
# **RoME**: A **Ro**bust **M**ixed-**E**ffects Bandit Algorithm for Optimizing Mobile Health Interventions

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# Bandits in Mobile Health


$t = 1$
$\boldsymbol{S}_1, A_1, R_1$

$t = 1$ → $t = 2$
$\boldsymbol{S}_1, A_1, R_1$ → $\boldsymbol{S}_2, A_2, R_2$

$t = 1$ → $t = 2$ → $t = 3$
$\boldsymbol{S}_1, A_1, R_1$ → $\boldsymbol{S}_2, A_2, R_2$ → $\boldsymbol{S}_3, A_3, R_3$

Time

# Challenges of Mobile Health Setting

- **Heterogeneity** in advantage function (treatment effects) over time and across participants
- **Nonstationary** rewards even under no treatment
- **Nonlinear** relationships between contexts and rewards
- **Network structure** among participants, such as students within a school

# Our Solution

Advantage Function: $\boldsymbol{S}_{it}^{T}\left(\boldsymbol{\theta}+\boldsymbol{\theta}_{i}^{\text{user}}+\boldsymbol{\theta}_{t}^{\text{time}}\right)$

Fixed effect

Participant random effect

Time random effect

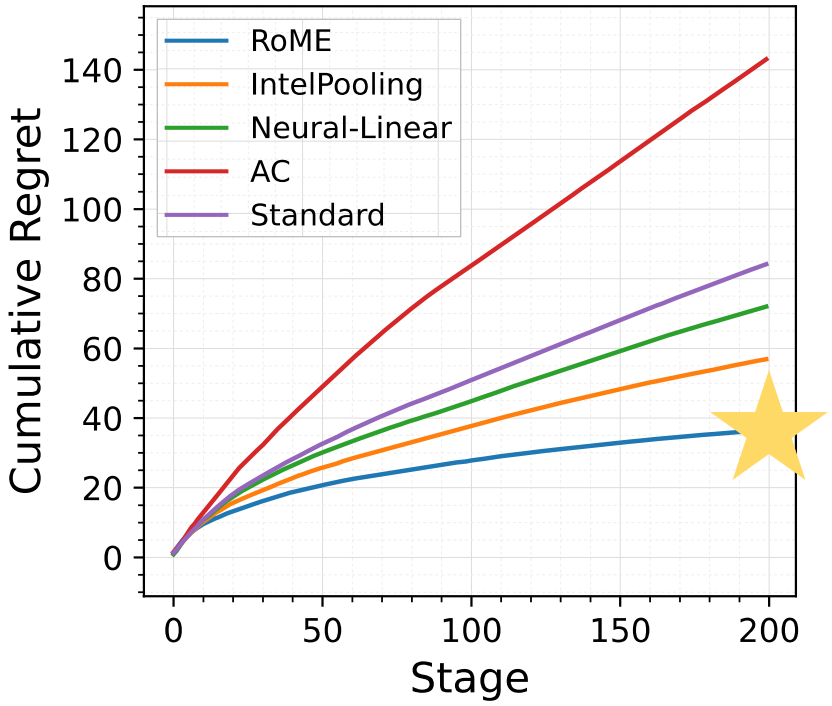
Other Method Components

- Debiased machine learning (Chernozhukov et al. 2018)
- Nearest-neighbor regularization (Yang, Toni, & Dong 2020)
- Thompson sampling (Agrawal & Goyal 2012)

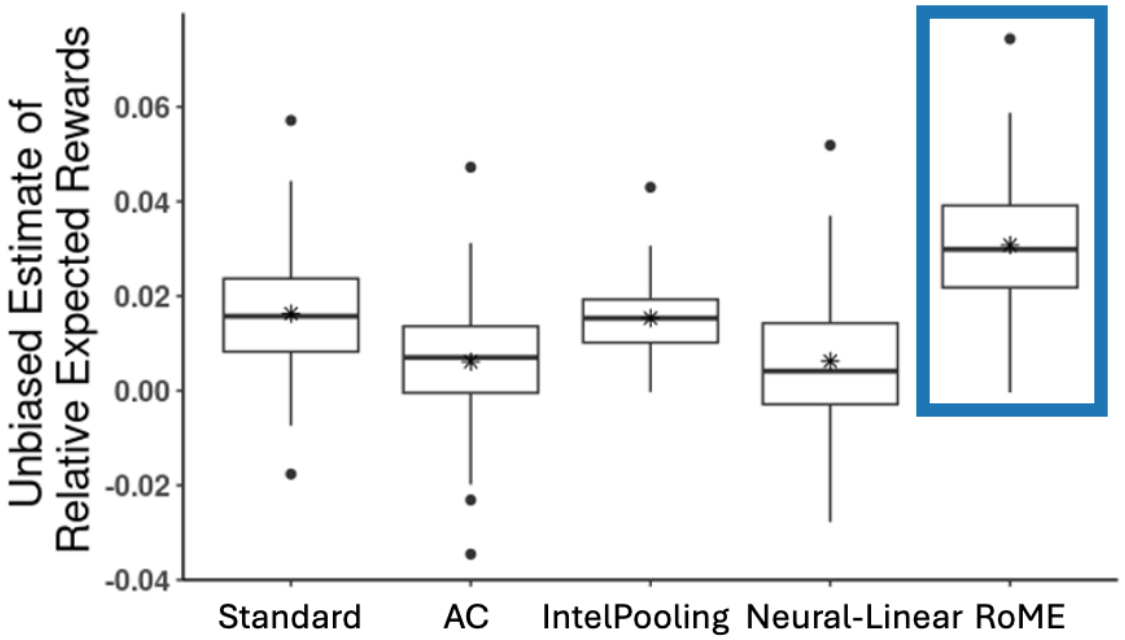
Up to log factors, the regret scales like $\sqrt{K}$, where $K$ is the number of stages (time points)

# Results

## Simulation




## Off-policy Evaluation Study




Lower regret (higher rewards) across both settings!

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# Thank you!

Check out our repository at github.com/eastonhuch/RoME.

Contact me with questions at ekhuch@umich.edu.

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# References


- Agrawal, Shipra, and Navin Goyal. Analysis of Thompson sampling for the multi-armed bandit problem. In *Conference on Learning Theory*, pp. 1-39. JMLR Workshop and Conference Proceedings, 2012.
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- Yang, K., Toni, L., and Dong, X. Laplacian-regularized graph bandits: Algorithms and theoretical analysis. In International Conference on Artificial Intelligence and Statistics, pp. 3133–3143. PMLR, 2020.