

A GREY-LEVEL IMAGE EMBEDDING ITS COLOR PALETTE

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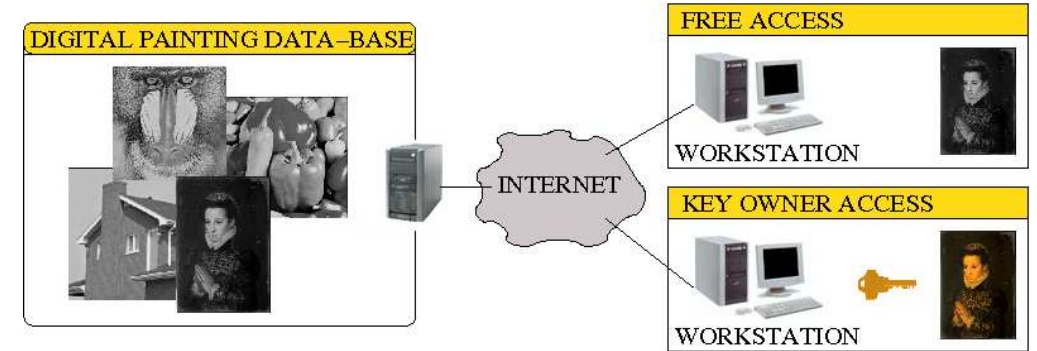
OBJECTIVE :

COLOR SECURED of image database.

- ↳ free access to grey-level images,
- ↳ key-manage access to the color information.

PRINCIPLE :

A solution based on a DATA-HIDING method where COLOR PALETTE is the message and INDEX IMAGE is the cover.

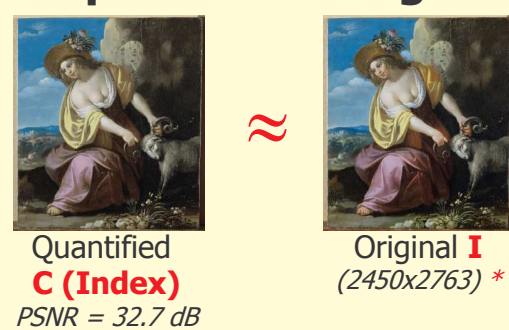


TWO MAIN STEPS:

1- Decomposition Algorithm:

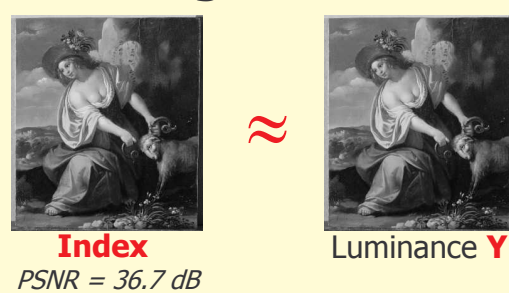
Find an index image and a color palette with :

- A color quantized image close to the color image



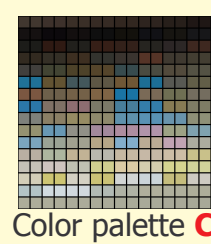
E1 first term

- An index image close to the luminance image



E1 second term

- A color palette owning consecutive couple of close color



(constraint for an unseen data-hiding)

E1 third term

(*) Louvre museum; « a woman praying », anonymous, flandres, XVI century, oil on oak.

Find an index image *Index* and a color palette *C* by minimizing **E1**:

$$E1 = \underbrace{\sum_{i=1}^N (C(Index(i)) - I(i))^2}_{\text{first term}} + \underbrace{\lambda_1 \sum_{i=1}^N (Index(i) - Y(i))^2}_{\text{second term}} + \underbrace{\lambda_2 \sum_{k|k \in [1..K] \text{ and } k \text{ is odd}} (C(k) - C(k+1))^2}_{\text{third term}}$$

E1 is non-derivable ⇒ Introduction of a close equation **E2** :

$$E2 = \sum_{i=1}^N \sum_{k=1}^K P_{i,k}^m (C(k) - I(i))^2 + \lambda_1 \sum_{i=1}^N \sum_{k=1}^K P_{i,k}^m (Y(i) - k)^2 + \lambda_2 \sum_{k|k \in [1..K] \text{ and } k \text{ is odd}} (C(k) - C(k+1))^2$$

Fuzzy Formulation

Decomposition Algorithm (Minimization of E2) :

- Compute **C** (solve linear system $A \cdot C = B$) with:

$$A = \begin{pmatrix} \lambda_2 + \sum_{i=1}^N P_{i,1}^m & -\lambda_2 & 0 & \dots \\ -\lambda_2 & \lambda_2 + \sum_{i=1}^N P_{i,2}^m & 0 & \dots \\ 0 & 0 & \lambda_2 + \sum_{i=1}^N P_{i,3}^m & \dots \\ \dots & \dots & \dots & \dots \end{pmatrix} \quad B = \begin{pmatrix} \sum_{i=1}^N P_{i,1}^m I(i) \\ \sum_{i=1}^N P_{i,2}^m I(i) \\ \dots \\ \sum_{i=1}^N P_{i,K-1}^m I(i) \\ \sum_{i=1}^N P_{i,K}^m I(i) \end{pmatrix}$$

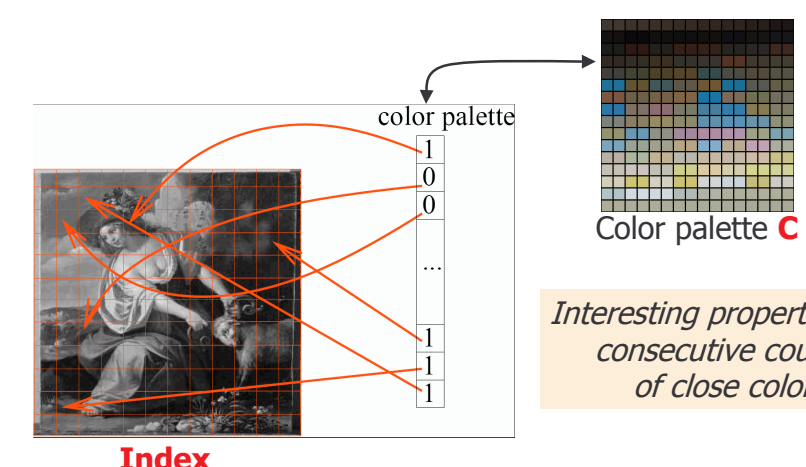
- Compute $P_{i,k}$: $P_{i,k} = \frac{(\sum_{l=1}^{l=K} \frac{1}{2 \times ((C(l) - I(i))^2 + \lambda_1 (Y(i) - l)^2)})^{-1}}{2 \times ((C(k) - I(i))^2 + \lambda_1 (Y(i) - k)^2)}$

obtain **C** and **Index** | $\forall i, Index(i) = \arg \max_k P_{i,k}$

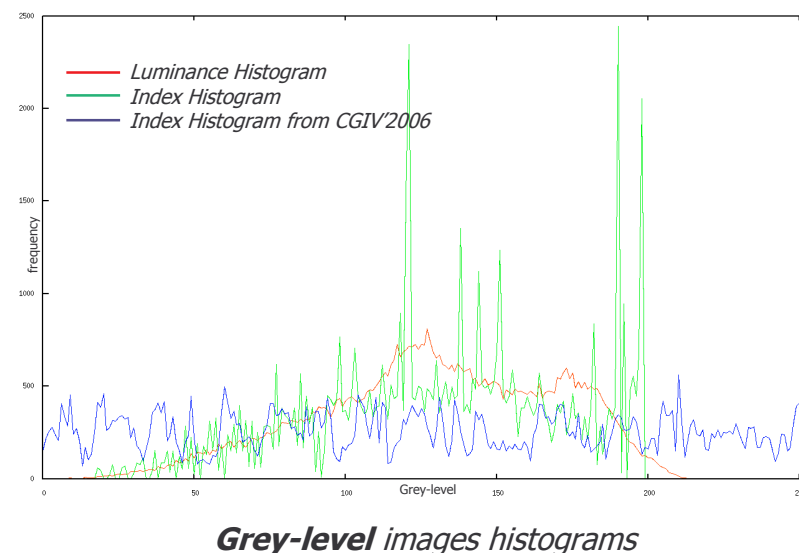
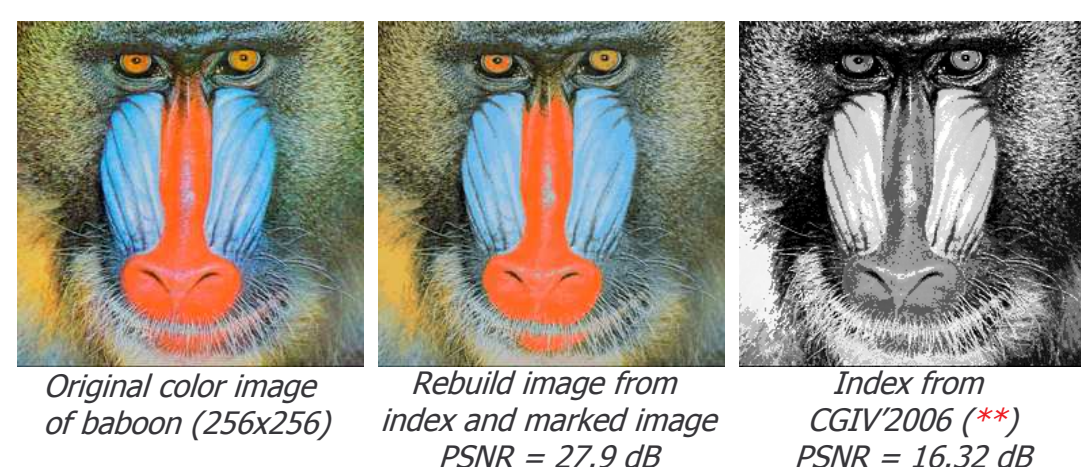
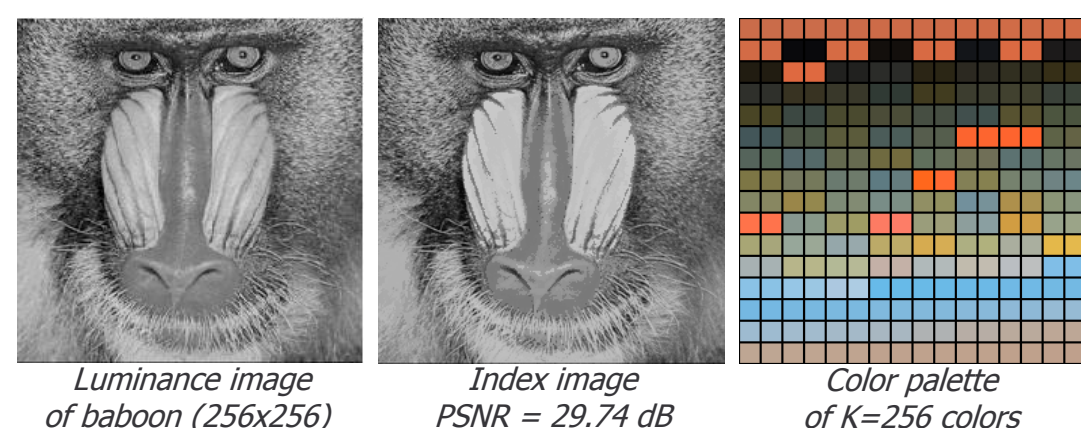
2- Data-Hiding:

- b_j : the bit to embed,
- $Index(i)$: the index value of pixel i
- $Index_w(i)$: the index marked value of pixel i

$$Index_w(i) = Index(i) - Index(i) \bmod 2 + b_j$$



RESULTS & CONCLUSION:



images	PSNR _{luminance (original.index-marked)}	PSNR _{color (original.rebuilt)}
baboon	29.74 dB	27.90 dB
airplane	35.95 dB	33.66 dB
pepper	35.03 dB	31.68 dB
house	35.40 dB	35.45 dB
barbara	34.86 dB	30.74 dB

PSNR comparisons with 256x256 images

Acknowledgments:

TSAR French Project ANR SSIA 2006-2008

Conclusion:

- An original **representation of an indexed image**,
- An original **cost-function model**,
- An original way to **securely hide color** information in an image.

(**) "A Color Image in a Grey-Level Image," M. Chaumont and W. Puech, in *IS&T Third European Conference on Colour in Graphics, Imaging, and Vision, CGIV'2006*, Leeds, UK, June 2006, pp. 226-231.