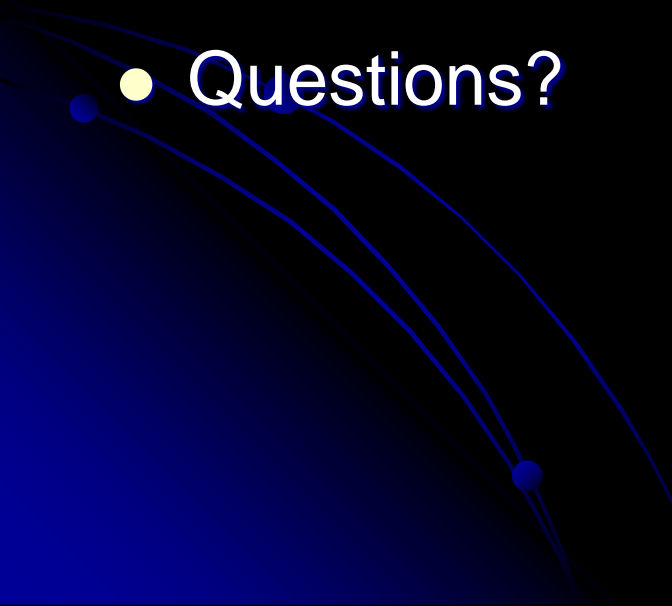


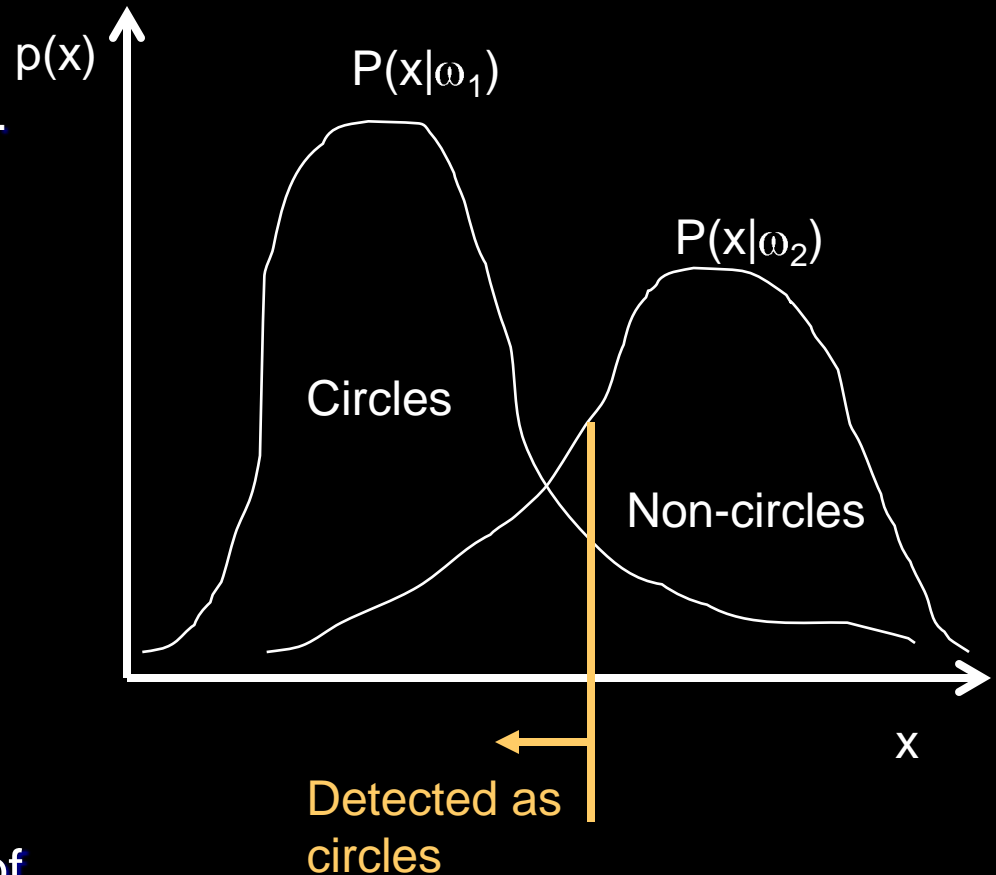
- Today: Bayesian classifiers
 - Tomorrow: Lightning talks and exam questions
 - Weds night: Lab 4 due
 - Thursday: **Exam**
 - Bring your calculator.
 - Questions?
- 

Exam Thursday

- Closed book, notes, computer
 - **BUT you may bring handwritten notes (1-side of paper)**
 - **You may also want a calculator.**
- Similar to the written assignment in format:
 - Some questions from daily quizzes
 - Some extensions of quizzes
 - Some applications of image-processing algorithms
 - Some questions asking about process you followed in lab
- Also a few Matlab-specific questions
- Write 2-3 lines of code to...

Bayesian classifiers

- Use training data
 - Assume that you know probabilities of each feature.
- If 2 classes:
 - Classes ω_1 and ω_2
 - Say, circles vs. non-circles
 - A single feature, x
 - Both classes equally likely
 - Both types of errors equally bad
- Where should we set the threshold between classes?
Here?
- Where in graph are 2 types of errors?



What if we have prior information?

- Bayesian probabilities say that if we only expect 10% of the objects to be circles, that should affect our classification

Bayesian classifier in general

- Bayes rule:
 - Verify with example
- For classifiers:
 - x = feature(s)
 - ω_i = class
 - $P(\omega|x)$ = posterior probability
 - $P(\omega)$ = prior
 - $P(x)$ = unconditional probability
 - Find best class by *maximum a posteriori (MAP)* principle. Find class i that maximizes $P(\omega_i|x)$.
 - Denominator doesn't affect calculations
 - Example:
 - indoor/outdoor classification

$$p(a | b) = \frac{p(b | a) p(a)}{p(b)}$$

$$p(\omega_i | x) = \frac{p(x | \omega_i) p(\omega_i)}{p(x)}$$

Learned from examples
(histogram)

Learned from training set (or
leave out if unknown)

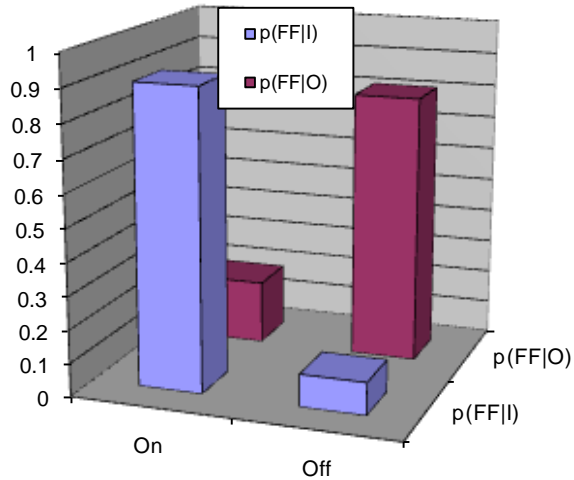
Fixed

Indoor vs. outdoor classification

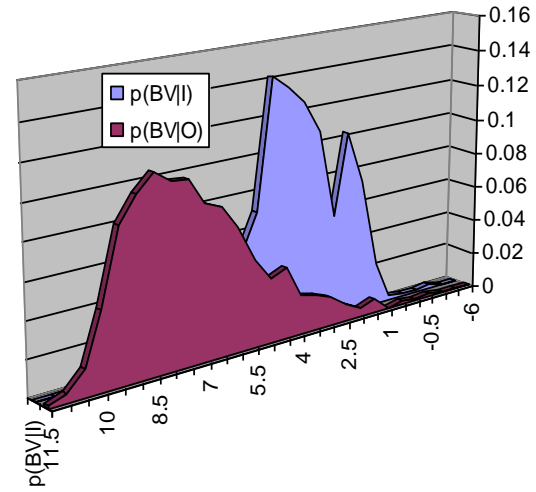
- I can use low-level image info (color, texture, etc)
- But there's another source of really helpful info!



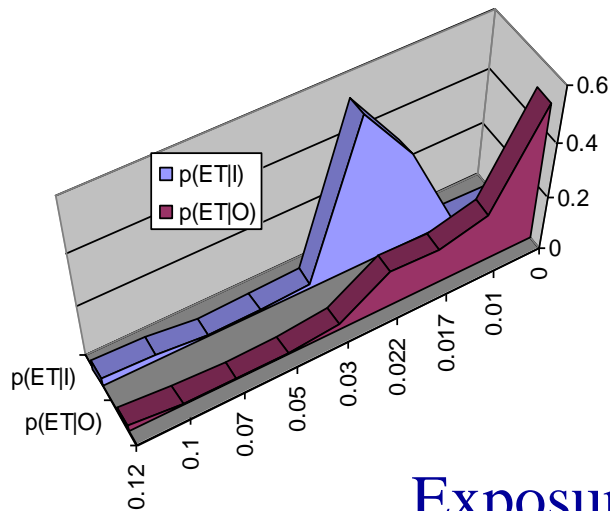
Camera Metadata Distributions



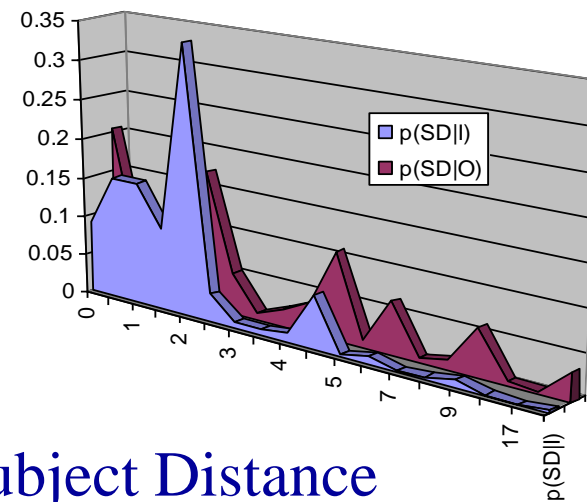
Flash



Scene Brightness



Exposure Time



Subject Distance

Why we need Bayes Rule

Problem:

We know conditional probabilities like $P(\text{flash was on} \mid \text{indoor})$

We want to find conditional probabilities like

$P(\text{indoor} \mid \text{flash was on, exp time} = 0.017, \text{sd}=8 \text{ ft, SVM output})$

Let ω = class of image, and x = all the evidence.

More generally, we know $P(x \mid \omega)$ from the training set (why?)

But we want $P(\omega \mid x)$

$$p(\omega_i \mid x) = \frac{p(x \mid \omega_i) p(\omega_i)}{p(x)}$$

Using Bayes Rule

$$P(\omega|x) = P(x|\omega)P(\omega)/P(x)$$

The denominator is constant for an image, so

$$P(\omega|x) = \alpha P(x|\omega)P(\omega)$$

Using Bayes Rule

$$P(\omega|x) = P(x|\omega)P(\omega)/P(x)$$

The denominator is constant for an image, so

$$P(\omega|x) = \alpha P(x|\omega)P(\omega)$$

We have two types of features, from image metadata (M) and from low-level features, like color (L)

Conditional independence means $P(x|\omega) = P(M|\omega)P(L|\omega)$

$$P(\omega|X) = \alpha P(M|\omega) P(L|\omega) P(\omega)$$

From histograms

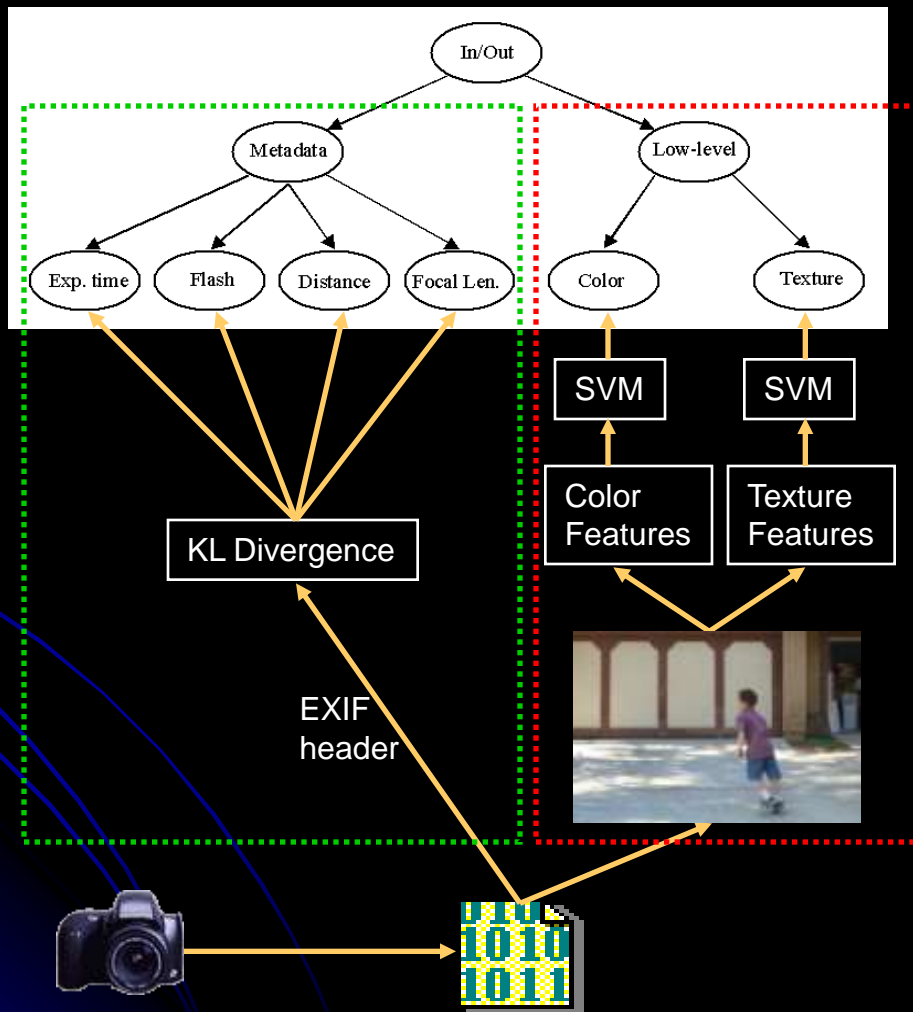
From SVM

Priors
(initial bias)

Bayesian network

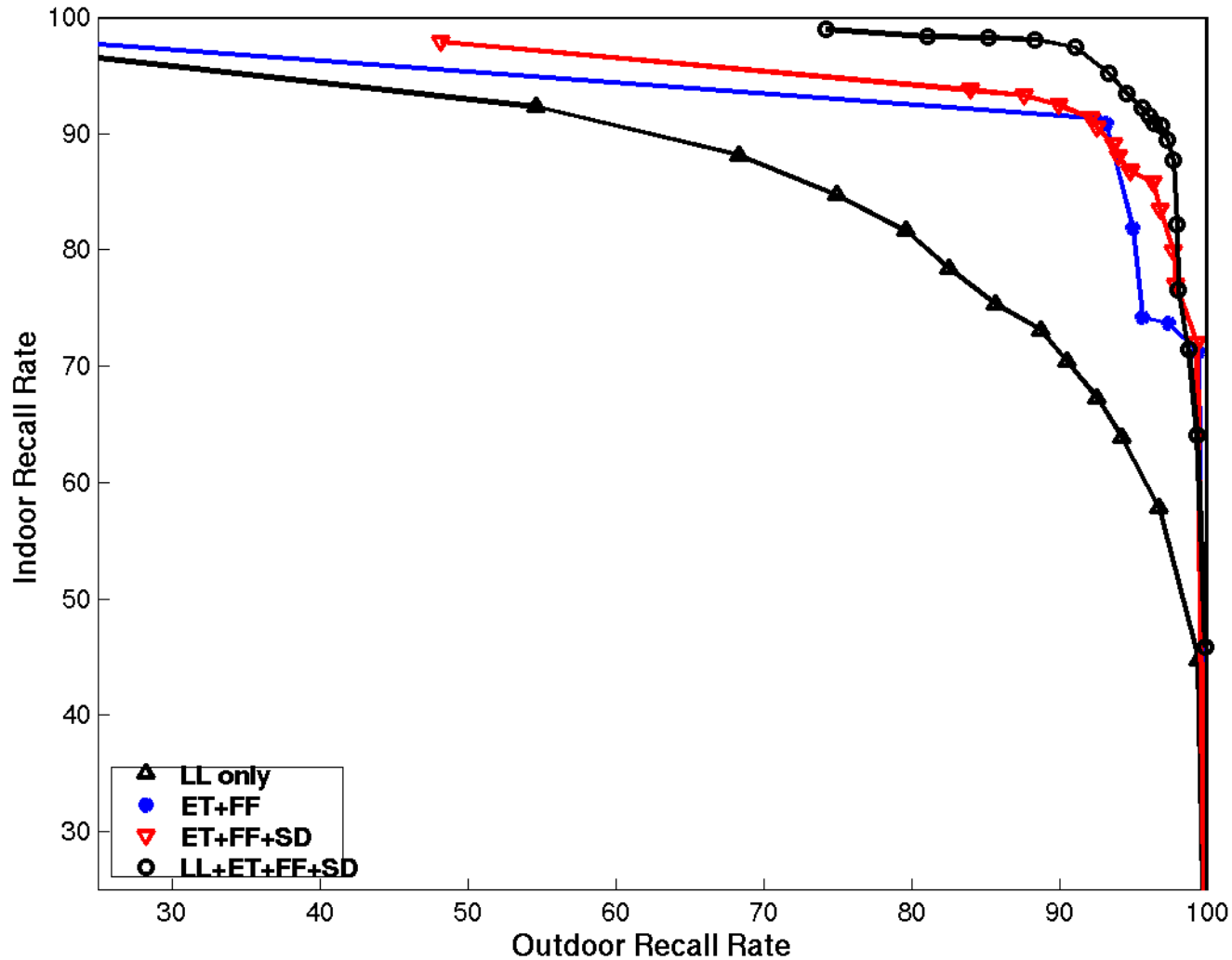
- Efficient way to encode conditional probability distributions and calculate marginals
- Use for classification by having the classification node at the root
 - Examples
 - Indoor-outdoor classification
 - Automatic image orientation detection

Indoor vs. outdoor classification



Each edge in the graph has an associated matrix of conditional probabilities

Effects of Image Capture Context



Recall for a class C is fraction of C classified correctly

Orientation detection

- See IEEE TPAMI paper
 - Hardcopy or posted
- Also uses single-feature Bayesian classifier (answer to #1-4)
- Keys:
 - 4-class problem (North, South, East, West)
 - Priors **really** helped here!
- You should be able to understand the two papers (both posted)