

Self-optimizing Digital Signage Advertising

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Abstract. *In this demo we present an approach to optimize advertising on digital signage automatically. We assume that advertising slots on signage are sold in auctions. Each advertisement is represented by an agent, which is given context data for the display, like current time and location. From this context data, the agent determines how much to bid in the auction. The winner of the auction is then shown on the display. To enable the agents to make optimal bids, some feedback on advertising effectivity needs to be fed back into the system. We propose to use the advertisement shown as a coupon, offering users to get a special offer at a certain location within a certain time window. Users can take a photograph of the sign, which acts as a coupon, with their mobile phone and show this photo to the cashier. The coupon contains a code that encodes where and when the user has seen the ad. This code is fed back into the system and used to retrain the advertising agents and measure advertising effectivity. Thus, for each context the advertisements that are liked most are shown.*

1. Introduction

Imagine an environment where digital signage is ubiquitous. Moreover, this *smart* digital signage adapts to the current context. When it's about to rain, it advertises umbrellas, and when the sun is shining, ice cream is advertised. All ads shown on the signs can be used as coupons, getting something cheaper than without it.

For advertisers, using the couponing system makes out-of-home advertising much simpler. Whenever they would like to have more people in the shop, they simply go to the systems website. They choose a certain time window, for example the next hour, and a special offer they want to provide. As soon as they press the submit button, the system automatically determines where and when it would be best to show this ad. When the advertiser approves the suggestion, the ad is immediately shown on the best advertising signs.

As soon as customers start coming in, the advertiser types the codes on their coupon into a web form, so he can trace back where and when they have seen the ad. This information makes the automatic suggestion for advertising time and location even better. To run such an advertising campaign, a very small budget of even a few cents may be sufficient, and the advertiser can accurately trace back how his investment paid off.

The concept of using auctions to select advertisements shown on digital signage was introduced in [4]. The concept of using decision theory to determine the optimal bid depending on the context was introduced in [1]. To make such optimal bids, a model of the environment of the signs is needed. An approach to automatically learn the topology of digital signs from the movement of people was presented in [2]. A general overview of work on situated public displays can be found in [3].

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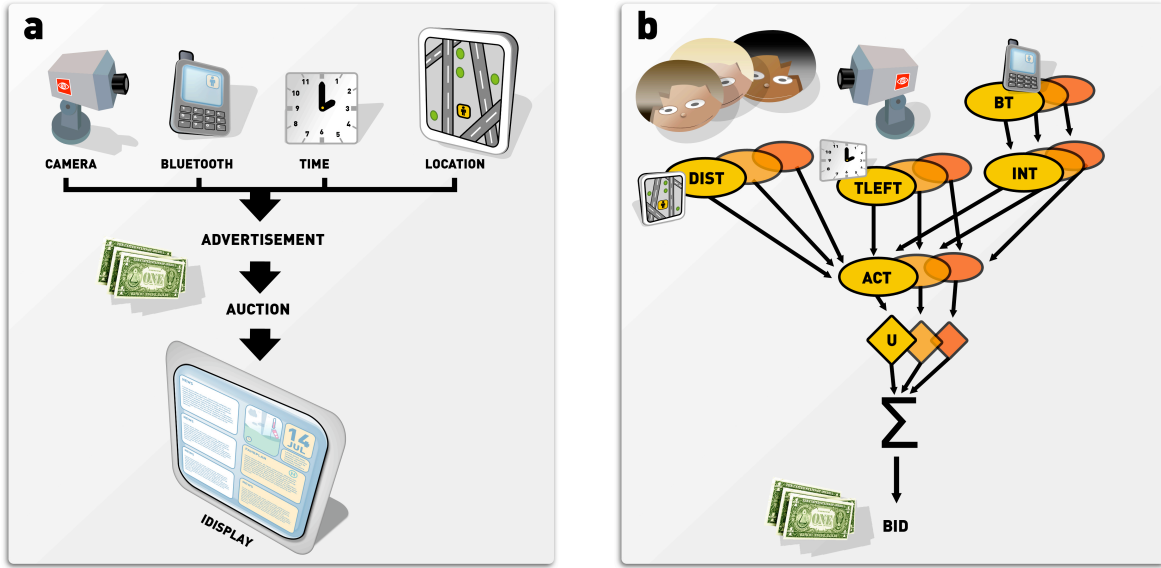


Figure 1. The auction process (a) and the bidding strategy (b) used in our approach. At the start of each advertising cycle, context information is gathered. The number of users looking at the display, if possible their identity, and the current time and location are provided to the advertisement. Advertisements take this context information and execute a Bayesian network to estimate the probability that the users will act. From this estimation they compute the total expected utility of being shown and generate their bids for the upcoming advertising cycle. In a generalized second price auction, the available advertising slots are then sold to the highest bidders. For the duration of the advertising cycle, the selected advertisements are shown on the display.

2. Coupons for Actionable Advertisements

We define actionable advertisements as advertisements that entice you to take a clearly defined action within a certain window of space and time. Examples would be special offers like those mentioned in the introduction. The critical decision is whether you want to take the action or not. We consider it important that action opportunities are offered as a pull process, instead of being pushed to the customer. Digital Signage provides an unobtrusive way to offer such action possibilities to customers in public space. In order to optimize the time and location of showing ads on digital signage, it is important to measure advertising efficiency. One way of doing this for actionable advertisements is to measure whether customers actually took the action. This can be done with coupons. The coupons contain a code that encodes where and when the ad was shown. By feeding back this code into the system, exact measurements are enabled on where and when certain ads work best.

3. Auctioning Advertising Space

To allocate the scarce resource of advertising space to multiple concurring advertisers, auctions seem well suited. Moreover, auctions have a natural pricing scheme where the amount of money advertisers pay is determined by the auction. Auctions for selling advertising space on websites are common practice, and auctions for selling advertising space on digital signage have been proposed in [4]. The complexity of advertising distribution is then within the bidding functions of the individual advertising agents. The agents should bid the right amount of money depending on the current context, like time and location. The auction process is depicted in figure 1 a.

4. Smart Bidding

We employ decision theory to compute the expected utility of showing an advertisement or not $EU(AD)$. A Bayesian network is used to compute the corresponding probabilities. This approach enables us to smoothly integrate live sensor data and a priori estimations, obtained by marketing studies or mining the recorded data history. The bidding process is depicted in figure 1 b.

Each advertisement should simply bid its expected utility of being shown, $EU(ad) - EU(\neg ad)$. These utilities depend on the profit the advertiser makes if the user takes the action or not $U(ACT)$ and the probability of the user taking the action $P(ACT|AD)$. We use upper case notation like $P(ACT)$ to denote probability distributions, while for binary variables lower case notation like $P(\neg act)$ denotes the individual probability that the variable takes this value. For simplicity we assume that the advertiser makes no profit if the user does not act $U(\neg act) = 0$ and that the client does not act if we do not advertise $P(act|\neg ad) = 0$. The set of users detected to observe the display is called *viewers*. The advertisement should then bid $EU(ad) = \sum_{j \in viewers} P(act_j|ad) * U(act_j)$. The probability that the user will act will be different under different contexts. Some properties of this context can be sensed by the display and be compiled into features. Simple features would be for example time of day or distance to the shop. This feature set can be different for different applications and is denoted $\{f_i | i = 1 \dots n\}$. Using the features, we can refine our equation to:

$$EU(ad) = \sum_{j \in viewers} P(act_j | f_1, \dots, f_n, ad) * U(act_j)$$

We assume $U(act)$ is entered manually by the advertiser. If we assume that the features f_i are conditionally independent given ACT and ad , we can apply this and use Bayes' theorem to obtain:

$$P(act | f_1, \dots, f_n, ad) = \frac{\prod_{i=1 \dots n} P(f_i | act, ad)}{\prod_{i=1 \dots n} P(f_i | ad)} P(act | ad)$$

5. Demonstration

We plan to install a number of digital signs at the conference. Attendants will be able to upload their own ads, for example for their poster, demo or talk. Each ad should resemble a coupon, for example for getting a special explanation or some cookies. Conference attendants will be able to take photos of the advertisements and convert them at the advertisers desk. Over time, the system will learn where and when conference attendants prefer certain offers. By the end of the demosection, the system should show the right ads for conference attendants at exactly the right time and locations. We hope that this will be an interesting and insightful experience for conference attendees and help building a community around situated public display technology.

References

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