Autonomous Trading with Options and Futures

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MAIF
Minutemen Alternative Investment Fund

Objective

We aim to leverage Autonomous Agents to create a risk-averse strategy that trades correlated options and futures together.

Financial Background

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Options and Futures

Options	Futures
• Enter position with less capital • Delta lies in between -1 and 1 • Underlying assets are usually equities	• Requires initial margin, involves taking on leverage • Delta is always 1 • Underlying assets are usually commodities

Correlation and Causation

Correlated options and futures bring about consistent movement between the two instruments which gives us the ability to trade them together.

The ETF 'XLE' (Energy Sector) is a weighted basket of energy equities.

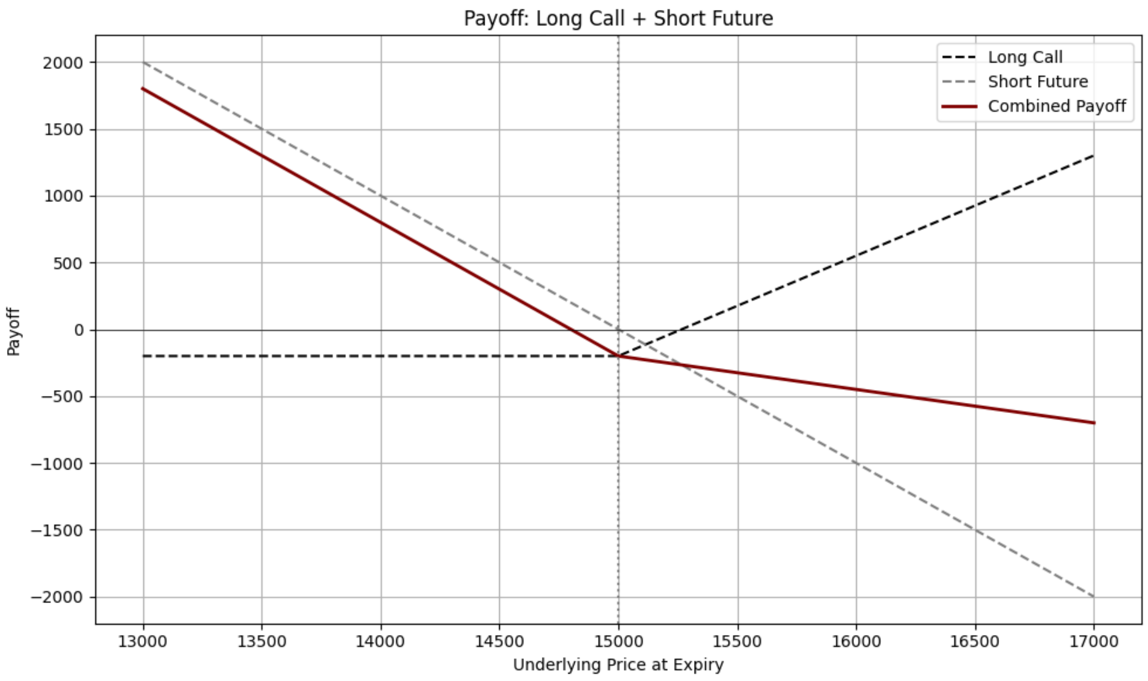
The future 'CL' (crude oil) tracks the commodity that drives the earnings of these energy equities.

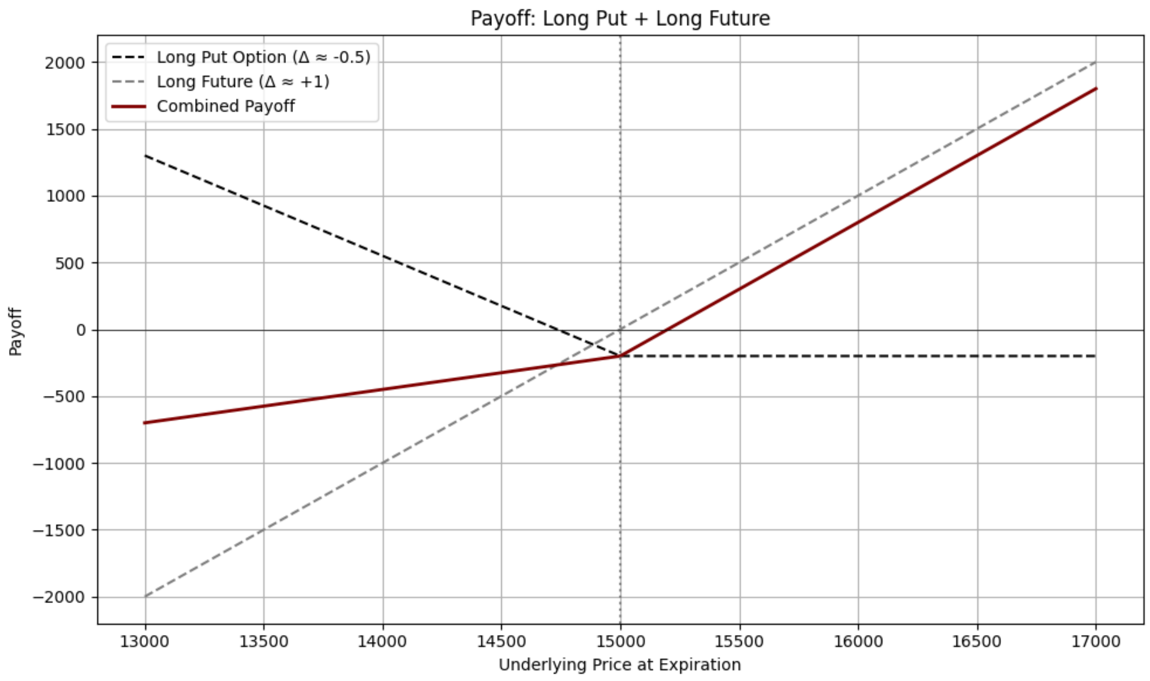
Oil price movement has a causal impact on XLE, so the option prices react to the price of the ETF.

Other option and future pairs we used were: XLC/NQ and XLK/NQ

Hedging a future with option(s)

The instruments traded are option-future pairs in a straddle-like structure.





Autonomous Trading

Reinforcement Learning

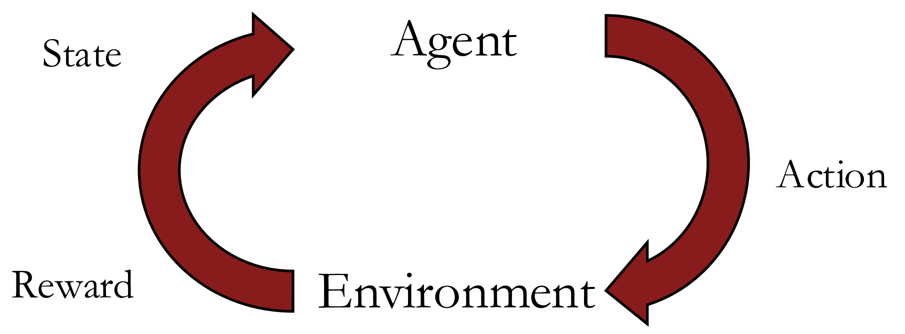
Reinforcement Learning (RL) is a field of Machine Learning that takes inspiration from behavioral psychology.

- RL models learn by taking actions in an environment and getting feedback in the form of a reward/penalty.

Over time, the model figures out the best action it can take given a particular environment state.

- ChatGPT: selecting the better answer
- DeepMind's AlphaGo

Reinforcement Learning originates from UMass Amherst and Professor Barto's work



Reinforcement Learning Cycle

Financial Agents

- The markets are incredibly complex – no amount of data can ever capture their entirety due to limitations in compute.
- Instead of trying to decide when to trade solely based on specific indicators, have the model/agent learn from its past successes and failures.
- Use the market as an environment, since we can never represent it with 100% accuracy or certainty.
- Have the model learn when to enter positions or hold based on making trades (timing the market).

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Hold

1

Trade a **Short Future** + **Long Call**

2

Trade a **Long Future** + **Long Put**

Our Model

Environment

State Space

- ETF Price
- MACD
- Bollinger Bands
- Option price
- Option delta
- Option IV
- Option time to expiry

Action Space

- Hold
- Short future + Long call
- Long future + Long Put

Methodology

Train

- State
- Active learning
- Reward
- Action

Test

- State
- Mapping
- Action

Reward Function

If no trades have been made yet (no data):
Randomly **choose** between short future + long call and long future + long put and assign a reward of **1**

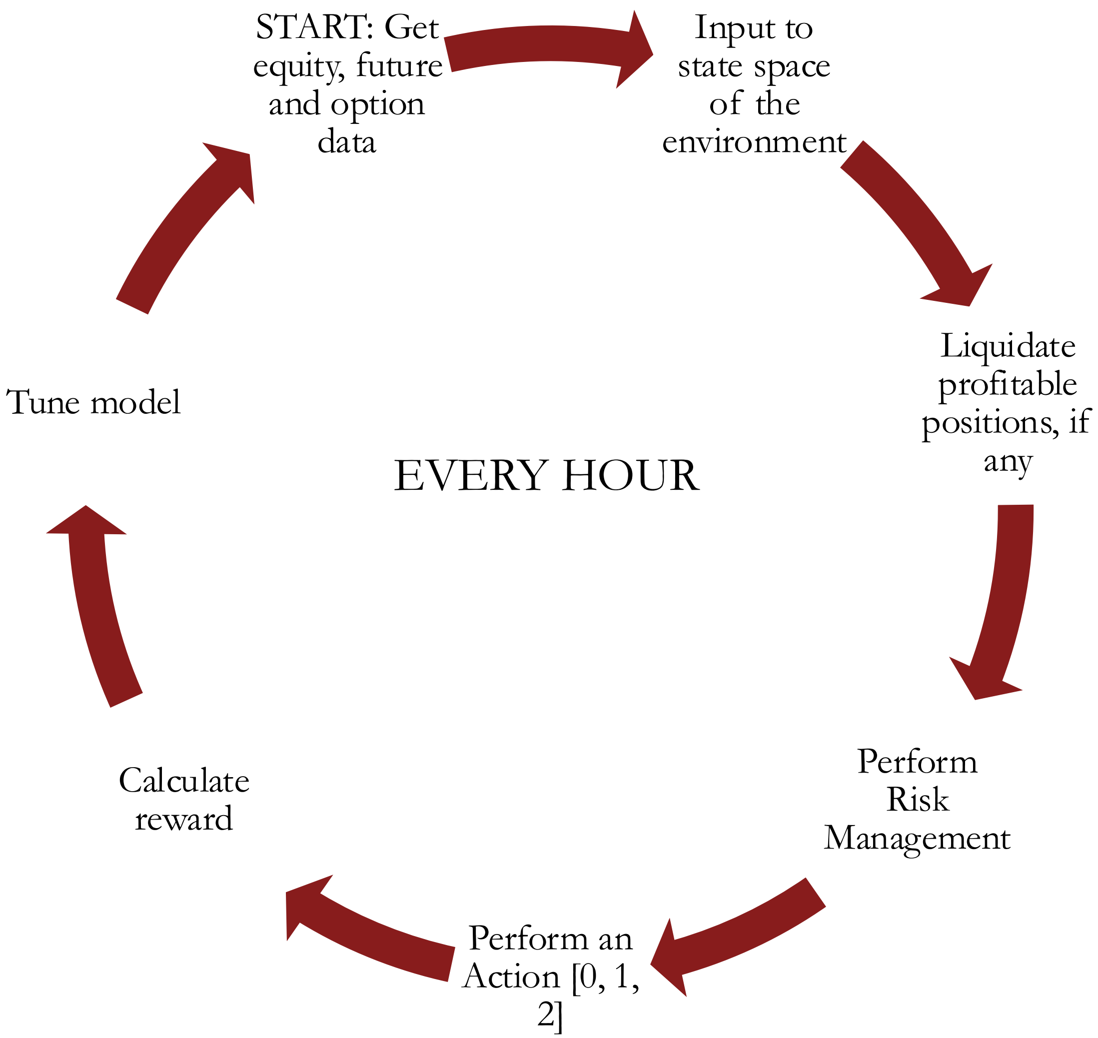
Otherwise:

1. Calculate the **change in the portfolio value** from the last hour of trading (i.e. between the last time new data was received and the current state) and assign the reward that value
2. Scaling the reward to match model criteria.
3. Calculate a **simplified Sharpe ratio term** (Mean/Std. Deviation) over the last 30 hours and add it to the reward.
4. Encourage trading by penalizing holding - when the reward is non-positive, **subtract 1** from the reward.

$$Reward = \Delta(Portfolio\ Value) * scale\_factor + \frac{mean}{std.\, deviation}$$

The Algorithm

Control Flow



Risk Management

15-20% Trailing Stop Loss

- Checked every hour
- Allows the model to explore and learn from mistakes
- 5% and 10% stop-loss fared worse, as our model incurred more losses gradually

Position Liquidation Timing

- Positions are liquidated when:
  - An option contract is 2 days from expiry.
  - The contract holds unrealized profit

Results

Evaluation

All algorithm parameters remaining constant, different backtesting results can occur.

Model "re-starts" every backtest (model persistence)

5-month training phase: Oct 7th, 2024 – Feb 27th, 2025

2-month testing phase: Feb 27th, 2025 – April 30th, 2025

Each backtest only trades one future-option pair – ensures causality between actions and rewards

We only need one backtest that learned timing signals to demonstrate efficacy, as that model can be used in testing mode beyond the scope of the backtest

Large number of trades and win rate expresses the statistical confidence in model decisions, drawdown indicates the exploratory nature of RL

XLE – CL Backtest

Returns: 30.27%

Net Profit: $151,335.00

Number of Trades: 5710

Win Rate: 77%

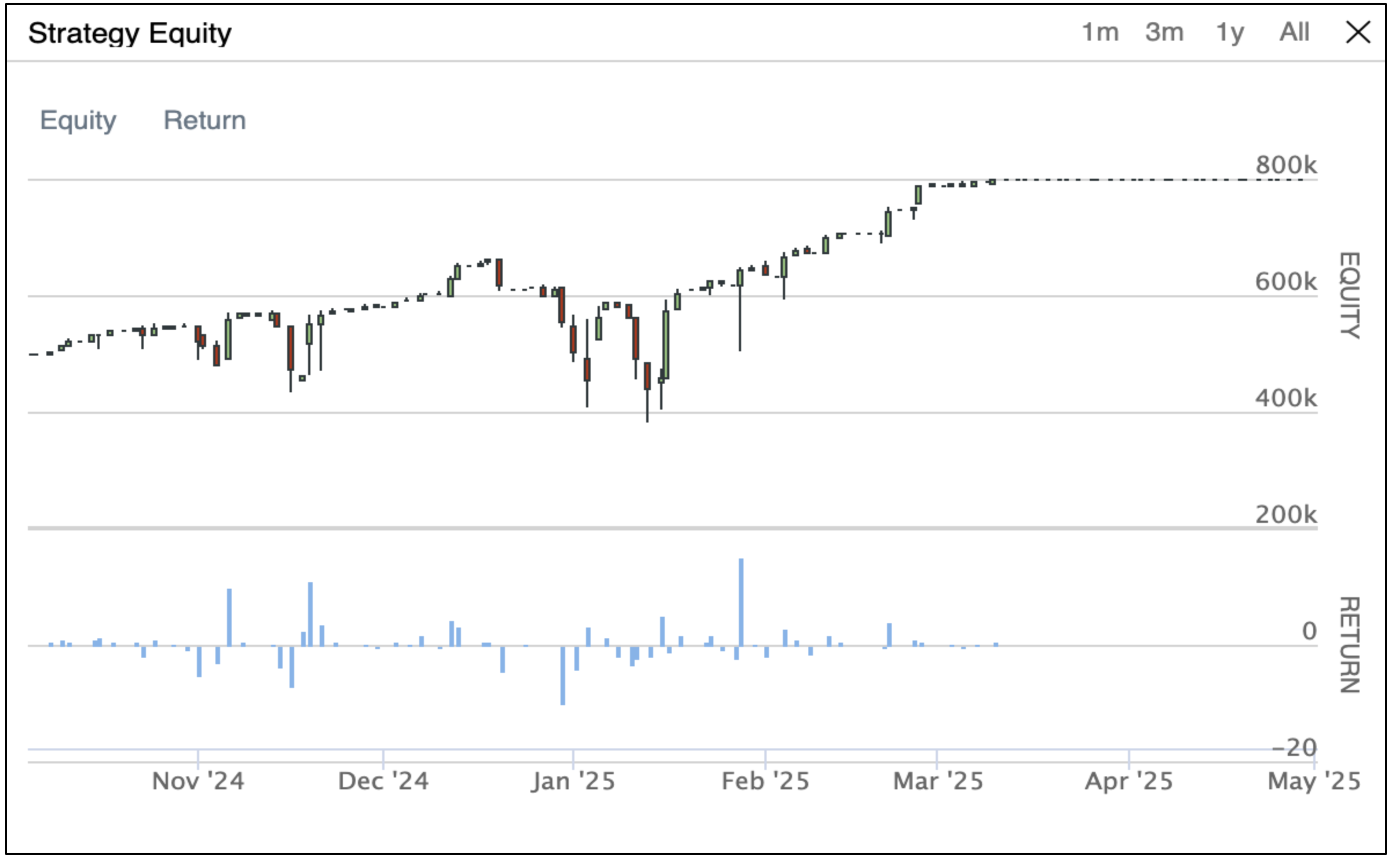
Sharpe Ratio: 1.11

Alpha: 0.43

Drawdown: 18.1%

SPY Returns: -2.34%

XLC – NQ Backtest



Returns: 60.18 %

Net Profit: $300,878.80

Number of Trades: 5673

Win Rate: 84%

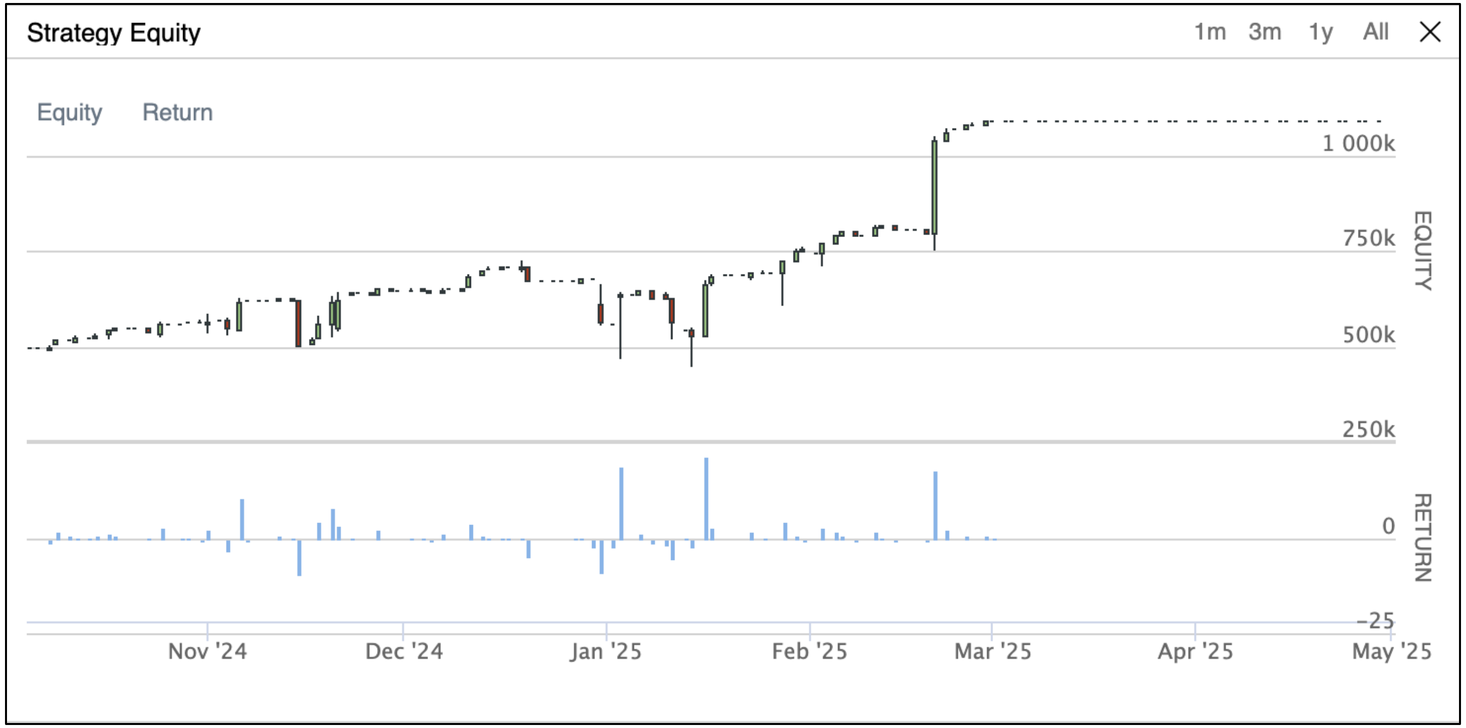
Sharpe Ratio: 1.688

Alpha: 1.192

Drawdown: 39.8%

SPY Returns: -2.34%

XLK – NQ Backtest



Returns: 118.15 %

Net Profit: $590,725.65

Number of Trades: 5688

Win Rate: 90%

Sharpe Ratio: 3.183

Alpha: 2.129

Drawdown: 35.3%

SPY Returns: -2.34%

Summary

1. The model trades contracts itself - it's not just an indicator, but an agent.
2. The model trades **call options with short futures** and **put options with long futures** to make profit in either direction of the underlying.
3. Works well in high volatility market conditions and outperforms the S&P by a great margin.
4. Future Work : Multiple Pairs, MARL, Stabilizing Testing Methods.

Questions?

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