Designing Architecture in a Bridge Engineering Simulation

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I. APPENDIX

A. Solution to Bridge Designer Environment

Unfortunately, the agent never converged on a solution for the bridge environment. This may be due in part to the 8192 max step limit on the episodes since the average episode length was 8192. Given more steps to explore, the agent could theoretically converge on a solution.

With the actions given as a $(nx7)$ matrix with n being the number of steps taken, an example solution of $n = 19$ with the actions:

$$\begin{bmatrix} 0 & 0 & 8 & 16 & 0 & 0 & 18 \\ 0 & 0 & 16 & 0 & 0 & 0 & 18 \\ 16 & 0 & 8 & 16 & 0 & 0 & 18 \\ 16 & 0 & 24 & 16 & 0 & 0 & 18 \\ 32 & 0 & 24 & 16 & 0 & 0 & 18 \\ 16 & 0 & 32 & 0 & 0 & 0 & 18 \\ 32 & 0 & 48 & 0 & 0 & 0 & 18 \\ 32 & 0 & 40 & 16 & 0 & 0 & 18 \\ 48 & 0 & 40 & 16 & 0 & 0 & 18 \\ 48 & 0 & 64 & 0 & 0 & 0 & 18 \\ 48 & 0 & 56 & 16 & 0 & 0 & 18 \\ 64 & 0 & 56 & 16 & 0 & 0 & 18 \\ 64 & 0 & 80 & 0 & 0 & 0 & 18 \\ 64 & 0 & 72 & 16 & 0 & 0 & 18 \\ 80 & 0 & 72 & 16 & 0 & 0 & 18 \\ 56 & 16 & 72 & 16 & 0 & 0 & 18 \\ 56 & 16 & 40 & 16 & 0 & 0 & 18 \\ 24 & 16 & 40 & 16 & 0 & 0 & 18 \\ 24 & 16 & 8 & 16 & 0 & 0 & 18 \end{bmatrix} \tag{1}$$

Then the Bridge is valid and the final reward is 2.7122.

TABLE I
APPENDIX - RUN STATISTICS

Obs	α	algo	seed	mean_rew	episodic_rew	train/approx_kl	train/entropy_loss	train/loss	train/value_loss
AdjObs	1	ppo	1497417522	-16384.0	-16082.80	1.26E-08	-4.534	7.01E-05	1.55E-04
AdjObs	1	ppo	3528720904	-16384.0	-10585.22	7.68E-09	-12.817	1.71E-04	3.65E-04
AdjObs	1	ppo	3026993240	-9012.7	**-7958.06**	1.00E-08	-9.858	4.75E-05	1.10E-04
AdjObs	1	ppo	2857969666	**-9012.4**	-11758.44	-6.98E-10	-4.263	1.83E-06	8.37E-06
AdjObs	1	ppo	756588678	-16384.0	-16385.14	-1.16E-09	-3.618	-7.02E-06	3.42E-08
AdjObs	1	ppo	66582418	-16384.0	-21220.35	8.38E-09	-4.023	8.32E-04	1.68E-03
AdjObs	-1	ppo	829447930	-16384.0	-16884.71	7.92E-09	-8.310	5.17E-05	1.18E-04
AdjObs	-1	ppo	1908241932	-16384.0	-16325.64	9.55E-09	-5.512	-5.34E-06	1.65E-06
AdjObs	-1	ppo	3210849873	-16384.0	-16384.38	6.75E-09	-5.094	-6.79E-06	5.65E-10
AdjObs	-1	ppo	1599268616	-16384.0	-16206.95	6.75E-09	-5.288	4.77E-06	1.91E-05
AdjObs	-1	ppo	4077572109	-11469.4	-10745.08	-4.42E-09	-2.485	1.05E+03	2.11E+03
AdjObs	-1	ppo	2545173757	-16384.0	-16385.52	1.02E-08	-6.608	-7.08E-06	9.58E-07
VecObsV1	1	ppo	532999799	-16384.0	-16384.00	0.00E+00	-0.300	0.00E+00	0.00E+00
VecObsV1	1	ppo	2820390773	-16384.0	-16384.00	-8.85E-09	-2.285	0.00E+00	0.00E+00
VecObsV1	1	ppo	61211071	-16384.0	-16385.66	8.85E-09	-6.536	-3.05E-06	1.13E-09
VecObsV1	1	ppo	2658117924	-16384.0	-16384.00	-2.10E-09	-6.969	0.00E+00	0.00E+00
VecObsV1	1	ppo	3722767945	-16384.0	-13283.58	3.49E-09	-10.755	2.21E-01	4.63E-01
VecObsV1	1	ppo	1883391423	-16384.0	-16384.00	-5.36E-09	-1.018	0.00E+00	0.00E+00
VecObsV1	-1	ppo	2847337578	-16384.0	-16384.00	0.00E+00	-0.005	0.00E+00	0.00E+00
VecObsV1	-1	ppo	2474332305	-16384.0	-16384.00	-1.63E-09	-6.413	0.00E+00	0.00E+00
VecObsV1	-1	ppo	4272333764	-16384.0	-16384.00	4.89E-09	-3.537	0.00E+00	0.00E+00
VecObsV1	-1	ppo	304827749	-16384.0	-16384.00	0.00E+00	-0.009	0.00E+00	0.00E+00
VecObsV1	-1	ppo	2132369049	-16384.0	-16384.00	3.26E-09	-7.163	0.00E+00	0.00E+00
VecObsV1	-1	ppo	4294742478	-16384.0	-16384.00	-3.49E-09	-9.130	0.00E+00	0.00E+00
VecObsV2	1	ppo	3635993121	-16384.0	-16384.00	-1.86E-09	-5.937	0.00E+00	0.00E+00
VecObsV2	1	ppo	3599319458	-16384.0	-16384.00	-6.98E-10	-8.251	0.00E+00	0.00E+00
VecObsV2	1	ppo	840901171	-16384.0	-16384.00	4.66E-09	-0.205	0.00E+00	0.00E+00
VecObsV2	1	ppo	220275371	-16384.0	-16384.00	6.98E-10	-1.877	0.00E+00	0.00E+00
VecObsV2	1	ppo	684520700	-16384.0	-16980.39	6.75E-09	-1.595	-1.12E-06	1.92E-10
VecObsV2	1	ppo	3316950902	-16384.0	-16384.00	-2.33E-10	-4.809	0.00E+00	0.00E+00
VecObsV2	-1	ppo	2548248853	-16384.0	-16384.00	1.37E-08	-2.422	-1.68E-06	7.86E-10
VecObsV2	-1	ppo	3136551905	-16384.0	-16384.00	3.73E-09	-4.391	0.00E+00	0.00E+00
VecObsV2	-1	ppo	517495998	-16384.0	-16384.00	-1.40E-09	-2.127	0.00E+00	0.00E+00
VecObsV2	-1	ppo	3890044289	-16384.0	-16387.42	7.22E-09	-8.555	-3.33E-06	2.42E-06
VecObsV2	-1	ppo	3538788142	-16384.0	-16385.90	9.31E-10	-4.783	0.00E+00	0.00E+00
VecObsV2	-1	ppo	1069666362	-16384.0	-16384.00	-3.73E-09	-0.637	0.00E+00	0.00E+00
AdjObs	1	ppo_lstm	3374119961	-16384.0	-14708.67	1.42E-08	-17.213	6.29E-03	1.27E-02
AdjObs	1	ppo_lstm	2168929252	-16384.0	-16350.22	8.38E-09	-9.603	-8.02E-06	2.09E-07
AdjObs	1	ppo_lstm	1708474877	-16384.0	-15888.29	3.49E-09	-22.372	4.22E-05	9.06E-05
AdjObs	1	ppo_lstm	2697239928	-16384.0	-16430.36	1.02E-08	-3.117	2.15E-06	3.31E-06
AdjObs	1	ppo_lstm	172131212	-16384.0	-16433.27	2.00E-08	-18.171	4.32E-03	8.93E-03
AdjObs	1	ppo_lstm	1271866869	-16384.0	-16569.67	3.73E-08	-18.580	6.98E-03	1.40E-02
AdjObs	-1	ppo_lstm	2200260195	-16384.0	-16293.97	1.12E-08	-17.567	5.56E-06	3.04E-05
AdjObs	-1	ppo_lstm	3770174836	-16384.0	-16329.84	1.23E-08	-13.807	8.43E-06	1.12E-05
AdjObs	-1	ppo_lstm	1675554950	-16384.0	-16227.62	8.61E-09	-21.208	-1.08E-06	6.66E-06
AdjObs	-1	ppo_lstm	578776622	-16384.0	-16400.87	1.00E-08	-6.074	-6.48E-06	2.64E-07
AdjObs	-1	ppo_lstm	1657949699	-16384.0	-16356.28	6.29E-04	-19.630	-5.94E-03	7.26E-05
AdjObs	-1	ppo_lstm	1467813143	-16384.0	-16402.89	8.15E-09	-3.245	-4.02E-06	9.47E-07
VecObsV1	1	ppo_lstm	3286812339	-16384.0	-16384.00	0.00E+00	-0.001	-5.10E-08	6.33E-07
VecObsV1	1	ppo_lstm	230896848	-16384.0	-16384.38	9.31E-10	-0.007	-1.90E-07	3.34E-07
VecObsV1	1	ppo_lstm	2297730412	-16384.0	-16388.56	0.00E+00	-0.004	4.33E-07	9.86E-07
VecObsV1	1	ppo_lstm	3949475661	-16384.0	-16384.00	0.00E+00	0.000	3.33E-07	1.04E-06
VecObsV1	1	ppo_lstm	1410117962	-16384.0	-16384.38	0.00E+00	-0.001	3.36E-07	1.00E-06
VecObsV1	1	ppo_lstm	2484067290	-16384.0	-16384.00	0.00E+00	-0.001	5.34E-07	9.27E-07
VecObsV1	-1	ppo_lstm	2161761117	-16384.0	-16384.00	0.00E+00	0.000	1.53E-07	4.69E-07
VecObsV1	-1	ppo_lstm	4068033983	-16384.0	-16384.00	0.00E+00	-0.005	4.27E-07	6.41E-07
VecObsV1	-1	ppo_lstm	1935360868	-16384.0	-16384.00	0.00E+00	-0.004	2.65E-07	9.45E-07
VecObsV1	-1	ppo_lstm	1752038016	-16384.0	-16384.00	0.00E+00	0.000	3.06E-07	1.06E-06
VecObsV1	-1	ppo_lstm	2281892720	-16384.0	-16384.00	0.00E+00	0.000	2.97E-07	3.22E-07
VecObsV1	-1	ppo_lstm	3850064069	-16384.0	-16384.00	0.00E+00	-0.001	3.59E-07	4.59E-07
VecObsV2	1	ppo_lstm	3180619897	-16384.0	-15925.11	1.05E-08	-18.929	-7.32E-06	1.61E-06
VecObsV2	1	ppo_lstm	1997675385	-16384.0	-16156.37	8.38E-09	-22.683	-7.65E-06	1.51E-06
VecObsV2	1	ppo_lstm	4184977383	-16384.0	-15853.15	3.96E-09	-12.949	2.24E-05	5.55E-05
VecObsV2	1	ppo_lstm	3323696426	-16384.0	-16000.52	5.12E-09	-20.601	1.02E-04	2.16E-04
VecObsV2	1	ppo_lstm	144139434	-16384.0	-15748.68	2.33E-09	-13.214	6.79E-02	1.36E-01
VecObsV2	1	ppo_lstm	1602759657	-16384.0	-16384.76	3.26E-09	-1.652	-3.93E-06	3.15E-07
VecObsV2	-1	ppo_lstm	99422966	-16384.0	-16339.41	7.68E-09	-6.341	1.11E-04	2.36E-04
VecObsV2	-1	ppo_lstm	2029324098	-16384.0	-16498.59	7.03E-02	-12.453	-8.99E-02	1.47E-05
VecObsV2	-1	ppo_lstm	1119934951	-16384.0	-16362.52	1.28E-08	-19.123	1.10E-04	2.35E-04
VecObsV2	-1	ppo_lstm	300775496	-16384.0	-16427.04	6.52E-09	-16.018	-7.09E-06	4.02E-07
VecObsV2	-1	ppo_lstm	1042314717	-16384.0	-16347.22	1.12E-08	-12.604	3.53E-06	1.65E-05
VecObsV2	-1	ppo_lstm	1352295779	-16384.0	-16384.38	8.15E-09	-1.480	-3.40E-07	9.85E-07

TABLE II
APPENDIX - RUN TIMES

Obs	α	algo	n_timesteps	runtime (secs)	time/fps	episode_len
AdjObs	1	ppo	2,000,000	80579	24	8126.14
AdjObs	1	ppo	2,000,000	99553	20	8192.00
AdjObs	1	ppo	2,000,000	119942	16	8192.00
AdjObs	1	ppo	2,000,000	166234	12	8192.00
AdjObs	1	ppo	2,000,000	80039	24	8192.00
AdjObs	1	ppo	2,000,000	98504	20	8192.00
AdjObs	-1	ppo	2,000,000	84208	23	8192.00
AdjObs	-1	ppo	2,000,000	78401	25	8192.00
AdjObs	-1	ppo	2,000,000	75158	26	8192.00
AdjObs	-1	ppo	2,000,000	78333	25	8192.00
AdjObs	-1	ppo	2,000,000	169422	11	8192.00
AdjObs	-1	ppo	2,000,000	76961	25	8192.00
VecObsV1	1	ppo	2,000,000	6824	294	8192.00
VecObsV1	1	ppo	2,000,000	7222	277	8192.00
VecObsV1	1	ppo	2,000,000	7161	280	8192.00
VecObsV1	1	ppo	2,000,000	7536	266	8192.00
VecObsV1	1	ppo	2,000,000	15124	132	8192.00
VecObsV1	1	ppo	2,000,000	7177	279	8192.00
VecObsV1	-1	ppo	2,000,000	7155	280	8192.00
VecObsV1	-1	ppo	2,000,000	7229	277	8192.00
VecObsV1	-1	ppo	2,000,000	7137	281	8192.00
VecObsV1	-1	ppo	2,000,000	7168	279	8192.00
VecObsV1	-1	ppo	2,000,000	7147	280	8192.00
VecObsV1	-1	ppo	2,000,000	7125	281	8192.00
VecObsV2	1	ppo	2,000,000	7252	276	8192.00
VecObsV2	1	ppo	2,000,000	7207	278	8192.00
VecObsV2	1	ppo	2,000,000	9763	205	8192.00
VecObsV2	1	ppo	2,000,000	7188	279	8192.00
VecObsV2	1	ppo	2,000,000	9464	211	8192.00
VecObsV2	1	ppo	2,000,000	11094	180	8192.00
VecObsV2	-1	ppo	2,000,000	11395	175	8192.00
VecObsV2	-1	ppo	2,000,000	7248	276	8192.00
VecObsV2	-1	ppo	2,000,000	7166	279	8192.00
VecObsV2	-1	ppo	2,000,000	7239	277	8192.00
VecObsV2	-1	ppo	2,000,000	7011	286	8192.00
VecObsV2	-1	ppo	2,000,000	6774	**296**	8192.00
AdjObs	1	ppo_lstm	2,000,000	90503	22	**7864.98**
AdjObs	1	ppo_lstm	2,000,000	86015	23	8147.08
AdjObs	1	ppo_lstm	2,000,000	90623	22	8192.00
AdjObs	1	ppo_lstm	2,000,000	84810	23	8192.00
AdjObs	1	ppo_lstm	2,000,000	85353	23	8185.17
AdjObs	1	ppo_lstm	2,000,000	89590	22	8137.06
AdjObs	-1	ppo_lstm	2,000,000	85564	23	8096.83
AdjObs	-1	ppo_lstm	2,000,000	84673	23	8152.59
AdjObs	-1	ppo_lstm	2,000,000	84640	23	8042.19
AdjObs	-1	ppo_lstm	2,000,000	84366	23	8190.18
AdjObs	-1	ppo_lstm	2,000,000	79952	22	8192.00
AdjObs	-1	ppo_lstm	2,000,000	83405	23	8191.26
VecObsV1	1	ppo_lstm	2,000,000	9173	218	8192.00
VecObsV1	1	ppo_lstm	2,000,000	9113	220	8192.00
VecObsV1	1	ppo_lstm	2,000,000	8966	223	8192.00
VecObsV1	1	ppo_lstm	2,000,000	8917	224	8192.00
VecObsV1	1	ppo_lstm	2,000,000	8966	223	8192.00
VecObsV1	1	ppo_lstm	2,000,000	8994	222	8192.00
VecObsV1	-1	ppo_lstm	2,000,000	9044	221	8192.00
VecObsV1	-1	ppo_lstm	2,000,000	9376	213	8192.00
VecObsV1	-1	ppo_lstm	2,000,000	8995	222	8192.00
VecObsV1	-1	ppo_lstm	2,000,000	8929	224	8192.00
VecObsV1	-1	ppo_lstm	2,000,000	9130	219	8192.00
VecObsV1	-1	ppo_lstm	2,000,000	9565	209	8192.00
VecObsV2	1	ppo_lstm	2,000,000	10448	191	8192.00
VecObsV2	1	ppo_lstm	2,000,000	10653	188	8192.00
VecObsV2	1	ppo_lstm	2,000,000	13669	146	8192.00
VecObsV2	1	ppo_lstm	2,000,000	10605	188	8192.00
VecObsV2	1	ppo_lstm	2,000,000	12381	161	8192.00
VecObsV2	1	ppo_lstm	2,000,000	9697	206	8192.00
VecObsV2	-1	ppo_lstm	2,000,000	9633	208	8152.80
VecObsV2	-1	ppo_lstm	2,000,000	3387	174	8173.45
VecObsV2	-1	ppo_lstm	2,000,000	10595	189	8192.00
VecObsV2	-1	ppo_lstm	2,000,000	9872	203	8192.00
VecObsV2	-1	ppo_lstm	2,000,000	12216	164	8192.00
VecObsV2	-1	ppo_lstm	2,000,000 -	9221	217	8192.00