

CSCI 166 Project Presentation

# A Comparison of DQN and Double DQN

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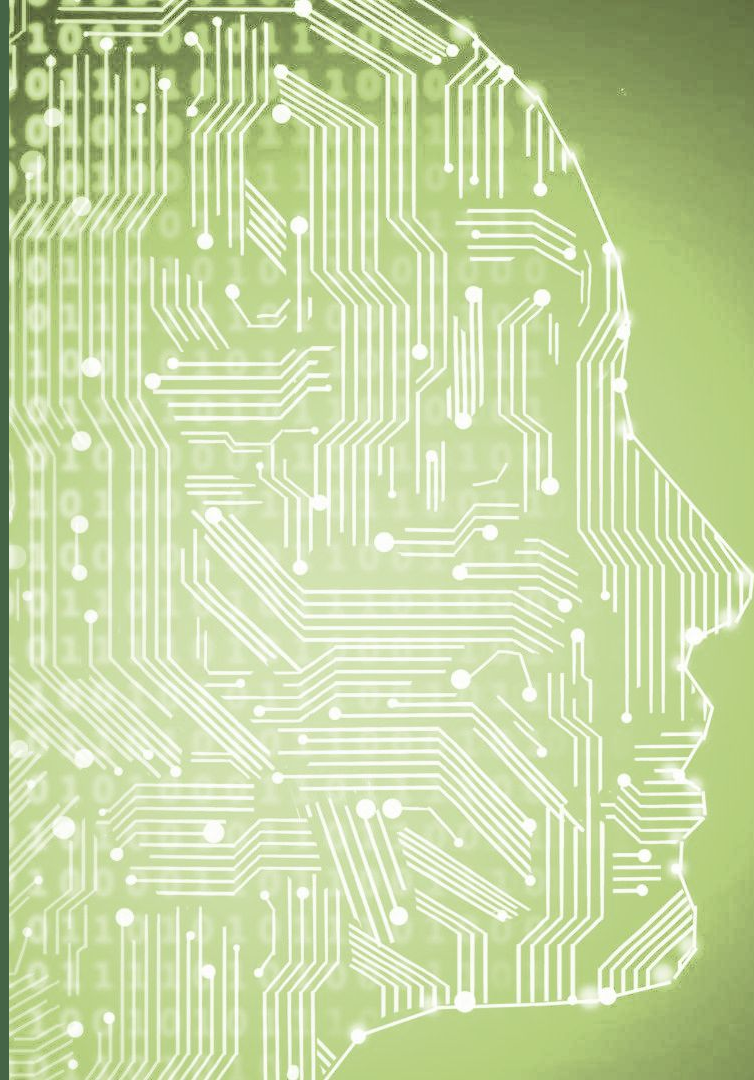
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Future Research

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# Introduction

- Who am I?
- Interest in this topic?
- Why this style of project?
- Any additions made beyond the model?
- Objective?



```
tgt_net = DQN(env.observation_space.shape, env.action_space.n).to(device)
writer = SummaryWriter(comment=f"--{env_name}-{model_comment}")
print(net)

# Experience replay buffer and agent
buffer = ExperienceBuffer(config["REPLAY_SIZE"])
agent = Agent(env, buffer)
epsilon = config["EPSILON_START"]

# Optimizer setup
optimizer = optim.Adam(net.parameters(), lr=config["LEARNING_RATE"])
total_rewards = []
frame_idx = 0
ts_frame = 0
ts = time.time()
best_m_reward = None

if USE_DOUBLE_DQN:
    model_name = "Double-DQN"
```

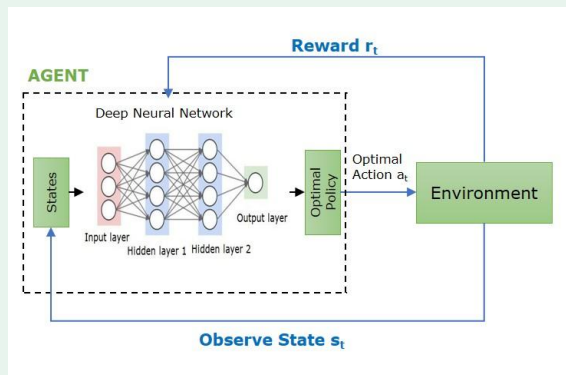
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# Objective

To simply compare and contrast DQN and Double DQN via experiments on two different games with varying complexities. Small changes to hyperparameters was the main focus, with observations on how they affected each variant, positively or negatively.

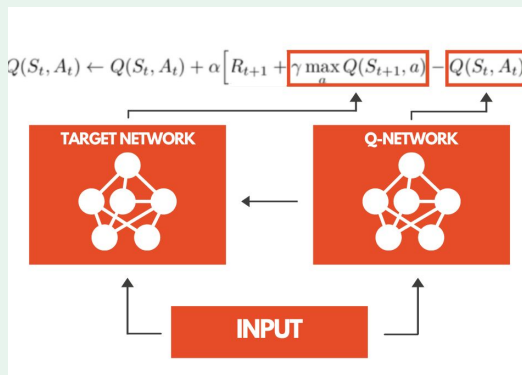
# Models

Selected a variant of DQN to compare.



## Deep Q-Network (DQN)

Original network, where Q states are calculated using a single online network, which is prone to overestimation and instability.



## Double Deep Q-Network

Corrects DQN's over estimated q states by decoupling actions and evaluation. It also removes maximization bias due to these two networks, leading to more stable data

## Comparison:

- Stability
- Learning Ability Across Environments
- Convergence capability
- Sensitivity to Hyperparameter changes
- Benefits due to said hyperparameter changes

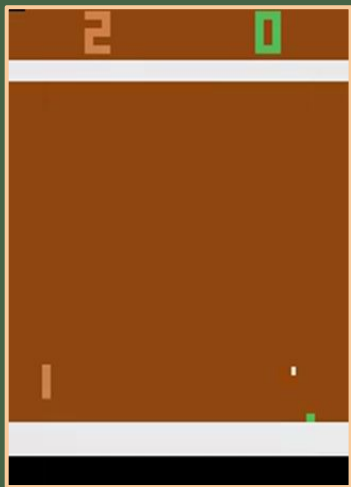
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# Domains



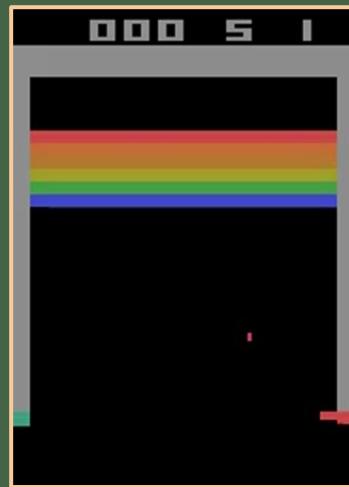
## Game: Pong-v5

Simple game requiring the model to learn how to not only prevent the ball from hitting their side but also deflect it to score a point



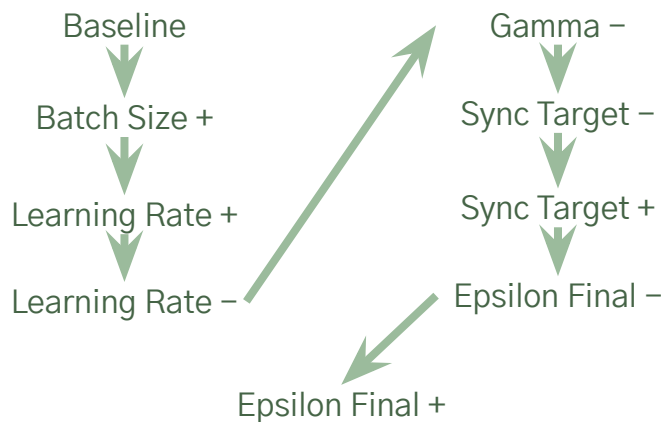
## Game: Breakout-v5

Similar to pong, but more sparadict due to ball's movement on broken blocks. This game was selected to add challenge.



# Hyper Parameters

During the experiments extra effort was put into helping the two models learn more efficiently and less sporadically. Though it was much harder to find agreeable changes that benefited mutually.



# Parameters Used

Version	Timestamp	Mean Reward Bound	Gamma	Batch Size	Replay Size	Learning Rate	Sync Target Frames	Replay Start Size	Save Epsilon	Epsilon Decay Last Frame	Epsilon Start	Epsilon Final	Notes
0	2025-11-24 07:20:24	19	0.99	32	10000	0.0001	1000	10000	0.5	150000	1	0.01	Baseline run
1	2025-11-24 08:46:48	19	0.99	64	10000	0.0001	1000	10000	0.5	150000	1	0.01	Increase stability, try to help the GPU
2	2025-11-24 10:56:18	19	0.99	32	10000	0.0002	1000	10000	0.5	150000	1	0.01	Increased Learning rate to encourage more aggressive learning
3	2025-11-24 15:07:35	19	0.99	32	10000	7e-05	1000	10000	0.5	150000	1	0.01	Decreased Learning rate to encourage more stable learning
4	2025-11-24 21:33:35	19	0.97	32	10000	0.0001	1000	10000	0.5	150000	1	0.01	Decreased gamma to prioritise more immediate rewards
5	2025-11-24 22:59:08	19	0.99	32	10000	0.0001	500	10000	0.5	150000	1	0.01	Decreased sync target frames to encourage more frequent updates
6	2025-11-25 05:17:38	19	0.99	32	10000	0.0001	1500	10000	0.5	150000	1	0.01	Increased sync target frames to encourage less frequent and more stable updates
7	2025-11-25 09:21:56	19	0.99	32	10000	0.0001	1000	10000	0.5	150000	1	0.005	Decrease epsilon final to make the agent greedier and less random
8	2025-11-25 10:46:36	19	0.99	32	10000	0.0001	1000	10000	0.5	150000	1	0.02	Increase epsilon final to make the agent less greedy and more random

# Testing

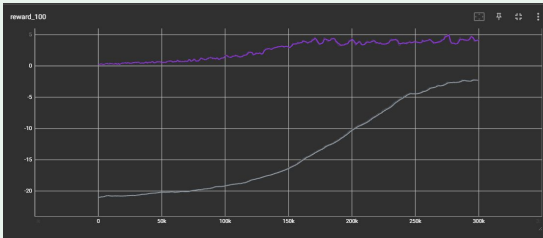
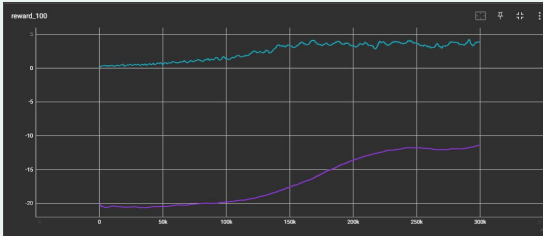
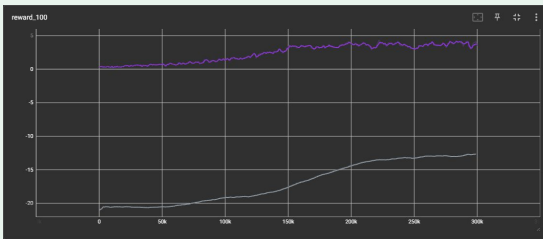
In the following page there will be a lot of data pertaining to Pong's learning process, we'll focus on:

- Benefits
- Losses
- Pitfalls
- The instability of the stable double-DQN

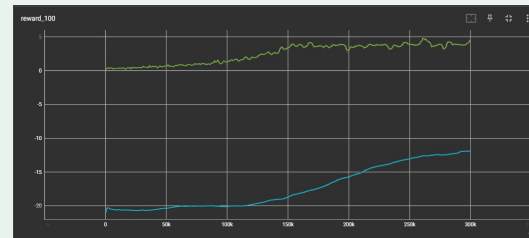
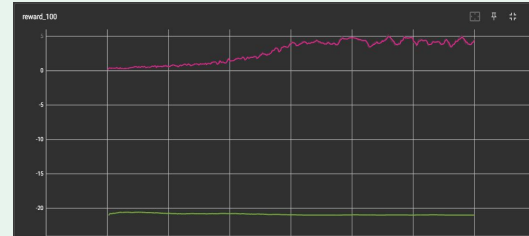
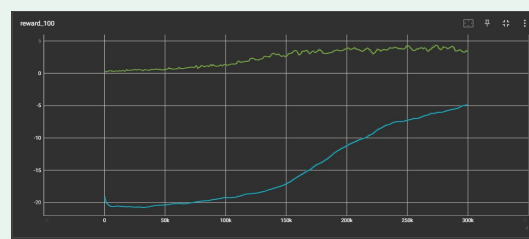
## Curve Graph Comparison

Showing key curve graphs, with the most interesting information

DQN



Double DQN





Output is truncated. View as a [scrollable element](#) or open in a [text editor](#). Adjust cell output settings.

Frame Index	model_name	Finished Games	Reward	Epsilon	Speed (f/s)	Elapsed Time (min)	timestamp
194	DQN	1	-21	0.998707	391.365	0.00822846	2025-11-24 07:20:25
4969	DQN	23	-20.4783	0.966873	405.314	0.239127	2025-11-24 07:20:39
74099	DQN	301	-19.97	0.506007	142.369	7.85781	2025-11-24 07:28:16
89857	DQN	351	-19.45	0.400953	140.955	9.70577	2025-11-24 07:30:07
120623	DQN	430	-18.92	0.195847	137.83	13.3607	2025-11-24 07:33:46
133516	DQN	457	-18.41	0.109893	137.586	14.9107	2025-11-24 07:35:19
144804	DQN	477	-17.89	0.03464	137.29	16.2808	2025-11-24 07:36:41
152931	DQN	489	-17.31	0.01	135.987	17.2679	2025-11-24 07:37:40
159799	DQN	499	-16.8	0.01	137.484	18.1032	2025-11-24 07:38:30
168960	DQN	513	-16.28	0.01	138.607	19.2154	2025-11-24 07:39:37
175891	DQN	523	-15.78	0.01	136.143	20.0627	2025-11-24 07:40:28
185268	DQN	536	-15.24	0.01	137.057	21.2076	2025-11-24 07:41:37
194730	DQN	548	-14.67	0.01	137.507	22.363	2025-11-24 07:42:46
204709	DQN	561	-14.12	0.01	136.544	23.5859	2025-11-24 07:43:59
215974	DQN	576	-13.61	0.01	138.854	24.9584	2025-11-24 07:45:22
254909	DQN	625	-13.06	0.01	136.345	29.6918	2025-11-24 07:50:06
249	Double DQN	1	-19	0.99834	377.123	0.0109711	2025-11-24 07:55:38
126678	Double DQN	444	-18.46	0.15548	130.01	15.0331	2025-11-24 08:10:39
136387	Double DQN	463	-17.95	0.0907533	128.879	16.2983	2025-11-24 08:11:55
145200	Double DQN	477	-17.41	0.032	116.711	17.4604	2025-11-24 08:13:05
151208	Double DQN	485	-16.88	0.01	124.727	18.272	2025-11-24 08:13:54
155866	Double DQN	491	-16.31	0.01	117.6	18.9045	2025-11-24 08:14:31
160704	Double DQN	497	-15.73	0.01	124.889	19.5559	2025-11-24 08:15:11
165921	Double DQN	503	-15.15	0.01	124.664	20.2553	2025-11-24 08:15:53
171111	Double DQN	509	-14.49	0.01	119.474	20.9684	2025-11-24 08:16:35
176117	Double DQN	515	-13.96	0.01	124.67	21.6482	2025-11-24 08:17:16
181340	Double DQN	521	-13.39	0.01	124.697	22.3422	2025-11-24 08:17:58
185585	Double DQN	526	-12.83	0.01	125.726	22.907	2025-11-24 08:18:32
188677	Double DQN	530	-12.25	0.01	108.12	23.344	2025-11-24 08:18:58
193649	Double DQN	536	-11.72	0.01	112.722	24.0834	2025-11-24 08:19:42
198966	Double DQN	542	-11.2	0.01	98.0234	24.9614	2025-11-24 08:20:35
204772	Double DQN	549	-10.64	0.01	117.857	25.807	2025-11-24 08:21:26
212382	Double DQN	558	-10.12	0.01	112.289	26.9075	2025-11-24 08:22:32
217423	Double DQN	564	-9.54	0.01	119.469	27.6347	2025-11-24 08:23:15
222591	Double DQN	570	-8.98	0.01	118.684	28.3586	2025-11-24 08:23:59
227239	Double DQN	575	-8.46	0.01	120.339	29.0097	2025-11-24 08:24:38
232535	Double DQN	581	-7.9	0.01	120.289	29.7515	2025-11-24 08:25:22
247369	Double DQN	599	-7.39	0.01	113.582	31.8396	2025-11-24 08:27:28
255673	Double DQN	608	-6.83	0.01	115.837	33.0414	2025-11-24 08:28:40
268239	Double DQN	621	-6.2	0.01	115.618	34.8437	2025-11-24 08:30:28
283385	Double DQN	637	-5.62	0.01	116.143	37.077	2025-11-24 08:32:42
293439	Double DQN	648	-5.07	0.01	105.695	38.5488	2025-11-24 08:34:10

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Frame Index	model_name	Finished Games	Reward	Epsilon	Speed (f/s)	Elapsed Time (min)	timestamp
254	DQN	1	-21	0.998307	362.79	0.0116356	2025-11-24 08:52:02
1147	DQN	5	-20.2	0.992353	366.274	0.0648015	2025-11-24 08:52:05
83494	DQN	325	-19.68	0.443373	110.599	10.9012	2025-11-24 09:02:55
98879	DQN	367	-19.14	0.340807	111.78	13.1686	2025-11-24 09:05:11
109310	DQN	393	-18.58	0.271267	113.012	14.7097	2025-11-24 09:06:44
118635	DQN	414	-18.07	0.2091	110.487	16.0951	2025-11-24 09:08:07
130175	DQN	438	-17.56	0.132167	97.2848	18.0522	2025-11-24 09:10:04
139463	DQN	455	-17.03	0.0702467	98.8048	19.625	2025-11-24 09:11:38
144516	DQN	463	-16.52	0.03656	96.99	20.4849	2025-11-24 09:12:30
151063	DQN	473	-15.99	0.01	88.5635	21.6198	2025-11-24 09:13:38
159526	DQN	486	-15.48	0.01	108.009	23.075	2025-11-24 09:15:05
167856	DQN	496	-14.97	0.01	108.131	24.3649	2025-11-24 09:16:23
177248	DQN	508	-14.44	0.01	105.828	25.8209	2025-11-24 09:17:50
185911	DQN	519	-13.88	0.01	107.274	27.1707	2025-11-24 09:19:11
192463	DQN	527	-13.35	0.01	107.029	28.1999	2025-11-24 09:20:13
201045	DQN	538	-12.82	0.01	107.559	29.5316	2025-11-24 09:21:33
210201	DQN	549	-12.31	0.01	107.339	30.9487	2025-11-24 09:22:58
219762	DQN	561	-11.79	0.01	107.82	32.4306	2025-11-24 09:24:27
226932	DQN	570	-11.27	0.01	107.643	33.5483	2025-11-24 09:25:34
236007	DQN	580	-10.75	0.01	106.976	34.9717	2025-11-24 09:26:59
242026	DQN	587	-10.24	0.01	107.301	35.9089	2025-11-24 09:27:56
251174	DQN	598	-9.69	0.01	107.028	37.3374	2025-11-24 09:29:21
272470	DQN	625	-9.16	0.01	107.089	40.6664	2025-11-24 09:32:41
293889	DQN	651	-8.6	0.01	106.994	44.0012	2025-11-24 09:36:01
211	Double DQN	1	-21	0.998593	367.938	0.00954115	2025-11-24 09:37:02
34937	Double DQN	156	-20.46	0.767087	110.31	4.13518	2025-11-24 09:41:10
70313	Double DQN	285	-19.94	0.531247	107.724	9.51843	2025-11-24 09:46:33
92536	Double DQN	352	-19.43	0.383093	108.251	12.9318	2025-11-24 09:49:58
102080	Double DQN	377	-18.91	0.319467	100.421	14.4636	2025-11-24 09:51:29
112447	Double DQN	403	-18.39	0.250353	96.938	16.1797	2025-11-24 09:53:12
119821	Double DQN	418	-17.84	0.201193	90.2388	17.525	2025-11-24 09:54:33
128301	Double DQN	434	-17.26	0.14466	77.0917	19.3969	2025-11-24 09:56:25
135100	Double DQN	446	-16.71	0.0993333	51.1304	21.8399	2025-11-24 09:58:52
141053	Double DQN	455	-16.13	0.0596467	50.9287	23.7744	2025-11-24 10:00:48
146880	Double DQN	463	-15.62	0.0308	56.3277	25.4725	2025-11-24 10:02:30
152066	Double DQN	470	-15.08	0.01	60.248	26.9306	2025-11-24 10:03:57
158257	Double DQN	479	-14.54	0.01	58.5886	28.6823	2025-11-24 10:05:43
163304	Double DQN	486	-14.02	0.01	59.0521	30.1065	2025-11-24 10:07:08
167026	Double DQN	490	-13.45	0.01	58.9479	31.1569	2025-11-24 10:08:11
171948	Double DQN	496	-12.91	0.01	59.5433	32.5416	2025-11-24 10:09:34
177172	Double DQN	502	-12.32	0.01	47.4764	34.2377	2025-11-24 10:11:16
182833	Double DQN	508	-11.76	0.01	55.4299	36.0704	2025-11-24 10:13:06
187664	Double DQN	513	-11.16	0.01	53.416	37.5992	2025-11-24 10:14:38
192846	Double DQN	519	-10.59	0.01	52.0527	39.2609	2025-11-24 10:16:17
196538	Double DQN	523	-10.03	0.01	48.8458	40.4686	2025-11-24 10:17:30
201089	Double DQN	528	-9.42	0.01	58.0427	41.9832	2025-11-24 10:19:01
206287	Double DQN	534	-8.89	0.01	59.4176	43.4576	2025-11-24 10:20:29
210869	Double DQN	539	-8.38	0.01	59.3242	44.7416	2025-11-24 10:21:46
218069	Double DQN	548	-7.88	0.01	59.5421	46.7622	2025-11-24 10:23:47
226668	Double DQN	558	-7.32	0.01	60.9225	49.1672	2025-11-24 10:26:12
238904	Double DQN	572	-6.78	0.01	59.9737	52.5959	2025-11-24 10:29:37
243399	Double DQN	577	-6.18	0.01	59.3604	53.8545	2025-11-24 10:30:53
259124	Double DQN	597	-5.66	0.01	59.3966	58.2935	2025-11-24 10:35:19

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Frame Index	model_name	Finished Games	Reward	Epsilon	Speed (f/s)	Elapsed Time (min)	timestamp
230	DQN	1	-20	0.998467	250.451	0.0152725	2025-11-24 10:58:13
115540	DQN	427	-19.48	0.229733	82.9073	20.9134	2025-11-24 11:19:07
126397	DQN	451	-18.96	0.157353	78.0606	23.1595	2025-11-24 11:21:22
136967	DQN	470	-18.4	0.086867	78.7169	25.3775	2025-11-24 11:23:35
144953	DQN	483	-17.87	0.0336467	76.6022	27.0965	2025-11-24 11:25:18
151861	DQN	492	-17.36	0.01	62.9092	28.7079	2025-11-24 11:26:55
160472	DQN	503	-16.79	0.01	65.5512	30.8926	2025-11-24 11:29:06
168210	DQN	513	-16.23	0.01	67.7452	32.839	2025-11-24 11:31:03
173805	DQN	520	-15.67	0.01	75.6557	34.1116	2025-11-24 11:32:19
179067	DQN	526	-15.1	0.01	76.0853	35.2837	2025-11-24 11:33:29
186987	DQN	535	-14.52	0.01	74.6161	37.0475	2025-11-24 11:35:15
193865	DQN	543	-14.01	0.01	74.6927	38.5858	2025-11-24 11:36:48
200804	DQN	551	-13.47	0.01	76.2634	40.1294	2025-11-24 11:38:20
210136	DQN	562	-12.93	0.01	76.1042	42.2167	2025-11-24 11:40:25
220758	DQN	575	-12.4	0.01	74.8354	44.5886	2025-11-24 11:42:48
238920	DQN	596	-11.84	0.01	74.7182	48.6357	2025-11-24 11:46:51
299310	DQN	668	-11.32	0.01	74.5822	62.1178	2025-11-24 12:00:20
232	Double DQN	1	-21	0.998453	333.889	0.0115474	2025-11-24 12:00:35

Output is truncated. View as a [scrollable element](#) or open in a [text editor](#). Adjust cell output [settings...](#)

Frame Index	model_name	Finished Games	Reward	Epsilon	Speed (f/s)	Elapsed Time (min)	timestamp
208	DQN	1	-21	0.998613	321.103	0.0107527	2025-11-24 15:08:18
40185	DQN	181	-20.49	0.7321	78.0788	6.44773	2025-11-24 15:14:44
72966	DQN	310	-19.96	0.51356	70.4063	14.2218	2025-11-24 15:22:31
105711	DQN	415	-19.47	0.29526	65.3976	21.8887	2025-11-24 15:30:11
122817	DQN	463	-18.95	0.18122	126.126	25.8162	2025-11-24 15:34:06
134167	DQN	489	-18.44	0.105553	129.954	27.2892	2025-11-24 15:35:35
148912	DQN	519	-17.89	0.01	128.222	29.1924	2025-11-24 15:37:29
157988	DQN	534	-17.36	0.01	129.129	30.3675	2025-11-24 15:38:40
167678	DQN	548	-16.81	0.01	129.018	31.6244	2025-11-24 15:39:55
179261	DQN	566	-16.29	0.01	129.17	33.1266	2025-11-24 15:41:25
188733	DQN	580	-15.72	0.01	129.846	34.3519	2025-11-24 15:42:39
199412	DQN	596	-15.2	0.01	128.762	35.732	2025-11-24 15:44:01
208944	DQN	610	-14.65	0.01	128.771	36.9659	2025-11-24 15:45:15
217477	DQN	621	-14.07	0.01	127.567	38.0742	2025-11-24 15:46:22
226483	DQN	632	-13.55	0.01	128.451	39.2418	2025-11-24 15:47:32
236508	DQN	643	-13.01	0.01	127.576	40.5373	2025-11-24 15:48:50
244284	DQN	652	-12.41	0.01	129.072	41.5415	2025-11-24 15:49:50
254669	DQN	664	-11.85	0.01	128.073	42.8862	2025-11-24 15:51:11
261223	DQN	672	-11.32	0.01	128.915	43.7344	2025-11-24 15:52:02
273976	DQN	687	-10.73	0.01	129.878	45.3806	2025-11-24 15:53:40
283457	DQN	698	-10.17	0.01	129.419	46.6031	2025-11-24 15:54:54
292467	DQN	708	-9.63	0.01	129.587	47.7848	2025-11-24 15:56:05
299261	DQN	715	-9.09	0.01	128.844	48.666	2025-11-24 15:56:57
290	Double DQN	1	-19	0.998067	374.71	0.0128823	2025-11-24 15:57:08
137009	Double DQN	485	-18.47	0.0866067	119.721	17.2206	2025-11-24 16:14:21
148458	Double DQN	506	-17.96	0.01028	118.686	18.82	2025-11-24 16:15:57
161141	Double DQN	527	-17.44	0.01	118.235	20.6006	2025-11-24 16:17:44
176008	Double DQN	552	-16.85	0.01	118.434	22.6887	2025-11-24 16:19:49
191072	Double DQN	577	-16.3	0.01	118.766	24.8105	2025-11-24 16:21:56
234303	Double DQN	638	-15.73	0.01	119.006	30.8786	2025-11-24 16:28:00
262225	Double DQN	673	-15.14	0.01	118.234	34.7956	2025-11-24 16:31:55
275450	Double DQN	689	-14.56	0.01	119.137	36.6508	2025-11-24 16:33:47
282160	Double DQN	697	-14.03	0.01	119.102	37.59	2025-11-24 16:34:43

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Frame Index	model_name	Finished Games	Reward	Epsilon	Speed (f/s)	Elapsed Time (min)	timestamp
242	DQN	1	-19	0.998387	376.797	0.0106715	2025-11-24 21:33:50
130359	DQN	455	-18.46	0.13094	130.529	15.1468	2025-11-24 21:48:58
138438	DQN	469	-17.93	0.07708	130.385	16.1784	2025-11-24 21:50:00
145176	DQN	479	-17.4	0.03216	130.646	17.0422	2025-11-24 21:50:52
151770	DQN	488	-16.84	0.01	129.142	17.896	2025-11-24 21:51:43
158927	DQN	497	-16.3	0.01	130.056	18.8223	2025-11-24 21:52:39
165744	DQN	506	-15.79	0.01	129.578	19.7039	2025-11-24 21:53:32
170976	DQN	512	-15.27	0.01	129.835	20.3781	2025-11-24 21:54:12
179148	DQN	523	-14.74	0.01	129.317	21.4377	2025-11-24 21:55:16
187457	DQN	533	-14.2	0.01	129.115	22.5122	2025-11-24 21:56:20
195900	DQN	543	-13.68	0.01	128.393	23.6045	2025-11-24 21:57:26
205532	DQN	554	-13.09	0.01	129.705	24.8481	2025-11-24 21:58:40
215469	DQN	566	-12.58	0.01	128.99	26.1319	2025-11-24 21:59:57
228203	DQN	581	-12.06	0.01	128.979	27.776	2025-11-24 22:01:36
245866	DQN	601	-11.53	0.01	128.813	30.0591	2025-11-24 22:03:53
261080	DQN	618	-11	0.01	129.98	32.0197	2025-11-24 22:05:51
279385	DQN	640	-10.48	0.01	128.379	34.3823	2025-11-24 22:08:12
291434	DQN	653	-9.94	0.01	129.017	35.9382	2025-11-24 22:09:46
207	Double DQN	1	-21	0.99862	389.017	0.00883528	2025-11-24 22:10:57
1130	Double DQN	5	-20.4	0.992467	402.152	0.0644899	2025-11-24 22:11:00
90169	Double DQN	363	-19.89	0.398873	125.544	10.7937	2025-11-24 22:21:44
105551	Double DQN	408	-19.38	0.296327	124.65	12.851	2025-11-24 22:23:47
118087	Double DQN	440	-18.85	0.212753	122.376	14.547	2025-11-24 22:25:29
134038	Double DQN	474	-18.29	0.106413	122.323	16.7299	2025-11-24 22:27:40
141702	Double DQN	487	-17.74	0.05532	121.232	17.7864	2025-11-24 22:28:43
152574	Double DQN	505	-17.18	0.01	118.279	19.3015	2025-11-24 22:30:14
159853	Double DQN	516	-16.67	0.01	119.124	20.3178	2025-11-24 22:31:15
165861	Double DQN	525	-16.13	0.01	119.987	21.156	2025-11-24 22:32:05
175725	Double DQN	540	-15.56	0.01	119.386	22.5336	2025-11-24 22:33:28
182757	Double DQN	549	-14.98	0.01	120.414	23.5121	2025-11-24 22:34:27
192872	Double DQN	562	-14.4	0.01	119.995	24.9185	2025-11-24 22:35:51
200355	Double DQN	573	-13.85	0.01	119.369	25.9635	2025-11-24 22:36:54
214843	Double DQN	590	-13.28	0.01	120.38	27.9796	2025-11-24 22:38:55
228554	Double DQN	607	-12.77	0.01	120.237	29.8925	2025-11-24 22:40:50
245438	Double DQN	626	-12.26	0.01	120.337	32.2451	2025-11-24 22:43:11
268642	Double DQN	653	-11.7	0.01	119.574	35.4733	2025-11-24 22:46:24
282473	Double DQN	669	-11.12	0.01	101.862	37.5328	2025-11-24 22:48:28
290087	Double DQN	677	-10.57	0.01	112.407	38.6934	2025-11-24 22:49:38
299531	Double DQN	687	-10.06	0.01	113.79	40.0967	2025-11-24 22:51:02

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Frame Index	model_name	Finished Games	Reward	Epsilon	Speed (f/s)	Elapsed Time (min)	timestamp
189	DQN	1	-21	0.99874	297.179	0.0105662	2025-11-24 23:00:00
671	DQN	3	-20.3333	0.995527	296.12	0.0605899	2025-11-24 23:00:03
101642	DQN	397	-19.83	0.322387	70.9643	20.8674	2025-11-24 23:20:52
122094	DQN	446	-19.32	0.18604	68.9396	25.7835	2025-11-24 23:25:47
132269	DQN	467	-18.81	0.118207	61.3768	28.3432	2025-11-24 23:28:20
139095	DQN	478	-18.29	0.0727	65.3811	30.141	2025-11-24 23:30:08
146732	DQN	489	-17.78	0.0217867	61.8566	32.098	2025-11-24 23:32:06
153851	DQN	499	-17.23	0.01	60.3133	34.076	2025-11-24 23:34:00
160333	DQN	508	-16.68	0.01	61.3567	35.8449	2025-11-24 23:35:50
168598	DQN	519	-16.12	0.01	61.1329	38.0938	2025-11-24 23:38:05
177946	DQN	532	-15.6	0.01	62.8268	40.4986	2025-11-24 23:40:30
185336	DQN	541	-15.07	0.01	72.9504	42.2236	2025-11-24 23:42:13
193999	DQN	552	-14.5	0.01	126.835	44.1247	2025-11-24 23:44:07
201698	DQN	561	-13.97	0.01	127.335	45.1506	2025-11-24 23:45:09
220035	DQN	585	-13.44	0.01	128.985	47.5164	2025-11-24 23:47:31
252432	DQN	624	-12.91	0.01	123.646	51.7122	2025-11-24 23:51:42
299859	DQN	681	-12.4	0.01	128.779	57.8387	2025-11-24 23:57:50
189	Double DQN	1	-21	0.99874	377.479	0.00831158	2025-11-24 23:57:57
429	Double DQN	2	-20	0.99714	159.323	0.0334178	2025-11-24 23:57:59
110095	Double DQN	434	-19.49	0.266033	123.315	13.4367	2025-11-25 00:11:23
124134	Double DQN	472	-18.98	0.17244	121.685	15.3395	2025-11-25 00:13:17
136079	Double DQN	500	-18.47	0.0928067	121.42	16.9735	2025-11-25 00:14:55
147216	Double DQN	522	-17.95	0.01856	120.361	18.5103	2025-11-25 00:16:27
157284	Double DQN	540	-17.44	0.01	120.818	19.9063	2025-11-25 00:17:51
166591	Double DQN	555	-16.92	0.01	120.728	21.1986	2025-11-25 00:19:09
173989	Double DQN	568	-16.4	0.01	119.464	22.2261	2025-11-25 00:20:20
183906	Double DQN	583	-15.86	0.01	118.438	23.6032	2025-11-25 00:21:33
197985	Double DQN	604	-15.33	0.01	120.639	25.5591	2025-11-25 00:23:30
216629	Double DQN	632	-14.8	0.01	119.686	28.1477	2025-11-25 00:26:06
236247	Double DQN	660	-14.25	0.01	121.131	30.8695	2025-11-25 00:28:49
254430	Double DQN	684	-13.67	0.01	118.947	33.9958	2025-11-25 00:31:20
267877	Double DQN	702	-13.14	0.01	119.709	35.2636	2025-11-25 00:33:12
277973	Double DQN	715	-12.63	0.01	120.118	36.6646	2025-11-25 00:34:37
285902	Double DQN	725	-12.1	0.01	120.552	37.7646	2025-11-25 00:35:43
296051	Double DQN	738	-11.52	0.01	120.201	39.173	2025-11-25 00:37:07

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Frame Index	model_name	Finished Games	Retard	Epsilon	Speed (f/s)	Elapsed Time (min)	timestamp
239	DQN	1	-21	0.998407	377.368	0.0105223	2025-11-25 05:18:14
44369	DQN	197	-20.49	0.704207	136.538	4.61749	2025-11-25 05:22:50
87250	DQN	351	-19.96	0.418333	130.737	9.9647	2025-11-25 05:28:11
101263	DQN	390	-19.42	0.324913	131.425	11.7479	2025-11-25 05:29:58
111371	DQN	416	-18.86	0.257527	130.585	13.0494	2025-11-25 05:31:16
124731	DQN	446	-18.34	0.16846	128.151	14.7823	2025-11-25 05:33:00
136722	DQN	468	-17.81	0.08852	126.687	16.3563	2025-11-25 05:34:35
146138	DQN	482	-17.3	0.0257467	126.895	17.5994	2025-11-25 05:35:49
156012	DQN	495	-16.79	0.01	125.857	18.9117	2025-11-25 05:37:08
162012	DQN	502	-16.28	0.01	125.468	19.7092	2025-11-25 05:37:56
170721	DQN	513	-15.75	0.01	121.789	20.8679	2025-11-25 05:39:06
180397	DQN	525	-15.21	0.01	125.425	22.1556	2025-11-25 05:40:23
187590	DQN	533	-14.66	0.01	122.961	23.1228	2025-11-25 05:41:21
194411	DQN	541	-14.15	0.01	122.1	24.0437	2025-11-25 05:42:16
200677	DQN	548	-13.63	0.01	125.473	24.8826	2025-11-25 05:43:06
205208	DQN	553	-13.09	0.01	125.52	25.4868	2025-11-25 05:43:43
211898	DQN	561	-12.54	0.01	126.048	26.3753	2025-11-25 05:44:36
219823	DQN	569	-11.89	0.01	125.381	27.3228	2025-11-25 05:45:33
228631	DQN	580	-11.31	0.01	125.644	28.5991	2025-11-25 05:46:49
236164	DQN	588	-10.75	0.01	126.159	29.5988	2025-11-25 05:47:49
240816	DQN	593	-10.17	0.01	125.684	30.2216	2025-11-25 05:48:27
246993	DQN	599	-9.57	0.01	125.644	31.0417	2025-11-25 05:49:16
254880	DQN	607	-8.87	0.01	125.323	32.0902	2025-11-25 05:50:19
263943	DQN	618	-8.33	0.01	125.615	33.2952	2025-11-25 05:51:31
268649	DQN	623	-7.69	0.01	125.173	33.9181	2025-11-25 05:52:09
279029	DQN	634	-7.18	0.01	126.294	35.2981	2025-11-25 05:53:31
284949	DQN	639	-6.44	0.01	123.681	36.0158	2025-11-25 05:54:14
289911	DQN	644	-5.87	0.01	125.997	36.7433	2025-11-25 05:54:58
292768	DQN	647	-5.36	0.01	125.185	37.1239	2025-11-25 05:55:21
229	Double DQN	1	-20	0.998473	383.947	0.0099736	2025-11-25 05:56:23
102404	Double DQN	389	-19.46	0.317307	122.311	12.4786	2025-11-25 06:08:51
113030	Double DQN	415	-18.92	0.246467	123.538	13.9243	2025-11-25 06:10:18
122396	Double DQN	436	-18.39	0.184027	120.967	15.2139	2025-11-25 06:11:35
131926	Double DQN	455	-17.8	0.120493	120.165	16.5386	2025-11-25 06:12:55
139823	Double DQN	469	-17.29	0.0678467	119.405	17.6329	2025-11-25 06:14:01
146000	Double DQN	478	-16.75	0.0266667	119.627	18.5018	2025-11-25 06:14:53
152531	Double DQN	488	-16.21	0.01	117.991	19.4246	2025-11-25 06:15:48
160422	Double DQN	499	-15.65	0.01	118.261	20.5388	2025-11-25 06:16:55
166389	Double DQN	507	-15.14	0.01	118.022	21.3817	2025-11-25 06:17:45
173680	Double DQN	517	-14.61	0.01	118.068	22.4096	2025-11-25 06:18:47
181832	Double DQN	529	-14.06	0.01	118.168	23.5559	2025-11-25 06:19:56
187463	Double DQN	537	-13.55	0.01	118.339	24.3491	2025-11-25 06:20:43
193409	Double DQN	545	-13.03	0.01	117.171	25.1901	2025-11-25 06:21:34
201639	Double DQN	556	-12.46	0.01	118.058	26.3494	2025-11-25 06:22:43
206291	Double DQN	562	-11.84	0.01	117.111	27.0048	2025-11-25 06:23:23
211178	Double DQN	568	-11.29	0.01	117.038	27.6939	2025-11-25 06:24:04
217899	Double DQN	578	-10.78	0.01	118.689	28.8638	2025-11-25 06:25:01
226974	Double DQN	590	-10.24	0.01	118.1	29.9325	2025-11-25 06:26:18
236015	Double DQN	601	-9.59	0.01	115.308	31.2087	2025-11-25 06:27:35
246624	Double DQN	613	-9.07	0.01	118.607	32.7049	2025-11-25 06:29:05
251192	Double DQN	618	-8.54	0.01	119.921	33.3481	2025-11-25 06:29:43
258482	Double DQN	627	-7.99	0.01	118.45	34.7367	2025-11-25 06:30:45
271442	Double DQN	643	-7.31	0.01	117.529	36.2076	2025-11-25 06:32:35
279502	Double DQN	652	-6.79	0.01	119.092	37.3344	2025-11-25 06:33:43

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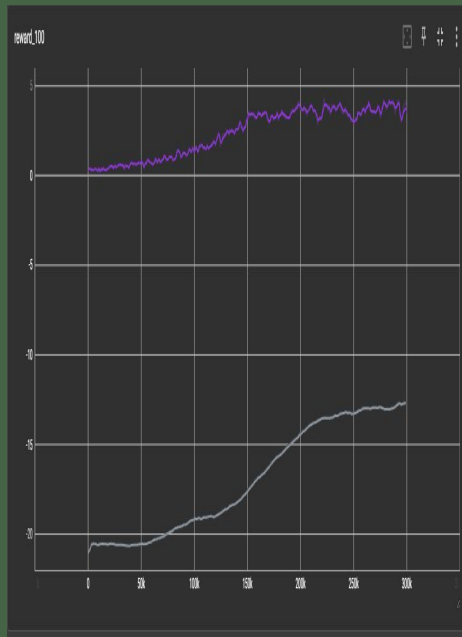
Frame Index	model_name	Finished Games	Retard	Epsilon	Speed (f/s)	Elapsed Time (min)	timestamp
189	DQN	1	-21	0.99874	332.699	0.00943478	2025-11-25 09:22:08
37194	DQN	167	-20.49	0.75204	139.999	3.69616	2025-11-25 09:25:49
72388	DQN	296	-19.96	0.517413	134.917	7.99413	2025-11-25 09:30:07
90428	DQN	352	-19.42	0.397147	132.317	10.2515	2025-11-25 09:32:22
106163	DQN	394	-18.88	0.292247	131.333	12.2452	2025-11-25 09:34:22
118894	DQN	424	-18.32	0.207053	129.74	13.8861	2025-11-25 09:36:00
128233	DQN	444	-17.81	0.145113	124.704	15.0877	2025-11-25 09:37:12
137574	DQN	461	-17.28	0.08284	125.615	16.3103	2025-11-25 09:38:26
145153	DQN	474	-16.73	0.0323133	126.709	17.3104	2025-11-25 09:39:26
150872	DQN	482	-16.15	0.005	125.228	18.0649	2025-11-25 09:40:11
156553	DQN	490	-15.6	0.005	126.41	18.8146	2025-11-25 09:40:56
160608	DQN	494	-15.04	0.005	125.623	19.2815	2025-11-25 09:41:24
164288	DQN	499	-14.49	0.005	125.363	19.8403	2025-11-25 09:41:57
169994	DQN	506	-13.88	0.005	124.581	20.5981	2025-11-25 09:42:43
174910	DQN	512	-13.33	0.005	126.138	21.2502	2025-11-25 09:43:22
178868	DQN	517	-12.78	0.005	125.802	21.7745	2025-11-25 09:43:54
185646	DQN	525	-12.2	0.005	126.622	22.6706	2025-11-25 09:44:47
189975	DQN	530	-11.69	0.005	126.142	23.2423	2025-11-25 09:45:22
193884	DQN	535	-11.06	0.005	126.122	23.7586	2025-11-25 09:45:53
197680	DQN	539	-10.39	0.005	125.171	24.2633	2025-11-25 09:46:23
202311	DQN	544	-9.82	0.005	126.818	24.8802	2025-11-25 09:47:00
208180	DQN	550	-9.25	0.005	126.317	25.6568	2025-11-25 09:47:46
212785	DQN	555	-8.69	0.005	126.263	26.2679	2025-11-25 09:48:23
216202	DQN	559	-8.17	0.005	126.459	26.7188	2025-11-25 09:48:50
220649	DQN	564	-7.61	0.005	126.261	27.3705	2025-11-25 09:49:26
224909	DQN	569	-7.02	0.005	127.022	27.8704	2025-11-25 09:49:59
230209	DQN	574	-6.41	0.005	126.362	28.5739	2025-11-25 09:50:42
233117	DQN	577	-5.85	0.005	124.184	28.9615	2025-11-25 09:51:05
237430	DQN	582	-5.24	0.005	125.795	29.5319	2025-11-25 09:51:39
242019	DQN	587	-4.71	0.005	125.299	30.1415	2025-11-25 09:52:16
245474	DQN	590	-4.13	0.005	126.408	31.819	2025-11-25 09:53:56
260450	DQN	606	-3.6	0.005	126.421	32.5774	2025-11-25 09:54:42
266940	DQN	613	-3.09	0.005	126.872	33.4358	2025-11-25 09:55:33
275674	DQN	622	-2.56	0.005	121.151	34.6545	2025-11-25 09:56:46
201	Double DQN	1	-21	0.99866	396.62	0.00841312	2025-11-25 10:00:09
975	Double DQN	4	-20	0.9935	378.816	0.0573402	2025-11-25 10:00:12
128626	Double DQN	485	-19.48	0.142493	122.046	16.1259	2025-11-25 10:16:16
145893	Double DQN	522	-18.94	0.02738	120.227	18.5465	2025-11-25 10:18:41
152760	Double DQN	533	-18.42	0.005	117.174	19.5185	2025-11-25 10:19:39
163832	Double DQN	550	-17.88	0.005	118.224	21.0821	2025-11-25 10:21:13
174610	Double DQN	565	-17.34	0.005	117.488	22.6038	2025-11-25 10:22:44
182045	Double DQN	575	-16.83	0.005	116.901	23.6523	2025-11-25 10:23:47
188453	Double DQN	583	-16.32	0.005	118.735	24.5555	2025-11-25 10:24:42
196562	Double DQN	594	-15.81	0.005	118.424	25.6938	2025-11-25 10:25:50
205641	Double DQN	606	-15.3	0.005	118.847	26.9726	2025-11-25 10:27:07
211999	Double DQN	613	-14.77	0.005	115.976	27.8726	2025-11-25 10:28:01
219659	Double DQN	623	-14.26	0.005	117.245	28.9621	2025-11-25 10:29:06
233582	Double DQN	638	-13.75	0.005	119.121	30.9461	2025-11-25 10:31:05
243101	Double DQN	648	-13.21	0.005	119.316	32.2925	2025-11-25 10:32:26
258051	Double DQN	666	-12.66	0.005	118.19	34.4061	2025-11-25 10:34:33
289283	Double DQN	702	-12.14	0.005	118.367	38.8066	2025-11-25 10:38:57

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Frame Index	model_name	Finished Games	Retard	Epsilon	Speed (f/s)	Elapsed Time (min)	timestamp
189	DQN	1	-21	0.99874	380.871	0.00820402	2025-11-25 10:47:03
61833	DQN	265	-20.47	0.58778	137.333	6.96032	2025-11-25 10:54:00
100114	DQN	392	-19.96	0.332573	129.474	11.7678	2025-11-25 10:58:49
116585	DQN	434	-19.45	0.222767	129.398	13.8876	2025-11-25 11:00:56
128836	DQN	459	-18.9	0.141093	128.055	15.4816	2025-11-25 11:02:32
137404	DQN	473	-18.38	0.0839733	128.203	16.601	2025-11-25 11:03:39
147576	DQN	487	-17.81	0.02	125.607	17.9413	2025-11-25 11:04:59
157230	DQN	501	-17.29	0.02	125.57	19.2158	2025-11-25 11:06:16
169478	DQN	518	-16.74	0.02	124.988	20.8374	2025-11-25 11:07:53
177483	DQN	529	-16.2	0.02	126.296	21.8959	2025-11-25 11:08:56
183915	DQN	537	-15.69	0.02	126.217	22.744	2025-11-25 11:09:47
192616	DQN	548	-15.15	0.02	125.772	23.8968	2025-11-25 11:10:56
207896	DQN	568	-14.63	0.02	127.781	25.9151	2025-11-25 11:12:58
226643	DQN	593	-14.12	0.02	127.015	28.3706	2025-11-25 11:15:25
235464	DQN	604	-13.59	0.02	126.134	29.5603	2025-11-25 11:16:36
248422	DQN	620	-13.07	0.02	125.095	31.2771	2025-11-25 11:18:19
279055	DQN	659	-12.56	0.02	126.333	35.3259	2025-11-25 11:22:22
294072	DQN	677	-12.01	0.02	127.425	37.3085	2025-11-25 11:

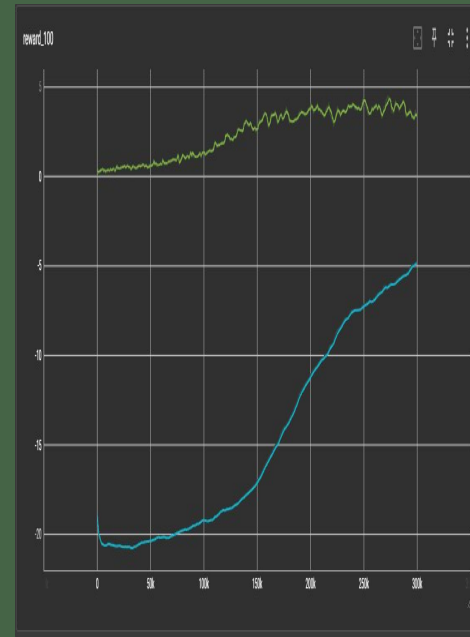
# Results

- DQN's innate instability and ease of adjustment
- Double-DQN's stability, but sensitivity and difficulty improving
  - Wants more data
  - Better suited for this use
- Notable: Double-DQN still learned on configuration 2, but only on breakout



DQN Baseline

Worse off on initial settings, comes down to a plateau after the 150,00 frame mark



Double-DQN Baseline

Exponential learning, began to learn more after the 150,000 mark.



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# Conclusion

It is important to examine a model's sensitivity and capability when it comes to changes to hyperparameters. It allows one to understand their strengths and weaknesses, and ultimately their place in this changing field.

- Key Takeaway?
- What the results mean
  - Preference for newer variants of DQN
- The specific importance

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# Future Research



If I had more time:

- Run till convergence for each hyperparameter
- Implement Prioritized Replay
- Organize everything more similarly