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Image Recognition for cats and dogs

Hyo Jin Chung and Minh N.Tran

Department of Mathematics and Statistics
California State University, Long Beach

May 20, 2010

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Can you tell what these images are?

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Problem

Given

Problem

Given

- 80 images of cats
- 80 images of dogs

Problem

Given

- 80 images of cats
- 80 images of dogs

Goal

Problem

Given

- 80 images of cats
- 80 images of dogs

Goal

- Classify 38 images of cats and dogs

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Image Recognition Algorithm

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Image Recognition Algorithm

1. Train the computer to know cats and dogs

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Image Recognition Algorithm

1. Train the computer to know cats and dogs
2. Ask the computer to classify unknown images

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Algorithm Structure

Edge Detection

Algorithm Development

Algorithm Structure

Edge Detection

Algorithm Development

Algorithm Structure

Edge Detection

$\Downarrow$

Dimension Reduction

Algorithm Development

Algorithm Structure

Edge Detection

⇓

Dimension Reduction

⇓

Algorithm Development

Algorithm Structure

Edge Detection

⇓

Dimension Reduction

⇓

Classification

Methods

Method 1

Method 1

1. 2-D Discrete Haar Wavelet Transform (DWT)

Methods

Method 1

1. 2-D Discrete Haar Wavelet Transform (DWT)
2. Principal Component Analysis (PCA)

Methods

Method 1

1. 2-D Discrete Haar Wavelet Transform (DWT)
2. Principal Component Analysis (PCA)
3. Fisher's Linear Discriminant Analysis (FDA)

Methods

Method 1

1. 2-D Discrete Haar Wavelet Transform (DWT)
2. Principal Component Analysis (PCA)
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Method 2

Methods

Method 1

1. 2-D Discrete Haar Wavelet Transform (DWT)
2. Principal Component Analysis (PCA)
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Method 2

1. Average Filter and Laplacian Filter

Methods

Method 1

1. 2-D Discrete Haar Wavelet Transform (DWT)
2. Principal Component Analysis (PCA)
3. Fisher's Linear Discriminant Analysis (FDA)

Method 2

1. Average Filter and Laplacian Filter
2. Principal Component Analysis (PCA)

Methods

Method 1

1. 2-D Discrete Haar Wavelet Transform (DWT)
2. Principal Component Analysis (PCA)
3. Fisher's Linear Discriminant Analysis (FDA)

Method 2

1. Average Filter and Laplacian Filter
2. Principal Component Analysis (PCA)
3. Fisher's Linear Discriminant Analysis (FDA)

Sample Images

Size of 64-by-64

Method 1

1. 2-D Discrete Haar Wavelet Transform (DWT)
2. Principal Component Analysis (PCA)
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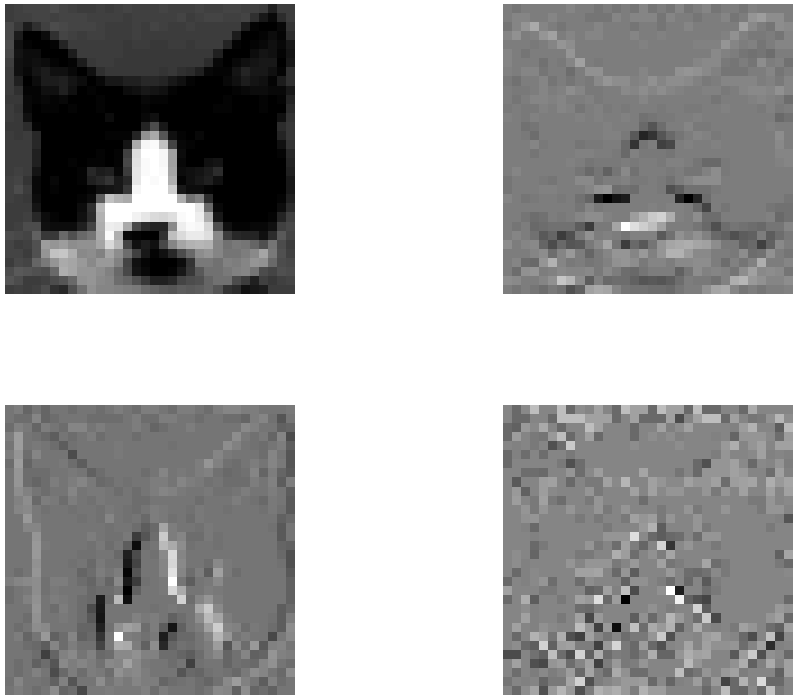
Method 1: Step1 - DWT

Step 1: 2-D Discrete Haar Wavelet Analysis (DWT)

LL	HL
LH	HH

Method 1: Step1 - DWT

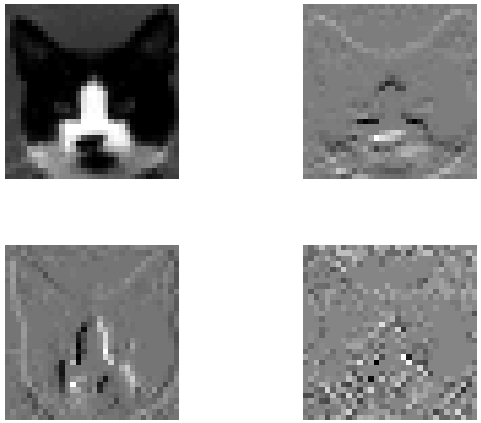
Wavelet decomposition of the cat



Now, each of the images are 32-by-32.

Method 1: Step1 - DWT

Extract the edges

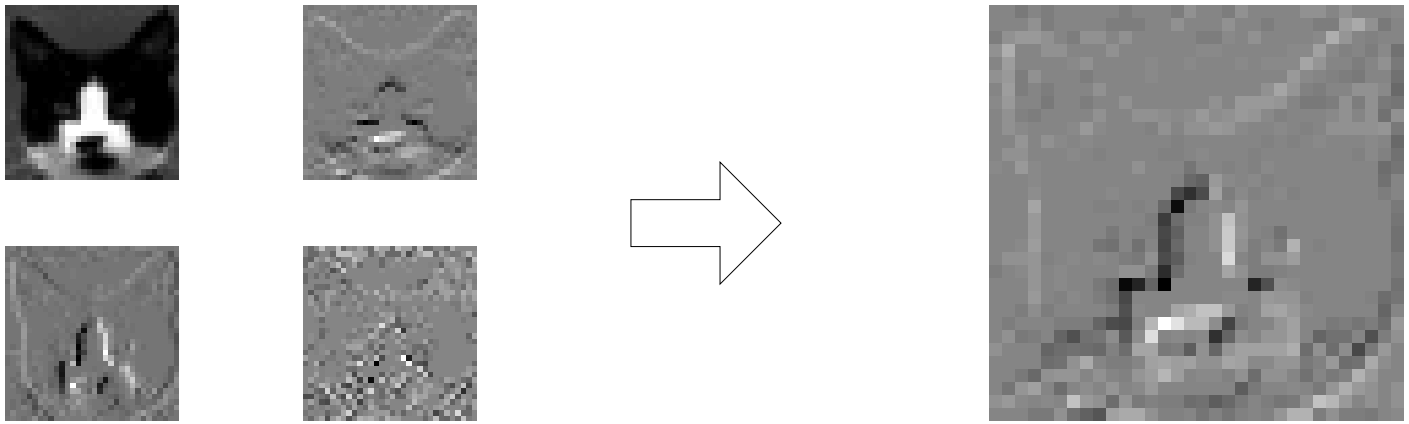


Method 1: Step1 - DWT

Extract the edges

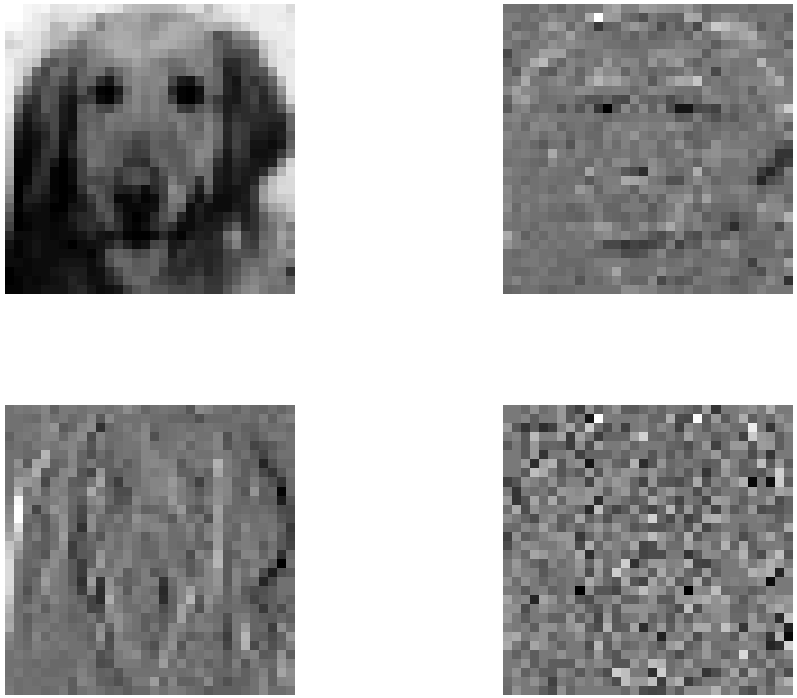
Method 1: Step1 - DWT

Extract the edges



Method 1: Step1 - DWT

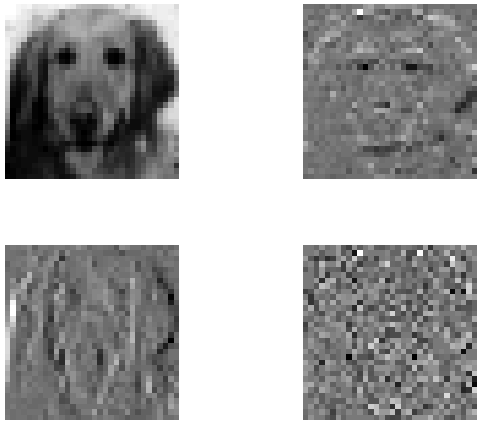
Wavelet decomposition of the dog



Now, each of the images are 32-by-32.

Method 1: Step1 - DWT

Extract the edges

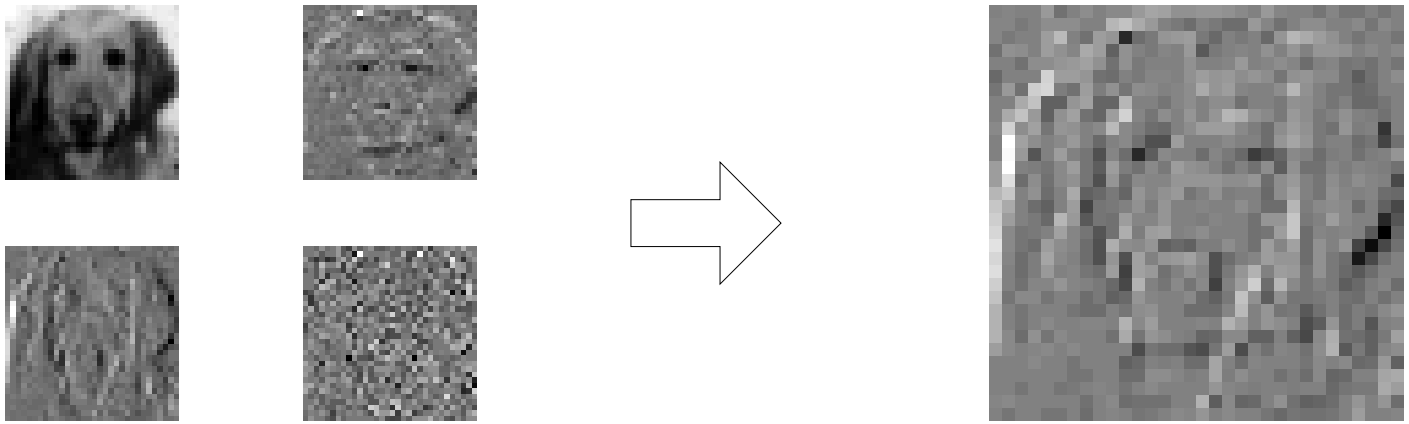


Method 1: Step1 - DWT

Extract the edges

Method 1: Step1 - DWT

Extract the edges

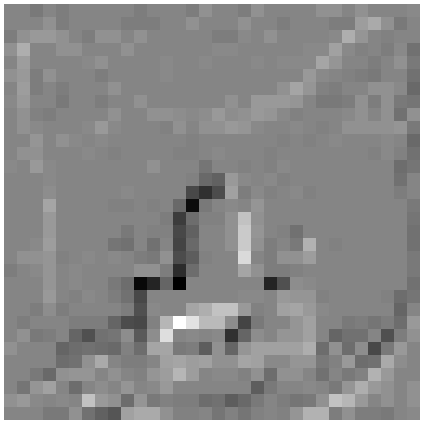


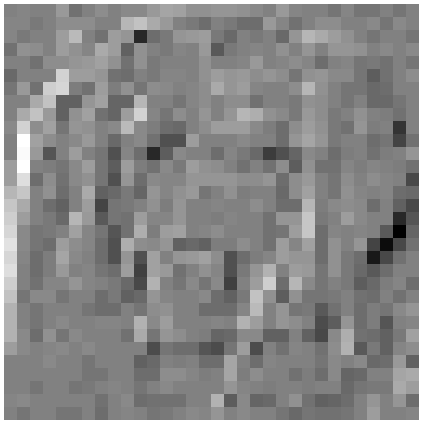
Method 1: Step1 - DWT

The original images

Method 1: Step1 - DWT

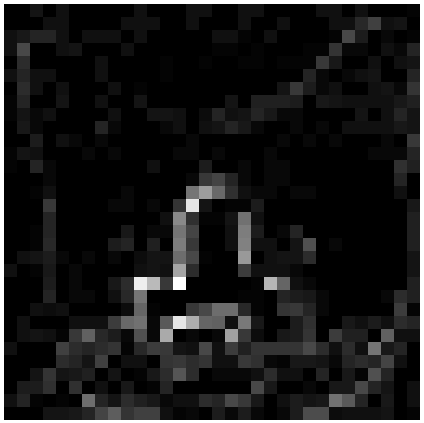
Images after wavelet decomposition

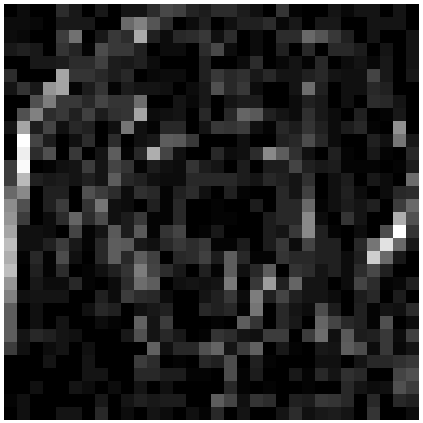




Method 1: Step1 - DWT

Images after color rescaling





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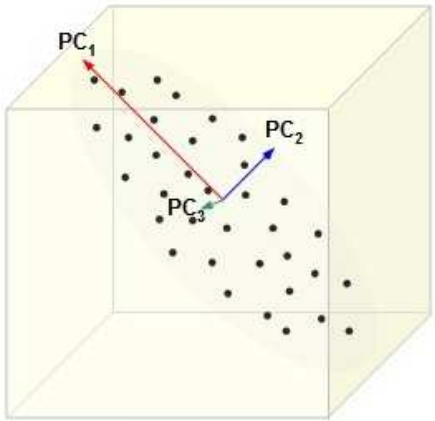
Method 1: Step2 - PCA

Step 2: Principal Component Analysis (PCA)



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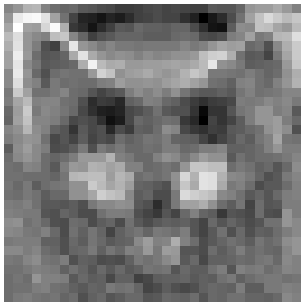
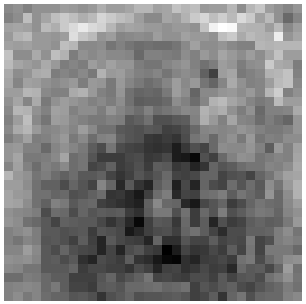
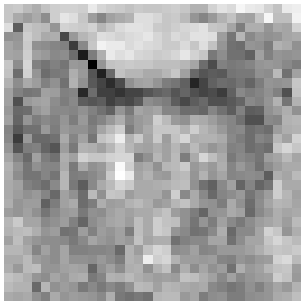
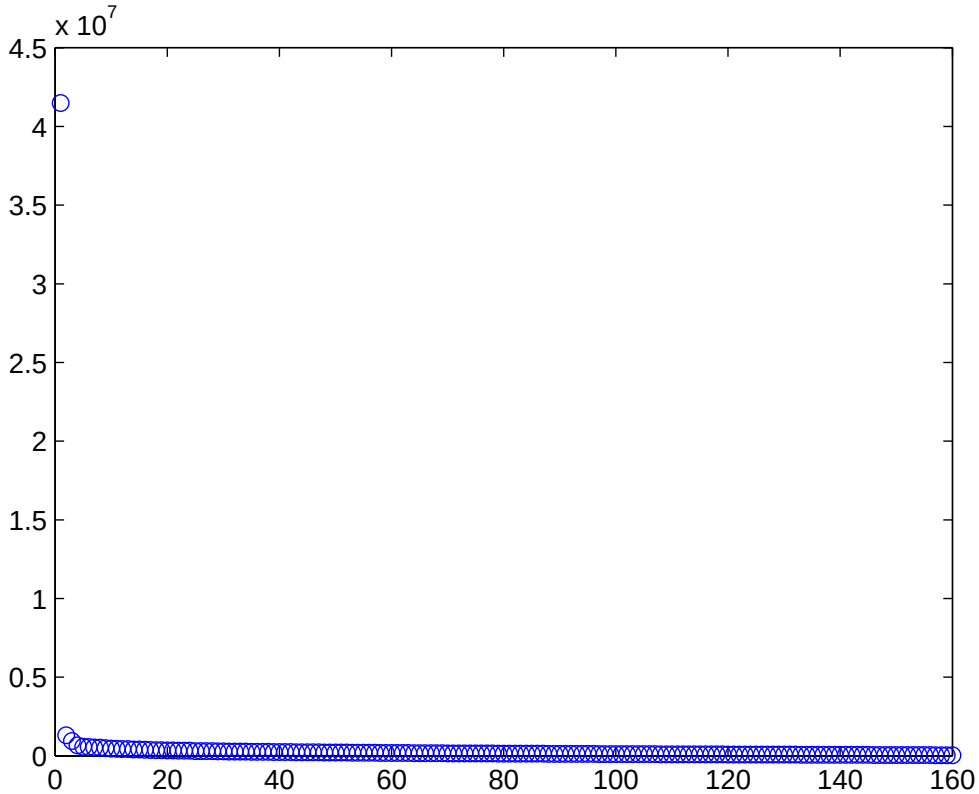
Method 1: Step2 - PCA

First 4 principal components

Method 1: Step2 - PCA

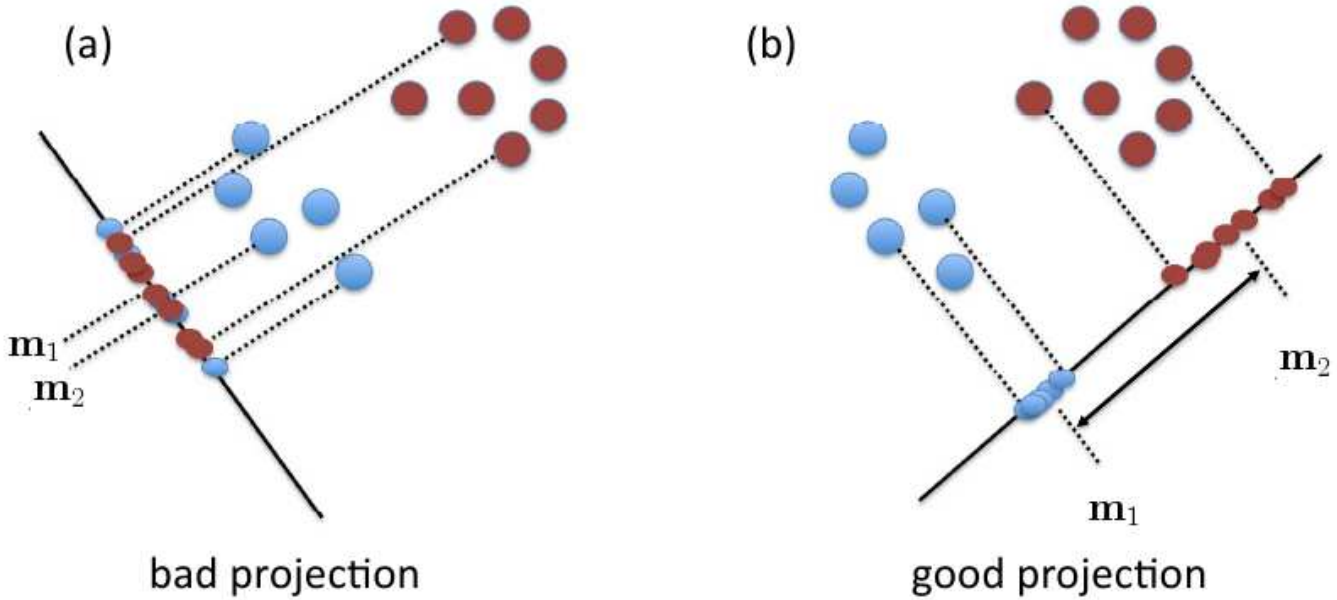
Plot of eigenvalues



We use 20 features for classification.

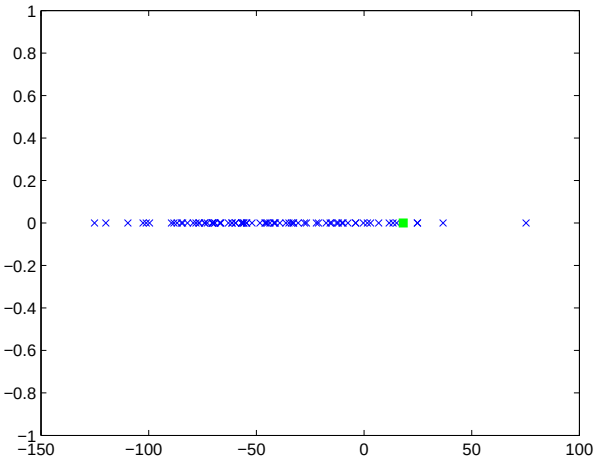
Method 1: Step3 - FDA

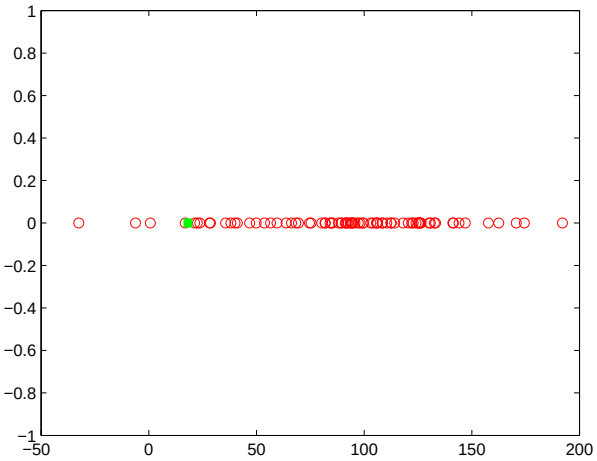
Step 3: Fisher's Linear Discriminant Analysis (FDA)



Method 1: Step3 - FDA

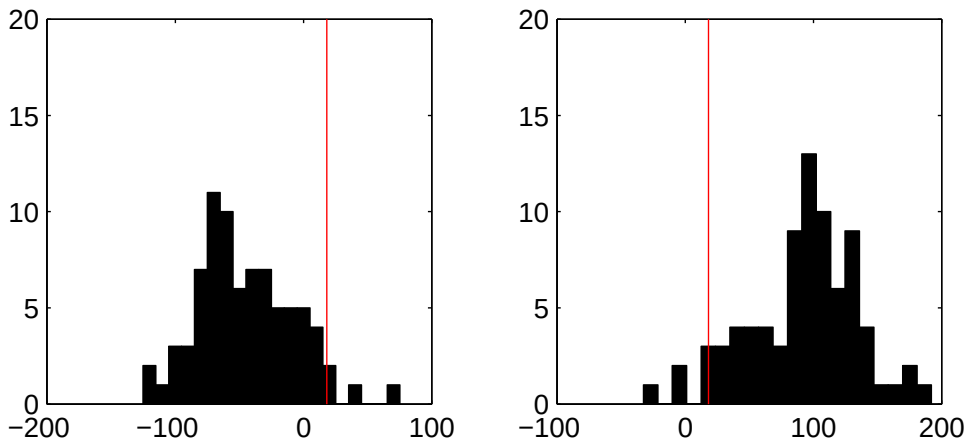
Classification of 80 cats and 80 dogs





Method 1: Step3 - FDA

Histogram of the classification



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Method 2

1. Average Filter and Laplacian Filter
2. Principal Component Analysis (PCA)
3. Fisher's Linear Discriminant Analysis (FDA)

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Method 2: Step1 - Mask

Step 1.1: Weighted Average Filter

$$\frac{1}{16}\begin{bmatrix}1 & 2 & 1\\ 2 & 4 & 2\\ 1 & 2 & 1\end{bmatrix}$$

Method 2: Step1 - Mask

Step 1.2: Laplacian Filter

$$\begin{bmatrix} -1 & -1 & -1 \\ -1 & 8 & -1 \\ -1 & -1 & -1 \end{bmatrix}$$

Method 2: Step1 - Mask

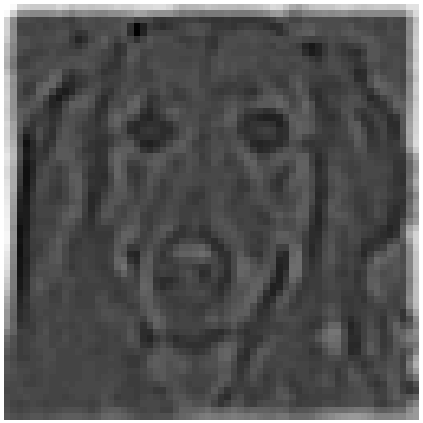
The original images

Method 2: Step1 - Mask

Images after average filter

Method 2: Step1 - Mask

Images after Laplacian filter



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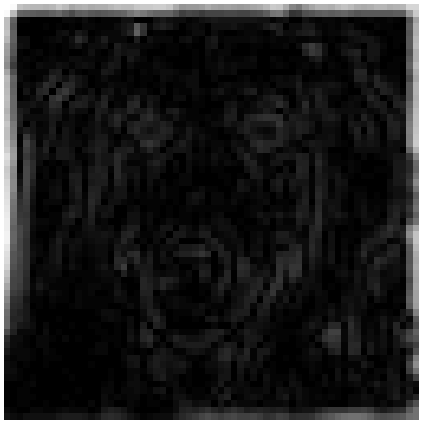
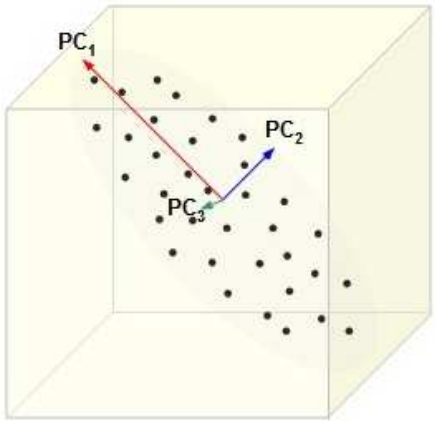
Method 2: Step1 - Mask

Images after color rescaling



Method 2: Step2 - PCA

Step 2: Principal Component Analysis (PCA)



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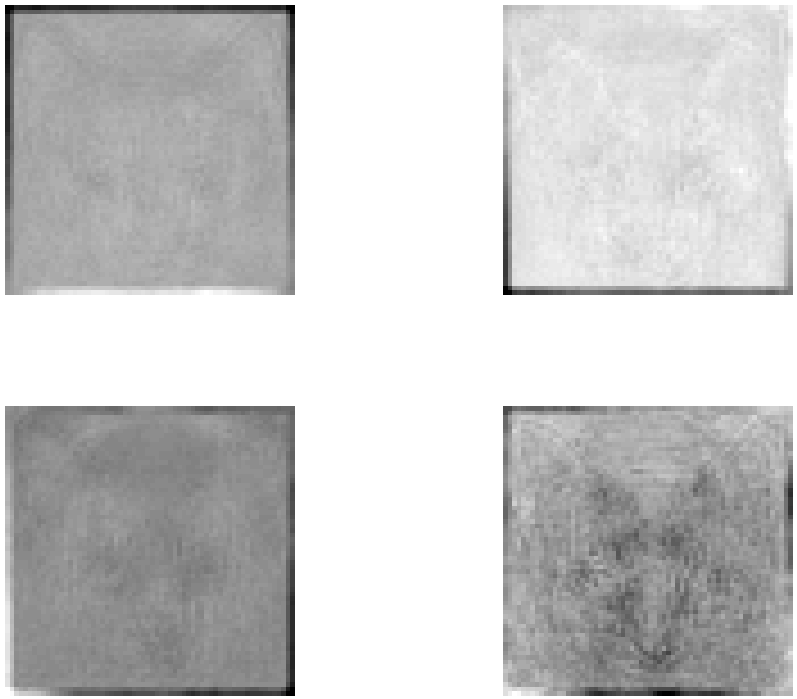
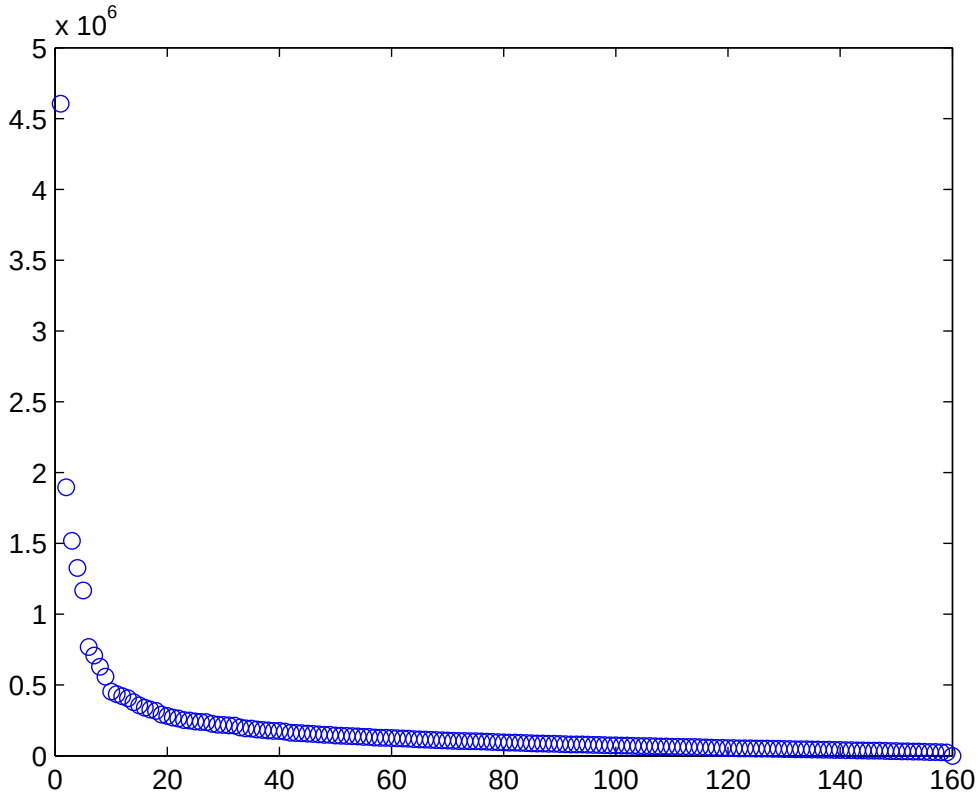
Method 2: Step2 - PCA

First 4 principal components



Method 2: Step2 - PCA

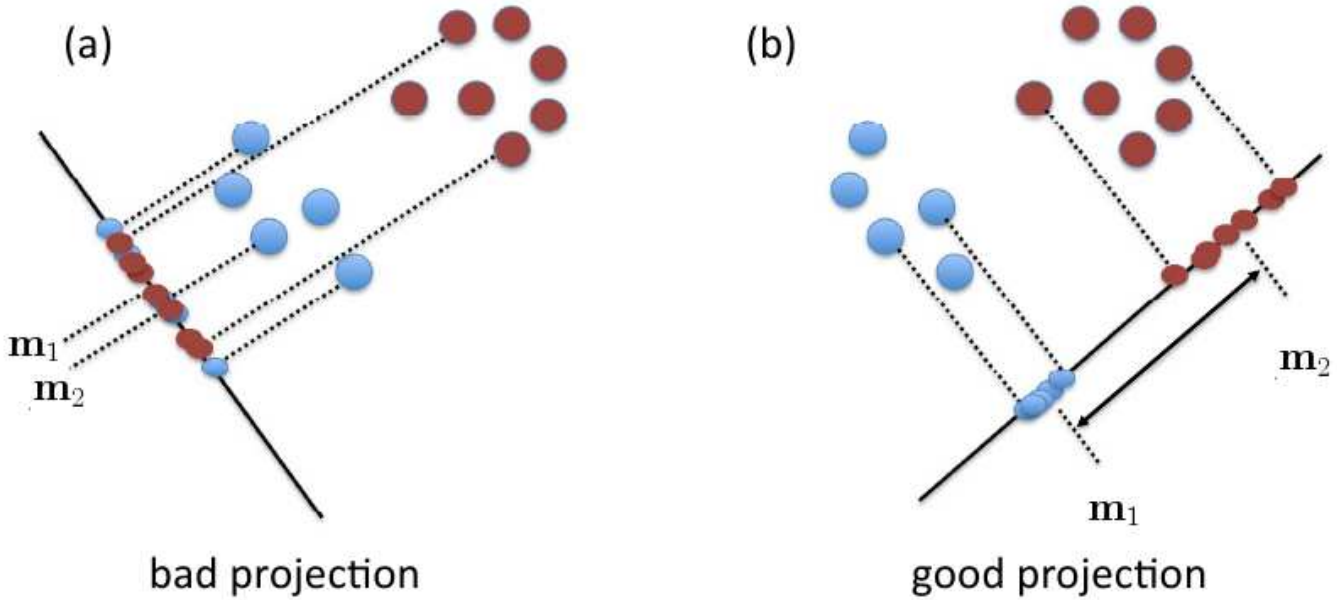
Plot of eigenvalues



We use 121 features for classification.

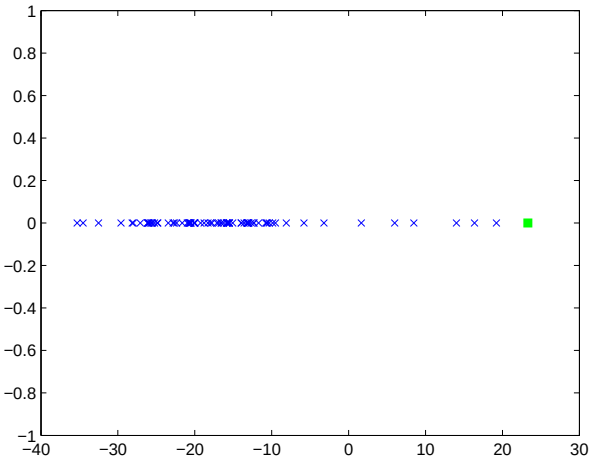
Method 2: Step3 - FDA

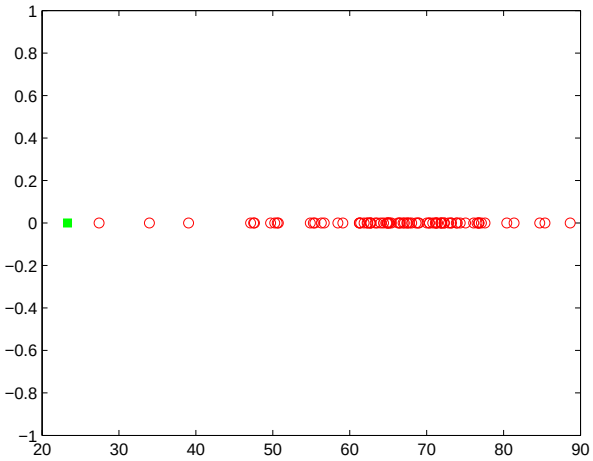
Step 3: Fisher's Linear Discriminant Analysis (FDA)



Method 2: Step3 - FDA

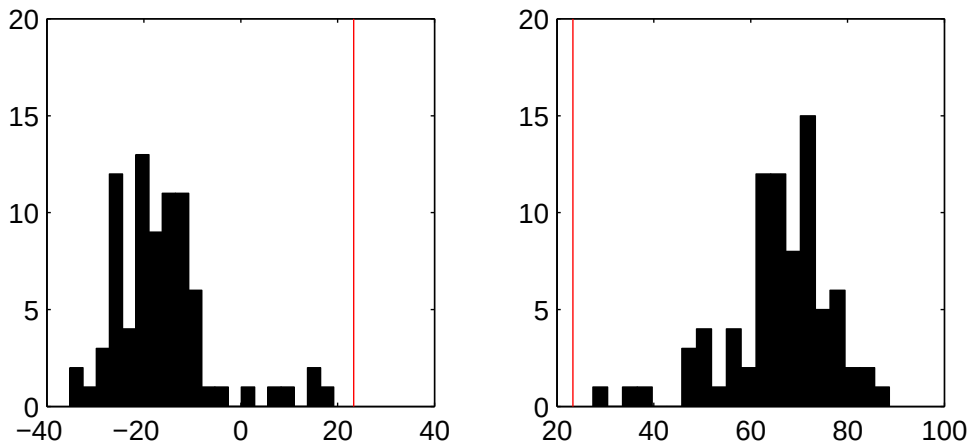
Classification of 80 cats and 80 dogs





Method 2: Step3 - FDA

Histogram of the classification



Classification

Now, classify 38 images as either cats or dogs.

Method 1

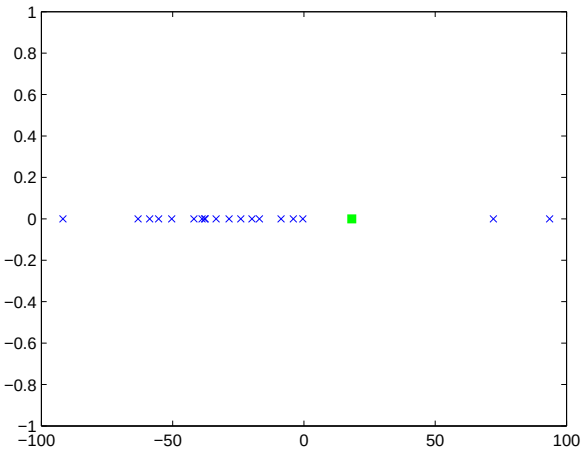
1. 2-D Discrete Haar Wavelet Transform (DWT)
2. Principal Component Analysis (PCA)
3. Fisher's Linear Discriminant Analysis (FDA)

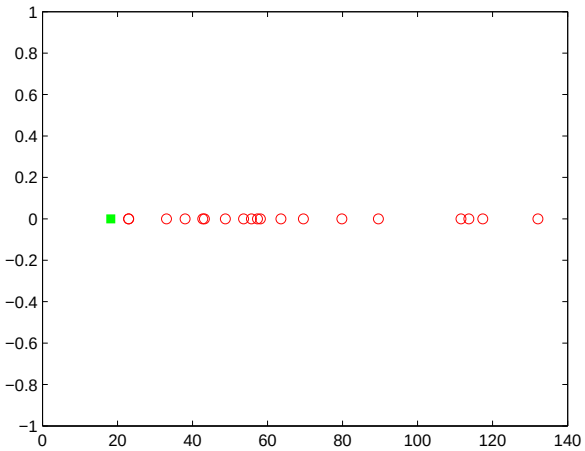
Method 2

1. Average Filter and Laplacian Filter
2. Principal Component Analysis (PCA)
3. Fisher's Linear Discriminant Analysis (FDA)

Result: Method 1

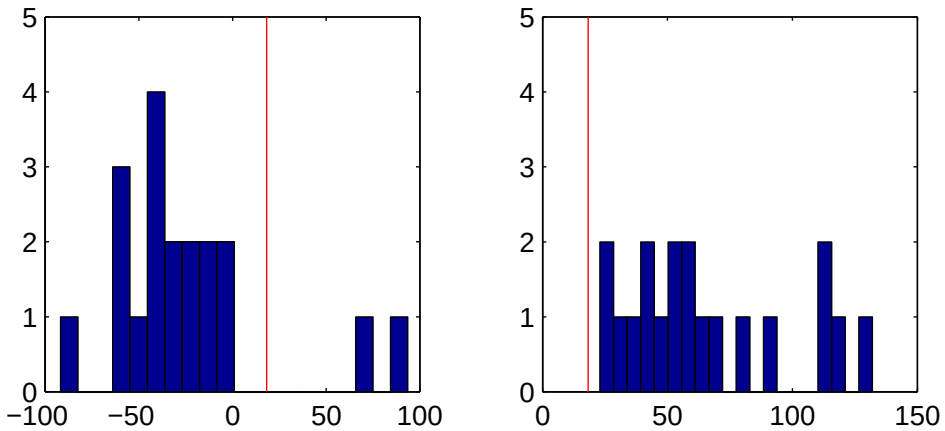
Classification of 38 unknown cats and dogs





Result: Method 1

Histogram of classificaion



Result: Method 1

Classification Result of Method 1

		Actual	
		cat	dog
Classified	cat	19	2
	dog	0	17

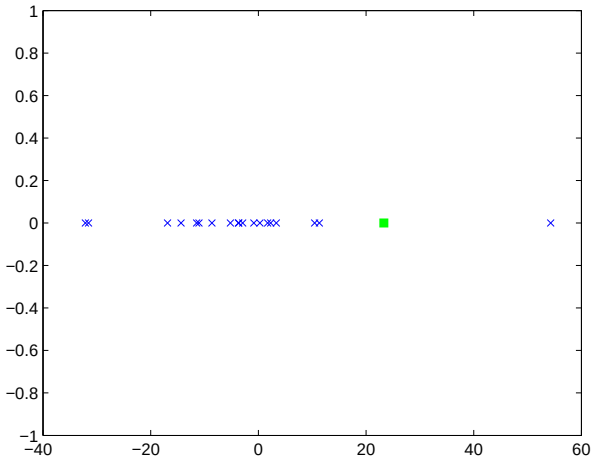
Classification rate: 94.74%

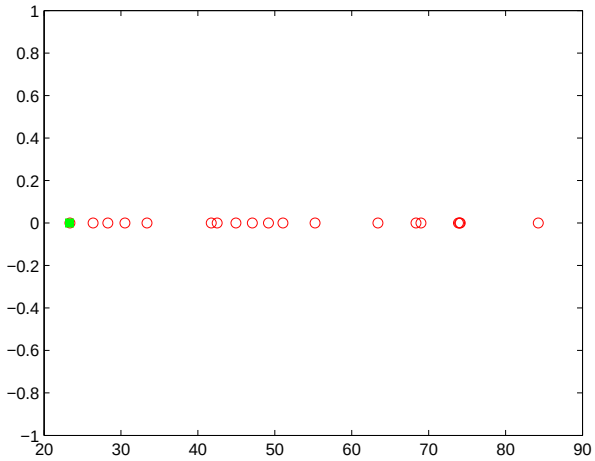
Result: Method 1

Misclassified Dogs

Result: Method 2

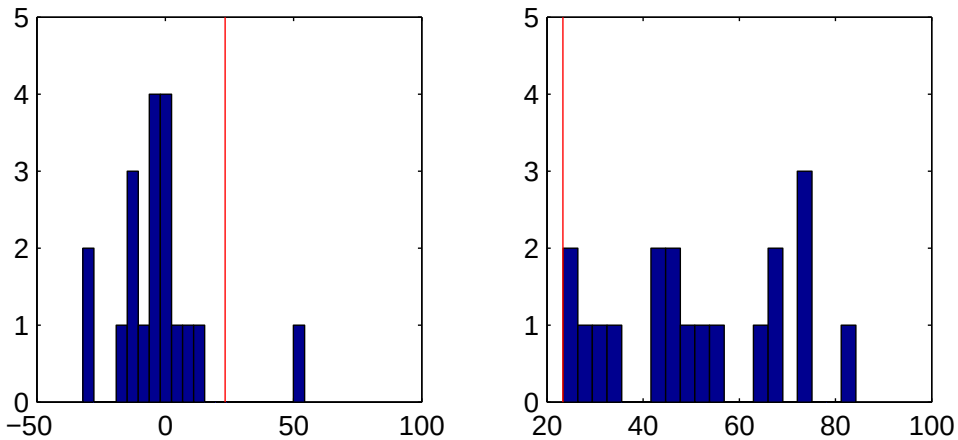
Classification of 38 unknown cats and dogs





Result: Method 2

Histogram of classificaion



Result: Method 2

Classification Result of Method 2

		Actual	
		cat	dog
Classified	cat	19	1
	dog	0	18

Classification rate: 97.37%

Result: Method 2

Misclassified Dog

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Summary

- Using 80 cats and 80 dogs, form a projection direction for classification

Summary

- Using 80 cats and 80 dogs, form a projection direction for classification
- Project 38 unknown images using the same direction

Summary

Method 1

1. 2-D Discrete Haar Wavelet Transform (DWT)
2. Principal Component Analysis (PCA)
3. Fisher's Linear Discriminant Analysis (FDA)

$\Downarrow$

94.74%

Method 2

1. Average Filter and Laplacian Filter
2. Principal Component Analysis (PCA)
3. Fisher's Linear Discriminant Analysis (FDA)

$\Downarrow$

97.37%

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Analysis

- The second method results in a better classification than the first method.

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- The second method results in a better classification than the first method.
- Why?

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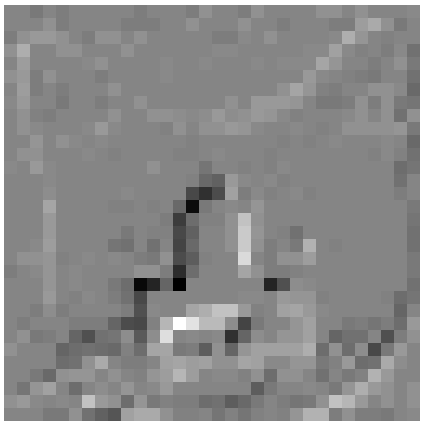
- The second method results in a better classification than the first method.
- Why?



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- Edge detection is important.
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Conclusion

- Edge detection is important.
- Laplacian mask works better than wavelet analysis in this case.
- Other methods might work better for a different set of images.

Reference

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