Detecting Pornographic Images by Localizing Skin ROIs

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ABSTRACT

In this study, a novel algorithm for recognizing pornographic images based on the analysis of skin color regions is presented. The skin color information essentially provides Regions of Interest (ROIs). It is demonstrated that the convex hull of these ROIs provides semantically useful information for pornographic image detection. Based on these convex hulls, the authors extract a small set of low-level visual features that are empirically proven to possess discriminative power for pornographic image classification. In this study, the authors consider multi-class pornographic image classification, where the “nude” and “benign” image classes are further split into two specialized sub-classes, namely “bikini”/“porn” and “skin”/“non-skin”, respectively. The extracted feature vectors are fed to an ensemble of random forest classifiers for image classification. Each classifier is trained on a partition of the training set and solves a binary classification problem. In this sense, the model allows for seamless coarse-to-fine-grained classification by means of a tree-structured topology of a small number of intervening binary classifiers. The overall technique is evaluated on the AIIA-PID challenge of 9,000 samples of pornographic and benign images. The technique is shown to exhibit state-of-the-art performance against publicly available integrated pornographic image classifiers.

Keywords: Convex Hull Calculation, Multi-class Classification, Porn Detection, Random Forests, Skin ROIs Localization

INTRODUCTION

With the galloping evolution of the Internet during the last two decades, pornographic images can be readily accessed even by certain sensitive groups of people, such as adolescents. Moreover, the ability to distribute and share images through public HTTP services without an autonomous content supervision process intervening in the content sharing loop encourages circulation of illicit images. For instance, pornographic content distributors may often

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exploit unprotected Web services in order to circulate or exchange child pornography and general pornographic content. The impact of pornography to people has long become a rising issue of concern and was under the spotlight of psychologists decades ago. Psychological research dated back to the 80’s stressed out that the exposure of children to pornography effectively impedes the smoothness of their behavioral evolution. In the same direction, similar studies have indicated that intense exposition to pornographic material affects human behavior and mood in adults. For some representative papers dealing with this problem see Brown, Amoroso, and Ware (1976), Pierce (1984), Cook, Fosen, and Pacht (1971), Lo and Wei (2005), Meyer (1972), and Padgett, Brislin-Slütz, and Neal (1989). The premier source of pornographic information on the Web has traditionally been pornographic images and video. We assert that the semantic load of such images is essentially the primal carrier of pornographic information to effectively engage the focus of attention of the end user, e.g., when browsing pornographic web pages. Thus, we contend that pornographic image detection is a crucial aspect in the loop of effectively identifying pornographic web pages.

A system tailored towards identifying pornographic images should exhibit a robust capability in distinguishing between regular benign images and assorted pornographic images. In a real world content filtering scenario, zero-error categorization is still an unrealized goal. That being said, systems proposed in the literature are characterized by certain strengths and weaknesses in detecting pornographic content. Among many challenging problems in this computer vision problem, the difficulty in constructing an accurate algorithmic framework for detecting pornography is often attributed to varied photometric conditions (which often come in the form of bad illumination), unconstrained clutter, occlusions and variation in the poses of involved human subjects. Thus, it is intrinsically difficult to construct a precise algorithm that encodes accurate prior information about what a pornographic image really is. To the best of our knowledge, many content filtering systems operate satisfactorily in identifying pornographic web pages by means of pornographic image detection. Despite the abundant availability of textual and structural information in common pornographic web pages, a system can exhibit more robust accuracy by being able to tell pornographic and benign images apart. Later, we review some previously proposed systems in the literature aimed at pornographic web page detection.

In previous works (Karavarsamis, Ntarmos, & Blekas, 2011; Karavarsamis, Pitas, & Ntarmos, 2012), we tackled the problem of identifying pornographic web pages. To the best of our intuition, by constructing an algorithm that can tell pornographic and benign images apart at a satisfactory rate (of, e.g., 80% of the time), we can further mine and employ different web page cues in order to come up with a stronger decision mechanism that can reliably tell if a web page is either pornographic or benign. In fact, by imposing a threshold on the ratio of the number of pornographic and benign images detected in a given web page, we can readily achieve a meaningful trade-off between detection accuracy and turnaround time (Karavarsamis, Ntarmos, & Blekas, 2011). We have observed that the probability of generating a false positive can be significantly lowered down when limiting our focus on web pages that are indeed of pornographic nature. At the same time, the true positive rate can be effectively boosted. However, this naive heuristic decision making criterion can plausibly suffer from artifacts when assessing web pages containing only a limited number of images in their document object model. In this class of web pages, the probability of false categorization can be relatively high depending on the underlying image classifier. Obviously, the presence of a large number of candidate images in the categorization pipeline poses a burden towards the user-perceived turnaround time in real-world content filtering systems. In the literature of pornographic content-filtering system design, many systems have employed techniques in or-
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