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ORCHID

Efficient Budget Allocation with Accuracy Guarantees for Crowdsourcing Classification Tasks

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1. Motivation

Crowdsourcing systems:

Use mass of human intelligence to solve hard AI problems

amazon mechanical turk™ Artificial Artificial Intelligence

Single response is *unreliable* ⟹ *redundant task allocation*

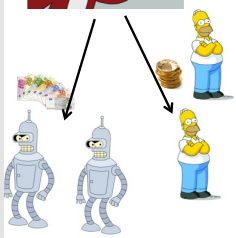
How many responses/task is *sufficient*?

- *users are paid* for their responses
- *restricted budget limit*

amazon mechanical turk™ Artificial Artificial Intelligence
oDesk Changing How the World Works.
ElanceOnline Everyday Outsourcing

- budget has to be *assigned* to tasks *at the beginning* (*online* approaches are *not suitable* here)
- different tasks may provide *different payments*

2. Model Description



K binary classification tasks

Budget limit B

Each task *k*:

- *unknown* ground truth $t_k \in \{0, 1\}$
- *response cost* c_k

Each user *u* and task *k*:

- response is drawn from unknown distribution

We assume that the expected response is *closer* to the ground truth

$$\mathbb{E}_{X_k}\left[\mu_{u,k}\right] = \mu_k \quad \forall k : |\mu_k - t_k| < \frac{1}{2}$$

Let $\hat{r}\left(n_k\right)$ denote the *estimate* of the truth

- derived from the received responses by using a *fusion method*

MV-efficient method: provides estimation *at least as good as* majority voting

Estimation error $\Delta\left(n_k\right) = |\hat{r}_k(n_k) - t_k|$

Total exp. error $\mathbb{E}[\Delta(B)] = \sum_{k=1}^{K} \mathbb{E}[\Delta(n_k)] = \sum_{k=1}^{K} P\{\hat{r}_k(n_k) \neq t_k\}$

Objective

Minimise the total expected error, s.t. budget limit *B*

Provide *theoretical performance guarantees*

3. Algorithm

Step 1: $n_k = \left\lfloor \frac{B}{c_k^2 \sum_{j=1}^{K} \frac{1}{c_j}} \right\rfloor$

Step 2: **while** $B^r \geq 0$ **and** $k \leq K$ **do**
$n_k = n_k + 1, B^r = B^r - c_k, k = k + 1$

Step 3: Use an MV-efficient method to estimate responses

4. Performance Analysis

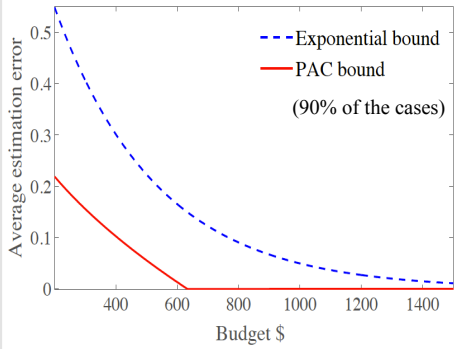
THEOREM 1 (MAIN RESULT 1). *For any* $B \geq \sum_{j=1}^{K} c_j$, *the expected estimation error of* CrowdBudget *is bounded as follows:*

$$\mathbb{E}\left[\Delta\left(B\right)\right] \leq K e^{\frac{-2Bd_{\min}^2}{c_{\max}^2 \sum_{j=1}^{K} \frac{1}{c_j}}}.$$

THEOREM 2 (MAIN RESULT 2). *For any* $B \geq \sum_{j=1}^{K} c_j$ *and* $0 < \beta < 1$, *the following bound holds for the expected estimation error of* CrowdBudget *with at least* $(1-\beta)^K$ *probability:*

$$\mathbb{E}\left[\Delta\left(B\right)\right] \leq \max\left\{0, \frac{K}{2} - d_{\min}\sqrt{\frac{2B}{-\ln\frac{\beta}{2}} \sum_{j=1}^{K} \frac{1}{c_j}}\right\}$$

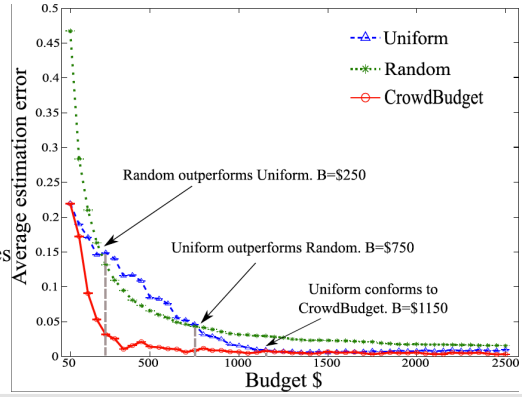
5. Empirical Evaluation



GalaxyZoo: 700 galaxies

- with at least 30 responses
- at least 80% consensus

Added cost to the system



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