

# **2-Class Classification**

## **A Study**

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MATH 695  
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# Outline

- Introduction
- Methods
- Implementation
- Results
- Conclusions

# Introduction

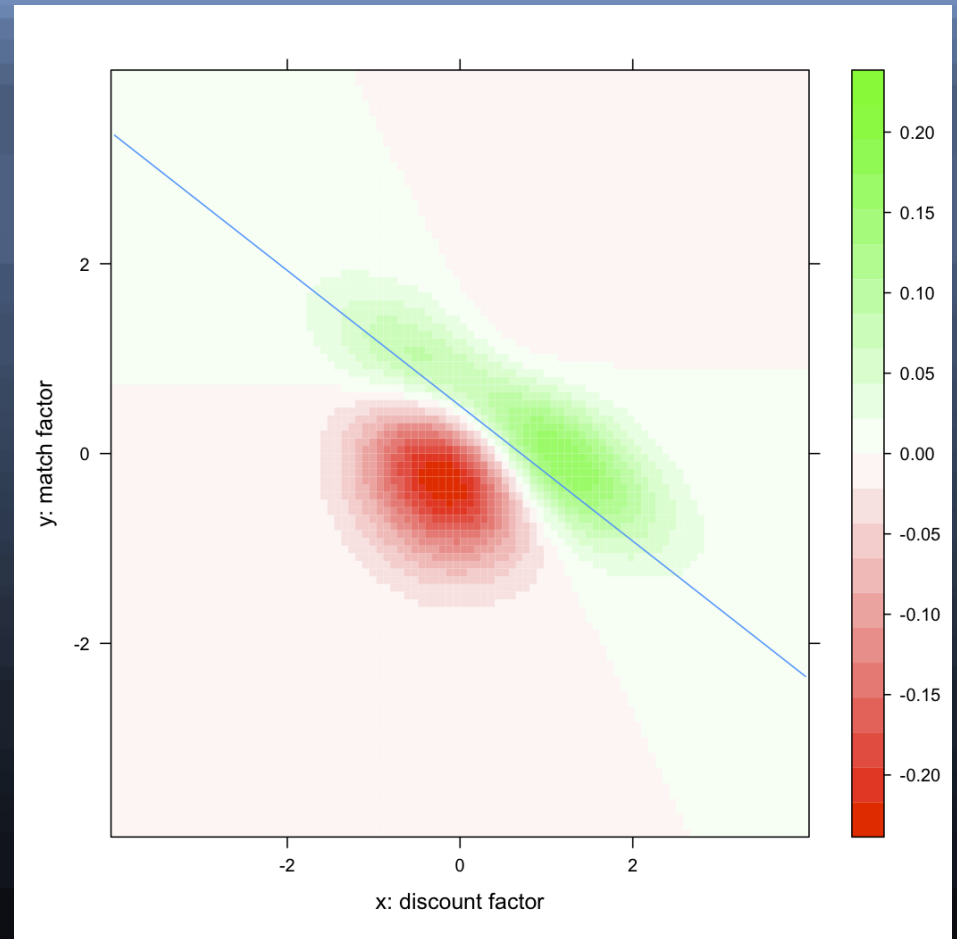
- Problem:
  - Given images of cats and dogs, create classifier that accurately classifies images as either “cat” or “dog”
- Solution: 2 kinds of algorithms:
  - Classifiers
  - Methods that help improve accuracy of classifiers

# Methods

- Fisher's Discriminant Analysis (FDA) \*
- Mean Vector Norm Difference (MVND)\*
- Principal Angles (PA)\*
- Wavelet Decomposition
- Principal Components Analysis (PCA)
- 2D Convolution

# Methods

- FDA (2 class)
- Decision rule used to classify image as cat or dog.
- Uses a projection onto the real line to try to separate class 1 and class 2



# Methods

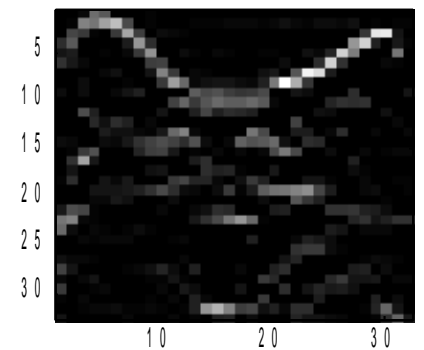
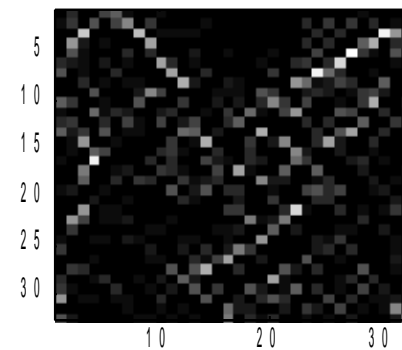
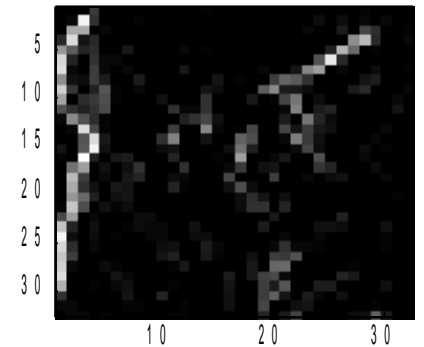
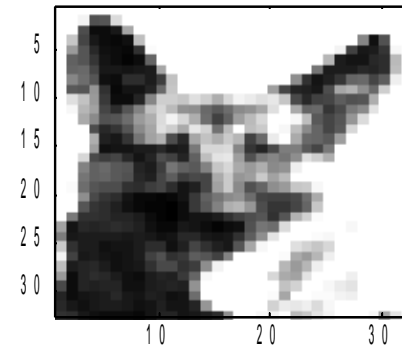
- Mean Vector Norm Difference (MVND) used to classify an unknown image
- Given: cat images, dog images, & an unknown probe image
  - Find the mean vector of the cats, subtract the probe vector, and take the norm of the result.
  - Find the mean vector of the dogs, subtract the probe vector, and take the norm of the result.
  - Whichever norm is smaller, classify probe as that kind of image

# Methods

- Principal Angles used to classify an unknown probe image.
- Given cat images, dog images, & an unknown probe image
  - Compute the principal angle between probe and the cats
  - Compute the principal angle between probe and the dogs
  - Whichever principal angle is smaller, classify probe as that kind of image

# Methods

- Wavelet Decomposition
- Used to improve correct classification
- Decompose an image into an approximation, horizontal, vertical and diagonal details



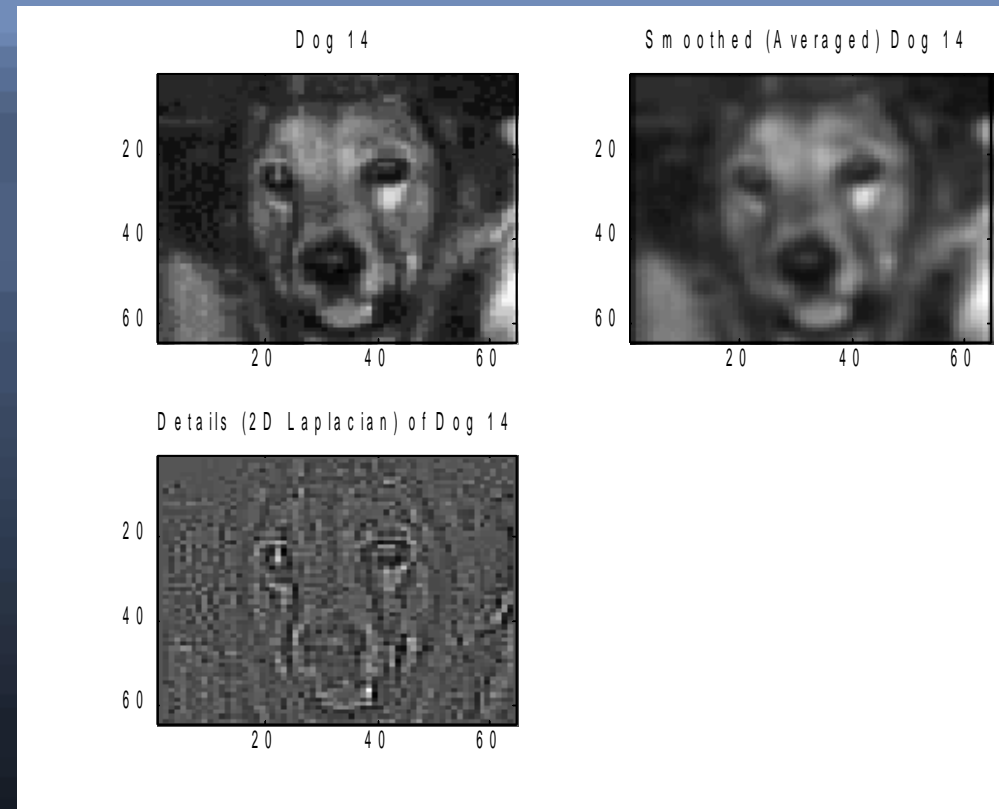


# Methods

- Principal Component Analysis
- Used to improve correct classification and reduces dimensionality
- It projects to lower dimensions while retaining the most information (variance)

# Methods

- 2D Convolution
- Used to improve correct classification
- 2 Types:
  - Averaging – smooths image
  - Laplacian – extracts features



# Implementation

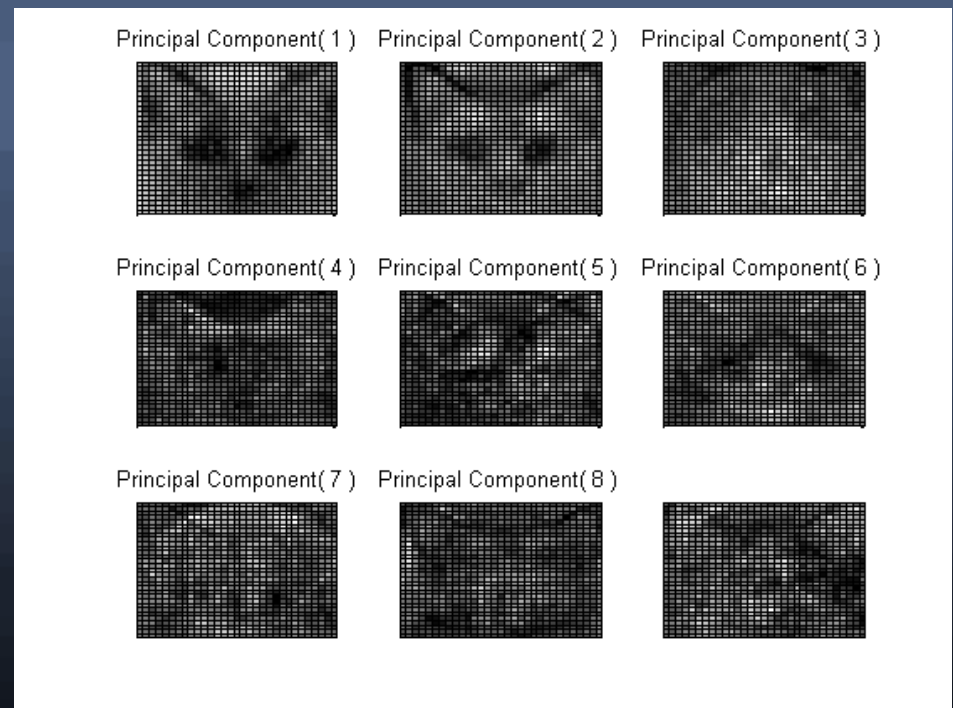
- Melissa's FDA classifier
- Kelly's MVND classifier
- Erich's PA Classifier

# Implementation

- Melissa's FDA classifier
- Preprocessing (before classifying)
  - Use wavelet decomposition to get details
  - PCA to project data for FDA
  - FDA finds a projection that tries to classify dogs and cats.

# Implementation

- Melissa's FDA classifier
- Uses wavelet decomposition and PCA.
- Mixes both classes of data and tries to separate class 1 and class 2



# Implementation

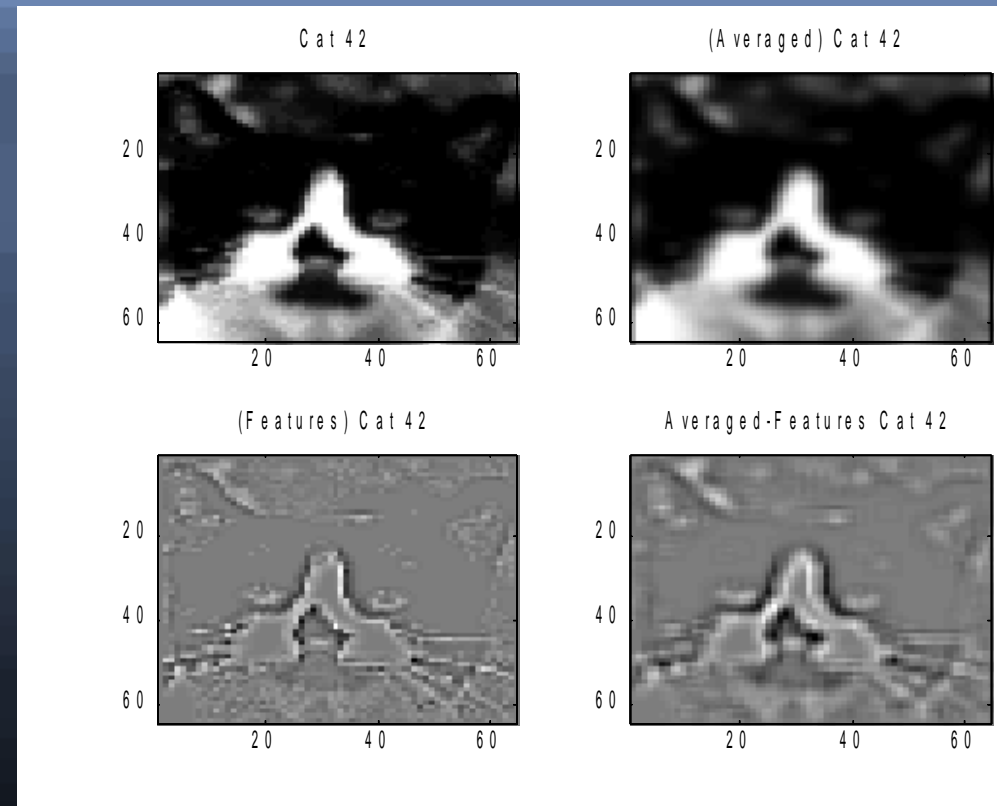
- Kelly's Mean Vector Norm Difference (MVND) classifier
- Classify probe image by minimum norm difference.
- Supporting methods – 2D Convolution (Laplacian, or averaging) & PCA did not improve accuracy.

# Implementation

- Erich's Principal Angle Classifier
- Preprocessing: (before classifying)
  - For every image (training & probe) get:
    - Average – Smooth every image with an average filter
    - Details – Extract details of every image with 2D Laplacian filter
    - Averaged-Details – Smooth the result of the 2D Laplacian with the average filter

# Implementation

- Erich's PA Classifier
- Classify using PAs on the average, detail, and averaged-detail images
- Vote for classification
- If 2 say “cat” and 1 says “dog” → classify as “cat”





# Results

- Melissa's Wavelet FDA classifier
- Kelly's MVND classifier
- Erich's Principal Angles classifier

# Results

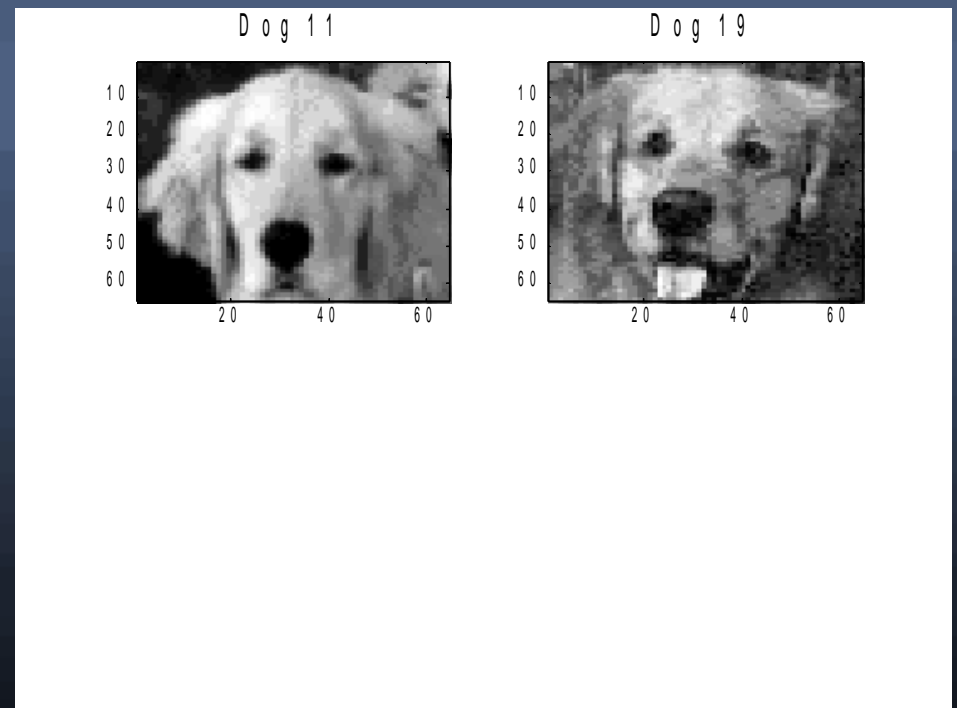
- Melissa's Wavelet FDA Classifier
- LOOC correct classification rate
  - 90%
- Correct classification rate on 38 test images
  - 94.74%

LOOC	Truth	
Classified as:	Cat	Dog
Cat	74	10
Dog	6	70
Correct (%)	92.5%	87.5%
Overall Correct(%)	90%	

Test Set	Truth	
Classified as:	Cat	Dog
Cat	19	2
Dog	19	17
Correct (%)	100%	89.47%
Overall Correct (%)	94.74%	

# Results

- FDA Classifier
- Misclassified Dog 11 and Dog 19 from the test set.
- LOOCV-Misclassified 10 dogs and 6 cats.



# Results

- Kelly's Classifier
- LOOC correct classification rate
  - 75.63%
- Correct classification rate on 38 test images
  - 63.16%

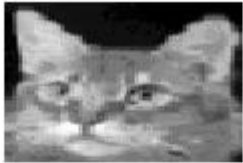
LOOC	Truth	
Classified as:	Cat	Dog
Cat	57	16
Dog	23	64
Correct (%)	71.25%	80%
Overall Correct(%)	75.63%	

Test Set	Truth	
Classified as:	Cat	Dog
Cat	12	7
Dog	7	12
Correct (%)	63.16%	63.16%
Overall Correct (%)	63.16%	

# Results

- Kelly's Classifier

2nd column picture



6th column picture



7th column picture



9th column picture



12th column picture



13th column picture



19th column picture



1th column picture



5th column picture



7th column picture



8th column picture



9th column picture



10th column picture



16th column picture



# Results

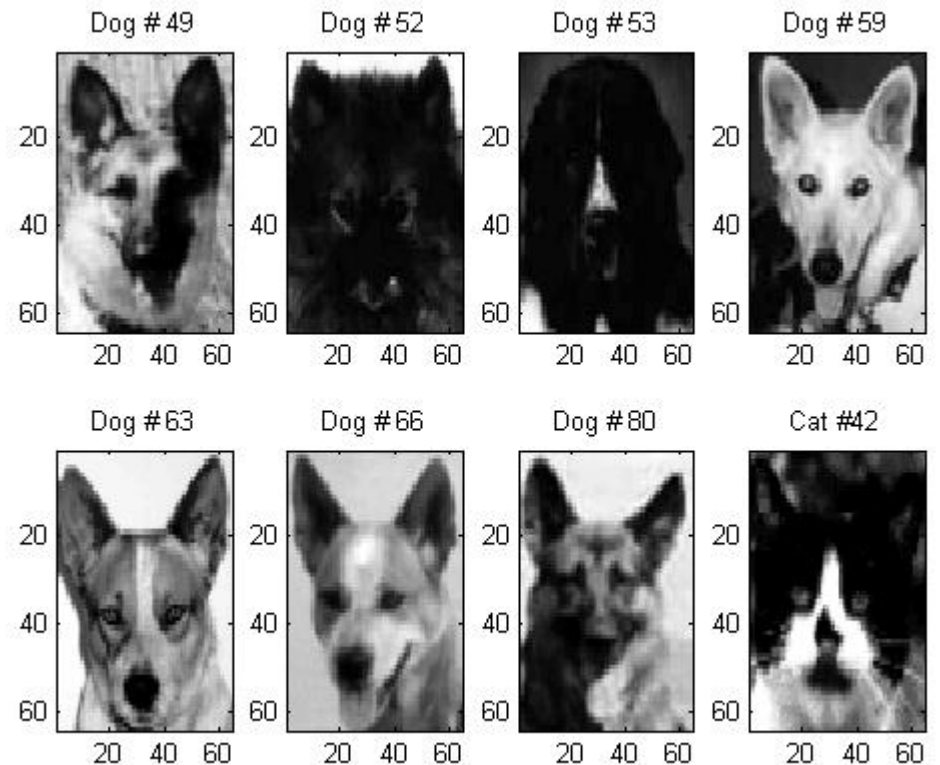
- Erich's PA Classifier
- LOOC correct classification rate
  - 95%
- Correct classification rate on 38 test images
  - 94.74%

LOOC	Truth	
Classified as:	Cat	Dog
Cat	79	7
Dog	1	73
Correct (%)	98.75%	91.25%
Overall Correct(%)	95%	

Test Set	Truth	
Classified as:	Cat	Dog
Cat	18	1
Dog	1	18
Correct (%)	94.74%	94.74%
Overall Correct(%)	94.74%	

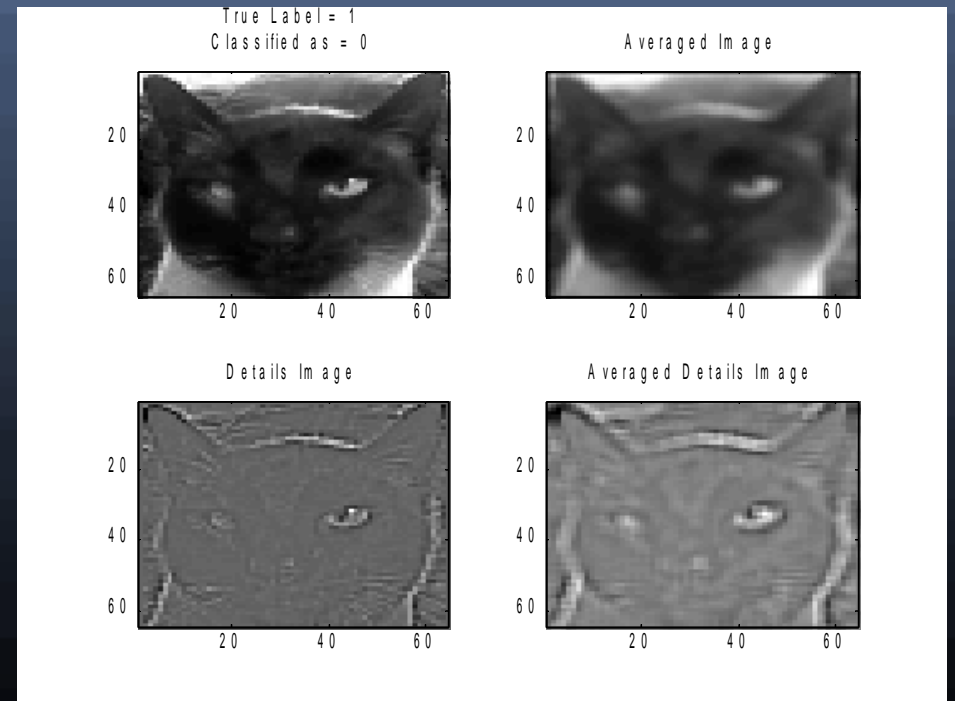
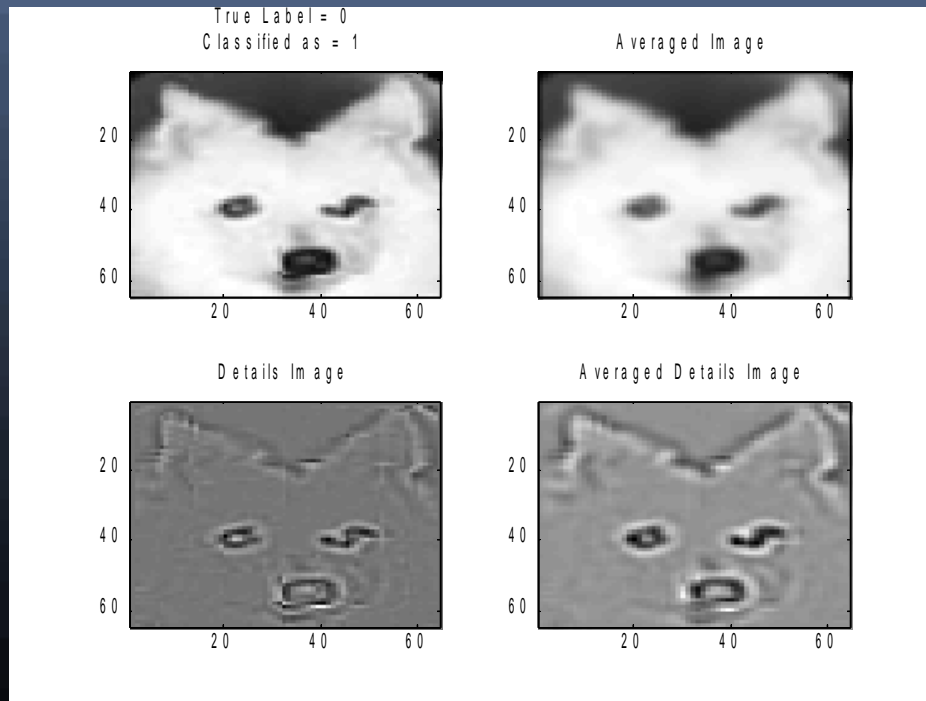
# Results

- Erich's Principal Angles Classifier LOOC Performance
- Misclassified 7 dogs
- Misclassified 1 cat



# Results

PA classifier missed 1 cat and 1 dog of the test set.





# Conclusions

- MVND – Very fast but can be tricked by overly bright images.
- Wavelet FDA – Very Accurate, fast.
- PA Voting Classifier – works well but very slow.