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

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Purpose: Robust visual learning-based pattern recognition
- Learning of appearance by PCA
- Recognition steps:
  • robust reconstruction \( a^* \) 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:
\[ e_i = c_i - c_i^* = c_i - \sum_{j=1}^{i-1} c_j + U_i \]

• Least Squares estimation (LS):
  \[ \arg \min_c \left\{ J_2(c) = \sum_{i=1}^{n} \rho_0(e_i) \right\} \]

• M-estimation:
  \[ \arg \min_c \left\{ J_2(c) = \sum_{i=1}^{n} \rho(c_i) \right\} \]

Half Quadratic Theory
Augmented energy
\[ \min J_1(c, b) = \min_c \min_b \left\{ J_1^*(c, b) = \sum_{i=1}^{n} \left( \rho(c_i) + b \rho'(c_i) \right) \right\} \]

Algorithm: Iterative Reweighted Least Squares
- repeat
  \[ \begin{align*}
  b_i^{(m+1)} &= \rho'(c_i^{(m)})/2c_i^{(m)} \\
  (U^T \cdot B^{(m+1)} \cdot U)c_i^{(m+1)} &= U^T \cdot B^{(m+1)} \cdot e
  \end{align*} \]
- until convergence

Scale parameter estimation
- Energy to minimize for convex functions (Huber):
  \[ \arg \min \sum_{i=1}^{n} \rho(c_i) a \frac{c_i}{\sigma} \]

Using (non convex) hard redescenders

Extension to color images
Residual at pixel \( i \): 
\[ e_i = (e_i^R - q_i^R, e_i^G - q_i^G, e_i^B - q_i^B) \]

Application to road signs recognition

Robust recognition:
- M-estimation
- HS, HL, GM
- Outlier masks
- LS estimation

Color discrimination:
- M-estimation
- HS, HL, GM
- Outlier masks