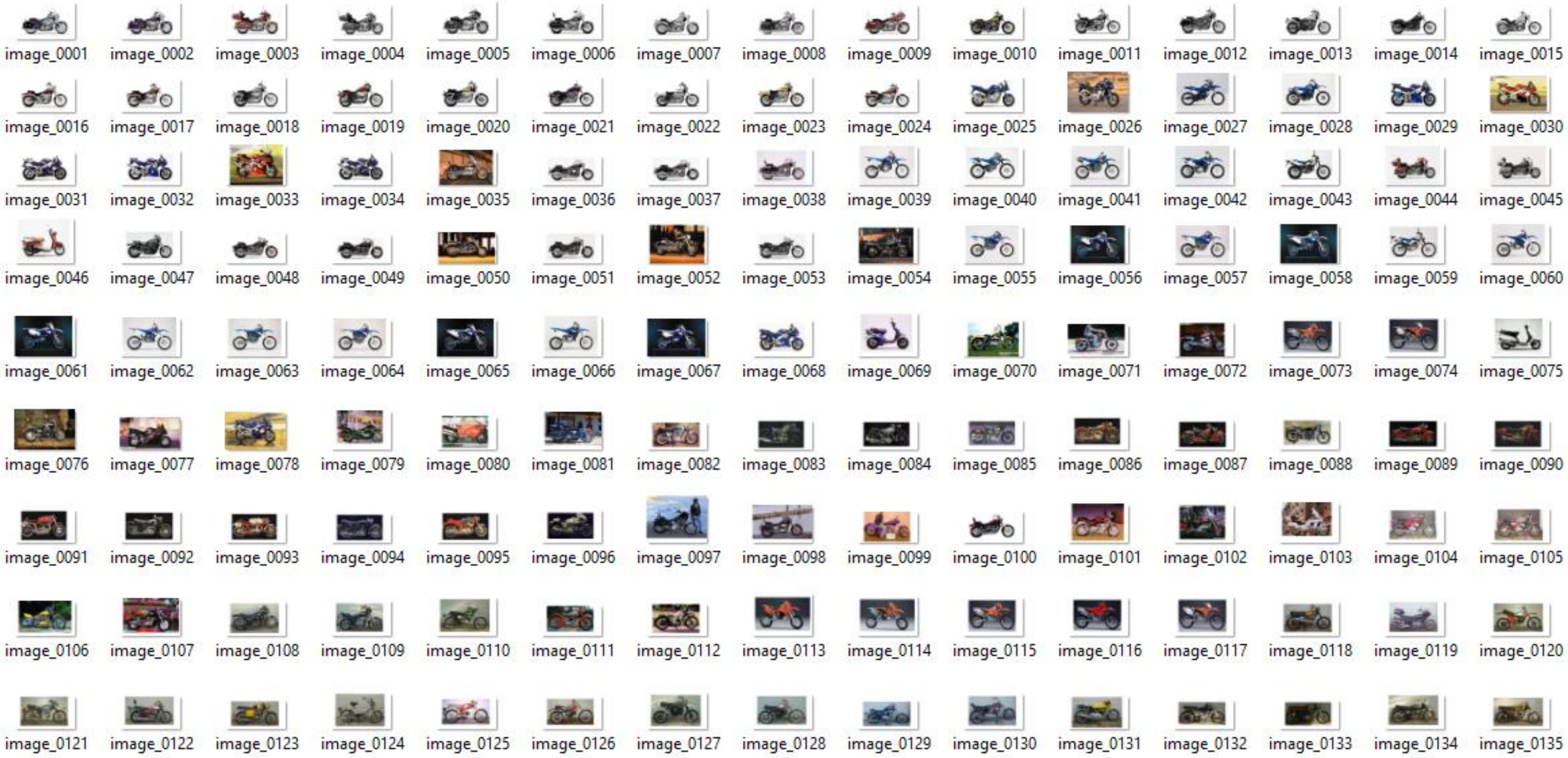
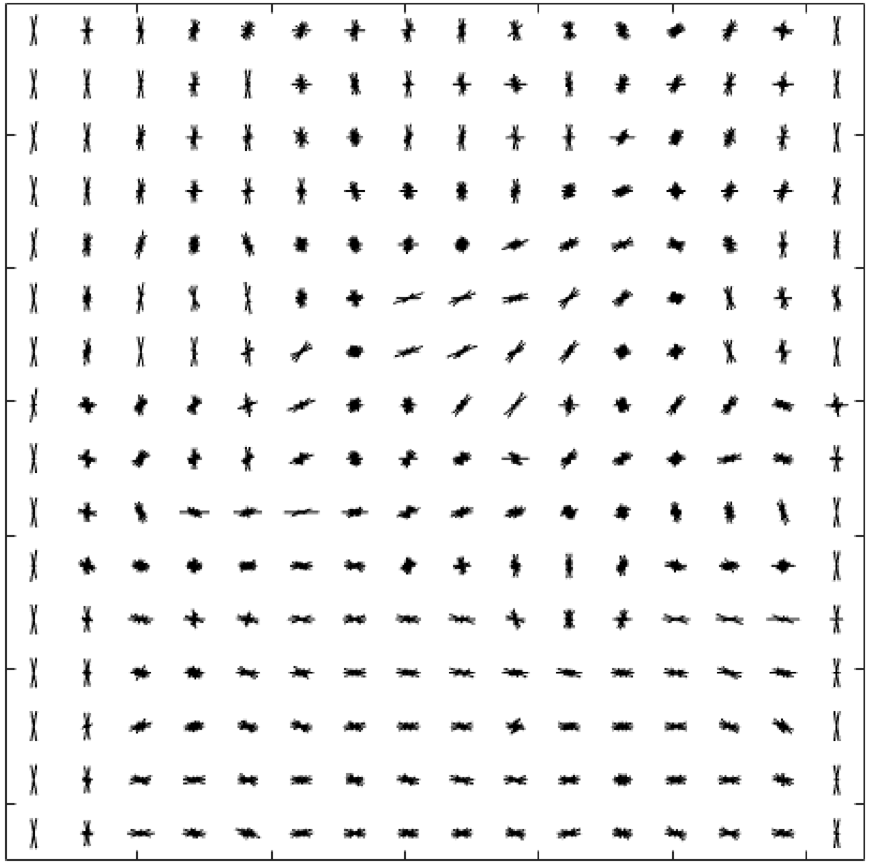


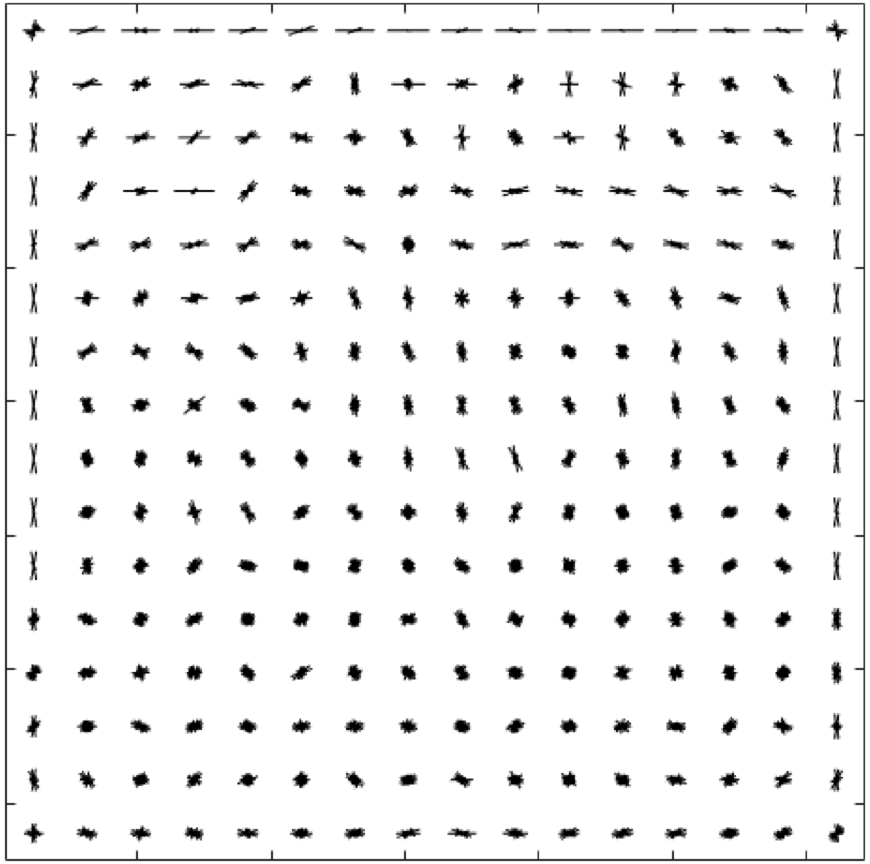
Image HoG Feature

```
h=32;w=32;
NAirplanes=100;
s='airplanes//image_';
C1=[];
for i=1:NAirplanes
    [i]
    str=sprintf('%s%04d.jpg',s,i);
    im=imread(str);
    im=rgb2gray(im);
    im=imresize(im,[h w]);
    [hog,visualization] = extractHOGFeatures(im);
    subplot(1,2,1);imshow(im);
    subplot(1,2,2);plot(visualization);
    pause(0.1)
    C1(i,:)=hog;
end
%%%%%%%%%%%%%%%%%%%%%
save('Airplanes.mat','C1')
%%%%%%%%%%%%%%%%%%%%%
```

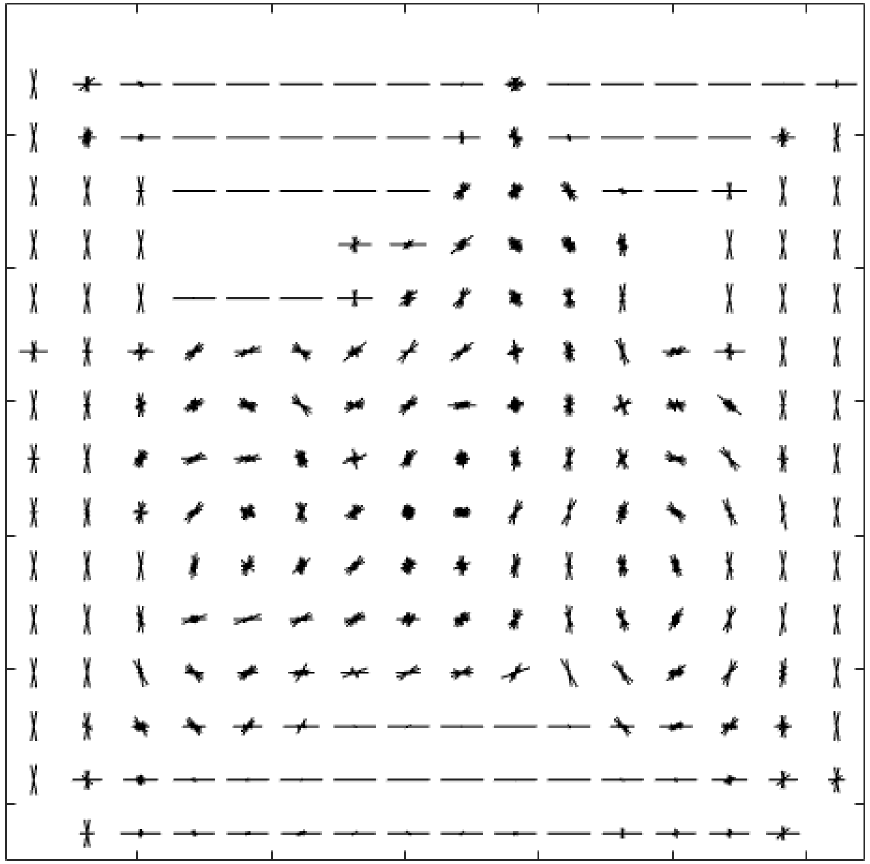
HoG Feature Visualization



HoG Feature Visualization



HoG Feature Visualization



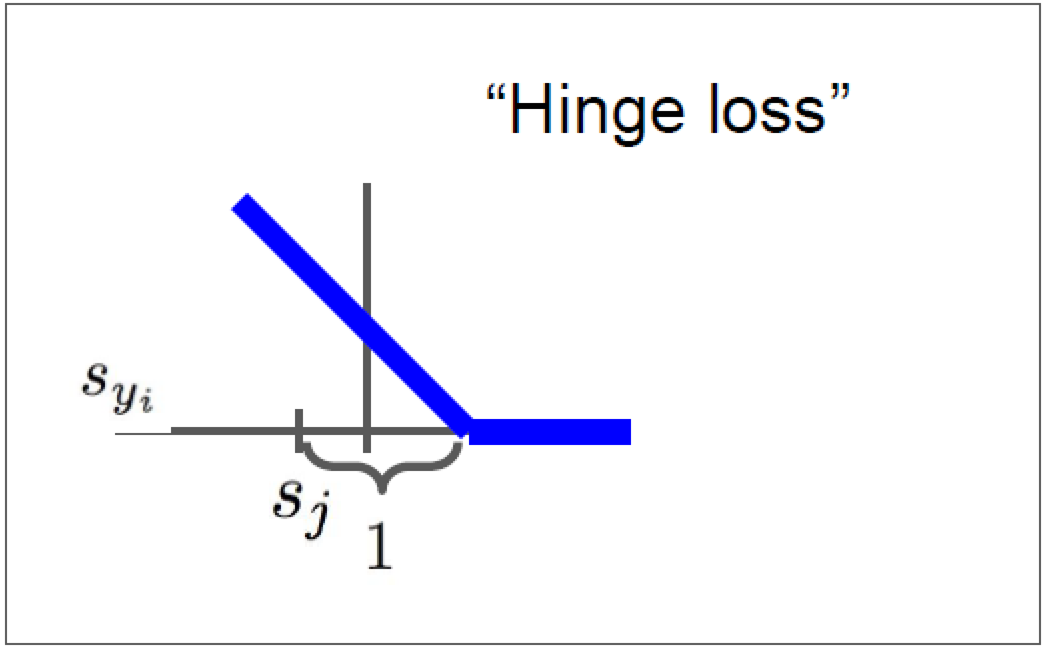
Class-i Score

$$S_i = f(X, W_i) = W_i.\mathrm{x}$$



Airplane	**1.1320**	-0.4493	-0.4845
Leopard	-0.9674	**0.6074**	-0.3249
Motorbike	-0.1651	-0.1583	**0.8091**

Class-i Loss



$$L_i = \sum_{j \neq y_i} \begin{cases} 0 & \text{if } s_{y_i} \geq s_j + 1 \\ s_j - s_{y_i} + 1 & \text{otherwise} \end{cases}$$

$$= \sum_{j \neq y_i} \max(0, s_j - s_{y_i} + 1)$$

Suppose: 3 training examples, 3 classes.
With some W the scores $f(x, W) = Wx$ are:



cat	**3.2**	1.3	2.2
car	5.1	**4.9**	2.5
frog	-1.7	2.0	**-3.1**
Losses:	2.9		

Multiclass SVM loss:

Given an example (x_i, y_i)
where x_i is the image and
where y_i is the (integer) label,

and using the shorthand for the scores vector: $s = f(x_i, W)$

the SVM loss has the form:

$$\boxed{L_i = \sum_{j \neq y_i} \max(0, s_j - s_{y_i} + 1)}$$

= max(0, 5.1 - 3.2 + 1)
+max(0, -1.7 - 3.2 + 1)
= max(0, 2.9) + max(0, -3.9)
= 2.9 + 0
= 2.9

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Losses:	2.9	0	

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= max(0, 1.3 - 4.9 + 1)
+max(0, 2.0 - 4.9 + 1)
= max(0, -2.6) + max(0, -1.9)
= 0 + 0
= 0

Suppose: 3 training examples, 3 classes.
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cat	**3.2**	1.3	2.2
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frog	-1.7	2.0	**-3.1**
Losses:	2.9	0	12.9

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the SVM loss has the form:

$$\boxed{L_i = \sum_{j \neq y_i} \max(0, s_j - s_{y_i} + 1)}$$

= max(0, 2.2 - (-3.1) + 1)
+max(0, 2.5 - (-3.1) + 1)
= max(0, 6.3) + max(0, 6.6)
= 6.3 + 6.6
= 12.9

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Loss over full dataset is average:

$$L = \frac{1}{N} \sum_{i=1}^{N} L_i$$

L = (2.9 + 0 + 12.9)/3
= **5.27**

Objective Function

$$L = \frac{1}{N}\sum_{i=1}^{N}\sum_{j\neq y_i}\max(0, f(x_i;W)_j - f(x_i;W)_{y_i} + 1) + \boxed{\lambda R(W)}$$

In common use:

L2 regularization $R(W) = \sum_k \sum_l W_{k,l}^2$

L1 regularization $R(W) = \sum_k \sum_l |W_{k,l}|$

Elastic net (L1 + L2) $R(W) = \sum_k \sum_l \beta W_{k,l}^2 + |W_{k,l}|$

Objective Function (SVM_LOSS) Minimization

```
close all; clear all; clc;
%Loading Data
load Airplanes
load Leopards
load Motorbikes
%Feature size = N
[ddd,N]=size(C1);

f=@(X)SVM_LOSS(X,C1,C2,C3);

options = optimoptions('fmincon','Display','iter','Algorithm','sqp');

A=[];b=[];Aeq=[];beq=[];lb=[];ub=[];nonlcon = [];

W=2*rand(3*(N+1),1)-1;

[W,fv]= fmincon(f,W,A,b,Aeq,beq,lb,ub,nonlcon,options)

save('W.mat','W')
```

Optimization Results