A COLLABORATIVE MECHANISM FOR CROWDSOURCING PREDICTION PROBLEMS

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DE FINETTI: 
“PROBABILITY DOES NOT EXIST”

• In other words: subjective probability beliefs can not be untethered from betting rates

I think X is 75% likely

I will buy or sell this contract at $0.75

Contract: Seller owes Purchaser $1 in the event of X

• Question: What’s the probability this talk finishes on time?
INTRADE PREDICTION MARKET

Any country currently using the Euro to announce their intention to drop it midnight ET 31 Dec 2013

Last prediction was: $5.05 / share
Today's Change: -

50.5% CHANCE

Event: Any Current User to Drop Euro as National Currency

Source: www.intrade.com ©
MARKETS MAKE GOOD PREDICTORS

- Racetrack odds beat track experts [Figlewski 1979]
- Sports betting markets provide accurate forecasts of game outcomes [Gandar 1998] [Thaler 1988] [Debnath EC’03] [Schmidt 2002]
WHAT TO DO WHEN THE MARKET IS THIN?

Example question: Will my NIPS paper be accepted?

Answer: Subsidized market maker -- is willing to buy/sell contracts to potential speculators

(lots of research on this....)
CONTRACT PRICING VIA AUTOMATED MARKET MAKER

Contract: Pays $1 if outcome is Perry

# Shares Sold: 0

Price: $0.03

Contract: Pays $1 if outcome is Cain

# Shares Sold: 19

Price: $0.33

Contract: Pays $1 if outcome is Cookiemonster

# Shares Sold: 20

Price: $0.93
LOGARITHMIC MARKET SCORING RULE

LMSR: \( C(q) := \frac{1}{\eta} \log \left( \sum_i \exp(\eta q[i]) \right) \)

Price vector \( \nabla C(q) := \left\langle \frac{\exp(\eta q[i])}{\sum_j \exp(\eta q[j])} \right\rangle_{i=1:N} \)

Market maker risk \( \leq \frac{\log N}{\eta} \)
INTERLUDE: PRIZE-DRIVEN COMPETITIONS

![Netflix Prize Leaderboard](Netflix Pics/NetflixPrizeLeaderboard.png)

<table>
<thead>
<tr>
<th>Rank</th>
<th>Team Name</th>
<th>Best Test Score</th>
<th>% Improvement</th>
<th>Best Submit Time</th>
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<tbody>
<tr>
<td>1</td>
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<td>0.8567</td>
<td>10.06</td>
<td>2009-07-26 18:18:28</td>
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</tr>
</tbody>
</table>

Grand Prize - RMSE = 0.8567 - Winning Team: BellKor's Pragmatic Chaos
PRIZES EVERYWHERE

Change the World, and Win Fabulous Prizes

$1 Million Prize to Speed Innovation in Retail Personalization
Online product recommendations are among the shopping tools most used by consumers who need to easily find relevant and enticing products from the millions available online. Overstock.com has worked with...
Index And Khosla Lead $11M Round In Kaggle, A Platform For Data Modeling Competitions

Kaggle, a platform for predictive data modeling competitions, has raised $11 million in Series A financing led by Index Ventures and Khosla Ventures. SV Angel, Yuri Milner’s Start Fund, Stanford Management Company, which
First place Team

Yehuda Koren

- Team A wants to merge with Team B without revealing predictions $\mathbf{x}$

- Team A sends $\mathbf{x} + \mathbf{z}$ where $\mathbf{z}$ is white noise, to Team B

- Team B’s predictions are $\mathbf{y}$, finds optimal mixture $a(\mathbf{x} + \mathbf{z}) + b\mathbf{y}$

- Team B can calculate:
  \[ \text{rmse}(a(\mathbf{x} + \mathbf{z}) + b\mathbf{y}) - \text{rmse}(\mathbf{x} + \mathbf{z}) \]
Rules of Grand Prize Team

1. Creation of Grand Prize Team

Team Gravity and Team Dinosaur Planet have decided to create the Grand Prize Team.

The home page of Grand Prize Team is: http://www.grandprizeteam.com/

The leader of Grand Prize Team is: Gábor Takács from team Gravity.

2. The goal of Grand Prize Team

The goal of Grand Prize Team (GPT) is to win the Netflix Grand Prize, by combining the predictions of many teams. Grand Prize Team is open to anybody for joining. The earlier you join, the larger your contribution to the GPT will likely be, and thus your share from the Grand Prize will be bigger. You can find the rules for calculating the share of Grand Prize Team members in this section.

Note, that a 0.0001 improvement in Grand Prize Team's Quiz RMSE is approximately equivalent to a 6666 USD share of the 1 Million USD Grand Prize. (The reason for the word "approximately": if Grand Prize Team wins the 1 Million USD with more than a 10% improvement over Cinematch, then the contribution of a 0.0001 improvement is lower).

3. Definitions, terminology

- founders of Grand Prize Team: team Gravity and team Dinosaur Planet
PROBLEMS WITH “NETFLIX-STYLE” COMPETITIONS

• Winner-take-all system **discourages team diversity**, leading instead to team merging

• Competition is **anti-collaborative**: competitors have no intrinsic incentive to reveal their strategies or predictions

• **Improper payout** structure: prize money for a single benchmark, but no bonus for further improvement?
OUR PROPOSAL: CROWDSOURCED LEARNING MECHANISM

Machine learning competitions ought to be designed in the mold of a prediction market, where participants must wager on their solutions.
INGREDIENT 1: LOSS FUNCTION

\[ L(w; X) \]

Test data

Hypothesis chosen from a convex set H
INGREDIENT II: LEARNING MECHANISM

PHASE 1:
For each $t$ while market open
Market posts $w_t$
Trader “bets” on $(w_t \rightarrow w_{t+1})$
Trader pays $\text{Cost}(w_t \rightarrow w_{t+1})$
Market updates to $w_{t+1}$
EndWhile

PHASE 2: Test data $X$ is revealed

PHASE 3: For every $t$, trader $t$ earns
Payout$(w_t \rightarrow w_{t+1}; X)$
INGREDIENT III: CORRECT INCENTIVES

\[
\text{Profit}(w_t, w_{t+1}, X) = \underbrace{\text{Payout}(w_t \rightarrow w_{t+1}; X) - \text{Cost}(w_t \rightarrow w_{t+1})}_{\text{Payout}(w_t \rightarrow w_{t+1}; X) - \text{Cost}(w_t \rightarrow w_{t+1})}
\]

\[
= L(w_t; X) - L(w_{t+1}; X)
\]

Participant gets paid by the amount they improved the hypothesis on the test data.
RESULT: EQUIVALENT TO A SHARE-TRADING MARKET?

• When is this CLM framework equivalent to the “share-based” cost fun. market maker framework presented previously?

• Share-based market \(\iff\) CLM: iff the loss function can be written as a divergence:

\[
L(w; X) \equiv D_R(\rho(X), \psi(w)) + f(X)
\]

• The cost function is just the dual

\[
C(q) = \max_p p \cdot q - R(p)
\]
CONCLUSIONS

• Offers **aligned incentives**, with payout proportional to contribution

• Mechanism has **built-in aggregation**

• Incentives **encourage diversity**, rewarding partial knowledge

• Currently working on prototype web app for managing such competitions
THANKS!