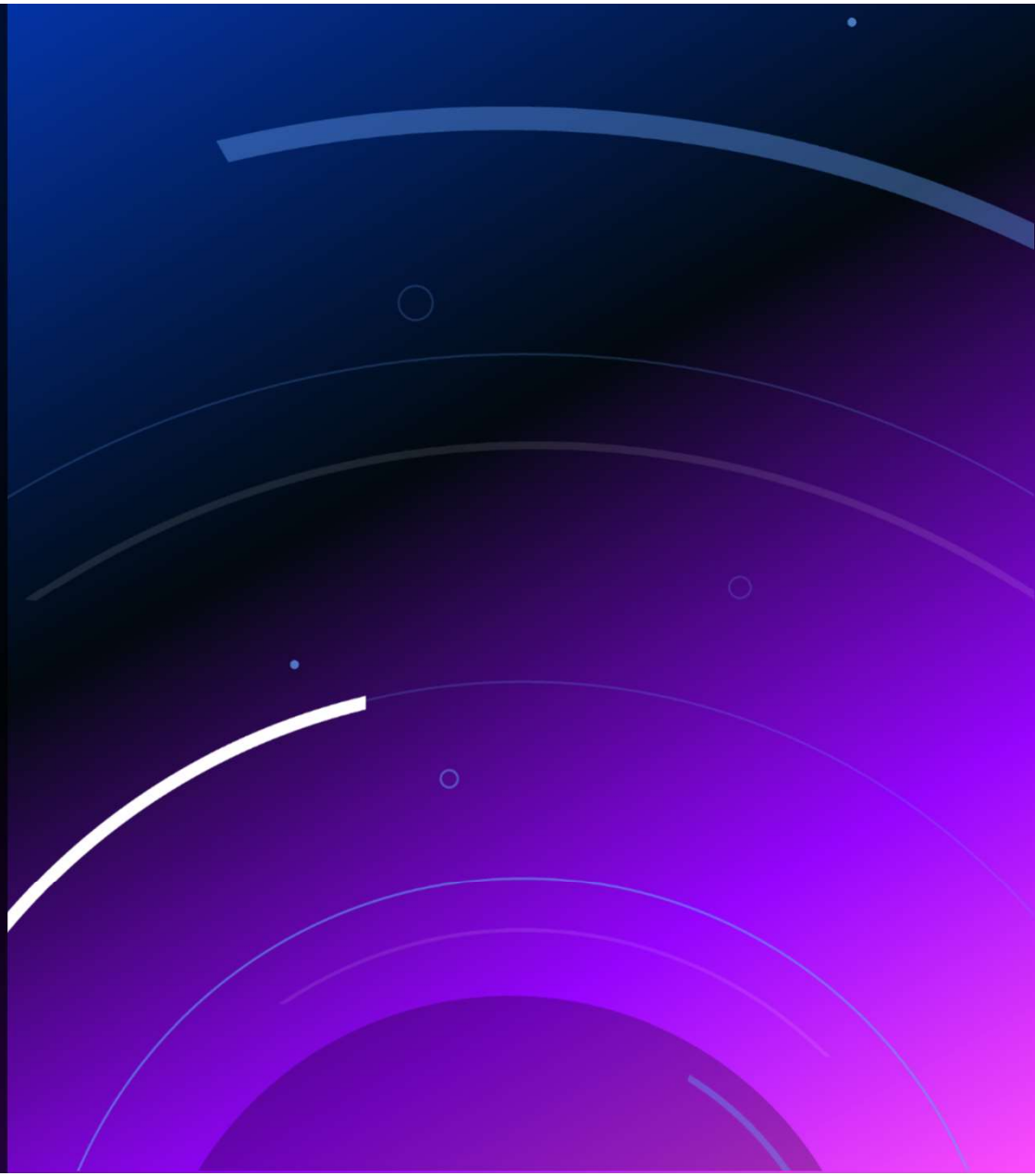
TRADING AS A GAME

PRESENTATION BASED ON "FINANCIAL TRADING AS A GAME: A DEEP REINFORCEMENT LEARNING APPROACH" BY CHIEN YI HUANG

Michał Jan Matejczuk, Aleks Patryk Kapich, Jakub Piotr Lange

AGENDA

1. Introduction – motivation, goals and challenges
2. Setting up the MDP
3. Model performance



MOTIVATION

Source: https://www.deviantart.com/sadbutambitious/art/Stonks-803456089

BASIC ASSUMPTIONS

The agent trades on Forex – an exchange for trading currencies

Every order is placed with all of the money available

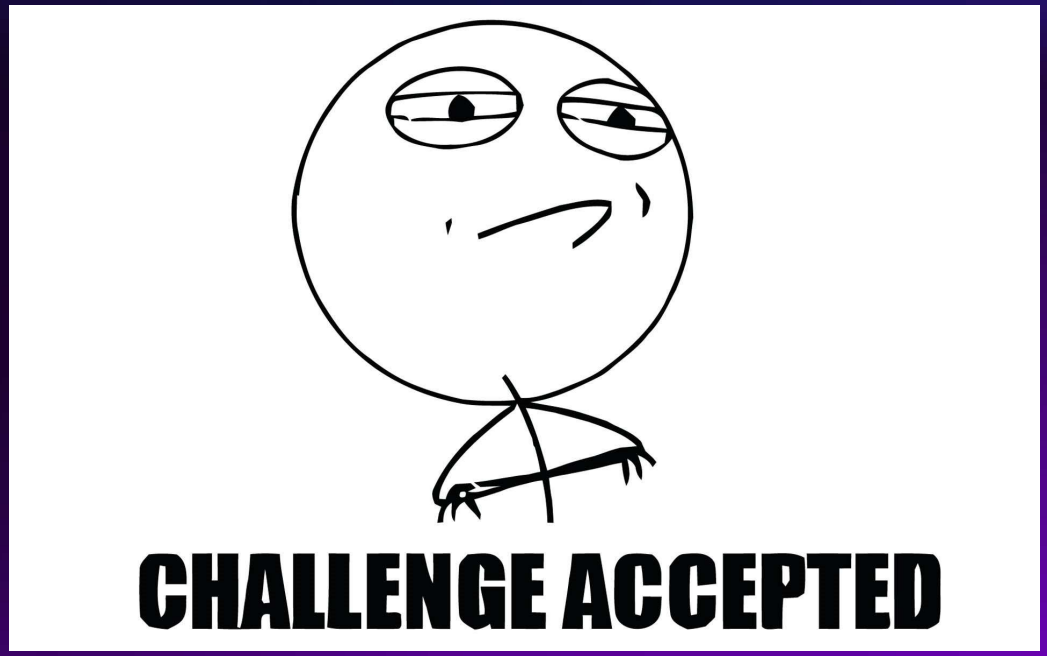
We evaluate the solution on 12 different currency pairs

HOW IS IT DONE "NORMALLY"?

Source: https://www.flickr.com/photos/danielfoster/48630187173

CHALLENGES

1. Lack of baseline
2. Data quality / availability
3. Partially observability of financial markets
4. Exploration / exploitation dilemma (transaction costs)



STATE SPACE

The state constists of three main parts:

- Time feature – vector of three values: minute, hour and day of week
- Market feature – OHLCV + 8 most recent log returns on both closing price + tick volume (number of price changes)
- Position feature – a set of three values: {-1, 0, 1}

REWARD FUNCTION & PORTFOLIO VALUE

$$r_t = \log\left(\frac{v_t}{v_{t-1}}\right)$$

$$v_t = v_{t-1} + a_t \cdot c \cdot (c_t - o_t) - d_t$$

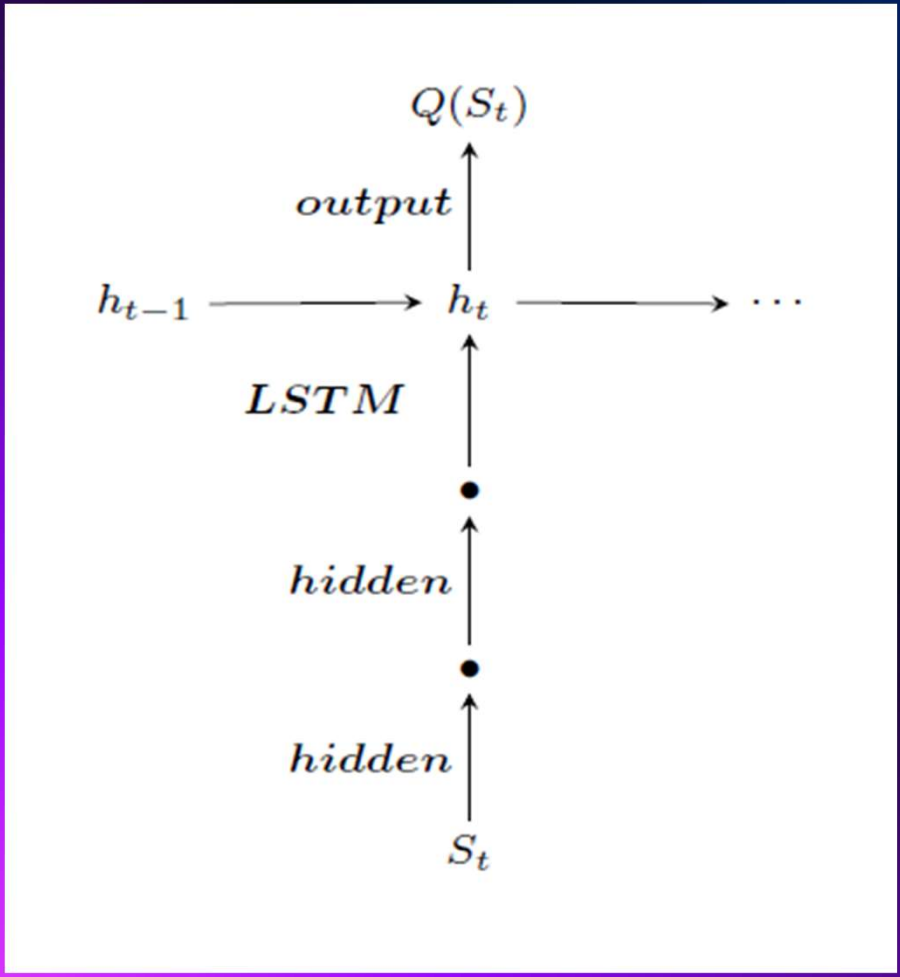
Source: https://arxiv.org/abs/1807.02787

DEEP Q-LEARNING

Key difference: q-function is represented as neural network instead of transition table.

The neural network takes **states** as inputs and the output consists of q-values **for each action.**

Any updates are imposed through neural network training

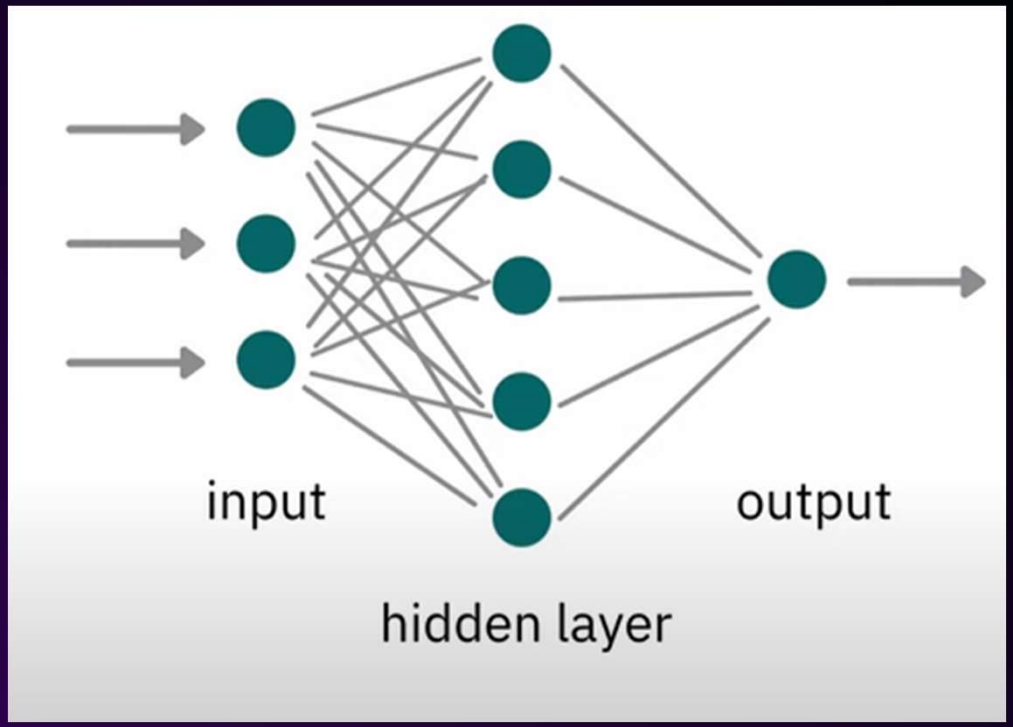


Source: https://arxiv.org/abs/1807.02787

TRAINING SCHEME

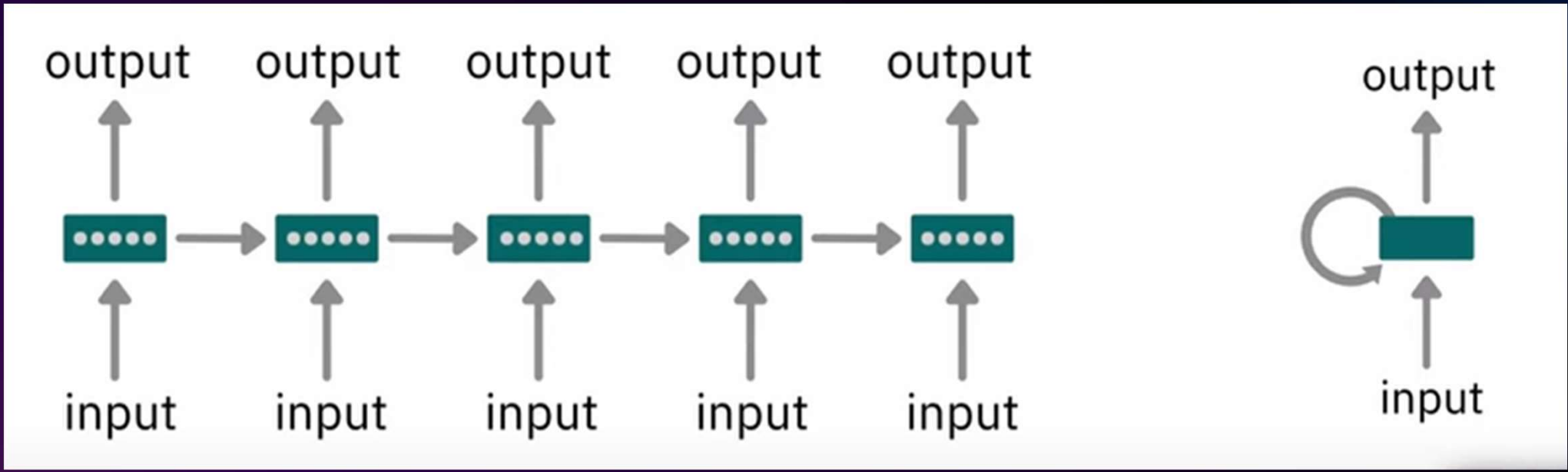
LSTM architecture brings advantage in the context where agent faces trading task

CLASSIC NEURAL NETWORKS



Source: https://www.youtube.com/watch?v=y9PLF2GsD-c&t=114s&ab_channel=M%C4%B1sraTurp

RECURRENT NEURAL NETWORKS



Source: https://www.youtube.com/watch?v=y9PLF2GsD-c&t=114s&ab_channel=M%C4%B1sraTurp

ACTION AUGMENTATION

$$v_t = v_{t-1} + a_t \cdot c \cdot (c_t - o_t) - d_t$$

Source: https://arxiv.org/abs/1807.02787

PARAMETERS

Hyperparameters	Value
Learning timestep T	96
Replay memory size N	480
Learning rate	0.00025
Optimizer	Adam[1]
Discount factor	0.99
Target network τ	0.001

Simulation Parameters	Value
Initial cash	100,000[2]
Trade size	100,000
Spread (bp[3])	0.08
Trading days	252 days/year

PERFORMANCE METRICS

$$Sharpe\ Ratio = \frac{R_p - R_f}{\sigma_p}$$

where:

R_p = return of portfolio

R_f = risk-free rate

σ_p = standard deviation of the portfolio's excess return

https://www.investopedia.com/terms/s/sharperatio.asp

PERFORMANCE METRICS

$$\text{Sortino Ratio} = \frac{R_p - r_f}{\sigma_d}$$

where:

R_p = Actual or expected portfolio return

r_f = Risk-free rate

σ_d = Standard deviation of the downside

https://www.investopedia.com/terms/s/sortinoratio.asp

MODEL PERFORMANCE

	Return	Sharpe	Sortino	MDD	Corr
GBPUSD	16.2% (-3.5%)	1.5	2.5	-8.63%	-0.09
EURUSD	9.5% (-1.6%)	1.0	1.6	-11.76%	0.01
AUDUSD	14.8% (-4.2%)	1.7	2.7	-6.96%	0.02
NZDUSD	17.1% (-1.2%)	2.2	4.0	-4.17%	-0.04
USDCAD	12.2% (4.0%)	1.4	2.5	-6.21%	0.11
EURGBP	12.8% (1.1%)	1.8	3.5	-5.51%	-0.21
AUDNZD	34.3% (-2.8%)	5.7	12.4	-1.21%	0.02
CADJPY	20.4% (3.2%)	1.8	3.1	-25.24%	0.20
AUDJPY	25.1% (2.0%)	2.0	3.3	-11.69%	0.18
CHFJPY	60.8% (7.0%)	3.1	6.3	-7.71%	0.31
EURJPY	23.6% (6.1%)	1.9	3.2	-12.90%	0.18
GBPJPY	39.0% (4.7%)	2.9	5.8	-7.73%	-0.07

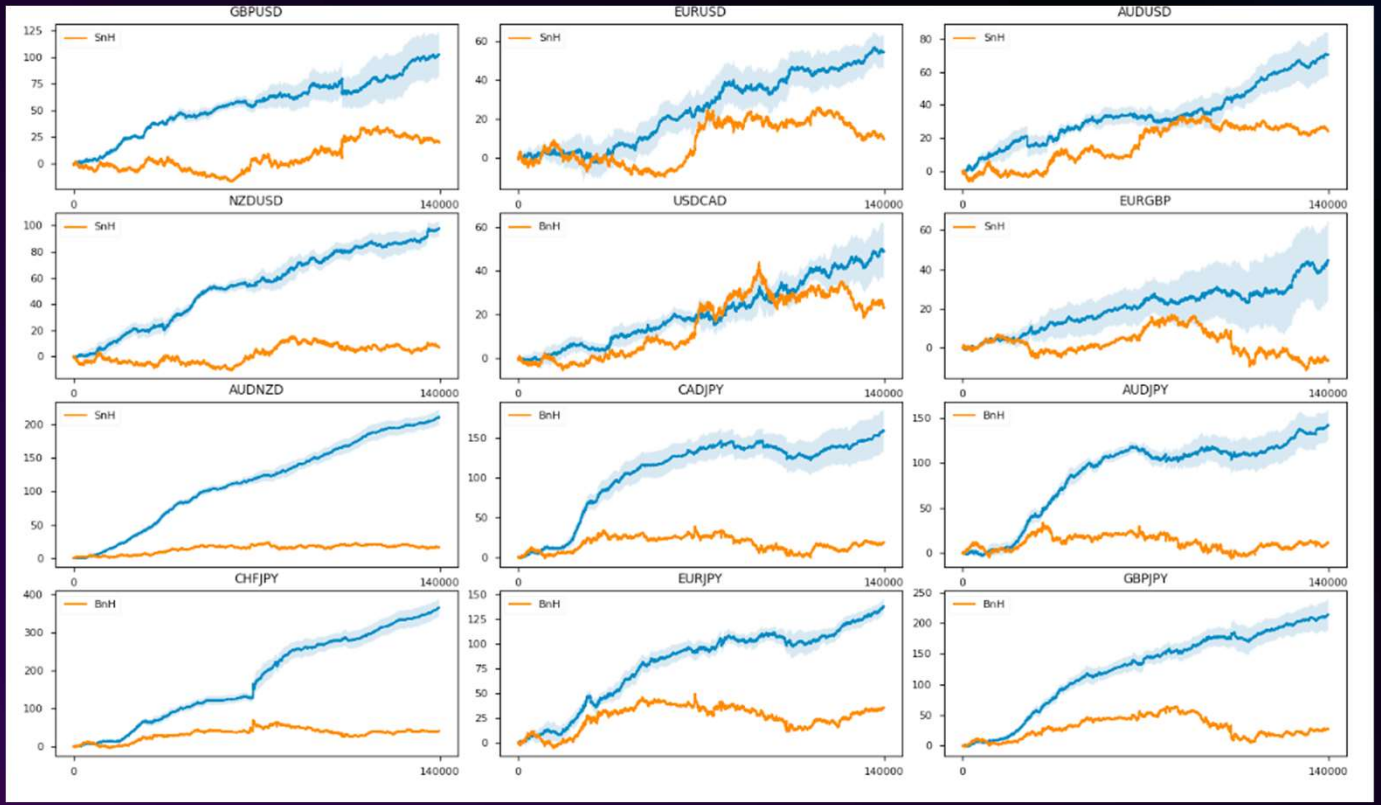
Table 1: Annualized simulation results

MODEL PERFORMANCE

	Num Trades	Win Rate	Avg Profit	Avg Loss	Expect	Freq
GBPUSD	33133	57.2%	70.25	-87.33	2.83	4.22
EURUSD	31215	57.2%	60.67	-77.12	1.76	4.48
AUDUSD	31263	57.2%	54.52	-66.6	2.74	4.47
NZDUSD	32382	59.6%	52.17	-69.34	3.06	4.32
USDCAD	26636	57.7%	63.46	-80.16	2.71	5.25
EURGBP	32032	61.2%	37.76	-54.58	1.93	4.36
AUDNZD	38173	63.2%	49.93	-67.18	6.83	3.66
CADJPY	26332	59.6%	6410.1	-8612.01	340.1	5.31
AUDJPY	26638	60.7%	7092.02	-9883.08	428.92	5.25
CHFJPY	32089	61.5%	7287.77	-9294.91	898.92	4.36
EURJPY	30509	61.5%	7483.41	-10801.23	445.0	4.58
GBPJPY	31204	60.8%	10791.52	-14503.05	864.67	4.48

Table 2: Trading statistics

MODEL PERFORMANCE



EXPERIMENTING WITH SPREAD

	0.08 bp	0.1 bp	0.15 bp	0.2 bp
GBPUSD	16.2%	**18.8%**	6.1%	6.7%
EURUSD	**9.5%**	5.8%	0.1%	1.1%
AUDUSD	**14.8%**	10.0%	7.3%	5.2%
NZDUSD	**17.1%**	14.2%	12.4%	4.2%
USDCAD	**12.2%**	9.0%	6.9%	-3.4%
EURGBP	**12.8%**	3.8%	-0.2%	-3.8%
AUDNZD	34.3%	**35.9%**	29.9%	23.4%
CADJPY	20.4%	**32.4%**	18.9%	14.8%
AUDJPY	25.1%	**26.4%**	15.3%	10.2%
CHFJPY	60.8%	**79.8%**	56.1%	43.5%
EURJPY	23.6%	**35.6%**	17.2%	15.2%
GBPJPY	39.0%	**44.4%**	31.0%	27.0%
	23.8%	**26.3%**	16.7%	11.9%

Table 3: Annualized return under different spreads.

EXPERIMENTING WITH SPREAD

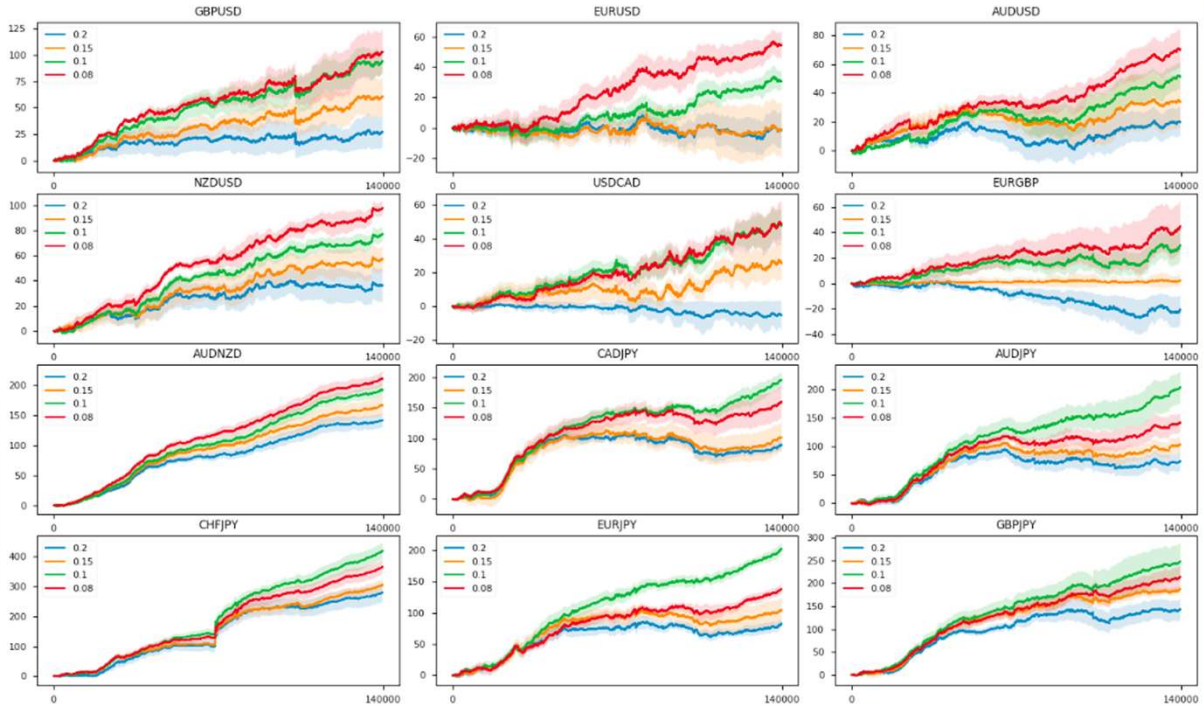


Figure 3: Performances under different spreads.

ACTION AUGMENTATION VS EPSILON