# Support Vector Machines – Final Parameter Tuning

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In this last report I am going to perform final parameter tuning for all 4 datasets we are dealing with.

### *Datasets:*

- ADL Normal Activities (1 Kyoto)
- ADL Activities with Errors (2 Kyoto)
- ADL Interweaved Activities (3 Kyoto)
- Daily Life 2010-2011 (17 Aruba)

### *Features:*

1. SECONDS FROM MIDNIGHT – FIRST RECORD in the window
2. SECONDS FROM MIDNIGHT – LAST RECORD in the window
3. DAY OF THE WEEK – binary feature
4. SECONDS ELAPSED – between the first and the last record of the window
5. SIMPLE COUNTS OF THE SENSORS

### *Scaling - preprocessing*

`sklearn.preprocessing.`**`StandardScaler`**

`sklearn.preprocessing.`**`RobustScaler`**

### *Principal Component Analysis*

`sklearn.decomposition.`**`PCA`**

### *Classifier*

`sklearn.svm.`**`SVC`**

### *Testing*

```
KFold(n_splits=5, shuffle=True, random_state=0)
```

### *Tuning cycle*

Every dataset is unique and needs separate tuning of its parameters. For that I used following tuning cycle:

1. **Window size + Scaler**
2. **PCA** ***(only for Daily Life 2010-2011 – Aruba – dataset)***
3. **Radial-basis function (RBF) kernel –> C (Regularization) + Gamma (Kernel coefficient)**
4. **Polynomial kernel –> C (Regularization) + Gamma (Kernel coefficient)**

## ADL Normal Activities (1 Kyoto)

*Table 1 – ADL Normal Activities – **Window size + Scaler tuning** Accuracy scores (%)*

| Window size | Standard Scaler | **Robust Scaler** |
|---|---|---|
| 5 | 76.1098 | 76.8366 |
| 7 | 80.9266 | 80.4650 |
| 10 | 84.6190 | 84.2324 |
| 12 | 87.2751 | 86.5446 |
| 15 | 89.8176 | 89.0786 |
| 17 | 91.2101 | 90.4652 |
| 19 | 92.3576 | 91.9238 |
| 22 | 93.0757 | 93.1939 |
| 25 | 93.8282 | 94.0676 |
| 27 | 94.1906 | 94.3113 |
| 30 | 94.3620 | 94.4842 |
| 32 | 94.6313 | 95.0360 |
| 35 | 94.8474 | 95.3824 |
| 37 | 95.0191 | 95.6125 |
| **40** | **95.0810** | **95.9738** |

I chose **Robust Scaler** with **Window size = 40** because it gained the best results.

*Table 2 – ADL Normal Activities – **RBF kernel -> C + Gamma tuning** Accuracy scores (%)*

| C | Gamma | Accuracy |
|---|---|---|
| 1 | 0.1 | 97.0850 |
| 1 | 0.15 | 97.4312 |
| 1 | 0.2 | 97.5769 |
| 1 | 0.25 | 97.8502 |
| 1 | 0.3 | 97.8684 |
| 1 | 0.35 | 97.8320 |
| 1 | 0.4 | 97.8138 |
| 1 | 0.45 | 97.8137 |
| 2 | 0.1 | 97.5223 |
| 2 | 0.15 | 97.7955 |
| 2 | 0.2 | 97.9413 |
| 2 | 0.25 | 98.0141 |
| 2 | 0.3 | 98.0506 |
| 2 | 0.35 | 97.9595 |
| 2 | 0.4 | 97.8684 |
| 2 | 0.45 | 97.9413 |
| 5 | 0.1 | 97.9595 |
| 5 | 0.15 | 98.1963 |
| 5 | 0.2 | 98.0506 |
| 5 | 0.25 | 98.1417 |
| 5 | 0.3 | 98.2146 |
| 5 | 0.35 | 98.1599 |
| 5 | 0.4 | 98.1781 |
| 5 | 0.45 | 98.2146 |
| 7 | 0.1 | 98.0506 |
| 7 | 0.15 | 98.1053 |
| 7 | 0.2 | 98.1964 |
| 7 | 0.25 | 98.1599 |
| 7 | 0.3 | 98.2146 |
| 7 | 0.35 | 98.1781 |
| 7 | 0.4 | 98.1781 |
| 7 | 0.45 | 98.1417 |
| 10 | 0.1 | 98.1417 |
| 10 | 0.15 | 98.1417 |
| 10 | 0.2 | 98.1781 |
| 10 | 0.25 | 98.2328 |
| 10 | 0.3 | 98.2328 |
| 10 | 0.35 | 98.1963 |
| 10 | 0.4 | 98.1964 |
| 10 | 0.45 | 98.1964 |

| C | Gamma | Accuracy |
|---|---|---|
| 13 | 0.1 | 98.1235 |
| 13 | 0.15 | 98.1964 |
| 13 | 0.2 | 98.2692 |
| 13 | 0.25 | 98.3239 |
| 13 | 0.3 | 98.3057 |
| 13 | 0.35 | 98.3239 |
| 13 | 0.4 | 98.2875 |
| 13 | 0.45 | 98.3057 |
| 15 | 0.1 | 98.1417 |
| 15 | 0.15 | 98.2875 |
| 15 | 0.2 | 98.3057 |
| 15 | 0.25 | 98.3421 |
| 15 | 0.3 | 98.3603 |
| 15 | 0.35 | 98.3057 |
| 15 | 0.4 | 98.3422 |
| 15 | 0.45 | 98.3422 |
| 17 | 0.1 | 98.1600 |
| 17 | 0.15 | 98.3057 |
| 17 | 0.2 | 98.3421 |
| 17 | 0.25 | 98.4332 |
| 17 | 0.3 | 98.3968 |
| 17 | 0.35 | 98.3604 |
| 17 | 0.4 | 98.3422 |
| 17 | 0.45 | 98.3239 |
| 20 | 0.1 | 98.2329 |
| 20 | 0.15 | 98.3968 |
| 20 | 0.2 | 98.5244 |
| 20 | 0.25 | 98.5061 |
| 20 | 0.3 | 98.4515 |
| 20 | 0.35 | 98.3786 |
| 20 | 0.4 | 98.3422 |
| 20 | 0.45 | 98.3239 |
| 30 | 0.1 | 98.4879 |
| 30 | 0.15 | 98.5244 |
| **30** | **0.2** | **98.6337** |
| **30** | **0.25** | **98.6337** |
| 30 | 0.3 | 98.5426 |
| 30 | 0.35 | 98.3968 |
| 30 | 0.4 | 98.3239 |
| 30 | 0.45 | 98.3240 |

| C | Gamma | Accuracy |
|---|---|---|
| **50** | **0.1** | **98.6701** |
| **50** | **0.15** | **98.6519** |
| **50** | **0.2** | **98.6337** |
| 50 | 0.25 | 98.5973 |
| 50 | 0.3 | 98.5608 |
| 50 | 0.35 | 98.5426 |
| 50 | 0.4 | 98.4515 |
| 50 | 0.45 | 98.3786 |
| **75** | **0.1** | **98.6337** |
| **75** | **0.15** | **98.6155** |
| **75** | **0.2** | **98.6519** |
| **75** | **0.25** | **98.6155** |
| 75 | 0.3 | 98.5790 |
| 75 | 0.35 | 98.5244 |
| 75 | 0.4 | 98.4879 |
| 75 | 0.45 | 98.4151 |
| **100** | **0.1** | **98.6337** |
| **100** | **0.15** | **98.6155** |
| **100** | **0.2** | **98.6883** |
| **100** | **0.25** | **98.6155** |
| 100 | 0.3 | 98.5790 |
| 100 | 0.35 | 98.5244 |
| 100 | 0.4 | 98.4879 |
| 100 | 0.45 | 98.4333 |
| **150** | **0.1** | **98.6155** |
| **150** | **0.15** | **98.6337** |
| **150** | **0.2** | **98.6519** |
| 150 | 0.25 | 98.5973 |
| 150 | 0.3 | 98.5790 |
| 150 | 0.35 | 98.5244 |
| 150 | 0.4 | 98.4697 |
| 150 | 0.45 | 98.4151 |
| 200 | 0.1 | 98.5973 |
| **200** | **0.15** | **98.6155** |
| **200** | **0.2** | **98.6337** |
| **200** | **0.25** | **98.6155** |
| 200 | 0.3 | 98.5972 |
| 200 | 0.35 | 98.5426 |
| 200 | 0.4 | 98.5062 |
| 200 | 0.45 | 98.4151 |

*Table 3 – ADL Normal Activities – **Polynomial kernel -> C + Gamma tuning** Accuracy scores (%)*

| C | Gamma | Accuracy |
|---|---|---|
| 1 | 0.1 | 97.5405 |
| 1 | 0.15 | 98.0325 |
| 1 | 0.2 | 98.1782 |
| 1 | 0.25 | 98.3786 |
| **1** | **0.3** | **98.4151** |
| 1 | 0.35 | 98.3422 |
| 1 | 0.4 | 98.2694 |
| 1 | 0.45 | 98.2330 |
| 2 | 0.1 | 97.8138 |
| 2 | 0.15 | 98.1965 |
| 2 | 0.2 | 98.3786 |
| **2** | **0.25** | **98.4151** |
| 2 | 0.3 | 98.2694 |
| 2 | 0.35 | 98.2330 |
| 2 | 0.4 | 98.2512 |
| 2 | 0.45 | 98.1965 |
| 5 | 0.1 | 98.2147 |
| 5 | 0.15 | 98.3968 |
| 5 | 0.2 | 98.3605 |
| 5 | 0.25 | 98.2694 |
| 5 | 0.3 | 98.2694 |
| 5 | 0.35 | 98.1601 |
| 5 | 0.4 | 98.2329 |
| 5 | 0.45 | 98.1783 |
| 7 | 0.1 | 98.2511 |
| 7 | 0.15 | 98.3787 |
| 7 | 0.2 | 98.2694 |
| 7 | 0.25 | 98.2512 |
| 7 | 0.3 | 98.1783 |
| 7 | 0.35 | 98.2512 |
| 7 | 0.4 | 98.1965 |
| 7 | 0.45 | 98.1236 |
| 10 | 0.1 | 98.2875 |
| **10** | **0.15** | **98.4151** |
| 10 | 0.2 | 98.2876 |
| 10 | 0.25 | 98.2512 |
| 10 | 0.3 | 98.2512 |
| 10 | 0.35 | 98.2329 |
| 10 | 0.4 | 98.1054 |
| 10 | 0.45 | 98.1600 |
| 13 | 0.1 | 98.3422 |
| 13 | 0.15 | 98.3422 |
| 13 | 0.2 | 98.2329 |
| 13 | 0.25 | 98.1783 |
| 13 | 0.3 | 98.2876 |
| 13 | 0.35 | 98.1601 |
| 13 | 0.4 | 98.1418 |
| 13 | 0.45 | 98.1964 |
| 15 | 0.1 | 98.3604 |
| 15 | 0.15 | 98.2694 |
| 15 | 0.2 | 98.2512 |
| 15 | 0.25 | 98.1965 |
| 15 | 0.3 | 98.2512 |
| 15 | 0.35 | 98.1236 |
| 15 | 0.4 | 98.1964 |
| 15 | 0.45 | 98.1964 |
| 17 | 0.1 | 98.3604 |
| 17 | 0.15 | 98.2876 |
| 17 | 0.2 | 98.2694 |
| 17 | 0.25 | 98.2512 |
| 17 | 0.3 | 98.1783 |
| 17 | 0.35 | 98.1600 |
| 17 | 0.4 | 98.1782 |
| 17 | 0.45 | 98.1964 |
| 20 | 0.1 | 98.3604 |
| 20 | 0.15 | 98.2694 |
| 20 | 0.2 | 98.2694 |
| 20 | 0.25 | 98.2512 |
| 20 | 0.3 | 98.1601 |
| 20 | 0.35 | 98.1600 |
| 20 | 0.4 | 98.1782 |
| 20 | 0.45 | 98.1964 |
| **30** | **0.1** | **98.4151** |
| 30 | 0.15 | 98.2329 |
| 30 | 0.2 | 98.2329 |
| 30 | 0.25 | 98.1783 |
| 30 | 0.3 | 98.1418 |
| 30 | 0.35 | 98.1964 |
| 30 | 0.4 | 98.1782 |
| 30 | 0.45 | 98.1964 |
| 50 | 0.1 | 98.3240 |
| 50 | 0.15 | 98.2694 |
| 50 | 0.2 | 98.2329 |
| 50 | 0.25 | 98.1418 |
| 50 | 0.3 | 98.1964 |
| 50 | 0.35 | 98.1964 |
| 50 | 0.4 | 98.1782 |
| 50 | 0.45 | 98.1964 |
| 75 | 0.1 | 98.2876 |
| 75 | 0.15 | 98.2694 |
| 75 | 0.2 | 98.1054 |
| 75 | 0.25 | 98.1964 |
| 75 | 0.3 | 98.1964 |
| 75 | 0.35 | 98.1964 |
| 75 | 0.4 | 98.1782 |
| 75 | 0.45 | 98.1964 |
| 100 | 0.1 | 98.2329 |
| 100 | 0.15 | 98.2512 |
| 100 | 0.2 | 98.1236 |
| 100 | 0.25 | 98.1964 |
| 100 | 0.3 | 98.1964 |
| 100 | 0.35 | 98.1964 |
| 100 | 0.4 | 98.1782 |
| 100 | 0.45 | 98.1964 |
| 150 | 0.1 | 98.2329 |
| 150 | 0.15 | 98.1783 |
| 150 | 0.2 | 98.1782 |
| 150 | 0.25 | 98.1964 |
| 150 | 0.3 | 98.1964 |
| 150 | 0.35 | 98.1964 |
| 150 | 0.4 | 98.1782 |
| 150 | 0.45 | 98.1964 |
| 200 | 0.1 | 98.1783 |
| 200 | 0.15 | 98.1236 |
| 200 | 0.2 | 98.1782 |
| 200 | 0.25 | 98.1964 |
| 200 | 0.3 | 98.1964 |
| 200 | 0.35 | 98.1964 |
| 200 | 0.4 | 98.1782 |
| 200 | 0.45 | 98.1964 |

From previous results we can see that best accuracy of **98.6883%** gets SVMs with **RBF kernel**, **C = 100** and **Gamma = 0.2.**

## ADL Activities with Errors (2 Kyoto)

*Table 4 – ADL Activities with Errors – **Window size + Scaler tuning** Accuracy scores (%)*

| Window size | Standard Scaler | **Robust Scaler** |
|---|---|---|
| 5 | 82.1693 | 82.6022 |
| 7 | 85.0223 | 86.1729 |
| 10 | 89.6205 | 90.2427 |
| 12 | 91.3376 | 91.8031 |
| 15 | 93.4643 | 93.3618 |
| 17 | 93.7616 | 94.4021 |
| 19 | 94.2720 | 94.2092 |
| 22 | 94.3681 | 94.5368 |
| 25 | 94.6808 | 94.9798 |
| 27 | 94.4191 | 94.9146 |
| **30** | 94.7610 | **95.1539** |
| 32 | 94.7810 | 94.8912 |
| 35 | **94.6665** | 94.8897 |
| 37 | 94.5281 | 94.8661 |
| 40 | 94.6584 | 95.0010 |

Chosen parameters: **Window size = 30** and **Robust Scaler.**

*Table 5 – ADL Activities with Errors –* ***RBF kernel -> C + Gamma tuning*** *Accuracy scores (%)*

| C | Gamma | Accuracy |
|---|---|---|
| 1 | 0.1 | 96.0926 |
| 1 | 0.15 | 96.5073 |
| 1 | 0.2 | 96.7037 |
| 1 | 0.25 | 96.8784 |
| 1 | 0.3 | 96.9875 |
| 1 | 0.35 | 97.1186 |
| 1 | 0.4 | 97.1623 |
| 1 | 0.45 | 97.1405 |
| 2 | 0.1 | 96.8566 |
| 2 | 0.15 | 97.1403 |
| 2 | 0.2 | 97.4242 |
| 2 | 0.25 | 97.4461 |
| 2 | 0.3 | 97.5771 |
| 2 | 0.35 | 97.5116 |
| 2 | 0.4 | 97.5770 |
| 2 | 0.45 | 97.6207 |
| 5 | 0.1 | 97.6424 |
| 5 | 0.15 | 97.9263 |
| 5 | 0.2 | 98.0355 |
| 5 | 0.25 | 98.0573 |
| 5 | 0.3 | 97.9263 |
| 5 | 0.35 | 98.0136 |
| 5 | 0.4 | 97.9263 |
| 5 | 0.45 | 97.8608 |
| 7 | 0.1 | 97.8826 |
| 7 | 0.15 | 98.1227 |
| 7 | 0.2 | 98.0791 |
| 7 | 0.25 | 98.0573 |
| 7 | 0.3 | 98.0136 |
| 7 | 0.35 | 98.0136 |
| 7 | 0.4 | 97.9918 |
| 7 | 0.45 | 97.8826 |
| 10 | 0.1 | 98.0572 |
| 10 | 0.15 | 98.1446 |
| 10 | 0.2 | 98.0573 |
| 10 | 0.25 | 98.0792 |
| 10 | 0.3 | 98.0355 |
| 10 | 0.35 | 98.0573 |
| 10 | 0.4 | 98.1447 |
| 10 | 0.45 | 98.0355 |
| 13 | 0.1 | 98.1664 |
| 13 | 0.15 | 98.1445 |
| 13 | 0.2 | 98.1010 |
| 13 | 0.25 | 98.1447 |
| 13 | 0.3 | 98.1883 |
| 13 | 0.35 | 98.1447 |
| 13 | 0.4 | 98.1665 |
| 13 | 0.45 | 98.1228 |
| 15 | 0.1 | 98.2319 |
| 15 | 0.15 | 98.1664 |
| 15 | 0.2 | 98.0792 |
| 15 | 0.25 | 98.2101 |
| 15 | 0.3 | 98.1883 |
| 15 | 0.35 | 98.1447 |
| 15 | 0.4 | 98.2320 |
| 15 | 0.45 | 98.1228 |
| 17 | 0.1 | 98.2100 |
| 17 | 0.15 | 98.2755 |
| 17 | 0.2 | 98.2538 |
| 17 | 0.25 | 98.2538 |
| 17 | 0.3 | 98.2320 |
| 17 | 0.35 | 98.2102 |
| 17 | 0.4 | 98.2102 |
| 17 | 0.45 | 98.1446 |
| 20 | 0.1 | 98.1664 |
| 20 | 0.15 | 98.3410 |
| 20 | 0.2 | 98.2756 |
| 20 | 0.25 | 98.3193 |
| 20 | 0.3 | 98.2975 |
| 20 | 0.35 | 98.2757 |
| 20 | 0.4 | 98.2538 |
| 20 | 0.45 | 98.1883 |
| 30 | 0.1 | 98.3410 |
| 30 | 0.15 | 98.3847 |
| 30 | 0.2 | 98.4284 |
| 30 | 0.25 | 98.4503 |
| 30 | 0.3 | 98.3848 |
| 30 | 0.35 | 98.3629 |
| 30 | 0.4 | 98.3629 |
| 30 | 0.45 | 98.2101 |
| 50 | 0.1 | 98.2973 |
| 50 | 0.15 | 98.4503 |
| 50 | 0.2 | 98.5158 |
| 50 | 0.25 | 98.5376 |
| 50 | 0.3 | 98.4284 |
| 50 | 0.35 | 98.3629 |
| 50 | 0.4 | 98.4066 |
| 50 | 0.45 | 98.3193 |
| 75 | 0.1 | 98.3847 |
| 75 | 0.15 | 98.4721 |
| 75 | 0.2 | 98.5813 |
| 75 | 0.25 | 98.5813 |
| 75 | 0.3 | 98.4284 |
| 75 | 0.35 | 98.4502 |
| 75 | 0.4 | 98.4066 |
| 75 | 0.45 | 98.3192 |
| 100 | 0.1 | 98.4502 |
| 100 | 0.15 | 98.4503 |
| **100** | **0.2** | **98.6468** |
| 100 | 0.25 | 98.5158 |
| 100 | 0.3 | 98.5157 |
| 100 | 0.35 | 98.4502 |
| 100 | 0.4 | 98.3847 |
| 100 | 0.45 | 98.2974 |
| 150 | 0.1 | 98.4066 |
| 150 | 0.15 | 98.5813 |
| **150** | **0.2** | **98.6468** |
| **150** | **0.25** | **98.6031** |
| 150 | 0.3 | 98.4939 |
| 150 | 0.35 | 98.4502 |
| 150 | 0.4 | 98.3629 |
| 150 | 0.45 | 98.3192 |
| 200 | 0.1 | 98.4285 |
| **200** | **0.15** | **98.6031** |
| **200** | **0.2** | **98.7123** |
| 200 | 0.25 | 98.5813 |
| 200 | 0.3 | 98.4939 |
| 200 | 0.35 | 98.4502 |
| 200 | 0.4 | 98.3629 |
| 200 | 0.45 | 98.3411 |

*Table 6 – ADL Activities with Errors – **Polynomial kernel -> C + Gamma tuning** Accuracy scores (%)*

| C | Gamma | Accuracy |
|---|---|---|
| 1 | 0.1 | 97.3369 |
| 1 | 0.15 | 98.0136 |
| 1 | 0.2 | 98.1009 |
| 1 | 0.25 | 98.2101 |
| 1 | 0.3 | 98.2974 |
| 1 | 0.35 | 98.2319 |
| 1 | 0.4 | 98.1883 |
| 1 | 0.45 | 98.1010 |
| 2 | 0.1 | 97.7735 |
| 2 | 0.15 | 98.1446 |
| 2 | 0.2 | 98.2101 |
| 2 | 0.25 | 98.2755 |
| 2 | 0.3 | 98.2101 |
| 2 | 0.35 | 98.1228 |
| 2 | 0.4 | 98.1446 |
| 2 | 0.45 | 98.2101 |
| 5 | 0.1 | 98.0136 |
| 5 | 0.15 | 98.1883 |
| 5 | 0.2 | 98.1882 |
| 5 | 0.25 | 98.1882 |
| 5 | 0.3 | 98.1664 |
| 5 | 0.35 | 98.2319 |
| 5 | 0.4 | 98.2101 |
| 5 | 0.45 | 98.1882 |
| 7 | 0.1 | 98.1446 |
| **7** | **0.15** | **98.3193** |
| 7 | 0.2 | 98.2101 |
| 7 | 0.25 | 98.0791 |
| 7 | 0.3 | 98.1883 |
| 7 | 0.35 | 98.1228 |
| 7 | 0.4 | 98.1882 |
| 7 | 0.45 | 98.1882 |
| 10 | 0.1 | 98.1446 |
| 10 | 0.15 | 98.2319 |
| 10 | 0.2 | 98.1664 |
| 10 | 0.25 | 98.2101 |
| 10 | 0.3 | 98.2101 |
| 10 | 0.35 | 98.1882 |
| 10 | 0.4 | 98.1882 |
| 10 | 0.45 | 98.1009 |
| 13 | 0.1 | 98.1228 |
| 13 | 0.15 | 98.2101 |
| 13 | 0.2 | *98.2101* |
| 13 | 0.25 | 98.2101 |
| 13 | 0.3 | 98.2756 |
| 13 | 0.35 | 98.1446 |
| 13 | 0.4 | 98.0791 |
| 13 | 0.45 | 98.0791 |
| 15 | 0.1 | 98.1665 |
| 15 | 0.15 | 98.2101 |
| 15 | 0.2 | 98.1446 |
| 15 | 0.25 | 98.2319 |
| 15 | 0.3 | 98.1882 |
| 15 | 0.35 | 98.1882 |
| 15 | 0.4 | 98.0572 |
| 15 | 0.45 | 98.0136 |
| 17 | 0.1 | 98.1883 |
| 17 | 0.15 | 98.2319 |
| 17 | 0.2 | 98.1664 |
| 17 | 0.25 | 98.2101 |
| 17 | 0.3 | 98.1882 |
| 17 | 0.35 | 98.0572 |
| 17 | 0.4 | 98.0791 |
| 17 | 0.45 | 98.0354 |
| 20 | 0.1 | 98.2101 |
| 20 | 0.15 | 98.2319 |
| 20 | 0.2 | 98.2101 |
| 20 | 0.25 | 98.1883 |
| 20 | 0.3 | 98.1446 |
| 20 | 0.35 | 98.0791 |
| 20 | 0.4 | 98.0136 |
| 20 | 0.45 | 98.0354 |
| 30 | 0.1 | 98.2755 |
| 30 | 0.15 | 98.1446 |
| 30 | 0.2 | 98.2319 |
| 30 | 0.25 | 98.1882 |
| 30 | 0.3 | 98.1009 |
| 30 | 0.35 | 98.0136 |
| 30 | 0.4 | 98.0572 |
| 30 | 0.45 | 98.1227 |
| 50 | 0.1 | 98.2101 |
| 50 | 0.15 | 98.2319 |
| 50 | 0.2 | 98.1882 |
| 50 | 0.25 | 98.1009 |
| 50 | 0.3 | 98.0136 |
| 50 | 0.35 | 98.0136 |
| 50 | 0.4 | 98.0791 |
| 50 | 0.45 | 98.1227 |
| 75 | 0.1 | 98.1664 |
| 75 | 0.15 | 98.2101 |
| 75 | 0.2 | 98.1882 |
| 75 | 0.25 | 98.0572 |
| 75 | 0.3 | 98.0136 |
| 75 | 0.35 | 98.0791 |
| 75 | 0.4 | 98.1009 |
| 75 | 0.45 | 98.1664 |
| 100 | 0.1 | 98.1446 |
| 100 | 0.15 | 98.2537 |
| 100 | 0.2 | 98.1009 |
| 100 | 0.25 | 98.0136 |
| 100 | 0.3 | 98.0791 |
| 100 | 0.35 | 98.0572 |
| 100 | 0.4 | 98.1227 |
| 100 | 0.45 | 98.1446 |
| 150 | 0.1 | 98.1664 |
| 150 | 0.15 | 98.1882 |
| 150 | 0.2 | 98.0354 |
| 150 | 0.25 | 98.1009 |
| 150 | 0.3 | 98.0572 |
| 150 | 0.35 | 98.1009 |
| 150 | 0.4 | 98.1009 |
| 150 | 0.45 | 98.1009 |
| 200 | 0.1 | 98.2101 |
| 200 | 0.15 | 98.1882 |
| 200 | 0.2 | 98.0136 |
| 200 | 0.25 | 98.0791 |
| 200 | 0.3 | 98.1227 |
| 200 | 0.35 | 98.0791 |
| 200 | 0.4 | 98.0572 |
| 200 | 0.45 | 98.0136 |

The best score for “Kyoto 2” dataset was **98.7123%** with **RBF kernel, C = 200** and **Gamma = 0.2.**

## ADL Interweaved Activities (3 Kyoto)

*Table 7 – ADL Interweaved Activities – **Window size + Scaler tuning** Accuracy scores (%)*

| Window size | **Standard Scaler** | Robust Scaler |
|---|---|---|
| 5 | 77.3508 | 77.6726 |
| 7 | 81.9491 | 82.9285 |
| 10 | 86.9517 | 87.3459 |
| 12 | 89.0252 | 88.7877 |
| 15 | 91.3563 | 90.7289 |
| 17 | 92.5400 | 90.9100 |
| 19 | 93.3520 | 91.6950 |
| 22 | 94.4517 | 93.1278 |
| 25 | 94.8536 | 93.5822 |
| 27 | 95.2707 | 93.5751 |
| 30 | 95.3532 | 93.8933 |
| 32 | 95.4879 | 94.4037 |
| 35 | 95.5935 | **94.9180** |
| 37 | 95.7516 | 94.8747 |
| **40** | **95.8285** | 94.8303 |

Chosen parameters: **Standard Scaler** and **Window size = 40.**

*Table 8 – ADL Interweaved Activities – **RBF kernel -> C + Gamma tuning** Accuracy scores (%)*

| C | Gamma | Accuracy |
|---|---|---|
| 1 | 0.1 | 97.5413 |
| 1 | 0.15 | 97.7514 |
| 1 | 0.2 | 97.7199 |
| 1 | 0.25 | 97.6148 |
| 1 | 0.3 | 97.4887 |
| 1 | 0.35 | 97.4257 |
| 1 | 0.4 | 97.3206 |
| 1 | 0.45 | 97.0684 |
| 2 | 0.1 | 98.0772 |
| 2 | 0.15 | 98.1717 |
| 2 | 0.2 | 98.2348 |
| 2 | 0.25 | 97.9931 |
| 2 | 0.3 | 97.7619 |
| 2 | 0.35 | 97.6148 |
| 2 | 0.4 | 97.6043 |
| 2 | 0.45 | 97.5203 |
| 5 | 0.1 | 98.3819 |
| 5 | 0.15 | 98.4975 |
| 5 | 0.2 | 98.5500 |
| 5 | 0.25 | 98.3609 |
| 5 | 0.3 | 98.1087 |
| 5 | 0.35 | 97.9616 |
| 5 | 0.4 | 97.7935 |
| 5 | 0.45 | 97.6569 |
| 7 | 0.1 | 98.5185 |
| 7 | 0.15 | 98.6761 |
| 7 | 0.2 | 98.6025 |
| 7 | 0.25 | 98.3714 |
| 7 | 0.3 | 98.0877 |
| 7 | 0.35 | 97.9406 |
| 7 | 0.4 | 97.8250 |
| 7 | 0.45 | 97.6674 |
| 10 | 0.1 | 98.6866 |
| 10 | 0.15 | 98.6971 |
| 10 | 0.2 | 98.6131 |
| 10 | 0.25 | 98.3609 |
| 10 | 0.3 | 98.0982 |
| 10 | 0.35 | 97.9511 |
| 10 | 0.4 | 97.8460 |
| 10 | 0.45 | 97.7199 |

| C | Gamma | Accuracy |
|---|---|---|
| **13** | **0.1** | **98.7286** |
| **13** | **0.15** | **98.7181** |
| 13 | 0.2 | 98.6236 |
| 13 | 0.25 | 98.3714 |
| 13 | 0.3 | 98.1297 |
| 13 | 0.35 | 97.9826 |
| 13 | 0.4 | 97.8565 |
| 13 | 0.45 | 97.6989 |
| **15** | **0.1** | **98.7286** |
| **15** | **0.15** | **98.7181** |
| 15 | 0.2 | 98.6130 |
| 15 | 0.25 | 98.3714 |
| 15 | 0.3 | 98.1297 |
| 15 | 0.35 | 97.9721 |
| 15 | 0.4 | 97.8355 |
| 15 | 0.45 | 97.6989 |
| **17** | **0.1** | **98.7391** |
| **17** | **0.15** | **98.7076** |
| 17 | 0.2 | 98.6341 |
| 17 | 0.25 | 98.3924 |
| 17 | 0.3 | 98.1297 |
| 17 | 0.35 | 97.9511 |
| 17 | 0.4 | 97.8250 |
| 17 | 0.45 | 97.6884 |
| **20** | **0.1** | **98.7602** |
| **20** | **0.15** | **98.7076** |
| 20 | 0.2 | 98.6446 |
| 20 | 0.25 | 98.3924 |
| 20 | 0.3 | 98.1087 |
| 20 | 0.35 | 97.9511 |
| 20 | 0.4 | 97.8145 |
| 20 | 0.45 | 97.6779 |
| **30** | **0.1** | **98.7496** |
| **30** | **0.15** | **98.7286** |
| 30 | 0.2 | 98.6341 |
| 30 | 0.25 | 98.3609 |
| 30 | 0.3 | 98.0877 |
| 30 | 0.35 | 97.9406 |
| 30 | 0.4 | 97.8145 |
| 30 | 0.45 | 97.6779 |

| C | Gamma | Accuracy |
|---|---|---|
| **50** | **0.1** | **98.7496** |
| **50** | **0.15** | **98.7076** |
| 50 | 0.2 | 98.6025 |
| 50 | 0.25 | 98.3503 |
| 50 | 0.3 | 98.0877 |
| 50 | 0.35 | 97.9406 |
| 50 | 0.4 | 97.8145 |
| 50 | 0.45 | 97.6884 |
| **75** | **0.1** | **98.7391** |
| **75** | **0.15** | **98.7076** |
| 75 | 0.2 | 98.6130 |
| 75 | 0.25 | 98.3609 |
| 75 | 0.3 | 98.0982 |
| 75 | 0.35 | 97.9406 |
| 75 | 0.4 | 97.8145 |
| 75 | 0.45 | 97.6884 |
| **100** | **0.1** | **98.7391** |
| **100** | **0.15** | **98.7076** |
| 100 | 0.2 | 98.6235 |
| 100 | 0.25 | 98.3609 |
| 100 | 0.3 | 98.0982 |
| 100 | 0.35 | 97.9406 |
| 100 | 0.4 | 97.8145 |
| 100 | 0.45 | 97.6884 |
| **150** | **0.1** | **98.7496** |
| **150** | **0.15** | **98.7181** |
| 150 | 0.2 | 98.6235 |
| 150 | 0.25 | 98.3609 |
| 150 | 0.3 | 98.0982 |
| 150 | 0.35 | 97.9406 |
| 150 | 0.4 | 97.8145 |
| 150 | 0.45 | 97.6884 |
| **200** | **0.1** | **98.7496** |
| **200** | **0.15** | **98.7181** |
| 200 | 0.2 | 98.6235 |
| 200 | 0.25 | 98.3609 |
| 200 | 0.3 | 98.0982 |
| 200 | 0.35 | 97.9406 |
| 200 | 0.4 | 97.8250 |
| 200 | 0.45 | 97.6989 |

*Table 9 – ADL Interweaved Activities –* ***Polynomial kernel -> C + Gamma tuning*** *Accuracy scores (%)*

| C | Gamma | Accuracy |
|---|---|---|
| 1 | 0.1 | 98.6866 |
| 1 | 0.15 | 98.7707 |
| 1 | 0.2 | 98.7707 |
| 1 | 0.25 | 98.7812 |
| **1** | **0.3** | **98.8022** |
| **1** | **0.35** | **98.8127** |
| 1 | 0.4 | 98.7917 |
| 1 | 0.45 | 98.7917 |
| 2 | 0.1 | 98.8022 |
| 2 | 0.15 | 98.7707 |
| 2 | 0.2 | 98.7812 |
| **2** | **0.25** | **98.8127** |
| **2** | **0.3** | **98.8022** |
| 2 | 0.35 | 98.7917 |
| **2** | **0.4** | **98.8022** |
| **2** | **0.45** | **98.8127** |
| 5 | 0.1 | 98.7707 |
| 5 | 0.15 | 98.7812 |
| **5** | **0.2** | **98.8232** |
| 5 | 0.25 | 98.7917 |
| **5** | **0.3** | **98.8022** |
| **5** | **0.35** | **98.8127** |
| **5** | **0.4** | **98.8232** |
| **5** | **0.45** | **98.8022** |
| 7 | 0.1 | 98.7707 |
| 7 | 0.15 | 98.7812 |
| **7** | **0.2** | **98.8022** |
| 7 | 0.25 | 98.7917 |
| **7** | **0.3** | **98.8127** |
| **7** | **0.35** | **98.8127** |
| **7** | **0.4** | **98.8022** |
| **7** | **0.45** | **98.8022** |
| 10 | 0.1 | 98.7812 |
| **10** | **0.15** | **98.8022** |
| 10 | 0.2 | 98.7917 |
| **10** | **0.25** | **98.8022** |
| **10** | **0.3** | **98.8337** |
| **10** | **0.35** | **98.8022** |
| **10** | **0.4** | **98.8022** |
| 10 | 0.45 | 98.7812 |

| C | Gamma | Accuracy |
|---|---|---|
| 13 | 0.1 | 98.7812 |
| **13** | **0.15** | **98.8022** |
| 13 | 0.2 | 98.7917 |
| **13** | **0.25** | **98.8127** |
| **13** | **0.3** | **98.8232** |
| 13 | 0.35 | 98.8022 |
| 13 | 0.4 | 98.7812 |
| 13 | 0.45 | 98.7812 |
| 15 | 0.1 | 98.7812 |
| **15** | **0.15** | **98.8022** |
| 15 | 0.2 | 98.7917 |
| **15** | **0.25** | **98.8232** |
| **15** | **0.3** | **98.8127** |
| **15** | **0.35** | **98.8022** |
| 15 | 0.4 | 98.7707 |
| 15 | 0.45 | 98.7496 |
| 17 | 0.1 | 98.7812 |
| **17** | **0.15** | **98.8022** |
| **17** | **0.2** | **98.8022** |
| **17** | **0.25** | **98.8337** |
| **17** | **0.3** | **98.8022** |
| 17 | 0.35 | 98.7812 |
| 17 | 0.4 | 98.7812 |
| 17 | 0.45 | 98.7076 |
| 20 | 0.1 | 98.7707 |
| 20 | 0.15 | 98.7917 |
| **20** | **0.2** | **98.8022** |
| **20** | **0.25** | **98.8127** |
| **20** | **0.3** | **98.8022** |
| 20 | 0.35 | 98.7812 |
| 20 | 0.4 | 98.7707 |
| 20 | 0.45 | 98.6866 |
| **30** | **0.1** | **98.8127** |
| 30 | 0.15 | 98.7917 |
| **30** | **0.2** | **98.8232** |
| **30** | **0.25** | **98.8022** |
| 30 | 0.3 | 98.7917 |
| 30 | 0.35 | 98.7707 |
| 30 | 0.4 | 98.6866 |
| 30 | 0.45 | 98.6551 |

| C | Gamma | Accuracy |
|---|---|---|
| **50** | **0.1** | **98.8022** |
| **50** | **0.15** | **98.8022** |
| **50** | **0.2** | **98.8127** |
| 50 | 0.25 | 98.7917 |
| 50 | 0.3 | 98.7496 |
| 50 | 0.35 | 98.6656 |
| 50 | 0.4 | 98.6235 |
| 50 | 0.45 | 98.5500 |
| 75 | 0.1 | 98.7917 |
| **75** | **0.15** | **98.8337** |
| **75** | **0.2** | **98.8022** |
| 75 | 0.25 | 98.7812 |
| 75 | 0.3 | 98.6656 |
| 75 | 0.35 | 98.6235 |
| 75 | 0.4 | 98.5185 |
| 75 | 0.45 | 98.4869 |
| 100 | 0.1 | 98.7917 |
| **100** | **0.15** | **98.8232** |
| 100 | 0.2 | 98.7917 |
| 100 | 0.25 | 98.7076 |
| 100 | 0.3 | 98.6551 |
| 100 | 0.35 | 98.5710 |
| 100 | 0.4 | 98.4869 |
| 100 | 0.45 | 98.4554 |
| **150** | **0.1** | **98.8022** |
| **150** | **0.15** | **98.8022** |
| 150 | 0.2 | 98.7812 |
| 150 | 0.25 | 98.6551 |
| 150 | 0.3 | 98.5710 |
| 150 | 0.35 | 98.4869 |
| 150 | 0.4 | 98.4449 |
| 150 | 0.45 | 98.4029 |
| **200** | **0.1** | **98.8127** |
| 200 | 0.15 | 98.7917 |
| 200 | 0.2 | 98.7076 |
| 200 | 0.25 | 98.6130 |
| 200 | 0.3 | 98.5080 |
| 200 | 0.35 | 98.4659 |
| 200 | 0.4 | 98.4029 |
| 200 | 0.45 | 98.4134 |

Unexpectedly **Polynomial kernel** gave the best accuracy **98.8337%** for three cases: **C = 10** and **Gamma = 0.3; C = 17** and **Gamma = 0.25; C = 75** and **Gamma = 0.15.**

## Daily Life 2010-2011 (17 Aruba)

Like the last time, I used only 5 days (35 624 sensor events) from this huge dataset.

This is the only one dataset for which I used PCA. Other datasets are too small for that.

*Table 10 – Daily life 2010-2011 (5 days) – **Window size + Scaler tuning** Accuracy scores (%)*

| Window size | **Standard Scaler** | Test time (s) | Robust Scaler | Test time (s) |
|---|---|---|---|---|
| 5 | 82.4756 | 167.6 | 77.2705 | 213.1 |
| 12 | 85.5049 | 161.9 | 80.7144 | 190.9 |
| 19 | 87.5832 | 142.8 | 81.7104 | 192.4 |
| 30 | 89.9112 | 132.0 | 83.0449 | 181.4 |
| **40** | **91.2461** | 122.2 | **84.3413** | 176.7 |

Chosen parameters: **Standard Scaler** and **Window size = 40.**

*Table 11 – Daily life 2010-2011 (5 days) – **PCA tuning** Accuracy scores (%)*

| PCA | | Accuracy (%) | Test time (s) |
|---|---|---|---|
| Variance retained | N components | | |
| No PCA used | 46 | **91.2461** | 122.2 |
| 0.99 | 42 | 91.1871 | 120.7 |
| 0.95 | 34 | 89.7538 | 110.5 |
| **0.9** | **28** | **88.5538** | **99.6** |
| 0.85 | 24 | 87.7304 | 97.8 |
| 0.8 | 21 | 87.0869 | 94.2 |
| 0.75 | 18 | 85.9150 | 89.7 |
| 0.7 | 16 | 85.1282 | 87.8 |
| 0.6 | 12 | 82.1689 | 83.9 |
| 0.5 | 8 | 78.8332 | 84.1 |

I tested PCA with multiple options for `n_components` parameter. When `n_components<1`, e.g. 0.8, it means that minimum number of components will be chosen such that 80% variance is going to be retained.

More at: https://towardsdatascience.com/pca-using-python-scikit-learn-e653f8989e60

From the table above, I decided to use **PCA with 0.9 variance retained**.

*Table 12 – Daily life 2010-2011 (5 days) – **RBF kernel -> C + Gamma tuning** Accuracy scores (%)*

| C | Gamma | Accuracy | Test time |
|---|---|---|---|
| 1 | 0.1 | 95.3266 | 121.0 |
| 1 | 0.2 | 96.6867 | 266.0 |
| 1 | 0.3 | 97.2122 | 577.9 |
| 5 | 0.1 | 97.3134 | 82.4 |
| 5 | 0.2 | 97.9232 | 230.5 |
| 5 | 0.3 | 98.1256 | 531.0 |
| 10 | 0.1 | 97.6619 | 71.1 |
| 10 | 0.2 | 98.1818 | 219.6 |
| 10 | 0.3 | 98.3419 | 527.4 |
| 17 | 0.1 | 97.9710 | 70.3 |
| 17 | 0.2 | 98.3335 | 209.3 |
| 17 | 0.3 | 98.4712 | 527.1 |
| 50 | 0.1 | 98.3363 | 63.6 |
| 50 | 0.2 | 98.5190 | 197.0 |
| 50 | 0.3 | 98.5640 | 496.8 |
| **150** | **0.1** | **98.6398** | **59.5** |
| 150 | 0.2 | 98.5780 | 184.5 |
| **150** | **0.3** | **98.6033** | **511.2** |

*Table 13 – Daily life 2010-2011 (5 days) – **Polynomial kernel -> C + Gamma tuning** Accuracy (%)*

| C | Gamma | Accuracy | Test time |
|---|---|---|---|
| 1 | 0.1 | 96.5435 | 13.4 |
| 1 | 0.2 | 97.2741 | 12.9 |
| 1 | 0.3 | 97.5973 | 13.1 |
| 5 | 0.1 | 97.1196 | 12.4 |
| 5 | 0.2 | 97.6254 | 13.9 |
| 5 | 0.3 | 97.7378 | 15.6 |
| 10 | 0.1 | 97.3163 | 12.8 |
| 10 | 0.2 | 97.6395 | 17.3 |
| **10** | **0.3** | **97.7940** | **21.2** |
| 17 | 0.1 | 97.6254 | 13.5 |
| 17 | 0.2 | 97.7659 | 17.5 |
| 17 | 0.3 | 97.7659 | 19.1 |
| 50 | 0.1 | 97.7097 | 15.5 |
| 50 | 0.2 | 97.7659 | 20.4 |
| 50 | 0.3 | 97.6816 | 23.6 |
| 150 | 0.1 | 97.7659 | 15.7 |
| 150 | 0.2 | 97.6676 | 22.0 |
| 150 | 0.3 | 97.4146 | 27.9 |

(In this case I did not use 5-fold testing. That is way the Test time is so low.)

**98.6398%** is the highest accuracy score I was able to achieve. **RBF kernel, C = 150** and **Gamma = 0.1** were used.

Now when we have these tuned parameters for “Aruba” dataset, let’s try to test SVMs again with a little bit bigger Aruba dataset:

- I used 2 months extracted from the whole set (456 285 sensor events)
- Window size = 40, Standard Scaler
- PCA = 0.9 variance retained, Number of components = 30
- RBF kernel, C = 105 and Gamma = 0.1

The final accuracy was: **97.0751%**

Test time: 11 106.8s = 3 hours, 5 minutes, 6.8 seconds

### *Conclusion*

*Table 14 – Comparison of results for datasets*

| Dataset | Window size | Scaler | PCA | Kernel | C | Gamma | Accuracy (%) |
|---|---|---|---|---|---|---|---|
| ADL Normal Activities (1 Kyoto) | 40 | Robust | - | RBF | 100 | 0.2 | **98.6883** |
| ADL Activities with Errors (2 Kyoto) | 30 | Robust | - | RBF | 200 | 0.2 | **98.7123** |
| ADL Interweaved Activities (3 Kyoto) | 40 | Standard | - | Polynomial | 10 | 0.3 | **98.8337** |
| Daily Life 2010-2011 (Aruba) 5 days | 40 | Standard | 0.9 | RBF | 150 | 0.1 | **98.6398** |
| Daily Life 2010-2011 (Aruba) 2 months | 40 | Standard | 0.9 | RBF | 150 | 0.1 | **97.0751** |

In the table above we can see the final results from this report. My guess is that by increasing window size we would achieve even higher accuracy. Another finding is that we cannot generalize what scaler is better or which kernel is better. It depends on the dataset itself. That is way I performed individual testing for every dataset.

### *Github*

https://github.com/emanuelzaymus/ActivityRecognition