UNIVERSITÉ CÔTE D'AZUR

Agent-Based Modeling (Master SIED)

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Unit 3
Creating Agent-Based Models

Four Characteristics of ABM

1) Simple rules generate complex phenomena
2) Randomness at the level of the individual can result in nearly deterministic population-level behavior
3) Complex patterns can “self-organize” without any central leader
4) Different models emphasize different aspects of the world

The “El Farol” Problem

- A well-known problem in Game Theory
- 100 people in Santa Fe, NM like Irish Music
- Every Thursday night, an Irish band plays at El Farol (The Lantern)
- However, the bar is quite small: if more than 60 people are at the bar, then it is crowded and no one has fun
- The newspaper publishes the attendance each week
- On the basis of the past *n* weeks how do individuals decide whether or not to go to the bar?
- What happens if everyone uses the same strategy?

Brian Arthur’s Experiment

Brian Arthur (1994) postulated this problem and proposed a solution:

- Individual have a bag of strategies to predict attendance such as:
  - Last week’s attendance times two
  - Two weeks ago’s attendance minus last week’s
- Each agent determines which strategy would have worked the best had they used it the last five weeks
- They then use that strategy to predict what this week’s attendance will be and decide whether to go to the bar on that basis

The Question of the El Farol Bar Problem

- Most humans do not act rationally, they act in a boundedly rational way
- Most humans do not reason deductively from first principles, they reason inductively from past experience
- We want to investigate what happens if we assume agents participating in this “game” act this way

A Mesa Model

- Each agent has:
  - a memory of *t* weeks
  - a set of *n* strategies to predict attendance of the form:

$$x_{t+1} = a_t x_t + a_{t-1} x_{t-1} + \ldots + a_0$$

  - So their strategy is defined by the *a*'s
- The agent determines the total error between predicted and actual attendance of each of their strategies given their memory
- The agent uses the least erring strategy this timestep to predict the attendance: ≤60, they go; >60, they do not.

What is Success?

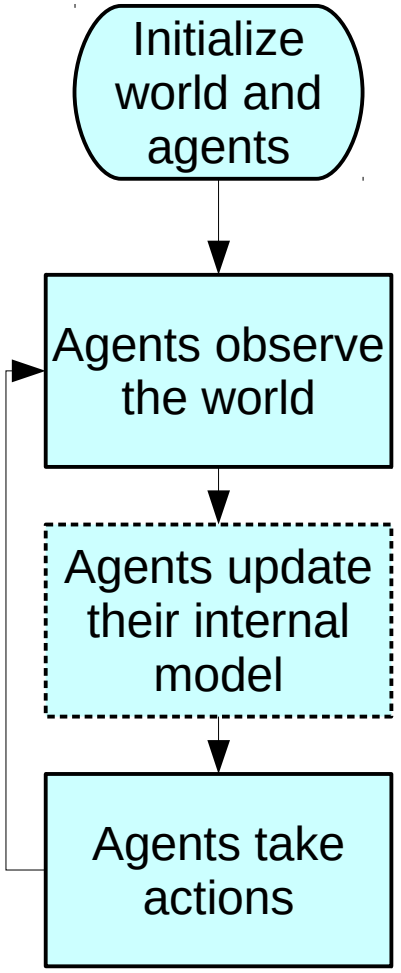
- The original model illustrates how many agents make it to the bar and whether or not the bar is crowded
- What if we want to know which agents are doing better at attending the bar than other agents?
- Add a reward:
  - Initialize reward at initialization
  - An agent gets rewarded for going to the bar when it is not crowded (reward++)

What to Observe/Report?

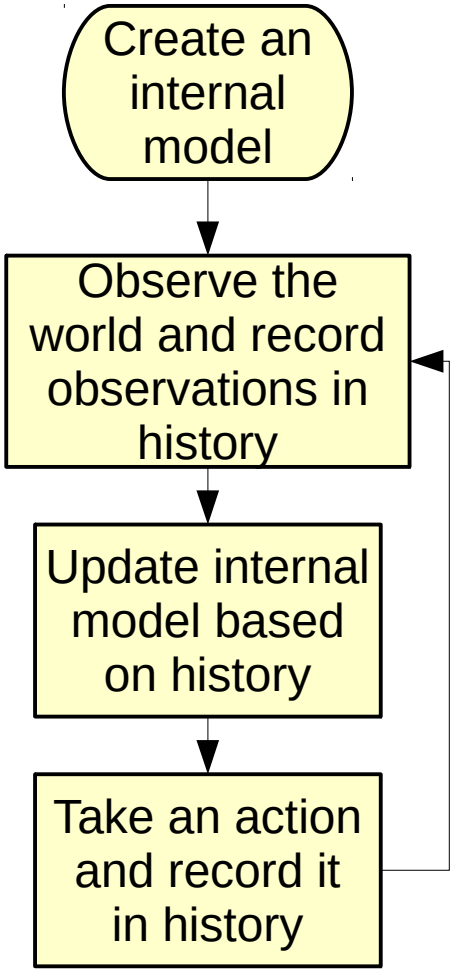
- Plot the attendance (as a function of time)
- Plot a histogram of attendance (distribution)
- Plot a distribution of reward

Machine Learning and ABM

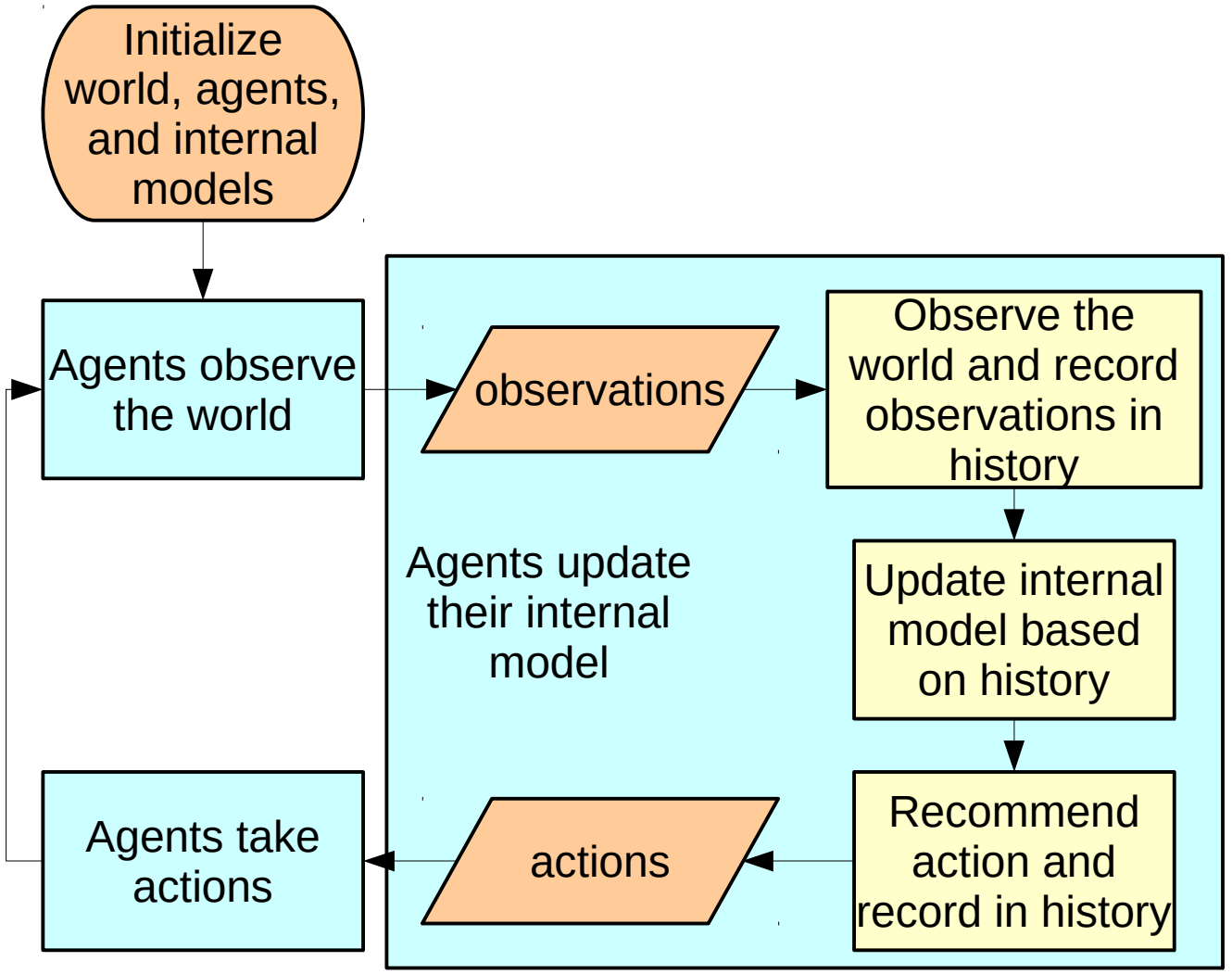
The ABM Processing Loop



The ML Processing Loop



Machine Learning and ABM



Revisiting the El Farol Bar Problem

- Arthur claimed that if a GA was used instead of a bag of strategies the result would be the same
- Fogel et al. (1999) took up Arthur's challenge and used a GA
  - They showed that the average attendance was 57
  - They allowed each individual to run a GA for 25 generations with 100 different strategies
- Random attendance is 50
- Arthur's attendance is 60
- Fogel et al. achieved an attendance of 57
- Perfectly rational agents – 50?

The Next Step

- Use an optimization method to optimize the strategy
- Try different methods and parameters:
  - Simple linear regression
  - Quadratic programming / Quasi-Newton
  - Simulated annealing
  - Genetic algorithms
  - Any other of your choice...
- Run the Model for 500 ticks
- Average over 30 runs
- Measure Mean Attendance per Week for last 100 weeks