Modeling Image Quality

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INTRODUCTION

Since digital images are subject to a wide variety of distortions during acquisition, processing, compression, storage, transmission and reproduction, it becomes necessary to have tools that make it possible to assess the Image Quality (IQ) during the whole production chain. By assessing the image quality during the image production stages make it possible to identify processing problems before the image is given/used by final users. For example, a printing office is required to print a given image (e.g. in a batch of brochures) as faithfully as requested by the customer. As another example, images that must be accessed on the Web often are compressed with a lossy algorithm (e.g. JPEG) to save bandwidth and download time. In order to retain the maximum quality and maximum compression ratio, image quality can be used to select the appropriate compression parameters. In both examples, image quality equates to faithfulness with an original one. We will see in the follows that other definitions of image quality exists and that they corresponds to other image properties. Image quality assessment can be done by manually subjective human rating or automatically by objective methods. This contribution aims to provide an overview of the state of the art of the Image Quality Assessment (IQA) methods reviewing the literature on objective image quality assessment, and classifying and summarizing the available metrics.

BACKGROUND

Different definitions of quality are found in the literature. It has been defined as the "totality of characteristics of a product that bear on its ability to satisfy stated or implied needs" by the International Organization of Standardization; "fitness for (intended) use" Juran (1988); "conformance to requirement" Crosby (1979); "user satisfaction" Wayne (1983). These definitions and their numerous variants could fit digital IQ as suggested by the Technical Advisory Service for Images: "The quality of an image can only be considered in terms of the proposed use. An image that is perfect for one use may well be inappropriate for another." According to the International Imaging Industry Association white paper, IQ is the "perceptually weighted combination of all visually significant attributes of an image when considered in its marketplace or application." We must, in fact, consider the application domain and expected use of the image data (thumbnailing, study, preservation, recognition task, etc…). Different properties contribute to define image quality and different models have been proposed in the literature. De Ridder and Endrikhovski (2002) proposed the Fidelity-Usefulness-Naturalness (FUN) IQ model that assumes the existence of three major dimensions: *Fidelity*, *Usefulness* and *Naturalness*.

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- *Fidelity* is the degree of apparent match of the image with the original (see Figure 1). Ideally, an image having the maximum degree of Fidelity should give the same impression to the viewer as the original. Genuineness and faithfulness are sometimes used as synonyms of Fidelity.
- *Usefulness* is the degree of apparent suitability of the image with respect to a specific task. In many application domains, such as medical or astronomical imaging, image processing procedures can be applied to increase the image usefulness. An example of image usefulness is shown in Figure 2. The image to the left may be accurate with respect to the original object but the image to the right is more usable in an OCR (Optical Character Recognition) application. The enhancement processing steps have an obvious impact on Fidelity.
- *Naturalness* is the degree of apparent match of the image with the viewer's internal references (see Figure 3). This attribute plays a fundamental role when we have to evaluate the quality of an image without having access to the corresponding original. Naturalness also plays a fundamental role when the image to be evaluated does not exist in reality, such as in virtual reality domains.

Recently, Moorthy et al. (2011) suggested extending the dimensions of image quality by considering also its *Visual Aesthetic* and *Content*. We may refer to their model as the QAC model (Quality, Aesthetic, Content).

Visual aesthetics is a measure of the perceived beauty of a visual stimulus. Notwithstanding the subjective nature of this dimension, several works tackle the problem to estimate the aesthetics of an image by developing computational procedures. These proce-

Figure 1. Image exhibiting low fidelity: a) Very saturated colors; b) Green/bluish color cast

Figure 2. Example of image usefulness for an OCR task: a) A faithful image; b) A more readable image