Robust Visual Recognition of Color Images

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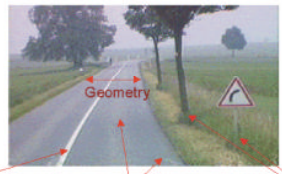
Context of this Work : Road Scene Analysis

Road scene image sequences are processed off-line to extract information about the road and its environment. This work focuses on the recognition of objects lying on the roadside.

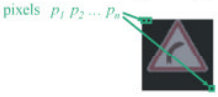


Objects are often difficult to recognize since many effects can occur in real scenes (occlusions ...).

Maintenance Diagnosis Location

Global Appearance-Based Representation

$B = \{\mathbf{m}_1, \cdots, \mathbf{m}_N\}$ Database of training images ordered as vectors

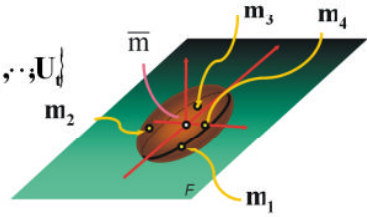


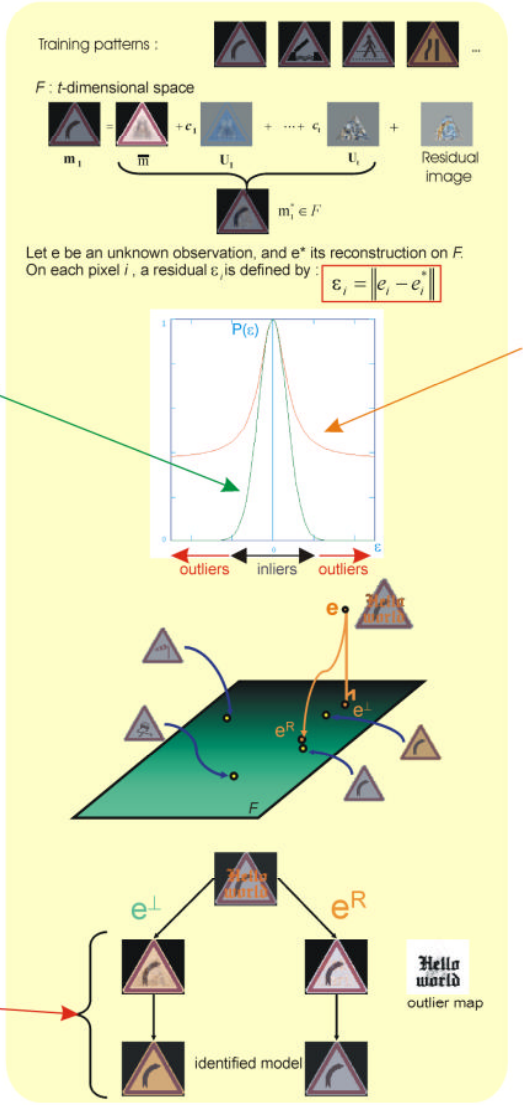
$$\mathbf{m} = \begin{pmatrix} p_1 \\ \vdots \\ p_n \end{pmatrix}$$

Information Reduction : Principal Component Analysis (**PCA**)

Eigenvectors : $\{\mathbf{U}_1, \cdots, \mathbf{U}_{N-1}\}$

t-dimensional eigenspace F : $\{\mathbf{U}_1, \cdots, \mathbf{U}_t\}$





Standard Recognition

❑ 1st Step : Least Square estimation

$$e^{\perp} = \arg\min_{e^* \in F} \left\{ J_0(e^*) = \|e - e^*\|^2 = \sum_{i=1}^{n} \varepsilon_i^2 \right\}$$

Assumption : normal distribution of ε

$$P(\varepsilon_1, \cdots, \varepsilon_n) \propto \exp -\left(\sum_{i=1}^{n} \varepsilon_i^2 \right)$$

Definition :

high residuals ⇔ outliers

low residuals ⇔ inliers

Minimization of J_0

Algorithm : Least Squares (LS)

❑ 2nd Step : Recognition

Identification of $e^{\perp}$ to the closest model in *F*

LS-Estimation Limitations

☹ sensitivity to outliers

Robust Recognition

❑ 1st Step : robust M-estimation

$$e^R = \arg\min_{e^* \in F} \left\{ J_1(e^*) = \sum_{i=1}^{n} \rho\left(\frac{\varepsilon_i}{\sigma_\rho} \right) \right\}$$

Assumption : robust distribution of ε

$$P(\varepsilon_1, \cdots, \varepsilon_n) \propto \exp -\left(\sum_{i=1}^{n} \rho\left(\frac{\varepsilon_i}{\sigma_\rho} \right) \right)$$

Minimization of J_1 using the **Half Quadratic Theory**

$$\min_{e^*} \{J_1(e^*)\} = \min_{e^*} \min_{b} \left\{ J_1^a(e^*, b) = \sum_{i=1}^{n} \left(b_i \varepsilon_i^2 + \beta(b_i) \right) \right\}$$

Weights : $b_i = \frac{\rho'\left(\varepsilon_i / \sigma_\rho\right)}{2\varepsilon_i / \sigma_\rho}$ **b** : outlier map

Algorithm : Re-Weighted Least Squares

❑ 2nd Step : Recognition

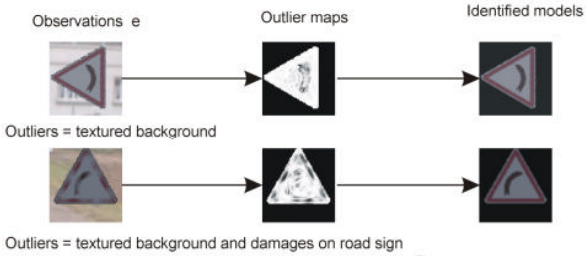
Identification of e^R to the closest model in *F*

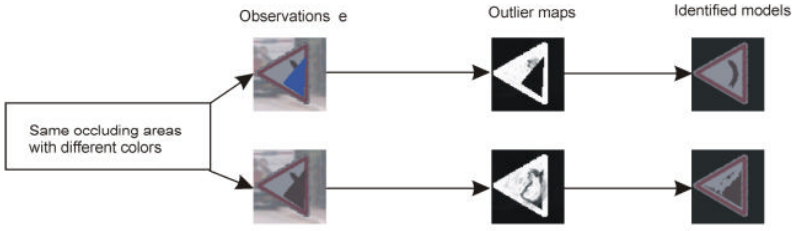
Scale Parameter σ_ρ

σ_ρ delimits the space of the inliers and is estimated from the training images.

Experimental Results of Robust Recognition

B : training database of 1548 images (76x76 pixels) of 43 road signs trained with their rotation in the image plane.
F : *60*-dimensional eigenspace





Computation time : about 1*s* on Pentium Pro 200MHz PC