

# Maintaining Predictions Over Time Without a (Generative) Model

Erik Talvitie, Satinder Singh  
University of Michigan

# Local/Partial Models

- Focused on making a few predictions
- May only apply in certain situations
  - Neville: “Pre- and post-conditions”
  - Russ: “Funnels”
  - Todd: “Leaves”
- Predictions may be abstract, long-range
  - May not make one-step predictions
  - Rich: “Projection”
- Stochastic, partially observable systems

# What good is a partial model?

- Combine many together to obtain a more complete model
- Use predictions directly for control
- Partial model-based planning

# Predictive Features

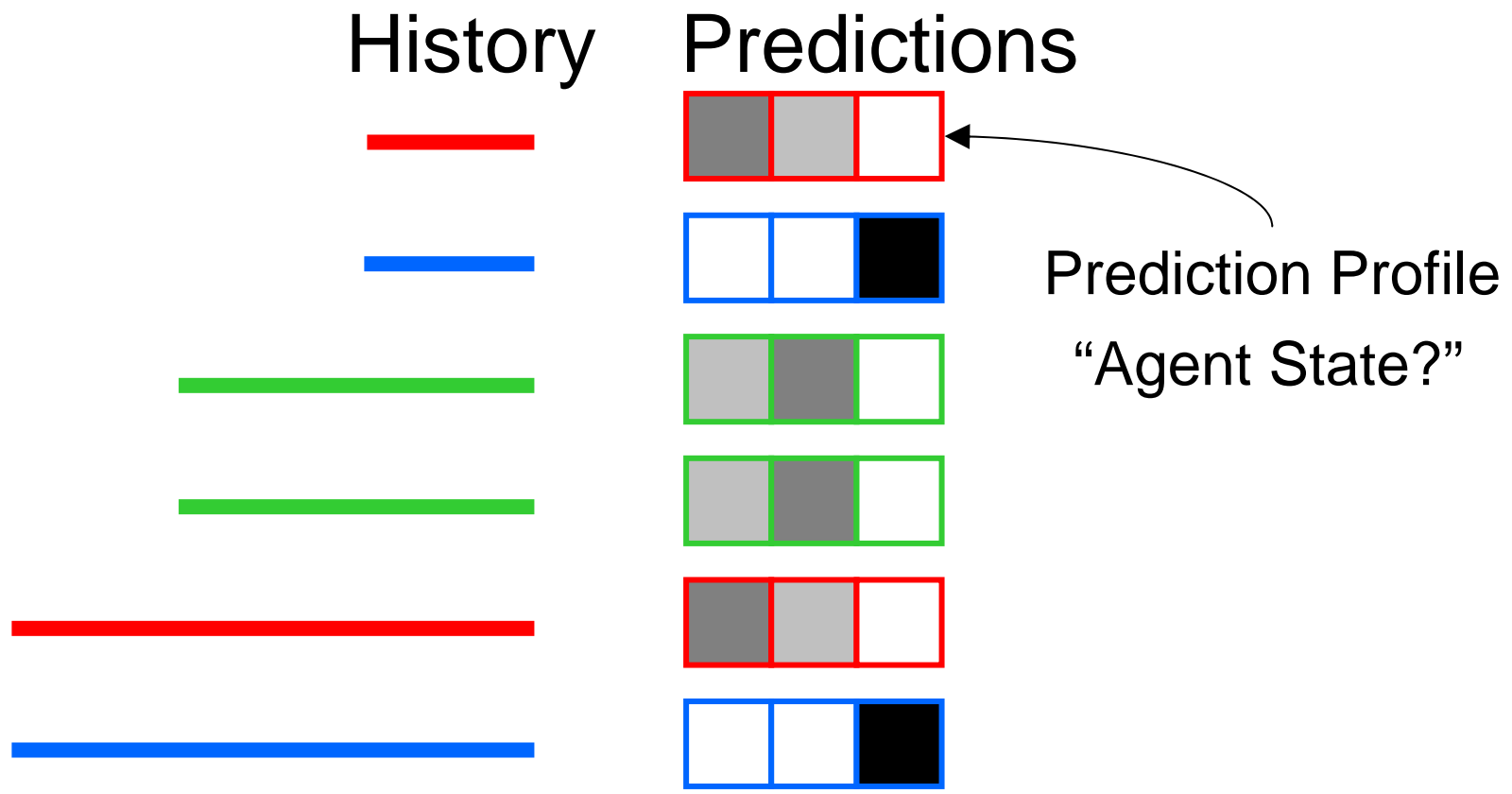
- Maybe a good policy can be expressed in terms of a small number of predictions
- Predictive features may be easier to select than historical features
  - Predictions have direct consequences for control
- Predictive features seem harder to maintain than historical features
  - Learn a model?

# Question

Can we learn to accurately maintain a set of predictions of interest over time more simply than learning a generative model?

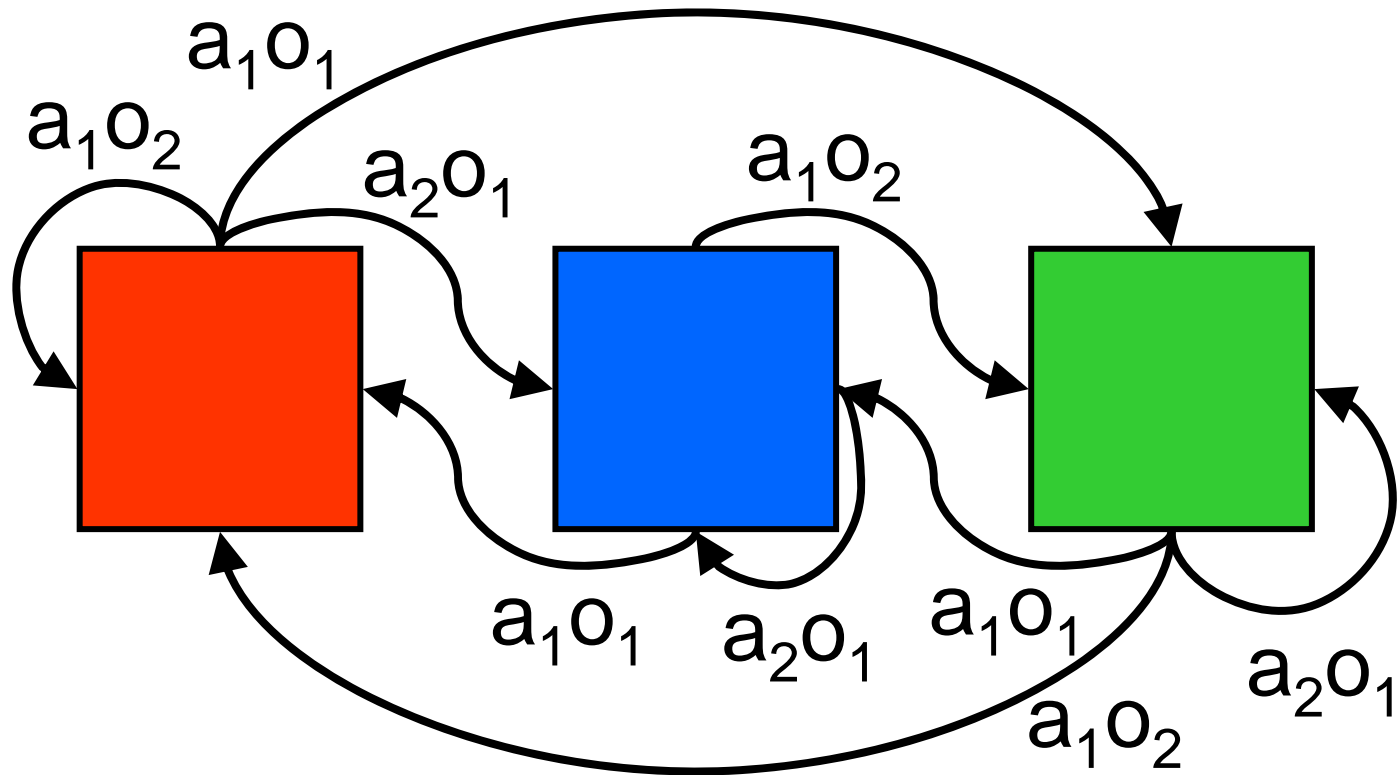
(Predictions at time  $t$  may not be sufficient to compute predictions at time  $t+1$ )

# Prediction Profiles



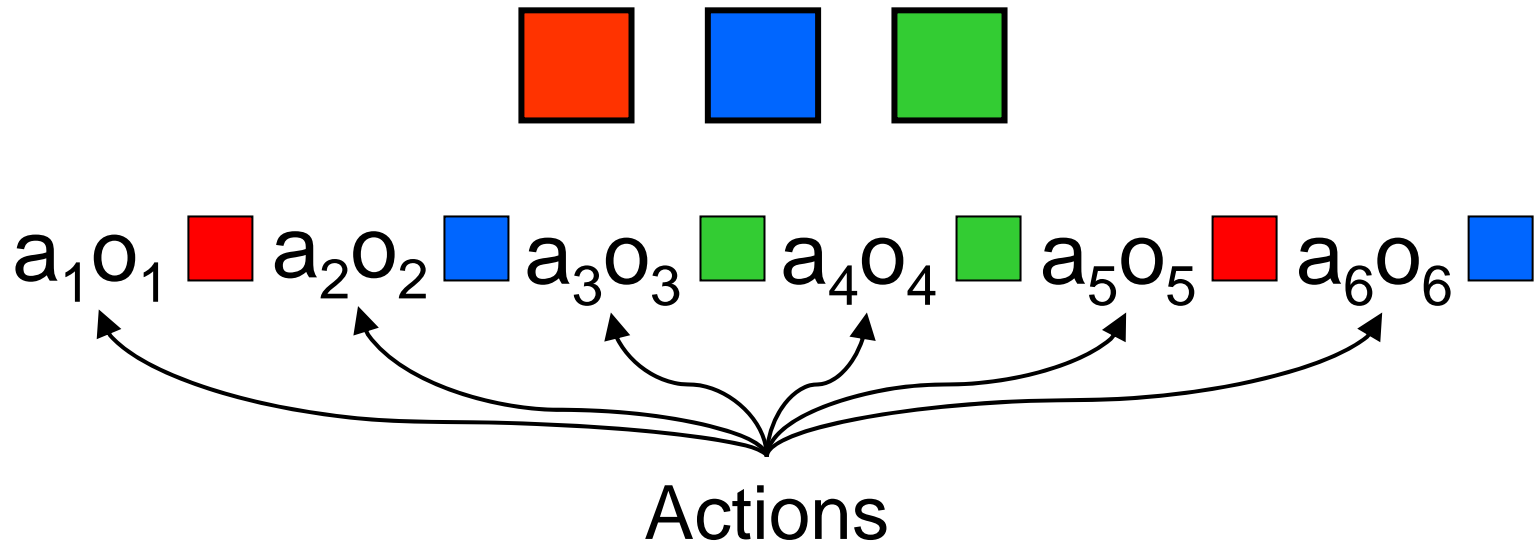
Learn to assign prediction profile to history

# Prediction Profile System



- Dynamics of the predictions over time, conditioned on the evolution of the system
- Deterministic, partially observable
- Monica: “History Machine”??

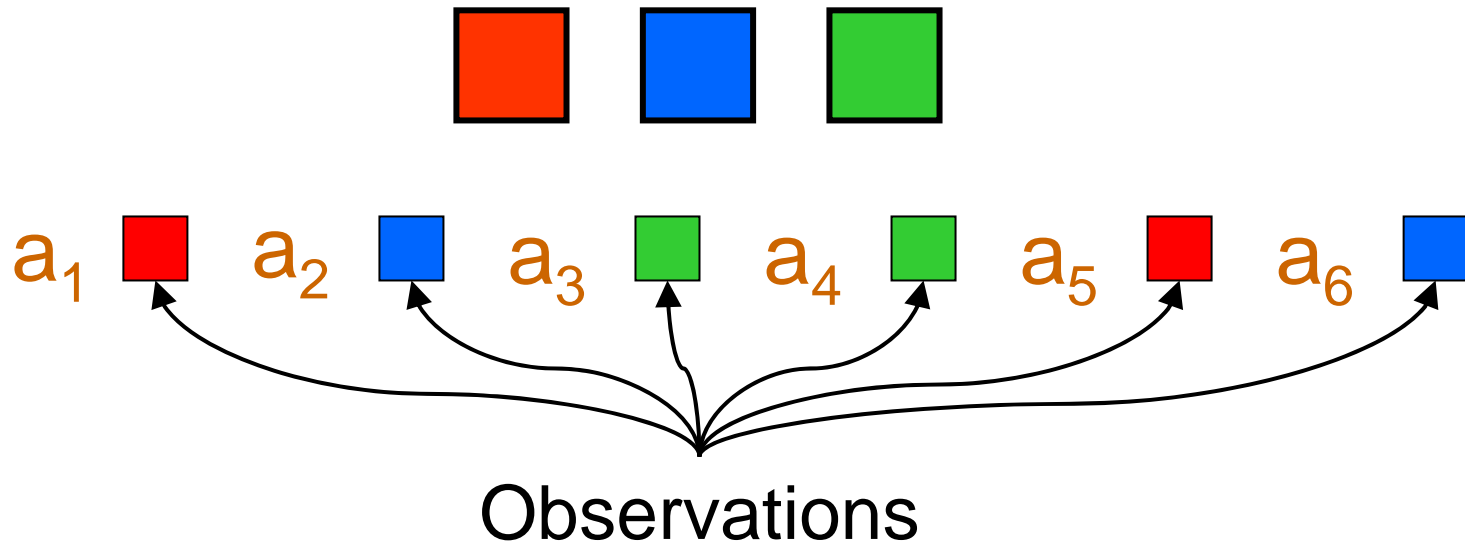
# Learning a Prediction Profile Model



- Estimate prediction profiles
  - Use statistical tests to find distinct profiles
- Translate data
  - Use statistical tests to assign profiles along sequences in data

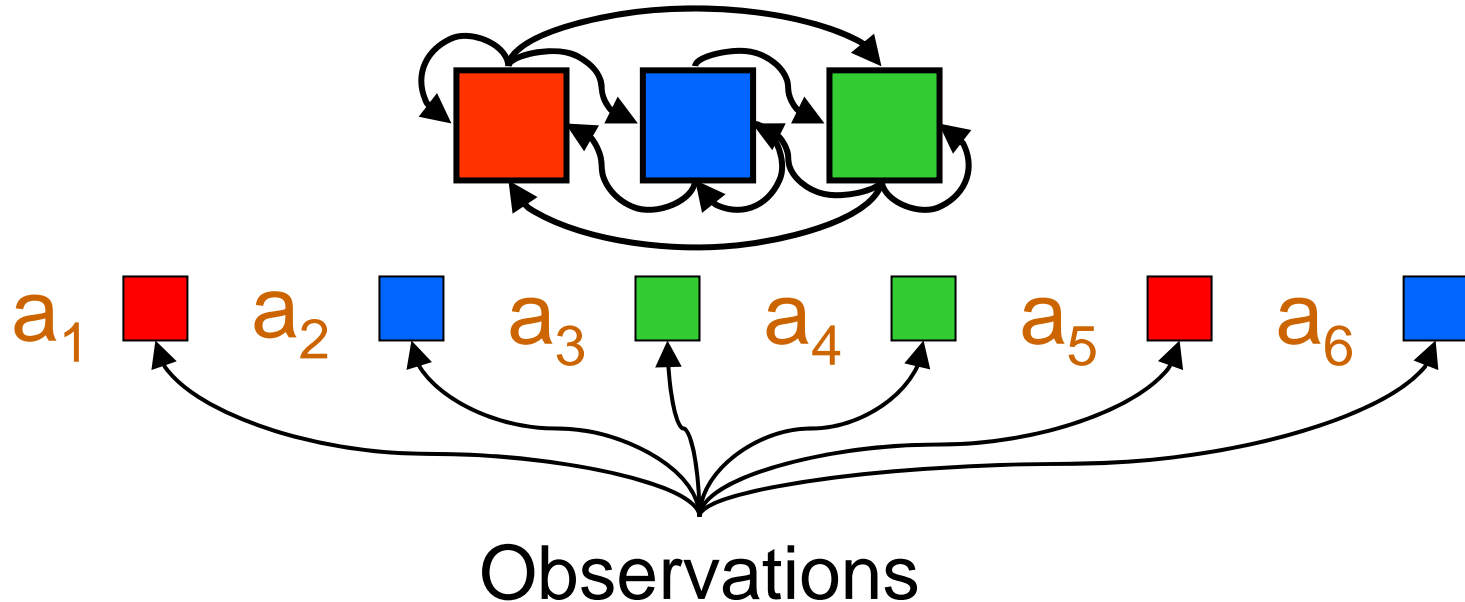


# Learning a Prediction Profile Model



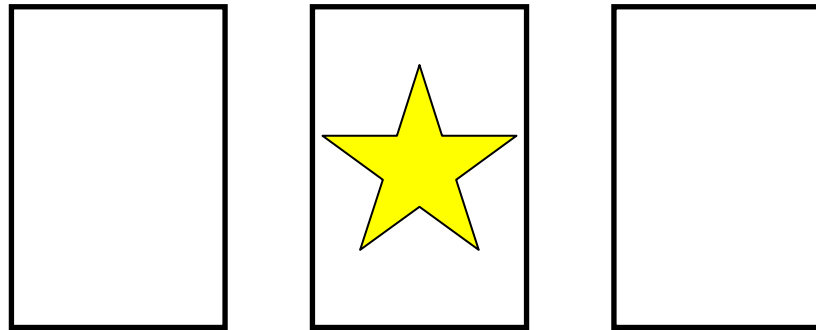
- Estimate prediction profiles
  - Use statistical tests to find distinct profiles
- Translate data
  - Use statistical tests to assign profiles along sequences in data

# Learning a Prediction Profile Model

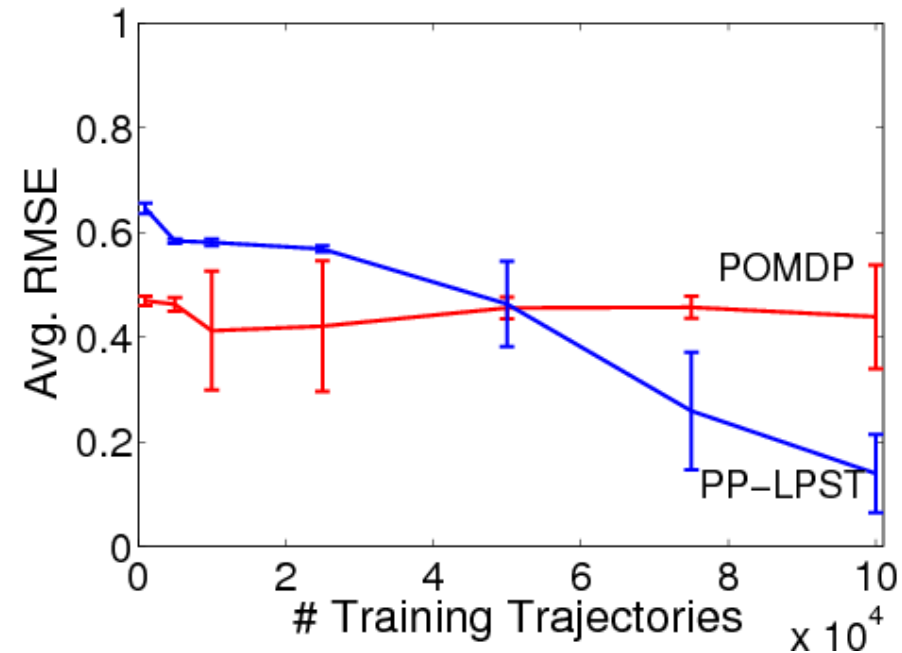


- Estimate prediction profiles
  - Use statistical tests to find distinct profiles
- Translate data
  - Use statistical tests to assign profiles along sequences in data
- Learn a model
  - Train any modeling method on translated data
    - Looping Predictive Suffix Trees (LPST)

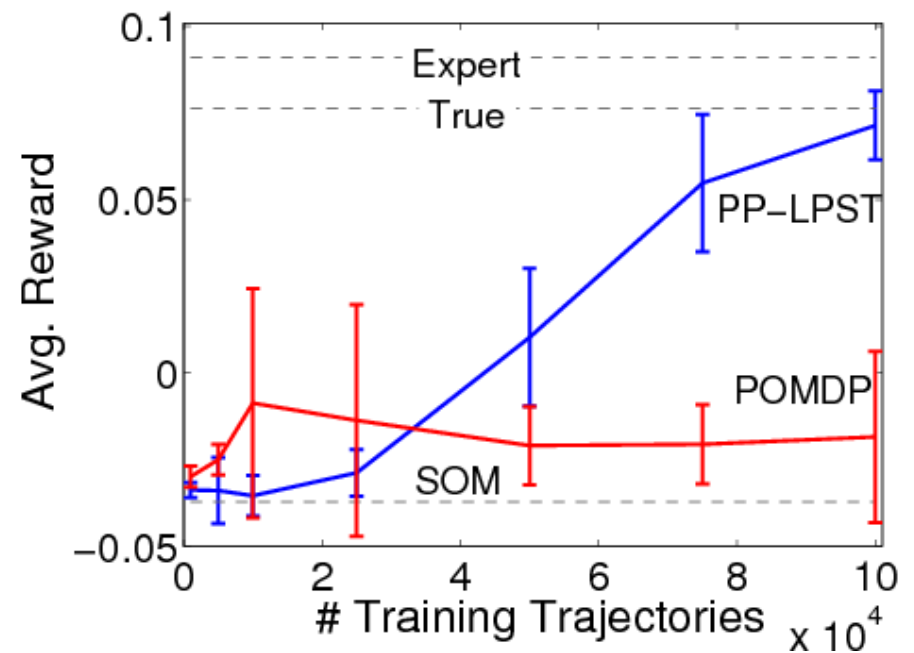
# Three Card Monte



Prediction Performance



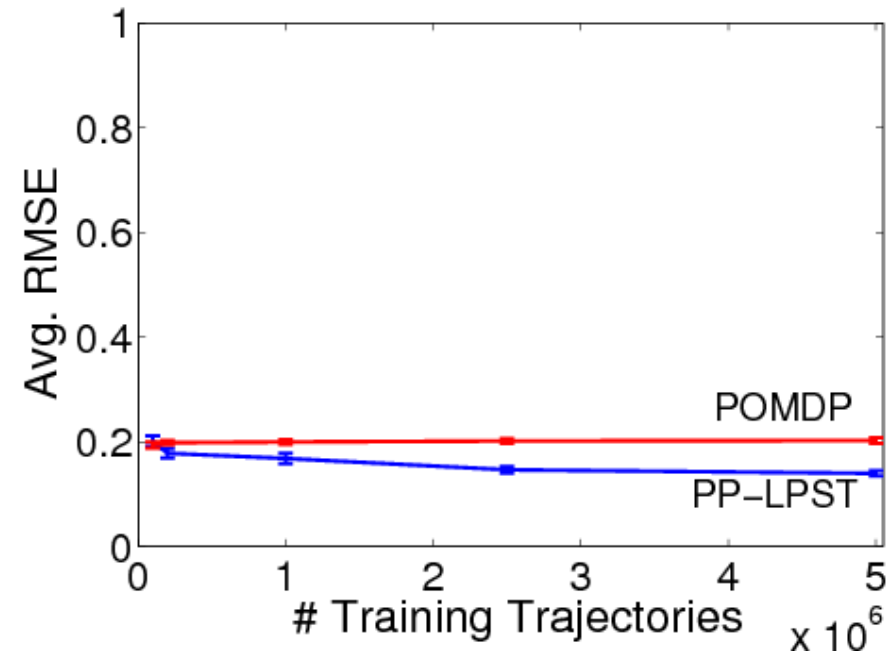
Control Performance



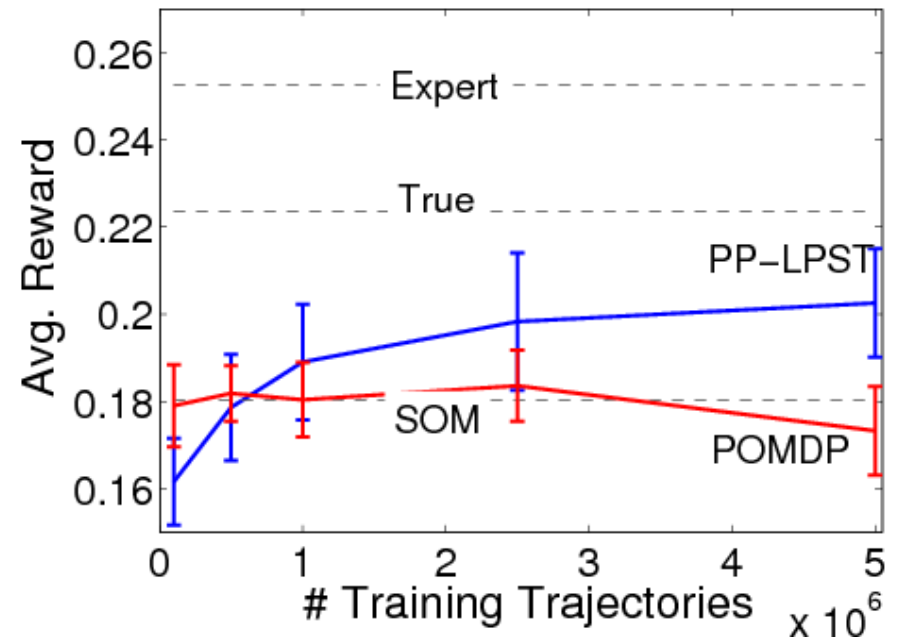
# Shooting Gallery I



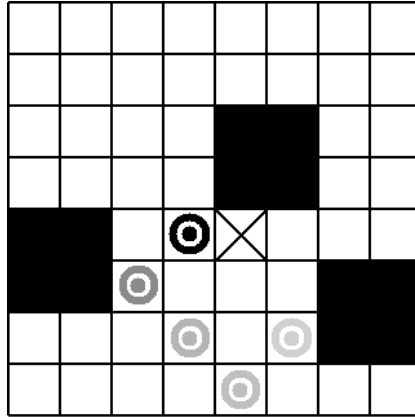
Prediction Performance



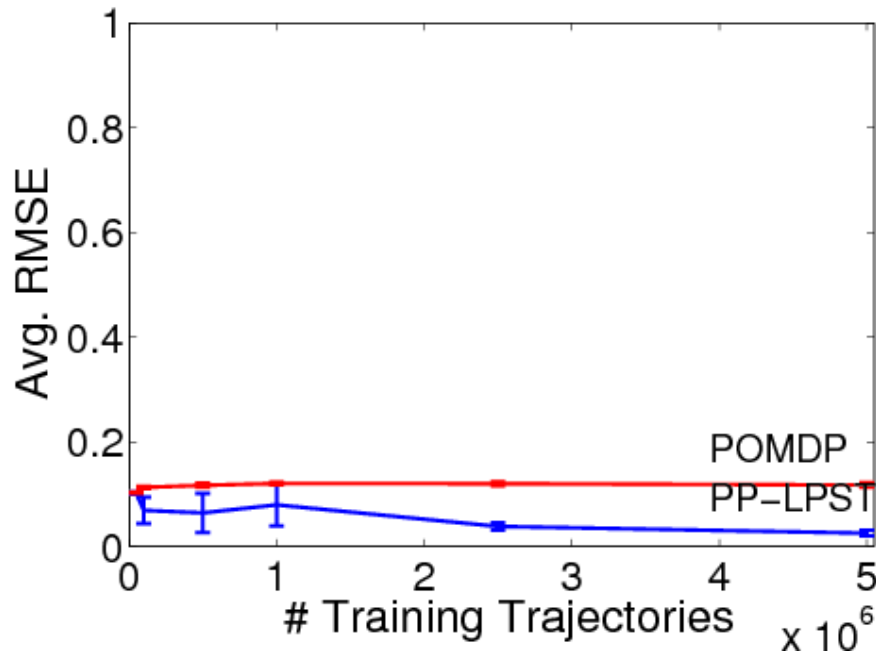
Control Performance



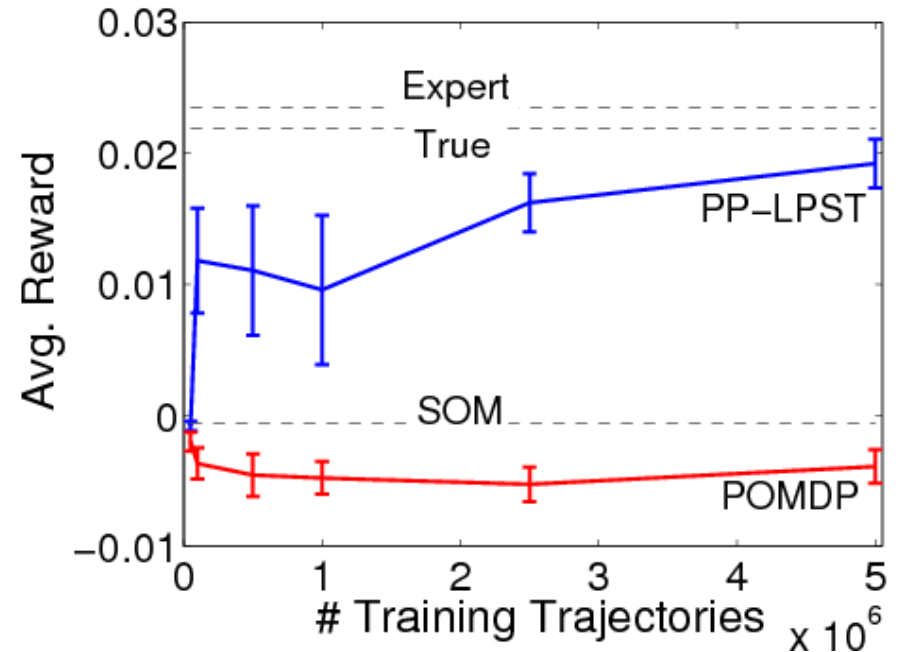
# Shooting Gallery II



Prediction Performance



Control Performance



# General Lessons

- Sometimes beneficial to condition on some things without predicting them
  - “Conditional”, “Discriminative”, “Direct” model
  - Separate easy predictions from hard predictions
- Predictions can make pretty good features for model free control
- Can model dynamics of predictions over time, rather than system itself
  - TD-nets, “Agent state” do this in a Markov way
  - We learn what is necessary to keep predictions updated accurately

# Future Directions

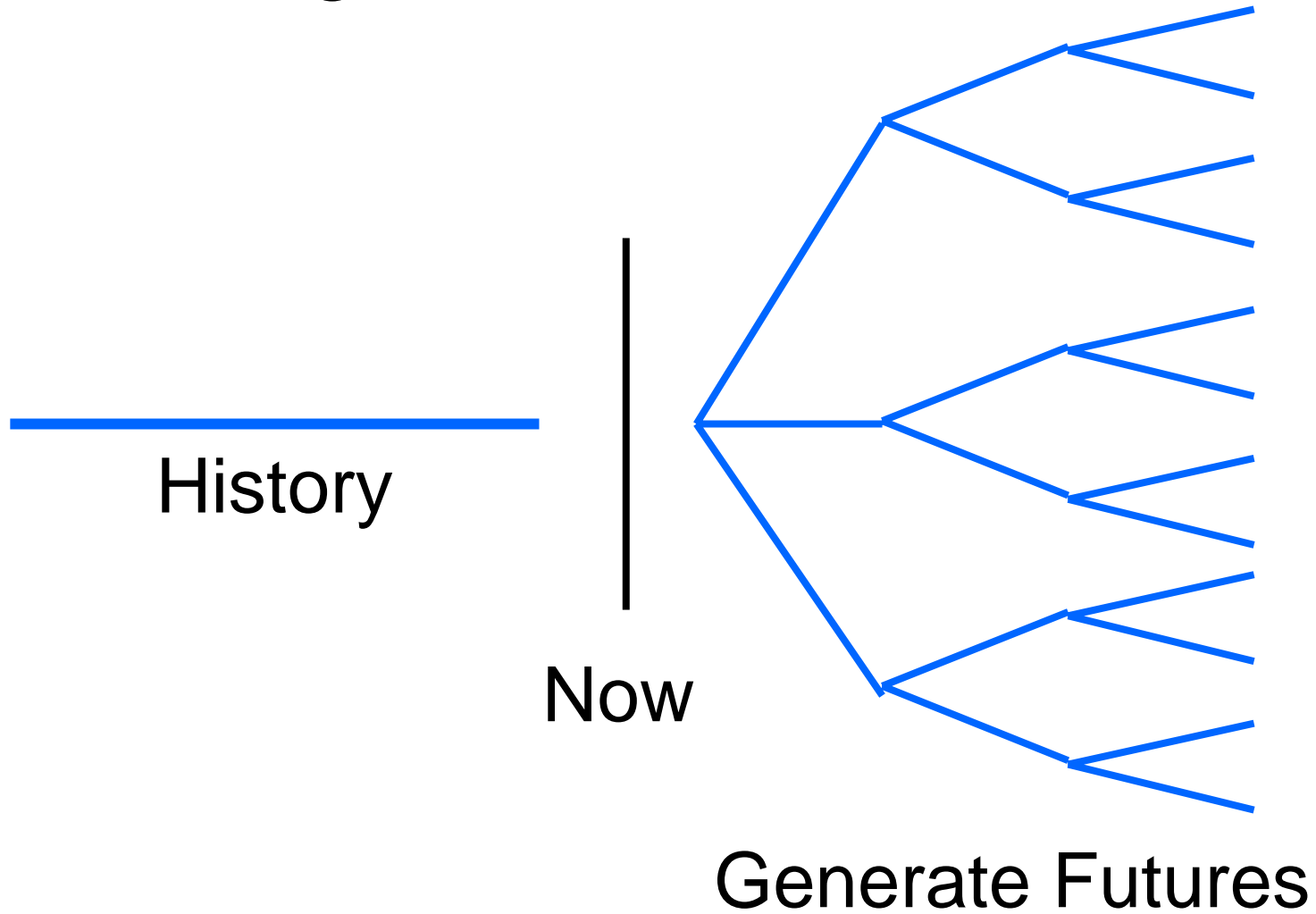
- Contingency Models
  - Here we didn't predict *any* dynamics
  - One way to back off from this extreme:
    - Contingency **C**: feature of **ao**
    - Abstract observation **O**: feature of **o**
    - $p(\mathbf{CO} \mid \mathbf{h}) = \Pr(\mathbf{O} \mid \mathbf{h}, \mathbf{C})$
    - Example: “If I drive to the airport and there is a traffic jam, it will take me 45 minutes.”
    - Example: “If I raise and my opponent calls, he is likely to show a straight.”

# Future Directions

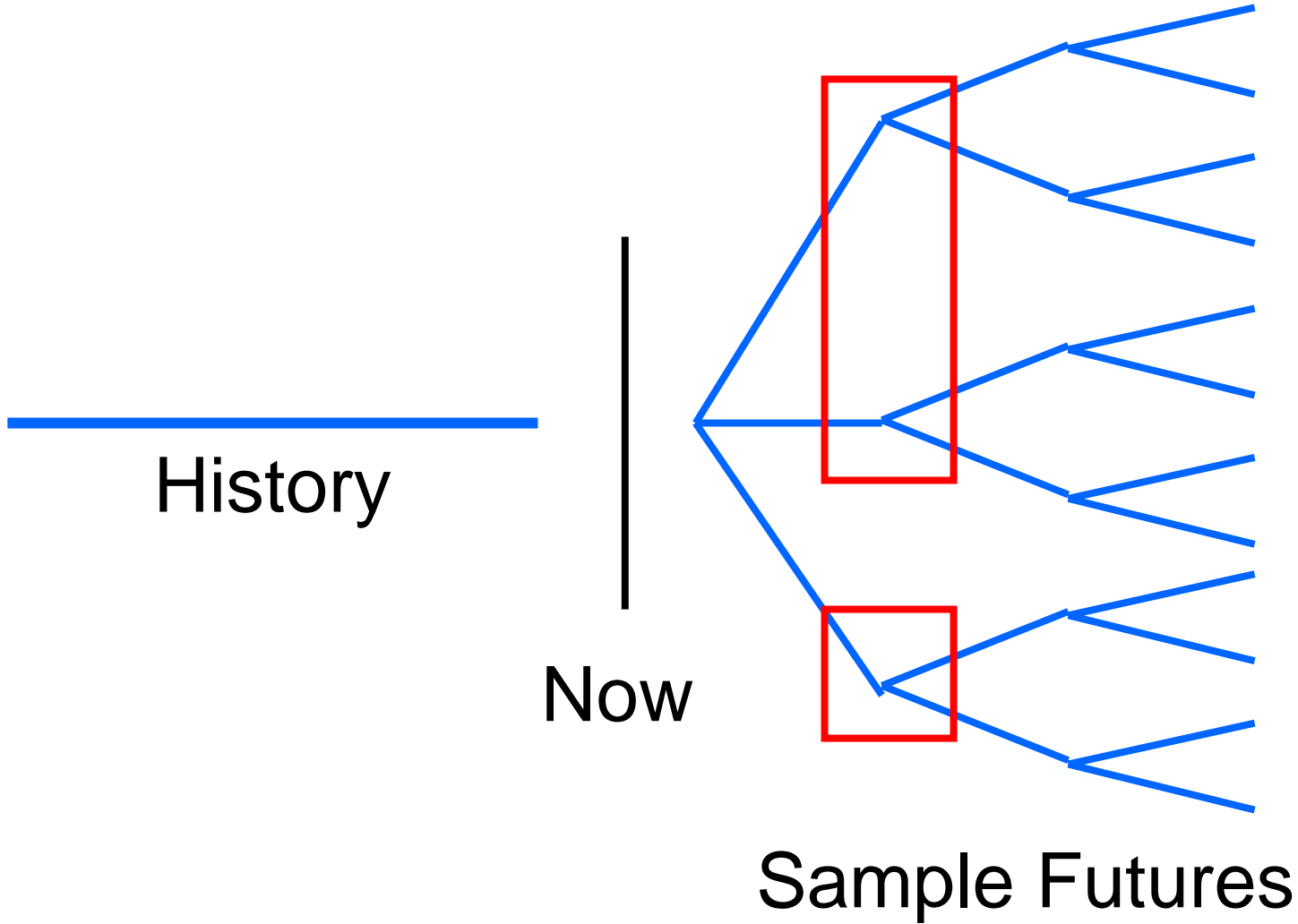
- How do we plan with partial models?
  - Here we used predictions as features for model-free control
  - Can we use partial models for model-based planning?



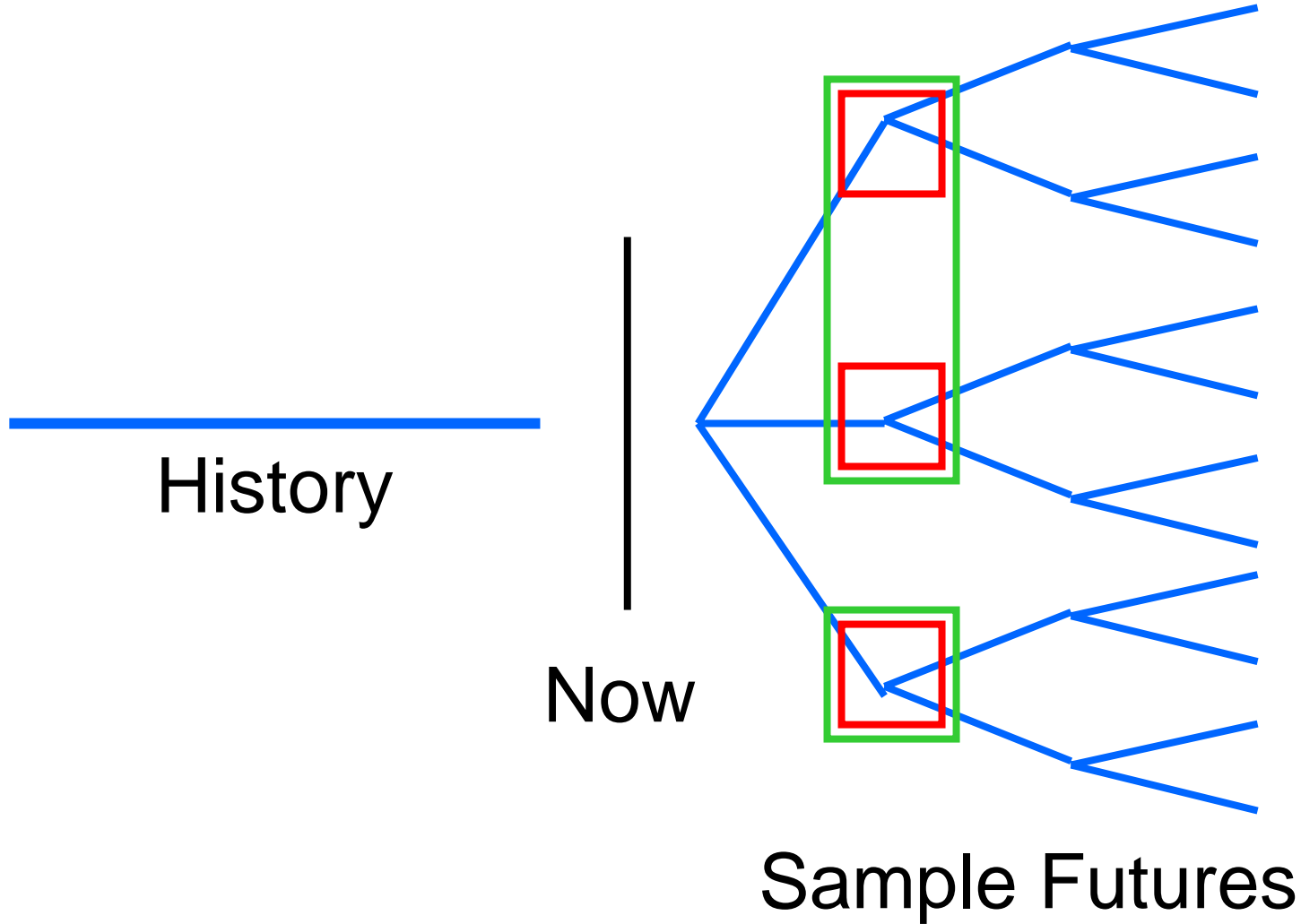
# Planning With Generative Models



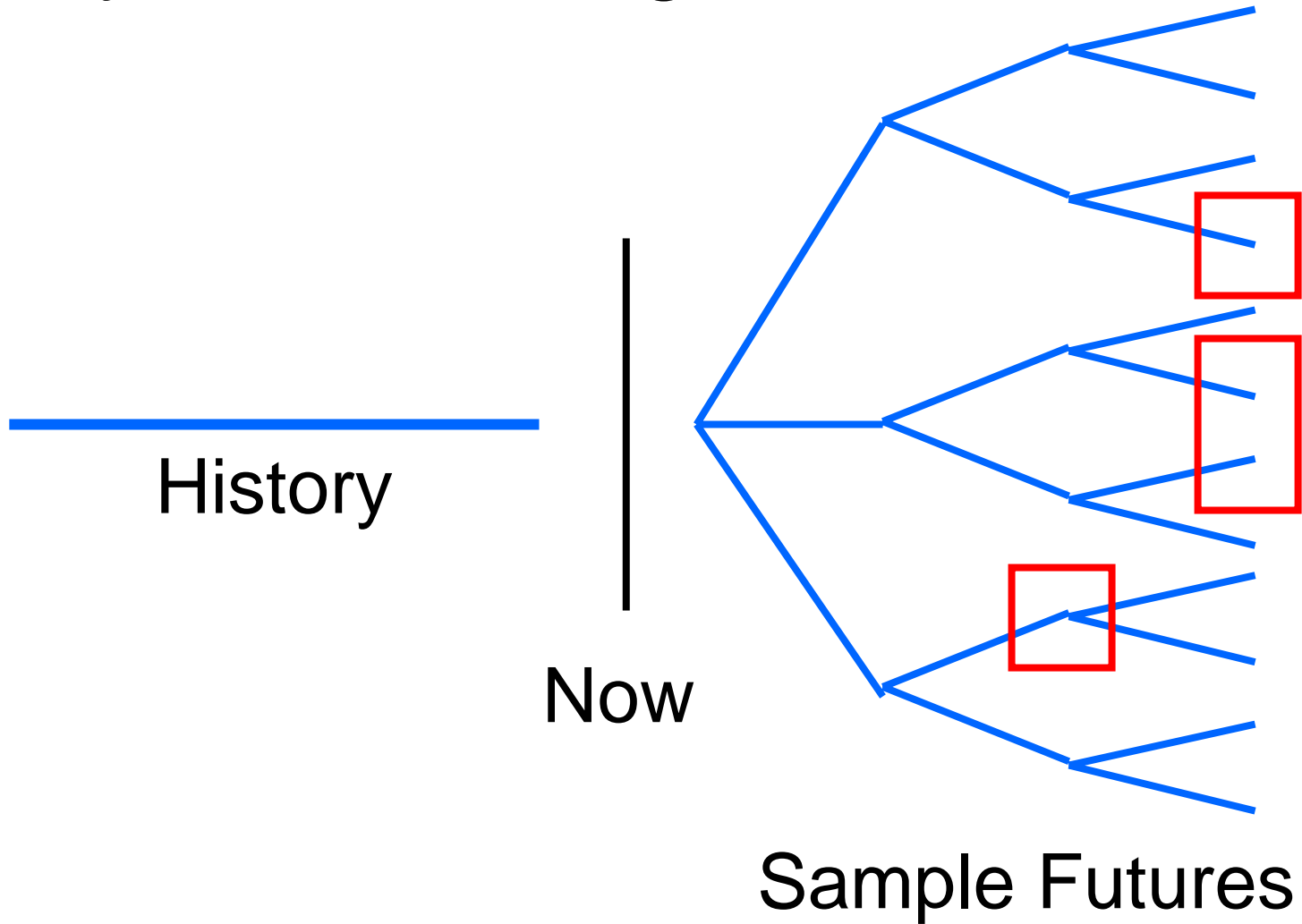
# Only Makes Abstract Predictions



# Only Makes Conditional Predictions



# Only Makes Long-Term Predictions



# How to Roll Forward?

- Approximate the one-step predictions
- Minimax/Regret Minimization
  - Treat unmodeled aspects as choices of some adversary
  - Robustness in the face of uncertainty
- Some mixture of the two
  - Michael B: “Untrustworthy models”
- Bayesian?

**Thanks!**