Non-Supervised Robust Visual Recognition of Color Images Using Half-Quadratic Theory

Rozenn DAHYOT [1], Pierre CHARBONNIER [1], Fabrice HEITZ [2].

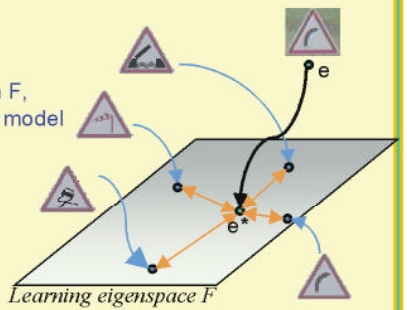
[1] Laboratoire Régional des Ponts-et-Chaussées de Strasbourg
11 Rue Jean Mentelin, BP 9
F-67035 STRASBOURG cedex, FRANCE

Rozenn.Dahyot@equipement.gouv.fr, Pierre.Charbonnier@equipement.gouv.fr,
fabrice.heitz@ensps.u-strasbg.fr

[2] LSIIT UPRESA CNRS 7005
Université Strasbourg I
Boulevard Sébastien Brant
67400 ILLKIRCH, FRANCE

Purpose : Robust visual learning-based pattern recognition

- Learning of appearance by PCA
- Recognition steps :
  - robust reconstruction e* on F,
  - identification to the closest model



Contributions

- M-estimation using Half Quadratic Theory
- Joint pattern reconstruction and parameter estimation
- Extension to color images

Robust recognition

Residual at pixel *i* for gray level images :

$$\varepsilon_i(c) = e_i - e_i^*(c) = e_i - \sum_{j=1}^{t} c_j \cdot U_{ij}$$

- Least Squares estimation (LS) :
  ➪ *quadratic but not robust*

$$\arg\min_c \left\{ J_0(c) = \sum_{i=1}^{n} (\varepsilon_i(c))^2 \right\}$$

- M-estimation :
  ➪ *robust but not quadratic*

$$\arg\min_c \left\{ J_1(c) = \sum_{i=1}^{n} \rho(\varepsilon_i(c)) \right\}$$

Half Quadratic Theory

Augmented energy

$$\min_c \{J_1(c)\} = \min_c \min_b \left\{ J_1^{\#}(c,b) = \sum_{i=1}^{n} \left(b_i \varepsilon_i^2 + \beta(b_i) \right) \right\}$$

☺ *b* fixed, $J_1^{\#}$ convex w.r.t. *c* ☺ *c* fixed, $b(\varepsilon) = \rho'(\varepsilon)/2\varepsilon$

Algorithm : Iterative Reweighted Least Squares

repeat

$$\begin{cases} b_i^{(m+1)} = \rho'\left(\varepsilon_i^{(m)}\right)/2\varepsilon_i^{(m)} \\ (U^T \cdot B^{(m+1)} \cdot U)c^{(m+1)} = U^T \cdot B^{(m+1)} \cdot e \end{cases}$$

until convergence

Scale parameter estimation

- Energy to minimize for **convex** functions (*Huber*) :

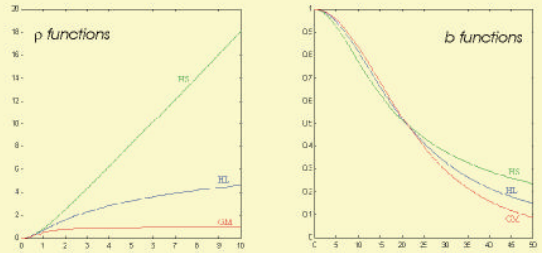
$$\arg\min_c \left\{ J_3(c,\sigma) = \sum_{i=1}^{n} \left[\rho\left(\varepsilon_i/\sigma\right) + a \right] \sigma \right\}$$

➪

$$\left(\sigma^{(m+1)}\right)^2 = \frac{1}{na} \sum_{i=1}^{n} \chi\left(\varepsilon_i^{(m)}/\sigma^{(m)}\right) \left(\sigma^{(m)}\right)^2$$

a = known parameter , $\chi(x) = x \cdot \rho'(x) - \rho(x)$

Using (non convex) hard redescenders



M-estimators in continuation :

Extension to color images

color outliers

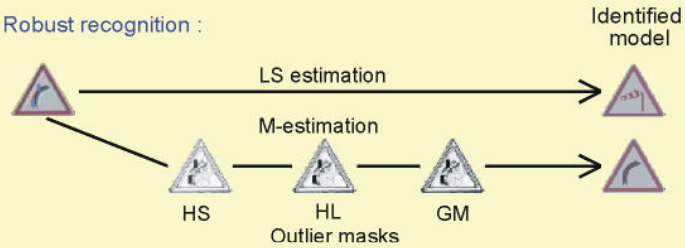
Residual at pixel *i* :

$$\varepsilon_i(c) = \sqrt{\left(e_i^R - e_i^{R^*}(c)\right)^2 + \left(e_i^G - e_i^{G^*}(c)\right)^2 + \left(e_i^B - e_i^{B^*}(c)\right)^2}$$

Application to road signs recognition

Learning Database :
(43 road signs)

➢ Robust recognition :



➢ Color discrimination :