NEWDIGS Incentives v2

Prediction Algorithm Funding in Presence of Free-Riding and Heterogeneity

Andy Haupt

Massachusetts Institute of Technology
NEWDIGS

March 26, 2020

Outline

Main Challenges

- How to fund training of prediction algorithms in healthcare?
- Perfect state of the world: Insight demander sponsors a data competition, results are published
- Problem: Free-Riding by others, expensive to set up.

→ Design centralized system that incentivizes specific and high-quality prediction algorithms that makes it cheap to set up "competitions".

Not-so-much Problems

- ~~First-to-market effects~~ free-riding is the main problem
- ~~Incentivizing provision of data~~ Incentivizing prediction algorithms

Definitions

Data Suppliers i Training Set $\{(x, y)\}$ from model $Y = f(X, \varepsilon)$, $X \sim F_i$.

- Want "fair" division.
- No relevant incentives to misreport – audits possible

Data Demanders j Test sets $\{(x, y)\}$ from $Y = f(X, \varepsilon)$, $X \sim G_i$, WTP μ_i for percent accuracy on test set

- Strategic in report of G_i, μ_i.

Data Scientists k Algorithms $f_i(x; (x_1, y_1), \ldots, (x_n, y_n))$, $i = 1, \ldots, k$.

- Faces investment problem
- Algorithms can be audited, manipulations limited

Goal Design a mechanism that maximises revenue that can be distributed to data scientists.

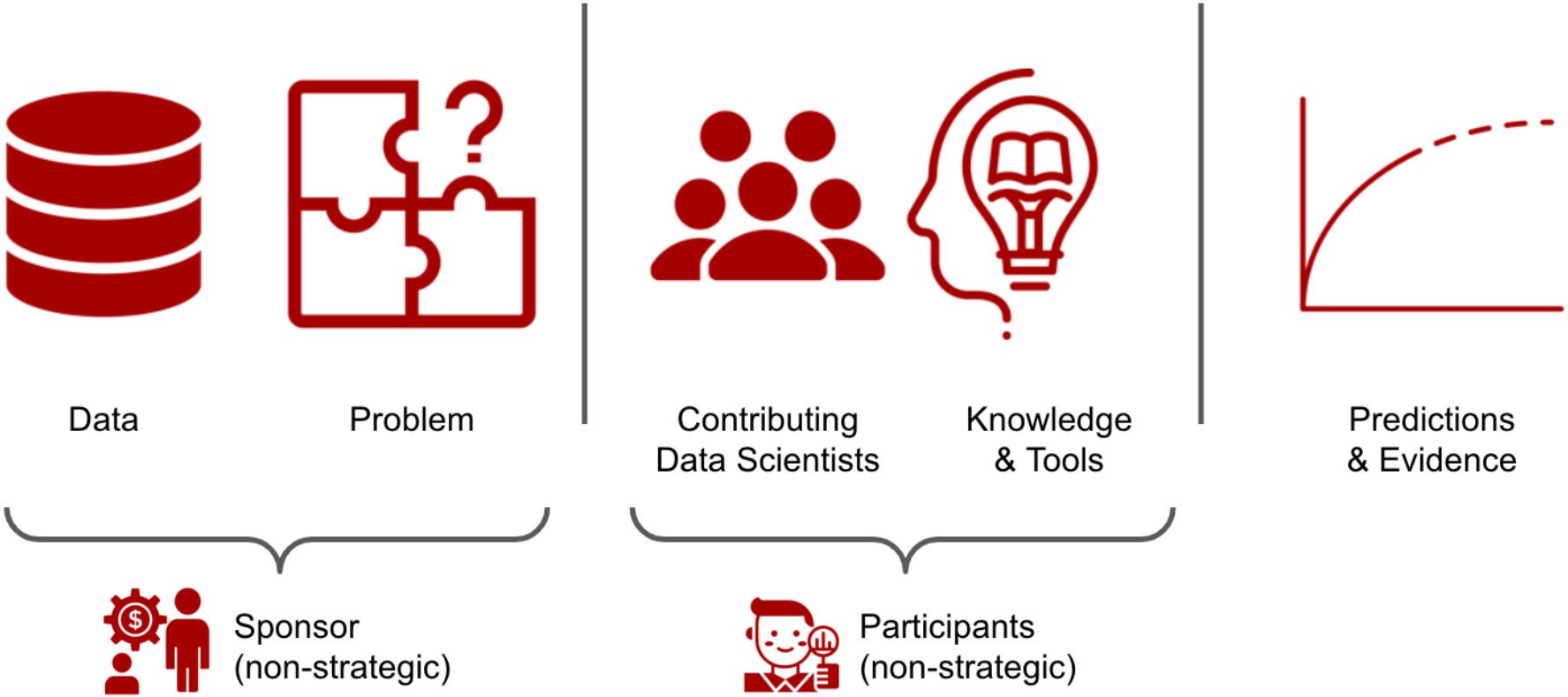
Components of the Proposed Mechanism

Extended Shapley Value A surplus division algorithm for non-strategic algorithm and data providers

Data Injection Autonomization A way to ensure that algorithms perform well on a specific subset of the task

Reserve Price Setting Using prior information on downstream use of data to set reserve prices.

Framing of such a System



Extended Shapley Value

Extending Agarwal et al. 2019; Ohrimenko et al. 2019; Ghorbani et al. 2020; Yona et al. 2019

Compute division of received payments (net of commission) such that (Shapley axioms)

- Data or Algorithm that does not improve accuracy beyond any other dataset/algorithm does not get reimbursed
- Twice as high accuracy gains are reimbursed twice as much
- Same improvement of accuracy beyond the rest of data/algorithm gives the same reimbursement
- Is also outcome of a bargaining game (Nash program)

Data Injection Autonomization

Related to Zheng et al. 2018 and other literature on adversarial ML attacks.

- Can get payments only from heterogenuous part of preferences
- As in sponsored research: trade-off quality vs. specificity
- Make this algorithmic:
  Inject further training data into algorithm to make it perform worse on tasks where data demanders have small WTP.

Reserve Price Setting

Use insights from Bergemann et al. 2018; Howard 1962

Viewing the problem as a Multidimensional Auction

- There three distinct patient populations A, B, C
- One data demander, a is interested in A 80% of the cases, 20% in B, the other 70% in C and 30% in B
- Willingness to pay per $\%$ accuracy is \$10k for a, \$8k for b
- We compute the normalised values of accuracy on patient populations: For A, \$ 8k. For B, \$ 3k resp. \$ 2.4k, and for C \$ 5.6k
- Assume: Can independently "set" accuracies on patient populations
- Pricing scheme would be: If you offer small WTP, mechanism will give less accuracy
- (Hard) combinatorial optimization problem

Properties

1. Demanders pay only their % increase, nothing if no gains for them.
2. Algorithm contributers have incentives to design specific and performant prediction algorithms
3. Data can be offered before the payments – "competition"
4. Data Scientists must be required to not open-source their code

Discussion

- Who are market participants Andy could talk to
- How relevant are heterogeneities?
- Which contacts to CS would be helpful?