# The Cheetah problem

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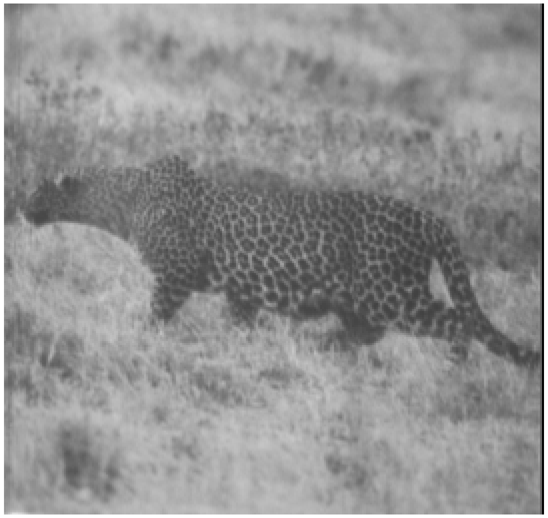
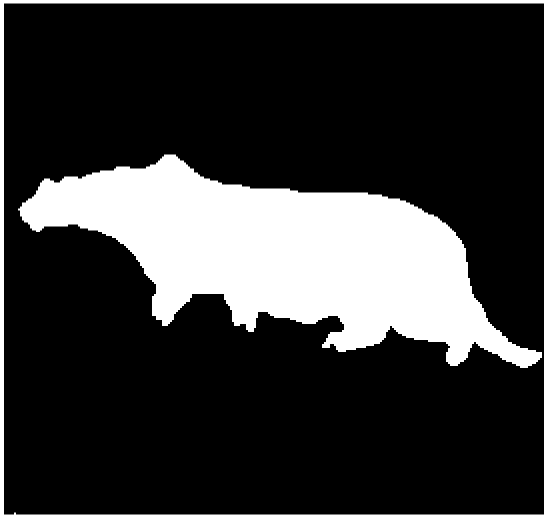
ECE 271A

# Cheetah

- statistical learning only makes sense when you try it on data
- we will test what we learn on a image processing problem
  - given the cheetah image, can we teach a computer to segment it into object and foreground?
  - the question will be answered with different techniques, typically one problem per week
- first problem this week
  - brief introduction to image representation (features) and other pre-processing steps





# Image representation

- we will use the discrete cosine transform (DCT)
  - think of it as a Fourier Transform, but real
  - maps an array of pixels (image block) into an array of frequency coefficients
  - for block x(i,j)

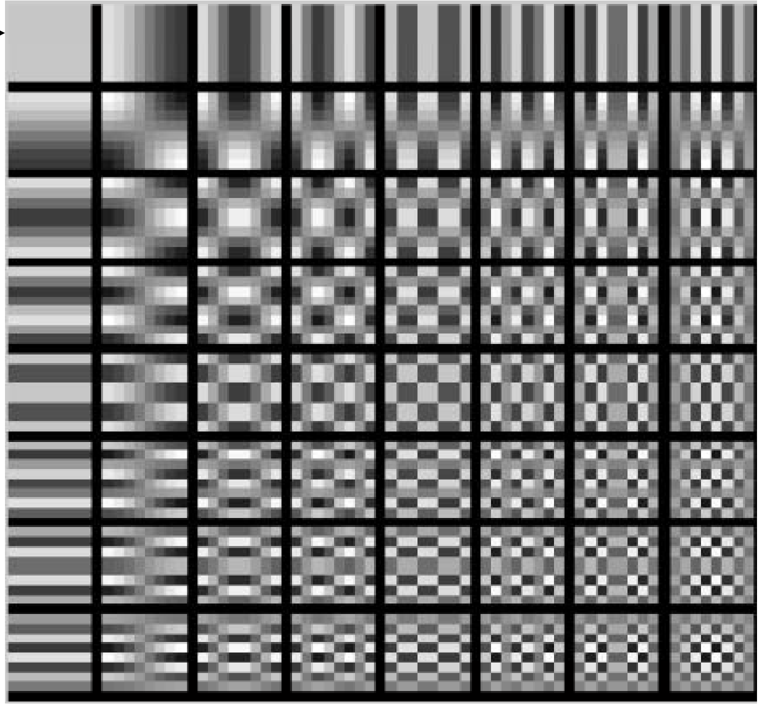
$$T(k_1,k_2) = \sum_{i=0}^{N-1}\sum_{j=0}^{N-1} 4x(i,j)\cos\left[\frac{\pi k_1}{2N}(2i+1)\right]\cos\left[\frac{\pi k_1}{2N}(2j+1)\right]$$

  - each coefficient is a projection onto a basis function
  - basis functions are 2D sinusoids of different frequencies
  - *$T(k_1,k_2)$* captures image information on the frequency band

$$\left[\frac{\pi k_1}{2N},\frac{\pi k_1}{2N}+1\right]x\left[\frac{\pi k_2}{2N},\frac{\pi k_2}{2N}+1\right]$$

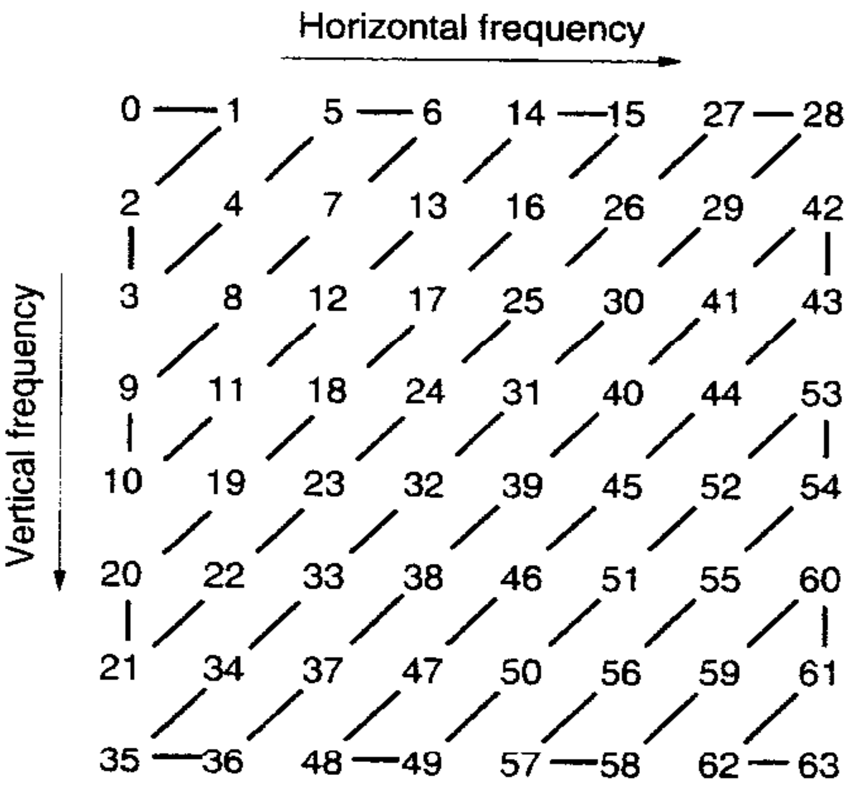
# In a picture

- we will use blocks of 8 x 8 pixels
- the DCT basis functions are →
- 1st function is constant, 1st coefficient is the block mean, not very interesting (depends on illumination etc.)
- there is a MATLAB function – dct2(.) – that computes the DCT coefficients



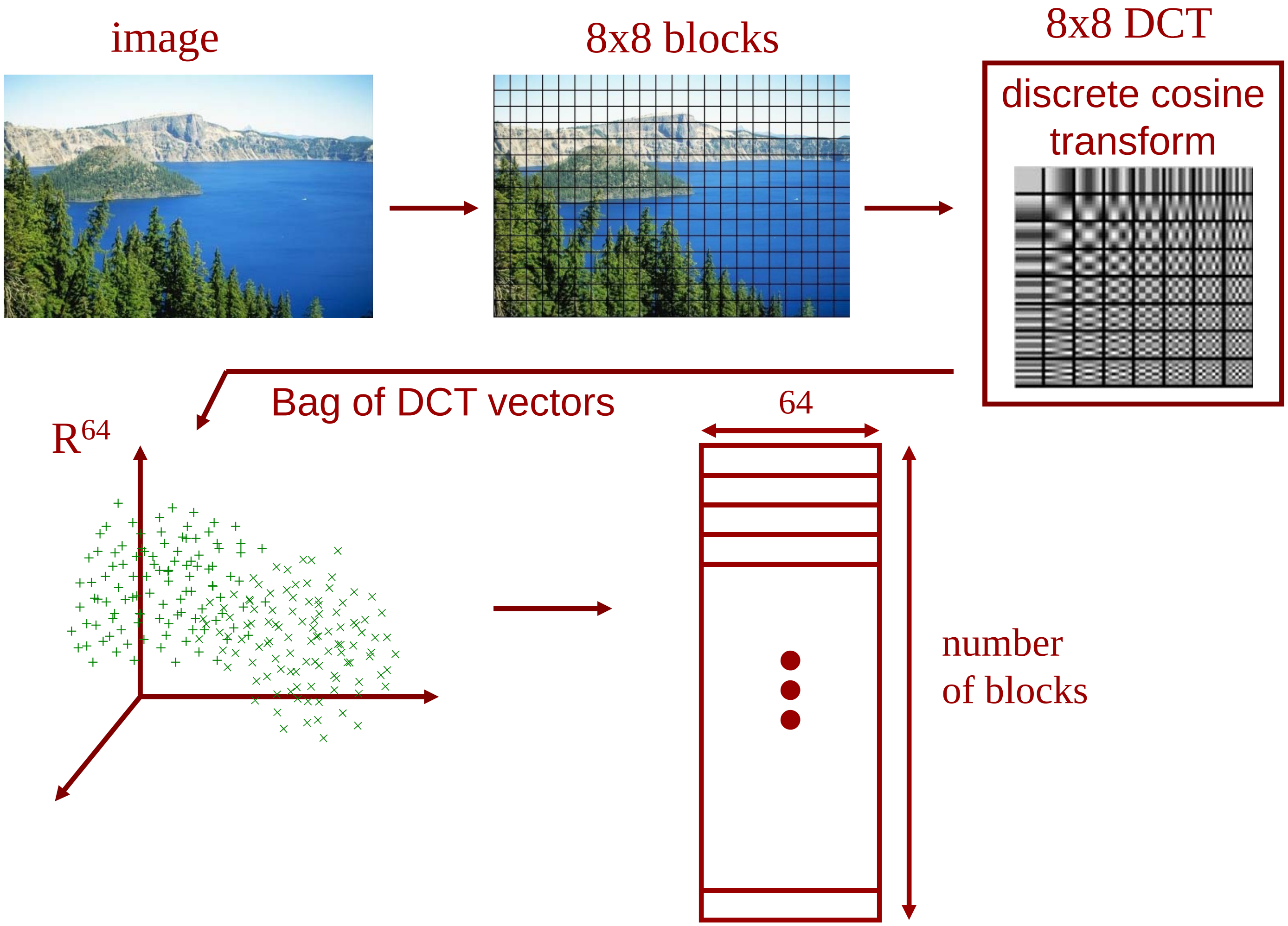
# In a picture

- coefficients have a natural order by frequency
- it is called the zig-zag pattern
- allows us to transform the 2D array of coefficients into a vector
- this vector has 64 features, i.e. is a point on a 64D space
- we will make available a file with this zig-zag pattern



| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 0 | 1 | 5 | 6 | 14 | 15 | 27 | 28 |
| 2 | 4 | 7 | 13 | 16 | 26 | 29 | 42 |
| 3 | 8 | 12 | 17 | 25 | 30 | 41 | 43 |
| 9 | 11 | 18 | 24 | 31 | 40 | 44 | 53 |
| 10 | 19 | 23 | 32 | 39 | 45 | 52 | 54 |
| 20 | 22 | 33 | 38 | 46 | 51 | 55 | 60 |
| 21 | 34 | 37 | 47 | 50 | 56 | 59 | 61 |
| 35 | 36 | 48 | 49 | 57 | 58 | 62 | 63 |

# Image representation



image

8x8 blocks

8x8 DCT

discrete cosine transform

Bag of DCT vectors

$R^{64}$

64

number of blocks

# Features

- 64D is a lot, we will see later in the course how to pick good features
- for now we will use a single feature

X = location of the coefficient of 2nd largest magnitude

- e.g. for vector (100, 12, -32, -53, 14) we have X = 4
- rationale: 1st coefficient is always the largest, but not very informative, 2nd largest gives the dominant frequency band
- note that X is now a scalar feature, we can estimate all CCDs with histograms

# Classifier

- Training:
  - break training images into 8x8 blocks
  - for each block
    - compute DCT,
    - order coefficients with zig-zag scan
    - pick position of 2nd largest magnitude as the feature value
  - note: we will give you this!

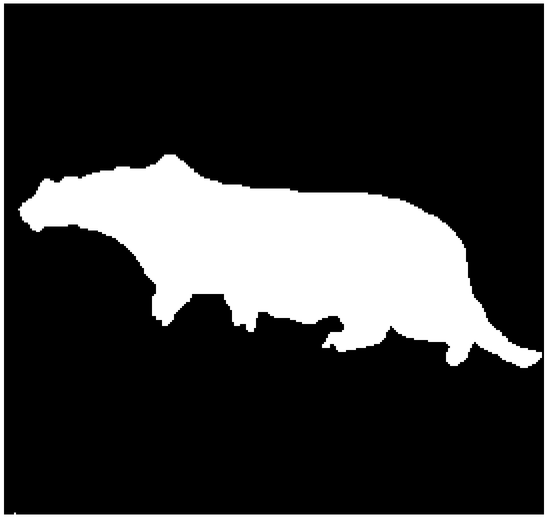
  - the collection of all such positions is the training set
  - from training set estimate $P_{X|Y}(x|\text{cheetah})$, $P_{X|Y}(x|\text{background})$, using histograms, and $P_Y(\text{cheetah})$, $P_Y(\text{background})$, using common-sense

# Classifier

- classification:
  - break training images into 8x8 blocks
  - for each block
    - compute DCT,
    - order coefficients with zig-zag scan
    - pick position of 2nd largest magnitude as the feature value
  - use BDR to find class Y for each block
  - create a binary mask with 1’s for foreground blocks and 0’s for background blocks
- note: you’ll have to implement all of this on your own

# Remarks

- this is a realistic problem
- the solution WILL NOT BE PERFECT
- there is no unique right answer
- by looking at the resulting segmentation mask, you will know if the results are "decent"
  - holes, noisy, is OK
  - but it should look somewhat like this



# Most common problems

- “my segmentation mask is very blocky”
  - during classification, use a sliding window that moves by one pixel at each step
  - this will give you a binary value per pixel (e.g. assign it to the central pixel in the block, or the top left corner) for the segmentation mask
- “I get complete garbage”
  - make sure to always work with doubles in the range [0-1] (this is how the training data was created)
  - after you read the image do
    - *im2double(image)*
    - or *double(image)/255*

# Most common problems

- “my probability of error is too high”
  - make sure to use the same histogram binning in all histograms
  - MATLAB let’s you do this easily
- “how do I read an image on MATLAB?”
  - you should be able to figure out the answers to these type of questions on your own
  - MATLAB’s help, tutorials, etc.
- other questions, email the TA, but please be gentle on her