RL based Falsification

CS659 Project

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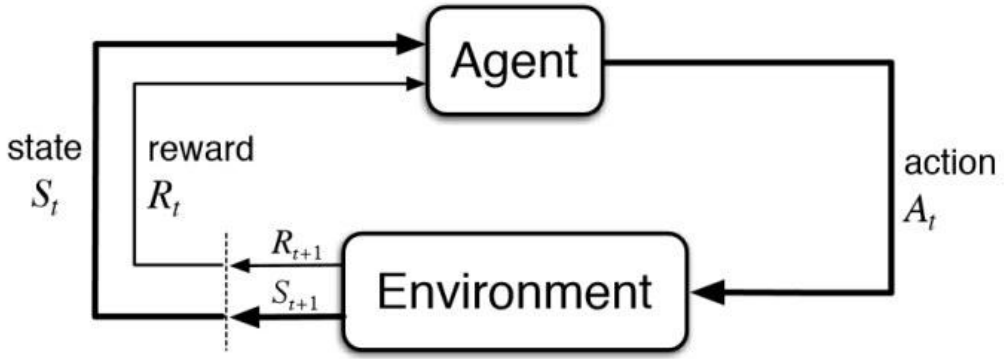
What is Falsification ?

Falsification refers to the problem of finding out input values ‘u’ for the model such that the output fails to satisfy a given STL property.

It is in a sense opposite to the Verification problem where we try to check that the Model satisfies the STL property over all inputs ‘u’.

Reinforcement Learning

A machine learning technique that optimizes an agent's behaviour using rewards from the environment.



RL Algorithms

Double DQN

- Both Q-learning and DQN, are over-optimistic.
- DDQN solves this by decoupling the function estimators that calculate value function and advantage function.
- The value function calculates the value of a given input frame, and the advantage function calculates the benefits of taking a given action.

RL Algorithms

Asynchronous Advantage Actor Critic (A3C)

- In A3C there is a global network, and multiple worker agents which each have their own set of network parameters.

- The experience of each agent is independent of the experience of the others. This makes the overall experience available for training becomes more diverse.

- But as experience of one agent is not longer affecting the others (as in *A2C*), and as at any time an agent may be dealing with a different version of policy (*asynchronous*) the aggregated update would not be optimal.

STL grammar

We use the following STL grammar :

$$\varphi ::= v \sim c \mid p \mid \neg\varphi \mid \varphi_1 \vee \varphi_2 \mid \varphi_1 \mathcal{U}_I \varphi_2 \mid \varphi_1 \mathcal{S}_I \varphi_2$$

v is real variable, *c* is a rational number, *p* is atomic formula, ~ ∈ {<, ≤}

U is the until operator.

S is the since operator.

This is the same grammar as mentioned in the paper.

Robustness

For a given formula φ , output signal x and time t we can calculate the robustness value $\rho(\varphi,x,t)$.

The robustness is a real value :

- ➢ Its sign indicates whether the output satisfies the property (+ve is *true*)
- ➢ Its magnitude tells us how robustly the property is satisfied. (larger the better for +ve sign)

S-Taliro and Breach

S-Taliro and Breach are fault detection tools that turn the falsification problem into a numerical minimization problem. They can be used to produce trajectories with minimal robustness values.

S-Taliro can be used to calculate the robustness.

Problem Description

We need to create an RL agent that can search for inputs using the robustness value as rewards, thus making efficient searches in the input space. This in turn can result in faster falsification of the model.

For Evaluation we use the Automatic Transmission Model.

Steps

- Create an RL agent using chainerRL.
- Generate Inputs using the RL agent and send them to the simulink model.
- Pass the Outputs of the Model to S-Taliro / Breach to calculate robustness value.
- Pass the reward i.e, robustness value and Update the Agent Parameters and Agent State.

Environment : Automatic Transmission (AT) Model

- AT is a Simulink Model of a Transmission System.
- Inputs are Throttle and Brake.
- Outputs are Vehicle Velocity, Engine RPM and Gear State.
- Vehicle Velocity, Engine RPM, Throttle and Brake are real valued quantities.
- Gear State is a categorical variable.

STL Formulae

Here w bar = 4500.0 ; v bar = 150.0

id	Formula
φ_1	$\square \omega \leq \overline{\omega}$
φ_2	$\square(v \leq \overline{v} \wedge \omega \leq \overline{\omega})$
φ_3	$\square((g_2 \wedge \Diamond_{[0,0.1]} g_1) \rightarrow \square_{[0.1,1.0]} \neg g_2)$
φ_4	$\square((\neg g_1 \wedge \Diamond_{[0,0.1]} g_1) \rightarrow \square_{[0.1,1.0]} g_1)$
φ_5	$\square \bigwedge_{i=1}^{4}((\neg g_i \wedge \Diamond_{[0,0.1]} g_i) \rightarrow \square_{[0.1,1.0]} g_i)$

id	Formula
φ_6	$\square(\square_{[0,t_1]} \omega \leq \overline{\omega} \rightarrow \square_{[t_1,t_2]} v \leq \overline{v})$
φ_7	$\square v \leq \overline{v}$
φ_8	$\square \Diamond_{[0,25]} \neg(\underline{v} \leq v \leq \overline{v})$
φ_9	$\square \neg \square_{[0,20]}(\neg g_4 \wedge \omega \geq \overline{\omega})$

Current Progress

- The DDQN Model is completed and working.
- The A3C Model has some bug because of which its not working. (In Progress)
- Falsification using S-Taliro is also done.
- As the implementation is not parallelized it takes a lot of time to run the experiments on Laptop.
- Currently results for DDQN for sample time = 1,5,10, Max Episodes = 200 for 20 runs are available for STL formulae 1,2,5,6,7.
- Code also works for formulae 3,4,8,9 but it takes enormous amounts of time to compute for those values.

Post-Presentation Work

Nothing more has been done since then, since I (Sudhanshu) got sick after the presentation due to Covid. Before submitting the presentation some extra results have been tabulated and they have been added here, namely, results with sample time= 5,10. The complete results will be uploaded on the github link. Additionally, I (Sudhanshu) will try to work on fixing the A3C code before presentation with the mentor and if done, it will be uploaded on github.

I (Niskarsh) was slammed with other project presentation, report and assignments.

Results Formula 1

ATRLDDQNstformula1Time1

id	modelN...	expName	algoName	sampleT...	numEpis...	elapsedTime	bestRob
Number	Categor...	Number	Categor...	Number	Number	Number	Number
id	modelNa...	expName	algoName	sampleTi...	numEpis...	elapsedTime	bestRob
1	AT_RL_D...	formula1	RL_DDQN	1	1	2.410449	-0.047147470...
2	AT_RL_D...	formula1	RL_DDQN	1	4	2.799161	-0.033570306...
3	AT_RL_D...	formula1	RL_DDQN	1	3	1.591581	-0.070072007...
4	AT_RL_D...	formula1	RL_DDQN	1	2	1.044773	-0.073472259...
5	AT_RL_D...	formula1	RL_DDQN	1	1	0.615998	-0.106611918...
6	AT_RL_D...	formula1	RL_DDQN	1	1	0.592789	-0.102755105...
7	AT_RL_D...	formula1	RL_DDQN	1	1	0.57127	-0.109131181...
8	AT_RL_D...	formula1	RL_DDQN	1	1	0.582847	-0.086215929...
9	AT_RL_D...	formula1	RL_DDQN	1	4	2.000806	-0.079835165...
10	AT_RL_D...	formula1	RL_DDQN	1	1	0.571847	-0.050516240...
11	AT_RL_D...	formula1	RL_DDQN	1	1	0.579021	-0.041888860...
12	AT_RL_D...	formula1	RL_DDQN	1	2	1.072522	-0.105738358...
13	AT_RL_D...	formula1	RL_DDQN	1	2	1.041125	-0.081564636...
14	AT_RL_D...	formula1	RL_DDQN	1	2	1.055613	-0.105843997...
15	AT_RL_D...	formula1	RL_DDQN	1	1	0.585465	-0.081102579...
16	AT_RL_D...	formula1	RL_DDQN	1	4	1.943466	-0.046591195...
17	AT_RL_D...	formula1	RL_DDQN	1	3	1.532044	-0.082028849...
18	AT_RL_D...	formula1	RL_DDQN	1	1	0.609335	-0.034625548...
19	AT_RL_D...	formula1	RL_DDQN	1	1	0.580857	-0.050261423...
20	AT_RL_D...	formula1	RL_DDQN	1	1	0.58287	-0.105757105...

ATRLDDQNstformula1Time5

	A	B	C	D	E	F	G	H
	id	modelN...	expName	algoName	sampleT...	numEpis...	elapsed...	bestRob
	Number	Categor...	Number	Categor...	Number	Number	Number	Number
	id	modelNa...	expName	algoName	sampleTi...	numEpis...	elapsedT...	bestRob
1	1	AT_RL_D...	formula1	RL_DDQN	5	3	3.643978	-0.07597...
2	2	AT_RL_D...	formula1	RL_DDQN	5	1	0.721421	-0.07509...
3	3	AT_RL_D...	formula1	RL_DDQN	5	10	4.379847	-0.10981...
4	4	AT_RL_D...	formula1	RL_DDQN	5	11	4.383534	-0.07959...
5	5	AT_RL_D...	formula1	RL_DDQN	5	10	4.103579	-0.08122...
6	6	AT_RL_D...	formula1	RL_DDQN	5	7	2.99941	-0.08070...
7	7	AT_RL_D...	formula1	RL_DDQN	5	1	0.550733	-0.08135...
8	8	AT_RL_D...	formula1	RL_DDQN	5	7	2.891672	-0.10698...
9	9	AT_RL_D...	formula1	RL_DDQN	5	1	0.534246	-0.08105...
10	10	AT_RL_D...	formula1	RL_DDQN	5	12	4.769603	-0.08025...
11	11	AT_RL_D...	formula1	RL_DDQN	5	13	5.13284	-0.07942...
12	12	AT_RL_D...	formula1	RL_DDQN	5	1	0.553621	-0.07987...
13	13	AT_RL_D...	formula1	RL_DDQN	5	3	1.371487	-0.05929...
14	14	AT_RL_D...	formula1	RL_DDQN	5	5	2.204022	-0.08187...
15	15	AT_RL_D...	formula1	RL_DDQN	5	5	2.245919	-0.01471...
16	16	AT_RL_D...	formula1	RL_DDQN	5	4	1.814132	-0.07900...
17	17	AT_RL_D...	formula1	RL_DDQN	5	3	1.374674	-0.06328...
18	18	AT_RL_D...	formula1	RL_DDQN	5	12	4.835254	-0.07912...
19	19	AT_RL_D...	formula1	RL_DDQN	5	3	1.393028	-0.10471...
20	20	AT_RL_D...	formula1	RL_DDQN	5	4	1.794615	-0.07985...

ATRLDDQNstformula1Time10

id	modelN...	expName	algoName	sampleT...	numEpis...	elapsed...	bestRob
Number	Categor...	Number	Catego...	Number	Number	Number	Number
id	modelNa...	expName	algoName	sampleTi...	numEpis...	elapsedT...	bestRob
1	AT_RL_D...	formula1	RL_DDQN	10	1	2.263717	-0.07583...
2	AT_RL_D...	formula1	RL_DDQN	10	4	2.630254	-0.00432...
3	AT_RL_D...	formula1	RL_DDQN	10	16	6.259137	-0.07663...
4	AT_RL_D...	formula1	RL_DDQN	10	200	74.558753	0.20116...
5	AT_RL_D...	formula1	RL_DDQN	10	1	0.57668	-0.07601...
6	AT_RL_D...	formula1	RL_DDQN	10	200	74.100105	0.20774...
7	AT_RL_D...	formula1	RL_DDQN	10	200	74.592872	0.22504...
8	AT_RL_D...	formula1	RL_DDQN	10	200	74.114219	0.12124...
9	AT_RL_D...	formula1	RL_DDQN	10	200	76.274564	0.22658...
10	AT_RL_D...	formula1	RL_DDQN	10	1	0.621402	-0.07298...
11	AT_RL_D...	formula1	RL_DDQN	10	6	2.63076	-0.07791...
12	AT_RL_D...	formula1	RL_DDQN	10	1	0.563024	-0.08071...
13	AT_RL_D...	formula1	RL_DDQN	10	22	8.398729	-0.08128...
14	AT_RL_D...	formula1	RL_DDQN	10	200	74.28967	0.09702...
15	AT_RL_D...	formula1	RL_DDQN	10	200	74.964	0.26026...
16	AT_RL_D...	formula1	RL_DDQN	10	200	73.02461	0.24710...
17	AT_RL_D...	formula1	RL_DDQN	10	1	0.53553	-0.08100...
18	AT_RL_D...	formula1	RL_DDQN	10	16	6.154094	-0.05989...
19	AT_RL_D...	formula1	RL_DDQN	10	4	1.836062	-0.04564...
20	AT_RL_D...	formula1	RL_DDQN	10	200	74.668094	0.03390...

Results Formula 2

ATRLDDQNstformula2Time1

id	modelN...	expName	algoName	sampleT...	numEpis...	elapsed...	bestRob
Number	Categor...	Number	Categor...	Number	Number	Number	Number
id	modelNa...	expName	algoName	sampleTi...	numEpis...	elapsedT...	bestRob
1	AT_RL_D...	formula2	RL_DDQN	1	6	5.324498	-0.02079...
2	AT_RL_D...	formula2	RL_DDQN	1	1	0.740264	-0.10966...
3	AT_RL_D...	formula2	RL_DDQN	1	2	1.10422	-0.04690...
4	AT_RL_D...	formula2	RL_DDQN	1	1	0.59074	-0.04648...
5	AT_RL_D...	formula2	RL_DDQN	1	1	0.671133	-0.10755...
6	AT_RL_D...	formula2	RL_DDQN	1	1	0.597918	-0.13627...
7	AT_RL_D...	formula2	RL_DDQN	1	1	0.587897	-0.12016...
8	AT_RL_D...	formula2	RL_DDQN	1	7	3.214852	-0.08069...
9	AT_RL_D...	formula2	RL_DDQN	1	3	1.550342	-0.01282...
10	AT_RL_D...	formula2	RL_DDQN	1	2	1.046195	-0.10975...
11	AT_RL_D...	formula2	RL_DDQN	1	9	4.049602	-0.10623...
12	AT_RL_D...	formula2	RL_DDQN	1	5	2.398338	-0.10504...
13	AT_RL_D...	formula2	RL_DDQN	1	1	0.611546	-0.03025...
14	AT_RL_D...	formula2	RL_DDQN	1	2	1.056573	-0.10895...
15	AT_RL_D...	formula2	RL_DDQN	1	1	0.591936	-0.10858...
16	AT_RL_D...	formula2	RL_DDQN	1	3	1.515919	-0.10767...
17	AT_RL_D...	formula2	RL_DDQN	1	5	2.364883	-0.10661...
18	AT_RL_D...	formula2	RL_DDQN	1	3	1.529135	-0.08102...
19	AT_RL_D...	formula2	RL_DDQN	1	6	2.85341	-0.07700...
20	AT_RL_D...	formula2	RL_DDQN	1	2	1.054945	-0.02686...

ATRLDDQNstformula2Time5

id	modelN...	expName	algoName	sampleT...	numEpis...	elapsed...	bestRob
Number	Categor...	Number	Categor...	Number	Number	Number	Number
id	modelNa...	expName	algoName	sampleTi...	numEpis...	elapsedT...	bestRob
1	AT_RL_D...	formula2	RL_DDQN	5	2	3.019514	-0.10695...
2	AT_RL_D...	formula2	RL_DDQN	5	3	2.058475	-0.07925...
3	AT_RL_D...	formula2	RL_DDQN	5	2	1.281338	-0.05807...
4	AT_RL_D...	formula2	RL_DDQN	5	1	0.56381	-0.11192...
5	AT_RL_D...	formula2	RL_DDQN	5	1	0.59642	-0.12875...
6	AT_RL_D...	formula2	RL_DDQN	5	1	0.550406	-0.16320...
7	AT_RL_D...	formula2	RL_DDQN	5	1	0.546727	-0.13287...
8	AT_RL_D...	formula2	RL_DDQN	5	2	0.975341	-0.07741...
9	AT_RL_D...	formula2	RL_DDQN	5	2	1.000534	-0.06309...
10	AT_RL_D...	formula2	RL_DDQN	5	3	1.394769	-0.08132...
11	AT_RL_D...	formula2	RL_DDQN	5	5	2.144302	-0.05496...
12	AT_RL_D...	formula2	RL_DDQN	5	5	2.243617	-0.07846...
13	AT_RL_D...	formula2	RL_DDQN	5	1	0.548559	-0.07731...
14	AT_RL_D...	formula2	RL_DDQN	5	1	0.542998	-0.10787...
15	AT_RL_D...	formula2	RL_DDQN	5	2	0.981794	-0.05055...
16	AT_RL_D...	formula2	RL_DDQN	5	1	0.54665	-0.02931...
17	AT_RL_D...	formula2	RL_DDQN	5	1	0.554766	-0.07891...
18	AT_RL_D...	formula2	RL_DDQN	5	1	0.57852	-0.11365...
19	AT_RL_D...	formula2	RL_DDQN	5	22	8.521678	-0.09613...
20	AT_RL_D...	formula2	RL_DDQN	5	10	4.165797	-0.08059...

ATRLDDQNstformula2Time10

id	modelN...	expName	algoName	sampleT...	numEpis...	elapsed...	bestRob
Number	Categor...	Number	Categor...	Number	Number	Number	Number
id	modelNa...	expName	algoName	sampleTi...	numEpis...	elapsedT...	bestRob
1	AT_RL_D...	formula2	RL_DDQN	10	2	3.009835	-0.10304...
2	AT_RL_D...	formula2	RL_DDQN	10	11	5.087816	-0.02471...
3	AT_RL_D...	formula2	RL_DDQN	10	3	1.412179	-0.06298...
4	AT_RL_D...	formula2	RL_DDQN	10	1	0.5524	-0.08084...
5	AT_RL_D...	formula2	RL_DDQN	10	24	9.32874	-0.01612...
6	AT_RL_D...	formula2	RL_DDQN	10	200	75.29955	0.04378...
7	AT_RL_D...	formula2	RL_DDQN	10	9	3.785117	-0.07679...
8	AT_RL_D...	formula2	RL_DDQN	10	1	0.698131	-0.03065...
9	AT_RL_D...	formula2	RL_DDQN	10	1	0.643607	-0.03458...
10	AT_RL_D...	formula2	RL_DDQN	10	8	3.340346	-0.01890...
11	AT_RL_D...	formula2	RL_DDQN	10	4	1.807872	-0.03354...
12	AT_RL_D...	formula2	RL_DDQN	10	24	9.262912	-0.06892...
13	AT_RL_D...	formula2	RL_DDQN	10	20	7.88247	-0.02696...
14	AT_RL_D...	formula2	RL_DDQN	10	4	1.858376	-0.07817...
15	AT_RL_D...	formula2	RL_DDQN	10	2	0.973079	-0.07849...
16	AT_RL_D...	formula2	RL_DDQN	10	9	3.717272	-0.07741...
17	AT_RL_D...	formula2	RL_DDQN	10	19	7.727382	-0.00690...
18	AT_RL_D...	formula2	RL_DDQN	10	4	1.846168	-0.11232...
19	AT_RL_D...	formula2	RL_DDQN	10	7	2.918949	-0.06722...
20	AT_RL_D...	formula2	RL_DDQN	10	1	0.544004	-0.01961...

Results Formula 5

ATRLDDQNstformula5Time1

id	modelN...	expName	algoName	sampleT...	numEpis...	elapsed...	bestRob
Number	Categor...	Number	Categor...	Number	Number	Number	Number
id	modelNa...	expName	algoName	sampleTi...	numEpis...	elapsedT...	bestRob
1	AT_RL_D...	formula5	RL_DDQN	1	5	5.095796	-0.33333...
2	AT_RL_D...	formula5	RL_DDQN	1	2	1.262167	-0.33333...
3	AT_RL_D...	formula5	RL_DDQN	1	2	1.178307	-0.33333...
4	AT_RL_D...	formula5	RL_DDQN	1	1	0.645226	-0.33333...
5	AT_RL_D...	formula5	RL_DDQN	1	3	1.696877	-0.33333...
6	AT_RL_D...	formula5	RL_DDQN	1	1	0.640755	-0.33333...
7	AT_RL_D...	formula5	RL_DDQN	1	1	0.634104	-0.33333...
8	AT_RL_D...	formula5	RL_DDQN	1	7	3.447357	-0.33333...
9	AT_RL_D...	formula5	RL_DDQN	1	3	1.622716	-0.33333...
10	AT_RL_D...	formula5	RL_DDQN	1	3	1.668323	-0.33333...
11	AT_RL_D...	formula5	RL_DDQN	1	6	3.11001	-0.33333...
12	AT_RL_D...	formula5	RL_DDQN	1	5	2.570305	-0.33333...
13	AT_RL_D...	formula5	RL_DDQN	1	1	0.629185	-0.33333...
14	AT_RL_D...	formula5	RL_DDQN	1	6	3.064075	-0.33333...
15	AT_RL_D...	formula5	RL_DDQN	1	1	0.62528	-0.33333...
16	AT_RL_D...	formula5	RL_DDQN	1	2	1.128488	-0.33333...
17	AT_RL_D...	formula5	RL_DDQN	1	8	3.914126	-0.33333...
18	AT_RL_D...	formula5	RL_DDQN	1	5	2.561923	-0.33333...
19	AT_RL_D...	formula5	RL_DDQN	1	1	0.671601	-0.33333...
20	AT_RL_D...	formula5	RL_DDQN	1	2	1.13139	-0.33333...

ATRLDDQNstformula5Time5

id	modelN...	expName	algoName	sampleT...	numEpis...	elapsed...	bestRob
Number	Categor...	Number	Categor...	Number	Number	Number	Number
id	modelNa...	expName	algoName	sampleTi...	numEpis...	elapsedT...	bestRob
1	AT_RL_D...	formula5	RL_DDQN	5	200	88.031663	0.33333...
2	AT_RL_D...	formula5	RL_DDQN	5	200	83.507423	0.33333...
3	AT_RL_D...	formula5	RL_DDQN	5	200	86.327024	0.33333...
4	AT_RL_D...	formula5	RL_DDQN	5	200	83.3222	0.33333...
5	AT_RL_D...	formula5	RL_DDQN	5	200	83.019906	0.33333...
6	AT_RL_D...	formula5	RL_DDQN	5	200	90.671866	0.33333...
7	AT_RL_D...	formula5	RL_DDQN	5	200	83.853289	0.33333...
8	AT_RL_D...	formula5	RL_DDQN	5	200	83.328344	0.33333...
9	AT_RL_D...	formula5	RL_DDQN	5	200	85.212364	0.33333...
10	AT_RL_D...	formula5	RL_DDQN	5	200	87.443828	0.33333...
11	AT_RL_D...	formula5	RL_DDQN	5	200	83.674345	0.33333...
12	AT_RL_D...	formula5	RL_DDQN	5	200	85.597098	0.33333...
13	AT_RL_D...	formula5	RL_DDQN	5	200	83.027737	0.33333...
14	AT_RL_D...	formula5	RL_DDQN	5	200	87.99631	0.33333...
15	AT_RL_D...	formula5	RL_DDQN	5	200	85.377469	0.33333...
16	AT_RL_D...	formula5	RL_DDQN	5	200	85.182622	0.33333...
17	AT_RL_D...	formula5	RL_DDQN	5	200	561.016...	0.33333...
18	AT_RL_D...	formula5	RL_DDQN	5	200	89.131746	0.33333...
19	AT_RL_D...	formula5	RL_DDQN	5	200	83.322033	0.33333...
20	AT_RL_D...	formula5	RL_DDQN	5	200	82.3835	0.33333...

ATRLDDQNstformula5Time10

id	modelN...	expName	algoName	sampleT...	numEpis...	elapsed...	bestRob
Number	Categor...	Number	Categor...	Number	Number	Number	Number
id	modelNa...	expName	algoName	sampleTi...	numEpis...	elapsedT...	bestRob
1	AT_RL_D...	formula5	RL_DDQN	10	200	96.05016	0.33333...
2	AT_RL_D...	formula5	RL_DDQN	10	200	85.988682	0.33333...
3	AT_RL_D...	formula5	RL_DDQN	10	200	87.340522	0.33333...
4	AT_RL_D...	formula5	RL_DDQN	10	200	90.441015	0.33333...
5	AT_RL_D...	formula5	RL_DDQN	10	200	93.91776	0.33333...
6	AT_RL_D...	formula5	RL_DDQN	10	200	103.030...	0.33333...
7	AT_RL_D...	formula5	RL_DDQN	10	200	100.134...	0.33333...
8	AT_RL_D...	formula5	RL_DDQN	10	200	99.32447	0.33333...
9	AT_RL_D...	formula5	RL_DDQN	10	200	102.426...	0.33333...
10	AT_RL_D...	formula5	RL_DDQN	10	200	102.470...	0.33333...
11	AT_RL_D...	formula5	RL_DDQN	10	200	102.430...	0.33333...
12	AT_RL_D...	formula5	RL_DDQN	10	200	103.734...	0.33333...
13	AT_RL_D...	formula5	RL_DDQN	10	200	105.532...	0.33333...
14	AT_RL_D...	formula5	RL_DDQN	10	200	104.436...	0.33333...
15	AT_RL_D...	formula5	RL_DDQN	10	200	104.916...	0.33333...
16	AT_RL_D...	formula5	RL_DDQN	10	200	107.075...	0.33333...
17	AT_RL_D...	formula5	RL_DDQN	10	200	108.105...	0.33333...
18	AT_RL_D...	formula5	RL_DDQN	10	200	108.856...	0.33333...
19	AT_RL_D...	formula5	RL_DDQN	10	200	110.086...	0.33333...
20	AT_RL_D...	formula5	RL_DDQN	10	200	110.628...	0.33333...

Results Formula 6

ATRLDDQNstformula6Time1

id	modelN...	expName	algoName	sampleT...	numEpis...	elapsed...	bestRob
Number	Categor...	Number	Categor...	Number	Number	Number	Number
id	modelNa...	expName	algoName	sampleTi...	numEpis...	elapsedT...	bestRob
1	AT_RL_D...	formula6	RL_DDQN	1	1	2.851194	-0.26325...
2	AT_RL_D...	formula6	RL_DDQN	1	1	1.404079	-0.28318...
3	AT_RL_D...	formula6	RL_DDQN	1	1	1.384942	-0.29036...
4	AT_RL_D...	formula6	RL_DDQN	1	1	1.082108	-0.23664...
5	AT_RL_D...	formula6	RL_DDQN	1	1	1.38117	-0.25273...
6	AT_RL_D...	formula6	RL_DDQN	1	1	1.030445	-0.29540...
7	AT_RL_D...	formula6	RL_DDQN	1	1	1.065115	-0.05820...
8	AT_RL_D...	formula6	RL_DDQN	1	1	1.024384	-0.22357...
9	AT_RL_D...	formula6	RL_DDQN	1	2	1.915162	-0.20081...
10	AT_RL_D...	formula6	RL_DDQN	1	2	1.935681	-0.07994...
11	AT_RL_D...	formula6	RL_DDQN	1	1	1.013095	-0.28425...
12	AT_RL_D...	formula6	RL_DDQN	1	2	1.982149	-0.26517...
13	AT_RL_D...	formula6	RL_DDQN	1	1	1.013079	-0.21235...
14	AT_RL_D...	formula6	RL_DDQN	1	1	1.006398	-0.27237...
15	AT_RL_D...	formula6	RL_DDQN	1	1	1.039713	-0.29186...
16	AT_RL_D...	formula6	RL_DDQN	1	2	1.926466	-0.23323...
17	AT_RL_D...	formula6	RL_DDQN	1	1	1.009098	-0.15892...
18	AT_RL_D...	formula6	RL_DDQN	1	1	1.074928	-0.21810...
19	AT_RL_D...	formula6	RL_DDQN	1	1	1.036675	-0.18642...
20	AT_RL_D...	formula6	RL_DDQN	1	1	1.035989	-0.32678...

ATRLDDQNstformula6Time5

id	modelN...	expName	algoName	sampleT...	numEpis...	elapsed...	bestRob
Number	Categor...	Number	Categor...	Number	Number	Number	Number
id	modelNa...	expName	algoName	sampleTi...	numEpis...	elapsedT...	bestRob
1	AT_RL_D...	formula6	RL_DDQN	5	2	3.678301	-0.20676...
2	AT_RL_D...	formula6	RL_DDQN	5	1	1.234328	-0.31591...
3	AT_RL_D...	formula6	RL_DDQN	5	1	1.058385	-0.29151...
4	AT_RL_D...	formula6	RL_DDQN	5	1	1.542966	-0.27287...
5	AT_RL_D...	formula6	RL_DDQN	5	1	1.124906	-0.23859...
6	AT_RL_D...	formula6	RL_DDQN	5	1	1.267813	-0.29880...
7	AT_RL_D...	formula6	RL_DDQN	5	3	3.331348	-0.27400...
8	AT_RL_D...	formula6	RL_DDQN	5	1	1.20994	-0.29822...
9	AT_RL_D...	formula6	RL_DDQN	5	1	1.421667	-0.23728...
10	AT_RL_D...	formula6	RL_DDQN	5	1	1.07825	-0.32177...
11	AT_RL_D...	formula6	RL_DDQN	5	1	0.978451	-0.18239...
12	AT_RL_D...	formula6	RL_DDQN	5	1	1.004864	-0.32125...
13	AT_RL_D...	formula6	RL_DDQN	5	1	2.100164	-0.32154...
14	AT_RL_D...	formula6	RL_DDQN	5	1	0.974323	-0.05940...
15	AT_RL_D...	formula6	RL_DDQN	5	1	0.926258	-0.19745...
16	AT_RL_D...	formula6	RL_DDQN	5	1	0.959459	-0.18991...
17	AT_RL_D...	formula6	RL_DDQN	5	1	1.046138	-0.28913...
18	AT_RL_D...	formula6	RL_DDQN	5	1	1.016451	-0.32756...
19	AT_RL_D...	formula6	RL_DDQN	5	1	0.975405	-0.19787...
20	AT_RL_D...	formula6	RL_DDQN	5	2	1.686532	-0.19487...

ATRLDDQNstformula6Time10

id	modelN...	expName	algoName	sampleT...	numEpis...	elapsed...	bestRob
Number	Categor...	Number	Categor...	Number	Number	Number	Number
id	modelNa...	expName	algoName	sampleTi...	numEpis...	elapsedT...	bestRob
1	AT_RL_D...	formula6	RL_DDQN	10	1	2.648423	-0.32024...
2	AT_RL_D...	formula6	RL_DDQN	10	2	2.212567	-0.31824...
3	AT_RL_D...	formula6	RL_DDQN	10	2	1.941967	-0.29114...
4	AT_RL_D...	formula6	RL_DDQN	10	1	0.903036	-0.22334...
5	AT_RL_D...	formula6	RL_DDQN	10	2	1.625846	-0.32058...
6	AT_RL_D...	formula6	RL_DDQN	10	1	0.861743	-0.31240...
7	AT_RL_D...	formula6	RL_DDQN	10	1	0.861221	-0.30233...
8	AT_RL_D...	formula6	RL_DDQN	10	1	0.848179	-0.31669...
9	AT_RL_D...	formula6	RL_DDQN	10	1	0.867745	-0.10370...
10	AT_RL_D...	formula6	RL_DDQN	10	1	0.845436	-0.16084...
11	AT_RL_D...	formula6	RL_DDQN	10	1	0.850342	-0.20009...
12	AT_RL_D...	formula6	RL_DDQN	10	1	0.891915	-0.29245...
13	AT_RL_D...	formula6	RL_DDQN	10	1	0.863139	-0.30085...
14	AT_RL_D...	formula6	RL_DDQN	10	1	0.844646	-0.20757...
15	AT_RL_D...	formula6	RL_DDQN	10	1	0.906562	-0.31123...
16	AT_RL_D...	formula6	RL_DDQN	10	2	1.572671	-0.14407...
17	AT_RL_D...	formula6	RL_DDQN	10	1	0.876719	-0.20710...
18	AT_RL_D...	formula6	RL_DDQN	10	1	0.853654	-0.31150...
19	AT_RL_D...	formula6	RL_DDQN	10	3	2.28792	-0.14367...
20	AT_RL_D...	formula6	RL_DDQN	10	1	0.870476	-0.29761...

Results Formula 7

ATRLDDQNstformula7Time1

id	modelN...	expName	algoName	sampleT...	numEpis...	elapsed...	bestRob
Number	Categor...	Number	Categor...	Number	Number	Number	Number
id	modelNa...	expName	algoName	sampleTi...	numEpis...	elapsedT...	bestRob
1	AT_RL_D...	formula7	RL_DDQN	1	2	3.669034	-0.05495...
2	AT_RL_D...	formula7	RL_DDQN	1	10	7.487424	-0.05239...
3	AT_RL_D...	formula7	RL_DDQN	1	1	0.912702	-0.35583...
4	AT_RL_D...	formula7	RL_DDQN	1	2	1.588007	-0.07115...
5	AT_RL_D...	formula7	RL_DDQN	1	9	6.25738	-0.00402...
6	AT_RL_D...	formula7	RL_DDQN	1	3	2.244648	-0.07662...
7	AT_RL_D...	formula7	RL_DDQN	1	1	0.883613	-0.05405...
8	AT_RL_D...	formula7	RL_DDQN	1	1	0.878294	-0.02741...
9	AT_RL_D...	formula7	RL_DDQN	1	1	0.852057	-0.15246...
10	AT_RL_D...	formula7	RL_DDQN	1	1	0.872524	-0.08144...
11	AT_RL_D...	formula7	RL_DDQN	1	1	0.84841	-0.01242...
12	AT_RL_D...	formula7	RL_DDQN	1	2	1.597203	-0.14125...
13	AT_RL_D...	formula7	RL_DDQN	1	7	4.86825	-0.10338...
14	AT_RL_D...	formula7	RL_DDQN	1	1	0.852205	-0.04793...
15	AT_RL_D...	formula7	RL_DDQN	1	1	0.867176	-0.15898...
16	AT_RL_D...	formula7	RL_DDQN	1	1	0.888851	-0.10500...
17	AT_RL_D...	formula7	RL_DDQN	1	1	0.884762	-0.21803...
18	AT_RL_D...	formula7	RL_DDQN	1	1	0.855301	-0.01114...
19	AT_RL_D...	formula7	RL_DDQN	1	2	1.581135	-0.15069...
20	AT_RL_D...	formula7	RL_DDQN	1	2	1.616077	-0.36415...

ATRLDDQNstformula7Time5

id	modelN...	expName	algoName	sampleT...	numEpis...	elapsed...	bestRob
Number	Categor...	Number	Categor...	Number	Number	Number	Number
id	modelNa...	expName	algoName	sampleTi...	numEpis...	elapsedT...	bestRob
1	AT_RL_D...	formula7	RL_DDQN	5	3	4.132166	-0.18181...
2	AT_RL_D...	formula7	RL_DDQN	5	2	1.691896	-0.30693...
3	AT_RL_D...	formula7	RL_DDQN	5	1	0.795161	-0.27422...
4	AT_RL_D...	formula7	RL_DDQN	5	1	0.695953	-0.21852...
5	AT_RL_D...	formula7	RL_DDQN	5	1	0.778887	-0.26236...
6	AT_RL_D...	formula7	RL_DDQN	5	1	0.726556	-0.12740...
7	AT_RL_D...	formula7	RL_DDQN	5	1	0.676383	-0.18580...
8	AT_RL_D...	formula7	RL_DDQN	5	1	0.668984	-0.35913...
9	AT_RL_D...	formula7	RL_DDQN	5	1	0.702323	-0.30228...
10	AT_RL_D...	formula7	RL_DDQN	5	1	0.677772	-0.16488...
11	AT_RL_D...	formula7	RL_DDQN	5	1	0.674875	-0.14826...
12	AT_RL_D...	formula7	RL_DDQN	5	1	0.715264	-0.29573...
13	AT_RL_D...	formula7	RL_DDQN	5	1	0.690757	-0.29184...
14	AT_RL_D...	formula7	RL_DDQN	5	2	1.246513	-0.18584...
15	AT_RL_D...	formula7	RL_DDQN	5	4	2.366313	-0.09153...
16	AT_RL_D...	formula7	RL_DDQN	5	1	0.723151	-0.37484...
17	AT_RL_D...	formula7	RL_DDQN	5	3	1.796113	-0.09825...
18	AT_RL_D...	formula7	RL_DDQN	5	2	1.27512	-0.09459...
19	AT_RL_D...	formula7	RL_DDQN	5	2	1.235056	-0.05272...
20	AT_RL_D...	formula7	RL_DDQN	5	1	0.707869	-0.21788...

ATRLDDQNstformula7Time10

id	modelN...	expName	algoName	sampleT...	numEpis...	elapsed...	bestRob
Number	Categor...	Number	Categor...	Number	Number	Number	Number
id	modelNa...	expName	algoName	sampleTi...	numEpis...	elapsedT...	bestRob
1	AT_RL_D...	formula7	RL_DDQN	10	1	2.476138	-0.36759...
2	AT_RL_D...	formula7	RL_DDQN	10	3	2.437016	-0.37195...
3	AT_RL_D...	formula7	RL_DDQN	10	1	1.027708	-0.08626...
4	AT_RL_D...	formula7	RL_DDQN	10	2	1.258408	-0.01578...
5	AT_RL_D...	formula7	RL_DDQN	10	1	0.711087	-0.15034...
6	AT_RL_D...	formula7	RL_DDQN	10	9	4.678023	-0.35749...
7	AT_RL_D...	formula7	RL_DDQN	10	1	0.667296	-0.40025...
8	AT_RL_D...	formula7	RL_DDQN	10	7	3.76249	-0.00992...
9	AT_RL_D...	formula7	RL_DDQN	10	1	0.662043	-0.24703...
10	AT_RL_D...	formula7	RL_DDQN	10	2	1.209252	-0.07026...
11	AT_RL_D...	formula7	RL_DDQN	10	4	2.239495	-0.11160...
12	AT_RL_D...	formula7	RL_DDQN	10	1	0.71725	-0.28919...
13	AT_RL_D...	formula7	RL_DDQN	10	1	0.663797	-0.21183...
14	AT_RL_D...	formula7	RL_DDQN	10	1	0.659905	-0.16045...
15	AT_RL_D...	formula7	RL_DDQN	10	2	1.226342	-0.28731...
16	AT_RL_D...	formula7	RL_DDQN	10	1	0.653988	-0.16540...
17	AT_RL_D...	formula7	RL_DDQN	10	1	0.661507	-0.36849...
18	AT_RL_D...	formula7	RL_DDQN	10	5	2.821992	-0.35272...
19	AT_RL_D...	formula7	RL_DDQN	10	2	1.377917	-0.07695...
20	AT_RL_D...	formula7	RL_DDQN	10	1	0.662288	-0.29095...

Results Formula 8

ATRLDDQNstformula8Time1

id	modelN...	expName	algoName	sampleT...	numEpis...	elapsed...	bestRob
Number	Categor...	Number	Categor...	Number	Number	Number	Number
id	modelNa...	expName	algoName	sampleTi...	numEpis...	elapsedT...	bestRob
1	AT_RL_D...	formula8	RL_DDQN	1	66	88.050396	-0.00037...
2	AT_RL_D...	formula8	RL_DDQN	1	192	367.560...	-0.00710...
3	AT_RL_D...	formula8	RL_DDQN	1	166	319.619...	-0.00662...
4	AT_RL_D...	formula8	RL_DDQN	1	136	275.357...	-0.00110...
5	AT_RL_D...	formula8	RL_DDQN	1	151	309.630...	-0.01057...
6	AT_RL_D...	formula8	RL_DDQN	1	105	188.918...	-0.01186...
7	AT_RL_D...	formula8	RL_DDQN	1	174	356.266...	-0.02071...
8	AT_RL_D...	formula8	RL_DDQN	1	200	422.672...	0.00157...
9	AT_RL_D...	formula8	RL_DDQN	1	140	251.142...	-0.00053...
10	AT_RL_D...	formula8	RL_DDQN	1	20	19.118341	-0.00269...
11	AT_RL_D...	formula8	RL_DDQN	1	99	146.239...	-0.00049...
12	AT_RL_D...	formula8	RL_DDQN	1	108	162.619...	-0.00349...
13	AT_RL_D...	formula8	RL_DDQN	1	200	331.911...	0.00150...
14	AT_RL_D...	formula8	RL_DDQN	1	94	136.64143	-0.00229...
15	AT_RL_D...	formula8	RL_DDQN	1	122	204.692...	-0.00107...
16	AT_RL_D...	formula8	RL_DDQN	1	94	148.847...	-0.00543...
17	AT_RL_D...	formula8	RL_DDQN	1	95	152.645...	-0.00684...
18	AT_RL_D...	formula8	RL_DDQN	1	116	202.05144	-0.00937...
19	AT_RL_D...	formula8	RL_DDQN	1	200	398.05787	0.00369...
20	AT_RL_D...	formula8	RL_DDQN	1	167	340.744...	-0.01273...

Contribution

Sudhanshu Mishra - 70%

Niskarsh Kumar - 30%

Github link: https://github.com/ghostktjMactavish/CS659_Project

Future Work

- Generate plots for the input signals that falsify the property.
- Fix A3C bug.
- Try to use Breach for Reward calculation and Falsification.
- Compare results with paper.

Due to the ongoing pandemic, it is becoming very difficult to work because of which the above points have not been completed.

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