

Designing Architecture in a Bridge Engineering Simulation

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I. APPENDIX

A. Solution to Bridge Designer Environment

With the actions given as a $(n \times 7)$ matrix with n being the number of steps taken, an example solution of $n = 19$ with the actions:

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

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	3180619997	-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