Algorithmic Crowdsourcing
(and Applications in Social Networking)

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Road Map

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

What
Why
Basic Components
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)
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)
MECHANICAL TURK

Worker
HIT
Dashboard
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.

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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

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### All HITs

1-10 of 1982 Results

#### Sort by:
- HIT Creation Date (newest first)

<table>
<thead>
<tr>
<th>Requester</th>
<th>HIT Expiration Date</th>
<th>Time Allotted</th>
<th>Reward</th>
<th>Not Qualified to work on this HIT?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coupon Vision</td>
<td>Jun 21, 2014 (51 weeks 2 days)</td>
<td>10 minutes</td>
<td>$0.08</td>
<td>View a HIT in this group</td>
</tr>
<tr>
<td>Brian Robertson</td>
<td>Jul 3, 2013 (6 days 23 hours)</td>
<td>2 hours</td>
<td>$0.30</td>
<td>View a HIT in this group</td>
</tr>
<tr>
<td>shipping</td>
<td>Jul 1, 2013 (4 days 23 hours)</td>
<td>45 minutes</td>
<td>$0.03</td>
<td>View a HIT in this group</td>
</tr>
<tr>
<td>CrowdFlower</td>
<td>Jul 3, 2013 (6 days 23 hours)</td>
<td>30 minutes</td>
<td>$0.01</td>
<td>View a HIT in this group</td>
</tr>
<tr>
<td>Redwood</td>
<td>Jun 26, 2014 (52 weeks)</td>
<td>15 minutes</td>
<td>$0.02</td>
<td>View a HIT in this group</td>
</tr>
</tbody>
</table>

- **Select a HIT**
  - By creation date, payment amount, time allotment

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Reviewing a HIT

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

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During a HIT

- Shows duration of time
- Gives worker the option to "Return" the HIT

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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

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Sample Dashboard

Dashboard - Name (If you're not Name, click here.)

Total Earnings (What's this?)

<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 (What's this?)

<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 (What's this?)

<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>
APPLICATIONS: BIOLOGY

EteRNA

APPLICATIONS: BIOLOGY

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EteRNA: CMU, Stanford

- Choose difficulty level
- Solve puzzles: A to U, C to G
- Aim: to gain mastery over the way RNA folds
EteRNA: CMU, Stanford

Loop Strategy - Learn about the 1-1 Loop

Structure Notation

Puzzle Description

Welcome to the Strategy Puzzles Series. This series will help you learn basic strategies to solve more advanced puzzles in the Challenges and Lab sections of the game.

"Loops"

A loop is a series of unpaired bases between pairs. One of the loop is shown in the picture below. This loop has 2 bases, and it shows a

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EteRNA: CMU, Stanford

Your RNA must fold into the structure in white outline.

You must have 1 or fewer G–C pairs.

You must have 1 or more G–U pairs.
EteRNA: CMU, Stanford
GWAP.com
reCAPTCHA
OnToGalaxy

COMMONSENSE KNOWLEDGE

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GWAP.com: CMU (no longer available)

ESP Game
- Labeling images

Tag a Tune
- Labeling tunes

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reCAPTCHA: cmu
Remember this hint:
The keyword 'Grass' is related to 'green',
and it is also related to itself, to 'Grass'

Press ENTER to continue.
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
Galaxy Zoo
Fine-grained Recognition

IMAGE PROCESSING

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GalaxyZoo: Zooniverse
GalaxyZoo: Zooniverse

- Zooniverse
  - A website dedicated to citizen science projects
- A platform to label the different galaxies
- Step-by-step instructions and visual guidelines
Sequential
Iterative and Parallel
Divide-and-Conquer
Divide-and-Conquer and Aggregate
Map and Reduce: a Special Case

PARADIGMS

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Sequential: Collaborative Workflow

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

Iterative and Parallel

* Iterative improve and vote

* G. Little et al, “Exploring Iterative and Parallel Human Computation Processes,” HCOMP 2010

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**Divide-and-Conquer**

**Step 1: Find**
“Find a close-up image of a flower on flickr.com and load it in GIMP.”

**Step 2: Vote**

**Step 3: Crop**
“Crop the image so that only the petals and top of the stem are visible.”

**Step 4: Vote**

**Step 5: Label**
“Consult Wikipedia to label the petal, pistil, stamen, pedicel, and bract.”

**Step 6: Vote**

**Final**


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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

CHALLENGES AND OPPORTUNITIES

Challenges
Opportunities

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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

Query Parser

Optimizer

CPU

Turker Relationships

Crowdsourcing Templates

Files Access Methods

Disk 1

Disk 2

Disk 3

HIT Manager

HPU

Output Manager

Result

M. Franklin et al., "CrowdDB: Answering Queries with Crowdsourcing," SIGMOD 2011

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Challenges: Collaborative Workflows

Turkomatic

- Complex works require careful and accurate design workflow

Problems:
- Loop subtasks
- Task starvation

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


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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


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Beyond Independent Workers

- Social network of workers
- Iterative recruitment of workers through social ties
- Challenges
  - Graph searching
  - Timeliness of responses
  - Stoppage condition

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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

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
Iterative Request/Reply (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

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Iterative Request/Reply (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
Summary
Acknowledgements

CONCLUSION
Summary

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

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

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