



# DEEP REINFORCEMENT LEARNING FOR OPTIMAL PORTFOLIO MANAGEMENT

*The Timeline*





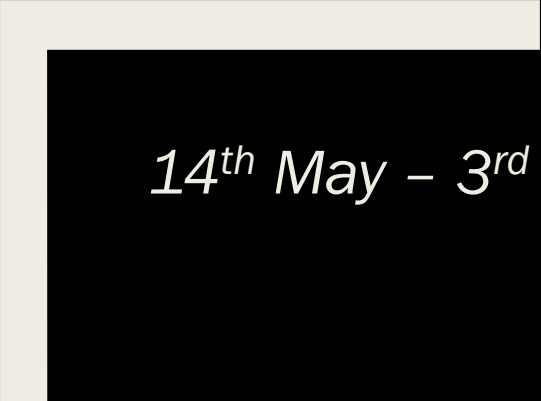
# Dates

- 14<sup>th</sup> May: Preliminary Report
- 5<sup>th</sup> July: Individual Meeting 1
- 26<sup>th</sup> July: Group Meeting 4
- 16<sup>th</sup> August: Individual Meeting 2
- 3<sup>rd</sup> September: Report Submission
- 6<sup>th</sup> September: Video Presentation

## Now – 14<sup>th</sup> May: Preliminary Report

- **Chapter 1: Introduction** - Aims, objectives, background, motivations, technical specifications, and outline of methodologies.
- Overview of requirements, minimum goals to accomplish
- **Chapter 2: Background and Literature Review**
  - *Overview of topic area, key concepts and relevant research*
  - *Description of previous work done in related areas,*
  - *Outline of existing methods/approaches proposed by others handling similar problems.*
  - *Constructive criticism on the existing methods/approaches*
- Project Schedule (Gantt chart)
  - *Data acquisition*
  - *Implementation*
  - *Analysis and evaluation*

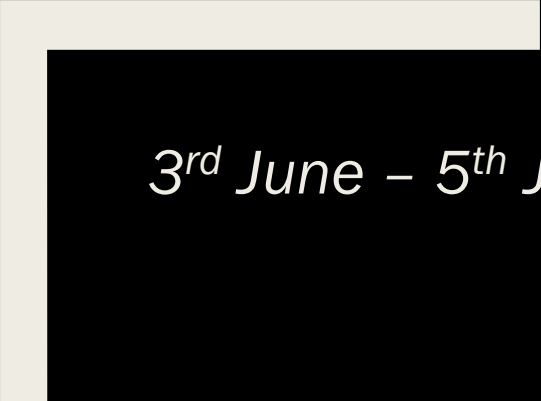
	Paper	Date	Status	Code	Comments	Algorithms	Author
2	<a href="#">A Deep Deterministic Policy Gradient-based Strategy for Stocks Portfolio Management</a>	Mar 2021				DDPG	H Zhang and Z Jiang
3	<a href="#">Deep Reinforcement Learning with Function Properties in Mean Reversion Strategies</a>	2021				PPO, OpenAI gym, Mean reversion	Sophia Gu
4	<a href="#">DRL for Portfolio Management based on the empirical study of Chinese Stock Market</a>	2021				DDPG, Arbitrage Pricing Theory, shorting, CNN	Gang Huang
5	<a href="#">Deep Reinforcement Learning for Automated Stock Trading: An Ensemble Strategy</a>	2020		FinRL		Ensemble - PPO, A2C, DDPG	Hongyang Yang
6	<a href="#">Application of Deep Q-Network in Portfolio Management</a>	2020				DD-DQN	Ziming Gao and Z Jiang
7	<a href="#">Deep Reinforcement Learning for Trading</a>	Nov 2019				Futures Contracts - DQN, PG, A2C	Zhang
8	<a href="#">A deep Q-learning portfolio management framework for the cryptocurrency market</a>	Nov 2019				DQN, D-DQN, DD-DQN	Lucarelli
9	<a href="#">A deep reinforcement learning approach for automated cryptocurrency trading</a>	May 2019					Lucarelli
10	<a href="#">Reinforcement Learning For Automated Trading</a>	2019				GPOMDP (Monte Carlo), PGPE	Necchi
11	<a href="#">Reinforcement Learning for Portfolio Management</a>	2019				DSRQN, REINFORCE, MSM	Filos
12	<a href="#">Model-based deep reinforcement learning for dynamic portfolio optimization</a>	Jan 2019				Model based - IPM, gen adv DAN, BCM	Yu
13	<a href="#">Portfolio Management Based on DDPG Algorithm of Deep Reinforcement Learning</a>	2018	????				Qi
14	<a href="#">Practical Deep Reinforcement Learning Approach for Stock Trading</a>	Dec, 2018		FinRL		DDPG	Xiong
15	<a href="#">Adversarial Deep Reinforcement Learning in Portfolio Management</a>	Nov, 2018		Github		DDPG, PPO, PG	Z Liang
16	<a href="#">Financial Trading as a Game: A Deep Reinforcement Learning Approach</a>	Jul 2018				DRQN	CY Huang
17	<a href="#">Market Self-Learning of Signals, Impact and Optimal Trading</a>	May 2018				Dynamic Portfolio Optimization, bounded rational agent, IRL	Halperin
18	<a href="#">MACHINE LEARNING FOR TRADING</a>	Dec 2017				Q learning	Gordon Ritter
19	<a href="#">A Deep RL Framework for the Financial Portfolio Management Problem</a>	Jul 2017		Github	12 Crypto asset portfolio	EIIE	Z Jiang
20	<a href="#">Cryptocurrency portfolio management with deep reinforcement learning</a>	May 2017				DPG	Z Jiang
21	<a href="#">Multi-Period Trading via Convex Optimization</a>	Apr 2017					Boyd
22	<a href="#">Deep Direct Reinforcement Learning for Financial Signal Representation and Trading</a>	2016			Solves without price prediction, Single asset movement		Deng
23	<a href="#">Portfolio Management using Reinforcement Learning</a>	2016			Basic implementation of DQN	2 stock DQN learner	Jin
24	<a href="#">An Investigation into the Use of RL Techniques within the Algorithmic Trading Domain</a>	2015			Solves without price prediction	Dissertation - LSTD for forex trading	Cumming
25	<a href="#">An automated FX trading system using adaptive reinforcement learning</a>	2006			Solves without price prediction, Single asset movement		Dempster
26	<a href="#">Learning to Trade via Direct Reinforcement</a>	2001			Solves without price prediction, Single asset movement		Moody
27	<a href="#">An Algorithm for Trading and Portfolio Management using Q-Learning and Sharpe Ratio</a>	2000				Novel local & global agents for learning behaviour and reward	Gao
28	<a href="#">Reinforcement Learning for Trading Systems and Portfolios</a>	1998					Moody
29	<a href="#">Performance Functions and Reinforcement Learning for Trading systems and Portfolios</a>	1997					Moody
30	<b>SURVEYS</b>						
31	<a href="#">Reinforcement learning in financial markets - a survey</a>	Dec 2018					
32	<a href="#">Model-Free Reinforcement Learning for Financial Portfolios: A Brief Survey</a>	May 2019					
33	<a href="#">Comprehensive Review of Deep Reinforcement Learning Methods and Applications in E</a>	2020					
34	<a href="#">Continuous versus discrete action spaces for deep reinforcement learning</a>						
35	<a href="#">Modern Perspectives on Reinforcement Learning in Finance</a>	Jan 2019					Gordon Ritter



*14<sup>th</sup> May – 3<sup>rd</sup> June*

# EXAMS





## *3<sup>rd</sup> June – 5<sup>th</sup> July: Individual Meeting 1*

- Implement simple versions of DQN and DDPG algorithms on arbitrary tasks
  - *Finalize tools and frameworks to use*
  - *Develop a taste for designing environments in OpenAI Gym*
- Finalize dataset to be used
- Begin environment design for portfolio allocation
  - *Feature Engineering*
  - *Data Normalization*
- Develop Python scripts for evaluation of metrics and against baselines
- Begin **Chapter 3: Methodology**


Starting point for beginners			Tutorials	RL for Portfolio Management		
OpenAI Spinning Up	GitHub	TF, Torch	Pytorch DQN	FinRL: A Deep Reinforcement Learning Library for Automated Stock Trading in Quantitative Finance	GitHub	
Udacity Deep RL repo	GitHub	Torch	Keras RL			
Denny Britz Github	GitHub	TF	Stable Baselines 3			
			OpenAI Gym			
Advanced implementations			FinRL: Portfolio Allocation			
OpenAI Baselines		TF	FinRL: Blog post			
Stable Baselines		TF				
Stable Baselines3	Used by FinRL <a href="https://araffin.github.io/post/sb3">https://araffin.github.io/post/sb3</a>	Torch		Implementations inspired by "A Deep Reinforcement Learning Framework for the Financial Portfolio Management Problem"	Data	Range
				<a href="https://github.com/liangzp/Reinforcement-learning-in-portfolio-manag">https://github.com/liangzp/Reinforcement-learning-in-portfolio-manag</a>	Chinese, American Stock Prices	2015-17
RLLib	GitHub	TF, Torch		<a href="https://github.com/wassname/rl-portfolio-management">https://github.com/wassname/rl-portfolio-management</a>	OHLCV for 14 cryptocurrencies	2015-17
Garage		TF, Torch		<a href="https://github.com/selimamrouni/Deep-Portfolio-Management-Reinfo">https://github.com/selimamrouni/Deep-Portfolio-Management-Reinfo</a>	5yr Stock Prices	2013-18
TRFL (incomplete)	Deepmind - Building blocks, mathematical operations for RL Agents	TF		<a href="https://github.com/vermouth1992/drl-portfolio-management">https://github.com/vermouth1992/drl-portfolio-management</a>	5yr S&P 500 prices	2013-18
Acme	Deepmind	TF		<a href="https://github.com/aws/amazon-sagemaker-examples/tree/master/re">https://github.com/aws/amazon-sagemaker-examples/tree/master/re</a>	Datamodel	
Dopamine	Google	TF				
ReAgent	Facebook	Torch				
Tensorforce		TF				
RLkit		Torch				
DeeR		Keras				
Sagemaker	Amazon	TF, Torch				



## *Data*

- S&P 500 stock prices (2013 – 18)
- 14 popular cryptocurrencies (2015 – 17)
- Stanford dataset for Finance and Portfolio Optimization (2006 – 16)
  - *52 popular ETFs*
- FinRL API to download stock market data
  - *NASDAQ 100, DJIA, S&P 500, HSI, SSE 50, CSI 300, etc.*






## *5<sup>th</sup> July – 26<sup>th</sup> July: Group Meeting 4*

- Train, (Back)Test, Analyse and Improve, Repeat
- Document performance and results
- Begin **Chapter 4: Evaluation and Results**
- (Hopefully freeze development by this meeting)



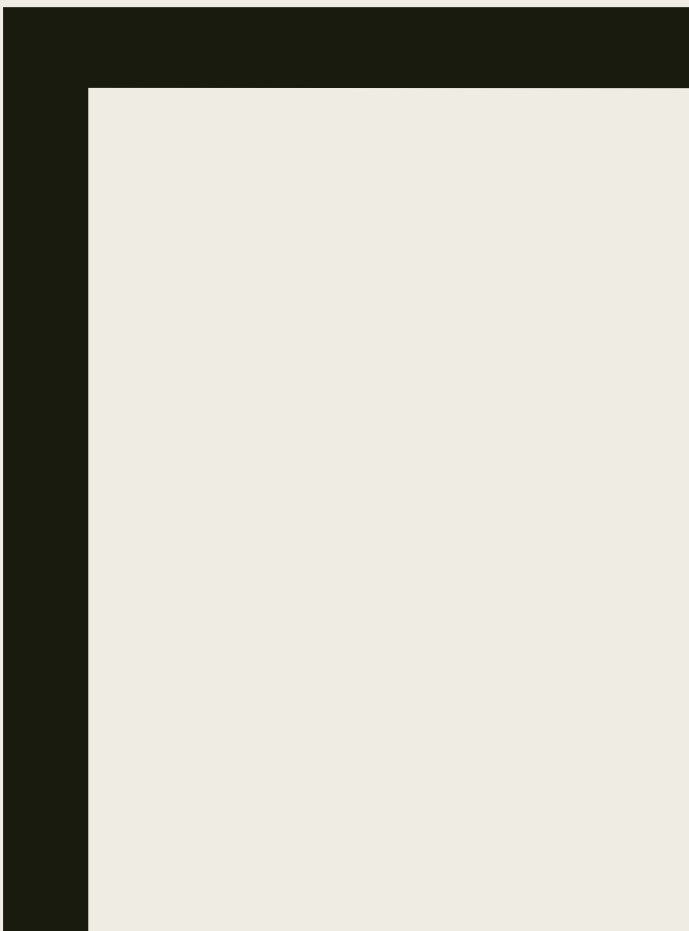
## *26<sup>th</sup> July – 16<sup>th</sup> August: Individual Meeting 2*

- Concentrate on completion of report and begin **Chapter 5: Discussion**
- Fine tune agents (if needed)



*16<sup>th</sup> August – 3<sup>rd</sup> September*

- Make sure everything is submitted.



*FIN*

