Discussion: Will Artificial Intelligence Replace Computational Economists Any Time Soon? by Maliar, Maliar, Winant

Raphael Schoenle
Brandeis University and Federal Reserve Bank of Cleveland

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Motivation

- Great paper:
  - Important research question:
    - Can a generic AI algorithm replace the need for computational economists to write model-specific code?
    - Answer: No!

      It's complicated ... My lesson learned: Efficient use will need experts to choose best implementation even if a lot is standardized.

      We can probably massively augment our computational capacity.
  - Particular contributions:
    - Elegant, clearly written "cookbook" of machine learning applied to economics
    - Presentation of a generic, non-supervised deep-learning algorithm with one static objective function

Summary 1/2

- What's in the cookbook?
  - Elegant formulation of commonly faced dynamic stochastic optimization problem as a single optimization problem, with two possible objective functions:
    - life-time reward function
    - total sum of squared residuals from model equations, e.g. Euler (relevant if there is more than a single agent)
  - Solution technique: deep learning which arises naturally from decision rules nested over time
    - employs stochastic gradient method
    - approximates policy function
    - assume full knowledge of the model
    - does not need wide data availability due to simulations
  - Specific recipe: Application to consumption-savings problem

Summary 2/2

- Advantages/disadvantages of the approach discussed:
  - The math is simple!
  - Linear, not quadratic growth of the number of parameters with dimensionality
  - Approximates kinked functions naturally
  - Represents complicated structures due to deep-learning
  - Technology-intensive: ideally, use Google Cloud TPU, Tensorflow or Pytorch software – a high fixed cost, but a technological improvement (graph representation)

Discussion Overview

Next:

- A layperson's questions
- 2 comments

Comment 1: Comparison to the literature, in particular reinforcement-learning

- How does your paper compare to Duarte (2018), both formally and in terms of content?
- In terms of content:
  - Your approach assumes that the model is known while reinforcement learning does not and is model-free
  - Online learning in reinforcement learning leads to some tradeoffs
  - Your formulation proposes offline learning in a single optimization problem setting
  - Can you flesh out 2 cases where either approach does clearly better? The reader would like some guidance what to look for when making algorithmic choices.

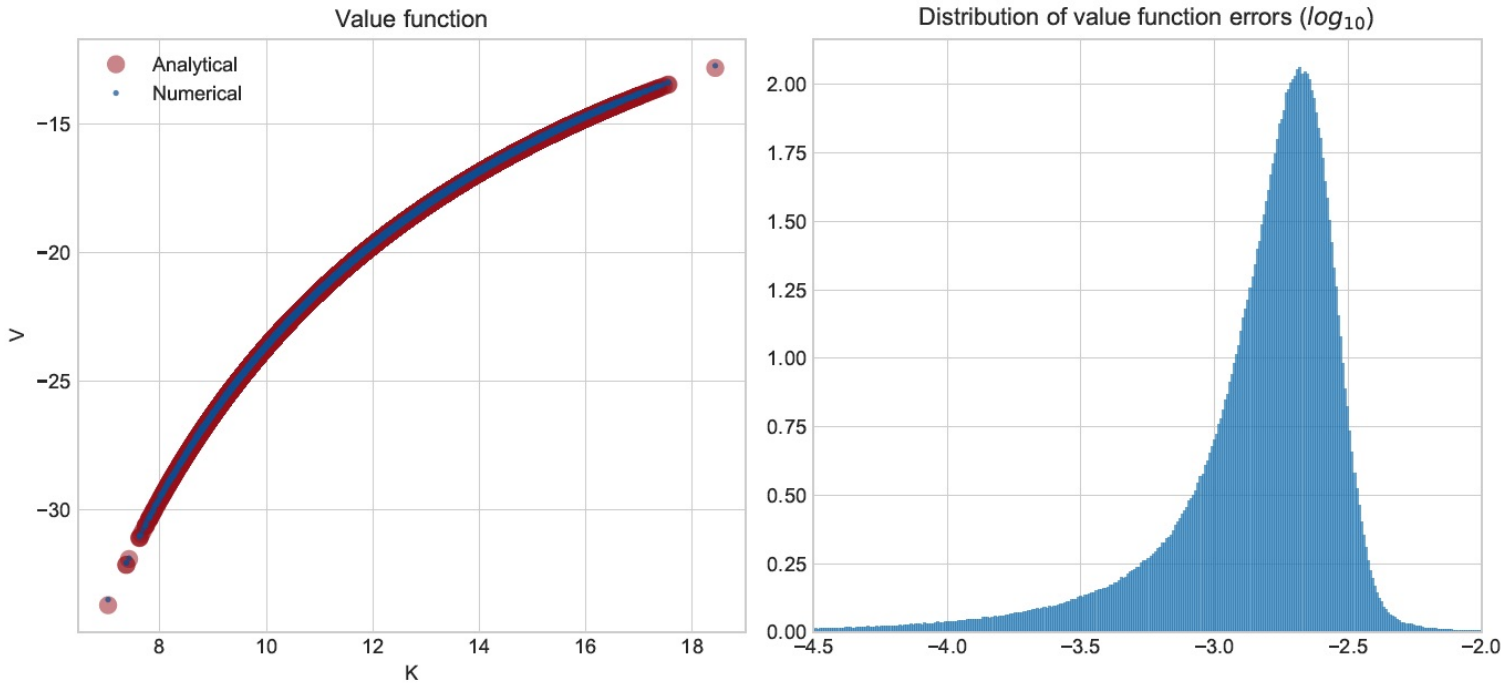
Comment 1: Comparison to the literature, in particular reinforcement-learning

- How does your paper compare to Duarte (2018), both formally and in terms of content?
- Formally:
  - Duarte explicitly compares reinforcement learning approximate solutions to exact numerical benchmarks
  - Overall conclusion: can handle up to 10 dimensions well
  - High-dimension application still missing in draft... Can you be more specific about its features?

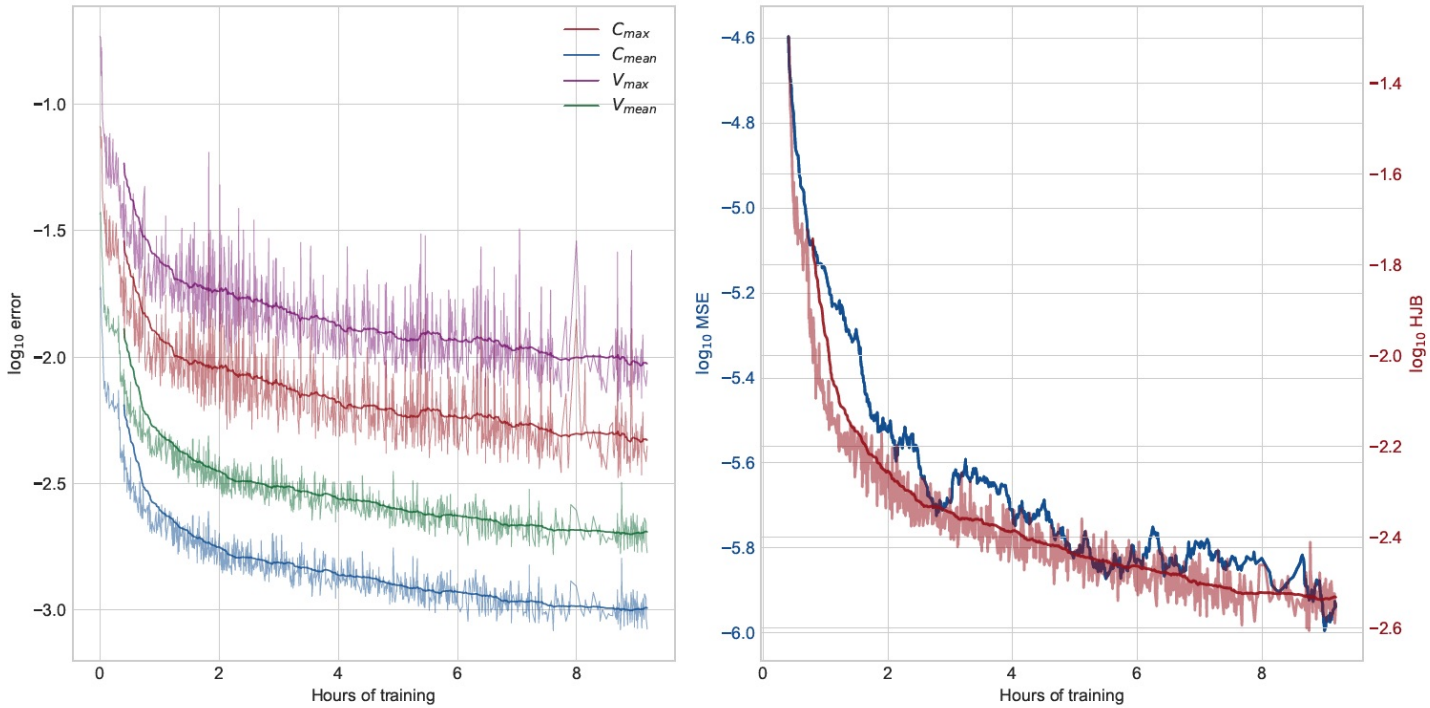
Comment 2: Careful comparisons of approaches?

- The reader would like some tables with more evaluations of your algorithm, and comparisons to other algorithms
  - Explicitly compare exact and approximate solutions where possible
  - Large-scale capacities? (e.g. multiproduct pricing problem as in Alvarez)
  - Performance in terms of time, and costs (e.g. Google Cloud)?
  - Can you present more of a cookbook, perhaps with some stylized "recipes"? When does a particular algorithm do well? What are some clearcut criteria - is it ultimately research $? (time yourselves) What about carbon emissions?
  - Given complexity of attention allocation, some clear discussion of pros and cons of algorithms in the context of specific examples might be more useful

Comment 2: Careful comparisons of approaches?



Comment 2: Careful comparisons of approaches?



Conclusion

- Very nice paper - great exposition of generic AI algorithm.
- Can become a useful guide as an AI cookbook.