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Letter

Non-uniform image compression using a biologically motivated selective attention model

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Abstract

We propose a new non-uniform image compression algorithm using a biologically motivated selective attention model for the effective storage and transmission of natural images. The proposed selective attention model, which uses a bottom-up saliency map (SM) together with top–down reinforcement and inhibition, can generate a scan path that contains plausible interesting objects in a natural scene. The proposed non-uniform image compression method uses the SM results of the proposed selective attention model, which compresses the selected areas that are interesting and the uninteresting areas in a different way by a lossless coding algorithm and lossy compression, respectively. Experimental results show that the proposed non-uniform compression method provides a better peak signal-to-noise ratio (PSNR), but slightly decreases the compression ratio.

Keywords: Selective attention; Saliency map; Non-uniform image compression; Region growing; Adaptive segmentation

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1. Introduction

In general, there exist two standard image compression methods [6]. One compresses an image by a lossless coding algorithm. A lossless compression method does not suffer from the missing problem of information, which means there is no decoding error. However, the compression ratio is not so high. The other method is lossy compression. Its compression ratio is very high, but a loss of information inevitably occurs. Even though the lossy compression method is efficient, important information may be lost because the uniform compression algorithms compress all contents equally. If we consider non-uniform image compression that compresses the contents in an image according to the relative importance in a different way, we are able to realize a more efficient image compression coding scheme.

Non-uniform image compression has been applied to many engineering domains such as mobile applications, biomedical applications, and tele-browsing [9,11]. However, it is difficult to discriminate between the regions that will be compressed by a lossless coding algorithm and those that will be compressed by a lossy coding method. However, the human visual attention system can focus on an attentive location in an input scene and select interesting visual information to process in the brain. Additionally, humans can ignore an uninteresting area even if it has salient primitive features, and they can memorize the characteristics of the unwanted area. Therefore, we propose a new non-uniform image compression method using a human-like selective attention mechanism that considers not only primitive input features, but also the interaction with the environment. The selective attention model can indicate a meaningful area in a natural image. The most salient point is used as the beginning mark to determine the segmentation region for a context. The proposed adaptive segmentation method, which uses the feature map and a region growing method, can successfully segment the context region. The segmented area is compressed by a lossless coding algorithm, and the background area is compressed by a lossy coding algorithm.

2. Biologically motivated selective attention model

Fig. 1 shows the architecture of a selective attention model including the trainable Fuzzy ART network for inhibition and reinforcement [2]. In order to model the human-like visual bottom-up attention mechanism, we used the four bases of edge (E), intensity (I), color (RG and BY), and symmetry information (Sym). The roles of the retina cells and the lateral geniculate nucleus (LGN) are reflected in the proposed attention model [3]. The symmetry information is obtained by a noise-tolerant generalized symmetry transformation (NTGST) and the dilation function of the morphology algorithm [10]. The feature maps ($\bar{\mathrm{I}}$, $\bar{\mathrm{E}}$, $\overline{\mathrm{Sym}}$, and $\bar{\mathrm{C}}$) are constructed by the center surround difference and the normalization (CSD & N) of the four bases, which mimics the on-center and off-surround mechanism of the human brain [4,7]. Then they are integrated by an independent component analysis (ICA) algorithm that models the roles of the primary visual cortex for redundancy reduction. A