

Computational Advertising: A Paradigm Shift for Advertising and Marketing?

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The umbrella term *computational advertising* encompasses a spectrum of computational systems, technologies, and methods of advertising and promotional behavioral analytics and decision making. Particularly, computational advertising refers to an advertising ecosystem with fruitful computing

capabilities that employ mathematical, physical, IT, and economic approaches to expressively represent a rich set of advertising objects and environments, model and analyze complex stakeholder behaviors, facilitate efficient, profitable delivery of advertising information to potential consumers across various media vehicles in different contexts of customer/product/brand/firm interactions

and touchpoints, and provide efficient, optimal solutions for advertising decision making and market design.

Impacts

The web, mobile devices, and social media, combined with the rapid proliferation of novel digital applications over them, have had a pronounced impact on human daily

lives. As a result, a rich set of advertising forms has emerged over a rich set of these media vehicles, such as display advertising, contextual advertising, textual advertising, sponsored search, real-time bidding advertising, viral advertising, mobile advertising, social advertising, and so on. In contrast with traditional advertising, computational advertising provides an ideal platform for monitoring, tracking, gauging, and evaluating advertising campaigns and consumer behaviors, thus enabling the possibility to provide accurate, personalized advertising services with quantifiable results. Nonetheless, in these novel advertising systems, the motivation, belief, and attitude behind consumer behaviors have become much more complex and elusive, thus calling for sophisticated market mechanisms, processes, and strategies to achieve satisfying results for all stakeholders.

Computational advertising is a rapidly growing interdisciplinary research area that overlaps a variety of established scientific disciplines, including computer science, artificial intelligence, advertising, marketing, linguistics, statistics, economics, psychology, and sociology. From the vantage point of discipline development, we've made an interesting observation. For a given research field that has developed independently and made it to a certain level (which is hard to quantitatively measure), a large-scale introduction (or invasion) of exterior knowledge from mathematics and IT often leads to an overwhelming revolution, along with a surge of joint research efforts across many disciplines, to name a few, from biology to bioinformatics, from geography to GIS (geographical information system), from economy to econometrics, from sociology to social computing, and so on. In this sense, we can view the birth of computa-

tional advertising as an unprecedented opportunity for both academic disciplines and industrial practices of advertising and marketing, although it's still at the infancy stage.

Potential Research Perspectives and Challenges

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consumers, advertisers, and publishers. The marketing and advertising vertical usually emphasizes the importance of communication efficiency, value delivery, the stock of goodwill, and profit expected from promotional campaigns. With this spectrum of goals, it's generally acknowledged that interdisciplinary efforts in the computational advertising area are essentially necessary. In this sense, we believe that there are many research challenges in integrating different viewpoints, methodologies, theories, and technologies at this disciplinary intersection. The ultimate goal of computational advertising is to create sustainable values (for example, profit for firms and utility for consumers) for—and reciprocal relationships among—various types of stakeholders in the advertising ecosystem.

From both the academic and industrial standpoints, several computational advertising research perspectives deserve further attention from all major disciplines.

First, emerging media vehicles (resulting from the development of IT technologies) open novel frontiers for advertising and marketing activities, such as sponsored search advertising from search engines. Actually, the survival and popularity of a media vehicle platform and the related advertising system depend to a high degree on the understanding of user perceptions, interaction styles, and concept drift in a given space (either physical or virtual), as observed in many industrial practices of web and mobile services. In addition, new advertising forms can also be born in existing media, due to either the development of technologies or the introduction of exterior knowledge. For example, the real-time bidding advertising form, developed for display and mobile advertising, has

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fundamentally changed the promotional landscape by scaling delivery across a large number of available demanding and advertising inventories in the Internet (or mobile) advertising ecosystem. The challenges in the creation of novel advertising forms are concerned with the design of truth-telling, incentive-compatible mechanism and efficient processes for advertisement storage, retrieval, ranking, and display, demanding a deep understanding of consumer behaviors and advertiser strategic actions.

Second, modern advertising practices entail tracking ability and thus accumulate plenty of real-world data. This situation provides an ideal context for various studies that couldn't be conducted before. On one hand, recent years have seen a surge in empirical advertising studies that employ statistical and econometric models to analyze the effects of advertising factors in the advertising and marketing fields. On the other hand, many data-driven techniques have been employed in advertising research, including information retrieval, statistical modeling, machine learning, optimization, econometric, large-scale search, and text analysis. Most of the efforts in the latter category have been done by researchers in the IT and statistics communities, but, with some notable exceptions, these works have attracted little attention from advertising and marketing scientists. Such a disciplinary gap has raised a large research challenge. Moreover, because potential consumers typically transfer across different media, it's increasingly necessary to make advertising decisions in an integrated way, especially in the context between virtual (online) and physical (offline) spaces.

Third, from a broad view, computational advertising can also leverage

prior research with advertising and marketing models in the past half-century in the course of theoretical development in the fundamental field. Those research efforts were mainly intended to build mathematical models for advertising systems and develop analytical solutions for advertising decision problems. Note that we usually make a distinction between analytical and statistical advertising models. Both have merits and disadvantages: the former concerns the delineation of advertising systems in a precise way, based on the deep understanding of the phenomenon of interest, and the latter, which is data-driven, can be used to evaluate the effect of advertising factors and interactions among them. On one hand, as we know, the realistic advertising system is much more complex than nearly any analytical model. Thus, to obtain a closed-form solution, scientists have to make a tradeoff decision. In this sense, analytical modeling of advertising might call for deep involvement from mathematicians and physical scientists to explore more realistic advertising models and solutions specialized to novel advertising forms. On the other hand, we envision that the integration of analytical and statistical advertising models could significantly improve the theoretical research of advertising systems, facilitate the understanding of advertising behaviors, and help make optimal advertising decisions for advertisers and design-efficient market rules for publishers (or advertising service providers).

In This Issue

This special issue samples the state of the art in computational advertising research with relevance to the computer science and artificial intelligence.

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Woo-Jong Ryu, Jung-Hyun Lee, and SangKeun Lee's article "Utilizing Verbal Intent in Semantic Contextual Advertising," proposes a methodology that effectively identifies verbal intent in webpages and ads texts and incorporates it into an ad-ranking framework. Verbal intent describes what a user wants to do, that is, from an action perspective, complementing the topical intent, as experimentally proved by the efficacy of verb and topic associations. Experimental results based on real-world datasets show that the proposed method obtains a significant improvement of precision at a high level of recall in ad ranking, as well as a precision improvement of 35 percent on average in verbs identification.

Advertisers use online advertising for branding and direct response. In "AdScope: Search Campaign Scoping Using Relevance Feedback," Kevser Nur Çoğalmiş, Oğuzhan Sağoğlu, and Ahmet Bulut present a platform

called AdScope to rank user queries with respect to relevance by combining feedback from both users and advertisers; the tool then recommends to advertisers the top queries to be included in their campaigns. AdScope achieves a good classification accuracy of 89.3 percent for queries containing at least two terms; quality achieved an inter-rater agreement score of 0.79.

In "A Three-Phase Approach for Exploiting Opinion Mining in Computational Advertising," Mauro Dragoni proposes a three-phase model for the content analysis of product review sites. The model considers in tandem the aspects discussed by users on review websites, the opinion polarity associated with those aspects, and user profiles on social networks aiming to detect the most interesting aspects and use them to generate attractive messages. The authors also evaluate the effectiveness of the proposed approach in a real-world scenario with two

Twitter seeds. Experimental results illustrate messages created by analyzing that content (products' aspects and associated polarities) could significantly improve the overall attractiveness of generated advertisements.

We express our sincere gratitude to all contributing authors for their meaningful works in this special issue and the reviewers for their valuable time and comments to help improve the quality of the submitted articles. We also thank the magazine's EICs (Daniel Zeng and V.S. Subrahmanian) and editorial staff (Jennifer Stout) for their patience and generous support during the entire process.

We hope that the outlined perspectives and challenges, technological development, and research findings presented in this special issue will encourage exciting new and synergetic research in this important field. ■

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