Robust Multi-agent Coordination via Evolutionary Generation of Auxiliary Adversarial Attackers

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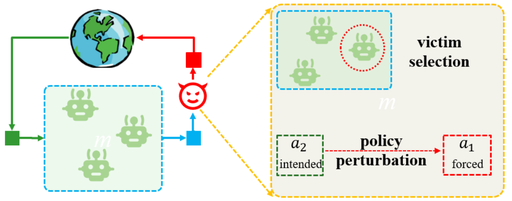
Introduction

Despite of promising potential of MARL, lack of robustness makes it difficult to be applied in the real world.

To solve a robust policy, we formalize LPA-Dec-POMDP and train a robust policy via evolutionary generation of attackers.



Method

Attacker Optimization Objective:

- minimize the reward of the ego-system
- sparsity prior regularization
- JSD diversity regularization

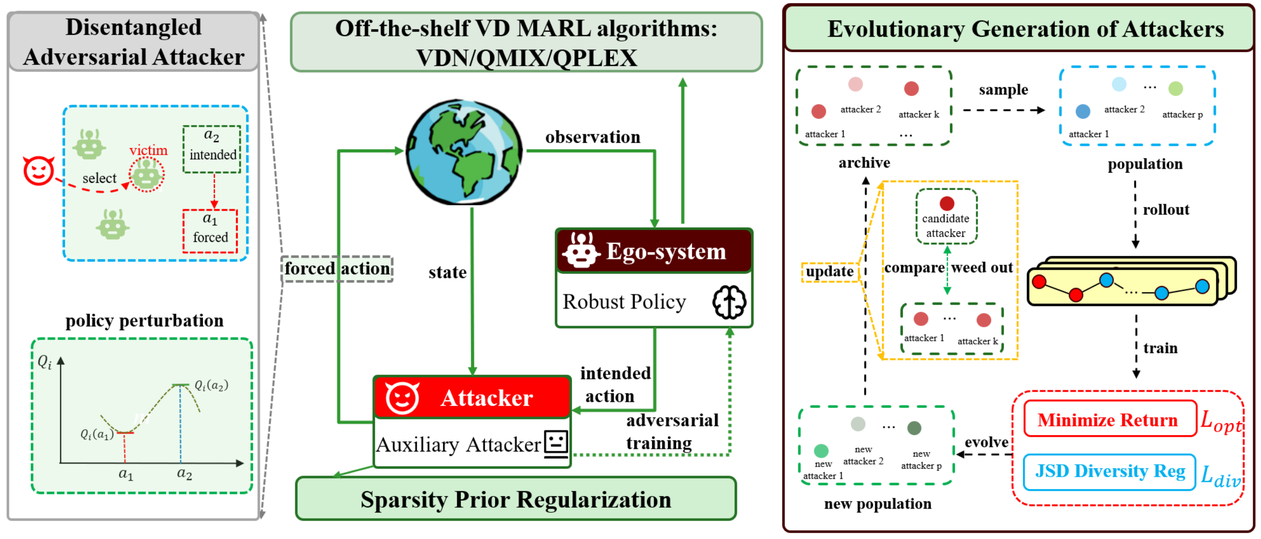
Attacker Population Generation:

- Quality-Diversity algorithm
- customized selection and update mechanism

Robustness Training Paradigm:

- application of any off-the-shelf MARL algorithm

Workflow

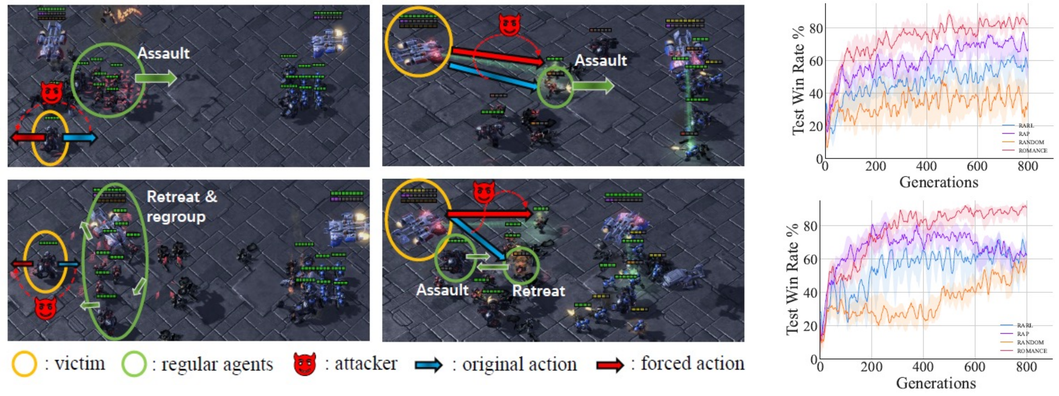


Experiments

Performance on different SMAC maps

Method	Map_Name	2s3z $K=8$	3m $K=4$	3s_vs_3z $K=8$	8m $K=5$	MMM $K=8$	1c3s5z $K=6$	+/−/≈
Natural	vanilla QMIX	92.8 ± 1.62	$\mathbf{97.9 \pm 1.02}$	98.3 ± 0.78	98.2 ± 0.45	95.8 ± 1.59	88.8 ± 2.13	1/1/4
	RARL	96.4 ± 1.19	86.0 ± 5.38	80.6 ± 27.5	95.3 ± 3.31	89.3 ± 7.01	76.9 ± 9.85	0/4/2
	RAP	$\mathbf{98.1 \pm 0.76}$	91.3 ± 4.93	$\mathbf{99.3 \pm 0.51}$	91.7 ± 7.96	95.3 ± 4.98	86.7 ± 10.5	0/1/5
	RANDOM	98.0 ± 0.60	95.3 ± 2.07	99.6 ± 0.35	$\mathbf{98.6 \pm 0.90}$	93.8 ± 7.56	93.1 ± 4.41	1/0/5
	ROMANCE	97.9 ± 1.34	96.0 ± 1.83	97.8 ± 1.78	94.3 ± 3.94	$\mathbf{97.1 \pm 1.49}$	$\mathbf{93.9 \pm 1.24}$	
Random Attack	vanilla QMIX	78.8 ± 1.28	$\mathbf{78.7 \pm 1.49}$	87.0 ± 0.36	66.2 ± 2.08	70.0 ± 3.97	66.6 ± 2.03	0/5/1
	RARL	84.3 ± 2.40	67.6 ± 5.01	70.1 ± 29.1	75.7 ± 7.00	62.2 ± 10.2	56.5 ± 10.8	0/5/1
	RAP	87.3 ± 1.87	73.5 ± 3.49	89.8 ± 4.81	$\mathbf{78.4 \pm 8.22}$	84.2 ± 9.05	66.8 ± 9.66	0/1/5
	RANDOM	83.9 ± 6.38	76.4 ± 2.27	91.9 ± 1.32	72.0 ± 3.46	72.9 ± 7.09	60.5 ± 21.3	0/2/4
	ROMANCE	$\mathbf{89.1 \pm 1.97}$	78.1 ± 5.13	$\mathbf{93.0 \pm 1.82}$	76.2 ± 5.36	$\mathbf{85.8 \pm 8.66}$	$\mathbf{77.9 \pm 1.96}$	
EGA	vanilla QMIX	26.7 ± 4.28	20.7 ± 2.13	30.9 ± 1.52	42.7 ± 9.79	37.9 ± 3.13	35.2 ± 8.66	0/6/0
	RARL	56.1 ± 11.8	86.1 ± 0.98	60.9 ± 14.2	66.3 ± 7.25	41.5 ± 11.6	35.3 ± 4.00	0/6/0
	RAP	64.1 ± 11.9	84.0 ± 4.27	65.1 ± 4.41	84.4 ± 8.88	74.9 ± 15.5	45.4 ± 6.83	0/4/2
	RANDOM	48.3 ± 17.3	66.2 ± 16.6	54.4 ± 7.83	55.6 ± 12.5	53.1 ± 6.09	43.3 ± 10.3	0/6/0
	ROMANCE	$\mathbf{81.6 \pm 0.84}$	$\mathbf{89.7 \pm 1.52}$	$\mathbf{90.5 \pm 1.97}$	$\mathbf{86.2 \pm 5.11}$	$\mathbf{84.0 \pm 11.5}$	$\mathbf{66.5 \pm 3.24}$	

Visualization Analysis



- Policy learned without ROMANCE ignores the emergent situation and still tries to assault when the attacked marauder is drawn away.
- Policy learned with ROMANCE learns to wait for the victim Marauder
- to regroup for efficient coordination.