A Theoretical Framework for Data-Hiding in Digital and Printed Text Documents

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Introduction

- Is the problem of text data-hiding too difficult to solve?
- Answer depends on the application requirements:
  - If *robust data-hiding* is required (e.g. copyright protection): probably YES, the attacker can always use Optical Character Recognition.
  - If either *semi-fragile* or *fragile data-hiding* is required (e.g. identification, authentication and tamper proofing): NO
- Goals:
  - New theoretical framework for the text data-hiding problem.
  - New semi-fragile text data-hiding method, *color quantization*, that is fully automatable, has high information embedding rate, is resistant to printing and scanning, and can be applied to both digital and printed text documents.

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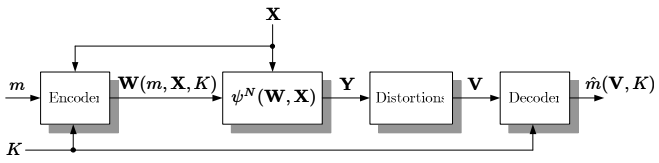
Text Data-Hiding as a Gel'fand-Pinsker (G-P) Problem [1]



- The text is represented by $\mathbf{X}$. Each component X_n, $n = 1, 2, \ldots, N$ of $\mathbf{X}$ represents *one character* from this text.
- A character is as an element from a given language alphabet (e.g. {A, B, …,Z}). More precisely, a character X_n is a *data structure consisting of multiple component fields* (features): name, shape, position, orientation, size, color, etc.

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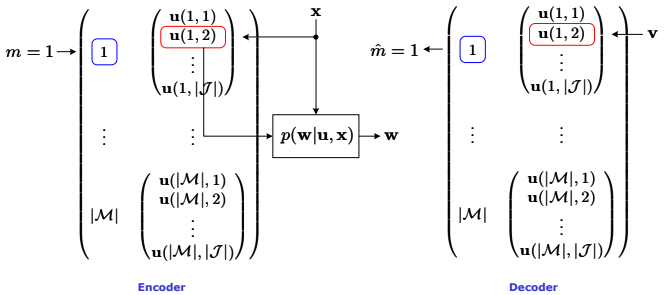
Gel'fand-Pinsker Encoder and Decoder



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Example of G-P text data-hiding

- Consider the so-called Scalar Costa Scheme (SCS) [2]. The auxiliary random variable U is approximated by:

$$U = W + \alpha' X = \alpha' Q_m(X)$$

- The stego text Y is obtained as:

$$Y = W + X = \alpha' Q_m(X) + (1 - \alpha') X \qquad (*)$$

compensation parameter factor

high rate scalar quantizer

- For a practical implementation based on the SCS, just select a character feature (e.g. color) and use it as the cover character X.

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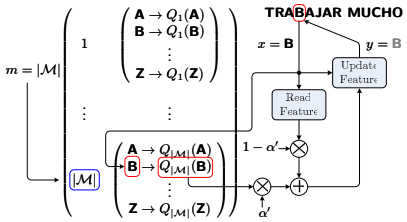
Example of G-P text data-hiding (cont.)



- Generalization: $Q_m(\cdot) \rightarrow \mathbf{Q}_m(\cdot)$ E.g.: $\mathbf{Q}_m(\mathbf{TRABAJAR})$
- *Open space methods* and *character feature methods* are particular cases of the vector and the scalar schemes, respectively.

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Practical Implementation of G-P Text Data-Hiding

- Color quantization: the stego text is obtained via (*), where the character feature to quantize is *color*:

VAMOS A TRABAJAR → **VAMOS A TRABAJAR**

- Main idea: quantize the color of each character in such a manner that the HVS cannot make the difference between original and quantized characters, but it is possible for an specialized reader.
- Embedding rate: 1-2 bits per character.
- Automation: correct character segmentation is needed for decoding; however OCR is not necessary.
- *Two-level* or *multilevel* quantizers can be used.

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Practical Implementation of G-P Text Data-Hiding

- Halftone quantization: it exploits the fact that there exists a number of choices for the halftone screen leading to the same gray shade.
- Typical halftone screen characteristics that can be exploited are: *screen angle* and *screen dot shape* (elliptical, round, square).

$\mathbf{Q}_0(\mathbf{T})$ $\mathbf{Q}_1(\mathbf{T})$

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Conclusions and Future Work

- New theoretical framework for data-hiding in digital and printed text documents: *G-P text data-hiding*.
- Main idea: consider a text character as a *data structure consisting of multiple features*.
- We presented *color quantization* as a new method for data-hiding in digital and printed text documents.
- Future work: Experimental results on the robustness of color quantization against printing and scanning.
- References:

1. Gel'fand, S., Pinsker, M.: Coding for channel with random parameters. Problems of Control and Information Theory 9 (1980) 19–31
2. Eggers, J., Su, J., Girod, B.: A blind watermarking scheme based on structured codebooks. In: Secure Images and Image Authentication, IEE Colloquium, London, UK (2000) 4/1–4/6