

# CSI 747 – Midterm Submission

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## Introduction:

Previous implementation of SVM-2: Primal Dual SVM for classifying 3 and 6 digits gave very low accuracy than expected. The same case was found in SVM-5 with very low accuracy and the value of  $b$  to be different for different cases (instead of being same for all as expected)

The resubmission report has all the changes done to the previous versions of the program and their results. Particularly the bugs which resulted in low accuracy.

## Preparing Data Sets:

The data set for SVM-5 in particular was re- formed as the main problem was found to be in the datasets used for Training and Testing the SVM. The data set for SVM-2 was kept the same

## SVM-2: Debugging Primal Soft-Margin SVM:

The minimization condition for primal-dual soft-margin SVM had the following bug:

Bugs in Initial Implementation:

---

```
minimize SVM {j in POINTS} : 0.5*(w[j]*w[j])+(C*sum {i in DATASET} eta[i]);
```

---

The rectified code is as follows:

---

```
minimize SVM: 0.5* sum {j in POINTS} (w[j]*w[j])+(C*sum {i in DATASET} eta[i]);
```

---

The code gave a much high accuracy:

Result: SVM-2-Train.mod

---

```
SNOPT 7.2-8 : Optimal solution found.  
7500 iterations, objective 0.9331388318  
b = -0.100834
```

```
hit3 = 490  
miss3 = 10  
hit6 = 495  
miss6 = 5
```

```
total_hits = 985
total_misses = 15
```

```
Accuracy_Percent = 98.5
```

```
Error_Percent = 1.5
```

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## Dual-soft Margin SVM with Radial Basis Kernel to differentiate Even from Odd

The **previous implementation had resulted in erroneous output due to incorrect normalizing of data points extracted from the training/test files**. As this was only due to data, the testing code and the training code were unchanged.

The data set was formed by normalizing the columns of the data set and the results improved dramatically.

The values of support vectors obtained using the new dataset were as follows:

SVM-5.mod: Output

---

```
ampl: model SVM-5.mod;
SNOPT 7.2-8 : Optimal solution found.
843 iterations, objective 215.9182622
alpha [*] :=
  1 0.147325      251 0.16691      501 0.474246      751 0.928426
  2 0.406827      252 0.356395      502 0.757657      752 0.981692
  3 0.381954      253 0.336424      503 0.531049      753 0
  4 0.00620903    254 0.872131      504 0.751707      754 0.489322
  5 0.56531       255 0.605958      505 0.495631      755 1.05542
  6 0.4221        256 0.424846      506 0.95681       756 0.767091
  7 0.605741      257 0.0964577     507 0.526087      757 0
  8 0.607531      258 0.801234      508 0.979608      758 0.569771
  9 0.41139       259 0.356321      509 0.2429        759 0.582796
 10 0.58316       260 0.422819      510 0.253488      760 0
 11 0.378796      261 0.54242       511 0.497289      761 0.536847
 12 0.254541      262 0.323343      512 0.544858      762 0
 13 0             263 0.935547      513 0.640402      763 0.460868
 14 0.510664      264 0.436946      514 0.101706      764 0.605523
 15 0.395243      265 0.0602602     515 0.829443      765 0.182204
 16 0.401241      266 0.303605      516 0.133199      766 0.448539
 17 0             267 0.624269      517 0.728025      767 0.506119
 18 0.519446      268 0.974023      518 0.352632      768 0.22658
 19 0.621973      269 0.494164      519 0.946599      769 0
 20 0.257867      270 0.792135      520 0.222367      770 0.591828
```

21 0.113519	271 0	521 1.14685	771 0.32707
22 0.550608	272 1.08453	522 0.825754	772 0
23 0.178483	273 0.277453	523 0.160888	773 0
24 0.755613	274 0.821147	524 1.07226	774 0
25 0.624854	275 0.257487	525 0.907199	775 0.181927
26 0.40258	276 0.652955	526 0.824797	776 0
27 0.320548	277 0.235268	527 0.51529	777 0.134944
28 0.904987	278 0.273876	528 0.395812	778 0.282138
29 0.758325	279 0.257302	529 1.22278	779 0
30 0.319076	280 0.243704	530 0.70272	780 0.567732
31 0.91202	281 0.18244	531 0.123827	781 0.478717
32 0.196208	282 0.32862	532 0.282648	782 0.282983
33 0.362105	283 0.174101	533 0.27205	783 0
34 0.376435	284 0.567494	534 0	784 0
35 0	285 0.378601	535 0.315249	785 0.298324
36 0.209617	286 0.467352	536 0.19101	786 0
37 0.160944	287 0.501393	537 0.40593	787 0.149016
38 0.249469	288 1.74574	538 0.980799	788 0.0724184
39 0.0851684	289 0.562677	539 0.449286	789 0.282582
40 0.235501	290 0.498702	540 0.972431	790 0.221659
41 0	291 0.9202	541 0.756608	791 0.0714093
42 0.272045	292 0.418511	542 0.878488	792 0
43 0.531256	293 0.58063	543 0.0277019	793 0.46057
44 0.554757	294 0.252071	544 0.467336	794 0
45 0.354214	295 0.31335	545 1.15401	795 0.405248
46 0.295101	296 0.527454	546 0.0898848	796 1.28591
47 0.453182	297 0.12384	547 0.0393821	797 0.197171
48 0.480994	298 0.567235	548 0.473928	798 0.0335257
49 0.349814	299 0.256243	549 0.639959	799 0.0808209
50 0.595425	300 0.502636	550 0.752857	800 0.337986
51 0.13112	301 0.133691	551 0.86493	801 0.472556
52 0.503697	302 0.203534	552 1.00719	802 0.325018
53 0.108718	303 0.560127	553 0.806659	803 0.161017
54 0.643113	304 0.628426	554 0.83298	804 0.832501
55 0.319211	305 0.820793	555 1.02882	805 0.90378
56 0.16378	306 0.508322	556 0.845857	806 0.634721
57 0.423933	307 0.221007	557 1.54424	807 0.394969
58 0.285096	308 0.0921654	558 0.531099	808 0
59 0.207163	309 0.00685297	559 0.421579	809 0.606129
60 0.209512	310 0.858891	560 0.0674671	810 1.13038
61 0.512464	311 0	561 1.05871	811 0.408874
62 0	312 0.312775	562 0.65581	812 0.153528
63 0.00879107	313 1.01409	563 0.818498	813 1.11874
64 0.405267	314 0.154003	564 0.960439	814 0.613463
65 0.357992	315 0.311779	565 0.331335	815 0.187544
66 0.774924	316 0.557974	566 0.198258	816 0.990424
67 0.507595	317 0.6657	567 0.565427	817 0.744158
68 0	318 0.116703	568 0.85165	818 1.06701
69 0.160351	319 0.607507	569 0.14557	819 0
70 0.358674	320 0.624898	570 0.704535	820 0.369703
71 0.427247	321 0.989047	571 1.22765	821 0
72 0.288707	322 0.353992	572 0.124076	822 1.18899
73 0.39316	323 0.822388	573 0	823 0.574822
74 0.192293	324 0	574 0.215233	824 0.541833
75 0.137599	325 0.995195	575 0.482799	825 0.056582

76 0.43149	326 0.134324	576 0.940849	826 0.346186
77 0	327 0.709783	577 0.0675321	827 0.868983
78 0.133975	328 1.12645	578 0.421092	828 0.647067
79 0.698065	329 0.986785	579 0.928591	829 0.91333
80 0.654794	330 0.391324	580 1.11344	830 0.0597729
81 0.116861	331 0.589956	581 0.771347	831 1.38097
82 0.318613	332 0.594164	582 0.586631	832 0.645077
83 0.365669	333 0.134181	583 0.437171	833 1.40113
84 0.00356396	334 0.241554	584 1.35032	834 0.351794
85 0.31902	335 0	585 0.65311	835 0
86 0.493351	336 0.482905	586 0.992761	836 0.404199
87 0.427328	337 0.280541	587 0.605146	837 0.605952
88 0.353573	338 0.423225	588 0.303059	838 0.532835
89 0	339 0.69064	589 0.825097	839 0
90 0.727771	340 0.367053	590 0.617576	840 0.545222
91 0.353848	341 0.905896	591 0.877566	841 0.628756
92 0.497927	342 0.292369	592 0.234821	842 0.741134
93 0.551432	343 0.728549	593 1.13571	843 0.83664
94 0.429397	344 0.384731	594 0.723297	844 0.483187
95 0	345 1.04259	595 0.363034	845 0.0448303
96 0.592174	346 0.613679	596 0.405076	846 0.613548
97 0	347 0.161487	597 0.23948	847 0
98 0.579785	348 0.656752	598 1.13213	848 0.182237
99 0.804233	349 0.0639267	599 0.730236	849 0.693464
100 0.398001	350 0.775309	600 0.895082	850 1.1792
101 0.0737188	351 0.951519	601 0	851 0.526809
102 0.462237	352 0.894956	602 0.907187	852 0.692113
103 0.110531	353 0.666758	603 0.250189	853 0.925785
104 0	354 0.827148	604 0.195136	854 0
105 0.04261	355 0.436592	605 0.0594162	855 1.07522
106 1.11571	356 0.394258	606 0.466334	856 0.191113
107 0	357 0.968877	607 0.381673	857 0.671104
108 0	358 0.529092	608 0	858 2.06612
109 0.00163474	359 0.505393	609 0.267459	859 0.305181
110 1.10582	360 0.234048	610 0	860 0.591138
111 0.026528	361 0.416421	611 0.236541	861 0.65157
112 0	362 0.651343	612 0.391994	862 1.07131
113 0.0248081	363 0.601659	613 0.218961	863 1.11541
114 0.0480652	364 1.03867	614 0.00436093	864 0.677202
115 0.175997	365 1.30497	615 0	865 0.550091
116 0.17869	366 0	616 0	866 0
117 0.306449	367 0	617 0	867 0.207947
118 0	368 0	618 0	868 0.471164
119 0.372754	369 0	619 0.376175	869 0.165868
120 0	370 0.62699	620 0.0255228	870 0.863108
121 0.430676	371 0.539072	621 0.14107	871 0
122 1.058	372 0.282718	622 0.151775	872 0.676498
123 0.0816505	373 0.0641659	623 0.20224	873 0.322311
124 0	374 0.444955	624 0.361949	874 0.394626
125 0.0283432	375 0.319751	625 0.899621	875 0.0645077
126 0	376 0.53733	626 0	876 0
127 0	377 0.837942	627 0.648946	877 0.615654
128 0.206598	378 0.0875907	628 0.498963	878 0.250329
129 0	379 0.609919	629 0.0661487	879 0.668724
130 0	380 0.202665	630 0	880 0.0177407

131 0	381 0.021199	631 0.00603692	881 0.338467
132 0.772797	382 0.684178	632 0.27439	882 0
133 0.773497	383 1.10859	633 0	883 0.0921163
134 0.541219	384 0.313316	634 0.0150706	884 0.867884
135 0.0155281	385 0.517568	635 0.601403	885 0.322281
136 0	386 0.710962	636 0	886 0.700922
137 0.41746	387 0.526419	637 0.320488	887 0.224392
138 0	388 0.704874	638 0	888 0.66698
139 0	389 1.27708	639 0.152909	889 0.845441
140 0.296459	390 0.478313	640 0	890 0.874388
141 0	391 0.368415	641 0	891 0.173071
142 0	392 0.505446	642 0.109508	892 0.854392
143 0	393 0.961786	643 0.56761	893 0.861649
144 0.272226	394 0.511766	644 0.483255	894 0.471845
145 0	395 0.142961	645 0.0415063	895 0.385796
146 0	396 0.560813	646 0.51226	896 0.768706
147 0.476596	397 0.607093	647 0.475948	897 0.545375
148 0	398 0.436886	648 0.14239	898 0.562498
149 0.73479	399 0.690662	649 0.0738708	899 0.412007
150 0.557472	400 1.3704	650 0.113739	900 0.278474
151 0	401 0.596002	651 0.59765	901 0.766059
152 0	402 0.296049	652 0.375845	902 0.167583
153 0	403 0.412035	653 0.152921	903 0.814871
154 0	404 1.28295	654 0.245296	904 0
155 0.689168	405 1.61966	655 0.36065	905 0
156 0	406 0.727679	656 0.0150769	906 0.0773363
157 0	407 0.560866	657 0.775193	907 0.685264
158 0	408 0.861191	658 0	908 0.93987
159 0	409 0.458962	659 0.367185	909 0
160 0	410 0.155673	660 0.266593	910 1.60562
161 0.398762	411 0.702163	661 0.380079	911 0.471238
162 0.950904	412 0.533776	662 0.237241	912 0.700545
163 0	413 0.415864	663 0.246656	913 0.270308
164 0.0238236	414 0.562484	664 0.153945	914 0.00109455
165 0.371661	415 0.222602	665 0.143891	915 0.074004
166 0.51528	416 0.465627	666 0	916 0.477184
167 0.0308052	417 0.792242	667 0.142486	917 0.381963
168 0	418 0.214202	668 0.143666	918 0.121141
169 0.329525	419 0.345948	669 0.330754	919 0
170 1.31086	420 0.234569	670 0.0831087	920 0.690671
171 0.454041	421 0.328741	671 0.64569	921 0.353218
172 0	422 0.226559	672 0	922 0.14368
173 0.621746	423 0.530625	673 0.236165	923 0
174 0	424 0.238531	674 0.0915731	924 0.222729
175 0.407572	425 0	675 0.504138	925 0.0222513
176 0.65482	426 0.0317836	676 0	926 0.310337
177 0	427 1.04581	677 0	927 1.2076
178 0.0962981	428 0	678 0.0221825	928 0
179 0	429 0	679 0.584956	929 0.424205
180 0.25057	430 0.801186	680 0.173048	930 0.80058
181 0	431 0.523385	681 0	931 0.175693
182 0	432 0	682 0.830635	932 0.420411
183 0.898136	433 0.461322	683 0	933 0.186489
184 0	434 0	684 0.56348	934 0
185 0	435 0.44514	685 0.446742	935 1.08362

186 0	436 0.51449	686 0.60526	936 1.21237
187 0	437 0.626159	687 0.504049	937 0.758957
188 0	438 0.76347	688 0.360352	938 0.280379
189 0	439 0.472923	689 0.594843	939 0
190 0	440 0.288147	690 0	940 0.0999484
191 0	441 0.570359	691 0.461778	941 0.877874
192 0	442 0	692 0.436163	942 0.899551
193 0.281251	443 0.120507	693 0.240329	943 0.0363242
194 0	444 0.527572	694 0.0661321	944 0
195 0.305249	445 0.225408	695 0	945 0
196 0	446 1.30686	696 0.318388	946 0.113295
197 0	447 0.291282	697 0.764638	947 0
198 0.640989	448 0.694255	698 0.251511	948 0.942258
199 0	449 0.70647	699 0.15426	949 0.330703
200 0.414827	450 0.590675	700 0.78098	950 1.20585
201 0.696127	451 0.33718	701 0.0595793	951 0
202 0.760196	452 0.153394	702 0.955806	952 0.623086
203 0.473638	453 0.121235	703 0.976897	953 0.120891
204 0.759305	454 0.432181	704 0.19204	954 0.581086
205 0.480136	455 0.63794	705 0.204888	955 0.0600282
206 0.417788	456 0.170958	706 0.0543907	956 0.315283
207 0.662873	457 1.28079	707 0.133749	957 0.454797
208 0.540435	458 0.341332	708 0.249857	958 0.359216
209 0.788223	459 1.02877	709 0.247225	959 0.569964
210 0.356708	460 0.423514	710 0	960 0
211 0.486091	461 0.643707	711 0.496073	961 0.0967055
212 0.283953	462 0.639719	712 0	962 0.141553
213 0.680252	463 0.462598	713 0.325966	963 0
214 0.251033	464 0.129443	714 0.544872	964 0.672199
215 0.538424	465 1.17274	715 0.249626	965 0
216 1.72173	466 0	716 1.30409	966 0.506207
217 0.593209	467 0.534411	717 1.10571	967 0.441233
218 0.547157	468 0.589686	718 1.01073	968 0.383951
219 0.426479	469 1.21869	719 0.206518	969 1.2803
220 0.422688	470 0.692896	720 0.322739	970 0.773454
221 0.368844	471 0.343628	721 0.512169	971 0.534017
222 0.637024	472 0.484912	722 0.294774	972 0
223 0.0133939	473 0.837397	723 0.369874	973 1.24705
224 0.295426	474 0.383802	724 0.35441	974 0
225 0.320995	475 1.20433	725 0	975 0
226 0.904865	476 0.42	726 0.0644103	976 0.568475
227 1.26897	477 0.57069	727 0	977 1.10441
228 0.366391	478 0.770418	728 0.0468668	978 0.575634
229 0.19131	479 1.05576	729 0	979 0.561474
230 0.17136	480 1.32457	730 0	980 1.01015
231 0.789283	481 0.515685	731 0.0738891	981 1.06679
232 0.125216	482 0.52454	732 0	982 1.22232
233 0.0854394	483 0.638567	733 0.56151	983 1.56163
234 0.0349213	484 0.367212	734 0.148566	984 0
235 0.576601	485 0.800562	735 0.71838	985 0.722962
236 0.275961	486 0.302346	736 0.256852	986 0.140805
237 0.119619	487 0.532806	737 0	987 0.154227
238 0.436915	488 0.324011	738 0.214743	988 0
239 0.294142	489 0.338771	739 0.363681	989 1.28783
240 0.410668	490 0.191026	740 0.0818416	990 0.515712



... ..

Columns 801 through 810

-0.2650	-0.2650	-0.2650	-0.2650	-0.2650	-0.2650	-0.2650	-0.2650	-
0.2650	-0.2650							

Columns 811 through 820

-0.2650	-0.2650	-0.2650	-0.2650	-0.2650	-0.2650	-0.2650	-0.2650	-
0.2650	-0.2650							

Columns 821 through 830

-0.2650	-0.2650	-0.2650	-0.2650	-0.2650	-0.2650	-0.2650	-0.2650	-
0.2650	-0.2650							

Columns 831 through 840

-0.2650	-0.2650	-0.2650	-0.2650	-0.2650	-0.2650	-0.2650	-0.2650	-
0.2650	-0.2650							

Columns 841 through 844

-0.2650	-0.2650	-0.2650	-0.2650
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Accuracy Percent: 81.000000

Error Percent: 19.000000

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It can be seen that the Accuracy increased from 50 % to 81% and the b values for all alpha using the support vectors are same.