Algorithmic Crowdsourcing: Current State and Future Perspective

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Road Map

- Introduction and Motivation
- Mechanical Turk
- Applications
- Paradigms
- Challenges and Opportunities
- Social Crowdsourcing
- Conclusion
INTRODUCTION

What
Why
Basic components
Motivation examples
Big Data is Everywhere!

- Lots of data is being collected:
  - **Volume, Variety, Velocity**
    - Web data, e-commerce
    - Purchases
    - Bank/credit card transactions
    - Video and images
    - Social networks
How Much Data?

- Google processes 100 PB a day
- Wayback Machine has 3 PB + 100 TB/month (3/2009)
- WeChat has 600 M users and 20 B message per day
- Facebook has 2.5 PB of user data + 15 TB/day (4/2009)
- eBay has 6.5 PB of user data + 50 TB/day (5/2009)

640K ought to be enough for anybody.
“In information technology, big data consists of datasets that grow so large that they become awkward to work with using on-hand database management tools.”

Computers are not efficient in processing certain data (e.g., image processing)
What is Crowdsourcing?

- Coordinating a crowd (a large group of people online) to do micro-work (small jobs) that solves problems (that software or one user cannot easily do)

For Fun!

For Money!
The Benefits of Crowdsourcing

- **Performance**
  - Inexpensive
  - Fast

- **Human Processing Unit (HPU)**
  - More effective than CPU (for some apps)
    - Image labeling
    - Language translation
    - Social network survey
    - ...

Basic Components

- **Requester**
  - People submit jobs
  - Human Intelligence Tasks (HITs)

- **Worker**
  - People work on jobs

- **Platform**
  - Job management
  - Amazon Mechanical Turk (MTurk)
Malaysia Airlines Flight MH 370

- DigitalGlobe
  - Crowdsourcing volunteers comb satellite photos for Malaysia Airlines jet

- March 11 (from a CSU prof. email)

I just saw on our local Denver Fox news (KDVR.com) that a local company, DigitalGlobe, has reoriented their satellites to take high-res images in the area where the plane may have crashed. Crowdsourcing efforts are on to have people scan these images and find signs of debris. I was reminded of Jie Wu's talk earlier this month.
Help Find Jim Gray

- Jim Gray, Turing Award winner, went missing with his sailboat outside San Francisco Bay in January 2007.

- Use satellite image to search for his sailboat.
DARPA Network Challenges

Problem (2009): $40,000 challenge award for the first team to find 10 balloons.

MIT team won under 9 hours.

Winning strategy
- $2,000 per balloon to the first person to send the correct location
- $1,000 to the person who invited the winner
- $500 to whoever invited the inviter
- ... (or to charity) ...
Tag Challenges

- Winner from UCSD CrowdScanner: located 3 of the 5 suspects.
- Winning strategy: same as MIT. Also, recruiters of the first 2,000 get $1.

- Washington DC
- New York City
- Bratislava
AI Could End Human Race (Stephen Hawking)

- Stephen Hawking
  - "Humans, who are limited by slow biological evolution, couldn't compete, and would be superseded."

- Recent movies
Who is smarter
  • Human or computer?

AI will redefine
  • What it means to be human

Our Machine Masters
NY Times, Oct. 31, 2014

1997 (Chess)
  • Kasparov vs. Deep Blue

1998
  • Kasparov vs. Topalov: 4:0
  • Kasparov + machine vs. Topalov + machine: 3:3

2005 (freestyle tournament)
  • Grand-master (>2,500)
  • Machine (Hydra)
  • Grand-master + machine
  • Amateurs (>1,500) + machine

2016 (Go game)
  • AlphaGo vs. Lee Sedol: 4:1
Worker
HIT
Dashboard
Requester

MECHANICAL TURK
Mechanical Turk is a marketplace for work.
We give businesses and developers access to an on-demand, scalable workforce.
Workers select from thousands of tasks and work whenever it's convenient.

293,089 HITs available. View them now.

Make Money by working on HITs

As a worker, make an average of $0.03 per task
Paid directly to Amazon account

As requester, set up simple tasks for workers to complete

Quality control is possible through MTurk services
Worker: Contract for a HIT

- Select a HIT
  - By creation date, payment amount, time allotment
Worker: Reviewing a HIT

- Review the HIT before accepting
  - Shown full task, allotted time (10 minutes), reward amount ($0.02)

Please Copy Text from Business Card:

Your Current Quality Score is:
If you have a high enough score, you will be considered for promotion to a Trusted Worker.

<table>
<thead>
<tr>
<th>Name</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Title</td>
<td>Company</td>
</tr>
<tr>
<td>Email</td>
<td>Website</td>
</tr>
<tr>
<td>Address</td>
<td></td>
</tr>
<tr>
<td>Phone</td>
<td></td>
</tr>
</tbody>
</table>

NOTE: This is a Sample
Worker: Completing a HIT

- Confirmation message in green
- Automatically shows the next HIT submitted by the same requester
- Check Dashboard to see if HIT is accepted
Worker: Sample Dashboard

### Total Earnings

<table>
<thead>
<tr>
<th>Rewards You Have Earned</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Approved HITs</td>
<td>$4.72</td>
</tr>
<tr>
<td>Bonuses</td>
<td>$0.00</td>
</tr>
<tr>
<td>Total Earnings</td>
<td>$4.72</td>
</tr>
</tbody>
</table>

### Your HIT Status

<table>
<thead>
<tr>
<th>Date</th>
<th>Submitted</th>
<th>Approved</th>
<th>Rejected</th>
<th>Pending</th>
<th>Earnings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Today</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>$0.00</td>
</tr>
<tr>
<td>Jun 3, 2013</td>
<td>7</td>
<td>7</td>
<td>0</td>
<td>0</td>
<td>$4.72</td>
</tr>
</tbody>
</table>

### HIT Totals

<table>
<thead>
<tr>
<th>HITs You Have Accepted</th>
<th>Value</th>
<th>Rate</th>
<th>HITs You Have Submitted</th>
<th>Value</th>
<th>Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>HITs Accepted</td>
<td>9</td>
<td>—</td>
<td>HITs Submitted</td>
<td>8</td>
<td>—</td>
</tr>
<tr>
<td>... Submitted</td>
<td>8</td>
<td>88.9%</td>
<td>... Approved</td>
<td>7</td>
<td>100.0%</td>
</tr>
<tr>
<td>... Returned</td>
<td>1</td>
<td>11.1%</td>
<td>... Rejected</td>
<td>0</td>
<td>0.0%</td>
</tr>
<tr>
<td>... Abandoned</td>
<td>0</td>
<td>0.0%</td>
<td>... Pending</td>
<td>1</td>
<td>—</td>
</tr>
</tbody>
</table>
Avoid Shady Requester

How Turkopticon works:

Turkopticon adds functionality to Amazon Mechanical Turk as you browse for HITs and review status of work you've done. As you browse HITs, Turkopticon places a button next to each requester and highlights requesters for whom there are reviews from other workers. Bad reviews let you avoid shady employers and good reviews help you find fair ones. You can view reports made against requesters with a quick click.

As you review HITs you've completed, are there HITs you weren't fairly paid for? Turkopticon adds a button that lets you review requesters from your "Status Detail" page.
EteRNA
Galaxy Zoo
Fine-grained Recognition

APPS: IMAGE PROCESSING
Biology: EteRNA: CMU, Stanford

- Aim: to gain mastery over the way RNA molecules folds.

G-C is the strongest pair. (highest brightness)
U-A is the next strongest. (medium brightness)
G-U is the weakest. (lowest brightness)
By assigning different colors (RNA nucleotides), a RNA chain will fold into different structure.
GalaxyZoo: Zooniverse

**SHAPE**
Is the galaxy simply smooth and rounded, with no sign of a disk?

- Smooth
- Features or disk
- Star or artifact
GalaxyZoo: Zooniverse
GWAP.com
OnToGalaxy
reCAPTCHA
ChaCha
Crowdsourcing

APPS: COMMONSENSE KNOWLEDGE
GWAP.com: CMU

ESP Game
- Labeling images

Tag a Tune
- Labeling tunes
OnToGalaxy: University of Bremen

- Given a keyword
  - e.g., “tourism”

- Collect pods with words related to keyword
  - e.g., “voyage”

- Shoot down pods with unrelated words
  - e.g., “resist”

- An experimental game platform
reCAPTCHA: CMU
ChaCha Search Engine: powered by people

- ChaCha is a human-guided search engine.
- Questions are answered real-time in an “ask a smart friend” format.
- One can access ChaCha via its website, text message, or mobile apps.
Crowdsensing: Smart City

Traveling safety

Activity census


Waze Social GPS, Maps & Traffic

- Waze is the world's largest community-based traffic and navigation app.
Smartphone-based Crowdsensing

- Smart city
  - Personalized recommendation
  - Public transportation
  - Indoor map construction
  - Speaker counting

- Some challenges
  - GPS-less (energy efficient)
  - Trustfulness & Game
    Z. Feng et al, “TRAC: Truthful Auction for Location-aware Collaborative Sensing in Mobile Crowdsourcing,” INFOCOM 2014
  - Coverage
  - Privacy
PARADIGMS

Sequential
Iterative and Parallel
Divide-and-Conquer and Aggregate
Map and Reduce: a Special Case
Publish/Subscribe
Sequential: Collaborative Workflow

- Lexical translation
  (weak bilinguals or machine)
- Assistive translation
  (strong bilinguals)
- Refine sentence
  (monolinguals)

Iterative and Parallel

- Iterative improve and vote

Divide-and-Conquer and Aggregate

- **Divide-and-Conquer and Aggregate**
  - Decompose a problem statement and aggregate the results

- **Two special aggregates**
  - Merge
  - Reduce

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Map and Reduce: A Special Case

Publish and Subscribe

- Pub/Sub middleware-based task assignments

Challenges
Opportunities

CHALLENGES AND OPPORTUNITIES
Challenges

- Trade-offs: time, cost, and quality
  - Max algorithm with human error (with a probability)
  - Maximize quality (via redundancy) subject to cost and time


- Incentive: money, glory, and love
  - Platform-centric: a Stackelberg game
  - User-centric: auction-based incentive mechanism

Challenges: HPU + CPU

- CrowdDB:

M. Franklin et al, “CrowdDB: Answering Queries with Crowdsourcing,” SIGMOD 2011
CPU-assisted HPU

- **Entity Matching**
  - e.g. JHU matches John Hopkins Univ.

- **Radiology**
  - **Filter**
    - HPU: [Images]
  - **Diagnose**
    - [Images]

Challenges: Collaborative Workflows

Turkomatic

- Complex works require careful and accurate design workflow
- Problems:
  - Loop subtasks
  - Task starvation
  - Multi-stage task with limited budget


C. Fofi et al, “Design Patterns for Hybrid Algorithmic-Crowdsourcing Workflows,” CBI 2014
Challenges: Multi-dimensional Data

Multi-dimension

Integrate all context

- Personal activity data:
  - Eating hobby
  - Shopping preferences
  - Incomes
  - Emotional state

- Social data:
  - Close friends
  - Similar users

- Environmental data:
  - Locations
  - Climates

Opportunities

- Beyond simple workflows
  - Graph search
  - Graph match

- Beyond simple worker selection
  - Dynamic procurement

- Beyond independent workers
  - Social networks
Beyond Simple Workflows

- **Graph search**
  - Human-assisted graph search
  - Best sequence of questions with simple Y/N answers

  A. Parameswaran et al, “Human-Assisted Graph Search: It’s Okay to Ask Questions,” VLDB 2010

- **Graph match**
  - People graph (who knows and/or communicates with whom)
  - Puzzle graph (ideas are compatible and can merge)
  - Natural dynamic for people to merge their compatible ideas

Beyond Simple Worker Selection

Dynamic Procurement (multi-armed bandit)

- A gambler facing a row of slot machines
- Which one to play, how many times, and in which order
- Each machine having a random reward from a fixed distribution

Objective: maximizing the sum of rewards earned through a sequence of lever pulls

Beyond Independent Workers

- Social network of workers
- Iterative recruitment of workers through social ties

Challenges
  - Graph searching
  - Timeliness of responses
  - Stoppage condition
Computational Surplus Around
QQ Example

SOCIAL CROWDSOURCING
Computational Surplus Around

- Friends help friends
  - Fixed individual capability
  - Probabilistic friends’ capability
- Makes dissemination decisions
  - Based on the estimations of the fixed and potential computational capacities

Water Filling Schedule

- Response delay
- Computation (by a friend)
- Reply delay

- $d_i$: response + reply

M. Xiao et al, “Multi-task Assignment for Crowdsensing in Mobile Social Networks,” INFOCOM 2015

- Scheduling across time: assign jobs to workers

QQ Example

- Tencent QQ, or **QQ**
  - Instant messaging
- As of March 2013
  - 798.2 million active QQ accounts
  - Peak of 176.4 million simultaneous online users
- QQ experiment
  - Exploring social status of QQ users by responses
Recursive Doubling \((\text{reduce})\)

- Initial label is \(L = "2"\) (subtract \(L\) by 1 when forwarding this request to QQ friends)

- When \(L = 0\), return the total number of QQ friends

- When \(L > 0\), do the following:
  - Forward this request to all QQ friends
  - After receiving the first 10 replies, compute the average number of friends, and send them back to me
Recursive Doubling (merge)

- Initial label is $L = "2"$ (subtract $L$ by 1 when forwarding this request to QQ friends)

- When $L = 0$, return the following:
  - Basic information ($B$)
  - Number of friends ($N$)
  - Timestamps ($T$)

- When $L > 0$, do the following:
  - Forward this request to all QQ friends
  - Pack the first 10 replies, together with your own information ($B$, $N$, $T$), and send them back to me
CONCLUSION
Summary

- HPU as a new paradigm to compliment the traditional CPU-based computing for big data

- Many unexplored algorithmic problems
  - Worker selection
  - Social connections of workers
  - Workflow design
  - Cost-time-quality trade-offs
  - Incentive mechanisms
Acknowledgements

- Wei Chang
  Temple University

- Grace Ju
  Carnegie Mellon University

- Wenjun Jiang and Ying Dai
  Hunan University and LinkedIn