Approval Voting and Incentives in Crowdsourcing

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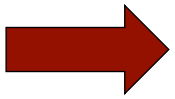
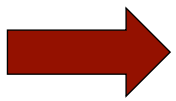
Crowdsourcing for labeled data





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CAT

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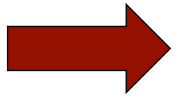
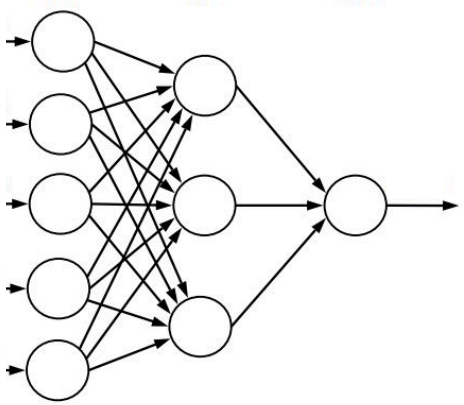
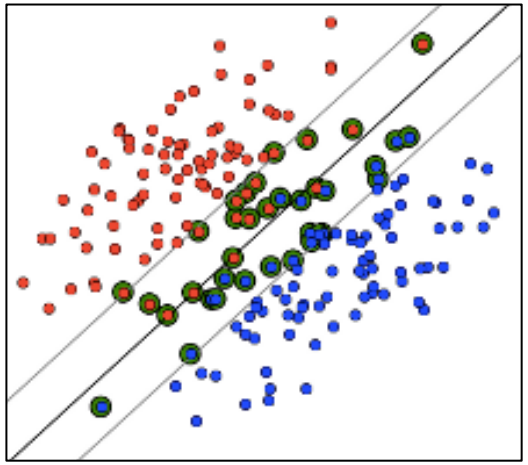
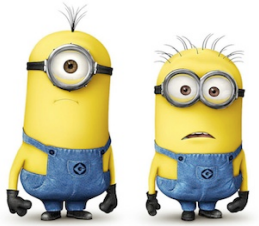






Data is often of low-quality

1. Workers not experts  , freeloaders 
2. Absence of proper incentives
3. Interface does not allow workers to convey their knowledge accurately

Want to get higher quality data for same or lower costs

Standard interface: “single selection”

Identify the language in the picture

- Hindi
- Chinese
- Hebrew
- Japanese
- French
- German

Worker must select **one** option

Psychology suggests “Approval voting”

Identify the language in the picture

- ☐ Hindi
- ☐ Chinese
- ☐ Hebrew
- ☐ Japanese
- ☐ French
- ☐ German

- Worker can select any number of options
- Many advantages [Horst 1932; Collet 1971; Brams & Fishburn 1978; Gibbons et al. 1979]
  - More flexibility of expression
  - Utilizes partial knowledge more effectively

Example

Identify the language in the picture

- Hindi
- Chinese
- Hebrew
- Japanese
- French
- German

Workers 1 & 2: Know its either Chinese or Japanese but clueless between the two

Worker 3: Knows its Chinese

Example

Identify the language in the picture

- ○ Hindi
- ○ Chinese
- ○ Hebrew
- ○ Japanese
- ○ French
- ○ German

Workers 1 & 2: Know its either Chinese or Japanese but clueless between the two

Worker 3: Knows its Chinese

Worker 1

- ○ Hindi
- ○ Chinese
- ○ Hebrew
- ● Japanese
- ○ French
- ○ German

Worker 2

- ○ Hindi
- ○ Chinese
- ○ Hebrew
- ● Japanese
- ○ French
- ○ German

Worker 3

- ○ Hindi
- ● Chinese
- ○ Hebrew
- ○ Japanese
- ○ French
- ○ German

Final conclusion: Japanese (wrong)

Example

Identify the language in the picture

- ☐ Hindi
- ☐ Chinese
- ☐ Hebrew
- ☐ Japanese
- ☐ French
- ☐ German

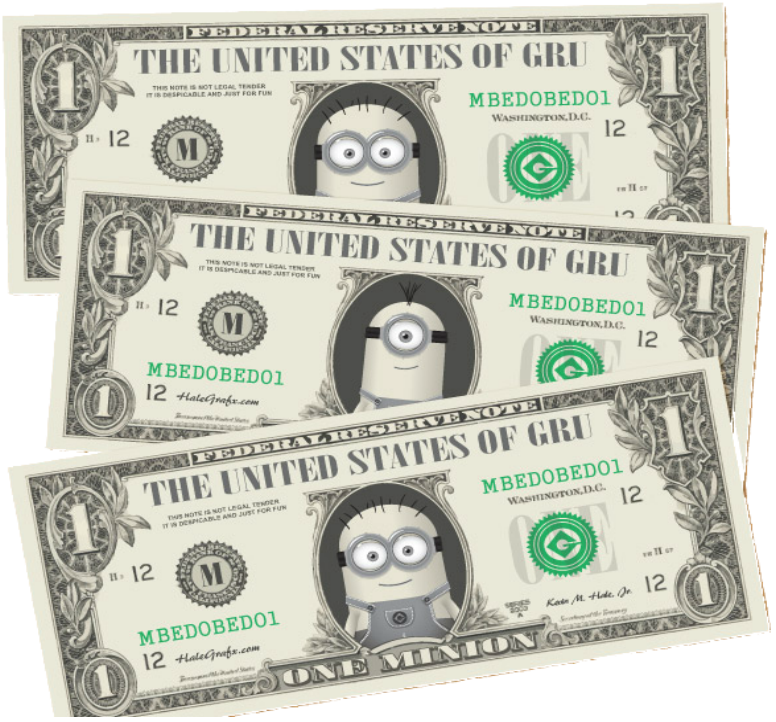
Workers 1 & 2: Know its either Chinese or Japanese but clueless between the two

Worker 3: Knows its Chinese

Worker 1	Worker 2	Worker 3
☐ Hindi	☐ Hindi	☐ Hindi
☑ Chinese	☑ Chinese	☑ Chinese
☐ Hebrew	☐ Hebrew	☐ Hebrew
☑ Japanese	☑ Japanese	☐ Japanese
☐ French	☐ French	☐ French
☐ German	☐ German	☐ German

Final conclusion: Chinese (correct)

Goal: Design payment mechanisms to incentivize workers to respond “appropriately”



Outline

- Problem setting
- Roadblock, and detour
- Mechanism
- Why this (and only this) mechanism
- Preliminary experiments

Problem setting

- Multiple-choice questions

1. Identify the language in the picture

- ☐ Hindi
- ☐ Chinese
- ☐ Hebrew
- ☐ Japanese
- ☐ French
- ☐ German

2. Identify the language in the picture

- ☐ Hindi
- ☐ Chinese
- ☐ Hebrew
- ☐ Japanese
- ☐ French
- ☐ German

3. Identify the language in the picture

▪
▪
▪

Problem setting

- Multiple-choice questions
- One or more “gold standard” questions: answers known apriori
- Evaluate worker on gold standard

1. Identify the language in the picture

- ☐ Hindi
- ☐ Chinese
- ☐ Hebrew
- ☐ Japanese
- ☐ French
- ☐ German

2. Identify the language in the picture

- ☐ Hindi
- ☐ Chinese
- ☐ Hebrew
- ☐ Japanese
- ☐ French
- ☐ German

3. Identify the language in the picture

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- Evaluate worker on gold standard
- Worker aims to maximize expected payment

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- ☐ Hindi
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- ☐ Japanese
- ☐ French
- ☐ German

3. Identify the language in the picture

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Problem setting

- Multiple-choice questions
- One or more “gold standard” questions: answers known apriori
- Evaluate worker on gold standard
- Worker aims to maximize expected payment
- Payment non-negative

1. Identify the language in the picture

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- ☐ Japanese
- ☐ French
- ☐ German

3. Identify the language in the picture

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Problem setting

- Multiple-choice questions
- One or more “gold standard” questions: answers known apriori
- Evaluate worker on gold standard
- Worker aims to maximize expected payment
- Payment non-negative
- Budget “B” = maximum payment to a worker

1. Identify the language in the picture

- ☐ Hindi
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3. Identify the language in the picture

▪
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Which options do we want the worker to select?

Select ALL options that could be the language in this image

- ☐ Hindi
- ☐ Chinese
- ☐ Hebrew
- ☐ Japanese
- ☐ French
- ☐ German

- Coombs 1953: "should be instructed to cross out all the alternatives which they consider wrong"
- Coombs, Milholland, Womer 1956: experimental verification of usefulness

Belief of worker for a question

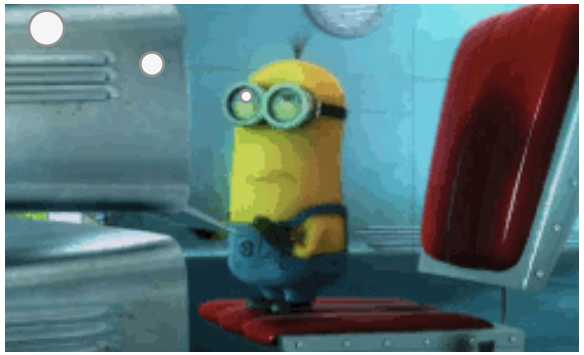
= probability distribution over all options

- ☐ Hindi
- ☑ Chinese
- ☐ Hebrew
- ☑ Japanese
- ☐ French
- ☐ German

Chance of being correct:

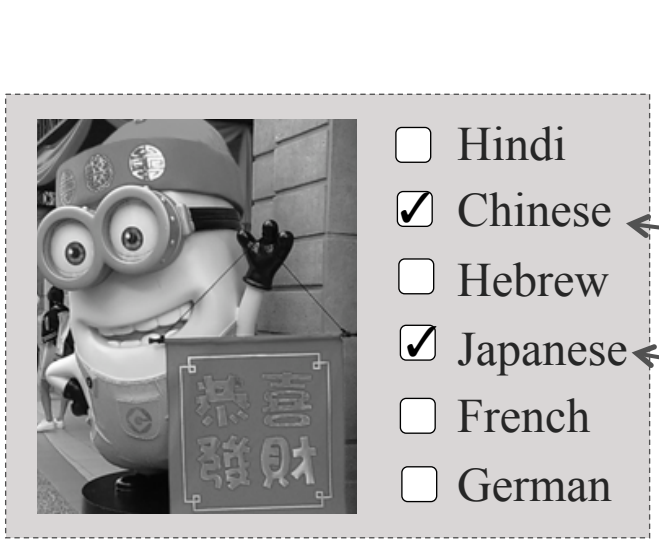
50%

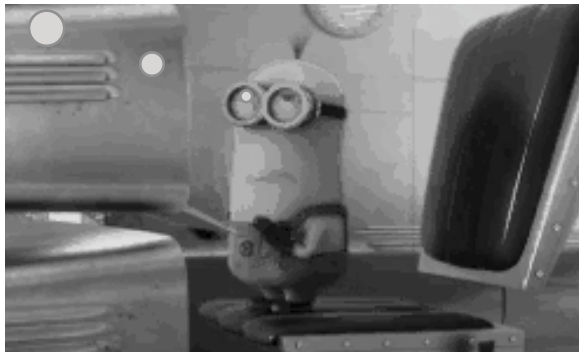
50%



Belief of worker for a question

= probability distribution over all options





Goal: Design payment mechanism such that for each question, worker incentivized to select all options for which belief > 0

- In other words, elicit **support** of belief
- "**Incentive-compatible** mechanism"

An impossibility result

THEOREM

No payment mechanism can be incentive compatible.

Coarse beliefs

Extensive literature in psychology on coarseness of processing and perception in humans

[Miller 1956, Shiffrin & Nosofsky 1994, Saaty & Ozdemir 2003, Mullainathan et al. 2008, Siddiqi 2011, Jones & Loe 2013]

Coarse beliefs assumption: For some (fixed and known) value $\rho > 0$, all non-zero values in the belief are $>\rho$

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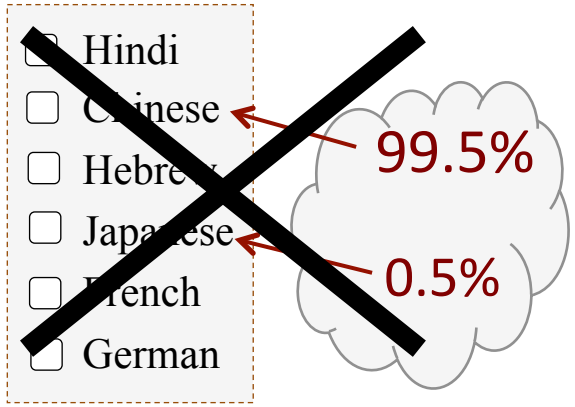
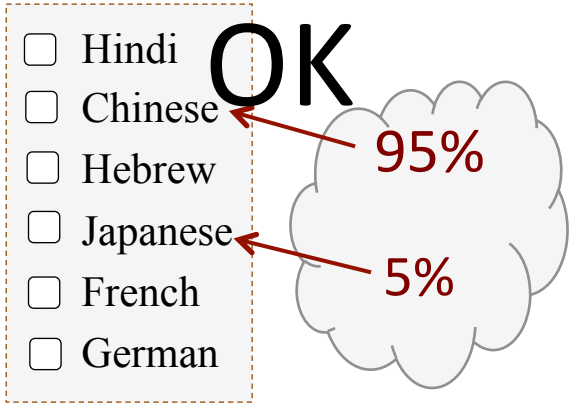
Coarse beliefs assumption: For some (fixed and known) value $\rho > 0$, all non-zero values in the belief are $>\rho$

Example: $\rho = 1\%$





Our mechanism

Input: coarse belief parameter ρ, budget B,
worker's answers to gold standard questions

Output:

- Payment starts at B
- For every question in gold standard:
  - For every wrong option selected, payment is multiplied by (1-ρ)
  - If the correct option is not selected, payment becomes zero

Example (ρ = 5%, B = $1)

1.

- ☐ Hindi
- ☑ **Chinese**
- ☐ Hebrew
- ☐ Japanese
- ☐ French
- ☐ German

2.

- ☐ Hindi
- ☐ Chinese
- ☐ Hebrew
- ☐ Japanese
- ☑ **French**
- ☐ German

Payment = B = $ 1

Example (ρ = 5%, B = $1)

1.

- ☐ Hindi
- ☑ **Chinese**
- ☐ Hebrew
- ☑ Japanese
- ☐ French
- ☐ German

2.

- ☑ Hindi
- ☑ Chinese
- ☑ Hebrew
- ☑ Japanese
- ☑ **French**
- ☑ German

Payment = $B (1 - \rho)^6 = \$ .74$

Example (ρ = 5%, B = $1)

1.

- ☐ Hindi
- ☑ **Chinese**
- ☐ Hebrew
- ☐ Japanese
- ☐ French
- ☐ German

2.

- ☐ Hindi
- ☐ Chinese
- ☑ Hebrew
- ☐ Japanese
- ☐ **French**
- ☑ German

Payment = $ 0

Our mechanism: analytical guarantees

THEOREM

Our mechanism is incentive-compatible under the coarse-beliefs assumption.

Continues to do something desirable even when beliefs are not coarse
(ask me offline)

There could be many other incentive-compatible mechanisms

Why use this mechanism?

Minimum possible expenditure on freeloaders

Selecting all options ⇒ Free money

- ☑ Hindi
- ☑ Chinese
- ☑ Hebrew
- ☑ Japanese
- ☑ French
- ☑ German

THEOREM

Among all possible incentive-compatible mechanisms, our mechanism makes the *strictly* smallest payment to a freeloader.

Unique under a no-free-lunch requirement

If **all** attempted answers are wrong, then payment must be zero.

[Shah and Zhou, 2014]

Unique under a no-free-lunch requirement

If **all** attempted answers are wrong, then payment must be zero.

doesn’t select all options

Unique under a no-free-lunch requirement

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doesn't select correct option

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This is a weak requirement: no restriction if even one of the answers is correct

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THEOREM

Our mechanism is the one and only incentive-compatible mechanism that satisfies no-free-lunch.

Preliminary experiments

Goal: to evaluate the primary hypotheses underlying the theory

- Are workers making judicious use of the approval voting setup?
- Does presence of a mechanism improve quality?
- Is there is any opposition from the workers?

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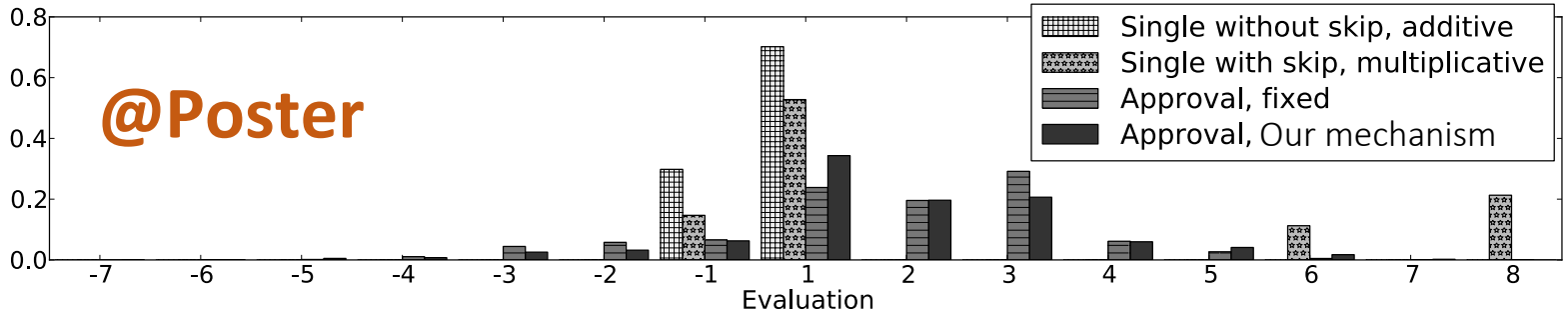
400 workers

(Collected data available online)



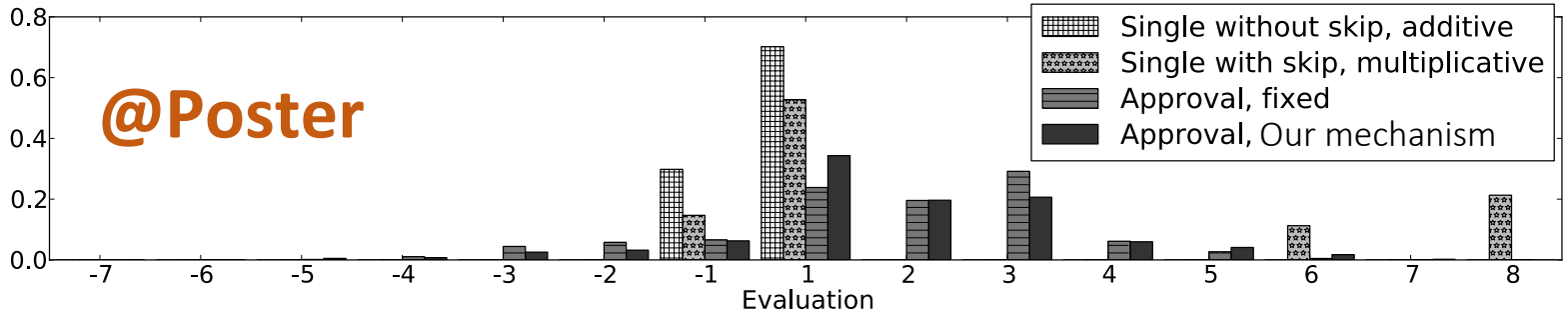
Preliminary experiments

Goal: to evaluate the primary hypotheses underlying the theory

- Are workers making judicious use of the approval voting setup? **Yes**
- Does presence of a mechanism improve quality? **Yes**
- Is there is any opposition from the workers? **No**

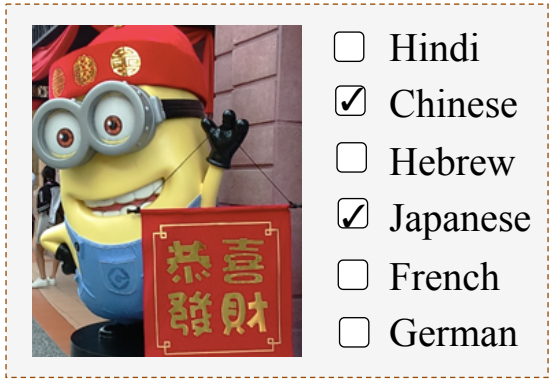
400 workers

(Collected data available online)



Summary and future work

- "Approval voting" interface for crowdsourcing
- Design mechanism:
  - Incentive-compatible
  - Strictly minimum payment to freeloaders
  - Only one to satisfy a natural "no-free-lunch" requirement
  - Simple
- Future work: Design statistical aggregation algorithms
  - Incorporate approval voting setting
  - Exploit structure of data due to mechanism



Thanks! Questions?

(Hope to chat more
with you at the poster)

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