Simulation for Bandit Algorithm Comparison

Siyu Xie

2025-10-21

In this simulation study, I compared the performance of two bandit algorithms. The algorithm framework is given in Algorithm Framework. OLS bandit uses OLS update in the beta updating stage.

Why these DGPs? Why these sample sizes/conditions? Truncated normal contextual vector : Following the theoretical part of Online Decision Making with High-Dimensional Covariates, we require the l-2 norm of contextual vector is bounded.

Two different uniformly distributed beta : With assumption 2, we expect the arms are "distinguishable" with high probability. Uniform distribution can be easily generated with some overlapping.

Heavy-tailed error : We expect the quantile update have robustness property compared with OLS update.

Sample size : Time frame T may grow large, but up to some point, the proportion of forced-sampling exploration becomes too small compared with the total number of samples.

How did you ensure your simulation design was fair and unbiased? I tried several different degrees of freedom for the error student t-distribution to avoid cherry-picking.

What are the limitations of your simulation study? I did not explore the impact of different β distribution and also the high-dimensional cases.

What scenarios did you not include, and why might they matter? When the target focuses on different quantile level, the results may differ a lot. However, I do not have a good benchmark algorith to compare with. It can be applied for conservative decision-making. Also, I think it would be valuable to study the scenarios with multiple arms to choose from.

How do your results inform practice or theory? It aligns with the theory that a quantile estimator in this case provides a more robust and more accurate β estimation. But this can be inferred from the quantile regression property.

What would you investigate next if you had more time/resources? I may want to work on high-dimensional setting simulation, as the main contribution of the paper was based on high-dimensional contextual data. Also, multiple arms scenarios case is worth investigating.

Which aspects of the implementation were most challenging? Modularize my code is definitely a pain. When I write them in functions, I get confused about which one should be called first. Also, the structure must be designed more carefully compared with working directly with interface notebook. Making the results reproducible – adding a random seed in each part and creating a makefile are quite challenging.

How confident are you in your results? What could undermine that confidence? I feel quite confident in my simulation results.