Multi-armed Bandits

Tom Vodopivec

Bandits??

One-armed bandit

 = slot machine

+

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One-armed bandit

 = slot machine

When you have more,
which one has better odds?

Problem definition

Single-state MDP

Maximize reward

Learn optimal policy

Exploration-exploitation trade-off

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Types of Bandits

Stochastic

Adversarial (game theory and Nash equilibria)

Markovian (some underlying state space - use RL techniques)

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Non-stationary

Budget-limited bandits
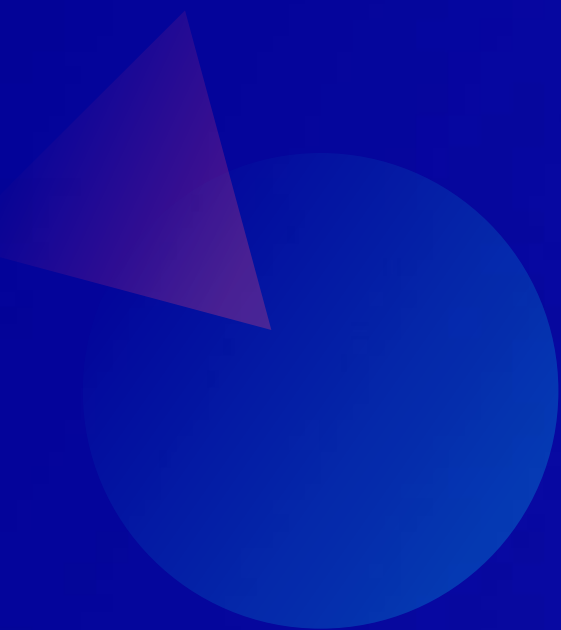
Contextual bandits (with covariates)

Sleeping bandits

Many-armed bandits

Solutions (policies)

Epsilon-greedy

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Upper Confidence Bounds (UCB)
- Optimism in the face of uncertainty   +
- Optimal in the limit

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Thompson Sampling

- Bayesian: draw samples from (Beta) distribution
- Number of pulls of an arm should match probability of the arm being optimal

Performance Metrics

Cumulative reward

Regret

Probability of choosing optimal arm

Use in Marketing

A/B testing with real-time optimization

Pros (over A/B testing)

● Faster identification of best variant - more cumulative reward   +
● Adapts to non-stationarity (no need to repeat A/B tests)
● No need to select best variant manually (additional step at end of A/B test)

Cons (over A/B testing)

● More difficult to understand and to implement
● More difficult to measure benefits

Reading Material

Kuleshov and Precup, Algorithms for the Multi-armed Bandit Problem

Auer et al., Finite-time Analysis of the Multiarmed Bandit Problem

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Vermorel and Mohri, Multi-Armed Bandit Algorithms and Empirical Evaluation