Market Design and Machine Learning
Lecture #1: Introduction

Prof. Dr. Sven Seuken

20.2.2019

Agenda

1. Introduction to “Market Design and ML”
2. Course Overview
   - Goals of this course
   - Course schedule
   - Logistics
   - Quick Presentation of Papers
   - Details about “Projects”
   - Next Steps
   - Questions

The Success Story of Market Design

- Beautiful theoretical foundations:
  - Game Theory (Nobel Prize)
  - Auction Theory (Nobel Prize)
  - Mechanism Design (Nobel Prize 2007)
- First applications:
  - National Resident Matching Market (1990)
  - Spectrum Auctions (1994)
  - Internet Advertising Auctions (2000)
- Market Design (Nobel Prize, 2012)
- Explosion of applications:
  - eBay
  - Uber
  - AirBnB
  - Markets without money (courses, students, organs, etc.)
  - Auctions for resources (gas, wind, coal, diamonds, etc.)
  - Markets for carbon tax certificates
  - Markets for roads
  - Markets on the Blockchain
  - Etc.

The Success Story of ML

- Long history (back to the 1960s), part of AI
  - Learning from data
- Since then, closer to statistics and probability theory
- Recent success stories:
  - Recommender systems (e.g., Netflix, Amazon)
  - Classification (e.g., email filtering)
  - Computer vision systems (self-driving cars)
  - NLP (Siri, etc.)
  - Computer games (Alpha Go, etc.)
  - Etc.

Exciting Combination: Market Design + ML

- How can we use ML to improve market design?
  1. Design better market mechanisms (like auctions or matching mechanisms)
  2. Improve the performance of complex marketplaces (like Uber, eBay, or AirBnB)

Goals of this Course

1. Understand how machine learning can be useful in the design of specific market mechanisms and in the design of complex marketplaces
2. Understand the difficulties involved when combining machine learning with market design techniques.
3. Be able to read advanced research papers.
4. Be able to critically reflect on and discuss a advanced research papers.
5. Be able to identify how machine learning could help solve a new market design problem.
6. Successfully complete a project combining machine learning and market design.

Course Schedule

- 20.2.2019: Introduction: Course Overview
- 27.2.2019: Marketplaces, Markets, and Market Design (Roth, 2018) | [paper]
- 6.3.2019: Fast Iterative Combinatorial Auctions via Bayesian Learning (Brero et al., 2019) | [paper]
- 13.3.2019: Machine Learning-powered Iterative Combinatorial Auctions (Brero et al., 2018) | [paper]
- 20.3.2019: Payment Rules through Discriminant-Based Classifiers (Dütting et al., 2015) | [paper]
- 27.3.2019: Optimal Auctions through Deep Learning (Dütting et al., 2018) | [paper]
- 10.4.2019: Reducing Mechanism Design to Algorithm Design via Machine Learning (Balcan et al., 2007) | [paper]
- 17.4.2019: Project Idea Presentations
- 24.4.2019: no class (Easter)
- 1.5.2019: no class ("Tag der Arbeit")
- 8.5.2019: Improving refugee integration through data-driven algorithmic assignment (Bansak et al., 2018) | [paper][supplementary]
- 15.5.2019: Canary in the e-Commerce Coal Mine: Detecting and Predicting Poor Experiences Using Buyer-to-Seller Messages (Masterov et al., 2015) | [paper]
- 22.5.2019: Search, Matching, and the Role of Digital Marketplace Design in Enabling Trade: Evidence from Airbnb (Fradkin, 2018) | [paper]
- 29.5.2019: Project: Final Presentations

Pre-requisites

1. Successful completion of one of the following courses:
   - Economics and Computation (Seuken)
   - Algorithmic Game Theory (Penna/Dütting/Widmayer)
   - Introduction to Market Design (Pycia)
   - Or equivalent course (but not simply economics 1,2,3, game theory)

   Important topics that must be covered: auction theory (e.g., VCG), combinatorial auctions, mechanism design, matching theory (e.g., Gale-Shapley)
2. Successful completion of a machine learning course

All students who want to take the course for credit must send an email to the TA (Ludwig):

- Which course have you taken to satisfy requirement #1
- Which course have you taken to satisfy requirement #2
- (Why do you think you deserve an exception (probably not!))

Grading

- Presentation of papers and leading class discussion: 20%
- Response essays and class participation: 30%
- Project: 50%

Weekly

- Every week:
  - Read the assigned paper at home, in detail (not necessarily the proofs)
  - Submit response essay (0.5 pages) via OLAT until Mondays, 23:59
  - Tips on how to "read" a paper and how to "write a response essay": http://www.eecs.harvard.edu/~michaelm/postscripts/ReadPaper.pdf

- More tips on how to read a paper:
  - Focus questions to help identify the main contributions of a paper, a
  - Survival kit for reading the technical sections, and a
  - Three-pass approach to tie it all together.

Paper Presentations

- Paper presentation:
  - Present one paper to the class
  - Search for related literature
  - Note: do not just repeat the whole paper in slides. Prepare something that is complementary
    - Can summarize the main idea and/or technical contributions of the paper
    - Can provide background/related information
    - Can raise questions/challenges/limitations/extensions
    - Topics that start a discussion
    - Incorporate response essays, if this makes sense
  - Lead discussion
- How to give a talk:
  - These two articles have a number of good suggestions.
  - This video is pretty good as well.

Project

- You can do this project alone, or in teams of 2 or 3
- Task #1: Find a good "market design project" idea
  - Look around, in the world:
    - Where would a new market be useful?
    - Where is a market that could be fixed
    - Where is an interesting market that you could analyze/compare?
  - Listen to podcasts: Freakonomics, Econ Talk, Planet Money, etc.
  - Read blogs, e.g.: http://marketdesigner.blogspot.ch/ ← this is very useful to get ideas!
- Task #2: Find a team: post your idea on the OLAT forum, or talk to your colleagues
- Task #3: Do the project!
  - Identify a new market design problem, formalize it, and study it (formally and/or computationally).
  - Or take an existing market design solution (from the literature or from the real-world) and extend or analyze it further (formally and/or computationally).
  - Main criterion: the project has to be interesting. The reader has to learn something new! (not just a literature review!!)
  - Ideal project: will lead to a workshop paper/conference paper!

Projects: Timeline

- Project Proposals:
  - Written proposal (1 page): due via OLAT, on Monday, 15.4.2019, 23.59
  - Present project proposal in class (5-10 min): 17.4.2019
- Project report (min=10 pages; max=20 pages):
  - Deadline: May 29, 2019, 10:15am
  - Succinctness is good! Present what makes sense!
- Project Presentations:
  - In class (10min): May 29, 2019

MSc/PhD Level + Auditors

- **For Credit: MSc/PhD**
  - UZH: The course is listed as an MSc/PhD course in the UZH catalogue → straightforward
  - MSc/PhD students from ETH → I am happy to sign any forms at the end of the semester
- **Auditors:**
  - you are welcome, but I expect that you at least read the papers each week (you do not need to present a paper or do the project)

Teaching Staff

- Lecturer: Prof. Sven Seuken

- Teaching Assistants:
  - Ludwig Dierks (TA)

- **Questions? → ask on OLAT; alternatively, email TA: Ludwig Dierks!**
- **No fixed office hours; email Ludwig for appointments**

OLAT

- Please “register for the course” now, so that you automatically get enrolled into the OLAT Campus course
- Alternatively, manually request access to the OLAT course. If you have trouble, please email: dierks@ifi.uzh.ch
- What you will find on OLAT:
  - All required readings/papers (to prepare for class)
  - All lecture slides (from myself, and from students when they present)
  - Upload link for response essays
  - Forum to discuss project ideas
  - Optional reading material
  - Opportunity to ask questions (in the forum)

- (Let’s take a look…)

Optional Text Books

- *“Who Gets What--And Why: The New Economics of Matchmaking and Market”, Alvin E. Roth, 2015.*
- *“Discovering Prices: Auction Design in Markets with Complex Constraints”, Paul Milgrom, 2017.*

Collaboration Policy

- **Single-person response essays:**
  Submit your own response essay, without sharing it with someone else!

- **Penalties:**
  Copying/plagiarism will not be accepted (from other students, from the Internet, or from other sources). We carefully check for this and if detected will take appropriate steps including severe penalties (-100% per homework) and we will inform the University.

- **Discussions with class mates:**
  You are free to and encouraged to discuss the papers with your fellow students, before and/or after writing your response essay!

Course Advice (MSc)

For MSc students who select "Computing and Economics" as their major/minor, we recommend the following courses:

- **Seminar: Advanced Topics in Economics and Computation**
- Empirical Methods
- Advanced Microeconomics I
- Advanced Microeconomics II
- Combinatorial and Approximation Algorithms (Spring 2019)
- **Online and Approximation Algorithms (Spring 2019)**
- **Randomized and Online Algorithms (Spring 2020)**
- Practical AI
- Big Data Analytics / Big Data and Business Analytics
- Introduction to Operations Research

Workload Estimates…

- ~4 h/week: reading (the paper)
- 0.5 h/week: writing response essay
- 2 h/week: lecture
- ~15 hours to prepare paper presentation
- Project: ~60 hours

Next Steps (1/2): Assigning Papers

- We will put these slides online on my teaching website within next 2 hours: https://www.ifi.uzh.ch/en/ce/teaching/spring2019/MDandML.html
-
- Until Friday (22.2.2018), 23:59, send an email to Ludwig Dierks (dierks@ifi.uzh.ch) containing the following information:
  - Name
  - Matrikelnummer (ETH/UZH)
  - Completion of AGT/E&C course (when?) or explicit consent of instructor?
  - Completion of ML course (when?) or explicit consent of instructor?
  - Ordinal preferences for topics, with indifferences (e.g., 3a, 3b, 3c):
    - 1) Number of Topic A
    - 2) Number of Topic B
    - 3a) Number of Topic C
    - 3b) Number of Topic D
    - 3c) Number of Topic E
    - 4) Number of Topic F
- See next page for numbers!! (from 3 to 10!)
- Next Monday, we will use the Random Serial Dictatorship (RSD) Mechanism to assign papers to students
- We will then send you your assigned paper via email

List of Papers/Topics

A. ~~20.2.2019: Introduction: Course Overview~~
B. ~~27.2.2019: Marketplaces, Markets, and Market Design (Roth, 2018) | [paper]~~
C. 6.3.2019: Fast Iterative Combinatorial Auctions via Bayesian Learning (Brero et al., 2019) | [paper]
D. 13.3.2019: Machine Learning-powered Iterative Combinatorial Auctions (Brero et al., 2018) | [paper]
E. 20.3.2019: Payment Rules through Discriminant-Based Classifiers (Dütting et al., 2015) | [paper]
F. 27.3.2019: Optimal Auctions through Deep Learning (Dütting et al., 2018) | [paper]
G. 10.4.2019: Reducing Mechanism Design to Algorithm Design via Machine Learning (Balcan et al., 2007) | [paper]
H. 8.5.2019: Improving refugee integration through data-driven algorithmic assignment (Bansak et al., 2018) | [paper][supplementary]
I. 15.5.2019: Canary in the e-Commerce Coal Mine: Detecting and Predicting Poor Experiences Using Buyer-to-Seller Messages (Masterov et al., 2015) | [paper]
J. 22.5.2019: Search, Matching, and the Role of Digital Marketplace Design in Enabling Trade: Evidence from Airbnb (Fradkin, 2018) | [paper]

Next Steps (2/2): Read Paper + Write Response Essay

- Read first paper until next week, i.e:
  - “Marketplaces, Markets, and Market Design (Roth, 2018)
- Write response essay (0.5 pages):
  - Deadline: Monday, 23:59
  - Submit via OLAT

Questions

- More information: https://www.ifi.uzh.ch/en/ce/teaching/spring2019/MDandML.html

- More questions? →email: dierks@ifi.uzh.ch