

FedIRT: An R package with shiny app for Estimating Federated Response Model

Biying Zhou¹ and Feng Ji¹

¹ Department of Applied Psychology & Human Development, University of Toronto, Toronto, Canada

DOI: [10.xxxxxx/draft](https://doi.org/10.xxxxxx/draft)

Software

- [Review](#)
- [Repository](#)
- [Archive](#)

Editor: [Open Journals](#)

Reviewers:

- [@openjournals](#)

Submitted: 01 January 1970

Published: unpublished

License

Authors of papers retain copyright and release the work under a Creative Commons Attribution 4.0 International License ([CC BY 4.0](#)).

Summary

We developed an R package FedIRT, to enable estimating traditional IRT models with additional privacy, allowing estimation in a distributed manner without losing estimation accuracy. Numerical experiments demonstrate that Federated IRT estimation achieves comparable statistical performance compared to normal IRT, with the benefits of privacy preservation and minimal communication costs. Our shiny app built in this package allows schools and educational centers use our algorithm in a distributed approach.

Statement of Need

Traditional IRT estimation requires all individual raw response data to be centralized in one place, thus potentially causing privacy issues. We developed an R package FedIRT to address this problem, which could estimate IRT model in a distributed way, without centering the dataset in schools.

Our package include a function `fedirt` and a shiny app, including a `server.R` and a `client.R`, which could be used as the educational center and distributed schools.

Method

We use Maximum Likelihood Estimation (MLE) to estimate IRT model.

In `server.R`, we implement the functions to update the model parameters, and in `client.R`, we implement the functions to calculate the likelihood values. Thus, by iterations, we could estimate the model parameters.

Comparison with existing packages

We compared our algorithm performance with two existing packages: `ltm` ([Rizopoulos, 2007](#)) and `mirt` ([Chalmers, 2012](#)), which are used to estimate classical IRT models. Simulation results show that our package perform as efficient and accurate as these two packages.

We use the following formula to calculate the MSE.

$$\widehat{MSE} = \frac{\sum_{t=1}^T \sum_{j=1}^J ((\hat{\alpha}_{jt} - \alpha_j)^2 + (\hat{\beta}_{jt} - \beta_j)^2)}{2JT}$$

The figure below shows the MSE comparison.

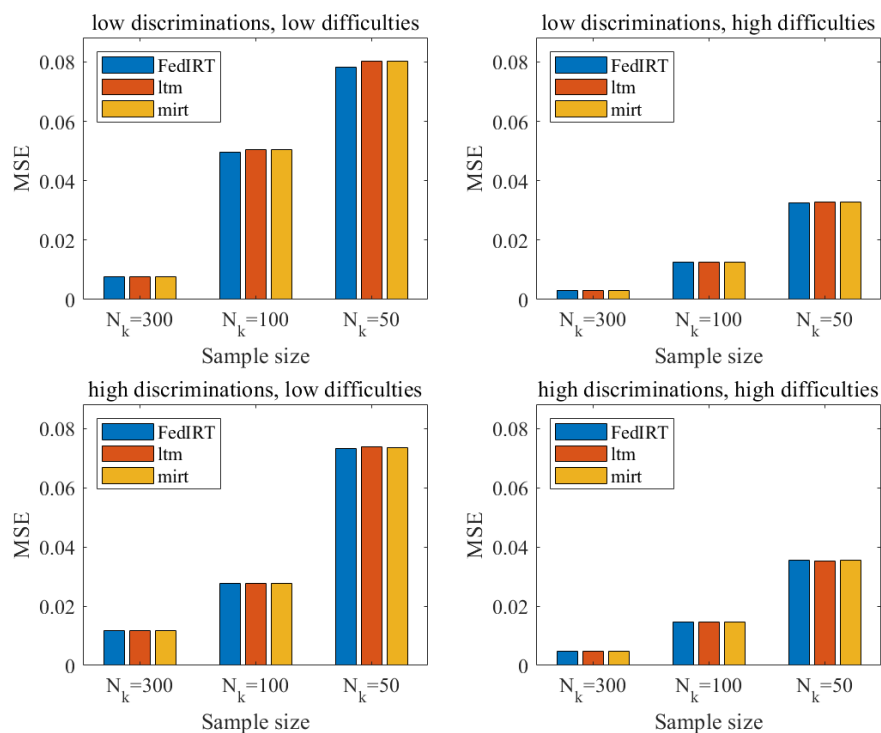


Figure 1: MSE comparison

30 We also show the bias in the following figure, showing that our package has low bias.

$$\widehat{bias} = \frac{\sum_{t=1}^T \sum_{j=1}^J ((\hat{\alpha}_{jt} - \alpha_j) + (\hat{\beta}_{jt} - \beta_j))}{2JT}$$

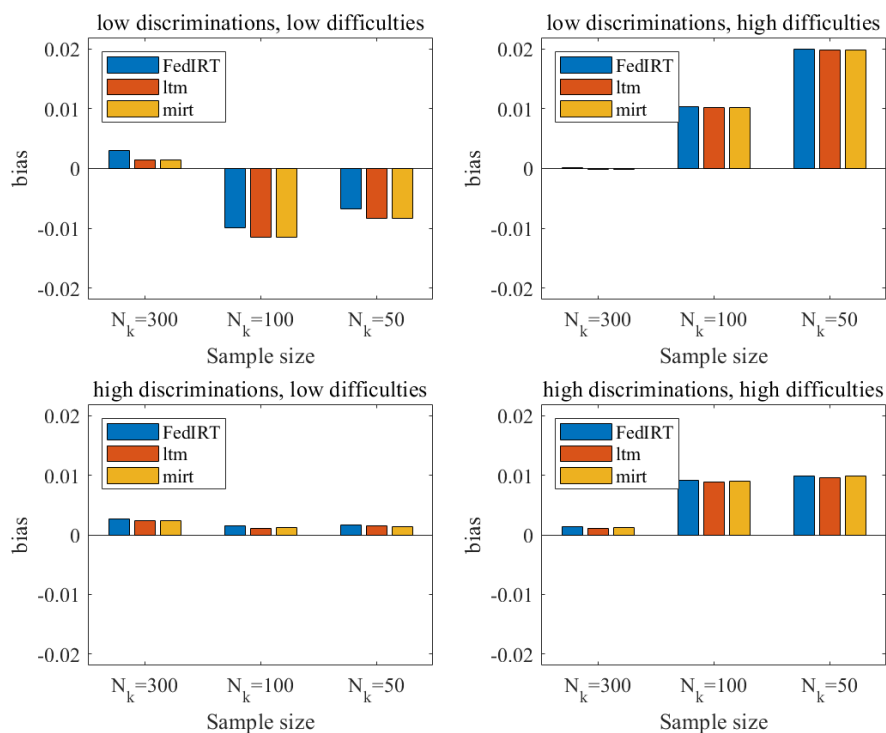


Figure 2: Bias comparison

Availability

The R package FedIRT is publicly available on [Github](https://github.com). It could be installed and run by using the following commands:

```
devtools::install_github("zby0327/fedirt")
library(fedirt)
```

Acknowledgements

References

- Chalmers, R. P. (2012). Mirt: A multidimensional item response theory package for the r environment. *Journal of Statistical Software*, 48, 1–29.
- Rizopoulos, D. (2007). Ltm: An r package for latent variable modeling and item response analysis. *Journal of Statistical Software*, 17, 1–25.