Parallel Tabu Search for Robust Image Filtering*

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ABSTRACT — **We propose to perform detail-preserving filtering by minimizing an objective function that uses a fairly simple regularization function to control smoothing interaction of pixel neighbors where discontinuities are implicitly addressed. To accomplish the minimization of this objective function, we use Tabu search. Tabu search adapts to the particular structure of the problem it tries to solve, and thus preforms an intelligent exploration of the state space.**

1 Introduction

Robust image restoration consists of suppressing image noise while preserving significant details such as sharp edges. Given a noisy image with pixel intensities $\{d_1, ..., d_N\}$, the goal is to find the filtered version of this image $\{x_1, ...x_N\}$ in which noise has been removed. A common approach to this problem is to express the problem of image filtering with a functionnal whose global minimum corresponds to the desired image [1]. Typically, this objective function is of the form:

$$F(\mathbf{x}) = \sum_{i=1}^{N} \alpha(x_i - d_i)^2 + \lambda \sum_{j \in \mathcal{N}_i} g(x_i - x_j)$$

where $g(s)$ is the regularization function that defines how the neighborhood $\mathcal{N}_i$ of pixel i interacts with the candidate solution x_i. In this context, suitable filtering will be achieved if 1) $F(\mathbf{x})$ is easily computable, 2) smoothing properties of $g(s)$ preserve discontinuities and 3) minimization can be performed at a reasonable computational cost.

A common solution to realize an edge-preserving regularization is to introduce in the defintion of $g(s)$ a line process to delineate regions on which smoothing can applied [2]. But this formulation renders the objective function too complex by considerably increasing the dimensionality of the search space.

Under the assumption that the restored image must correspond to the state of minimum energy of the objective function, it is essential to proceed to this global minimization. Simulated annealing in the context of MRF modeling has been widely used to perform this task [2][3]. This technique is known for its high computational cost. More recently, a technique called graduated non convexity (GNC) has been proposed [4][5]. GNC can be seen as a deterministic annealing approach and its complexity strongly depends on the adopted mathematical formulation.

We propose to perform detail-preserving filtering by minimizing an objective function that uses a fairly simple regularization function to control smoothing interaction of pixel neighbors where discontinuities are implicitly addressed as proposed in [6]. Minimization of the objective function is performed by Tabu search [7] -[11],

2 Tabu search

Let $F(\mathbf{x})$, $\mathbf{x} = \{x_1, ..., x_N\}$, be an objective function that one whishes to minimize. And let the state space $\mathcal{X}$ be the set of all feasible