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A novel methodology for optimizing display advertising campaigns using genetic algorithms

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ABSTRACT

Online advertising campaigns have attracted the attention of many advertisers willing to promote their business on the Internet. One of the main problems faced by advertisers, especially by those who have little experience in Internet advertising, is configuring their campaigns in an efficient way. To configure a campaign properly it is required to select the appropriate target, so it is guaranteed a high acceptance of users to adverts. It is also required that the number of visits that satisfy the configuration requirements is high enough to cover the advertisers' campaigns. Thus, this paper presents a novel methodology for optimizing the micro-targeting technique in direct response display advertising campaigns by using genetic algorithms as the basis optimization model and a machine-learning based click-through rate (CTR) model. We implement our methodology to optimize display advertising campaigns on mobile devices using a real dataset. Results show that our methodology is feasible to optimize the campaigns by selecting the set of the best features required. Also, customization of the advertising campaign selecting some features by an advertiser, e.g. applying micro-targeting, can be optimized efficiently.

1. Introduction

Internet advertising campaigns have experienced a tremendous increase in recent years. The growth in the number of users and in the number of hours they spend connected has caused that the business volume of this sector increases year-over-year (Goldfarb, 2014). In addition, online campaigns offer advertisers interesting advantages that traditional campaigns can hardly do.

There are different types of online advertising such as sponsored search engines and display advertising. In sponsored search advertising, it considers to get the business found on search engines by using related keywords; while display advertising considers showing ads to a target audience, mainly in form of banners (Aksakalli, 2012; Pandey et al., 2017). In this paper, display advertising is in focus.

Depending on the type of displaying ads, campaigns can be of the form as branding or direct response (Aksakalli, 2012). Branding refers to long-term advertisement investments in order to maximize the reach of the campaign; while direct response is more focused on the immediate response, maximizing the revenue obtained when customers reach banners (Aksakalli, 2012).

Particularly in display advertising, optimization has been a typical concern and widely explored. Different approaches to optimization have been implemented. In (Aksakalli, 2012), optimization for display advertising is classified into three groups. First, ad-scheduling and placement optimization considers determining where to expose ads on websites. Second, revenue management and pricing optimization consider define pricing schemes and revenue management models. Third, it is the approach for display advertising effectiveness that considers the impact of content and design based on the click-through rate (CTR) metric (i.e. the probability that a user generates a click on an advertisement (Richardson et al., 2007)) and the ad allocation problem.

Furthermore, micro-targeting is a widely applied technique in display advertising campaigns due to its high performance (Goldfarb and Tucker, 2011). It offers advertisers the possibility to configure many parameters of a campaign, such as age, time, browser, operating system, device type, among others, allowing advertisers to address their campaigns to a very specific public. To this end, optimization of the effectiveness of micro-targeting, i.e. select suitable values in the parameters of campaigns, can also be considered.

Thus, this paper presents a novel methodology for optimizing the micro-targeting technique in direct response display advertising campaigns as an ensemble of genetic algorithms and a machine-learning based CTR model. From the advertiser's point

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of view, our methodology consists on optimizing display advertising campaigns by the selection and configuration of the parameters in a campaign, to satisfy advertisers' constraints for possible micro-targeting approach. In the optimization model, we employ an ensemble of computational intelligence techniques composed of genetic algorithms as the basis of the optimization model and the online logistic regression algorithm for CTR modeling. In addition, we validate our methodology by implementing our model to optimize display advertising campaigns on mobile devices, that is, adverts are displayed on mobile screens through apps as banners. For this implementation, we use a real dataset of a self-serve mobile advertising platform called Avazu (Avazu, 2015).

In summary, our methodology heuristically considers to display the most interesting adverts for customers and that the number of visits that meet the configuration requirements is sufficient to cover the advertisers' demand. Thus, the proposed methodology maximizes the objective function (formally known as fitness function for GA) considering: (i) the interest of users for the adverts measured as the average CTR of all predicted visits, and (ii) the number of visits that matches those settings, not looking for configurations that include a huge number of visits, but seeking configurations that ensure a sufficient number of visits to meet the demand of the majority of the advertisers. In addition, the estimation of the average CTR of the objective function is implemented by using the online logistic regression method since its performance has been widely demonstrated (McMahan et al., 2013; Chapelle et al., 2015).

Our proposal allows suggesting advertisers profitable configurations in their direct response display advertising campaigns, mainly used in micro-targeting. It is also easy to implement and cost-effective in terms of space-time complexity. Thus, the main contribution of this work considers the implementation of genetic algorithms for optimizing direct response display advertising campaigns, since to the best of the authors' knowledge, heuristic optimization approaches have not been considered before in that domain, especifically to maximize nonlinear objective functions.

The rest of the paper is organized as follows. In Section 2, we describe the state of the art of online advertising campaigns. Section 3 firstly presents the notation of the proposed methodology and later Section 4 describes the proposed optimization methodology in direct response display advertising campaigns using genetic algorithms. Section 5 describes two experiments that were conducted to set the parameters of the proposal. Section 6 presents the results on a real dataset and the discussion of the work. Lastly, Section 7 concludes the paper and suggests future work.

2. Online advertising campaigns

In this section, a review of the ecosystem for online advertising campaigns, the optimization on display advertising, and the micro-targeting are described.

2.1. Ecosystem for online advertising

Digital advertising, including online and mobile advertising, has experienced a sharp growth year-over-year, according to the Interactive Advertising Bureau (IAB) (IAB, 2016). In the ecosystem for online advertising, publishers have ad spaces on their webpages, and advertisers spend money to place their ads on those spaces (Miralles-Pechuán et al., 2017). Large advertisers can directly negotiate with large publishers. Nevertheless, direct collaboration is commonly done through brokers including ad networks and ad exchanges. Ad networks provide intermediation services between publishers and advertisers, and they also prevent fraud in the online advertising ecosystem (Wilbur and Zhu, 2009). Ad exchange enterprises provide auctions for ad spaces similar to a traditional stock exchange (Chen et al., 2016).

For a general view, the process of publishing adverts (i.e. display advertising) on the Internet has several steps, as shown in Fig. 1: (i) advertisers configure their campaigns by selecting and configuring a set of parameters; (ii) the advertising network estimates the price and traffic for each configuration. Usually, advertisers keep setting their campaigns until they get a satisfactory visit volume and a price within their budget. (iii) Advertisers set a maximum price and a maximum budget for the campaign. When everything is set, the campaign is launched. Adverts are displayed only to users that accomplishes the advertiser restrictions. Each time an advert is displayed, the ad network selects a single one among all candidates. In the selection process, an auction mechanism such as the Generalized Second Price (GSP) (Lucier et al., 2012) and the Vickrey-Clarke-Groves (VCG) (Edelman and Ostrovsky, 2007) takes place. Sometimes many platforms collaborate each other creating a global market where advertisers bid in real-time for placing an advert on the publisher's sites. This is known as Real-Time Bidding (RTB) (Yuan et al., 2013). (iv) Finally, adverts are displayed until the budget runs out. Meanwhile, the advertising platform updates report about the campaign performance. Particularly, this work is focused on the optimization of the first step.

The main issue is how to solve the continuous massive matching problem between users and advertisers in order to obtain the best performance and return-of-investment (ROI) for the whole ecosystem. On the Internet, a large number of advertisers deliver multiple messages to an enormous number of consumers (Evans, 2009). There is a variety of strategies and technologies to solve the matching problem. The two more used types of advertising are search-based advertising and display advertising. In search advertising, advertisers and consumers are matched based on keywords entered in a search query.

The most relevant ads are displayed as sponsored links resulting from a query. The most common pricing models in search advertising are cost per click (CPC), cost per action (CPA), and cost per lead (CPL). In display advertising, different types of ads are displayed on publisher websites. Recently, real-time bidding is used to display the most relevant ad impression for the consumer based usually on demographic information. Display advertising is mainly related to cost per mille (CPM) pricing model, but it also includes CPC, CPA, and CPL (Chen et al., 2016). Contextual and behavioral advertising are also related to display advertising. Contextual strategies take into account the browser query to identify opportunities to show ads related to the current search. One challenge is how to match the content of a site with the product or service advertised. Big digital advertising stakeholders play several roles in digital advertising monopolizing the online advertising market. The largest Internet advertising companies have great advantages when compared with small ad networks (Evans, 2008):

- *Volume and market* – when a product is released to the market it can be oriented to win money by margin or volume. Large ad networks have understood that Internet business is not in the margin but in volume. Few people are willing to pay for an Internet service, but millions are willing to use it for free. Millions of users imply opportunities to show them ads and make money. On the other hand, it is very difficult for a business to survive with few users.
- *Synergies* – when a large company develops a module, this module can be incorporated into many of its products. Thus, users can be directed to websites through ad networks' search engine; but also, these large networks can manage the adverts of the websites.