The Efficacy of Technical Indicators

Stephen Crawford and Tuguldur Davaadorj

Financial Machine Learning

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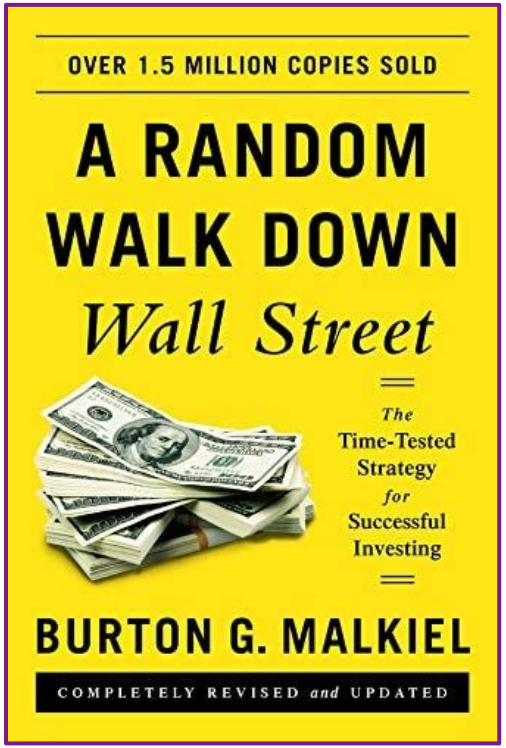
Research into the most effective technical indicators for Deep Q Networks to build stock trading policies with.

Introduction



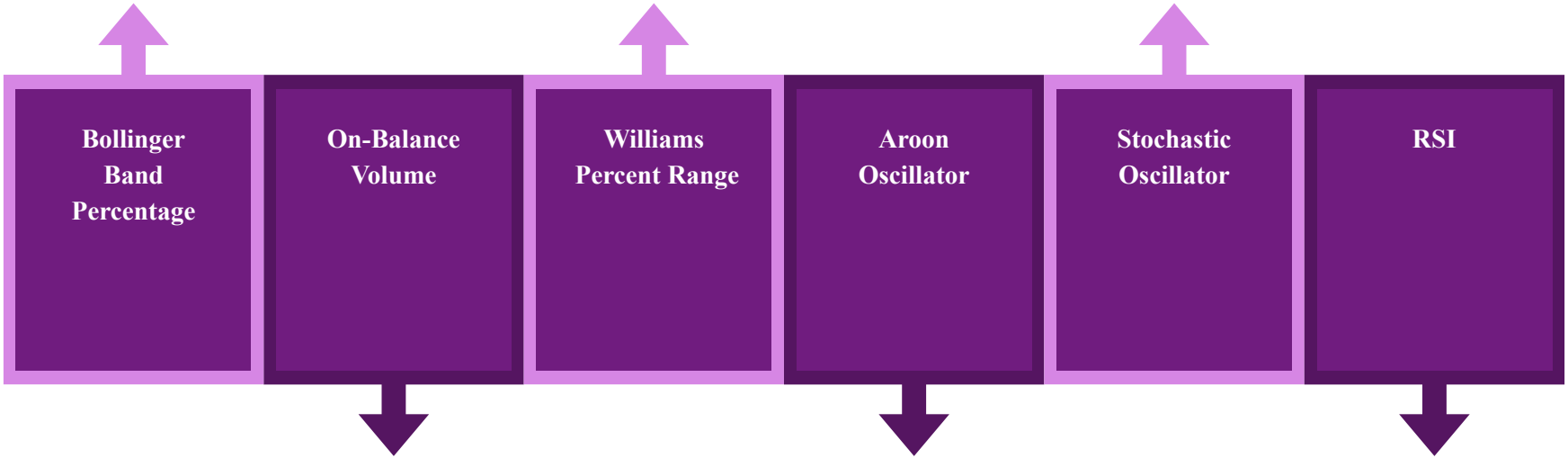
Efficient Market Hypothesis:

- Burton Malkeil (*A Random Walk Down Wall Street*, 1973)
- Three forms: Strong, Semi-Strong, Weak
- Know Strong and Semi-Strong are all but disproven but what about Weak?

Image source: Amazon.com

What technical indicators are best?

Finding the best indicator



Experimental Model

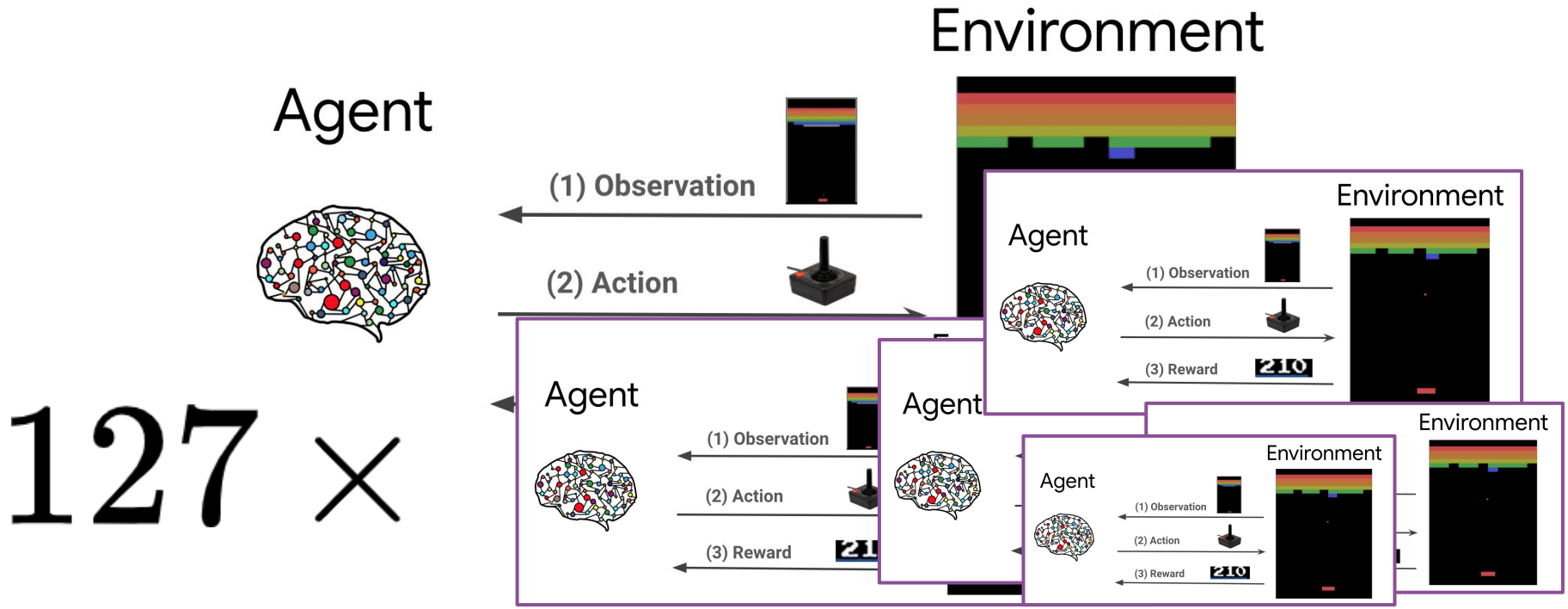


Image source: tensorflow.org

Details

- Modified aspects of ER and DDQN
  - Do not select mini-batches
  - Not completely decoupled

- Loss: Huber Loss function
- Memory Size: 100,000 experiences
- Update target every 1,000

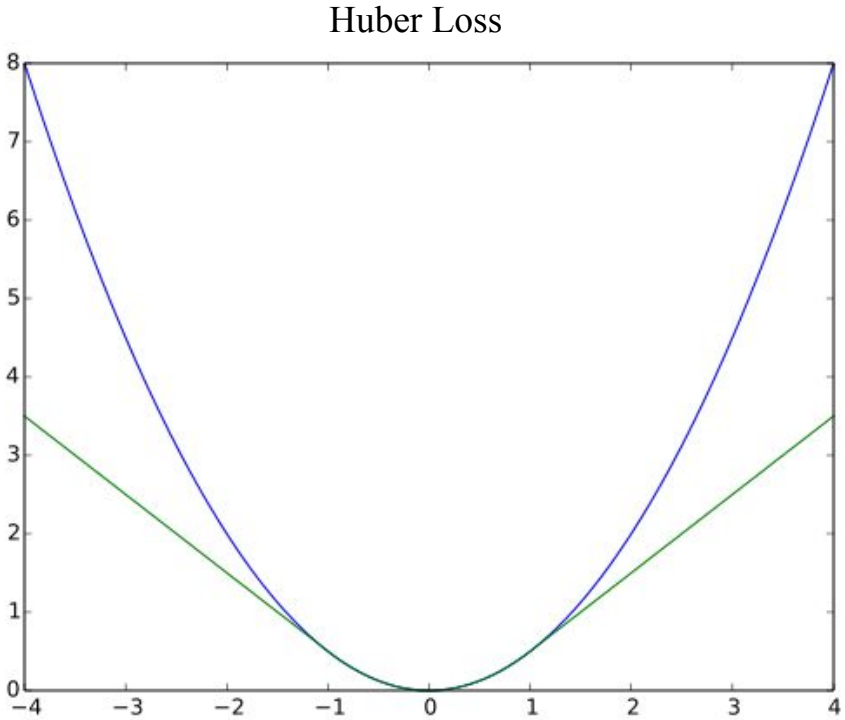


Image source: wikipedia.org

Operation

Total CPU Time = 127 combinations * 500 trips * ~20 seconds/trip = 14.7 days…

Solutions:

1. Cut trips to 200
2. Convert into parallel programs
3. Run on Bowdoin HPC
4. Exclude with 1 & 2 indicator combinations

New CPU Time = 99 combinations * 200 trips * ~20 seconds/trip * four learners at a time = 1.15 days

Experimentation

Training

Per indicator combo:

- Train DQN on DIS
- 200 Trips
- 2018-01-01 to 2019-12-31

Testing

Per trained learner:

- Test DQN on DIS
- In-sample: 2018-01-01 to 2019-12-31
- Out-of-sample: 2020-01-01 to 2021-12-31

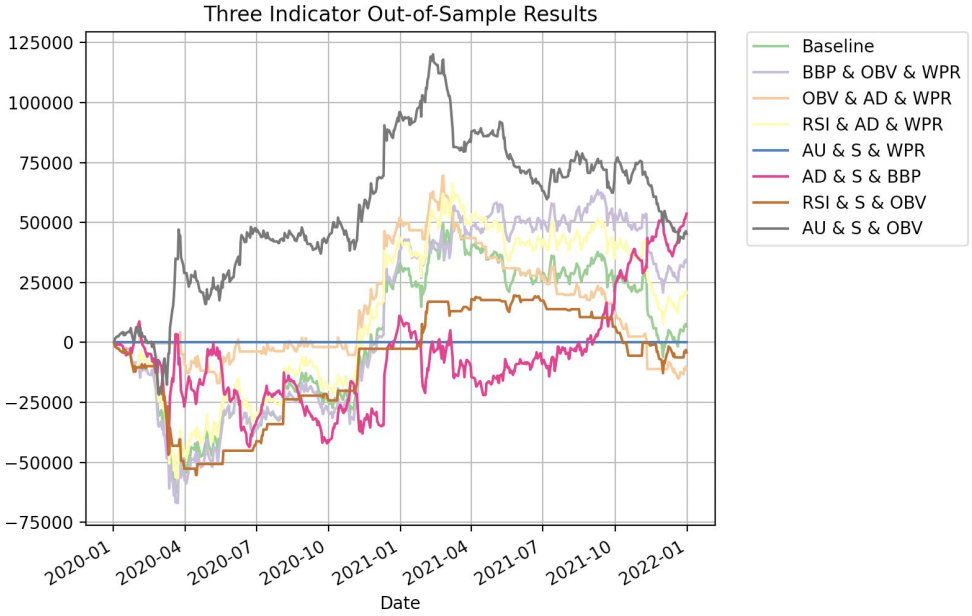
Comparison

Compare trained learners:

- Trends
- Best & Worst
- Plot vs. Baseline

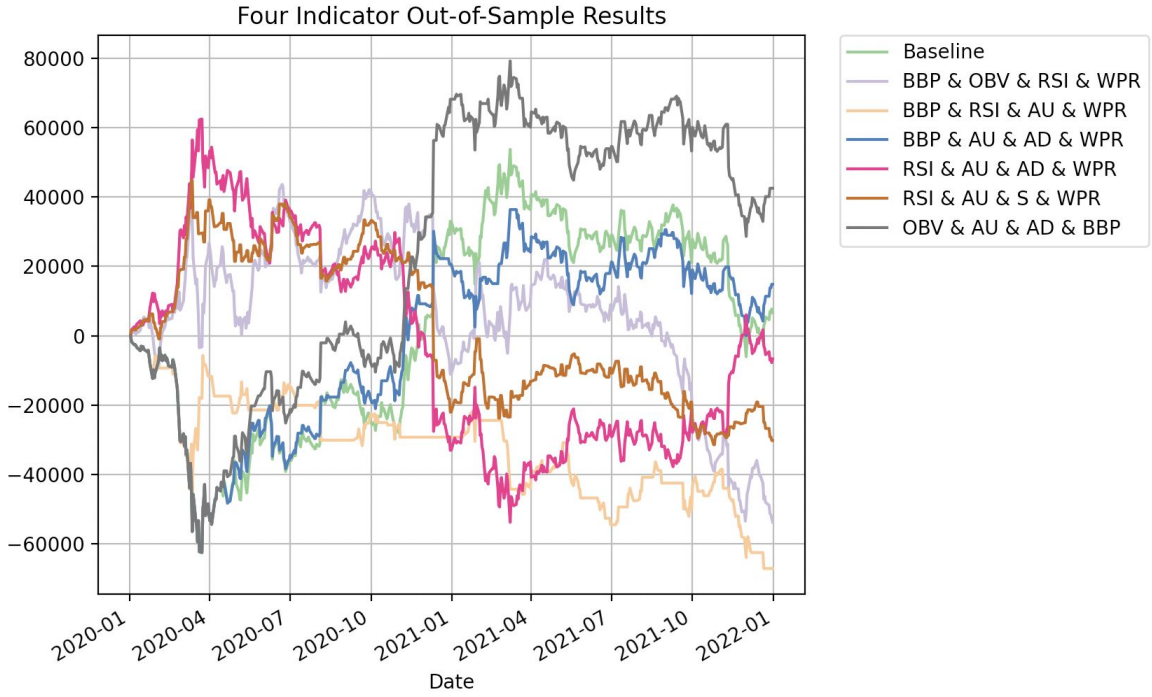
Indicator Analysis for 3 indicators

- 7/35 combinations do not "converge" to the baseline
- (AD, S, BBP), (AU, S, OBV), (BBP, OBV, WPR), (RSI, AD, WPR) outperform baseline
- (AD, S, BBP) makes $53,650
- WPR, OBV, AD, S perform the best



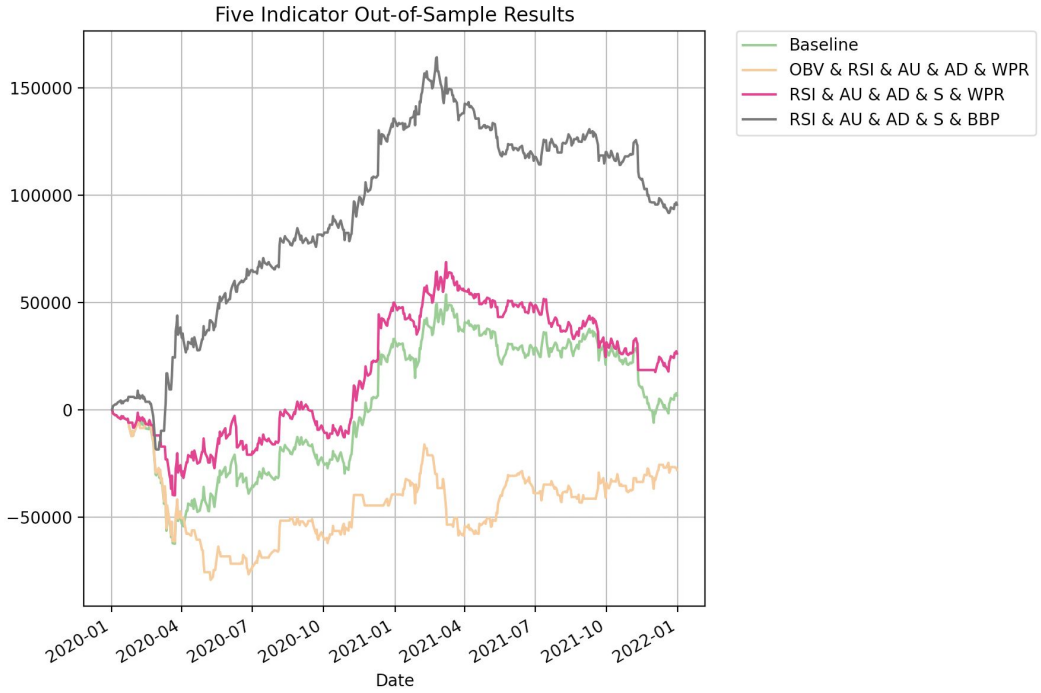
Indicator Analysis for 4 indicators

- 6/35 combinations do not "converge" to the baseline
- (OBV, AU, AD, BBP), (BBP, AU, AD, BBP) outperform baseline
- (OBV, AU, AD, BBP) makes $42,500
- AU, AD, BBP perform the best



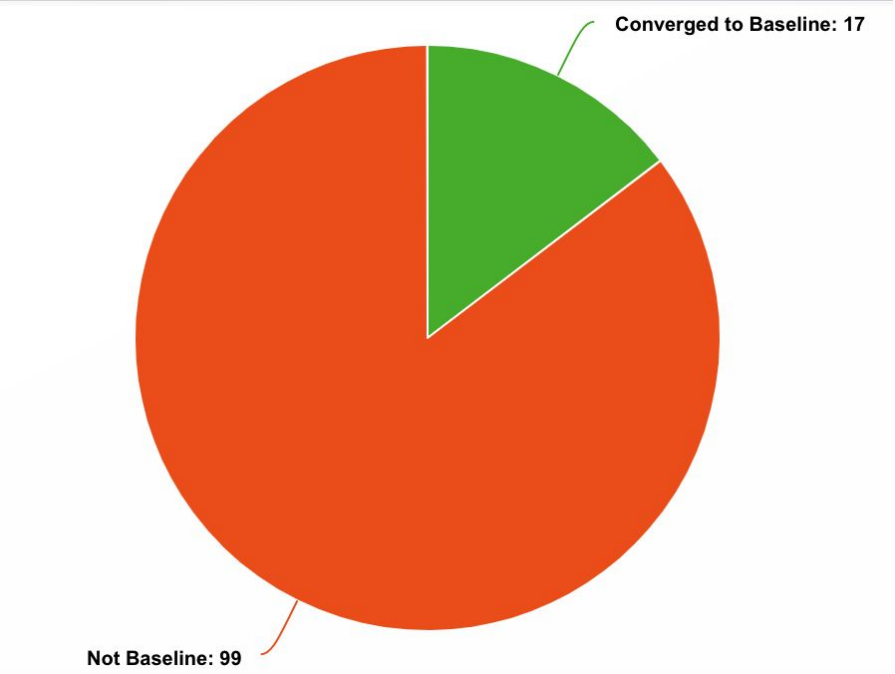
Indicator Analysis for 5 indicators

- 3/21 combinations do not “converge” to the baseline
- (RSI, AU, AD, S, BBP), (RSI, AU, AD, S, WPR) outperform baseline
- (RSI, AU, AD, S, BBP) makes $95,550
- AU, AD, RSI perform the best

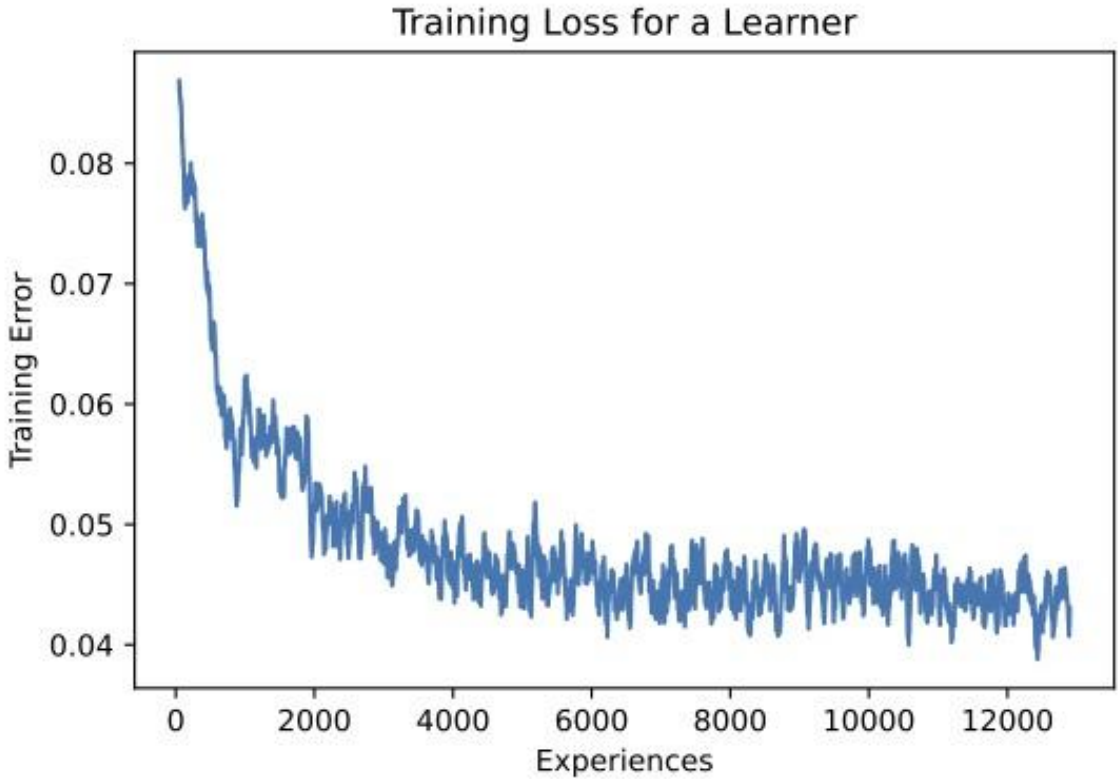


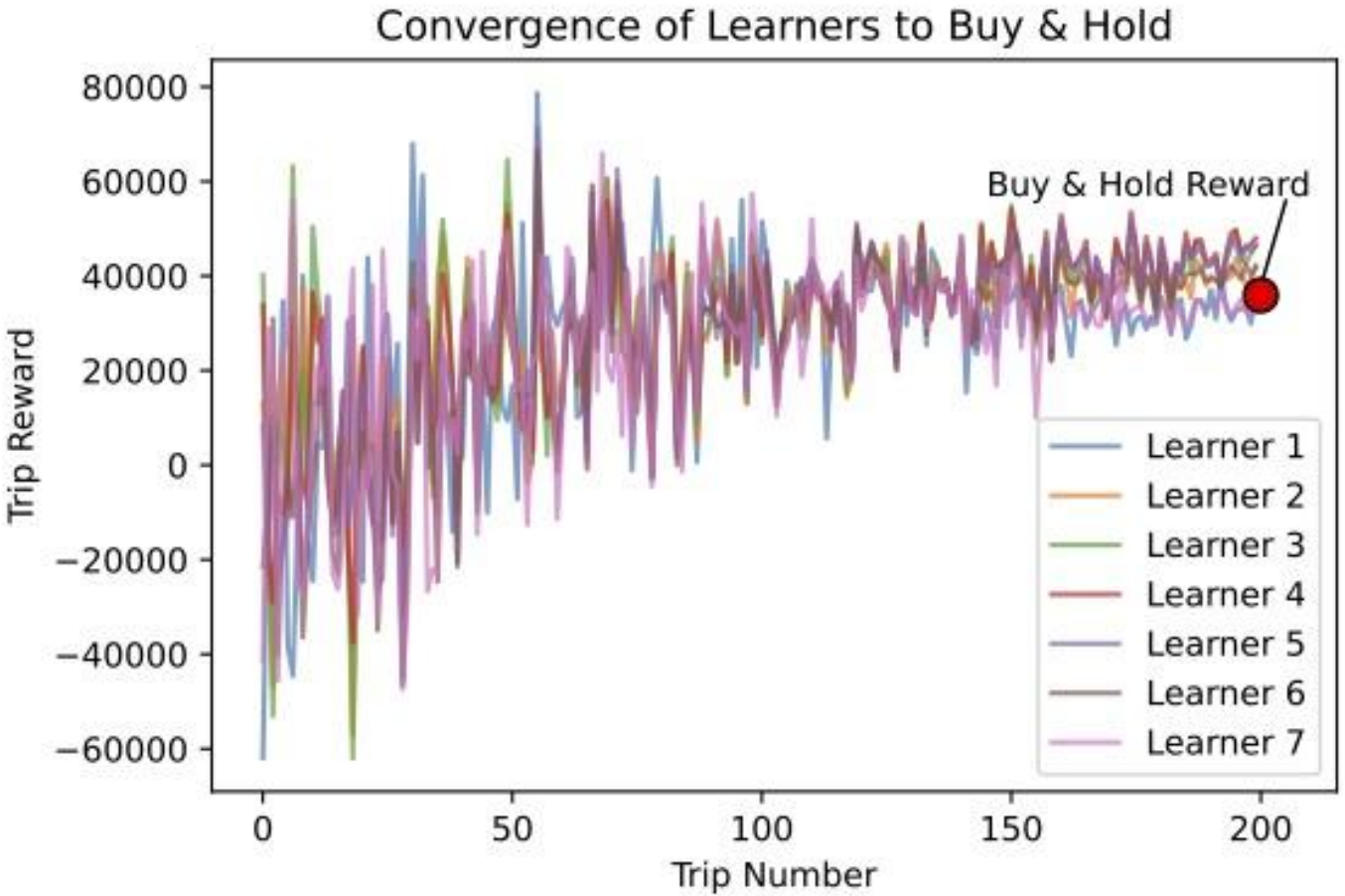
Indicator Analysis for All Combinations

- 1/7 combinations of size 6 do not "converge" to the baseline
- All 7 indicators converged
- (RSI, AU, AD, S, BBP) performed the best
- AU, AD, BBP perform the best
- (17/99) High convergence rate!



Learner Analysis




Convergence of Learners to Buy & Hold
Buy & Hold Reward
Trip Reward
Trip Number
80000
60000
40000
20000
0
−20000
−40000
−60000
0
50
100
150
200
Learner 1
Learner 2
Learner 3
Learner 4
Learner 5
Learner 6
Learner 7

Future Research

Analyzing Indicators:

- Compare different learner types–A2C in particular
- Analyze for true high-frequency trading
- Compare indicator characteristics

Improving learner strategies:

- Force DQNs to trade every day
- Encourage trading
- Slow target network updates to slow convergence

Conclusion

What is the best indicator?	Compared 99 Combinations	Evaluation
Bollinger Bands Williams % Range Stochastic Oscillator RSI OBV Aroon Oscillators	Used DQN to construct a trading strategy on 99 combinations	Verified learner efficacy and analyzed indicator outcomes