

Extension Using Chapter 12: Quantifying Uncertainty

In addition to the deterministic simulation of heats and progression, I introduced a probabilistic reasoning component inspired by Chapter 12 of *Artificial Intelligence: A Modern Approach*. This extension models **uncertainty in athlete performance** and applies **decision theory** to make rational choices under uncertainty.

What was added:

1. Probabilistic Performance Profiles

- Each athlete is assigned a probability distribution (Gaussian) over their race times.
- Example: Athlete A1 has a mean of 10.8s with a small standard deviation (consistent performer), while Athlete A3 has a faster mean of 10.6s but a larger standard deviation (erratic performer).
- This reflects the idea that agents must act under uncertainty, as described in Chapter 12.

2. Simulation of Outcomes

- Instead of a single deterministic race time, the system generates thousands of samples from each athlete's distribution.
- This allows us to estimate probabilities such as:
 - The chance that A3 beats A1.
 - The chance that A1 runs under 10.75 seconds.

3. Decision-Theoretic Planning

- A utility function is defined to capture preferences:
 - High utility for finishing under 10.75s.
 - Medium utility for finishing under 11.0s.
 - Low utility otherwise.
- Expected utility is computed for each athlete by averaging across simulated outcomes.
- The rational choice (principle of maximum expected utility) is to select the athlete with the highest expected utility as the relay anchor.

4. Connection to Chapter 12 Concepts

- **Belief states:** Probabilistic distributions represent the agent's beliefs about athlete performance.
- **Bayes' rule and probability axioms:** Used implicitly in updating probabilities based on simulated evidence.
- **Decision theory:** Combines probabilities with utilities to make rational choices, exactly as outlined in Chapter 12.
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By incorporating uncertainty, the system no longer assumes athletes always perform at their base ability. Instead, it accounts for variability and risk, allowing planners to make rational decisions about team selection and race strategy. This extension demonstrates how probabilistic reasoning and planning under uncertainty can enhance a track and field management system.