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Zapping prediction for online advertisement based on cumulative smile sparse representation

Xiaojing Chen [a], Le An [b], Songfan Yang [c,*]

[a] Department of Computer Science and Engineering, University of California, Riverside, CA 92521, USA
[b] Department of Electrical and Computer Engineering, University of California, Riverside, CA 92521, USA
[c] College of Electronics and Information Engineering, Sichuan University, Chengdu 610064, China

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ABSTRACT

As the amount of online multimedia keeps growing rapidly, study of online user behavior is highly demanded in many applications to provide better user experience and online services. Due to the surging online user population in recent years, more and more online contents are now associated with advertisements. For marketers, online advertising can reach broader audience with reduced cost. Meanwhile, the revenue for many IT companies such as Google mainly comes from advertisement hosting. Therefore, for both marketers and advertisement hosts, effective online advertising is the primary goal. Thus, it is of great interest to predict and prevent the users from zapping, i.e., skipping the advertisement. Reduced zapping would increase the possibility for the user to become potential consumer. Despite its importance, zapping prediction for online advertising has received very limited attention. Since the zapping behavior is related to the user's emotional states, in this paper, we propose to predict zapping from user's facial expressions. Our prediction is non-intrusive, meaning that the user's experience during advertisement watching is not disturbed. Specifically, a robust encoding of the smile responses termed as Cumulative Smile Sparse Representation (CSSR) is extracted from the user's facial expressions. Then, this representation is incorporated in a semi-supervised hypergraph learning framework to predict the moment-to-moment zapping behavior. The hypergraph is able to discover both pairwise and higher order data relationships, leading to more accurate prediction as compared to conventional classifiers. Experiments are conducted on a recently published zapping behavior analysis dataset and state-of-the-art performance is achieved as compared to other competing methods.

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1. Introduction

In recent years, a surging amount of multimedia contents have been made available online, attracting more and more online users all over the world. As a result, increasing advertising and marketing efforts have been made on the online contents. On the other hand, due to the raised advertising cost on conventional advertising platforms such as TV, marketers have started shifting their main focus to online advertising with reduced cost. For example, the cost of a 30-second advertisement on TV at prime time in US was about 500,000 US dollars in 2012,[1] while each click for an advertisement on Google search costs only a few US dollars.[2] Although individual click incurs tiny cost, due to high advertisement volume targed for online users, it is estimated that the revenue for online advertising will hit about 200 billion US dollars by 2018.[3]

On one hand, delivering effective advertisements is essential to marketers in order to yield increased gain. On the other hand, most popular websites such as Google and Facebook depend on advertising as their major revenue source. Therefore, effective advertising is important to both marketers and advertisement hosts. To evaluate the effectiveness of advertising, user behavior can be monitored and analyzed. Among various indicators of user preference, *zapping* is considered as one of the most important metrics [1]. Zapping is defined as the action when a user chooses to stop watching an advertisement by either switching to another source or simply turning off the current source. This action

* Corresponding author.
E-mail address: syang@scu.edu.cn (S. Yang).

[1] http://domainestimations.com/?p=14174
[2] http://www.pennapowers.com/how-much-do-ads-on-google-cost/
[3] http://www.digitalstrategyconsulting.com/intelligence/2014/06/

http://dx.doi.org/10.1016/j.neucom.2015.10.107
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indicates that the user is no longer interested in the advertisement. As a result, accurately predicting zapping and applying interventions may retain the user's interest in the advertisement, leading to more effective advertising.

For online advertising, the option of zapping is usually available to the users. For example, the TrueView advertising by Google [2] provides a user the option to skip the advertisement and directly jump to the demanded video contents, after a 5-second preview of an advertisement. In this case, if a user chooses to skip the advertisement, the user is less likely to become a potential consumer, and the advertisement host, i.e., Google in this case, also fails to collect profit from this incidence of advertising. Thus, for both advertisement provider and host, it is their common interest to retain the user's attention to the advertisement.

To understand zapping, various approaches have been devised. In the early days, self-report was employed in which a user is asked to provide feedback about the reasons for zapping. However, self-report is not always accurate and may suffer from cognitive bias [3]. Recently, Abbasi et al. [4] pointed out that user behavior is affected by perceptual considerations such as personal feelings, which can be conveyed through the user's facial expressions. As a rich source of communication, facial expressions can be detected non-intrusively [5]. In light of this, recent efforts aimed to predict zapping from facial expressions [6,7].

In this paper, our goal is to predict zapping behavior based on facial expressions. In particular, we predict zapping from the user's smile response, since most advertisements are designed with entertaining factors to retain the user's interest. Fig. 1 contrasts examples of smile responses accompanied with zapping or non-zapping behavior. It is clearly observed that the smile responses and dynamics in these two cases are quite distinct. Essentially, the user's smile response is a time series and zapping at a moment is dependent on both current and previous smile responses. Therefore, we design a feature descriptor termed Cumulative Smile Sparse Representation (CSSR), which can robustly encode smile responses along the temporal axis.

We cast zapping prediction into a binary classification problem and propose a semi-supervised hypergraph learning framework. This hypergraph is able to model both pairwise and higher order data relationships by constructing hyperedges that connect multiple data samples simultaneously [8]. As evidenced by many previous works [9–13], learning a hypergraph can be more effective than using conventional classifiers. Our prediction is moment-to-moment, meaning that the zapping prediction is based on the dynamics of the smile responses. In this way, timely user behavior understanding and intervention become possible, which may help achieve better advertising goal.

The rest of this paper is organized as follows. In Section 2, we discuss related works in facial expression analysis and zapping prediction, as well as hypergraph learning related works. Background on hypergraph learning is first introduced in Section 3. Then, details of our zapping prediction framework are elaborated in Section 4. Experimental results are reported in Section 5. Finally, conclusions are drawn in Section 6, with a pointer to our future work.

2. Related works

2.1. Zapping behavior analysis

Zapping prediction has been mainly studied in marketing research, primarily for TV advertisements. It was shown that by retaining a user's attention (i.e., keeping the user from zapping), desired communication effect can be achieved [14]. Elpers et al. [1] conducted study to discover why consumers stop watching TV

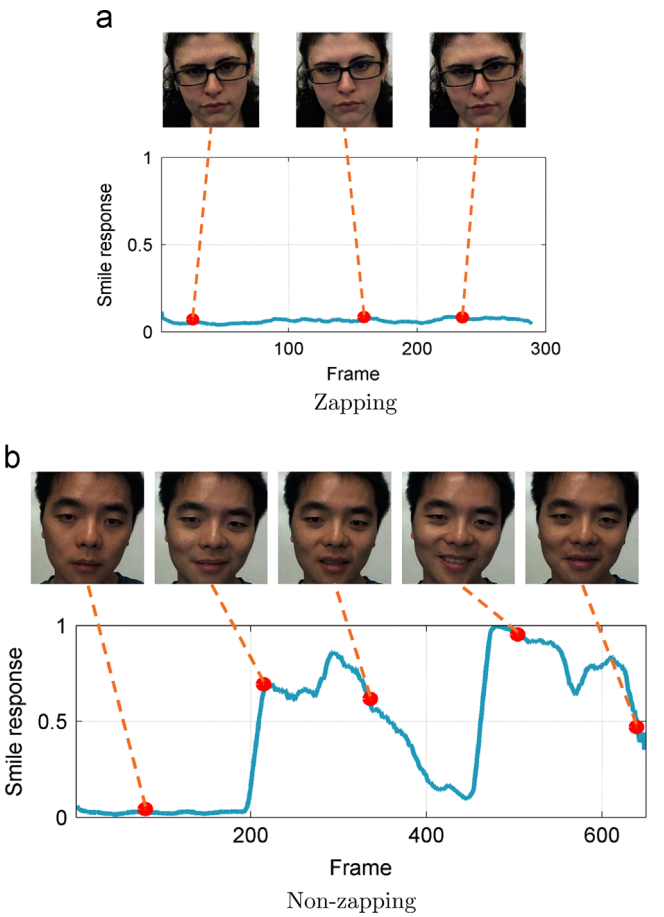

Fig. 1. Examples of smile responses for (a) zapping, and (b) non-zapping behavior. The smile responses and dynamics are quite distinctive in zapping and non-zapping cases. For the zapping case, the smile responses of the user are constantly low, indicating that the advertisement fails to catch her interest. On the other hand, for non-zapping case, the user is engaged in the advertisement, as evidenced by the high smile responses. (a) Zapping. (b) Non-zapping.

advertisements and demonstrated the effectiveness of moment-to-moment entertainment, and its impact on zapping likelihood. Gustafson et al. [15] applied a hierarchical Bayes approach for analyzing dynamics of attention during TV advertisement watching. Kooij et al. [16] showed that user's quality of experience (QoE) is affected by zapping behavior for Internet Protocol TV (IPTV). Later on, Siebert et al. [17] proposed multiple solutions for reducing the zapping, which is also termed as Channel Change Time (CCT), for IPTV systems.

For advertising study, a few works have been reported with an emphasis on facial expression analysis. Teixeira et al. [14] demonstrated that advertisers can use emotion patterns to engage users in watching advertisements on the Internet. They applied a Bayesian Neural Network classification framework to predict the user's zapping behavior, particularly based on joy and surprise expressions. Yang et al. [6] collected a dataset of user response from online advertisement watching and formulated zapping as a binary classification problem. They employed smile responses for feature extraction to predict zapping, and a Zapping Index (ZI) is proposed as a moment-to-moment measurement of a user's zapping probability. This dataset, containing users' facial expressions and zapping behavior from watching various online advertisements, is now made publicly available for zapping study [7]. Recently, Lewinski et al. [18] conducted a psychophysiological study of facial expressions of happiness produced by advertisements. A commercial facial analysis system was used for automatic analysis of facial expressions of basic emotions. This study

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