Optimal Bidding Strategy for Auto Bidding Campaigns

Problem Statement

- Auto bidding requires advertisers to set a campaign budget.
- Bidding strategies are automated by an algorithm.
- Objective: Design a bidding algorithm to maximize ad engagement within budget.
- Importance: Poor performance could lead to advertiser churn and revenue loss.

Solution: Notations

- B: Campaign budget
- T: Total auction opportunities
- t: t^{th} auction opportunity
- I_t: Indicator if the campaign wins the t^{th} auction
- G: Engagement cost of the t^{th} auction
- b_t: Bid price at t
- θ: Conversion rate at t

Optimization Problem: CPC Campaign Example

- **Objective**: Maximize expected engagement

$$\mathbb{E}\left[\sum_t r_t I_t\right]$$

- **Constraint**: Stay within budget

$$\sum_t b_t I_t \leq B$$

Lagrangian Formulation

- Lagrangian:

$$L = \sum_t r_t I_t - \lambda \left(\sum_t G_t - B \right)$$

- Dual Problem:

$$\min_\lambda \sum_t (r_t I_t - \lambda G_t) + \lambda B$$

Optimality Condition and Solution

- **Optimality Condition**:

$$\sum_t l_t = \dots$$

- **Solution via Online Gradient Descent (OGD)**:

Update Rule: $\dots$

Alternative Solution: Model Predictive Control (MPC)

- Uses MPC to solve the problem.
- Sensitive to forecasting accuracy.

A/B Testing: Budget Split Test

- Baseline: PID controller
- Treatment: OGD
- **Result**: 10% improvement in ROI metrics.