11/7

Consider 3D example

CS4640_Week 10

Given N observations on M variables

i.e., N M-tuples

$\bar{x}_i$ (zero mean set)

define $y_{ij} = \sum_{j=1}^{M} a_{ij} x_{ij}$

$$\underbrace{\begin{bmatrix} y_{i1} \\ y_{i2} \\ \vdots \\ y_{iM} \end{bmatrix}}_{\bar{y}_i} = \underbrace{\begin{bmatrix} a_{11} & a_{12} & \cdots & a_{1M} \\ \vdots & & & \\ \vdots & & & \\ a_{M1} & & & a_{MM} \end{bmatrix}}_{R} \underbrace{\begin{bmatrix} x_{i1} \\ x_{i2} \\ \vdots \\ x_{iM} \end{bmatrix}}_{\bar{x}_i}$$

$\bar{y}_i = R\bar{x}_i$

$C_y = \bar{y}\bar{y}^T = R\bar{x}\bar{x}^T R^T = R C_x R^T$

eigenvalue problem

pts → 0-mean pts → covariance matrix

→ V, D

see CS4640_Week 1

11/8

PCA for modeling data

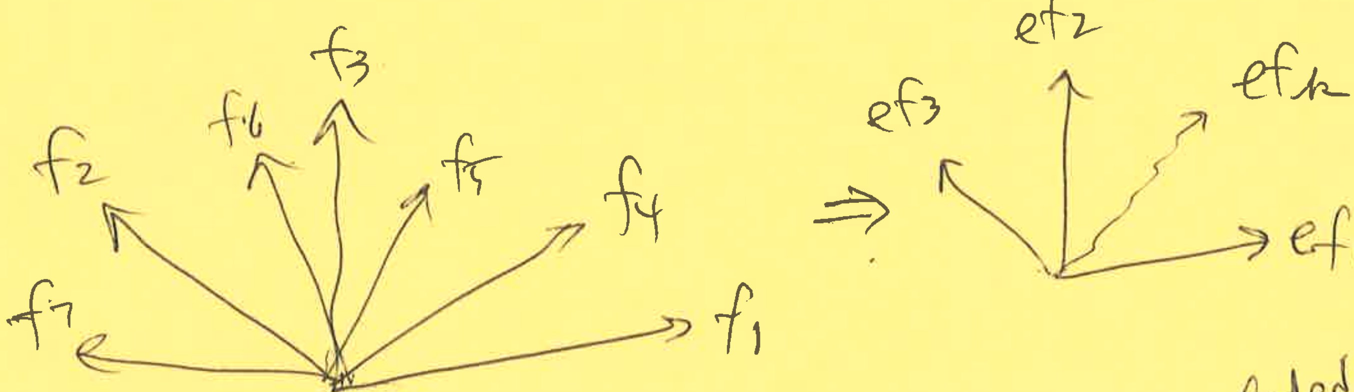
e.g., human faces

given a DB of faces,

determine a set of eigenfaces

and represent new faces in terms of

the coordinate value of the PCA transform



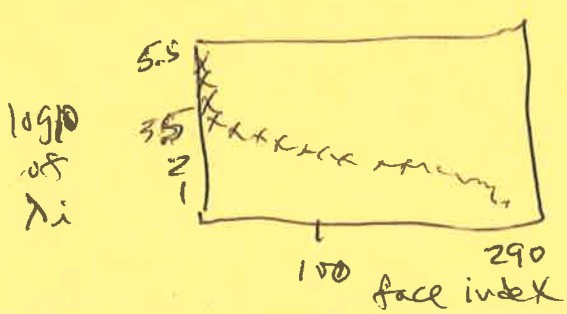
k decorrelated dims

New face is projected onto each

ef axis & the coordinates used

to represent the face

$$a_i = \frac{P_i^T (I - \bar{I})}{\lambda_i} \approx \frac{\text{eigenvec (face - mean)}}{\text{eigen val}}$$



12\1

Weeks: 11-12 Segmentation

segmentation: vital first step

* How to assign pixels to a set of related pixels?

- Edge/boundary : look for differences
- Region : look for similarities

qualities of image

(1) color
(2) texture
(3) motion
*(4) shape
*(5) proximity
*(6) affordance

A case study: robot motion

12\2

affordance

something a physical feature offers in terms of action

handle : human can hold it

roof : shelter from ...

flat surface : can walk

how can image be converted to affordance info ?

The Notion of Symmetry

Given a point set, some operation on the set results in the same set.

Example:

a line ($\mathbb{R}$)

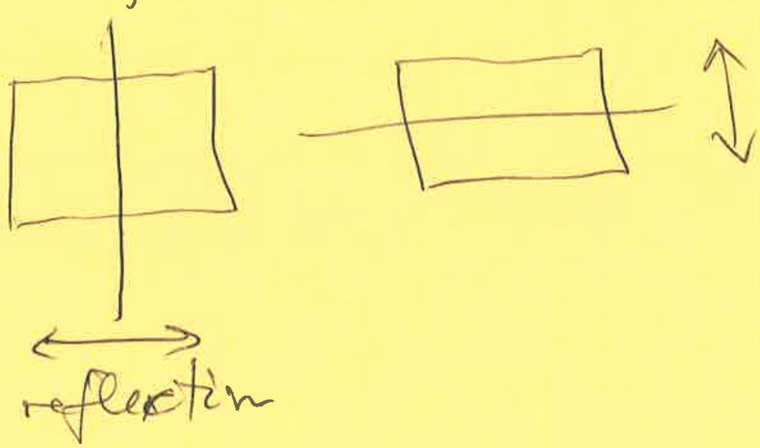
operation: slide the line to the right 1 unit
$(\ell_2(x) = \ell_1(x) + 1 = x + 1$

still $\mathbb{R}$

combine action + perception in representation

Consider a square:

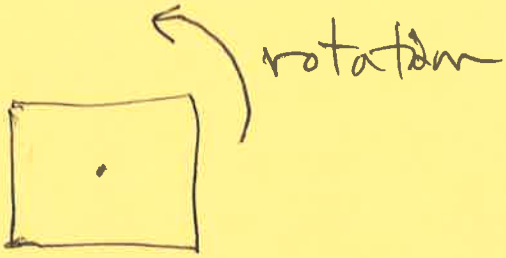
some symmetries:



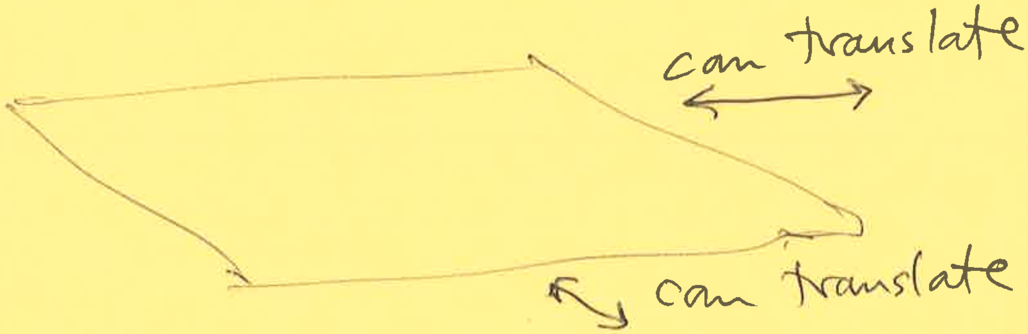
reflection

reflection

12/4



Consider a plane



Consider affordance to move forward on flat surface

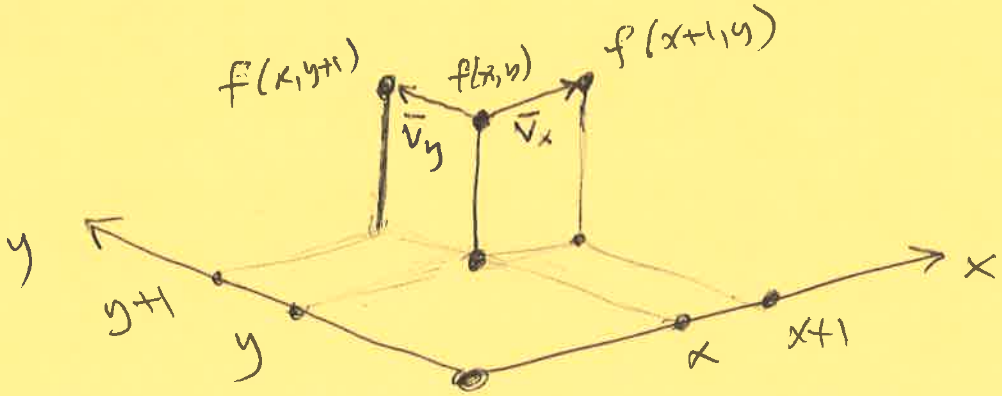
Assume a range map $f(x,y)$ = distance to surface
(called a Monge patch)

12/5

Surface normals can be found:

$$\frac{\partial f(x,y)}{\partial x} = \frac{f(x+1,y)-f(x,y)}{\Delta x} = f_x(x,y)$$

$$\frac{\partial f(x,y)}{\partial y} = \frac{f(x,y+1)-f(x,y)}{\Delta y} = f_y(x,y)$$



Let $\bar{v}_x = [x+1, y, f(x+1,y)] - [x, y, f(x,y)] = [1, 0, f_x(x,y)]$

$\bar{v}_y = [x, y+1, f(x, y+1)] - [x, y, f(x,y)] = [0, 1, f_y(x,y)]$

normal $\bar{n} = \bar{v}_x \times \bar{v}_y$

$$= \begin{vmatrix} 0 & f_x(x,y) \\ 1 & f_y(x,y) \end{vmatrix} \bar{i} - \begin{vmatrix} 1 & f_x(x,y) \\ 0 & f_y(x,y) \end{vmatrix} \bar{j} + \begin{vmatrix} 1 & 0 \\ 0 & 1 \end{vmatrix} \bar{k}$$

$$= -f_x(x,y)\,\bar{i} - f_y(x,y)\,\bar{j} + 1\,\bar{k}$$

See Powerpoint