



Progressive Comparison for Ranking Estimation

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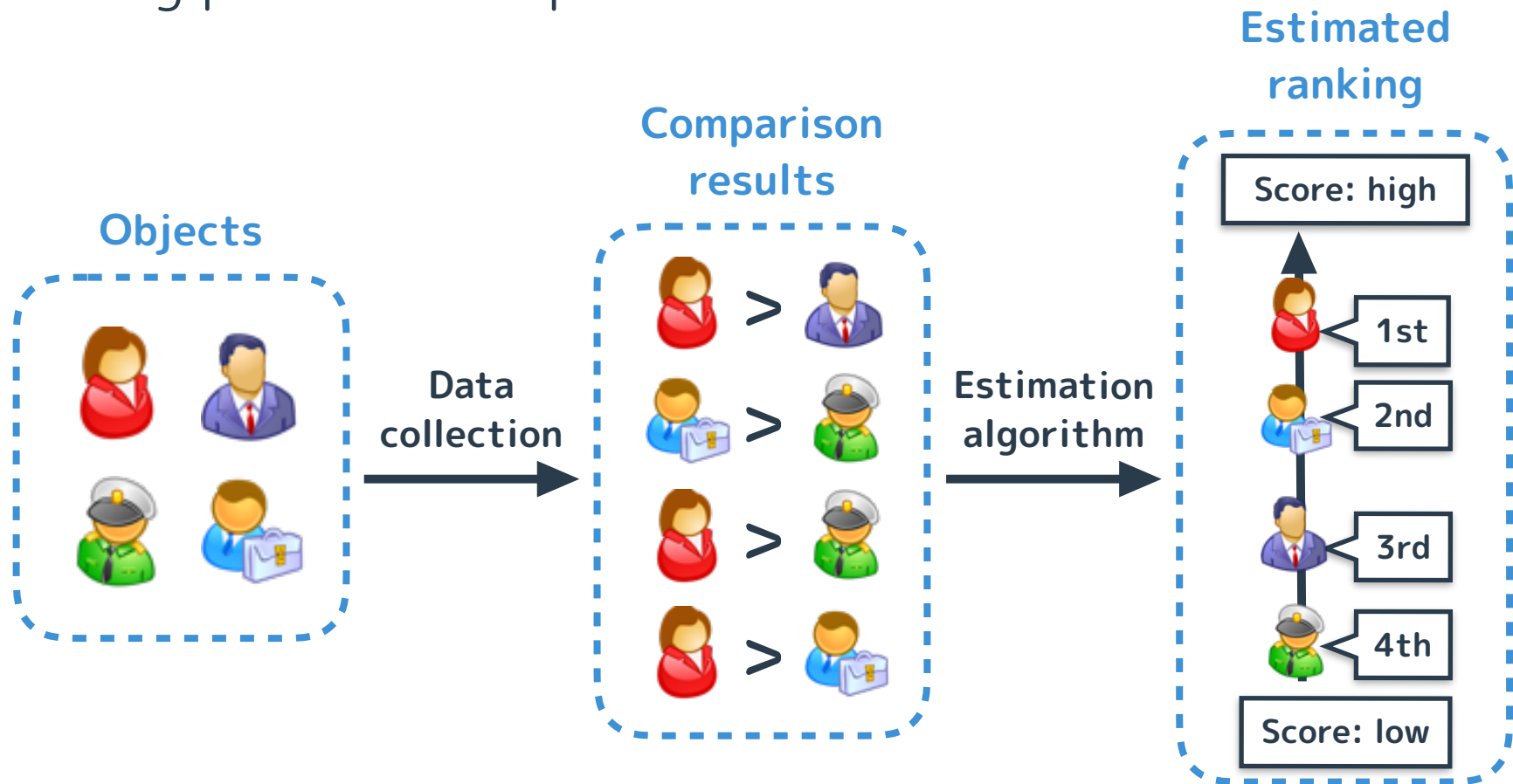
Outline

- Problem setting
- Background
- **Progressive Comparison**
- **Active learning** of Progressive Comparison
 - Change in Distributions
 - Change in Winning Probabilities
- Experimental results

Problem setting:

Estimate ranking from pairwise comparison data

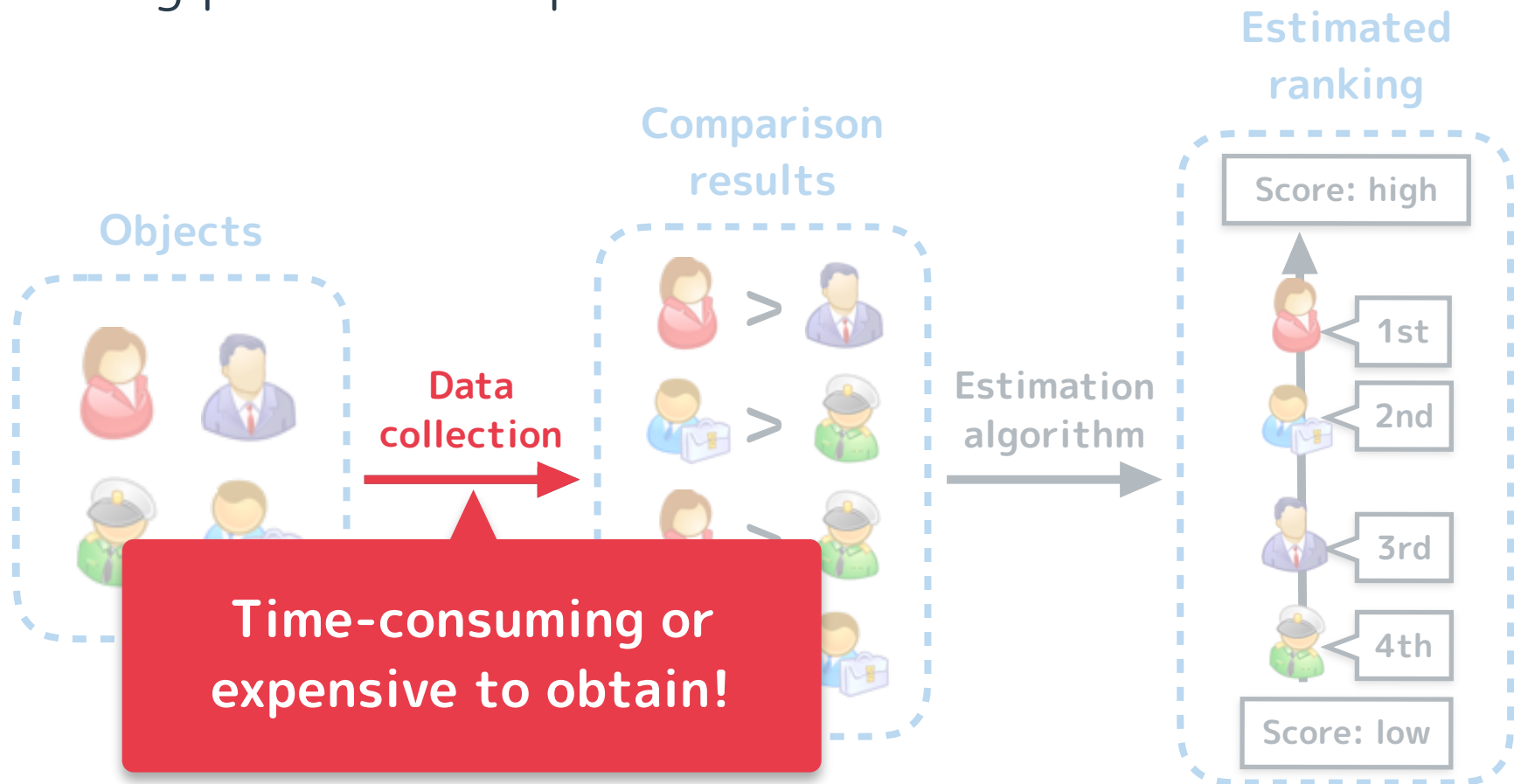
- Problem setting: estimate ranking of objects using pairwise comparison results



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Estimate ranking from pairwise comparison data

- Problem setting: estimate ranking of objects using pairwise comparison results





MAST
COFFEE
CHOCOLATE

MAST
MILK
CHOCOLATE

MAST
SMOKE
CHOCOLATE

MAST
MINT
CHOCOLATE

MAST
GOAT MILK
CHOCOLATE

MAST
SHEEP MILK
CHOCOLATE

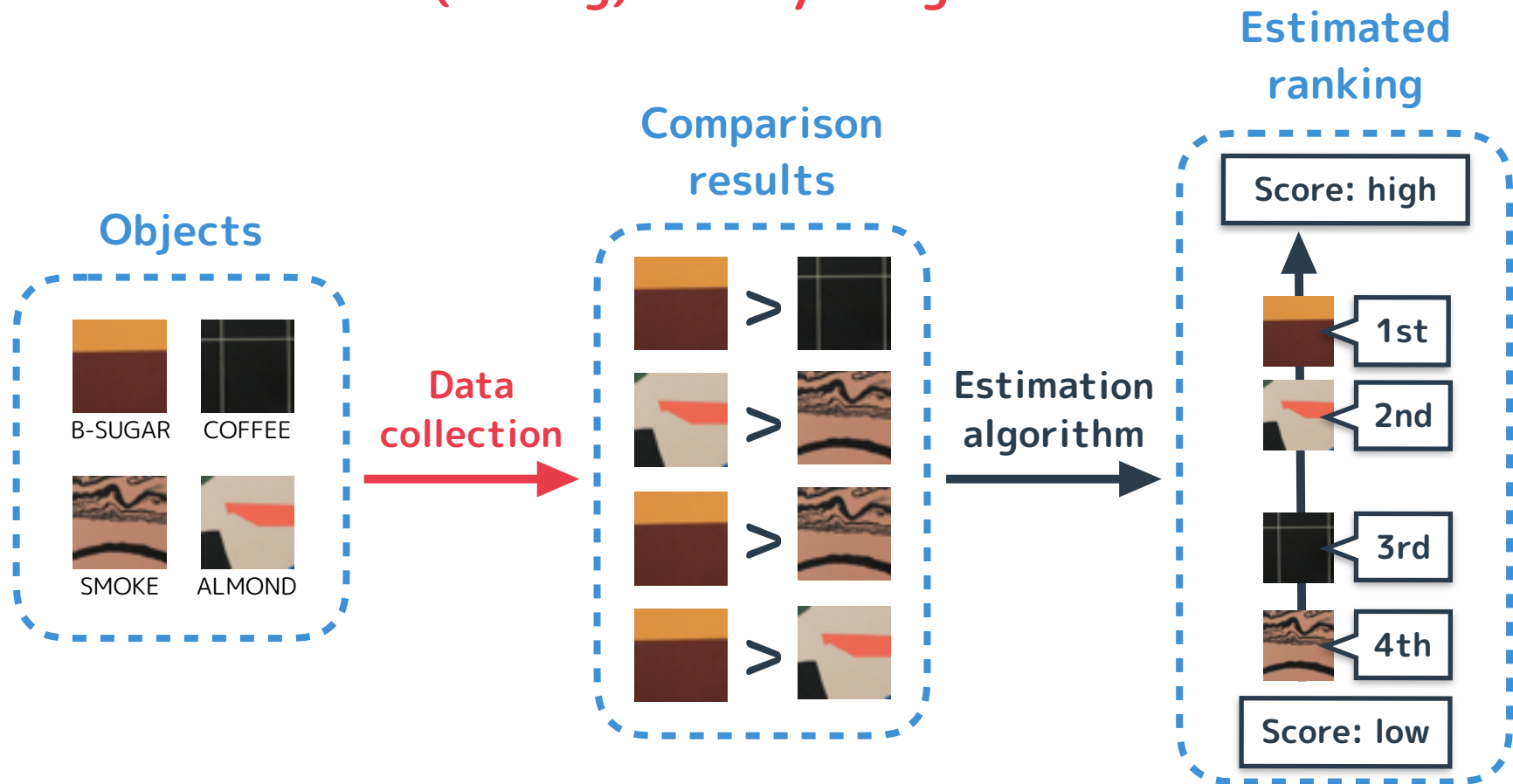
MAST
ALMOND
CHOCOLATE

MAST
SEA SALT
CHOCOLATE

Background:

efficient data-collection method is needed

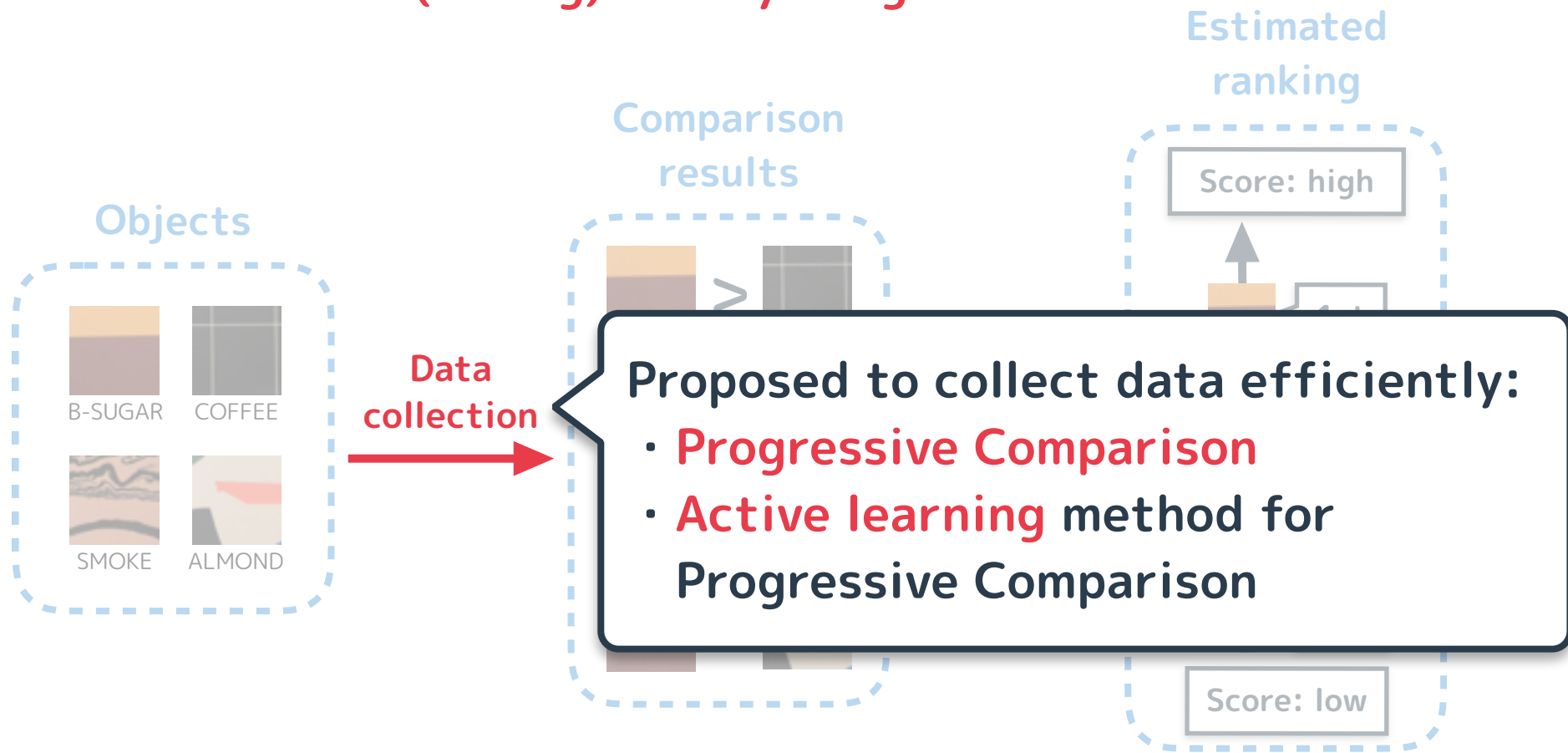
- Example: want to know taste ranking of chocolates
 - **Data-collection (eating) is very tough**



Background:

efficient data-collection method is needed

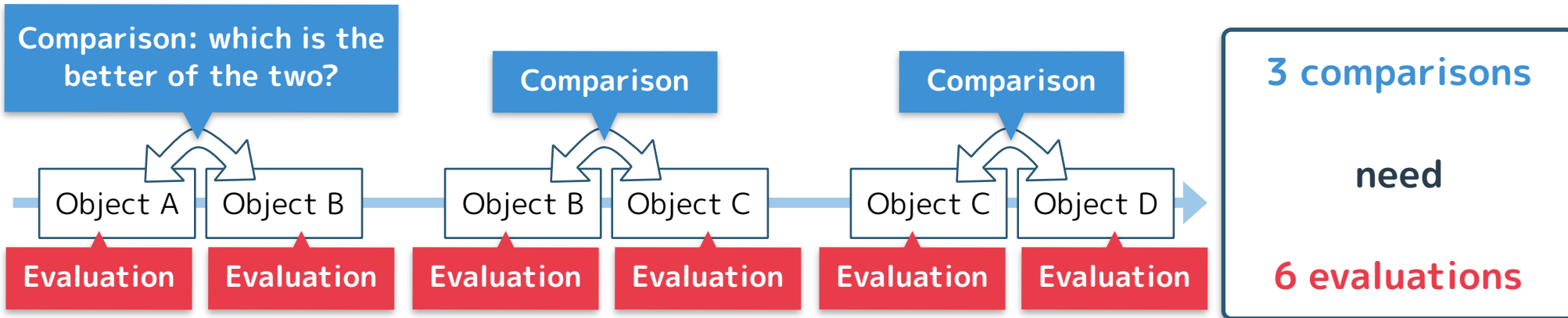
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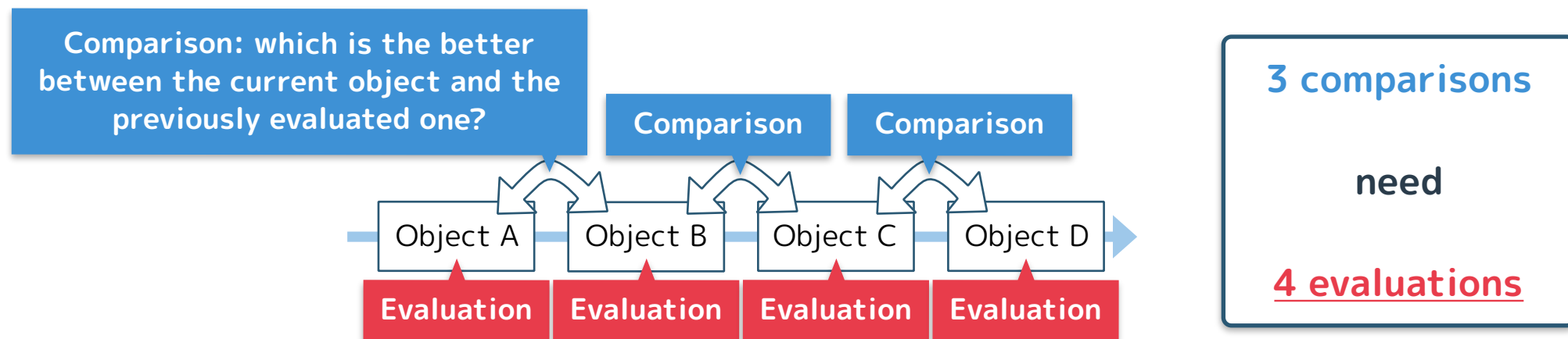
Progressive Comparison:

Data-collection method needing fewer evaluations

- Existing method (Standard pairwise comparison):



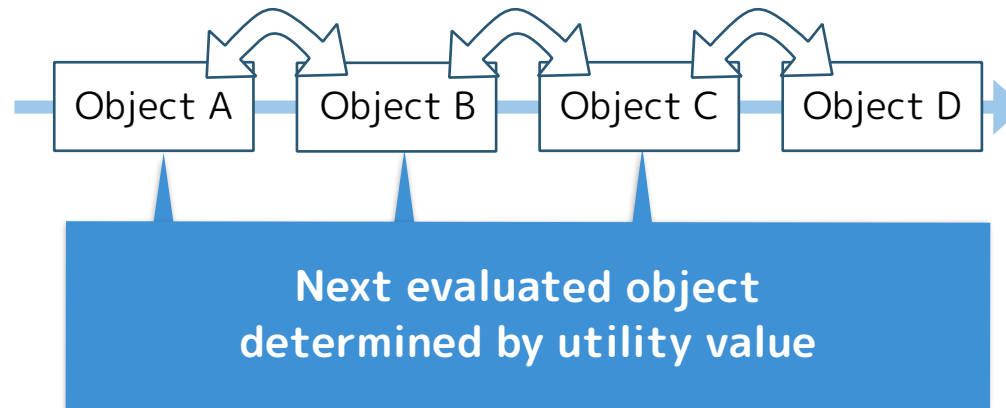
- Proposed method (**Progressive Comparison**):



Active learning for Progressive comparison:

Estimate ranking efficiently by selecting pairs

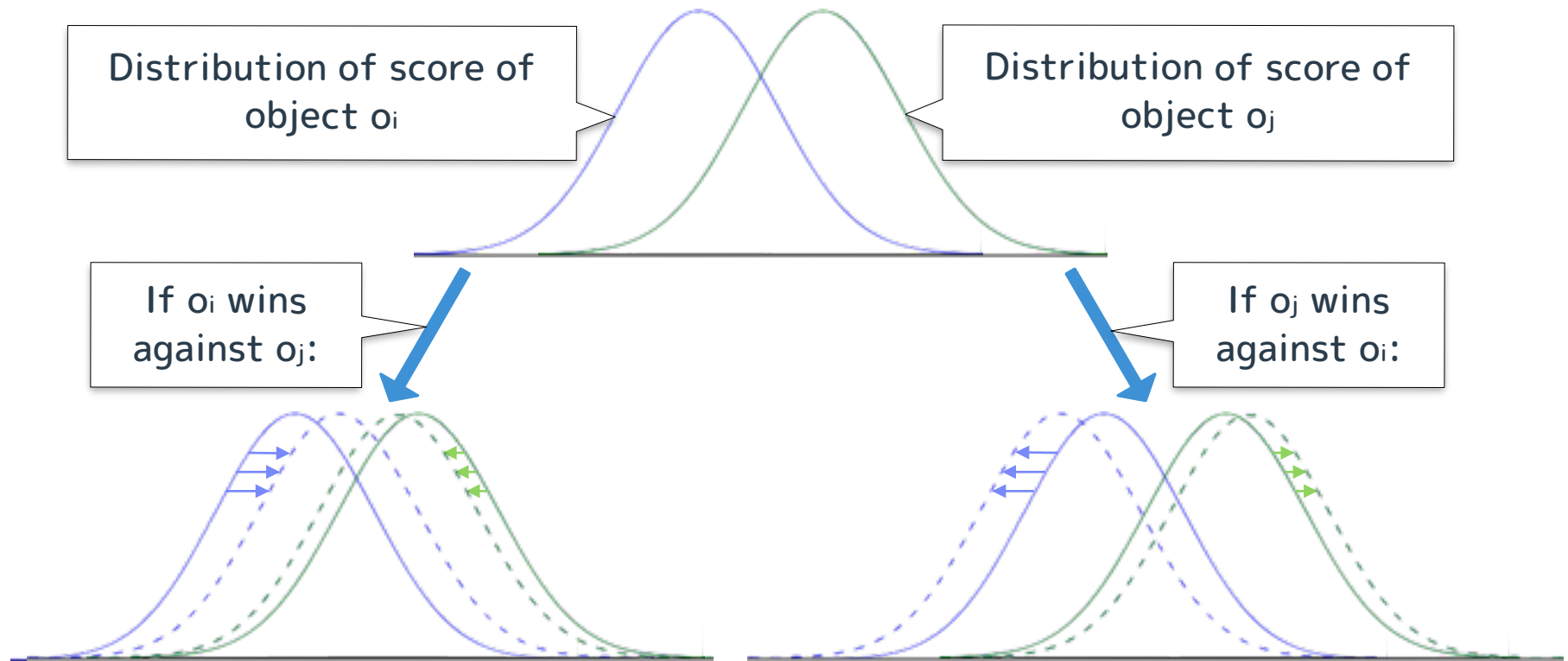
- **Utilities** calculated for each pair
- Priority given to a pair that has larger utility value
- Two definitions of utility proposed:
 - (i) Change in Distributions (CiD):**
expectation of changes in distributions of object scores
 - (ii) Change in Winning Probabilities (CiWP):**
expectation of changes in winning probability matrices



(i) Change in Distributions (CiD):

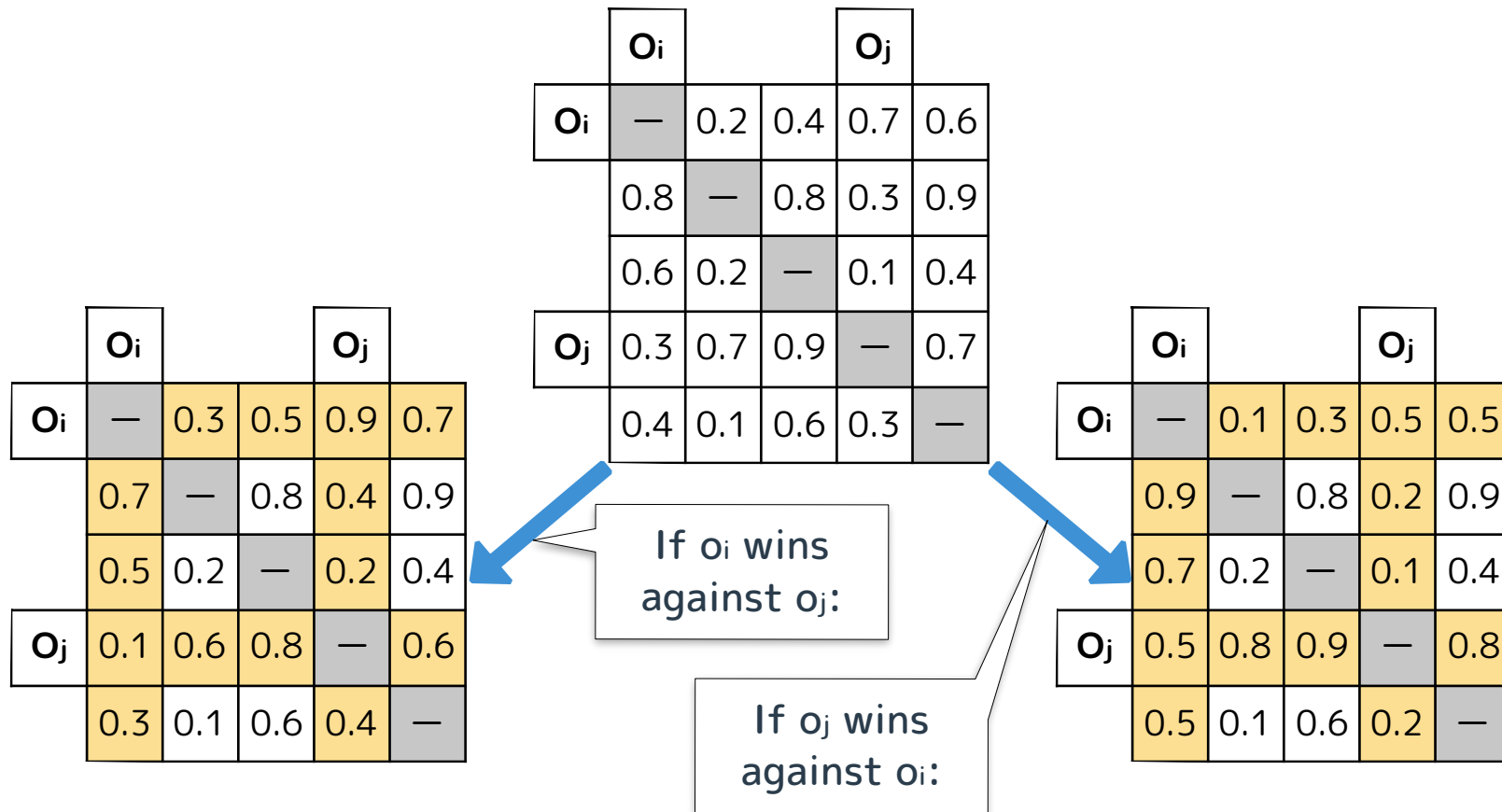
Calculate expectation of changes in distributions

- Expectation of changes in distributions calculated by KL divergence between normal distributions:



(ii) Change in Winning Probabilities (CiWP): Calculate expectation of changes of matrices

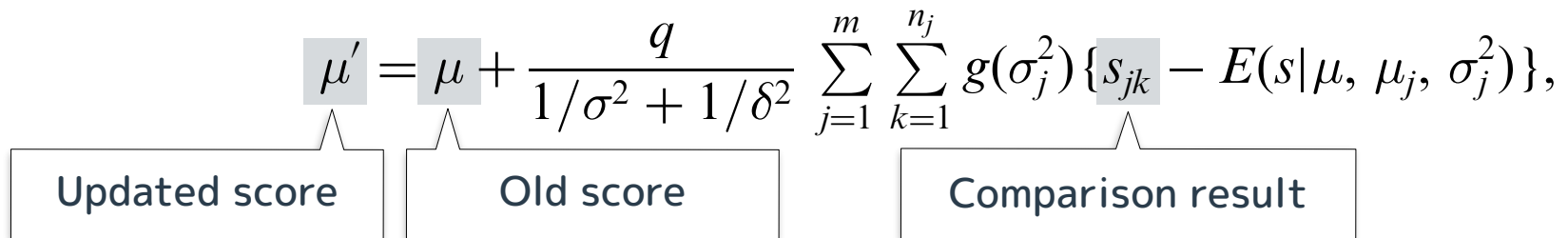
- Expectation of changes in matrices calculated by KL divergence between Bernoulli distributions:



Experiment settings:

Ranking estimation using Glicko Update Equation

- Glicko Update Equation:
 - Online ranking estimation algorithm of Bradley-Terry model
 - Update scores of object using comparison result

$$\mu' = \mu + \frac{q}{1/\sigma^2 + 1/\delta^2} \sum_{j=1}^m \sum_{k=1}^{n_j} g(\sigma_j^2) \{s_{jk} - E(s|\mu, \mu_j, \sigma_j^2)\},$$


The diagram illustrates the Glicko Update Equation. The equation is
$$\mu' = \mu + \frac{q}{1/\sigma^2 + 1/\delta^2} \sum_{j=1}^m \sum_{k=1}^{n_j} g(\sigma_j^2) \{s_{jk} - E(s|\mu, \mu_j, \sigma_j^2)\},$$
 where μ' is the updated score, μ is the old score, q is a constant, σ^2 and δ^2 are variance parameters, m is the number of objects, n_j is the number of comparisons for object j , $g(\sigma_j^2)$ is a function of the variance, and s_{jk} is the comparison result. Three callout boxes are present: 'Updated score' pointing to μ' , 'Old score' pointing to μ , and 'Comparison result' pointing to s_{jk} .

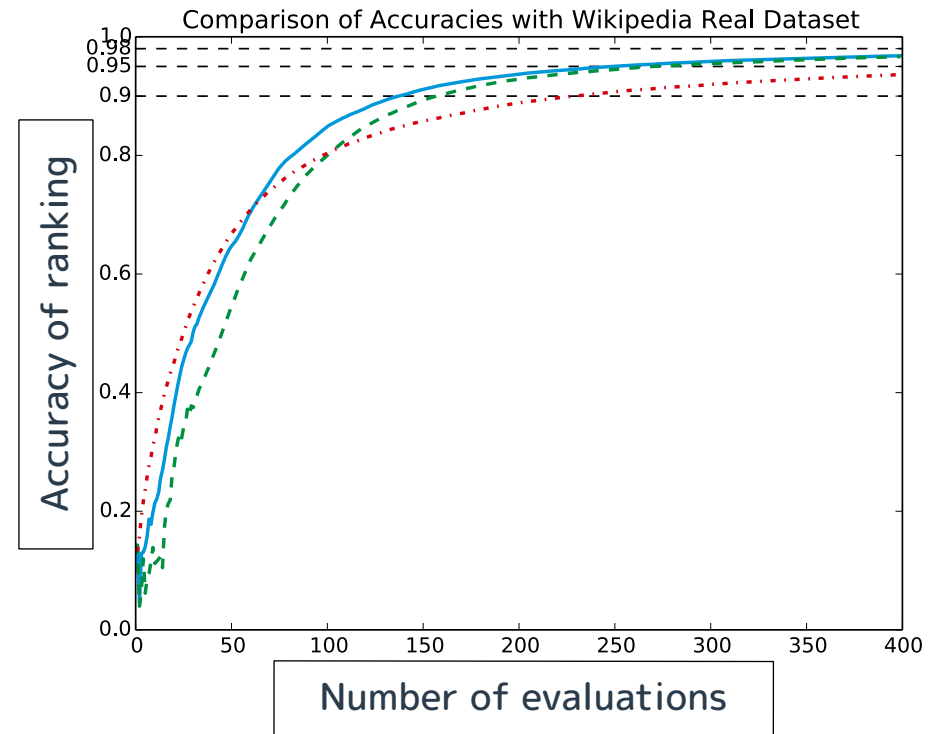
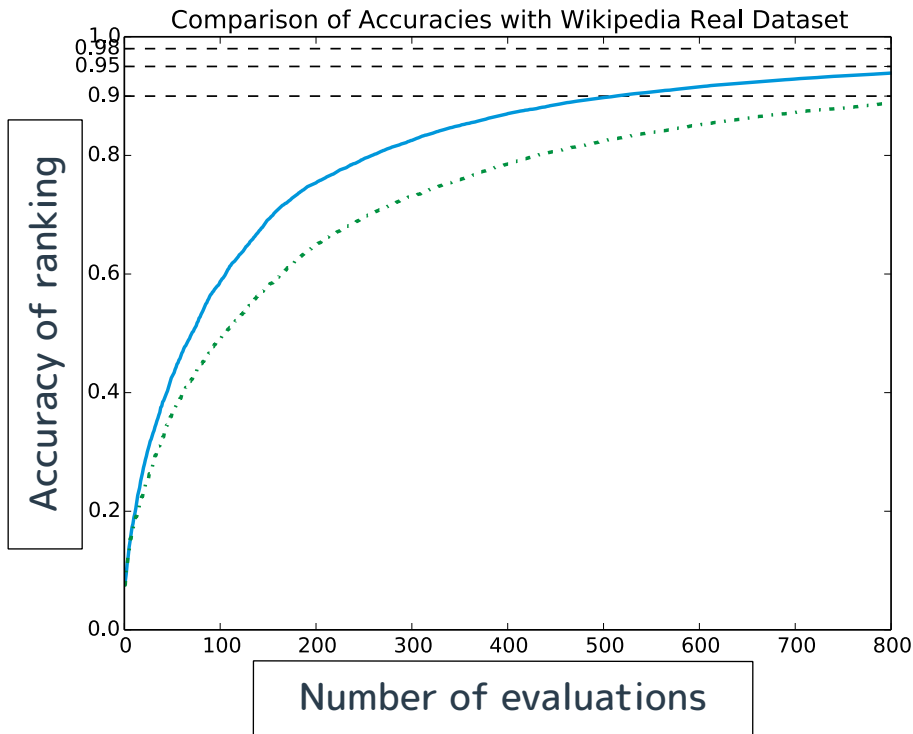
Glickman, Mark E. "Parameter estimation in large dynamic paired comparison experiments." *Journal of the Royal Statistical Society: Series C (Applied Statistics)* 48.3 (1999): 377-394.

- Dataset:
 - Synthetic (100 objects)
 - Image comparison (50 objects)
 - Wikipedia article comparison (30 objects)

Experiment results:

Progressive Comparison and active learning methods

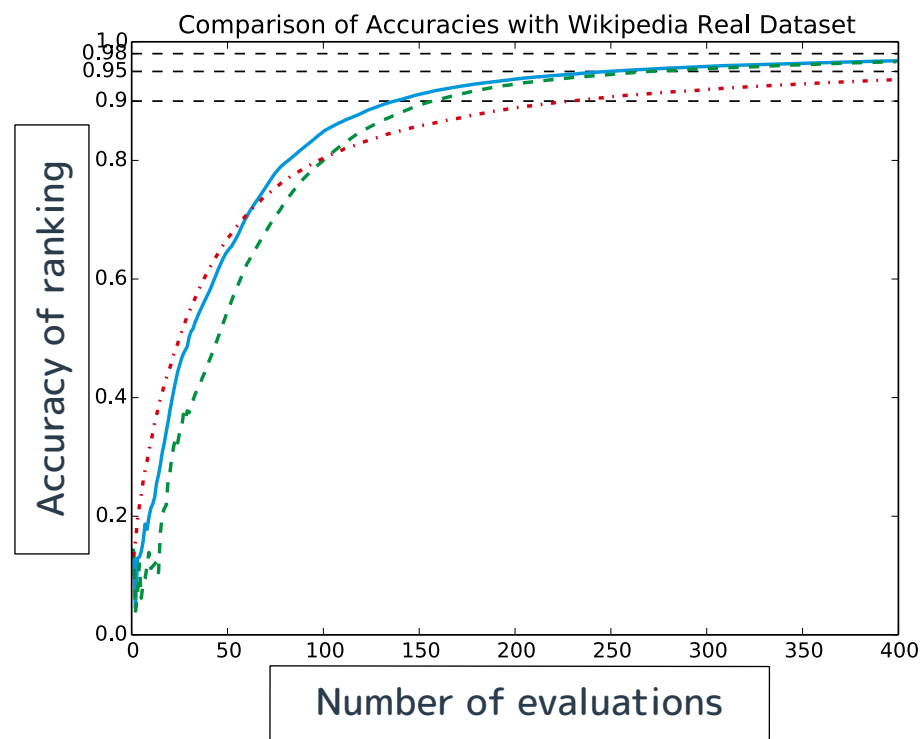
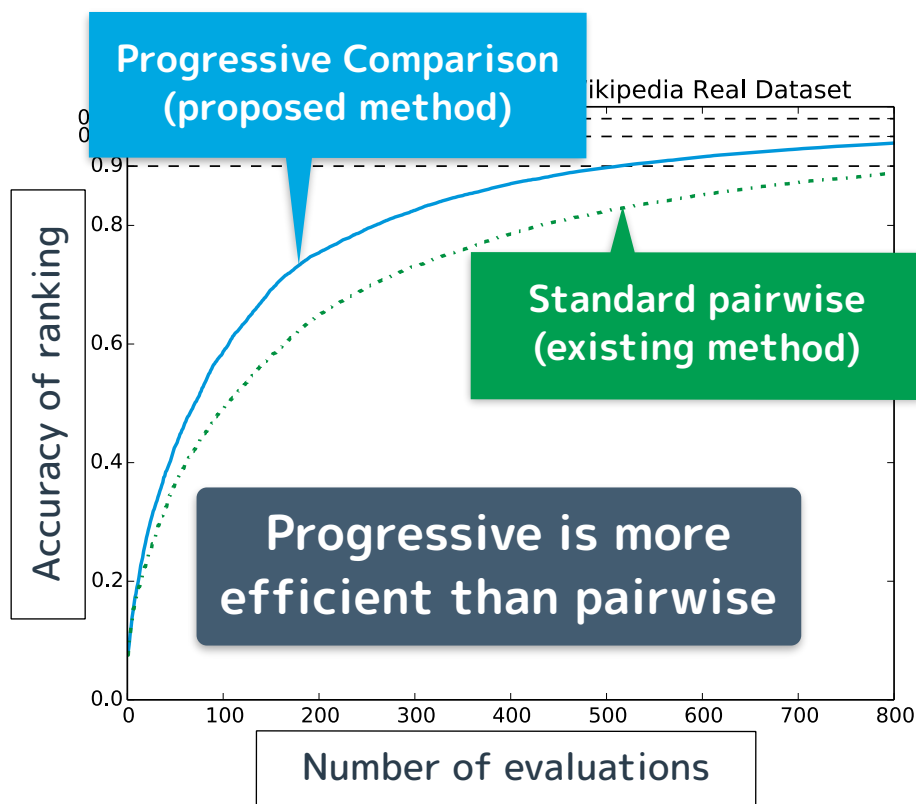
- Experimental results demonstrate the efficiency of Progressive Comparison and its active learning methods



Experiment results:

Progressive Comparison and active learning methods

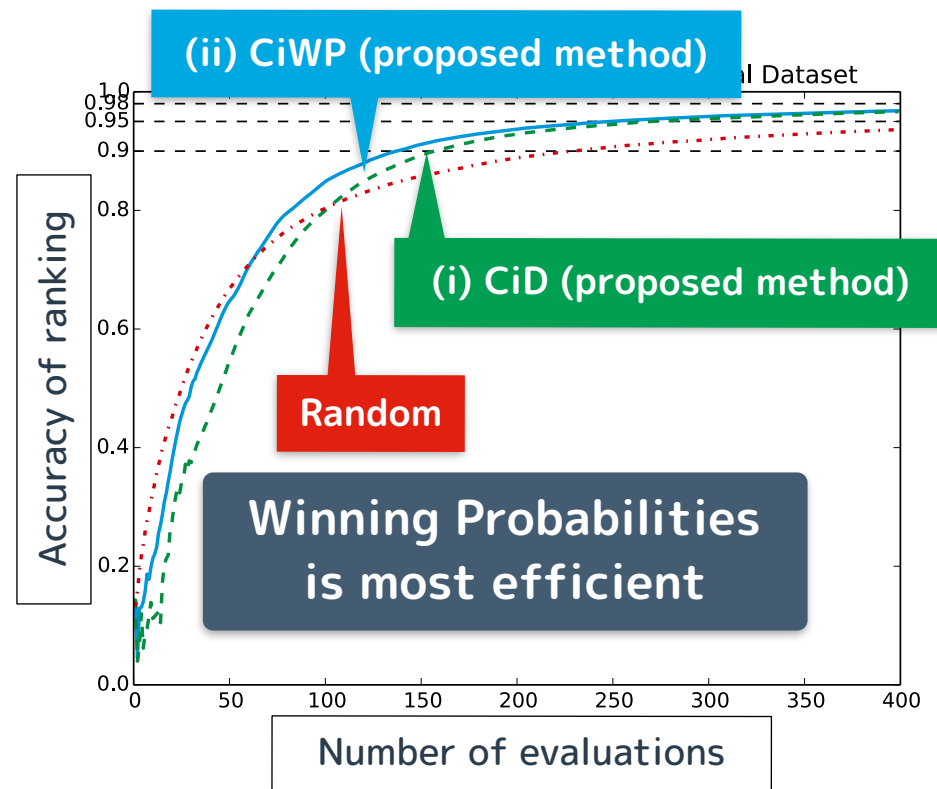
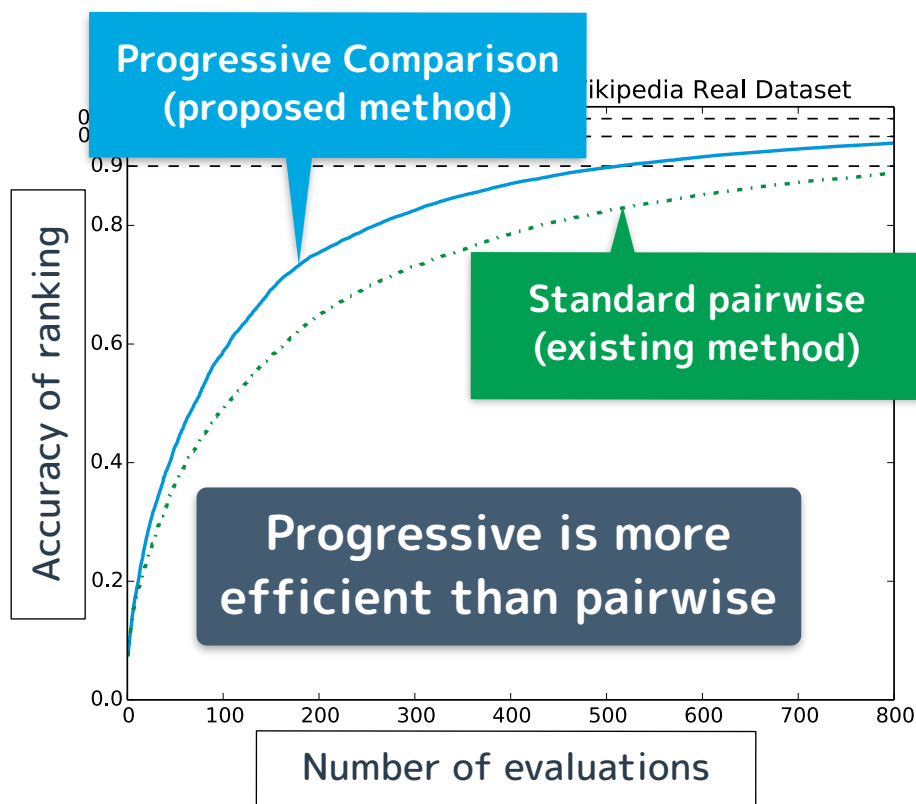
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Experiment results:

Progressive Comparison and active learning methods

- Experimental results demonstrate the efficiency of Progressive Comparison and its active learning methods



Conclusions:

Progressive Comparison for Ranking Estimation

- **Ranking estimation** problem addressed
- Proposed:
 - **Progressive comparison**
 - **Active learning** method of Progressive Comparison
 - Change in Distributions
 - Change in Winning Probabilities
- Experimental results show:
 - Superiority of Progressive Comparison to standard pairwise
 - Efficiency of active learning methods for Progressive Comparison (especially (ii) CiWP)