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A critical examination of the assumptions used in dynamic allocation

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ABSTRACT

In dynamic allocation quantizers are capable of choosing between limited allocation of bits and bit allocation without restriction. The goal of this paper is to perform a comparative analysis of the assumptions used in a transmission system which still has quantizers using restrained bit allocation in the long time and in a transmission system for which all quantizers end up using heavy bit allocation. Then, based on the validity of the assumptions derived, we will be able to predict the performance of each system in a real problem.

1. Introduction

If we wish that a transmission system can operate in a more efficient fashion, one way is to allow a dynamic allocation of bits to the most needed quantizers. There, quantizers monitor the level of utility of bit allocation across bit rates and, at any point of the transmission, they might decide to switch the behavior between restrained bit allocation and heavy bit allocation. Restrained bit allocation implies limitation, as on quantizer's freedom of bit allocation; while heavy allocation means bit allocation without restriction. Thus, at any given bit rate, quantizers evaluate the perceived payoff for restrained and heavy allocation and switch to the strategy with the highest benefit.

To illustrate this process, Figs. 2 and 3 show plots of the number of quantizers, noted as n_1, which choose the strategy of restrained allocation at each transmission time while using the REWIC coder, [1,2], on each test image of the dataset in Fig. 1. As can be seen from these plots, initially all quantizers ($n = 16$) make use of restrained allocation but in the long transmission time all quantizers end up using heavy bit allocation.

We have developed a modified version of the REWIC coder, called as the REWIC with Congestion Control (RCC), which implements a congestion control algorithm described in Ref. [3] (see Appendix A). Figs. 2 and 3 also display plots of the number of quantizers, n_1, which choose the strategy of restrained allocation at each transmission time while using the RCC coder on each test image of the dataset in Fig. 1. From these figures, it can be seen that RCC still has quantizers using restrained bit allocation in the long transmission time limit.

The goal of this paper is to made a comparison of assumptions behind dynamic allocation in a transmission system like RCC (which still has quantizers using restrained bit allocation in the long time limit) and in a system like REWIC in which all quantizers end up using heavy bit allocation. And based on the validity of assumptions derived we will be able to predict the performance of each transmission system in real applications.

Section 2 examines the assumptions behind a transmission system like the REWIC coder in which in the long transmission time all quantizers end up using heavy bit allocation to uncover that (i) the payoffs to each quantizer are independent of what the others are doing; and (ii) there is perfect knowledge in the transmission system. In most circumstances however, perfect knowledge about the state of the transmission is not available, which often results in a degradation of the performance of the transmission system.

On the contrary, Section 2 shows that, the assumption of imperfect knowledge may be true for a transmission system like the RCC coder which still has quantizers using restrained bit allocation in the long time limit. In this case, assumptions derived are more realistic, and it probably results in a better performance.

Section 3 shows an objective and subjective coder evaluation, in order to investigate the performance of the RCC coder as compared with that of the REWIC coder. The main conclusions of the paper are summarized in Section 4.

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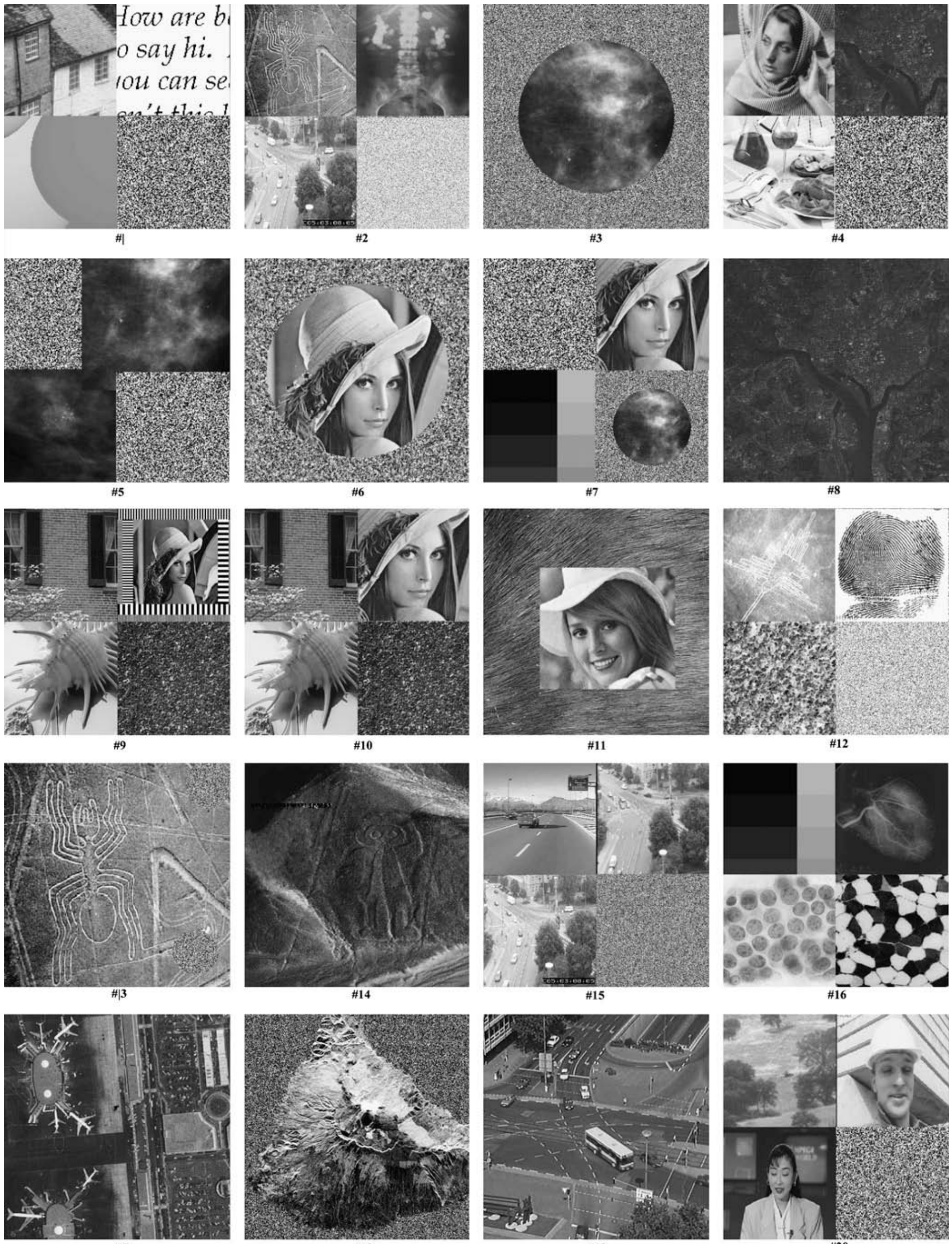

Fig. 1. Image database used in the experiments.

2. Dynamic allocation model

We assume that the image can be divided into a finite number n of regions, each of which is represented by a quantizer. Quantizers are capable of choosing between restrained bit allocation and heavy bit allocation. Thus, at any time, quantizers might decide to switch their behavior among restrained and heavy allocation according to the perceived payoff.

Transmission times of relevant information are often quite different for various quantizers, so only a fraction of them will consider switching between restrained and heavy bit allocation during a given interval $\triangle t$ of transmission time, if $\triangle t$ is small enough. Hence probabilistic dynamics can be used to provide an analytic description of this process at which quantizers may decide to switch their behavior.

Let $n_1(t)$ be the number of quantizers following restrained bit allocation at time t; and $n_2(t)$ be the number of quantizers using the strategy of heavy bit allocation at this time. Here, we assume that $n_2(t) = n - n_1(t)$. Assuming that the perceived payoff does not change over $\triangle t$, the probability p that a quantizer changes from restrained bit allocation to heavy bit allocation in $\triangle t$ is given by:

$$p = (1 - \rho) \cdot r \cdot \triangle t \qquad (1)$$

where ρ is the probability that restrained bit allocation will be perceived by a quantizer to be better than heavy bit allocation; and r is the average rate at which quantizers reevaluate their preferences regarding bit allocation.