Optimal Crowdsourced Classification with a Reject Option in the Presence of Spammers

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Outline

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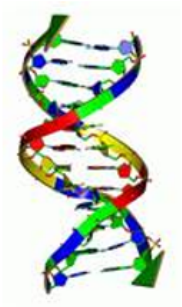
Humans and Machines

- Besides the success of machine learning techniques
- Machines need proper training
- Machines need a tremendous amount of labeled training data



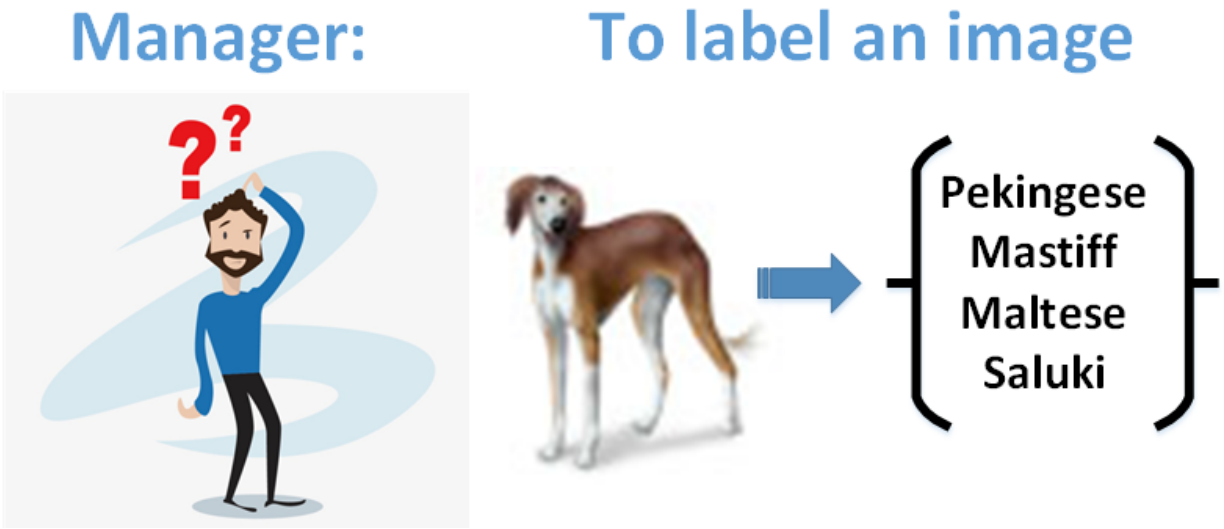
Pattern Search

Data Interpretation

Crowdsourcing

- A major source to provide training data for machines
- Crowd + Sourcing = Crowdsourcing

Crowdsourcing Example



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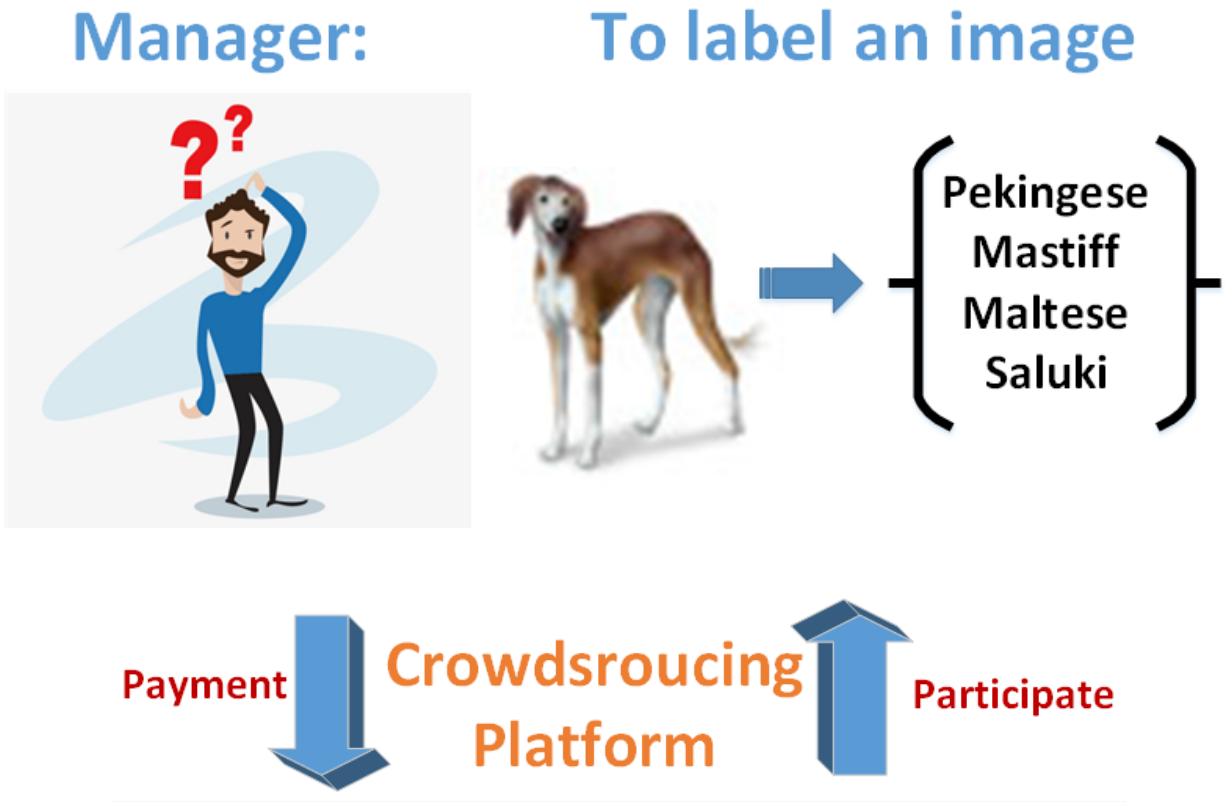

Crowdsourcing

- Key Features
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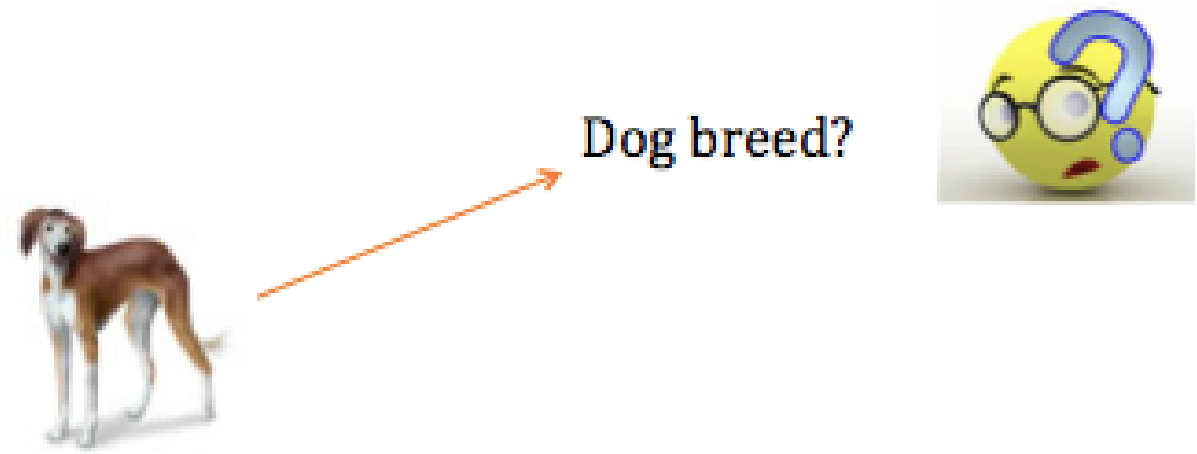
- Key Features
  - Members of the crowd are anonymous
  - Spammers in the crowd
- What is a spammer?
  - only cares about reward in participating in a crowdsourcing task
  - completes the questions with random guesses
  - typically completes all the questions in the task
- Problems to address
  - How to maximize the reward (How would the spammers behave?)
  - How to get reliable performance (How would the task manager behave?)

Outline

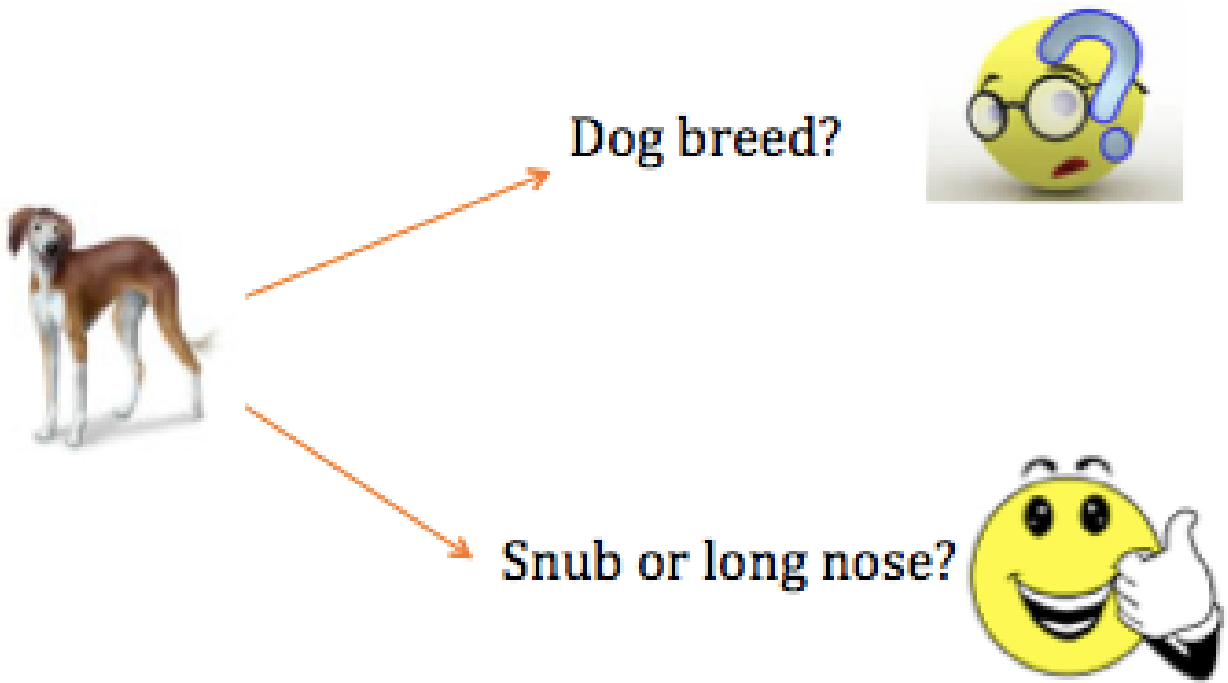
Problem

- W crowd workers take part in an M-ary classification task
  - Example: labeling of dog image into one of four breeds ($M = 4$): Pekingese, Mastiff, Maltese, or Saluki



Problem

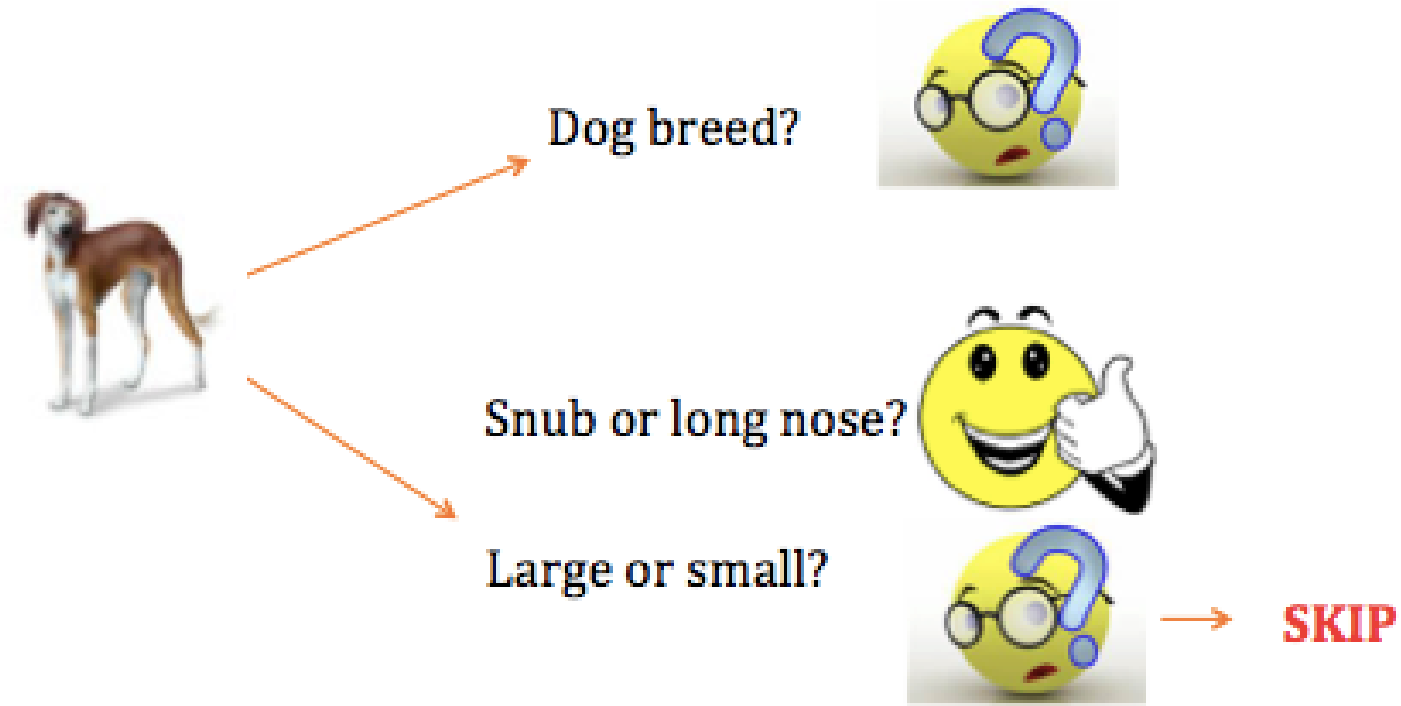
- Workers answer N simple binary questions to distinguish among classes (*Branson et al., 2010*)
  - Example: snub or long nose?



A. Vempaty, L. R. Varshney and P. K. Varshney, "Reliable Crowdsourcing for Multi-Class Labeling Using Coding Theory," in IEEE JSTSP, 2014.

Problem

- Workers have a reject option to skip the questions
  - Example: snub or long nose? large or small?



Q. Li, A. Vempaty, L. R. Varshney and P. K. Varshney, "Multi-Object Classification via Crowdsourcing With a Reject Option," in IEEE TSP, 2017.

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Optimal Behavior for a Spammer

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Theorem

The optimal behavior for a spammer is to complete or skip all the microtasks, according to a problem-dependent quantity.

Problem Formulation

- Conventionally, a spammer completes all the microtasks in hope for maximal reward.
- Assume M_A spammers complete all the microtasks
- Assume M_0 spammers skip all the microtasks
- A total of $M = M_A + M_0$ spammers in the crowd of size W

Outline

Aggregation Rule

- A widely used aggregation rule is majority voting
  - Each worker has a weight of "1" for his/her answer
  - For each microtask, the answer with the most collected overall weight is chosen

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Theorem

The optimal weight for the wth worker's answer is given by

$$W_w = \left[(W - M)\,\mu^n + \frac{M_A}{2^N (1-m)^N} \delta\,(n - N) \right]^{-1},$$

n: number of microtaskes completed

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- μ: averaged probability of a correct answer
  - insert additional G "gold standard" questions
- M_A: number of spammers who complete all the microtasks
- M_0: number of spammers who skip all the microtasks
  - W_{N+G} denotes the number of workers completing all $N+G$ microtasks, and W_0 denotes the number of workers skipping all the microtasks.
  - using the estimated m, write the joint probability function of W_{N+G} and W_0, $f(W_{N+G}, W_0 | M_N, M_0)$
  - with the MLE method, estimate M_A and M_0 by

$$\left\{\hat{M}_A, \hat{M}_0\right\} = \arg \max_{\{M_A, M_0\} \geq 0} f(W_{N+G}, W_0 | M_A, M_0). \quad (1)$$

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Simulation Results

- $W = 50$, $N = 3$, $G = 3$, $M_A = M_0 = 7$
- A honest worker skips a microtask$\sim U(0, 1)$
- A honest worker correctly answers a microtask $\sim U(x, 1)$

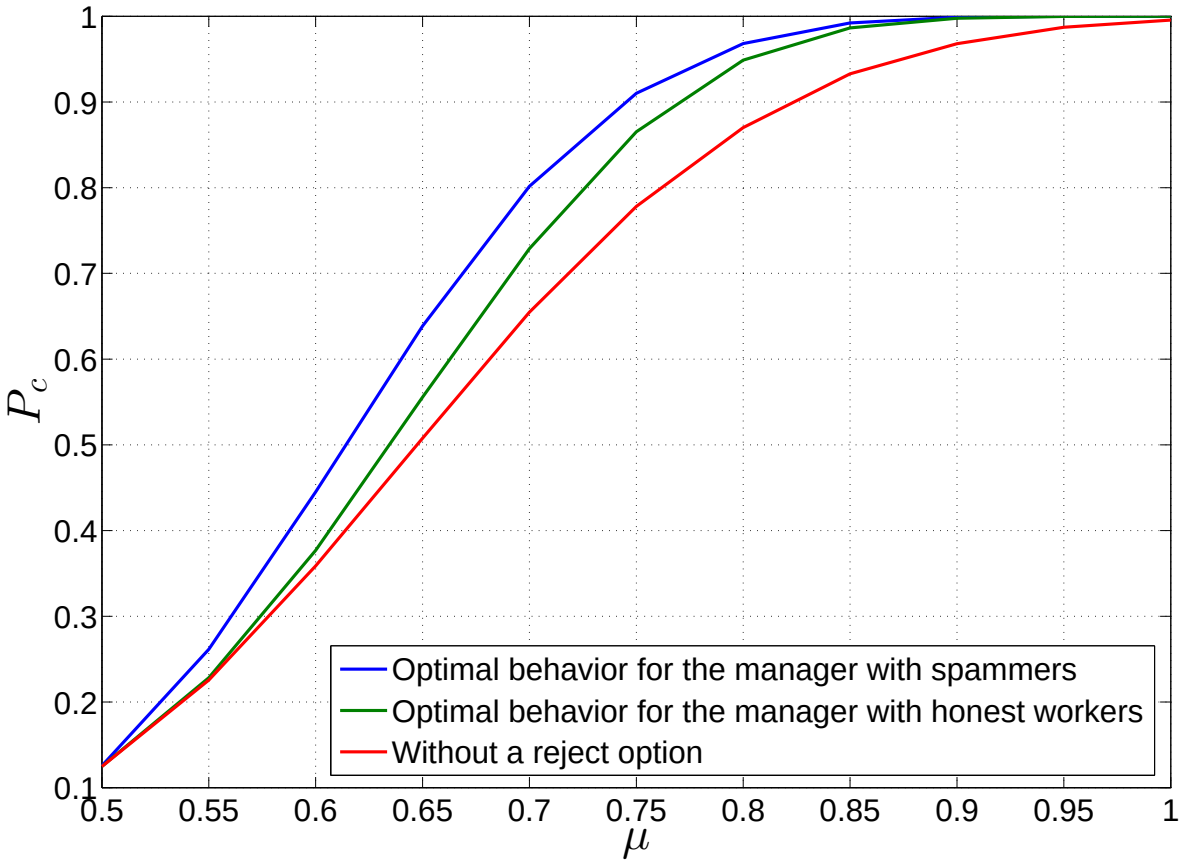

Figure 1: Performance comparison with various spammers.

Outline

Conclusion

- Investigated the impact of the spammers on the crowdsourced classification system
- Derived the optimal strategy for the manager to combat the spammers' influence.
- Showed the performance improvement with the proposed aggregation rule

Thank you !