

Fast and Flexible Multivariate Time Series Subsequence Search (supplemental material)

Kanishka Bhaduri

MCT Inc., NASA Ames Research Center

Kanishka.Bhaduri-1@nasa.gov

Qiang Zhu

Dept of CS, UC Riverside

qzhu@cs.ucr.edu

Nikunj C. Oza, Ashok N. Srivastava

NASA Ames Research Center

{Nikunj.C.Oza, Ashok.N.Srivastava}@nasa.gov

Data set	Variable Number	Thresholds		
		ϵ_1	ϵ_2	ϵ_3
CMAPSS $ D =6875$ $d=16$ $L=32,640,967$	2	100	300	500
	4	1	5	10
	5	0.5	1	2
	6	50	100	200
	8	0.02	0.04	2
	15	0.1	0.5	1
	18	0.1	1	5
	20	0.01	0.02	0.03
	22	0.2	0.5	5
	23	0.3	0.5	0.8
	24	5	20	40
	25	0.2	0.5	1
	26	0.0001	0.0005	0.001
	27	2	5	10
28	5	10	20	
29	0.5	1	2	
CarrierX $ D =3573$ $d = 9$ $L=22,207,852$	6	10	15	20
	7	10	30	50
	8	1500	2500	3500
	23	2	4	6
	27	100	500	1000
	28	1000	1500	4000
	29	100	300	500
	30	10	50	100
38	2	3	3.5	

TABLE I
 THRESHOLDS FOR THE VARIABLES OF CMAPSS AND CARRIERX DATASET.

Queryid	Cand ₁		Cand ₂		Cand ₁₂		C_{exact}	ϵ -NN	Prune rate ρ		Selectivity
	<i>LBS</i>	<i>RBS</i>	<i>LBS</i>	<i>RBS</i>	<i>LBS</i>	<i>RBS</i>			<i>LBS</i>	<i>RBS</i>	
CMAPSS											
1: (25, 27, 4)	18409	3007594	738	2477549	52	801400	6	6	0.9999	0.9741	1.94E-07
	81409	3263815	7567	2565309	2668	1003839	17	10	0.9999	0.9675	3.24E-07
	251981	3841664	81330	2702600	23694	1454776	540	297	0.9992	0.9529	9.62E-06
2: (20, 29, 5)	53585	870835	14969	2390063	1411	266022	252	6	0.9999	0.9914	1.94E-07
	179850	1295644	50502	2454707	13862	481096	1187	17	0.9995	0.9844	5.5E-07
	317793	1587719	141444	2633060	58905	633137	20124	259	0.9981	0.9795	8.38E-06
3: (5, 15, 28)	528470	4753958	14725	306706	6171	290593	453	8	0.9998	0.9906	2.59E-07
	1137522	4861533	87236	425813	63690	399972	16289	121	0.9979	0.9871	3.92E-06
	2115994	5101127	177992	550198	174391	536022	79332	1445	0.9944	0.9826	4.68E-05
4: (26, 5, 27)	1311	2013861	57144	3655449	344	86193	5	3	0.9999	0.9972	9.71E-08
	34492	2143905	193974	3894274	8034	194616	2060	337	0.9997	0.9937	1.09E-05
	115350	2317163	501207	4634240	38648	609697	22034	6471	0.9987	0.9803	2.1E-04
5: (5, 23, 2)	101344	4010042	74609	878140	12945	114419	18	9	0.9996	0.9963	2.91E-07
	316085	4101886	164881	1160134	49908	203004	332	49	0.9983	0.9934	1.59E-06
	771259	4356479	337201	1521911	150020	375037	4925	479	0.9951	0.9879	1.55E-05
6: (25, 8, 29)	46363	4595228	65	65	6	42	1	1	0.9999	0.9999	3.24E-08
	136769	7170465	261	261	52	167	5	4	0.9999	0.9999	1.29E-07
	289679	8944548	516822	531722	36888	224944	34979	6629	0.9988	0.9927	2.15E-04
7: (20, 6, 18)	37923	18427275	242	242	69	242	2	1	0.9999	0.9999	3.238E-08
	84171	18427275	1079	1079	687	1079	13	2	0.9999	0.9999	6.48E-08
	130210	18427275	4646	4645	3448	4645	111	26	0.9999	0.9998	8.42E-07
8: (8, 22, 5)	19559	50252	34212	64041	887	2632	874	834	0.9999	0.9999	2.7E-05
	38348	63990	78755	103926	1755	3510	1719	1661	0.9999	0.9999	5.38E-05
	1179944	1191783	891693	931116	32036	33524	31043	30614	0.9989	0.9989	9.91E-04
9: (20, 6, 24)	108326	18408391	199040	209990	3709	209990	3556	781	0.9999	0.9932	2.535E-05
	228466	18410910	297370	312592	29111	312592	28526	5571	0.9999	0.9898	1.8E-04
	415718	18417837	426340	450151	159481	450151	156717	11316	0.9948	0.9854	3.67E-04

TABLE II

RESULTS OF *LBS* AND *RBS* ON CMAPSS DATASET FOR TEN DIFFERENT QUERIES AND THREE DIFFERENT THRESHOLDS PER QUERY. FOR BOTH *LBS* AND *RBS*, THE PRUNE RATES ARE ALWAYS GREATER THAN 0.95, SIGNIFYING THAT LESS THAN 5% OF THE CANDIDATES NEED TO BE RETRIEVED FROM THE MTS DATABASE FOR EXACT CALCULATIONS. *LBS* HAS HIGHER PRUNE RATE COMPARED TO *RBS*.

Queryid	Cand ₁		Cand ₂		Cand ₁₂		C_{exact}	ϵ -NN	Prune rate ρ		Selectivity
	<i>LBS</i>	<i>RBS</i>	<i>LBS</i>	<i>RBS</i>	<i>LBS</i>	<i>RBS</i>			<i>LBS</i>	<i>RBS</i>	
CarrierX											
1: (29, 23, 28)	26235	469928	55610	530788	96	10226	3	3	0.9999	0.9995	1.41E-07
	79606	523225	204310	716418	952	14391	15	15	0.9999	0.9993	7.04E-07
	133451	583050	374437	896063	2640	20771	27	27	0.9998	0.999	1.27E-06
2: (8, 28, 27)	17338	1120516	16541	74930	450	26361	3	1	0.9999	0.9987	4.7E-08
	48149	1174920	62316	267710	3595	92246	7	3	0.9998	0.9957	1.41E-07
	83177	1218440	1577348	3028623	54214	754404	885	9	0.9974	0.9645	4.22E-07
3: (38, 8, 29)	935844	870535	223138	391564	71342	94594	12318	7	0.9966	0.9955	3.29E-07
	1500995	1369274	379346	555599	175800	213822	48395	64	0.9917	0.9899	3.01E-06
	1760160	1564834	527712	705614	277017	313020	102401	269	0.9869	0.9853	1.26E-05
4: (6, 27, 30)	22039	2164753	13866	901583	71	402047	10	10	0.9999	0.9811	4.69E-07
	103096	2289089	156448	1033504	2204	477704	30	30	0.9998	0.9775	1.41E-06
	213954	2429383	351061	1196446	9408	568003	48	48	0.9995	0.9733	2.25E-06
5: (6, 23, 7)	132658	3226264	17382	107330	243	21878	3	3	0.9999	0.999	1.41E-07
	239896	3368141	41273	129643	943	29617	9	9	0.9999	0.9986	4.22E-07
	352457	3496672	64210	152530	2392	36236	13	13	0.9998	0.9983	6.1E-07
6: (28, 8, 29)	1298247	2671533	184660	1649628	76445	476399	47559	2	0.9964	0.9776	9.39E-08
	1947774	3368141	205164	129643	105286	29617	78467	125	0.9951	0.9986	5.87E-06
	5161965	6417365	227501	1735525	168155	972349	136137	882	0.9921	0.9543	4.14E-05
7: (6, 38, 29)	2162	2740368	118088	167122	34	19971	3	3	0.9999	0.9991	1.41E-07
	6426	2842737	325728	261789	216	31024	5	5	0.9999	0.9985	2.35E-07
	13157	2940138	455551	319138	546	39280	5	5	0.9999	0.9982	2.35E-07
8: (8, 30, 23)	3516	1642906	5166	817047	5	150366	1	1	0.9999	0.9929	4.7E-08
	10245	1673070	221569	1211830	222	213286	19	9	0.9999	0.99	4.22E-07
	21134	1723769	645819	1712652	1332	294626	98	13	0.9999	0.9862	6.1E-07
9: (7, 30, 28)	773	501028	101	123253	3	9908	1	1	0.9999	0.9995	4.69E-08
	7778	568097	22961	169396	80	16218	3	3	0.9999	0.9992	1.41E-07
	21124	648066	70371	246155	347	31281	7	7	0.9999	0.9985	3.28E-07
10: (23, 27, 6)	12811	158149	10384	759791	15	10650	1	1	0.9999	0.9995	4.69E-08
	89280	346856	494288	1438199	1970	36430	11	11	0.9999	0.9983	5.16E-07
	297145	671351	1244531	2330136	19002	104004	23	19	0.999	0.9951	8.92E-07

TABLE III

RESULTS OF *LBS* AND *RBS* ON CARRIERX DATASET FOR TEN DIFFERENT QUERIES AND THREE DIFFERENT THRESHOLDS PER QUERY. FOR BOTH *LBS* AND *RBS*, THE PRUNE RATES ARE ALWAYS GREATER THAN 0.95, SIGNIFYING THAT LESS THAN 5% OF THE CANDIDATES NEED TO BE RETRIEVED FROM THE MTS DATABASE FOR EXACT CALCULATIONS. *LBS* HAS HIGHER PRUNE RATE COMPARED TO *RBS*.