

CAP6411

Computer Vision Systems

Lecture 2



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Object Representations

What is an object?

- Anything that is of interest for further analysis.
 - Boats
 - Birds
 - Fish
 - Humans
 - Bubbles

What is an object?



Study of birds



Surveillance



Behavior of fish



Military applications



Surveillance



Undersea studies



Autonomous vehicle

Possible Object Representations

- Shape of objects
- Appearance of objects



Object Shape Representations

Shape Based Representations



- Point Representations:
Suitable for objects that occupy small regions



We will discuss point detection later...

Shape Based Representations



- Primitive Geometric Shapes:
Suitable for rigid objects



Shape Based Representations



- Object silhouette and contour:



We will discuss contours later...

Shape Based Representations



- Articulated shape models:
Composed of object parts that are held together with joints.



We won't discuss these models...

Shape Based Representations



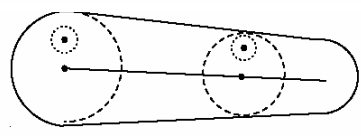
- Skeletal models:
Extracted by applying medial axis transform



Medial Axis Transform

Definition

- Shape representation
- Provides skeleton of an object
- Points on medial axis are the centers of maximal circular neighborhoods contained in the shape



Examples

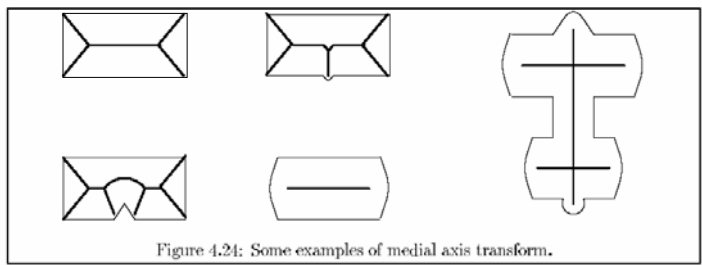


Figure 4.24: Some examples of medial axis transform.

Iterative Algorithm

1. Iteratively compute f^k as follows:

$$f^k(x, y) = f^0(x, y) + \min(f^{k-1}(p, q))$$

$\forall(p, q)$ such that $distance((x, y), (p, q)) \leq 1$.

2. Medial axis is given by all points (x, y) such that:

$$f^k(x, y) \geq f^k(p, q),$$

$\forall(p, q)$ such that $distance((x, y), (p, q)) \leq 1$.

Figure 4.20: Iterative algorithm for computing medial axis transform.

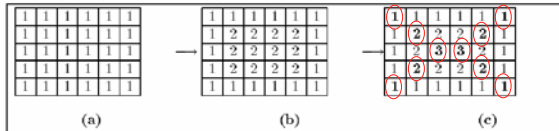


Figure 4.22: Medial axis transform. (a) Rectangular shape ($f^0(x, y)$). The background pixels, which are not shown, are all '0'. (b) intermediate step ($f^1(x, y)$). (c) $f^2(x, y)$. The points in Medial axis shown in boldface.

Object Appearance Representations

Appearance Representations

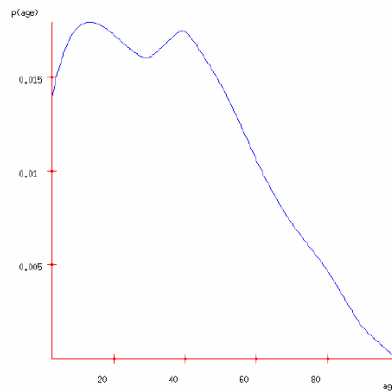
- PDFs
- Templates
- Multi-view appearance methods



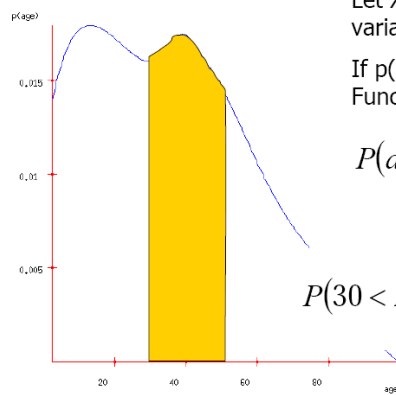
Probability Density Functions For Object Representation

- Describe the color, texture observation
- Provides reasonable range of values
- Describes co-occurrence of multiple attributes

A PDF of American Ages in 2000



A PDF of American Ages in 2000



Let X be a continuous random variable.

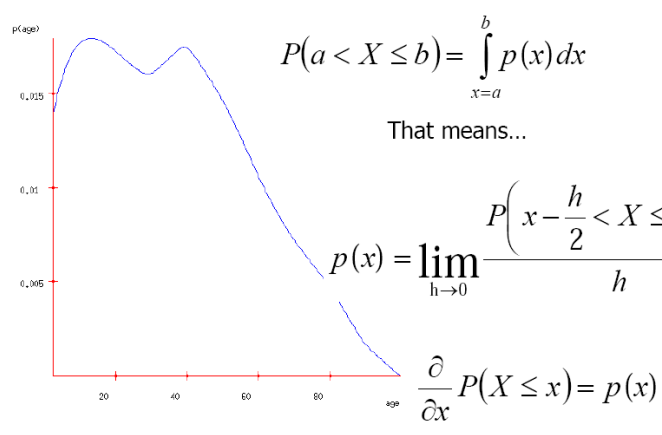
If $p(x)$ is a Probability Density Function for X then...

$$P(a < X \leq b) = \int_{x=a}^b p(x) dx$$

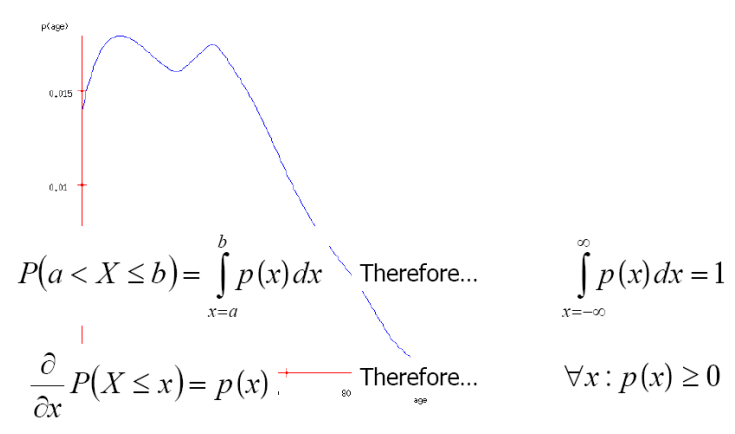
$$P(30 < \text{Age} \leq 50) = \int_{\text{age}=30}^{50} p(\text{age}) d\text{age} = 0.36$$



Properties of PDFs



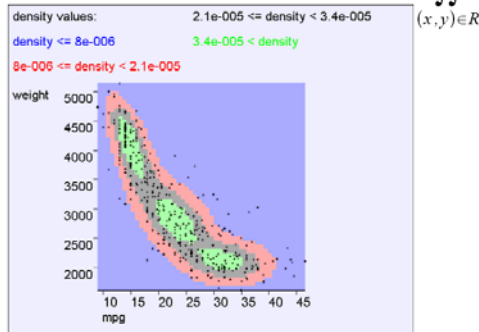
Properties of PDFs



In Two-Dimensions

- Let X, Y be a pair of continuous random variables, and let R be some region of (X, Y) space...

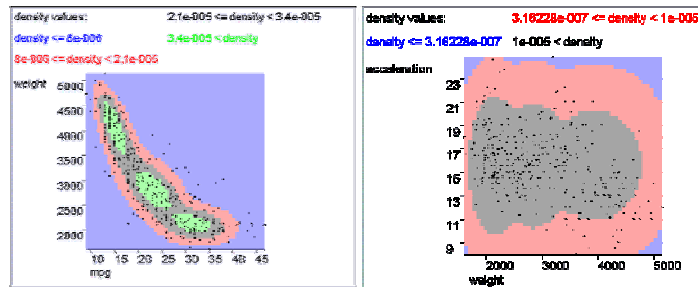
$$P((X, Y) \in R) = \iint_{(x,y) \in R} p(x, y) dy dx$$



Independence

- If X and Y are independent, knowing the value of X does not help predict Y

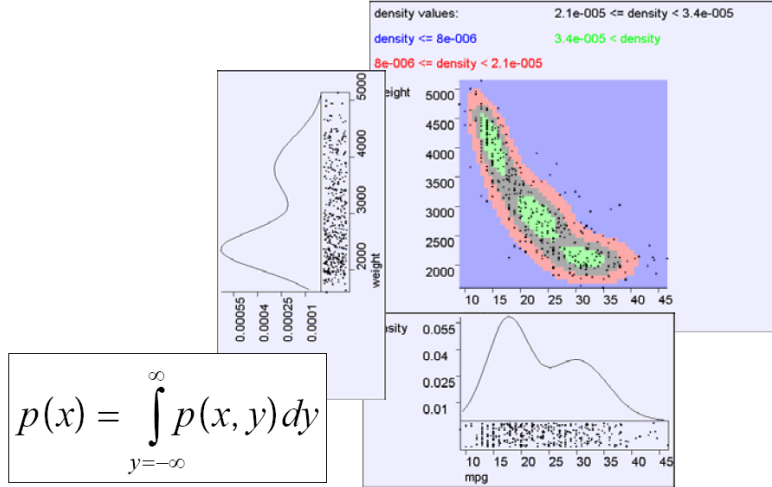
$$X \perp Y \text{ iff } \forall x, y : p(x, y) = p(x) p(y)$$



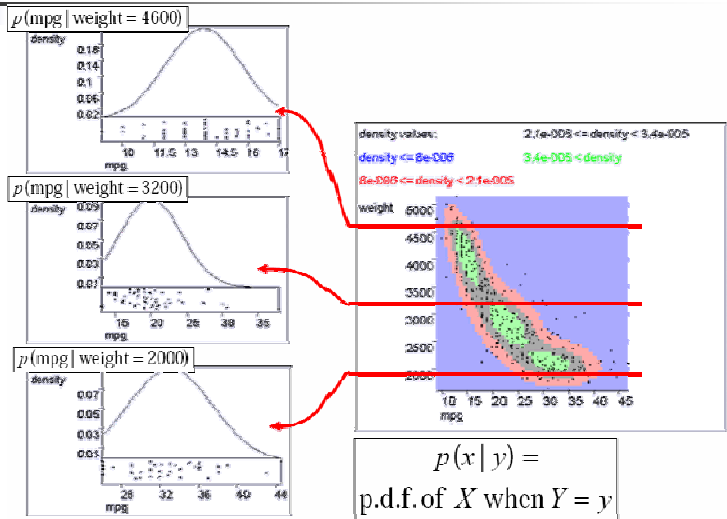
Dependent

Independent

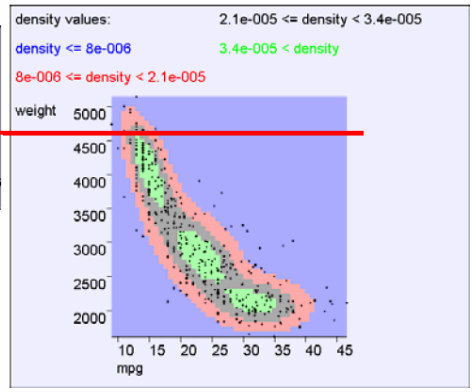
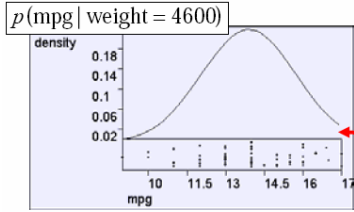
Marginal Distributions



Conditional Distributions



Conditional Distributions



$$p(x|y) = \frac{p(x,y)}{p(y)}$$

$\forall x, y: p(x, y) = p(x)p(y)$
 $\forall x, y: p(x|y) = p(x)$
 $\forall x, y: p(y|x) = p(y)$

$p(x|y) =$
 p.d.f. of X when $Y = y$

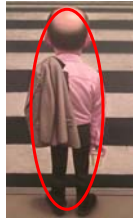
Useful Stuff

$$\int_{x=-\infty}^{\infty} p(x|y) dx = 1$$

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

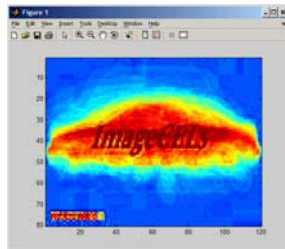
Template Based Representations

- Templates are formed using simple geometric shapes or silhouettes
- Difference from PDF: Encodes spatial coordinates implicitly



Test Your Understanding

- How can we encode spatial coordinates into image PDFs?
- Where can it be used?



Mean Car

```

clear;
names=ls;
for i=3:size(names,1)
    img=imread(names(i,:));
    ims(i-2,:,:)=(img(:,:,1)+img(:,:,2)+img(:,:,3))/3;
end;
for i=1:size(names,1)-2
    a=ims(i,:,:);
    b=a(i);
    C(i,:)=double(b);
end;
meann = mean(C);
for i=1:size(names,1)-2
    C(i,:)=C(i,:)-meann;
end
covvr=C*C';
[v,d]=eig(covvr);
eigcars=C'*d;
for i=1:12
    g=eigcars(:,i)';
    subplot(3,4,i);imagesc(reshape(g,[80 120]));
end;

```

