# Methods for Ordinal Peer Grading

## Peer Grading Toolkit

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This tool is designed for the problem of peer-grading/peer-reviewing. Given a set of assignments that need to be graded, we *aggregate* the grades provided by the peer graders/reviewers. The peer-grading toolkit takes as input a set of orderings provided by the reviewers indicating their preferences over the different assignments. For instance, in the example provided below reviewer 1 rates assignment 1 as being better than assignment 2 which in turn is better than assignment 3. Given these orderings you can use the tool to produce an overall ranking of all assignments as well as an estimate of how reliable each of the different reviewers were.

**DATA USAGE POLICY:** We do not store any of the data uploaded. The output rankings produced by the toolkit are deleted daily.

To learn more about the machine learning techniques we use please check out our papers. You can also download the code and run it offline.

Text Input

Questions about the PGF format?

```
task1 rvwrid_1 assgnid_1 > assgnid_2 > assgnid_3
task1 rvwrid_2 assgnid_1 > assgnid_2 > assgnid_3
task1 rvwrid_3 assgnid_1 > assgnid_3 > assgnid_2
```

Peer Grade Format File

CMT Export-Format File (XLS: XML Spreasheet)

Submit

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**Talk: Wednesday 11:00am (Empire West)**

# Evaluation at Scale is challenging


- Conventional Evaluation:
  - Small-scale classes (10-15 students) : Instructors evaluate students themselves
  - Medium-scale classes (20-200 students) :  TAs take over grading process.
  - MOOCs (10000+ students) : ??

- MCQs & Other Auto-graded questions are not a good test of understanding.
  - Limits kinds of courses offered.

# Peer Grading to the Rescue


- Students grade each other (anonymously)!
- Overcomes limitations of instructor/TA evaluation:
  - Number of *"graders"* scales with number of students!

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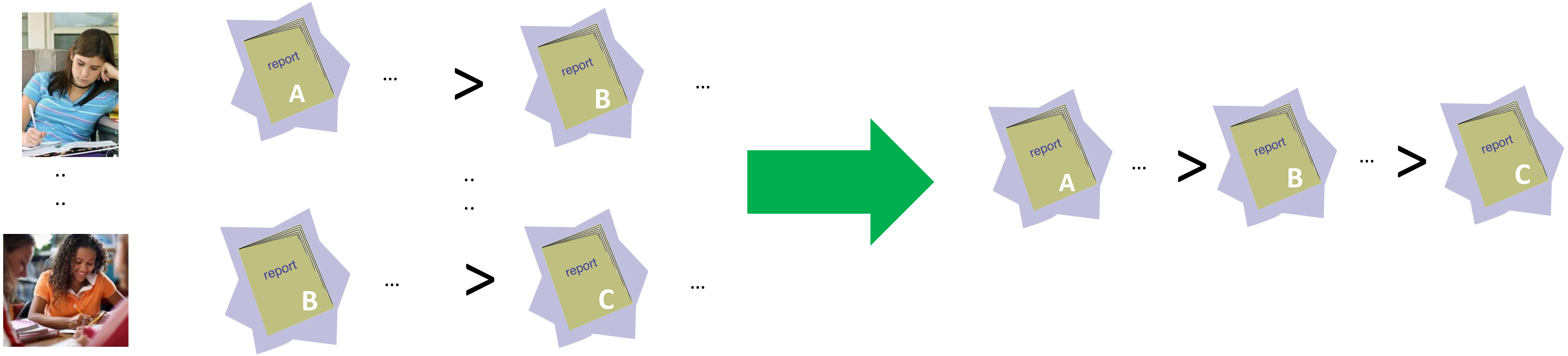
- Current methods [Piech et. al. 13] require cardinal labels for each assignment.
- Each peer grader *g* provides cardinal score for every assignment *d* they grade.
  - E.g.: Likert Scale, Letter grade

# Our Approach: Ordinal Peer Grading

- Challenge: Students are not trained graders.
  - Need to make feedback process simple!
- *Ordinal feedback* easier to provide and more reliable than *cardinal feedback:*
  - Project *X* is **better** than Project *Y* **vs.** Project *X* is a **B+.**
- **Ordinal Peer Grading:** Graders provide ordering of assignments they grade
  - Need to infer overall ordering and grader reliabilities.



# Mallows Model and Variants

- GENERATIVE MODEL: $$P(\sigma^{(g)}|\sigma^*) = \frac{e^{-\delta_K(\sigma^*,\sigma^{(g)})}}{\sum_{\sigma'} e^{-\delta_K(\sigma^*,\sigma')}}$$

$\delta_K(\sigma^*,\sigma^{(g)})$ is the Kendall-Tau distance between orderings (# of differing pairs).

- OPTIMIZATION: NP-hard. Greedy algorithm provides good approximation.
- WITH GRADER RELIABILITY:

$$P(\sigma^{(g)}|\sigma^*) = \frac{e^{-\eta_g\delta_K(\sigma^*,\sigma^{(g)})}}{\sum_{\sigma'} e^{-\eta_g\delta_K(\sigma^*,\sigma')}}$$

- Variant with score-weighted objective (MALS) also studied.

# Bradley-Terry Model & Variants

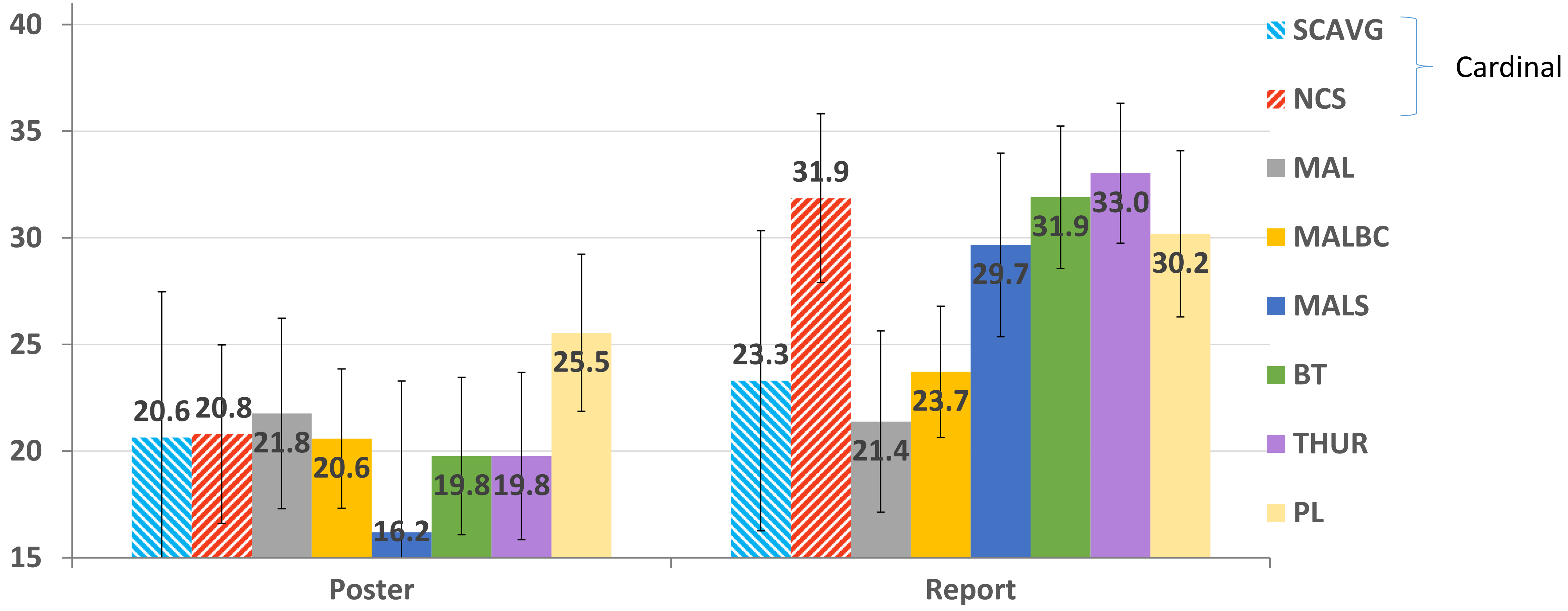
- GENERATIVE MODEL: $$P(\sigma^{(g)}|s) = \prod_{d_i \succ_{\sigma^{(g)}} d_j} \frac{1}{1 + e^{-(s_{d_i} - s_{d_j})}}$$
  - Decomposes as pairwise preferences using logistic distribution of (true) score differences.
- OPTIMIZATION: Alternating minimization to compute MLE scores (and grader reliabilities) using SGD subroutine.
- GRADER RELIABILITY: $$P(\sigma^{(g)}|s) = \prod_{d_i \succ_{\sigma^{(g)}} d_j} \frac{1}{1 + e^{-\eta_g(s_{d_i} - s_{d_j})}}$$
- Variants studied include Plackett-Luce model (PL) and Thurstone model (THUR).

# Experimental Setting: New Peer Grading Dataset

- Data collected during class project (Fall 2013):
  - First real *large-scale* scale evaluation of  machine-learning based peer-grading techniques.
- Used two-stages: Project Posters (PO) and Final-Reports (FR)
  - Students provided cardinal grades (10-point scale): 10-Perfect, 8-Good, 5-Borderline, 3-Deficient
- Also performed conventional grading: **TA and instructor grades**.

| Data Statistic | PO | FR |
|---|---|---|
| Number of Assignments | 42 | 44 |
| Number of Peer Reviewers | 148 | 153 |
| Total Peer Reviews | 996 | 586 |
| Total TA Reviews | 78 | 88 |
| Participating TAs | 7 | 9 |

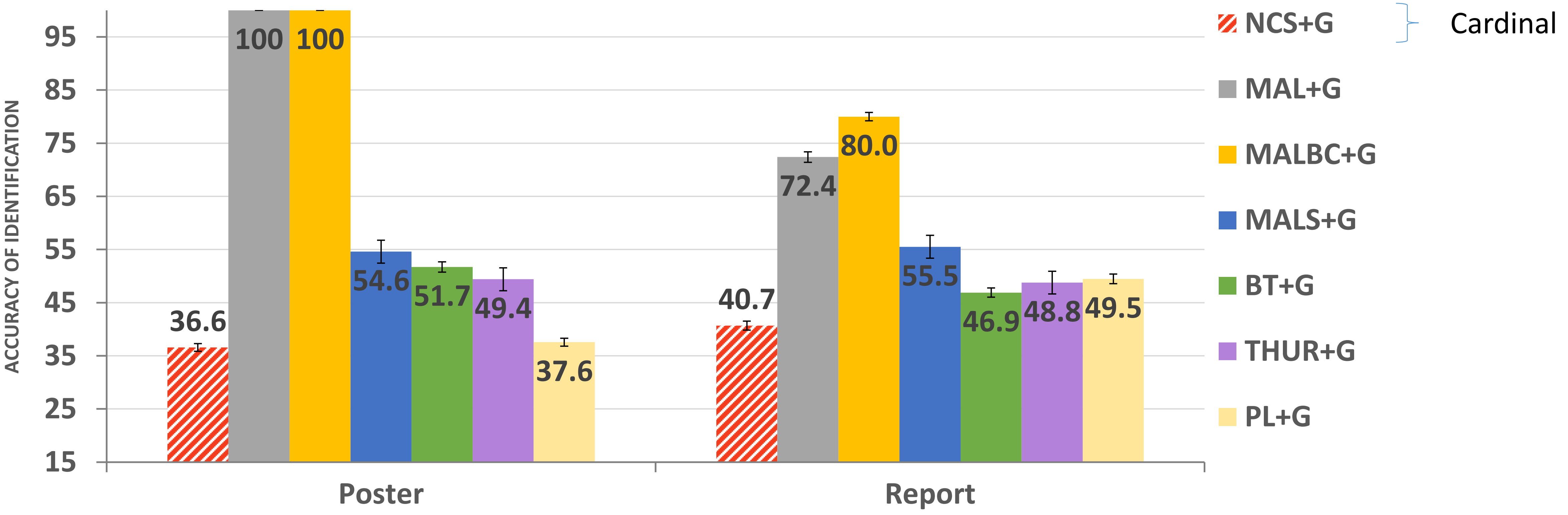
# How well do OPG methods do w.r.t. Instructor Grades?




- TAs had (Kendall-Tau) error of 22.0 ± 16.0 (Posters) and 22.2 ± 6.8 (Report).

# Benefit of grader reliability: Identify poor graders

- Added *lazy graders*. Can we identify them?




- Significantly better than cardinal methods and simple heuristics.
- Survey shows most students found process valuable and feedback helpful.