# Incentives in Human Computation

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# Introduction

- Human computation: It's everywhere, changing everything
  - Content production: Wikipedia, reviews, ...
  - Microtasks: Paid (Amazon Mechanical Turk) and Unpaid (Citizen Science, GWAPs)
  - Problem solving: Crowdsourcing contests, Q&A forums, ...
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- User behavior depends on *incentives*
  - Users have own costs; benefits to participation
  - Evidence (anecdotal, formal) of self-interested users

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- User behavior depends on *incentives*
  - Users have own costs; benefits to participation
  - Evidence (anecdotal, formal) of self-interested users
- **Incentives are central!**

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  - Why do users contribute: what motivates, or constitutes a reward?
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  - Design: **Aligning incentives** of users and system
  - Diverse spectrum of motivators across systems
  - Different rewards; constraints on rewards; observability of output

A user's basic decision problem:

$$\pi = v(a) - c(a)$$

- $a$: Action choice
- $v$: Value
- $c$: Cost

A more complete (and less) basic decision problem:

$$\pi_i = v_i(a_i, o(a_i, \mathbf{a}_{-i})) - c_i(a_i)$$

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# Understanding incentives and design: A decision problem

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  - Value from $a_i$: Intrinsic rewards
  - Value from $o(a_i, \mathbf{a}_{-i})$: Extrinsic rewards

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- $c_i$: $i$'s cost to action $a_i$

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- Design: **Aligning incentives** of users and system
  (i) Social psychology, HCI (ii) Game theory & economics

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  - What their data says: Empirical evidence
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- Comprehensive:
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Your decision problem: $\pi = v_i(o(a_i, a_{-i})) - c_i(a_i)$

- $c$: Opportunity cost of time
  (It's a beautiful day outside in Palm Springs...)

PART I

AN ILLUSTRATION: THE ESP GAME

# Games with a Purpose (GWAPs)

GWAPs: Players produce input to task as side effect of game play
von Ahn and Dabbish, CACM'08

- Verbosity: Generating word descriptions
  - Matches two players: Both 'win' if player 1 correctly guesses word described by player 2
- TagATune: Generating descriptions for sound clips
  - Two players create description for assigned sound clips
  - 'Win' if correctly determine whether they have same clip
- ESP Game: Labeling images
  - Both partners generate single-word descriptions for given image
  - Points if agree on descriptive word: Label for image!
- ...

# Incentives in Games with a Purpose (GWAPs)

GWAPs *align incentives* of system with incentives of players
(Assume players incentivized by points, winning)

- ‘Inversion-problem’ games: Win if guesser correctly guesses input
  - Verbosity: Incentives to create good word description
- ‘Input-agreement’ games: Win if correctly decide if inputs are same
  - TagATune: Incentives to generate accurate sound clip descriptions
- ‘Output-agreement’ games: Win if produce matching outputs
  - ESP game: Incentives to generate accurate labels

GWAP design: Principles from social psychology

- Effort designed to be enjoyable
  - ESP Game: Players asked to type what 'partner is thinking', rather than 'keyword'
- Challenge, (clear) goals elicit higher effort
  - Timed response
  - Score keeping
  - Player skill levels
  - High-score lists
  - Randomness

# Incentives in GWAPs: A closer look

Incentive analysis in the ESP game

- Basic incentives evidently well-designed: Over 200,000 players, 50 million tags in first $\approx 4$ years
  - Fun is valid reward; game generates adequate reward to compensate participation effort
  - Players do not know partner's identity (random pairings): Cannot coordinate; easiest way to agree on output is to base it on input
- But what about *quality* of generated labels?
  - Labels do not always give useful information: High percentage of colors, synonyms, generic words (Weber et al, MSR Technical Report'08)

# A game-theoretic analysis of the ESP game

Game-theoretic model: (i) Explaining label quality (ii) Designing for better quality (Jain and Parkes, GEB'13)

- Each player independently chooses low or high effort
  - Low effort: Player samples labels from 'frequent' (common) words (colors; generic common nouns)
  - High effort: Sample labels from entire universe of words
  - Assume players know relative frequencies of sampled words
- Player can choose in what *order* to output sampled words
- Rules of ESP game constitute *mechanism*: How are outcomes affected?

# An informal overview of the game-theoretic approach

- System design induces *mechanism*: Rules specifying reward allocation
- Agents make choices over *actions*:
  - Rules: Determine outcomes for all possible sets of agents' actions
  - Agent's *payoff* depends on outcome
- Equilibrium: Vector of action choices by agents such that no agent can improve payoff by choosing different action
  - Analysis: What actions will agents choose to maximize their payoffs, given (rules induced by) system design?
  - Design: Choose rules so agents pick 'desirable' actions

# The rules of the ESP game

- Two randomly paired players matched for a set of 15 images
- For each image:
  - Both players enter sequence of single-word descriptions
  - Move on to next image when common descriptive word ('label') is found
  - Neither player can see other's choices until common label entered
- 2.5 minute time limit: Continue labeling images until deadline
- Players awarded points for each successful labeling

# ESP game rules and player preferences

- 2.5 minute time limit induces *'match-early' preferences*:
  - Points awarded per labeled image
  - Players see more images if quickly agree on descriptive word per image
  - Players prefer to agree earlier in sequence of descriptive words attempted
    (more likely to earn more points with more viewed images)

- What player behavior, and therefore labels, arise in equilibrium for 'match-early' preferences induced by the ESP game design?

# Analysis: Generic labels as equilibrium behavior

**Theorem (Jain-Parkes'13, Informal.)**

*With match-early preferences, choosing low effort and returning labels in decreasing order of frequency (i.e., from most common to least common) is a Bayes-Nash equilibrium in the ESP game.*

- Such undesirable equilibria with coordination on common words are *only* equilibria
- Explains exactly *how* design choices (specific rules of the ESP game) can lead to observed outcomes of common or generic labels for images

# Improving the design: Eliciting rare-words labels

- Suppose game is designed to induce '*rare-words*' preferences
  - Player's utility depends only on frequency of matched label
  - Points awarded for *quality* of matches: Quality based on frequency of agreed-upon label

**Theorem ([Jain-Parkes'13, Informal.)**

*Suppose players have rare-words preferences, and have chosen effort levels.*
*Returning words in decreasing order of frequency (common words first) is a strictly* dominated *strategy, while* increasing *order of frequency (least common words first) is an ex-post Nash equilibrium.*

- Strictly dominated strategy: Another strategy always leads to larger payoffs regardless of other players' choice

# Improving the design: Eliciting rare-words labels

- Players ‘try’ rarer words first in equilibrium: More useful labels than under match-early preferences
- This change in reward design alone not adequate to induce *effort*
  - High effort sampling need not be equilibrium strategy even under rare-words preferences

**Theorem (Jain-Parkes’13, Informal)**

*High effort sampling followed by coordination on rare words becomes an equilibrium in the ESP game if*

- *Distribution of words in dictionary is Zipfian (as in English)*
- *Rewards designed so that utilities obey certain (multiplicative or additive) structure*

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PART II

WHY?

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MOTIVATIONS FOR CONTRIBUTION

# Why do people participate and contribute?

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- Motivations: Vary across, and *within* systems
  - Self-selection: User population and offered rewards
- Two broad classes of human computation systems:
  - Systems with financial incentives: Amazon Mechanical Turk, crowdsourcing contests, ...
  - Payment-free systems: Citizen Science projects, user-generated content (Wikipedia, Amazon reviews, Q&A forums), ...

# Motivators in unpaid online collective effort

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- Why participate and contribute in payment-free systems?
- *Social-pyschological* rewards
  - Social psychology theory: Intrinsic motivation, generalized reciprocity, reputation, status, . . .
- Qualitative studies, empirical investigations of motivation
  - A sample of surveys: Wikipedia, del.icio.us, Amazon,Citizen Science, . . .
  - Inferences from empirical studies: Attention, virtual points, . . .

# Why unpaid contributions?: Wikipedia

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  - Motivated to "collaboratively identify and publish true facts"
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- Survey of 151 Wikipedians (Nov, CACM'07)
  - Respondents rated motivations for volunteer contribution
  - Top motivations: Fun, ideology
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  - Social, career not highly ranked
  - Contribution level not significantly correlated with ideology motivation :)

# Why unpaid contributions?: Tagging

- Survey, data from 237 Flickr users (Nov et al, CHI'08)
- Explain tagging activity using three elements :
  - Intended target audience for tags (Self, Friends&Family, Public)
  - 'Social presence' indicators (groups, contacts)
  - Participation: Number of images uploaded (Control)
- Main findings:
  - 'Self', 'Public' motivation level positively correlated with tagging
  - 'Friends & family': Does not significantly affect activity
  - Number of contacts, groups also positively correlated

# Why unpaid contributions? Online Q&A forums

- Large number of online Q&A forums: Y! Answers, Naver, StackOverflow, Quora...
- Most sites are unpaid (Exception:Google Answers): Why provide answers?
- Qualitative study of Naver (Nam, Ackerman, Adamic'09)
  - Interview of 26 users
  - Frequent motivations for top answerers: Altruism, learning, competency
  - *Virtual points* system also motivator: Direct motivation from point accumulation; higher visibility, reputation from high point totals

# Why unpaid contributions? YouTube, Digg

- Hypothesis: Atttention is a reward in peer production (Wu, Wilkinson, Huberman, CSE'09)
- Empirical study of contributors on YouTube, Digg
- Main finding: 'Submitters who stop receiving attention tend to stop contributing'
    - Low attention leads to stopping
    - Positive feedback loop of attention for prolific contributors
    - Power law distribution of contributions

# Why unpaid contributions?: Amazon reviews

How Aunt Ammy Gets Her Free Lunch (Pinch and Kessler'11)

- Survey of Top-1000 reviewers on Amazon.com: 166 participants ranking 7 motivations
  - Self expression, enjoyment ranked amongst top 3 motivators by 80%
  - Writing skills, enhancing understanding ranked in top 3 by 60%
  - Responsibility to community ranked in top 3 by 46%, enhancing status by 34%
  - Utilitarian ranked in *bottom* 3 by 65%
- Free-form responses for 'additional motivations':
  - Altruism (very common, with 25 responses)
  - Developing sense of community
  - Using reviews as "memory device"
  - Reactive: Expressing disagreement with existing reviews

# Why unpaid contributions?: Citizen Science

Motivations in Online Citizen Science (Reed et al'13); Handbook of Human Computation

- Zooniverse: Virtual Citizen Science platform with 860,000 users
  - Few users make majority of contributions in both primary science tasks and talk forums
- Motivations for contribution: GalaxyZoo
  - Qualitative study: Contribution to science, learning and teaching, interaction, aesthetics, fun, helping, interest
  - Content analysis of online talk forum finds similar motivators
- Larger qualitative study of motivation (199 Zooniverse users)
  - Social engagement: Interaction with Zooniverse community
  - Enjoyment
  - Positive feelings from helping or volunteering

- Several common themes from case studies:
  - Intrinsic motivations: Fun, interest, altruism, social interactions
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# Understanding user motivation: Caveats

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  - Intrinsic motivations: Fun, interest, altruism, social interactions
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- Surveys and empirical studies, important but not adequate:
  - Common issue with survey methodologies: Framing effects, divergence between user response and behavior
  - System-dependent variation, specificities
  - Response to rewards are in context of system design
  - Chicken-egg problem: Spectrum of possible rewards restricted to those built into system

# Understanding contribution: Experimental studies

How do people vary participation, effort choices in response to incentives?

- Participation: Deciding to perform (at least) a task
- Dimensions of effort (conditional on participation):
  - Quantity: How *many* tasks ($\geq 1$) to perform
  - Quality: *Accuracy* on task
- Experiments on MTurk: Response to motivators/rewards
  - Extrinsic (financial) motivation
  - Intrinsic motivation
  - How do extrinsic and intrinsic motivations interact?

# Overview of findings

- Financial motivations do matter, *even* at AMT scales
- Effect of task price only partially fits standard economic model
  - Participation, quantity are (largely) sensitive to price
  - Quality (largely) unaffected by price
  - Target earning behavior
- Intrinsic motivation matters, interacts with extrinsic motivation
- Geographic variation in behavior patterns

# Extrinsic Motivation: Crowdsourcing labor markets

Financial Incentives and the Performance of Crowds, Mason & Watts, HCOMP'09

- Experiment on Amazon MTurk: Image ordering task
  - Sorting 2, 3, or 4 images from traffic camera in time order
  - Vary payment per task
  - Quantity: Number of tasks worker chooses to do
  - Quality: Accuracy of ordering
- Increasing financial incentives increases quantity, but *not quality* of work
- 'Anchoring' effect: Higher-paid workers perceive value of work to be greater
  - Workers across all payment levels report 'value' of work higher than payment

# Extrinsic Motivation: Content production

Price as a Predictor of Answer Quality in an Online Q&A Site; Jeon, Kim & Chen, CHI'10

- *Field experiment* on Google Answers: Effect of price on quality in user-generated content
  - Google Answers: Payment-based online Q&A (ex-)site
  - Users post questions, prices for answers
  - Questions answered by Google-approved contractors
- Price effect is two-fold
  - Higher price significantly increases likelihood of answer
  - For questions with an answer, price has no effect on answer quality
  - Answer price is incentive for quantity, but not quality

# Extrinsic Motivation: More evidence from crowdsourcing markets

The Labor Economics of Paid Crowdsourcing, Horton & Chilton, EC'10

- Rational model of crowdsourcing labor supply
  - Workers: Cost to time, choose how many tasks to perform
  - Number of tasks should decrease with (i) per-task pay rate (ii) difficulty of task (time to complete)
- Test predictions in AMT experiment: Vary difficulty, pay
  - Clear price sensitivity: Decrease output for lower prices
  - Insensitivity to difficulty: Per-task costs?
- *Target* earners: Preferences for 'focal point' earnings
  - Preference for earnings amounts evenly divisible by 5cents
  - $v(R)$: Step function rather than linear valuations to pay

# Intrinsic Motivation

Breaking Monotony with Meaning, Chandler and Kapelner'10

- How does task "meaningfulness" affect worker effort?
  - Effort: (i) Participation (ii) Quantity (iii) Quality
- Three conditions: Identical tasks, pay; different framings
  - 'Meaningful': Labeling tumor cells to assist cancer researchers
  - Control: No information on purpose of task
  - 'Shredded': No information; also told labels will be discarded
- Results:
  - Meaningful: Increase in participation, quantity; insignificant change in quality
  - Shredded: No change in quantity; decrease in quality
  - Meaning may affect how workers trade quantity for quality

# Comparative studies: Intrinsic and financial motivations

Intrinsic and Extrinsic Motivation on Task Performance in Crowdsourcing Markets, Rogstadius et al, ICWSM'11

- AMT experiment: Image analysis task, $2\times 3$ design
  - Intrinsic motivation: Not-profit and for-profit
  - Extrinsic motivation: 3 per-task payment levels
- Participation:
  - Higher pay yields higher uptake rates, number of tasks completed, irrespective of intrinsic motivation
- Quality:
  - Varying payment does not significantly affect accuracy
  - Intrinsic motivator has significant, consistent effect on quality
  - Effect is particularly strong at lower payment levels
  - Intrinsic value might need to be kept larger than extrinsic value for accuracy benefits

# Comparative studies: Social and financial incentives

Designing Incentives for Inexpert Human Raters, Shaw et al, CSCW'11

- Non-expert content analysis task: Compare fourteen incentive schemes on worker performance
- Framing of questions: 'Social' and 'financial' incentives
  - Social: Tournament scoring, Cheap Talk (Surveillance, Normative), Solidarity, Humanization, Trust, Priming
  - Financial: Reward/Punish Accuracy, Reward/Punish Agreement, Promise of future work, Bayesian truth serum
- Easy questions: Performance outdoes random guessing; negligible effect of treatment
- Difficult questions: Widely varying performance

# Experimental results (Shaw et al ’11)

- Only 2 of 14 treatments significantly improve worker performance: (i) Punishment Agreement (ii) Bayesian Truth Serum
  - Purely social incentives *do not* alter performance significantly
  - Punishment more consequential than reward agreement: Loss aversion effects?
- Hypothesis: Cause subjects to reason carefully about other subjects’ responses
- Higher engagement drives cognition, improved performance

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PART III

INCENTIVE DESIGN

- Understanding incentive design: Revisiting the decision problem
- Increasing expected benefit: Social psychology and HCI design
- Allocating reward to align incentives: Economics and game theory
  - Contest design
  - User-generated content
  - Social search
  - Incentives in peer evaluation

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# Designing incentives: Revisiting the decision problem

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Incentive design:

- Increase $v$, decrease $c$ for desired action $a$
  (Design guidelines from social psychology)

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- *Change the game:*
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- *Change the game:*
  - Space of available actions $a_i$
  - *What* is rewarded (Popovic: Rewarding growth mindsets)
  - What *rewards* are offered (von Ahn: Games with a Purpose)

# Incentive *design*

- Understanding incentive design: Revisiting the decision problem
- Increasing expected benefit: Guidelines from social psychology and HCI design
- Allocating reward to align incentives: Economics and game theory
  - Contest design
  - User-generated content
  - Social search
  - Incentives in peer evaluation

# Design guidelines: Eliciting contributions

*Building successful online communities: Evidence-based social design*, Kraut and Resnick, 2012

- Publicize lists of needed contributions; make list easily visible
  - Common pratice: Gnome open source project, Wikipedia, ...
- Easy-to-use tools for searching, tracking needed contributions
- Directed requests: Matching tasks to people by ability, interest
  - Automated (Y! Answers Suggestions) or human-driven (Quora)

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- Revisiting $\pi = v_i(a) - c_i(a)$: Decrease $c$; choose $i$ with low $c_i$

# Structuring Requests to Enhance Motivation

- Personal directed requests for contribution more effective than 'request-all'
- Originator of requests affect likelihood of compliance
  - High-status/authority community members more effective requesters than anonymous/low-status requesters
  - 'Friends', socially desirable members
- Social proof: Evidence of others' complying increases probability of compliance

# Structuring Requests to Enhance Motivation

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# Enhancing intrinsic motivation

- Intrinsic motivation: Process of performing activity provides utility
- Social interaction: Increase opportunities for social contact
- Design for 'flow': 'Immersive' experiences (game design)
- Feedback on contributions increases motivation
  - Feedback on relative performance comparisons: Mixed effects

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# Enhancing extrinsic motivation

- Extrinsic motivation: Outcome from activity provides utility
- Rewards (status, site privileges, money) increase contribution
  - Also create reasons to 'game the system'
  - (i) Reward for quality (ii) Non-transparent reward schemes
- Tradeoffs between extrinsic and intrinsic motivation
  - Rewards increase contribution, but can decrease intrinsic motivation
  - Effect larger for monetary rewards than prizes/gifts, status rewards
  - Size of monetary reward matters: Small rewards can worsen contribution overall

# Contributions to public goods projects

- Collective effort tasks: Outcome, value depends on others' action choices
- Collective effort model (Karau & Williams'93)
  - Higher contribution when value group outcomes more
  - Uniqueness of contribution: Higher effort when 'essential to group outcome'
- Cap group size, emphasize uniqueness of contribution

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# Contributions to public goods projects

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# Incentive *design*

- Understanding incentive design: Revisiting the decision problem
- Increasing expected benefit: Social psychology and HCI design
- Allocating reward to align incentives: Economics and game theory

What aspects of a system govern nature of reward allocation problem?

- Nature of reward:
  - Monetary versus social-psychological rewards (status, reputation, ...)
  - Constraints on rewards, reward regimes, objective functions vary across reward types
- Observability of (value of) agents' output
  - Can only reward what you can see
  - Spectrum of observability: Perfect rank-ordering (contests), imperfect (noisy votes in UGC), unobservable (judgement elicitation)

Allocating reward to align incentives: Economics and game theory

- Contest design: Crowdsourcing contests (Topcoder, Innocentive, TaskCN, . . . )
- User-generated content: Online Q&A forums, reviews, . . .
- Social search: DARPA challenge, . . .
- Incentives in peer evaluation

# Incentivizing effort in contests

- Basic contest design problem:
  - Contestants have cost to effort and value offered prize
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  - Contestants have cost to effort and value offered prize
  - How to split total available reward budget to induce 'optimal outcomes'?
- What constitutes optimal? Designer's objective:
  - Maximize expected value of total contributions, best contribution, expected value from top $k$ minus prize, ...
- Large and growing literature on contest design, analysis
  - Optimal design of single contest (Glazer-Hassin'88,. . . )
  - Crowdsourcing contests: Multiple contests, large contest limits (DiPalantino-Vojnovic'09, Archak-Sundararajan'09, . . . )

# Contest design: Overview

What parameters can affect structure of optimal contest?

- *Entry*: Number of competitors influences effort choices
  - Too many participants: Decreases winning probability; erodes incentives for effort
  - Individual effort *(typically)* decreases with contest size
  - Overall outcome may be better or worse: Optimal entry
  - *Open, free, entry may not be optimal* (Taylor, AER'95)

- Homogeneity versus heterogeneity of abilities
  - Homogeneity: Self-selection, ability correlation with enjoyment
  - Effort-governed versus ability *and* effort-governed output
  - Optimal contest designs can differ greatly (Glazer-Hassin, Economic Inquiry'88 cf Moldovanu-Sela, AER'01)

# Contest design: Overview

- Shape of effort cost function: Convexity vs concavity
  - Winner-take-all optimal with linear/concave costs, but not for convex costs (Moldovanu-Sela, AER'01)
  - Single versus sub-contests (Moldovanu-Sela, JET'06)
- Objective of designer: Maximum versus total output
  - Single contest versus two-divisional final (Moldovanu-Sela, JET'06)
- Risk preferences: Risk-neutral versus risk-averse contestants
  - Single versus multiple prizes (Archak-Sundararajan'09)
  - Size of reward (scale of contest) may determine risk preference (Large prize contests (Innocentive) versus little ones (TaskCN))

# Contest design with status rewards

- Results so far on contest design:
  - Reward is monetary (or equivalent): Participants derive value only from winning prize
- Social-psychological rewards from winning a contest: Prestige, status, . . .
  - Suppose agents care about *status*: Relative position in contest
  - How to 'design' contest to maximize contestant effort?
  - Design choice is *partition*: Number, size of status classes

# Incentivizing effort with status utility

Contests with status rewards (Moldovanu-Sela-Shi, Journal of Political Economy'07)

- Model with status-based utility:
  - Contestants partitioned into *status categories* by output
  - Reward derived based on number of contestants in classes above and below own
  - Agents choose effort, incur ability-dependent cost
  - Objective: Maximize total output across all agents
- Optimal *partition* structure:
  - Top category has single element: One 'best' contribution
  - Remainder of partition depends on ability distribution
- Coarse partitions work: Optimal two-category partition achieves $\geq 1/2$ of optimal effort

# Incentive design: Social search

Crowdsourcing information-seeking via social networks

- Provide incentives for (i) participation (ii) *propagating* query
- A real instance: The DARPA red balloon challenge (2009)
  - 10 red balloons, distributed across US
  - First team to correctly locate all balloons wins $40,000
  - Challenge won by MIT team in $< 9$ hours, recruiting $\approx$4400 participants
- 'Recursive' incentive scheme [Pickard et al, Science'11]
  - Exponential reward structure, decreasing from 'finder' to root
  - Respects total budget constraint
  - Incentivizes further propagation, does not create incentives to bypass 'inviters'

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  - *Does* provide incentives for false-name attacks: Sybil attacks

# Incentive properties of social search mechanisms

- *Fixed-payment* contracts (Kleinberg-Raghavan, FOCS'05)
  - Each node offers fixed reward to child if reporting answer
  - Cost to retrieve answer with constant probability is *linear* in depth if branching factor $b > 2$, exponential otherwise
- *Split* contracts (Cebrian et al, STOC'12)
  - Answer-holder receives entire reward, shares reward on path to root
  - Achieves low cost even with branching factor $b < 2$
  - Scheme *not sybil-proof* (unlike fixed-payment contracts)
- Direct referral mechanisms (Chen et al, EC'13)
  - Distribute most reward to agent with answer and its direct referral (parent)
  - Incurs low cost for any $b > 1$ *and* discourages sybils

# Incentive design: User-generated content

- User-generated content (UGC) on the Web:
  - Reviews (Amazon, Yelp, TripAdvisor, . . . )
  - Knowledge-sharing forums (Quora, StackOverflow, Y!A, . . . )
  - Comments (Slashdot, News, . . . )
  - Social media (Blogs, YouTube, Flickr, . . . )
  - Metadata: Tags, bookmarks (del.icio.us, . . . )
- (Typically) no monetary rewards for production
- Technology-reliant incentives for contribution:
  - Functionality in exchange for content (bookmarking, photo storage, . . . )
  - *Exclusion* mechanisms: Block or limit access to content based on contribution level (Glassdoor, P2P, . . . )

User-generated content: *Attention* rewards (Wu et al'09)

- Rank-order $\mathcal{M}_r$ or proportional ($\mathcal{M}_p$) mechanisms? (Ghosh-Hummel, EC'11)
  - $\mathcal{M}_r$: Order content by number of votes
  - $\mathcal{M}_p$: Randomize display order so attention proportional to votes
  - Contributors benefit from attention, incur cost to quality (Analysis agnostic to *why* users like attention)
  - Diverging attention regimes: Rank-order *dominates* proportional mechanism in equilibrium quality
- *Learning contribution qualities* (Ghosh-Hummel, ITCS'13)
  - Low regret explore-exploit mechanisms that incentivize contribution

# Incentives in UGC: Attention rewards

Should all contributions be displayed? (Ghosh-McAfee, WWW'12)

- Crowdsourced content (Q&A forums): Suppress low-ranked contributions (eliminate, display less prominently...)
  - $A_i$: Maximum possible attention ('eyeballs') at position $i$
  - $a_i < A_i$: Payoff to poor quality falls, but less reward overall
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- Full reward to *all but lowest possible rank* is optimal
  - $a_i = A_i, i = 1, \ldots, n-1; \quad a_n = \min(A_n, c(0))$
  - Optimal reward for lowest possible rank depends on cost of producing lowest quality
  - Reward structure optimal for *any* increasing function of qualities: Best, average, . . . (*accounting* for participation choices)

Virtual points rewards: Online Q&A forums (Nov et al'08)

- Many sites use *best-contribution* mechanisms (Y! Answers, MSN, ...)
  - Winner gets $p_B$, everyone else gets $p_C$
  - Objective may not always be to maximize 'best answer' quality
- Can $(p_B; p_C)$ structure '*implement* optimal outcomes'? (Ghosh-Hummel, WWW'12)
  - Yes: When contribution's value largely determined by expertise
  - When value depends on expertise and effort: Only (possibly) with noisy rankings!

# Incentives in *evaluation*

- System cannot directly observe quality of output in many human computation systems
- Relies on ratings from users
- What if raters are *strategic*? Different kinds of strategic issues:
  - Fixed available reward: Misreporting due to rater *competition*
  - Scalable evaluation-contigent reward: Low effort with rater *cooperation*

Incentives in competitive evaluation (Alon et al, TARK'11)

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- Online sites: Voters also contributors of content
- Compete with other contributors for high rankings
- Approval voting: Every voter is also a candidate
- Want to select *k*-best subset amongst candidates
    - Strategyproof, approximately optimal mechanisms: Lower bound for deterministic mechanisms, construct 4-optimal randomized mechanism
    - Optimality-simplicity tradeoffs

# Incentives in evaluation: Eliciting effort under peer evaluation

Eliciting effort in crowdsourced rating applications
(Dasgupta-Ghosh, WWW'13)

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(See also Witkowski et al, HCOMP'13)

# Outline: What we'll do

- An illustration: Incentives and the ESP Game
- Understanding why and how:
  - What they say: Qualitative studies
  - What their data says: Empirical evidence
  - What they do: Experimental studies
- Incentive *design*:
  - Increasing expected benefit: Guidelines from social psychology
  - Allocating reward to align incentives: Economics, game theory
- Incentives for overall contribution

PART IV

INCENTIVES FOR OVERALL CONTRIBUTION

# Moving beyond single tasks: Incentivizing overall contribution

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# Moving beyond single tasks: Incentivizing overall contribution

- So far: Models, incentives for *single* action/contribution/task
- Rewarding contributors for *overall* identity:
  - Site-level accomplishments based on cumulative contribution: Badges, leaderboards, reputations...
- Rewards valued by users: Increased engagement
  - Reputation: Value online and offline (StackOverflow, ...)
  - Badges: Formal inference from data [Anderson et al, WWW'13]
  - Anecdotal: Online discussion boards for Amazon Top-Reviewer list, Y! Answers Top-Contributor badge

# The social psychology of badges

What social-psychological rewards can badges provide?
(Antin & Churchill, CHI'11)

- *Goal setting*: Challenge users to achieve contribution goals
  - "Conceptual consumption": Individuals "consume" experience of striving for goals
- *Instruction*: Inform users what are valued activites
- *Reputation*: Identify trustworthy/expert users on site
- *Status and affirmation*: Advertise (and remind of) accomplishments
- *Group identification*: Communicate set of shared activities

# Badges and incentive design

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  - 'Competitive' badges: Top-contributor bades (Y!Answers, Quora, Tripadvisor, ...), top reviewer list on Amazon, ...
- What *incentives* do different badge designs create?
  - *'Absolute'* or *'competitive'* badges?
  - 'Competitive' badges: Fixed *number* or *fraction* of participants?

# Badges and incentive design: An economic framework

Equilibrium analysis of incentives created by badges; information visibility (Easley & Ghosh, ACM EC'13)

- Design recommendations from equilibrium analysis
  - Relative standards badges $\mathcal{M}_\rho$: Reward fixed number of winners ($\mathcal{M}_\rho^p$), not fraction of competitors
  - Absolute versus relative standards badges 'equivalent' if population parameters known
  - With uncertainty, or unknown parameters, $\mathcal{M}_\rho^p$ more 'robust': Guarantees non-zero participation

# Information and equilibrium effort

- Social-psychological reward: Perceived value from badge may depend on **scarcity**
  - Suppose value of badge depends on mass of other winners
  - $v(m)$: Value from winning when mass of winners is $m$
- Site design choice: Display information about number of winners or not

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- How does information about winners affect equilibrium effort?
  - Effort depends on *convexity of value* as function of winners
  - **Theorem (Easley & Ghosh'13):** Uncertainty decreases effort if $v(m)$ is concave, and increases it if $v(m)$ is convex

# Badges as mechanisms: Open questions

- Understanding user preferences:
  - How, and how much, do users *value* absolute and relative achievements?
  - Measuring $v(m)$: How does scarcity affect value?
  - *Endogeneity of contributor pool*: Offered rewards *select* site population
- Incentives created by *mixed* badge designs:
  - Awarding badges for both absolute and relative standards
  - What efforts are induced from different ability-users?
- Rank-based rewards: Top-contributor *rankings*

PART V

OPEN QUESTIONS

# Open directions: Overall contribution

- *Sustained* participation in payment-free systems:
  - Which motivators 'last'? Marginal returns from different reward types
  - Does motivation for contribution evolve over time?
  - Design: Provide, allocate rewards that incentivize sustained contribution

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- Incentivizing overall effort:
  - Leaderboard design: Unequal rewards to winners
  - Frequency of contribution (Ghosh-Kleinberg, ACM EC'13)
  - Reputation as reward for overall contribution
    - Qualitative differences between payment-free systems and labor markets
  - Incentivizing effort across multiple tasks: Unpaid systems (Anderson et al, WWW'13); labor markets

# (More) open directions

(*Game Theory and Incentives in Human Computation (in Handbook of Human Computation)*, Ghosh'13)

- Content production: More nuanced models of quality, output
  - Diversity; vertical and horizontal differentiation [MacKie Mason'09]
  - Modeling value from set of contributions
  - Incentives for production with strategic ratings

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- Game theory and *interface* design
  - Interfaces determine *meaning* and *space* of available inputs to mechanisms
  - Ratings, information visibility, ...

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  - Models, mechanism design
- User valuations of social-pyschological rewards
  - 'Shape' of reward functions: Marginal benefits (attention, ...)
  - Value from *set* of rewards
  - How do rewards retain value over time?