

COMPGW02/M041 Web Economics Coursework

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Submission Deadline: 23:55 06/04/2018

This coursework project consists of two reports and is worth 30% of your overall score

1. SUMMARY

In this assignment, you are required to work on an online advertising problem. You will help advertisers to form a bidding strategy in order to place their ads online in a real-time bidding system. You are required to train a bidding strategy based on a provided advertising impression training set. This project aims to help you understand some basic concepts and write a computer program in real-time bidding based display advertising. As you will be evaluated both as a *group* as well as *individually*, part of the assignment is to train a model of your choice independently. The performance of the model trained by your team, which is either a combination of the individually developed models or the best performing individually-developed model, will be (mainly) evaluated on the Click-through Rate achieved on a provided test set. For you to properly evaluate the performance of each of your models before that, a benchmark click-through rate on the validation set will be provided. Before the final submission, you are also given the opportunity to hand in the preliminary result of your team's model on the test set, which allows you to compare the performance to that of your peers. Should you have any question about the assignment, feel free to contact the TAs: Yean-Hoon Ong ([email](#)), Zheng Tian ([email](#)), Minne Li ([email](#)), and Ying Wen ([email](#)).

2. RULES

You are expected to work in a team of 3 people, and you can sign in the team through this [google sheet](#), by the end of this week (**the 9th Feb 2018**). You will write a joint group report as the group, and also an individual report on your own.

2.1 Submissions (In Moodle)

- Preliminary submission: **23:55 16/03/2018**. Please upload your submission through Moodle as a zip file, and rename the file as that: Group_xx.zip (e.g., Group_10.zip).

For the preliminary submission, only include a bid price generated using your team's model applied to the testing set in the zip file. Note that the preliminary submission is for the practice purpose, making sure the final submission would be correct. **We are working on an alternative online submission for a real-time update, stay tuned.**

- Final submission: **23:55 06/04/2018**. Both the *Group*

Report and *Individual Report* will be submitted together. Please upload your submission through Moodle as a zip file, and rename the file as that: Group_xx.zip (e.g., Group_10.zip). For the final submission, the file should include the reports (both the group and individuals) in PDF format (including the names of all members of your team, the reports should be named as group_xx_report.pdf and your_name_report.pdf), and your team's predictions for the provided test set. Please upload your code to GitHub and provide a link to it in the reports (again for both reports).

2.2 The Group and Individual Reports

Individually, you are required to submit an *Individual Report* (one per person). At the same time, as a group, you are required to submit one *Group Report* (one per group). Each of them will have 15 marks, and in total there are 30 marks. The rest 70 marks will come from the written exam in May.

The two reports will have different sets of questions, respectively, as given in Section 3.2. The reports shall summarise what you (or your group) did and how you addressed the posed questions as described in the problem description.

You will use the ACM Proceedings style LATEX files for writing your reports. You can find out more about these styles as well as LATEX templates on the [ACM website](#). Note that to make your report looks better, you could simply add the following lines before `\begin{document}` to remove the copyright notice:

```
\makeatletter
\def\@copyrightspace{\relax}
\makeatother
```

For the *Individual Report*, your submission should be 3-5 pages, with maximum 1 additional page for references. For the *Group Report*, your submission should be 5-7 pages, with maximum 1 additional page for references. Images and tables also count against the maximum. Rules written here trump all the non-formatting instructions in the ACM style files. Your report should address all the problems in Section 3.2.

2.3 Q&A and Office Hours of TAs

The office hours below are for this project only. For the office hours of the module itself, please refer to the Moodle page.

- Time: 12:30-13:30 20/02/2018 06/03/2018 and 20/03/2018.
- Location: Hub Level 1, 66-72 Gower Street.

3. THE PROJECT

In display and mobile advertising, the most significant evolution in recent years is the employment of the so-called Real-Time Bidding (RTB) mechanism to buy and sell ads. RTB essentially facilitates buying an individual ad impression in real time, automatically triggered by a user's visit. Although other types of auctions, such as the first price auction, are also popular, RTB exchanges typically employ the second price auction model. In this type of auction, the bidder winning the auction pays the price of the second highest offer. A summary of the process is provided in Figure 1. In this assignment you will be training your own bidding strategy models on a given impression dataset, as described in detail next.

3.1 Data Description

The dataset includes a training set, a validation set, and a testing set. The dataset for the task can be downloaded from <https://goo.gl/aqGmDX>.

This data comes in CSV format, the first line in the file containing the header formatted as described in Table 1. As the testing set is used for final evaluation purposes, it does not contain the three fields: 'bidprice', 'payprice' and 'click'. Note that that all number related to money (e.g., bid price, paying price and floor price) is Cost Per Mille (CPM), corresponding to the commonly adopted CPM pricing model. It uses the currency of CNY and the unit is Chinese fen. For instance the payprice in Table 1 means the cost is 322 Chinese fen per 1000 impressions. When someone won this impression, they had to pay 0.322 Chinese fen just for it.

You can develop your model on the training data and use the validation set to compare the different models and correct for overfitting.

3.2 Problem Description

In this assignment, you are required to train a bidding strategy based on the impressions in the training set. This objective has been divided into the following five sub-problems, and you are required to solve and report these problems in either the group or individual report, as indicated below. The concept of a bidding strategy has been visualized in Figure 2 and can also be found in the lecture notes.

3.2.1 Problem 1: Data Exploration

- Individual report, 5/30 marks

You should do some exploratory data analysis and show your understanding of this dataset. You can start from basic statistical information, such as num Imps, num Clicks, Cost, CTR, avg CPM, eCPC. You can also include further analysis on user feedback, bidding etc. A good example can be found in the paper [1].

3.2.2 Problem 2: Basic Bidding Strategies

- Group report, 5/30 marks

Evaluate the following strategies on the validation set and discuss your results. Use the performance metrics as defined in Section 3.3.

- Constant bidding (Const). Bid a constant value for all the bid requests. The parameter is the specific constant

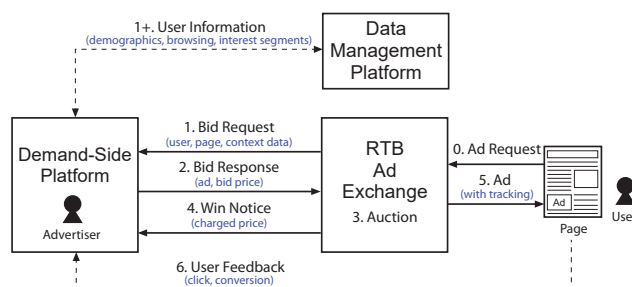


Figure 1: A brief illustration of the interactions between user, ad exchange and the advertiser's DSP bidding agent.

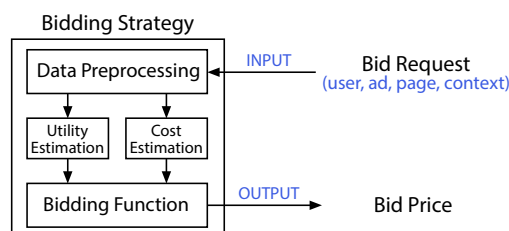


Figure 2: A bidding strategy can be abstracted as a function mapping from the given bid request (in a high dimensional feature space) to a bid price (a non-negative real or integer number).

bid price. Explain how you can experimental find an optimal constant value from the training set. Provide an analysis of your finding.

- Random bidding (Rand). Randomly choose a bid value in a given range. The parameter is the upper bound and lower bound of the random bidding range. Give your experiment results of finding the optimal bounds.

3.2.3 Problem 3: Linear Bidding Strategy

- Group report, 5/30 marks

Apply CTR estimation to create a linear bidding strategy. The bid value is linearly proportional to the pCTR (predicted CTR). The formula can be generally written as $bid = base_bid \times pCTR / avgCTR$, where the tuning parameter $base_bid$ is the bid price for the average CTR cases. Optimise the $base_bid$ and the CTR estimation and evaluate the performance of your model using the metrics as defined in Section 3.3. Discuss and compare your results.

3.2.4 Problem 4: Your Best Bidding Strategy

- Individual report, 10/30 marks

As the linear model may not be the best model, you are asked to experiment further in order to find a more optimal model. The model you developed can be tested over the validation set. and you should explain your approach and discuss your results in the individual report. This does include, but is not limited to, reporting the performance metrics as defined in Section 3.3 of your solution and the parameter turning results on the validation set.

Table 1: Fields in dataset

Field	Example	Supplement
click	1	1 if clicked, 0 if not.
weekday	1	
hour	12	
bidid	fdfe...b8b21	
userid	u_Vh1OPkFv3q5CFdR	
useragent	windows_ie	
IP	180.107.112.*	
region	80	
city	85	
adexchange	2	
domain	trq...Mi	
url	d48a...4efeb	
urlid	as3d...34frg	
slotid	2147...813	
slotwidth	300	
slotheight	250	
slotvisibility	SecondView	
slotformat	Fixed	
slotprice	0	
creative	hd2v...jhs72	
bidprice	399	
payprice	322	Paid price after win the bidding.
keypage	sasd...47hsd	
advertiser	2345	
usertag	123,5678,3456	Contains multi-values, ',' as segmentation.

Note that your bidding strategy described here may be part of the more complex model (either "cleverly" combined one or further developed one based on multiagent reinforcement learning) for the group, see problem 5 below, which will be tested over the test dataset. Therefore, it is advised, although not mandatory, that you try different models than your other team members in this section.

Some directions: A non-linear bidding strategy (e.g. [ORTB](#)) [2], a lift-based bidding [3] or using other CTR estimators. A collection of research papers can be found [here](#).

3.2.5 Problem 5: A Further Developed Bidding Strategy (Submission)

- Group report, 5/30 marks

As a group, you can either 1) compare the individual bidding strategies developed in problem 4 and design a combined strategy. Your report should include the discussion of the way you combine them and the performance of your combined model on the validation set. or 2) develop a (multi-agent) reinforcement learning (RL) approach for the bidding (you might want to make use of the basic bidding algorithms developed in problem 4 to start with). Hint 1: RL can be used to deal with budget constraints [4]. Hint 2: multiagent RL might be useful for taking into the competition among different group submissions.

Next, pick up the best bid strategy, and this can be the combined model or the (multiagent) RL based solution and make your predictions on the given test set. (There are also the predictions that you are allowed to hand in preliminary.)

3.3 Evaluation

Alongside the final report, you are required to submit the bid prices for the testing set, generated using your group's best performing model from problem 5. Performance will be evaluated based on the following metrics, within a limited budget of 6,250 CNY fen.

- Clicks (Num. of Clicks from Winning Impressions) **the main metric to rank the submissions**
- Click-Through Rate (Num. of Clicks over Winning Impressions)
- Spend (Total Money Paid) **spend all the budget to be a valid submission**
- Average CPM (Cost Per Mille)
- Average CPC (Cost Per Click)

The bidding prices on the testing set (not the training or validation set!), should be saved as a CSV file named 'testing_bidding_price.csv' with following format:

```
bidid,bidprice
xxxxxxxxxx,13.0
yyyyyyyyyy,23.0
....
```

An example submission file will be provided with the dataset, please strictly follow the format requirements. During the evaluation, we (our script) will go through the file and only consider the bids until the accumulated cost is higher than or equal to the allowed budget 6,250 CNY fen.

We would expect you to produce two final submissions (therefore files) to account for two different ways of calculating the winning and the actual paid price. Winning criterion #1: the winning is determined if $bid \geq payprice$ and the actual paid price is the $payprice$ from the data. Winning criterion #2: the winning is determined if $bid \geq payprice \& otherSubmittedBids$, and pay the highest among $payprice \& otherSubmittedBids$. Note that the latter setting is still the second price auction, but accounts for the competition among the bids coming from different groups as specified by Problem 5 option 2. If you don't choose option 2, we still require you to submit the result for Winning criterion #2, but only make it the same as the one for Winning criterion #1.

3.4 Format of your reports

Your reports (both the individual report and the group report) should consist of the following sections: 1) the introduction section briefly explains the problem context and what you intend to do and summarises your results; 2) the related work section briefly summarises the related work of the specific problems you have found from the research literature. You could use <https://scholar.google.co.uk/> or make use of the list [here](#) to obtain the related research papers; 3) the approach and result section gives your answers to each of the specific questions and provide the evaluation results and your discussions. 4) the conclusion section concludes your report and point out the potential direction to improve your report (e.g., if you have time, you will do...). For the individual report, in the conclusion section, create a paragraph to explain your role in the group project and also, if possible, comment on other members' contribution to the

group. We will gather the information to understand how the collaboration has been done in the group.

4. REFERENCES

- [1] Weinan Zhang, Shuai Yuan, Jun Wang, and Xuehua Shen. Real-time bidding benchmarking with ipinyou dataset. *arXiv preprint arXiv:1407.7073*, 2014.
- [2] Weinan Zhang, Shuai Yuan, and Jun Wang. Optimal real-time bidding for display advertising. In *Proceedings of the 20th ACM SIGKDD international conference on Knowledge discovery and data mining*, pages 1077–1086. ACM, 2014.
- [3] Jian Xu, Xuhui Shao, Jianjie Ma, Kuang-chih Lee, Hang Qi, and Quan Lu. Lift-based bidding in ad selection. In *AAAI*, pages 651–657, 2016.
- [4] Han Cai, Kan Ren, Weinan Zhang, Kleanthis Malialis, Jun Wang, Yong Yu, and Defeng Guo. Real-time bidding by reinforcement learning in display advertising. In *Proceedings of the Tenth ACM International Conference on Web Search and Data Mining*, pages 661–670. ACM, 2017.