

### Homework 3 (due Friday, April 7<sup>th</sup> at the beginning of class)

The goal is to design a mechanism that maximizes revenue on a set of sampled data. The data is in the file "HW3\_data.txt" that is found on the website. The data comes from samples from the true distribution of a single bidder and a (possibly correlated) external signal. The format of the data is a pair of values for every sample corresponding to a single line of the text file, where the bidders value is first, and the value of the external signal is second, i.e.:

4,3  
2,2  
1,1

means that in the first sample, the bidder has value 4 and the external signal has value 3. The second sample, the bidder has value 2 and the external signal has value 2, and so on. The bidder has a value in the set {1,2,3,4,5} and the external signal is also in the set {1,2,3,4,5}.

HINT: We do not provide a separate training and test set. It is good practice to hold out some data as a test set as a check for your mechanism to avoid overfitting the data. We recommend that you explicitly hold out some of the data as a test set.

The bidder's value is his valuation for the object. The external signal does not represent value for the object, you only ever sell to the bidder. The external signal is strictly an additional source of information that is potentially correlated with the bidder's valuation, and it is possible to construct a mechanism that ignores the external signal.

Each sample in the data is drawn independently from every other sample, and there are 2000 samples in the data set. The objective of this assignment is to **submit a text file entitled "mechanism.txt"** that defines a mechanism (a payment from the bidder to the seller and a probability of allocating the item to the bidder) for every combination of a reported valuation and a realized value of the external signal. The submission **must be formatted exactly** as below:

p=  
1,1,.5,.2,0  
.97826712,.512834712,.3,.1,1  
1,1,.5,.2,0  
1,1,.5,.2,0  
.97826712,.512834712,.3,.1,1  
x=  
12.21341,11,312,4.4,-14.1  
12.21341,11.23,312.56,4.4,-14.1  
13.21341,11.55,312,4.4,-14.1  
12.21341,11,312,4.4,-14.1  
12.21341,11,312,4.4,-14.1

The above mechanism is completely arbitrary and only intended to illustrate the formatting. There must be a "p=" preceding five lines where each of the five lines contains five comma separated numbers corresponding to the allocation probability (no spaces, just commas). The rows are indexed by the

bidder's valuation, and the columns are indexed by the external signal's value, i.e. a bidder that has valuation 2 and an external signal of value 4 would correspond to an allocation probability of ".1". The allocation probability must be less than 1 and larger than 0, and the mechanism will be rejected if any allocation probability is larger than 1 or less than 0.

After the allocation probability is specified, the payment must be specified by a line with "x=" and then five rows where each row consists of five comma separated numbers (can be positive or negative where a negative number corresponds to a payment **from the seller to the buyer**). The above example is included on the website in a file entitled "example\_mechanism.txt". Note that all numbers are separated **only by commas**, there are no spaces. The payment is **deterministic**, i.e. the payment is made whether or not the item is allocated. I.e. in the example mechanism for bidder valuation 3 and external signal of 3, the probability of allocation is only .5, so the item is not always allocated, but the bidder always pays 4.4 whether or not the item is allocated.

There is a file that allows you to check the formatting of your submission before submitting entitled "check\_submission.py". To check your formatting, **you must have python 3 installed**. If you do not have python 3 installed, you can install it by going to <https://www.continuum.io/downloads> and downloading the Anaconda distribution of python. The installation is self explanatory. Once python 3 is installed, the formatting can be checked by running the command "python check\_submission.py mechanism.txt" at a command line where python points to the python 3 installation, while in the directory where your mechanism.txt file is stored.

You do not need python 3 installed to complete the assignment, just to check formatting, so if you are certain that your formatting is correct, then you may skip this step. However, any mechanisms that are incorrectly formatted will be penalized significantly.

We want you to be focusing on your projects at the end of class, so the grading for this assignment will allow for as little or as much work as you would like to commit to the assignment. We will calculate the value of the mechanism using the true (but unknown to you) distribution, and the bidder (who is assumed to know the true distribution) will have the opportunity to optimally lie about his type in order to maximize his expected value. In other words, the bidder will always report the type that maximizes his expected utility, and if no choice provides positive expected value for a specific valuation of the bidder, the bidder will not participate in the mechanism if he has that value. Note that we will not be evaluating the mechanism on a test set of samples, we will simply compute the true expected value according to the (secret) distribution from which the samples were drawn.

Note that your mechanism does not have to be incentive compatible or individually rational, but if your mechanism is not BNE incentive compatible, the bidder will lie optimally, and if your mechanism is not ex-interim individually rational, the bidder will not participate achieving zero revenue for that type.

The grades for the assignment will be determined as follows.

- 0% - if "mechanism.txt" is incorrectly formatted and the mechanism can't be evaluated.
- 60% - if "mechanism.txt" is correctly formatted and revenue is at least 1

- 85% - if  $1.9 < \text{revenue} < 2.05$
- 90% - if  $2.05 < \text{revenue} < 2.5$
- 95% - if  $2.5 < \text{revenue} < 2.7$
- 100% - if  $2.7 < \text{revenue}$

Moreover, the person with the highest revenue will get an additional 3% bonus on their final course grade.

You are allowed to check your true expected revenue **one time** by emailing Michael Albert ([malbert@cs.duke.edu](mailto:malbert@cs.duke.edu)) your “mechanism.txt” file before the due date. We will evaluate your mechanism on the true distribution and tell you the expected revenue. However, this can only be done once, and if the mechanism is incorrectly formatted and can’t be read, it still counts as a submission.

It is fine to work in teams of up to three people, but please indicate that you worked together, and only submit a single submission for the entire group.

**Please submit the “mechanism.txt” file by email to Michael and Vince by the Friday, April 7<sup>th</sup> at the beginning of class. Also, please submit an additional file explaining your methodology for computing the mechanism.**