

IE 48B

Time Series Analytics

Project

Group 11

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## 1. Table of Contents

2.	Introduction .....	3
3.	Related Literature .....	4
4.	Approach .....	6
5.	Results .....	26
6.	Conclusions and Future Work.....	28
7.	Code .....	28
8.	References .....	28

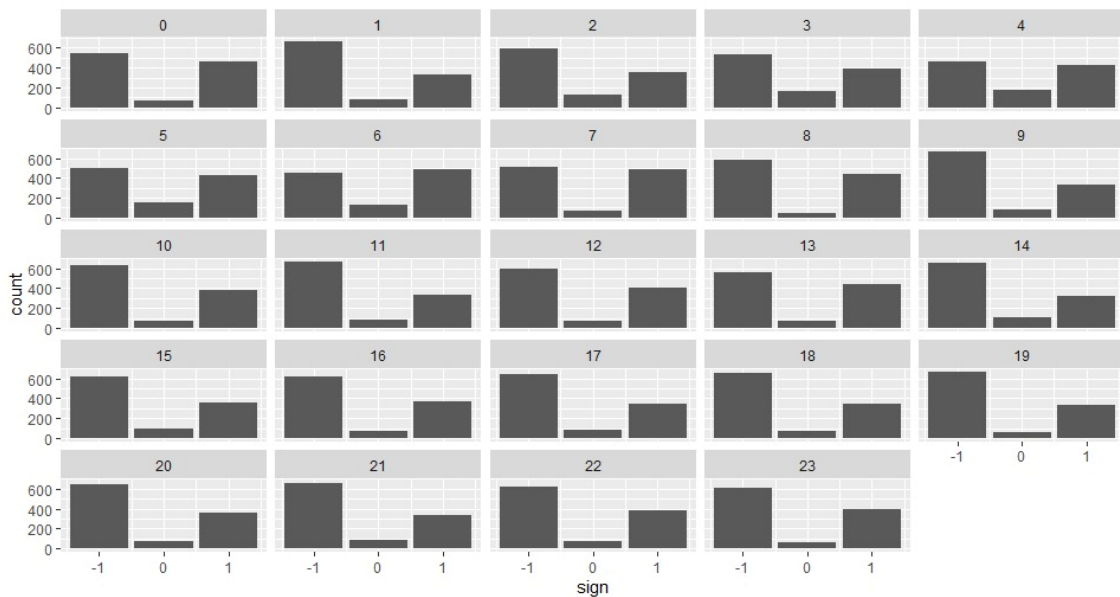
## 2. Introduction

In the electricity markets, there are two sides: producers and distributors. Both sides try to forecast their side of the equation as accurate as possible. Both sides try to foresee how much electricity is needed to supply the demand of the distributors for the producer's side and of the users for the distributor's side. The accuracy of this prediction is so crucial because of the severe penalties for the deficit and the surplus of the electricity. If a distributor forecasts some amount of demand which is less than the actual demand, the cost of buying more electricity is incomparably high.

The difficulty of the problem increases even more when the source of the electricity is a renewable energy source. The high volatility of the amount of electricity produced by these renewable energy sources makes long-term forecasts unavailable therefore, creates a requirement of the Day-Ahead market. Day-Ahead market in Turkey is where participants report their electricity needs or production for the next day, every day until 12PM. After the data for the following day is complete, market clearing prices are determined for 24 hours. This means the price of the electricity for different hours are not identical. These prices are obtained as a result of the negotiation of the parties: producers and distributors.

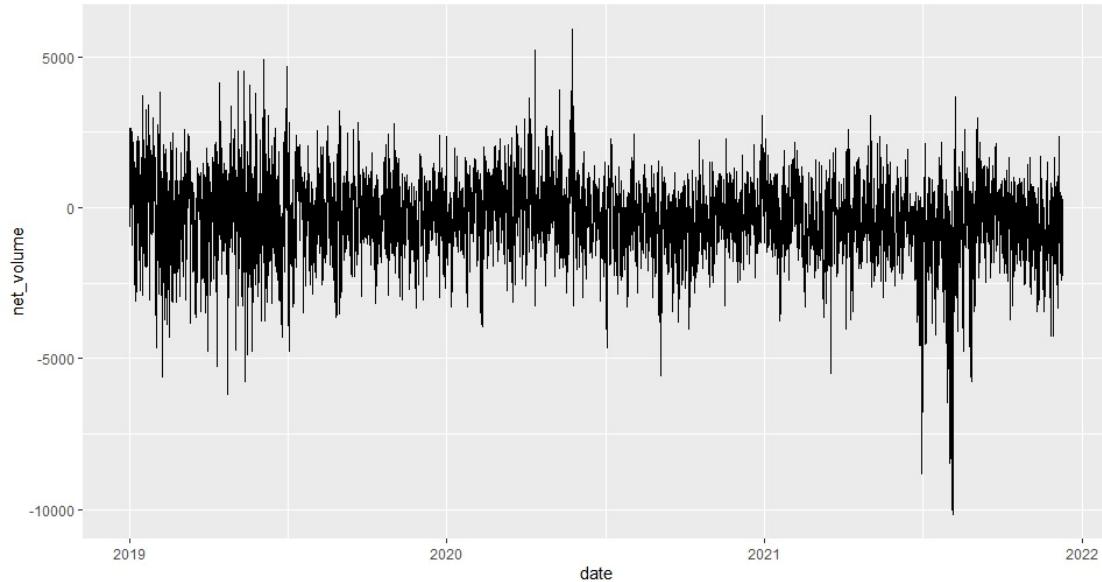
As is mentioned above these forecasts cannot be perfect. Thus, there will be a deficit or a surplus of electricity which is called imbalance. The problem intended to be solved in this project is creating a model that predicts the sign of the imbalance, in other words whether there is going to be a deficit or a surplus of electricity in the system.

To observe some features of the data we have plotted histograms of the signs of the imbalances per hour. In the Figure 1, -1 indicates negative net value and +1 indicates positive net value. We see that positive signs are dominant. We also included a zero sign for the small imbalance values to get rid of their weights and reduce the noise.



**Figure 1.** Imbalance sign distribution for each hour of day

Figure 2 shows the net imbalance values changing as time passes. We have seen that this is somehow stationary but at some periods there are high imbalances and very low ones this may be due to some seasonality.



**Figure 2.** Line Plot for Net Imbalance

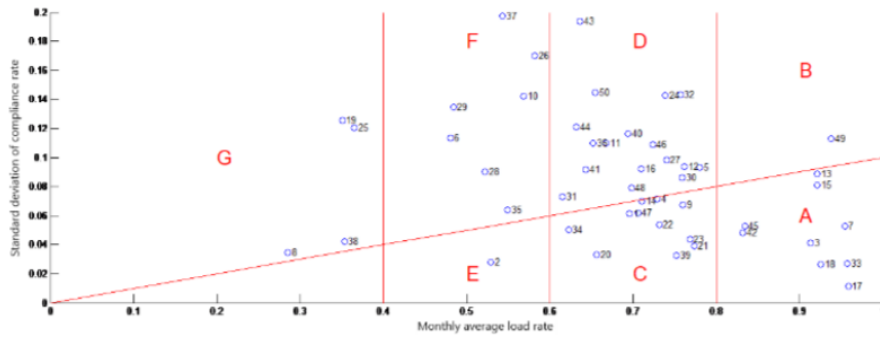
In our model, we represent every hour as a different model using the same hour of a number of previous days. The number of days is a parameter of the model and tuned as the window size. After constructing these 24 models we used k-nearest neighbors to make predictions where k is another parameter and also tuned. After that we have compared the accuracy of this model with some baseline models.

### **3. Related Literature**

#### **Forecasting Model of Electricity Sale Market Based on User's Electricity Consumption Information (Gao et al., 2020)**

The balance of power supply and demand is closely tied to the projection of the electricity selling market. The high-precision forecast approach for the power selling market would efficiently avoid system supply and demand imbalances, improving system security and economics.

It is possible to start from the bottom-up, starting with the development law of each user's power consumption, pack and cluster users with similar power consumption characteristics, find the best prediction model for each type of user's power consumption, and finally get a more accurate overall power sales prediction value in the massive power consumption information environment. Here in Figure 3 the user categories can be seen.



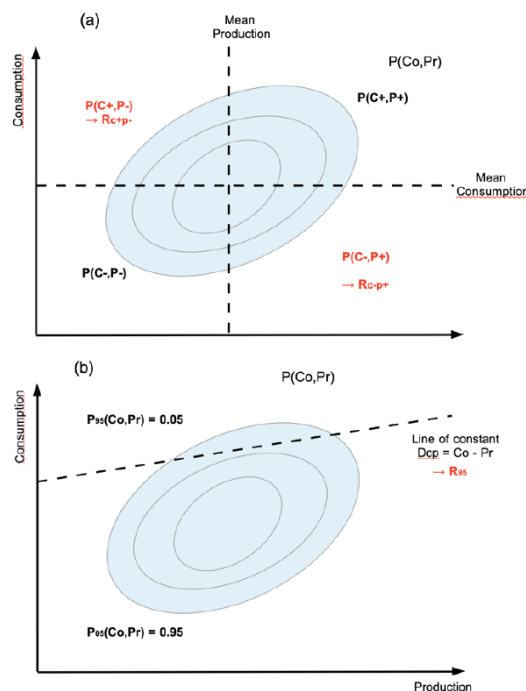
**Figure 3. User categories**

The benefit of this technique is that it can quickly and intuitively calculate the forecast value of future energy sales; however, it fails to consider the electrical development trend of all walks of life that make up the electricity sales in detail. This approach improves the accuracy of the forecasts of the distributors which eventually result in imbalances with lower variance.

### Measuring the Risk of Supply and Demand Imbalance at the Monthly to Seasonal Scale in France (Alonzo et al., 2020)

To assess the danger of supply-demand imbalance for the coming season, Transmission System Operators (TSOs) must predict the system condition on a seasonal scale. Seasonal electrical system planning is presently mostly addressed utilizing a climatological method to accommodate consumption and output fluctuation. A statistical model is created to reconstruct the joint likelihood of consumption and production at monthly to seasonal time horizons in order to anticipate the risks of supply-demand imbalance. It's based on the conditional likelihood of production and consumption in relation to indices derived from a linear regression of large-scale atmospheric predictors' main components.

Consider the daily wind energy production  $Pr$  and the daily maximum electricity consumption  $Co$  in France. Figure 4 shows the schematic of the joint distribution  $P(Co, Pr)$ .



**Figure 4. Schematic of the joint distribution**

This approach also improves the accuracy of the forecasts, again will eventually reduce the variance of the imbalance.

#### **4. Approach**

In our model, to predict imbalance sign of each hour, all hours are represented as time series of length  $w$  which includes the signs of previous  $w$  days' same hour.  $w$  is a representation parameter tuned together with model parameters for all hours. Since we have 1075 days in the train data, there will be  $(1075-w)$  time series for each hour 0 to 23. The Classification is obtained with n-Nearest Neighbor Classification. For each hour parameters ( $w$  and  $k$ ) are tuned with 10-fold 5-rep cross-validation. Euclidean distance, LCSS distance and EDR distance are tried. PAA distance was included in the tuning phase but later it left out due to time constraints. After the training is done and the forecasts are made the results are compared with 3 baseline methods:

1. Frequency based method: The sign predicted for each hour is the most frequent sign observed for that hour in the train data.
2. Lagged method 1: Predicted sign is the sign of yesterday same hour (lag24)
3. Lagged method 2: Predicted sign is the sign of prev. week same day same hour (lag168)

Here are the functions used to construct the model:

- `get_distances` – returns Euclidean, lcsc and edr distances given a dataset
- `nn_classify_cv` - returns the results and summary of results of k-fold cross validation of n-neares neighbor classification given distance matrix, train class labels, test indices and n.
- `test_classification` – returns the classifications results for new observations
- `get_paa` – returns paa representation given the dataset, segment length and method
- `eval_distances_for_rep` – evaluates Euclidean, lcsc and edr distances and n neighbors classification given the tuning list for n.
- `complete_paramater_evalutaion` – evaluates different representations and calls `eval_distances_for_rep` and representation functions
- `get_window` – get time series given window size and hour
- `evaluate_selected_method` – to observe the cv results of selected method once again

In order to obtain the best model, we have to decide the values of these three parameters for each hour (0 to 23):

1. Distance type : Euclidean, LCSS , EDR
2. Window size : 7, 14, 90
3.  $k$  :  $k$  nearest neighbour (5, 10, 15, 20, 25)

Parameter values that yield best accuracies are reported. Parameter values to be used are determined considering standard deviation of accuracy values and data preparation and model fitting times. Here are the chosen parameters for every hour:

## Hour0

```
> all_hours_summary[[1]] #0
  representation approach k w_size avg_acc sdev_acc result_count
1:      Raw      edr distance 10    90 0.5910555 0.04662649      50
2:      Raw      edr distance 5    90 0.5881818 0.04091798      50
3:      Raw      edr distance 15   90 0.5660895 0.04479557      50
4:      Raw      edr distance 25   90 0.5624428 0.04979103      50
5:      Raw      edr distance 20   90 0.5614183 0.05075066      50
6:      Raw euclidean distance 10   90 0.5402536 0.04199208      50
7:      Raw euclidean distance 25   90 0.5364007 0.04519872      50
8:      Raw euclidean distance 15   90 0.5325314 0.04127235      50
9:      Raw euclidean distance 20   90 0.5246114 0.03930109      50
10:     Raw euclidean distance 5    90 0.5193445 0.04234759      50
11:     Raw      lcsm distance 10   90 0.4604082 0.04559797      50
12:     Raw      lcsm distance 5    90 0.4545001 0.04550438      50
13:     Raw      lcsm distance 20   90 0.4540796 0.05169392      50
14:     Raw      lcsm distance 25   90 0.4530715 0.05219234      50
15:     Raw      lcsm distance 15   90 0.4510658 0.04636935      50
> |

- all_hours_summary[[1]] #0
  representation approach k w_size avg_acc sdev_acc result_count
1:      Raw euclidean distance 20   14 0.5822642 0.04123373      50
2:      Raw      edr distance 20   14 0.5771698 0.03158876      50
3:      Raw      edr distance 25   14 0.5769811 0.03202674      50
4:      Raw      edr distance 15   14 0.5741509 0.03550439      50
5:      Raw euclidean distance 25   14 0.5709434 0.04003580      50
6:      Raw      edr distance 10   14 0.5703774 0.03602242      50
7:      Raw euclidean distance 15   14 0.5652830 0.03830150      50
8:      Raw euclidean distance 10   14 0.5598113 0.03449766      50
9:      Raw      edr distance 5    14 0.5562264 0.04024937      50
10:     Raw euclidean distance 5    14 0.5371698 0.04762621      50
11:     Raw      lcsm distance 25   14 0.3816981 0.05028995      50
12:     Raw      lcsm distance 5    14 0.3749057 0.04131162      50
13:     Raw      lcsm distance 20   14 0.3747170 0.04765023      50
14:     Raw      lcsm distance 15   14 0.3737736 0.04403895      50
15:     Raw      lcsm distance 10   14 0.3698113 0.04304237      50
> |

> all_hours_summary[[1]] #0
  representation approach k w_size avg_acc sdev_acc result_count
1:      Raw euclidean distance 20    7 0.5846464 0.04871745      50
2:      Raw      edr distance 20    7 0.5838811 0.03928606      50
3:      Raw      edr distance 25    7 0.5814565 0.04176043      50
4:      Raw      edr distance 10    7 0.5784535 0.04991440      50
5:      Raw euclidean distance 25    7 0.5758349 0.04271875      50
6:      Raw      edr distance 15    7 0.5745019 0.04190851      50
7:      Raw euclidean distance 15    7 0.5724775 0.04402550      50
8:      Raw      edr distance 5     7 0.5480709 0.04584114      50
9:      Raw euclidean distance 10    7 0.5477165 0.04585383      50
10:     Raw euclidean distance 5     7 0.5475242 0.03900474      50
11:     Raw      lcsm distance 5     7 0.3849885 0.04448762      50
12:     Raw      lcsm distance 15    7 0.3836731 0.04802475      50
13:     Raw      lcsm distance 10    7 0.3832975 0.04585397      50
14:     Raw      lcsm distance 20    7 0.3815994 0.04694071      50
15:     Raw      lcsm distance 25    7 0.3804779 0.04452891      50
> |
```

Best Accuracy: EDR distance, k=10, w\_size=90

Used Model: Euclidean distance, k=20, w\_size = 7

## Hour1

```
> all_hours_summary[[2]] #1
  representation approach k w_size avg_acc sdev_acc result_count
1:      Raw euclidean distance 25   90 0.6278541 0.02518248      50
2:      Raw      edr distance 25   90 0.6246052 0.02814965      50
3:      Raw euclidean distance 20   90 0.6205195 0.02421722      50
4:      Raw      edr distance 20   90 0.6176974 0.02600720      50
5:      Raw      edr distance 15   90 0.6158833 0.03151359      50
6:      Raw      lcsm distance 25   90 0.6148382 0.01441411      50
7:      Raw euclidean distance 15   90 0.6099608 0.02544339      50
8:      Raw      lcsm distance 20   90 0.6097526 0.01738413      50
9:      Raw      edr distance 10   90 0.6073531 0.04298492      50
10:     Raw      lcsm distance 15   90 0.5979880 0.01872762      50
11:     Raw      edr distance 5    90 0.5955885 0.04640040      50
12:     Raw euclidean distance 10   90 0.5908844 0.03385155      50
13:     Raw      lcsm distance 10   90 0.5796887 0.02579817      50
14:     Raw euclidean distance 5    90 0.5612101 0.03804386      50
15:     Raw      lcsm distance 5    90 0.5487920 0.03600091      50
> |
```

```

> all_hours_summary[[2]] #1
  representation approach k w_size avg_acc sdev_acc result_count
1:      Raw      edr distance 25    14 0.6250943 0.02461626      50
2:      Raw      edr distance 20    14 0.6245283 0.03096799      50
3:      Raw euclidean distance 25    14 0.6220755 0.02117319      50
4:      Raw euclidean distance 20    14 0.6216981 0.02972607      50
5:      Raw euclidean distance 15    14 0.6154717 0.03034949      50
6:      Raw      edr distance 15    14 0.6147170 0.03196997      50
7:      Raw      edr distance 10    14 0.6120755 0.03594317      50
8:      Raw euclidean distance 10    14 0.6011321 0.03073486      50
9:      Raw      edr distance 5     14 0.5828302 0.03697196      50
10:     Raw euclidean distance 5     14 0.5741509 0.03550439      50
11:     Raw      lcsm distance 5     14 0.4084906 0.07190377      50
12:     Raw      lcsm distance 10    14 0.3733962 0.05254648      50
13:     Raw      lcsm distance 25    14 0.3679245 0.03690853      50
14:     Raw      lcsm distance 20    14 0.3632075 0.03384065      50
15:     Raw      lcsm distance 15    14 0.3586792 0.03861556      50
> |

> all_hours_summary[[2]] #1
  representation approach k w_size avg_acc sdev_acc result_count
1:      Raw      edr distance 25     7 0.6154047 0.02852312      50
2:      Raw      edr distance 15     7 0.6123929 0.03722728      50
3:      Raw      edr distance 20     7 0.6110968 0.02914657      50
4:      Raw euclidean distance 20     7 0.6052671 0.02859677      50
5:      Raw      edr distance 10     7 0.6050908 0.04117142      50
6:      Raw euclidean distance 25     7 0.6049110 0.02870744      50
7:      Raw euclidean distance 15     7 0.6022659 0.03730851      50
8:      Raw euclidean distance 10     7 0.6007530 0.03810331      50
9:      Raw euclidean distance 5      7 0.5744913 0.04181289      50
10:     Raw      edr distance 5      7 0.5686828 0.03599026      50
11:     Raw      lcsm distance 25     7 0.3610369 0.04086850      50
12:     Raw      lcsm distance 20     7 0.3520120 0.04120904      50
13:     Raw      lcsm distance 15     7 0.3486651 0.04528758      50
14:     Raw      lcsm distance 5      7 0.3411673 0.04024155      50
15:     Raw      lcsm distance 10     7 0.3409751 0.04145163      50
> |

```

Best Accuracy: Euclidean distance, k=25, w\_size=90

Used Model: Euclidean distance, k=20, w\_size = 14

## Hour2

```

> all_hours_summary[[3]] #2
  representation approach k w_size avg_acc sdev_acc result_count
1:      Raw      edr distance 25    90 0.5776520 0.03206598      50
2:      Raw      edr distance 20    90 0.5752113 0.03501124      50
3:      Raw      edr distance 15    90 0.5648444 0.03454251      50
4:      Raw      edr distance 10    90 0.5634158 0.03636738      50
5:      Raw      edr distance 5     90 0.5540590 0.03895622      50
6:      Raw euclidean distance 25    90 0.5418470 0.03234732      50
7:      Raw euclidean distance 20    90 0.5306968 0.03508522      50
8:      Raw      lcsm distance 25    90 0.5246362 0.03001587      50
9:      Raw euclidean distance 15    90 0.5211400 0.03488433      50
10:     Raw      lcsm distance 20    90 0.5181035 0.02951898      50
11:     Raw      lcsm distance 15    90 0.5142465 0.03111527      50
12:     Raw euclidean distance 10    90 0.4979386 0.03859284      50
13:     Raw      lcsm distance 10    90 0.4918594 0.04616185      50
14:     Raw      lcsm distance 5     90 0.4666790 0.04465195      50
15:     Raw euclidean distance 5     90 0.4589260 0.04040239      50
> |

> all_hours_summary[[3]] #2
  representation approach k w_size avg_acc sdev_acc result_count
1:      Raw      edr distance 25    14 0.5620755 0.03008079      50
2:      Raw      edr distance 15    14 0.5513208 0.03324009      50
3:      Raw      edr distance 20    14 0.5483019 0.03321166      50
4:      Raw      edr distance 10    14 0.5462264 0.03566976      50
5:      Raw euclidean distance 25    14 0.5415094 0.03200631      50
6:      Raw euclidean distance 20    14 0.5352830 0.03227812      50
7:      Raw euclidean distance 15    14 0.5347170 0.03603402      50
8:      Raw euclidean distance 10    14 0.5286792 0.03821224      50
9:      Raw      edr distance 5     14 0.5090566 0.04534234      50
10:     Raw euclidean distance 5     14 0.5035849 0.04118304      50
11:     Raw      lcsm distance 5     14 0.4230189 0.04463176      50
12:     Raw      lcsm distance 15    14 0.4024528 0.04635844      50
13:     Raw      lcsm distance 20    14 0.3949057 0.04078952      50
14:     Raw      lcsm distance 25    14 0.3896226 0.05421912      50
15:     Raw      lcsm distance 10    14 0.3883019 0.04084959      50
> |

```



```
> all_hours_summary[[3]] #2
  representation approach k w_size avg_acc sdev_acc result_count
1:      Raw      edr distance 25    7 0.5428513 0.03514907      50
2:      Raw euclidean distance 25    7 0.5417246 0.03094541      50
3:      Raw      edr distance 20    7 0.5358896 0.03061060      50
4:      Raw      edr distance 15    7 0.5325163 0.03235859      50
5:      Raw euclidean distance 20    7 0.5318092 0.02852990      50
6:      Raw euclidean distance 15    7 0.5271046 0.03817646      50
7:      Raw      edr distance 10    7 0.5147399 0.03400675      50
8:      Raw euclidean distance 10    7 0.4920437 0.03620406      50
9:      Raw      edr distance 5     7 0.4894445 0.04736610      50
10:     Raw euclidean distance 5     7 0.4644930 0.03792297      50
11:     Raw      lcss distance 15    7 0.4206613 0.05957794      50
12:     Raw      lcss distance 25    7 0.4107106 0.04970226      50
13:     Raw      lcss distance 20    7 0.4075242 0.04667701      50
14:     Raw      lcss distance 10    7 0.3690760 0.05062359      50
15:     Raw      lcss distance 5     7 0.3490266 0.03708275      50
> |
```

Best Accuracy: EDR distance, k=25, w\_size =90

Used Model: EDR distance, k=25, w\_size =14

### Hour3

```
> all_hours_summary[[1]] #3
  representation approach k w_size avg_acc sdev_acc result_count
1:      Raw      edr distance 10    90 0.5484230 0.03981804      50
2:      Raw      edr distance 5     90 0.5435786 0.05044164      50
3:      Raw      edr distance 15    90 0.5386910 0.03968992      50
4:      Raw      edr distance 20    90 0.5258710 0.03896230      50
5:      Raw      edr distance 25    90 0.5220305 0.04308193      50
6:     Raw euclidean distance 25    90 0.5132426 0.04229425      50
7:     Raw euclidean distance 20    90 0.5081694 0.04281561      50
8:     Raw euclidean distance 15    90 0.4990270 0.04028951      50
9:     Raw euclidean distance 10    90 0.4774851 0.04743870      50
10:    Raw euclidean distance 5     90 0.4482581 0.04889897      50
11:    Raw      lcss distance 5     90 0.3971635 0.03410395      50
12:    Raw      lcss distance 25    90 0.3962915 0.03868957      50
13:    Raw      lcss distance 15    90 0.3948856 0.04154526      50
14:    Raw      lcss distance 10    90 0.3942981 0.04122834      50
15:    Raw      lcss distance 20    90 0.3890002 0.03835588      50
> |
```

```
> all_hours_summary2[[1]] #3
  representation approach k w_size avg_acc sdev_acc result_count
1:      Raw      edr distance 10    14 0.5600000 0.03928103      50
2:      Raw      edr distance 15    14 0.5537736 0.04102219      50
3:      Raw      edr distance 25    14 0.5528302 0.03759117      50
4:      Raw      edr distance 20    14 0.5509434 0.04316878      50
5:     Raw euclidean distance 25    14 0.5356604 0.04181331      50
6:      Raw      edr distance 5     14 0.5343396 0.05197895      50
7:     Raw euclidean distance 20    14 0.5320755 0.04206061      50
8:     Raw euclidean distance 15    14 0.5284906 0.04280923      50
9:     Raw euclidean distance 10    14 0.5279245 0.04760904      50
10:    Raw euclidean distance 5     14 0.4845283 0.04553422      50
11:    Raw      lcss distance 15    14 0.3475472 0.04642696      50
12:    Raw      lcss distance 25    14 0.3473585 0.04561114      50
13:    Raw      lcss distance 20    14 0.3450943 0.04562706      50
14:    Raw      lcss distance 10    14 0.3447170 0.04396961      50
15:    Raw      lcss distance 5     14 0.3426415 0.04177637      50
> |
```

```
> all_hours_summary2[[1]] #3
  representation approach k w_size avg_acc sdev_acc result_count
1:      Raw      edr distance 25    7 0.5576459 0.03510823      50
2:      Raw      edr distance 20    7 0.5546447 0.03572938      50
3:     Raw euclidean distance 25    7 0.5537189 0.03377769      50
4:      Raw      edr distance 10    7 0.5514830 0.03950374      50
5:     Raw euclidean distance 10    7 0.5505484 0.04064732      50
6:     Raw euclidean distance 20    7 0.5505202 0.03420274      50
7:     Raw euclidean distance 15    7 0.5488556 0.03250326      50
8:      Raw      edr distance 15    7 0.5449110 0.03308328      50
9:     Raw euclidean distance 5     7 0.5218339 0.04196911      50
10:    Raw      edr distance 5     7 0.5214795 0.04381880      50
11:    Raw      lcss distance 15    7 0.3141580 0.03930424      50
12:    Raw      lcss distance 25    7 0.3121090 0.03940738      50
13:    Raw      lcss distance 20    7 0.3087216 0.03802528      50
14:    Raw      lcss distance 10    7 0.3061206 0.03648343      50
15:    Raw      lcss distance 5     7 0.3006842 0.03808109      50
> |
```

Best Accuracy: EDR distance, k=10, w\_size =14

Used Model: EDR distance, k=10, w\_size =14

#### Hour4

```
> all_hours_summary[[2]] #4
representation approach k w_size avg_acc sdev_acc result_count
1: Raw edr distance 10 90 0.5105607 0.04463283 50
2: Raw edr distance 5 90 0.5024510 0.05035989 50
3: Raw edr distance 25 90 0.5020202 0.04149263 50
4: Raw edr distance 15 90 0.4985652 0.04454997 50
5: Raw edr distance 20 90 0.4946939 0.04452698 50
6: Raw euclidean distance 15 90 0.4404411 0.04909662 50
7: Raw euclidean distance 20 90 0.4373263 0.04830865 50
8: Raw euclidean distance 25 90 0.4337291 0.04585031 50
9: Raw euclidean distance 10 90 0.4206844 0.05157627 50
10: Raw euclidean distance 5 90 0.4192249 0.04589398 50
11: Raw lcsc distance 20 90 0.3702577 0.04595913 50
12: Raw lcsc distance 10 90 0.3700454 0.03718759 50
13: Raw lcsc distance 15 90 0.3659802 0.04330799 50
14: Raw lcsc distance 25 90 0.3603257 0.03836682 50
15: Raw lcsc distance 5 90 0.3572191 0.04876494 50
> |

> all_hours_summary2[[2]] #4
representation approach k w_size avg_acc sdev_acc result_count
1: Raw edr distance 20 14 0.5260377 0.04331831 50
2: Raw edr distance 25 14 0.5213208 0.04131162 50
3: Raw edr distance 15 14 0.5073585 0.04417896 50
4: Raw euclidean distance 25 14 0.5022642 0.04134458 50
5: Raw edr distance 10 14 0.5018868 0.04123196 50
6: Raw euclidean distance 20 14 0.4983019 0.04525132 50
7: Raw edr distance 5 14 0.4971698 0.04438241 50
8: Raw euclidean distance 15 14 0.4954717 0.04547354 50
9: Raw euclidean distance 10 14 0.4743396 0.04955612 50
10: Raw euclidean distance 5 14 0.4469811 0.05656814 50
11: Raw lcsc distance 5 14 0.3483019 0.04069278 50
12: Raw lcsc distance 10 14 0.3441509 0.04137444 50
13: Raw lcsc distance 25 14 0.3405660 0.05182112 50
14: Raw lcsc distance 15 14 0.3392453 0.04586014 50
15: Raw lcsc distance 20 14 0.3375472 0.05150611 50
> |

> all_hours_summary2[[2]] #4
representation approach k w_size avg_acc sdev_acc result_count
1: Raw euclidean distance 25 7 0.5107688 0.04384287 50
2: Raw euclidean distance 20 7 0.5079598 0.04043549 50
3: Raw edr distance 25 7 0.4989755 0.05147665 50
4: Raw euclidean distance 15 7 0.4941016 0.03773047 50
5: Raw edr distance 20 7 0.4927667 0.04620762 50
6: Raw edr distance 15 7 0.4886475 0.05056036 50
7: Raw edr distance 10 7 0.4745935 0.04683963 50
8: Raw euclidean distance 10 7 0.4716276 0.03974835 50
9: Raw euclidean distance 5 7 0.4410386 0.03468264 50
10: Raw edr distance 5 7 0.4331670 0.03819458 50
11: Raw lcsc distance 10 7 0.3374008 0.05341162 50
12: Raw lcsc distance 15 7 0.3356780 0.05056108 50
13: Raw lcsc distance 25 7 0.3345794 0.04727486 50
14: Raw lcsc distance 20 7 0.3304620 0.05426296 50
15: Raw lcsc distance 5 7 0.3030700 0.04449537 50
> |
```

Best Accuracy: EDR distance, k=20, w\_size =14

Used Model: EDR distance, k=20, w\_size =14

## Hour5

```
> all_hours_summary[[3]] #5
representation approach k w_size avg_acc sdev_acc result_count
1: Raw edr distance 25 90 0.5305174 0.05678516 50
2: Raw edr distance 5 90 0.5196949 0.03690225 50
3: Raw edr distance 10 90 0.5180726 0.04144390 50
4: Raw edr distance 20 90 0.5128139 0.04651090 50
5: Raw edr distance 15 90 0.5118244 0.05090866 50
6: Raw euclidean distance 25 90 0.4780664 0.04326768 50
7: Raw euclidean distance 20 90 0.4670769 0.05181300 50
8: Raw euclidean distance 15 90 0.4632035 0.05363563 50
9: Raw euclidean distance 10 90 0.4412719 0.04507432 50
10: Raw lcss distance 10 90 0.4355329 0.04233988 50
11: Raw lcss distance 5 90 0.4339394 0.04239648 50
12: Raw lcss distance 15 90 0.4233230 0.04867493 50
13: Raw lcss distance 20 90 0.4198804 0.04030678 50
14: Raw euclidean distance 5 90 0.4195032 0.04400124 50
15: Raw lcss distance 25 90 0.4091053 0.03897383 50
> |

> all_hours_summary2[[3]] #5
representation approach k w_size avg_acc sdev_acc result_count
1: Raw edr distance 20 14 0.5177358 0.03968951 50
2: Raw edr distance 25 14 0.5171698 0.04019201 50
3: Raw edr distance 15 14 0.5132075 0.04043127 50
4: Raw euclidean distance 25 14 0.5130189 0.04140297 50
5: Raw edr distance 10 14 0.5069811 0.03413776 50
6: Raw euclidean distance 20 14 0.5054717 0.04039037 50
7: Raw euclidean distance 10 14 0.4983019 0.03423764 50
8: Raw euclidean distance 15 14 0.4916981 0.03742847 50
9: Raw edr distance 5 14 0.4862264 0.03980695 50
10: Raw euclidean distance 5 14 0.4771698 0.04703832 50
11: Raw lcss distance 10 14 0.3800000 0.04158463 50
12: Raw lcss distance 5 14 0.3777358 0.04453398 50
13: Raw lcss distance 15 14 0.3749057 0.04117951 50
14: Raw lcss distance 25 14 0.3701887 0.04018614 50
15: Raw lcss distance 20 14 0.3683019 0.04136215 50
> |

> all_hours_summary2[[3]] #5
representation approach k w_size avg_acc sdev_acc result_count
1: Raw euclidean distance 25 7 0.4998766 0.04107693 50
2: Raw edr distance 20 7 0.4925622 0.03798077 50
3: Raw edr distance 25 7 0.4918339 0.03484164 50
4: Raw euclidean distance 20 7 0.4916346 0.04122876 50
5: Raw euclidean distance 15 7 0.4873268 0.04224825 50
6: Raw edr distance 15 7 0.4854664 0.04331570 50
7: Raw euclidean distance 10 7 0.4809504 0.04139764 50
8: Raw edr distance 10 7 0.4684024 0.04019463 50
9: Raw euclidean distance 5 7 0.4586740 0.04259612 50
10: Raw edr distance 5 7 0.4545354 0.04171569 50
11: Raw lcss distance 20 7 0.3681961 0.03927464 50
12: Raw lcss distance 25 7 0.3676371 0.03874242 50
13: Raw lcss distance 15 7 0.3648140 0.03507485 50
14: Raw lcss distance 5 7 0.3632816 0.04463946 50
15: Raw lcss distance 10 7 0.3612432 0.03571946 50
> |
```

Best Accuracy: EDR distance, k=25, w\_size=90

Used Model: EDR distance, k=20, w\_size=14

## Hour6

```
> all_hours_summary2[[1]] #6
representation approach k w_size avg_acc sdev_acc result_count
1: Raw edr distance 25 90 0.5473428 0.03380078 50
2: Raw edr distance 10 90 0.5467244 0.04063619 50
3: Raw edr distance 5 90 0.5422614 0.04427486 50
4: Raw edr distance 20 90 0.5420491 0.03681463 50
5: Raw edr distance 15 90 0.5396125 0.04086833 50
6: Raw euclidean distance 20 90 0.4941311 0.04532277 50
7: Raw euclidean distance 25 90 0.4870109 0.03997354 50
8: Raw euclidean distance 15 90 0.4782663 0.04431925 50
9: Raw euclidean distance 10 90 0.4658586 0.03872352 50
10: Raw euclidean distance 5 90 0.4479509 0.03720716 50
11: Raw lcss distance 5 90 0.4091610 0.05424650 50
12: Raw lcss distance 10 90 0.4020284 0.04330355 50
13: Raw lcss distance 15 90 0.3983385 0.04578433 50
14: Raw lcss distance 20 90 0.3779984 0.05358058 50
15: Raw lcss distance 25 90 0.3696764 0.04628039 50
> |
```

```
> all_hours_summary2[[4]] #6
  representation approach k w_size avg_acc sdev_acc result_count
1:      Raw      edr distance 25    14 0.5250943 0.04460122      50
2:      Raw      edr distance 20    14 0.5245283 0.04043127      50
3:      Raw euclidean distance 20    14 0.5205660 0.04001084      50
4:      Raw      edr distance 10    14 0.5188679 0.03849827      50
5:      Raw euclidean distance 25    14 0.5164151 0.04290755      50
6:      Raw      edr distance 15    14 0.5162264 0.04621836      50
7:      Raw      edr distance 5     14 0.5116981 0.03875970      50
8:      Raw euclidean distance 15    14 0.5100000 0.03347151      50
9:      Raw euclidean distance 10    14 0.5001887 0.03880325      50
10:     Raw euclidean distance 5     14 0.4928302 0.04623879      50
11:     Raw      lcsm distance 5     14 0.4166038 0.03453713      50
12:     Raw      lcsm distance 10    14 0.4154717 0.03744400      50
13:     Raw      lcsm distance 15    14 0.3975472 0.03975216      50
14:     Raw      lcsm distance 20    14 0.3854717 0.03887434      50
15:     Raw      lcsm distance 25    14 0.3822642 0.04228629      50
~ |

> all_hours_summary2[[4]] #6
  representation approach k w_size avg_acc sdev_acc result_count
1:      Raw euclidean distance 20     7 0.4954223 0.04700109      50
2:      Raw      edr distance 25     7 0.4907547 0.04915566      50
3:      Raw euclidean distance 25     7 0.4903421 0.03840158      50
4:      Raw      edr distance 20     7 0.4881132 0.04711342      50
5:      Raw euclidean distance 15     7 0.4871698 0.04694155      50
6:      Raw      edr distance 15     7 0.4808552 0.04444363      50
7:      Raw euclidean distance 10     7 0.4740469 0.04166018      50
8:      Raw      edr distance 10     7 0.4630101 0.04099245      50
9:      Raw      edr distance 5      7 0.4527085 0.03905557      50
10:     Raw euclidean distance 5      7 0.4497020 0.04296847      50
11:     Raw      lcsm distance 5      7 0.3743202 0.04696054      50
12:     Raw      lcsm distance 10     7 0.3660695 0.04761651      50
13:     Raw      lcsm distance 20     7 0.3574326 0.04071097      50
14:     Raw      lcsm distance 15     7 0.3568753 0.04473170      50
15:     Raw      lcsm distance 25     7 0.3565086 0.04336933      50
~ |
```

Best Accuracy: EDR distance, k=25, w\_size=90

Used Model: EDR distance, k=20, w\_size = 14

## Hour7

```
> all_hours_summary2[[2]] #7
  representation approach k w_size avg_acc sdev_acc result_count
1:      Raw      edr distance 10    90 0.6159534 0.04016576      50
2:      Raw      edr distance 15    90 0.6057741 0.04191504      50
3:      Raw      edr distance 20    90 0.6037662 0.04919816      50
4:      Raw      edr distance 25    90 0.5999175 0.05444792      50
5:      Raw      edr distance 5     90 0.5929643 0.04402468      50
6:      Raw euclidean distance 20    90 0.5543558 0.05038624      50
7:      Raw euclidean distance 25    90 0.5539497 0.04622510      50
8:      Raw euclidean distance 15    90 0.5504700 0.05011376      50
9:      Raw euclidean distance 10    90 0.5339827 0.05065540      50
10:     Raw euclidean distance 5     90 0.5159369 0.04361653      50
11:     Raw      lcsm distance 5     90 0.4096908 0.05169313      50
12:     Raw      lcsm distance 10    90 0.3985013 0.04912329      50
13:     Raw      lcsm distance 15    90 0.3979097 0.04642512      50
14:     Raw      lcsm distance 20    90 0.3964894 0.04720765      50
15:     Raw      lcsm distance 25    90 0.3934611 0.04866157      50
~ |

> all_hours_summary3[[1]] #7
  representation approach k w_size avg_acc sdev_acc result_count
1:      Raw      edr distance 20    14 0.5883019 0.04744854      50
2:      Raw      edr distance 25    14 0.5832075 0.04407194      50
3:      Raw euclidean distance 25    14 0.5779245 0.04248213      50
4:      Raw euclidean distance 20    14 0.5720755 0.04374390      50
5:      Raw      edr distance 15    14 0.5711321 0.04523205      50
6:      Raw      edr distance 10    14 0.5690566 0.04579990      50
7:      Raw euclidean distance 15    14 0.5679245 0.04300015      50
8:      Raw euclidean distance 10    14 0.5584906 0.04761057      50
9:      Raw      edr distance 5     14 0.5490566 0.04227598      50
10:     Raw euclidean distance 5     14 0.5396226 0.04449481      50
11:     Raw      lcsm distance 5     14 0.5245283 0.05353645      50
12:     Raw      lcsm distance 10    14 0.4735849 0.05467780      50
13:     Raw      lcsm distance 15    14 0.3798113 0.03863061      50
14:     Raw      lcsm distance 20    14 0.3650943 0.03944208      50
15:     Raw      lcsm distance 25    14 0.3577358 0.04183719      50
~ |
```

```
> all_hours_summary3[[1]] #7
  representation approach k w_size avg_acc sdev_acc result_count
1:      Raw euclidean distance 20    7 0.5735761 0.03930623      50
2:      Raw      edr distance 25    7 0.5728214 0.04196055      50
3:      Raw euclidean distance 25    7 0.5726468 0.03623647      50
4:      Raw      edr distance 20    7 0.5666443 0.03955485      50
5:      Raw euclidean distance 15    7 0.5615694 0.03595306      50
6:      Raw      edr distance 15    7 0.5591377 0.03943953      50
7:      Raw      edr distance 10    7 0.5520243 0.03536352      50
8:      Raw euclidean distance 10    7 0.5415288 0.03472314      50
9:      Raw euclidean distance  5    7 0.5222236 0.03928730      50
10:     Raw      edr distance  5    7 0.5077764 0.04398217      50
11:     Raw      lcsm distance 10    7 0.3668436 0.05270129      50
12:     Raw      lcsm distance  5    7 0.3627085 0.05119444      50
13:     Raw      lcsm distance 20    7 0.3538811 0.04514461      50
14:     Raw      lcsm distance 15    7 0.3537313 0.04808380      50
15:     Raw      lcsm distance 25    7 0.3529430 0.04221786      50
~ |
```

Best Accuracy: EDR distance, k=10, w\_size=90

Used Model: EDR distance, k=10, w\_size=90

## Hour8

```
> all_hours_summary2[[3]] #8
  representation approach k w_size avg_acc sdev_acc result_count
1:      Raw euclidean distance 10   90 0.5902329 0.04388593      50
2:      Raw euclidean distance 15   90 0.5880128 0.04123099      50
3:      Raw euclidean distance 25   90 0.5851639 0.04047793      50
4:      Raw euclidean distance 20   90 0.5829107 0.03983027      50
5:      Raw      edr distance 25   90 0.5721274 0.03893780      50
6:      Raw      edr distance 15   90 0.5683137 0.04391631      50
7:      Raw      edr distance 20   90 0.5650526 0.04237090      50
8:      Raw euclidean distance  5   90 0.5619934 0.03985727      50
9:      Raw      edr distance  5   90 0.5536281 0.03752095      50
10:     Raw      edr distance 10   90 0.5476067 0.04607541      50
11:     Raw      lcsm distance  5   90 0.4615440 0.04917923      50
12:     Raw      lcsm distance 15   90 0.4581323 0.03901625      50
13:     Raw      lcsm distance 10   90 0.4576541 0.05643133      50
14:     Raw      lcsm distance 20   90 0.4445042 0.04311489      50
15:     Raw      lcsm distance 25   90 0.4367739 0.04715852      50
> |
```

```
> all_hours_summary3[[2]] #8
  representation approach k w_size avg_acc sdev_acc result_count
1:      Raw euclidean distance 25   14 0.5803774 0.03647489      50
2:      Raw      edr distance  5   14 0.5784906 0.04212275      50
3:      Raw euclidean distance 20   14 0.5781132 0.03754476      50
4:      Raw euclidean distance 15   14 0.5722642 0.03977956      50
5:      Raw      edr distance 10   14 0.5688679 0.04507275      50
6:      Raw      edr distance 15   14 0.5660377 0.03535007      50
7:      Raw      edr distance 20   14 0.5656604 0.03600981      50
8:      Raw euclidean distance 10   14 0.5611321 0.03750604      50
9:      Raw      edr distance 25   14 0.5579245 0.03430760      50
10:     Raw euclidean distance  5   14 0.5469811 0.04138542      50
11:     Raw      lcsm distance 10   14 0.5052830 0.03468407      50
12:     Raw      lcsm distance  5   14 0.4645283 0.04191180      50
13:     Raw      lcsm distance 15   14 0.4398113 0.03886873      50
14:     Raw      lcsm distance 20   14 0.4256604 0.04018975      50
15:     Raw      lcsm distance 25   14 0.4137736 0.04118833      50
> |
```

```
> all_hours_summary3[[2]] #8
  representation approach k w_size avg_acc sdev_acc result_count
1:      Raw      edr distance 25    7 0.5806965 0.04467956      50
2:      Raw euclidean distance 25    7 0.5805131 0.04237130      50
3:      Raw euclidean distance 20    7 0.5786422 0.04234192      50
4:      Raw euclidean distance 15    7 0.5703809 0.03864630      50
5:      Raw      edr distance 20    7 0.5700106 0.04354438      50
6:      Raw      edr distance 15    7 0.5647381 0.04234834      50
7:      Raw euclidean distance 10    7 0.5542603 0.04089664      50
8:      Raw      edr distance 10    7 0.5381167 0.03498948      50
9:      Raw euclidean distance  5    7 0.5216576 0.03255306      50
10:     Raw      edr distance  5    7 0.5109487 0.03335303      50
11:     Raw      lcsm distance 25    7 0.4619996 0.05045259      50
12:     Raw      lcsm distance 20    7 0.4390266 0.06421761      50
13:     Raw      lcsm distance 15    7 0.4243537 0.05365704      50
14:     Raw      lcsm distance 10    7 0.4207865 0.05833695      50
15:     Raw      lcsm distance  5    7 0.4007424 0.05582516      50
> |
```



Best Accuracy: Euclidean distance, k=10, w\_size =90

Used Model: Euclidean distance, k=25, w\_size =7

## Hour9

```
> all_hours_summary3[[1]] #9
  representation approach k w_size avg_acc sdev_acc result_count
1:      Raw euclidean distance 15    90 0.6924696 0.03183931      50
2:      Raw euclidean distance 25    90 0.6900392 0.03302446      50
3:      Raw euclidean distance 10    90 0.6894310 0.02838874      50
4:      Raw euclidean distance 20    90 0.6877798 0.03279726      50
5:      Raw euclidean distance  5    90 0.6683137 0.03161650      50
6:      Raw      edr distance 25    90 0.6481550 0.02624445      50
7:      Raw      edr distance  5    90 0.6479901 0.03729557      50
8:      Raw      edr distance 20    90 0.6455226 0.03228499      50
9:      Raw      edr distance 15    90 0.6428654 0.03551709      50
10:     Raw      edr distance 10    90 0.6394372 0.03025700      50
11:     Raw      lcsm distance  5    90 0.4780849 0.04718093      50
12:     Raw      lcsm distance 10    90 0.4408679 0.04210774      50
13:     Raw      lcsm distance 20    90 0.4199114 0.04640894      50
14:     Raw      lcsm distance 25    90 0.4134158 0.04849770      50
15:     Raw      lcsm distance 15    90 0.4117914 0.04081754      50
> |

> all_hours_summary3[[3]] #9
  representation approach k w_size avg_acc sdev_acc result_count
1:      Raw      edr distance 25    14 0.6518868 0.03888555      50
2:      Raw      edr distance 15    14 0.6503774 0.03832852      50
3:      Raw      edr distance 20    14 0.6503774 0.03813849      50
4:      Raw euclidean distance 15    14 0.6424528 0.03045047      50
5:      Raw euclidean distance 20    14 0.6405660 0.03346283      50
6:      Raw      edr distance 10    14 0.6403774 0.03708722      50
7:      Raw euclidean distance 25    14 0.6386792 0.03196372      50
8:      Raw      edr distance  5    14 0.6315094 0.04151337      50
9:      Raw euclidean distance 10    14 0.6303774 0.03423764      50
10:     Raw euclidean distance  5    14 0.6049057 0.03857556      50
11:     Raw      lcsm distance  5    14 0.3266038 0.03284043      50
12:     Raw      lcsm distance 10    14 0.3200000 0.04436563      50
13:     Raw      lcsm distance 15    14 0.3143396 0.04147091      50
14:     Raw      lcsm distance 20    14 0.3124528 0.03866962      50
15:     Raw      lcsm distance 25    14 0.3109434 0.04162479      50
> |

> all_hours_summary3[[3]] #9
  representation approach k w_size avg_acc sdev_acc result_count
1:      Raw      edr distance 25     7 0.6484006 0.03988709      50
2:      Raw euclidean distance 25     7 0.6461312 0.03548818      50
3:      Raw euclidean distance 20     7 0.6444419 0.03462693      50
4:      Raw      edr distance 20     7 0.6420138 0.03880982      50
5:      Raw euclidean distance 15     7 0.6399348 0.03228015      50
6:      Raw      edr distance 15     7 0.6363816 0.03691416      50
7:      Raw      edr distance 10     7 0.6277429 0.03551108      50
8:      Raw euclidean distance 10     7 0.6277341 0.03397967      50
9:      Raw      edr distance  5     7 0.6005643 0.03454434      50
10:     Raw euclidean distance  5     7 0.6005484 0.03402126      50
11:     Raw      lcsm distance  5     7 0.4689684 0.05951013      50
12:     Raw      lcsm distance 20     7 0.4131582 0.08733921      50
13:     Raw      lcsm distance 25     7 0.4041439 0.07876569      50
14:     Raw      lcsm distance 15     7 0.3924863 0.06877764      50
15:     Raw      lcsm distance 10     7 0.3281749 0.05589324      50
~ |
```

Best Accuracy: Euclidean distance, k=15, w\_size =90

Used Model: Euclidean distance, k=15, w\_size =14

## Hour10

```
> all_hours_summary3[[2]] #10
  representation approach k w_size avg_acc sdev_acc result_count
1:      Raw      edr distance 25    90 0.5898475 0.03530951      50
2:      Raw      edr distance 20    90 0.5839353 0.04236867      50
3:      Raw euclidean distance 25    90 0.5821192 0.02398771      50
4:      Raw      edr distance 10    90 0.5812966 0.04453263      50
5:      Raw euclidean distance 20    90 0.5800557 0.02609546      50
6:      Raw      edr distance 15    90 0.5796722 0.03922429      50
7:      Raw euclidean distance 15    90 0.5794352 0.03033947      50
8:      Raw      edr distance 5     90 0.5727396 0.04635087      50
9:      Raw euclidean distance 10    90 0.5613399 0.03217287      50
10:     Raw euclidean distance 5     90 0.5446877 0.03809382      50
11:     Raw      lcss distance 5     90 0.4900309 0.04012505      50
12:     Raw      lcss distance 15    90 0.4890435 0.05109670      50
13:     Raw      lcss distance 10    90 0.4881880 0.04962084      50
14:     Raw      lcss distance 20    90 0.4642672 0.04810184      50
15:     Raw      lcss distance 25    90 0.4636178 0.05310950      50
> |
```

```
> all_hours_summary3[[4]] #10
  representation approach k w_size avg_acc sdev_acc result_count
1:      Raw euclidean distance 25    14 0.6020755 0.03664628      50
2:      Raw euclidean distance 20    14 0.5920755 0.03506945      50
3:      Raw      edr distance 20    14 0.5854717 0.03879951      50
4:      Raw      edr distance 25    14 0.5841509 0.03211056      50
5:      Raw euclidean distance 15    14 0.5839623 0.03916480      50
6:      Raw      edr distance 10    14 0.5813208 0.03933325      50
7:      Raw      edr distance 15    14 0.5783019 0.03696999      50
8:      Raw      edr distance 5     14 0.5767925 0.03979782      50
9:      Raw euclidean distance 10    14 0.5730189 0.03758199      50
10:     Raw euclidean distance 5     14 0.5596226 0.04194992      50
11:     Raw      lcss distance 5     14 0.5360377 0.05019885      50
12:     Raw      lcss distance 10    14 0.5101887 0.04033412      50
13:     Raw      lcss distance 15    14 0.4869811 0.03665620      50
14:     Raw      lcss distance 20    14 0.4654717 0.04596497      50
15:     Raw      lcss distance 25    14 0.4416981 0.03579379      50
> |
```

```
> all_hours_summary3[[4]] #10
  representation approach k w_size avg_acc sdev_acc result_count
1:      Raw      lcss distance 5     7 0.5840628 0.02195164      50
2:      Raw      lcss distance 10    7 0.5829360 0.02027964      50
3:      Raw      lcss distance 15    7 0.5775031 0.02479484      50
4:      Raw euclidean distance 25    7 0.5703897 0.03416974      50
5:      Raw      edr distance 25    7 0.5684994 0.03278690      50
6:      Raw      lcss distance 20    7 0.5677358 0.03212121      50
7:      Raw      edr distance 15    7 0.5674008 0.03533464      50
8:      Raw      edr distance 20    7 0.5657256 0.03206747      50
9:      Raw euclidean distance 20    7 0.5651226 0.03488690      50
10:     Raw      lcss distance 25    7 0.5552019 0.03811455      50
11:     Raw      edr distance 10    7 0.5510809 0.02856090      50
12:     Raw euclidean distance 15    7 0.5456604 0.03285117      50
13:     Raw      edr distance 5     7 0.5387127 0.04102622      50
14:     Raw euclidean distance 10    7 0.5379792 0.03599140      50
15:     Raw euclidean distance 5     7 0.5175260 0.03961538      50
> |
```

Best Accuracy: Euclidean distance, k=25, w\_size = 14

Used Model: euclidean distance, k=20, w\_size = 14

## Hour11

```
> all_hours_summary3[[3]] #11
  representation approach k w_size avg_acc sdev_acc result_count
1:      Raw      edr distance 10    90 0.6239579 0.04007635      50
2:      Raw euclidean distance 15    90 0.6205360 0.01887805      50
3:      Raw euclidean distance 20    90 0.6199155 0.01692144      50
4:      Raw      edr distance 5     90 0.6192909 0.04308279      50
5:      Raw euclidean distance 25    90 0.6188971 0.01636895      50
6:      Raw euclidean distance 10    90 0.6168666 0.02557879      50
7:      Raw      edr distance 15    90 0.6148402 0.04405229      50
8:      Raw      edr distance 20    90 0.6103814 0.03588974      50
9:      Raw      edr distance 25    90 0.6091548 0.03228351      50
10:     Raw euclidean distance 5     90 0.5902474 0.03041768      50
11:     Raw      lcss distance 20    90 0.5896660 0.02827152      50
12:     Raw      lcss distance 25    90 0.5872129 0.02823705      50
13:     Raw      lcss distance 15    90 0.5743950 0.02899434      50
14:     Raw      lcss distance 10    90 0.5438776 0.03809542      50
15:     Raw      lcss distance 5     90 0.5252154 0.03820736      50
> |
```

```
> all_hours_summary[[1]] #11
  representation approach k w_size avg_acc sdev_acc result_count
1:      Raw      edr distance 10    14 0.6194340 0.03810038      50
2:      Raw      edr distance 25    14 0.6090566 0.02412060      50
3:      Raw euclidean distance 20    14 0.6073585 0.02129977      50
4:      Raw euclidean distance 25    14 0.6067925 0.02002969      50
5:      Raw      edr distance 20    14 0.6064151 0.02977430      50
6:      Raw      edr distance 15    14 0.6045283 0.02793629      50
7:      Raw euclidean distance 15    14 0.6009434 0.02412738      50
8:      Raw euclidean distance 10    14 0.5983019 0.03540603      50
9:      Raw      lcsm distance 25    14 0.5969811 0.02585635      50
10:     Raw      lcsm distance 10    14 0.5856604 0.03554683      50
11:     Raw      edr distance  5    14 0.5850943 0.03742119      50
12:     Raw euclidean distance  5    14 0.5771698 0.03923153      50
13:     Raw      lcsm distance 20    14 0.5743396 0.03838676      50
14:     Raw      lcsm distance  5    14 0.5724528 0.03052137      50
15:     Raw      lcsm distance 15    14 0.5528302 0.03892056      50
> |
```

```
> all_hours_summary[[1]] #11
  representation approach k w_size avg_acc sdev_acc result_count
1:      Raw      edr distance 25     7 0.6177993 0.02863631      50
2:      Raw euclidean distance 15     7 0.6163163 0.03339086      50
3:      Raw      edr distance 20     7 0.6127350 0.02765938      50
4:      Raw euclidean distance 25     7 0.6114601 0.03273085      50
5:      Raw      edr distance 15     7 0.6086087 0.03310145      50
6:      Raw euclidean distance 20     7 0.6033962 0.03122586      50
7:      Raw      edr distance 10     7 0.5958843 0.03560601      50
8:      Raw euclidean distance 10     7 0.5885999 0.03651037      50
9:      Raw      edr distance  5     7 0.5535179 0.04506188      50
10:     Raw euclidean distance  5     7 0.5463886 0.04747073      50
11:     Raw      lcsm distance 15     7 0.5389684 0.05568991      50
12:     Raw      lcsm distance 20     7 0.5262493 0.06328446      50
13:     Raw      lcsm distance 25     7 0.5190901 0.05190900      50
14:     Raw      lcsm distance 10     7 0.4962493 0.06775996      50
15:     Raw      lcsm distance  5     7 0.4671416 0.04118365      50
> |
```

Best Accuracy: EDR distance, k=10, w\_size=90

Used Model: EDR distance, k=15, w\_size=7

## Hour12

```
> all_hours_summary3[[4]] #12
  representation approach k w_size avg_acc sdev_acc result_count
1:      Raw      edr distance  5    90 0.6174521 0.04301672      50
2:      Raw      edr distance 10    90 0.6081447 0.04169169      50
3:      Raw      edr distance 25    90 0.6022676 0.04010002      50
4:      Raw      edr distance 20    90 0.5992146 0.03623258      50
5:      Raw      edr distance 15    90 0.5922985 0.03522694      50
6:      Raw euclidean distance 15    90 0.5559101 0.03317450      50
7:      Raw euclidean distance 20    90 0.5520491 0.03322111      50
8:      Raw euclidean distance 25    90 0.5447330 0.03271013      50
9:      Raw euclidean distance 10    90 0.5431169 0.03837923      50
10:     Raw euclidean distance  5    90 0.5123995 0.04026689      50
11:     Raw      lcsm distance 25    90 0.4993589 0.02922160      50
12:     Raw      lcsm distance 15    90 0.4991651 0.03444365      50
13:     Raw      lcsm distance 20    90 0.4969511 0.02686756      50
14:     Raw      lcsm distance 10    90 0.4961204 0.04127119      50
15:     Raw      lcsm distance  5    90 0.4875737 0.04346842      50
> |
```

```
> all_hours_summary[[2]] #12
  representation approach k w_size avg_acc sdev_acc result_count
1:      Raw      edr distance 25    14 0.5928302 0.03953912      50
2:      Raw      edr distance 15    14 0.5879245 0.04524128      50
3:      Raw      edr distance 20    14 0.5860377 0.03918288      50
4:      Raw      edr distance 10    14 0.5824528 0.03640361      50
5:      Raw euclidean distance 25    14 0.5801887 0.04215766      50
6:      Raw euclidean distance 15    14 0.5792453 0.03570793      50
7:      Raw euclidean distance 20    14 0.5760377 0.03813849      50
8:      Raw euclidean distance 10    14 0.5728302 0.03725337      50
9:      Raw      edr distance  5    14 0.5633962 0.05271730      50
10:     Raw euclidean distance  5    14 0.5496226 0.03101546      50
11:     Raw      lcsm distance  5    14 0.5171698 0.04113008      50
12:     Raw      lcsm distance 20    14 0.4943396 0.04554379      50
13:     Raw      lcsm distance 15    14 0.4900000 0.05279889      50
14:     Raw      lcsm distance 25    14 0.4815094 0.04676220      50
15:     Raw      lcsm distance 10    14 0.4811321 0.04641287      50
> |
```



```
> all_hours_summary[[2]] #12
  representation approach k w_size avg_acc sdev_acc result_count
1:      Raw euclidean distance 20    7 0.5737806 0.03676685      50
2:      Raw      edr distance 20    7 0.5692682 0.04016579      50
3:      Raw euclidean distance 15    7 0.5658879 0.03950365      50
4:      Raw euclidean distance 25    7 0.5638459 0.04160083      50
5:      Raw      edr distance 25    7 0.5623241 0.03837730      50
6:      Raw euclidean distance 10    7 0.5544437 0.04258044      50
7:      Raw      edr distance 15    7 0.5527561 0.03888299      50
8:      Raw      edr distance  5    7 0.5504920 0.03693189      50
9:      Raw      edr distance 10    7 0.5490143 0.04607424      50
10:     Raw euclidean distance  5    7 0.5424405 0.03942868      50
11:     Raw      lcsm distance  5    7 0.5414671 0.04272595      50
12:     Raw      lcsm distance 15    7 0.4798148 0.04822838      50
13:     Raw      lcsm distance 10    7 0.4725198 0.05995799      50
14:     Raw      lcsm distance 20    7 0.4262617 0.05548946      50
15:     Raw      lcsm distance 25    7 0.3924828 0.04453385      50
> |
```

Best Accuracy: EDR distance, k=5, w\_size =90

Used Model: EDR distance, k=15, w\_size =14

### Hour13

```
> all_hours_summary[[1]] #13
  representation approach k w_size avg_acc sdev_acc result_count
1:      Raw      edr distance  8    90 0.5992187 0.04787652      50
2:      Raw      edr distance 10    90 0.5951391 0.04481326      50
3:      Raw      edr distance  7    90 0.5888394 0.04544517      50
4:      Raw      edr distance  9    90 0.5868027 0.04038203      50
5:     Raw euclidean distance  7    90 0.5343579 0.04410878      50
6:     Raw euclidean distance  8    90 0.5311029 0.04417051      50
7:     Raw euclidean distance  9    90 0.5292929 0.04496927      50
8:     Raw euclidean distance 10    90 0.5203525 0.04341969      50
9:      Raw      lcsm distance  7    90 0.4869347 0.04594823      50
10:     Raw      lcsm distance  9    90 0.4861307 0.04569593      50
11:     Raw      lcsm distance  8    90 0.4802556 0.04452043      50
12:     Raw      lcsm distance 10    90 0.4720800 0.04554686      50
> |
```

```
> all_hours_summary[[3]] #13
  representation approach k w_size avg_acc sdev_acc result_count
1:      Raw euclidean distance 25    14 0.5722642 0.03876204      50
2:      Raw      edr distance 15    14 0.5715094 0.03735318      50
3:      Raw      edr distance 25    14 0.5709434 0.04305250      50
4:      Raw      edr distance 20    14 0.5707547 0.04066643      50
5:     Raw euclidean distance 20    14 0.5564151 0.04339916      50
6:      Raw      edr distance 10    14 0.5556604 0.04515328      50
7:      Raw      edr distance  5    14 0.5549057 0.04496947      50
8:     Raw euclidean distance 15    14 0.5547170 0.04354581      50
9:     Raw euclidean distance 10    14 0.5535849 0.03823505      50
10:     Raw euclidean distance  5    14 0.5220755 0.04327846      50
11:     Raw      lcsm distance  5    14 0.4033962 0.04678550      50
12:     Raw      lcsm distance 10    14 0.3935849 0.04158463      50
13:     Raw      lcsm distance 15    14 0.3892453 0.03987989      50
14:     Raw      lcsm distance 20    14 0.3864151 0.04114200      50
15:     Raw      lcsm distance 25    14 0.3828302 0.04408842      50
> |
```

```
> all_hours_summary[[3]] #13
  representation approach k w_size avg_acc sdev_acc result_count
1:      Raw      edr distance 20    7 0.5761929 0.04484605      50
2:      Raw      edr distance 25    7 0.5679545 0.04239575      50
3:      Raw      edr distance 15    7 0.5655193 0.04942094      50
4:      Raw      edr distance 10    7 0.5640011 0.04790691      50
5:     Raw euclidean distance 25    7 0.5581820 0.04224651      50
6:     Raw euclidean distance 20    7 0.5512485 0.03771624      50
7:     Raw euclidean distance 10    7 0.5503209 0.04712493      50
8:     Raw euclidean distance 15    7 0.5484306 0.04714389      50
9:     Raw euclidean distance  5    7 0.5366126 0.04943224      50
10:     Raw      edr distance  5    7 0.5332604 0.04905208      50
11:     Raw      lcsm distance  5    7 0.4906013 0.06627071      50
12:     Raw      lcsm distance 10    7 0.4752266 0.06636148      50
13:     Raw      lcsm distance 15    7 0.4341933 0.07386496      50
14:     Raw      lcsm distance 20    7 0.4285364 0.04956232      50
15:     Raw      lcsm distance 25    7 0.4047470 0.05431631      50
> |
```

Best Accuracy: EDR distance, k=8, w\_size =90

Used Model: EDR distance, k=20, w\_size =7

## Hour14

```
> all_hours_summary[[2]] #14
  representation approach k w_size avg_acc sdev_acc result_count
1:      Raw      edr distance 9    90 0.6106226 0.04149759      50
2:      Raw      edr distance 8    90 0.6104453 0.04323705      50
3:      Raw      edr distance 7    90 0.6104267 0.04134055      50
4:      Raw      edr distance 10   90 0.6073799 0.03911898      50
5:      Raw euclidean distance 10   90 0.5979757 0.03236898      50
6:      Raw euclidean distance 9    90 0.5896434 0.02786206      50
7:      Raw euclidean distance 8    90 0.5855514 0.02755076      50
8:      Raw euclidean distance 7    90 0.5759967 0.02881589      50
9:      Raw      lcsm distance 10   90 0.5233849 0.03809842      50
10:     Raw      lcsm distance 9    90 0.5225768 0.04088026      50
11:     Raw      lcsm distance 8    90 0.5079674 0.04297735      50
12:     Raw      lcsm distance 7    90 0.5030715 0.04657455      50
> |
```

```
> all_hours_summary[[4]] #14
  representation approach k w_size avg_acc sdev_acc result_count
1:      Raw      edr distance 25   14 0.6198113 0.03062889      50
2:      Raw euclidean distance 15   14 0.6113208 0.03031596      50
3:      Raw euclidean distance 20   14 0.6101887 0.02595451      50
4:      Raw      edr distance 15   14 0.6090566 0.03706371      50
5:      Raw euclidean distance 25   14 0.6090566 0.02965940      50
6:      Raw      edr distance 20   14 0.6081132 0.03617337      50
7:      Raw      edr distance 10   14 0.6075472 0.03646294      50
8:      Raw      edr distance 5    14 0.5958491 0.03926253      50
9:      Raw euclidean distance 10   14 0.5909434 0.03077738      50
10:     Raw      lcsm distance 25   14 0.5832075 0.02292611      50
11:     Raw      lcsm distance 20   14 0.5800000 0.02273118      50
12:     Raw euclidean distance 5    14 0.5745283 0.03235905      50
13:     Raw      lcsm distance 15   14 0.5726415 0.02690359      50
14:     Raw      lcsm distance 5    14 0.5596226 0.03448871      50
15:     Raw      lcsm distance 10   14 0.5522642 0.03696803      50
. |
```

```
> all_hours_summary[[4]] #14
  representation approach k w_size avg_acc sdev_acc result_count
1:      Raw euclidean distance 20    7 0.6240081 0.03217544      50
2:      Raw euclidean distance 15    7 0.6148510 0.03494222      50
3:      Raw euclidean distance 25    7 0.6129325 0.03277128      50
4:      Raw      edr distance 25    7 0.6118198 0.03387347      50
5:      Raw      edr distance 20    7 0.6082419 0.03722658      50
6:      Raw euclidean distance 10    7 0.6048951 0.03078124      50
7:      Raw      edr distance 15    7 0.6033645 0.04095517      50
8:      Raw      edr distance 10    7 0.5973691 0.03819269      50
9:      Raw      edr distance 5     7 0.5761911 0.03704902      50
10:     Raw euclidean distance 5     7 0.5683301 0.03971541      50
11:     Raw      lcsm distance 10    7 0.5668436 0.04164442      50
12:     Raw      lcsm distance 15    7 0.5617581 0.02954594      50
13:     Raw      lcsm distance 25    7 0.5598977 0.02659755      50
14:     Raw      lcsm distance 20    7 0.5508958 0.02873865      50
15:     Raw      lcsm distance 5     7 0.5460254 0.03643962      50
~ |
```

Best Accuracy: Euclidean distance, k=20, w\_size = 7

Used Model: Euclidean distance, k=20, w\_size = 7

## Hour15

```
> all_hours_summary[[3]] #15
  representation approach k w_size avg_acc sdev_acc result_count
1:      Raw      edr distance 10   90 0.6144259 0.03694089      50
2:      Raw      edr distance 8    90 0.6059019 0.03098397      50
3:      Raw      edr distance 9    90 0.6056916 0.03789648      50
4:      Raw      edr distance 7    90 0.6042672 0.03858710      50
5:      Raw euclidean distance 10   90 0.5953350 0.02785772      50
6:      Raw euclidean distance 9    90 0.5890311 0.02766331      50
7:      Raw euclidean distance 8    90 0.5778458 0.02935940      50
8:      Raw euclidean distance 7    90 0.5741888 0.03245173      50
9:      Raw      lcsm distance 10   90 0.5093300 0.03747881      50
10:     Raw      lcsm distance 9    90 0.5074851 0.03500284      50
11:     Raw      lcsm distance 7    90 0.5019810 0.04239412      50
12:     Raw      lcsm distance 8    90 0.4999526 0.04390721      50
> |
```

```

> all_hours_summary2[[1]] #15
representation approach k w_size avg_acc sdev_acc result_count
1: Raw edr distance 10 14 0.6073585 0.04278376 50
2: Raw edr distance 20 14 0.6045283 0.03849072 50
3: Raw edr distance 15 14 0.6011321 0.03641508 50
4: Raw edr distance 25 14 0.5979245 0.04209903 50
5: Raw euclidean distance 25 14 0.5924528 0.02634073 50
6: Raw euclidean distance 20 14 0.5807547 0.02922758 50
7: Raw euclidean distance 15 14 0.5803774 0.03173504 50
8: Raw edr distance 5 14 0.5788679 0.03630118 50
9: Raw lcsc distance 25 14 0.5783019 0.02479565 50
10: Raw lcsc distance 20 14 0.5690566 0.02924497 50
11: Raw lcsc distance 15 14 0.5613208 0.03453134 50
12: Raw euclidean distance 10 14 0.5547170 0.03143370 50
13: Raw lcsc distance 10 14 0.5500000 0.03793986 50
14: Raw lcsc distance 5 14 0.5349057 0.04224374 50
15: Raw euclidean distance 5 14 0.5290566 0.03445710 50

> all_hours_summary2[[1]] #15
representation approach k w_size avg_acc sdev_acc result_count
1: Raw edr distance 25 7 0.6052707 0.03740614 50
2: Raw edr distance 20 7 0.5964433 0.04135789 50
3: Raw euclidean distance 15 7 0.5938459 0.03557929 50
4: Raw edr distance 10 7 0.5915500 0.04141997 50
5: Raw euclidean distance 25 7 0.5889631 0.04214398 50
6: Raw euclidean distance 20 7 0.5887692 0.03666292 50
7: Raw edr distance 15 7 0.5870711 0.03987039 50
8: Raw euclidean distance 10 7 0.5840540 0.04020856 50
9: Raw lcsc distance 25 7 0.5192083 0.03300266 50
10: Raw lcsc distance 20 7 0.5173268 0.05299747 50
11: Raw lcsc distance 10 7 0.5122677 0.06990890 50
12: Raw lcsc distance 15 7 0.5117087 0.05901374 50
13: Raw lcsc distance 5 7 0.5053447 0.08249855 50
14: Raw edr distance 5 7 0.4964204 0.04983223 50
15: Raw euclidean distance 5 7 0.4814160 0.04726139 50
> |

```

Best Accuracy: EDR distance, k=10, w\_size =90

Used Model: EDR distance, k=10, w\_size =14

## Hour16

```

> all_hours_summary2[[1]] #16
representation approach k w_size avg_acc sdev_acc result_count
1: Raw edr distance 5 90 0.6092002 0.03475246 50
2: Raw euclidean distance 25 90 0.6071202 0.02099669 50
3: Raw edr distance 10 90 0.6068914 0.03943986 50
4: Raw euclidean distance 20 90 0.6048753 0.02607469 50
5: Raw euclidean distance 15 90 0.5995671 0.03115815 50
6: Raw edr distance 25 90 0.5967759 0.03924086 50
7: Raw euclidean distance 10 90 0.5880210 0.03714322 50
8: Raw edr distance 15 90 0.5780643 0.04980181 50
9: Raw edr distance 20 90 0.5740054 0.04269566 50
10: Raw euclidean distance 5 90 0.5619769 0.04272840 50
11: Raw lcsc distance 20 90 0.5337415 0.04004983 50
12: Raw lcsc distance 25 90 0.5317151 0.03860646 50
13: Raw lcsc distance 15 90 0.5225809 0.03693737 50
14: Raw lcsc distance 10 90 0.5029087 0.03934619 50
15: Raw lcsc distance 5 90 0.4999959 0.04456515 50
> |

```

```
> all_hours_summary2[[2]] #16
  representation approach k w_size avg_acc sdev_acc result_count
1:      Raw      edr distance 15    14 0.6030189 0.03753508      50
2:      Raw      edr distance 20    14 0.6001887 0.03445973      50
3:      Raw euclidean distance 25    14 0.5975472 0.02603626      50
4:      Raw      edr distance 25    14 0.5958491 0.03087165      50
5:      Raw      edr distance 10    14 0.5913208 0.03678233      50
6:      Raw euclidean distance 20    14 0.5907547 0.02976515      50
7:      Raw      edr distance 5     14 0.5884906 0.03705048      50
8:      Raw euclidean distance 15    14 0.5854717 0.03395638      50
9:      Raw euclidean distance 10    14 0.5843396 0.03145738      50
10:     Raw      lcsc distance 20    14 0.5737736 0.03129994      50
11:     Raw      lcsc distance 25    14 0.5709434 0.02107258      50
12:     Raw      lcsc distance 15    14 0.5613208 0.02743837      50
13:     Raw euclidean distance 5     14 0.5573585 0.03820654      50
14:     Raw      lcsc distance 10    14 0.5447170 0.03370943      50
15:     Raw      lcsc distance 5     14 0.4952830 0.04681228      50

> all_hours_summary2[[2]] #16
  representation approach k w_size avg_acc sdev_acc result_count
1:      Raw euclidean distance 25    7 0.5942074 0.03120314      50
2:      Raw euclidean distance 20    7 0.5885787 0.02971911      50
3:      Raw euclidean distance 15    7 0.5853765 0.03152453      50
4:      Raw      edr distance 20    7 0.5836960 0.03366980      50
5:      Raw      edr distance 25    7 0.5805167 0.03699934      50
6:      Raw euclidean distance 10    7 0.5714953 0.04279177      50
7:      Raw      edr distance 15    7 0.5694251 0.03538270      50
8:      Raw      edr distance 10    7 0.5655034 0.03892769      50
9:      Raw euclidean distance 5     7 0.5441474 0.03875091      50
10:     Raw      lcsc distance 25    7 0.5364662 0.03520021      50
11:     Raw      lcsc distance 5     7 0.5296985 0.06412941      50
12:     Raw      edr distance 5     7 0.5263075 0.04542114      50
13:     Raw      lcsc distance 20    7 0.5226010 0.04996094      50
14:     Raw      lcsc distance 15    7 0.5205308 0.05114287      50
15:     Raw      lcsc distance 10    7 0.4609222 0.07307574      50
```

Best Accuracy: EDR distance, k=5, w\_size =90

Used Model: Euclidean distance, k=25, w\_size =7

## Hour17

```
> all_hours_summary2[[1]] #17
  representation approach k w_size avg_acc sdev_acc result_count
1:      Raw      edr distance 25    90 0.6205298 0.03252918      50
2:      Raw      edr distance 5     90 0.6195362 0.04630513      50
3:      Raw euclidean distance 15    90 0.6120202 0.03111163      50
4:      Raw      edr distance 10    90 0.6107689 0.03610864      50
5:      Raw euclidean distance 20    90 0.6099794 0.02280555      50
6:      Raw      edr distance 20    90 0.6093445 0.03381376      50
7:      Raw euclidean distance 25    90 0.6089734 0.02095956      50
8:      Raw      edr distance 15    90 0.6059060 0.03341937      50
9:      Raw euclidean distance 10    90 0.6038961 0.03258501      50
10:     Raw      lcsc distance 25    90 0.5837497 0.03102781      50
11:     Raw      lcsc distance 20    90 0.5733684 0.03463164      50
12:     Raw euclidean distance 5     90 0.5707792 0.04184720      50
13:     Raw      lcsc distance 10    90 0.5668790 0.03993086      50
14:     Raw      lcsc distance 15    90 0.5666935 0.03745370      50
15:     Raw      lcsc distance 5     90 0.5520326 0.04676915      50

> all_hours_summary2[[3]] #17
  representation approach k w_size avg_acc sdev_acc result_count
1:      Raw      edr distance 25    14 0.6230189 0.03560401      50
2:      Raw      edr distance 15    14 0.6218868 0.03743818      50
3:      Raw      edr distance 10    14 0.6183019 0.03793795      50
4:      Raw      edr distance 20    14 0.6175472 0.03701713      50
5:      Raw euclidean distance 25    14 0.6109434 0.03088342      50
6:      Raw euclidean distance 20    14 0.6092453 0.03161175      50
7:      Raw      edr distance 5     14 0.5994340 0.04093176      50
8:      Raw euclidean distance 15    14 0.5945283 0.03237252      50
9:      Raw euclidean distance 10    14 0.5926415 0.03733373      50
10:     Raw euclidean distance 5     14 0.5679245 0.03194951      50
11:     Raw      lcsc distance 15    14 0.5167925 0.06433218      50
12:     Raw      lcsc distance 10    14 0.5077358 0.06612542      50
13:     Raw      lcsc distance 5     14 0.4922642 0.06035238      50
14:     Raw      lcsc distance 20    14 0.4856604 0.06630509      50
15:     Raw      lcsc distance 25    14 0.4660377 0.05411013      50
```

```
> all_hours_summary2[[3]] #17
  representation approach k w_size avg_acc sdev_acc result_count
1:      Raw euclidean distance 25      7 0.6116205 0.03131865      50
2:      Raw euclidean distance 20      7 0.6103033 0.03357446      50
3:      Raw euclidean distance 15      7 0.6088009 0.03271634      50
4:      Raw edr distance 20      7 0.6075207 0.03120521      50
5:      Raw edr distance 25      7 0.6048986 0.03600381      50
6:      Raw euclidean distance 10      7 0.5977623 0.03721770      50
7:      Raw edr distance 15      7 0.5960554 0.03774091      50
8:      Raw edr distance 10      7 0.5831194 0.04120589      50
9:      Raw euclidean distance 5      7 0.5213155 0.04405479      50
10:     Raw edr distance 5      7 0.5145495 0.04615398      50
11:     Raw lcass distance 10      7 0.4844631 0.07954212      50
12:     Raw lcass distance 5      7 0.4826521 0.05336137      50
13:     Raw lcass distance 20      7 0.4764821 0.06116380      50
14:     Raw lcass distance 15      7 0.4565685 0.07515457      50
15:     Raw lcass distance 25      7 0.4457009 0.07400197      50
```

Best Accuracy: EDR distance, k=25, w\_size=14

Used Model: EDR distance, k=15, w\_size=14

## Hour18

```
> all_hours_summary2[[2]] #18
  representation approach k w_size avg_acc sdev_acc result_count
1:      Raw edr distance 10      90 0.6429066 0.03535136      50
2:      Raw euclidean distance 15      90 0.6390085 0.02614223      50
3:      Raw euclidean distance 25      90 0.6369821 0.01676554      50
4:      Raw edr distance 20      90 0.6335354 0.03102725      50
5:      Raw edr distance 5      90 0.6323150 0.04451054      50
6:      Raw edr distance 25      90 0.6310987 0.03319249      50
7:      Raw euclidean distance 20      90 0.6304783 0.02361062      50
8:      Raw euclidean distance 10      90 0.6268151 0.02986095      50
9:      Raw edr distance 15      90 0.6246052 0.03080115      50
10:     Raw euclidean distance 5      90 0.6099175 0.03637901      50
11:     Raw lcass distance 10      90 0.5636096 0.04248285      50
12:     Raw lcass distance 25      90 0.5570480 0.04603752      50
13:     Raw lcass distance 15      90 0.5520388 0.04825269      50
14:     Raw lcass distance 20      90 0.5461142 0.04600938      50
15:     Raw lcass distance 5      90 0.5435147 0.04113069      50
```

```
> all_hours_summary2[[4]] #18
  representation approach k w_size avg_acc sdev_acc result_count
1:      Raw edr distance 10      14 0.6496226 0.03892103      50
2:      Raw edr distance 15      14 0.6413208 0.03972839      50
3:      Raw edr distance 25      14 0.6377358 0.03863954      50
4:      Raw edr distance 20      14 0.6322642 0.03588501      50
5:      Raw edr distance 5      14 0.6301887 0.04578245      50
6:      Raw euclidean distance 15      14 0.6247170 0.03642755      50
7:      Raw euclidean distance 25      14 0.6200000 0.03540347      50
8:      Raw euclidean distance 20      14 0.6192453 0.03589867      50
9:      Raw euclidean distance 10      14 0.6171698 0.03883133      50
10:     Raw euclidean distance 5      14 0.5854717 0.03870577      50
11:     Raw lcass distance 25      14 0.5739623 0.03780125      50
12:     Raw lcass distance 20      14 0.5701887 0.03540962      50
13:     Raw lcass distance 15      14 0.5641509 0.03621302      50
14:     Raw lcass distance 10      14 0.5566038 0.05205716      50
15:     Raw lcass distance 5      14 0.5183019 0.09047554      50
```

```
> all_hours_summary2[[4]] #18
  representation approach k w_size avg_acc sdev_acc result_count
1:      Raw edr distance 25      7 0.6159460 0.03950276      50
2:      Raw edr distance 15      7 0.6134932 0.04274888      50
3:      Raw edr distance 20      7 0.6069547 0.03814560      50
4:      Raw euclidean distance 25      7 0.6065861 0.03879808      50
5:      Raw euclidean distance 10      7 0.6026327 0.03900149      50
6:      Raw euclidean distance 15      7 0.5971804 0.03799407      50
7:      Raw euclidean distance 20      7 0.5960871 0.03654053      50
8:      Raw edr distance 10      7 0.5925445 0.04648368      50
9:      Raw euclidean distance 5      7 0.5685311 0.04426252      50
10:     Raw edr distance 5      7 0.5613595 0.04582377      50
11:     Raw lcass distance 5      7 0.4999365 0.10062365      50
12:     Raw lcass distance 10      7 0.4346235 0.09642784      50
13:     Raw lcass distance 15      7 0.4260730 0.08131886      50
14:     Raw lcass distance 20      7 0.3375965 0.04696765      50
15:     Raw lcass distance 25      7 0.3283812 0.03147719      50
```



Best Accuracy: EDR distance, k=10, w\_size = 14

Used Model: EDR distance, k=10, w\_size = 14

## Hour19

```
> all_hours_summary2[[3]] #19
  representation approach k w_size avg_acc sdev_acc result_count
1:      Raw      edr distance 10    90 0.6539167 0.03496324      50
2:      Raw      edr distance 25    90 0.6498310 0.03476530      50
3:      Raw      edr distance 20    90 0.6498207 0.03386697      50
4:      Raw      edr distance 15    90 0.6494228 0.03730370      50
5:      Raw      edr distance 5     90 0.6396805 0.04346406      50
6:      Raw euclidean distance 20    90 0.6372377 0.02243943      50
7:      Raw euclidean distance 25    90 0.6366213 0.02175352      50
8:      Raw euclidean distance 15    90 0.6337642 0.02512960      50
9:      Raw euclidean distance 10    90 0.6331622 0.03383707      50
10:     Raw euclidean distance 5     90 0.6045331 0.03832260      50
11:     Raw      lcsm distance 20    90 0.6016904 0.03316887      50
12:     Raw      lcsm distance 15    90 0.6014842 0.03387104      50
13:     Raw      lcsm distance 25    90 0.5931396 0.03150936      50
14:     Raw      lcsm distance 10    90 0.5925459 0.03432488      50
15:     Raw      lcsm distance 5     90 0.5734240 0.04068370      50
> |

> all_hours_summary3[[1]] #19
  representation approach k w_size avg_acc sdev_acc result_count
1:      Raw      edr distance 25    14 0.6366038 0.03850959      50
2:      Raw euclidean distance 20    14 0.6324528 0.02896540      50
3:      Raw      edr distance 20    14 0.6318868 0.04195208      50
4:      Raw euclidean distance 25    14 0.6311321 0.03150585      50
5:      Raw      edr distance 10    14 0.6294340 0.04201913      50
6:      Raw      edr distance 15    14 0.6294340 0.04154093      50
7:      Raw euclidean distance 15    14 0.6192453 0.03112945      50
8:      Raw euclidean distance 10    14 0.6154717 0.03866586      50
9:      Raw      edr distance 5     14 0.6037736 0.04383681      50
10:     Raw euclidean distance 5     14 0.5896226 0.03731231      50
11:     Raw      lcsm distance 5     14 0.5605660 0.04889379      50
12:     Raw      lcsm distance 10    14 0.5435849 0.03933325      50
13:     Raw      lcsm distance 15    14 0.5394340 0.04632238      50
14:     Raw      lcsm distance 20    14 0.5258491 0.06653943      50
15:     Raw      lcsm distance 25    14 0.4967925 0.08179183      50
~ |

> all_hours_summary3[[1]] #19
  representation approach k w_size avg_acc sdev_acc result_count
1:      Raw      edr distance 25     7 0.6223082 0.03225600      50
2:      Raw euclidean distance 25     7 0.6217351 0.03542760      50
3:      Raw      edr distance 20     7 0.6206260 0.02734467      50
4:      Raw      edr distance 15     7 0.6196896 0.03417459      50
5:      Raw euclidean distance 20     7 0.6178046 0.02990880      50
6:      Raw euclidean distance 15     7 0.6172633 0.02924119      50
7:      Raw euclidean distance 10     7 0.6041421 0.03602371      50
8:      Raw      edr distance 10     7 0.5938159 0.03808537      50
9:      Raw euclidean distance 5      7 0.5822130 0.03531369      50
10:     Raw      edr distance 5      7 0.5702204 0.04024235      50
11:     Raw      lcsm distance 5      7 0.4948827 0.10372129      50
12:     Raw      lcsm distance 15     7 0.4041227 0.08534690      50
13:     Raw      lcsm distance 20     7 0.3789773 0.07281228      50
14:     Raw      lcsm distance 25     7 0.3482490 0.06056573      50
15:     Raw      lcsm distance 10     7 0.3480832 0.05351204      50
> |
```

Best Accuracy: EDR distance, k=10, w\_size =90

Used Model: Euclidean distance, k=20, w\_size =14

## Hour20

```
> all_hours_summary2[[4]] #20
representation approach k w_size avg_acc sdev_acc result_count
1: Raw edr distance 25 90 0.6284601 0.03328132 50
2: Raw edr distance 10 90 0.6246176 0.03679190 50
3: Raw edr distance 20 90 0.6231561 0.03323539 50
4: Raw edr distance 15 90 0.6128035 0.03070997 50
5: Raw euclidean distance 20 90 0.6095506 0.02407361 50
6: Raw euclidean distance 15 90 0.6093259 0.02524892 50
7: Raw edr distance 5 90 0.6089363 0.03933362 50
8: Raw euclidean distance 25 90 0.6085467 0.01953640 50
9: Raw euclidean distance 10 90 0.6044651 0.02664854 50
10: Raw lcss distance 25 90 0.6016388 0.02194222 50
11: Raw lcss distance 20 90 0.5973758 0.02202664 50
12: Raw lcss distance 15 90 0.5884436 0.02740752 50
13: Raw lcss distance 10 90 0.5786745 0.02660960 50
14: Raw euclidean distance 5 90 0.5766151 0.04880746 50
15: Raw lcss distance 5 90 0.5404886 0.04009477 50
> |
```

```
> all_hours_summary3[[2]] #20
representation approach k w_size avg_acc sdev_acc result_count
1: Raw edr distance 15 14 0.6058491 0.03302794 50
2: Raw edr distance 20 14 0.6047170 0.02941898 50
3: Raw edr distance 10 14 0.6018868 0.03910679 50
4: Raw edr distance 25 14 0.6000000 0.02599367 50
5: Raw euclidean distance 20 14 0.5986792 0.02841142 50
6: Raw euclidean distance 25 14 0.5979245 0.02506086 50
7: Raw euclidean distance 15 14 0.5930189 0.03212018 50
8: Raw euclidean distance 10 14 0.5907547 0.03529299 50
9: Raw edr distance 5 14 0.5820755 0.04075566 50
10: Raw euclidean distance 5 14 0.5677358 0.03781711 50
11: Raw lcss distance 25 14 0.4550943 0.05792201 50
12: Raw lcss distance 20 14 0.4445283 0.05748385 50
13: Raw lcss distance 10 14 0.4409434 0.07002408 50
14: Raw lcss distance 15 14 0.4211321 0.05873785 50
15: Raw lcss distance 5 14 0.4173585 0.05907087 50
~ |
```

```
> all_hours_summary3[[2]] #20
representation approach k w_size avg_acc sdev_acc result_count
1: Raw edr distance 20 7 0.6013208 0.03480384 50
2: Raw euclidean distance 25 7 0.5983054 0.03111666 50
3: Raw edr distance 25 7 0.5951137 0.03381476 50
4: Raw euclidean distance 20 7 0.5925022 0.02993155 50
5: Raw edr distance 15 7 0.5878029 0.03645602 50
6: Raw euclidean distance 15 7 0.5810598 0.03774490 50
7: Raw edr distance 10 7 0.5670199 0.03957716 50
8: Raw euclidean distance 10 7 0.5628919 0.03325720 50
9: Raw edr distance 5 7 0.5599154 0.03919851 50
10: Raw euclidean distance 5 7 0.5555775 0.04121224 50
11: Raw lcss distance 15 7 0.5048051 0.04803519 50
12: Raw lcss distance 25 7 0.4993564 0.04950504 50
13: Raw lcss distance 20 7 0.4929907 0.04902108 50
14: Raw lcss distance 10 7 0.4495098 0.08623657 50
15: Raw lcss distance 5 7 0.4208676 0.09111422 50
> |
```

Best Accuracy: EDR distance, k=25, w\_size=90

Used Model: EDR distance, k=15, w\_size=14

## Hour21

```
> all_hours_summary3[[1]] #21
representation approach k w_size avg_acc sdev_acc result_count
1: Raw edr distance 25 90 0.6453700 0.03079261 50
2: Raw edr distance 20 90 0.6404535 0.03268654 50
3: Raw edr distance 10 90 0.6347784 0.03341012 50
4: Raw edr distance 15 90 0.6341826 0.03766643 50
5: Raw euclidean distance 25 90 0.6211626 0.02151672 50
6: Raw edr distance 5 90 0.6197093 0.04008846 50
7: Raw euclidean distance 20 90 0.6158710 0.02160797 50
8: Raw euclidean distance 10 90 0.6148938 0.03427345 50
9: Raw euclidean distance 15 90 0.6097959 0.02838211 50
10: Raw euclidean distance 5 90 0.5953577 0.03728906 50
11: Raw lcss distance 15 90 0.5164275 0.04091613 50
12: Raw lcss distance 10 90 0.5148567 0.04438397 50
13: Raw lcss distance 20 90 0.5142342 0.04983282 50
14: Raw lcss distance 25 90 0.5113956 0.05172305 50
15: Raw lcss distance 5 90 0.5051185 0.04654415 50
> |
```

```
> all_hours_summary3[[3]] #21
  representation approach k w_size avg_acc sdev_acc result_count
1:      Raw euclidean distance 25    14 0.6260377 0.02951206      50
2:      Raw      edr distance 10    14 0.6245283 0.03425408      50
3:      Raw euclidean distance 20    14 0.6239623 0.02827042      50
4:      Raw      edr distance 25    14 0.6233962 0.03233603      50
5:      Raw      edr distance 20    14 0.6222642 0.03435786      50
6:      Raw      edr distance 15    14 0.6220755 0.03588096      50
7:      Raw euclidean distance 15    14 0.6145283 0.03451872      50
8:      Raw      edr distance 5     14 0.6011321 0.03452029      50
9:      Raw euclidean distance 10    14 0.5994340 0.03499946      50
10:     Raw euclidean distance 5     14 0.5809434 0.03561064      50
11:     Raw      lcsm distance 10    14 0.4062264 0.05915843      50
12:     Raw      lcsm distance 15    14 0.3752830 0.06345090      50
13:     Raw      lcsm distance 20    14 0.3690566 0.04000857      50
14:     Raw      lcsm distance 25    14 0.3673585 0.04194862      50
15:     Raw      lcsm distance 5     14 0.3552830 0.05459835      50
```

```
> all_hours_summary3[[3]] #21
  representation approach k w_size avg_acc sdev_acc result_count
1:      Raw euclidean distance 25    7 0.6102768 0.02679119      50
2:      Raw euclidean distance 20    7 0.6093440 0.02915036      50
3:      Raw      edr distance 20    7 0.6044930 0.03011764      50
4:      Raw      edr distance 25    7 0.5992329 0.02784611      50
5:      Raw      edr distance 15    7 0.5980850 0.03498062      50
6:      Raw euclidean distance 15    7 0.5964010 0.02966938      50
7:      Raw      edr distance 10    7 0.5900353 0.03091133      50
8:      Raw euclidean distance 10    7 0.5786316 0.02822693      50
9:      Raw      edr distance 5     7 0.5675983 0.03811303      50
10:     Raw euclidean distance 5     7 0.5617616 0.03774157      50
11:     Raw      lcsm distance 5     7 0.5614266 0.06228598      50
12:     Raw      lcsm distance 10    7 0.4015094 0.04679865      50
13:     Raw      lcsm distance 15    7 0.3940293 0.04892418      50
14:     Raw      lcsm distance 20    7 0.3737965 0.05618678      50
15:     Raw      lcsm distance 25    7 0.3647452 0.05343712      50
```

Best Accuracy: EDR distance, k=25, w\_size=90

Used Model: Euclidean distance, k=25, w\_size=14

## Hour22

```
> all_hours_summary3[[2]] #22
  representation approach k w_size avg_acc sdev_acc result_count
1:      Raw      edr distance 25    90 0.5995960 0.03742051      50
2:      Raw      edr distance 20    90 0.5963430 0.03377461      50
3:      Raw      edr distance 15    90 0.5957390 0.03941280      50
4:      Raw      edr distance 10    90 0.5904205 0.04342739      50
5:      Raw      edr distance 5     90 0.5904143 0.04346178      50
6:      Raw euclidean distance 25    90 0.5837188 0.02825459      50
7:      Raw euclidean distance 20    90 0.5782416 0.02830734      50
8:      Raw euclidean distance 15    90 0.5666543 0.03231286      50
9:      Raw euclidean distance 10    90 0.5597217 0.03958984      50
10:     Raw euclidean distance 5     90 0.5353535 0.04541796      50
11:     Raw      lcsm distance 5     90 0.5240095 0.04492254      50
12:     Raw      lcsm distance 10    90 0.5229932 0.03991930      50
13:     Raw      lcsm distance 25    90 0.5209112 0.04615903      50
14:     Raw      lcsm distance 15    90 0.5191342 0.03331265      50
15:     Raw      lcsm distance 20    90 0.5152360 0.04330496      50
```

```
> all_hours_summary3[[4]] #22
  representation approach k w_size avg_acc sdev_acc result_count
1:      Raw      edr distance 25    14 0.5937736 0.03638365      50
2:      Raw      edr distance 15    14 0.5913208 0.03903427      50
3:      Raw      edr distance 20    14 0.5896226 0.03500153      50
4:      Raw euclidean distance 25    14 0.5856604 0.02806602      50
5:      Raw      edr distance 5     14 0.5786792 0.04059312      50
6:      Raw euclidean distance 20    14 0.5775472 0.02942145      50
7:      Raw      edr distance 10    14 0.5733962 0.04202994      50
8:      Raw euclidean distance 15    14 0.5716981 0.02946524      50
9:      Raw euclidean distance 10    14 0.5671698 0.03053327      50
10:     Raw euclidean distance 5     14 0.5558491 0.04477315      50
11:     Raw      lcsm distance 5     14 0.4767925 0.07080822      50
12:     Raw      lcsm distance 10    14 0.4367925 0.07499488      50
13:     Raw      lcsm distance 15    14 0.4135849 0.04634865      50
14:     Raw      lcsm distance 20    14 0.4086792 0.04751281      50
15:     Raw      lcsm distance 25    14 0.4009434 0.04084470      50
```



```
> all_hours_summary3[[4]] #22
representation approach k w_size avg_acc sdev_acc result_count
1: Raw euclidean distance 20 7 0.5902839 0.03457964 50
2: Raw euclidean distance 25 7 0.5872756 0.03409229 50
3: Raw edr distance 20 7 0.5825727 0.03503871 50
4: Raw edr distance 25 7 0.5820155 0.03171029 50
5: Raw euclidean distance 15 7 0.5713260 0.03870749 50
6: Raw edr distance 15 7 0.5652954 0.04149125 50
7: Raw euclidean distance 10 7 0.5606665 0.03479769 50
8: Raw euclidean distance 5 7 0.5578293 0.03901217 50
9: Raw edr distance 10 7 0.5574537 0.02938487 50
10: Raw edr distance 5 7 0.5437824 0.03872013 50
11: Raw lcass distance 15 7 0.4091201 0.06155388 50
12: Raw lcass distance 10 7 0.3968066 0.06897834 50
13: Raw lcass distance 20 7 0.3851737 0.04217768 50
14: Raw lcass distance 25 7 0.3808570 0.04261508 50
15: Raw lcass distance 5 7 0.3786069 0.06093863 50
> |
```

Best Accuracy: EDR distance, k=25, w\_size=90

Used Model: Euclidean distance, k=20, w\_size = 7

## Hour23

```
> all_hours_summary3[[3]] #23
representation approach k w_size avg_acc sdev_acc result_count
1: Raw edr distance 5 90 0.5880602 0.04130076 50
2: Raw euclidean distance 25 90 0.5823706 0.03151769 50
3: Raw edr distance 25 90 0.5823191 0.03361712 50
4: Raw edr distance 10 90 0.5758256 0.04312333 50
5: Raw euclidean distance 20 90 0.5724078 0.03349269 50
6: Raw edr distance 20 90 0.5717666 0.03108405 50
7: Raw euclidean distance 15 90 0.5705710 0.03217994 50
8: Raw edr distance 15 90 0.5662750 0.03660536 50
9: Raw euclidean distance 10 90 0.5626757 0.04116079 50
10: Raw euclidean distance 5 90 0.5352463 0.04456630 50
11: Raw lcass distance 10 90 0.5018038 0.04802922 50
12: Raw lcass distance 25 90 0.4959720 0.04849291 50
13: Raw lcass distance 20 90 0.4898392 0.04735789 50
14: Raw lcass distance 5 90 0.4867512 0.04740027 50
15: Raw lcass distance 15 90 0.4814884 0.04533948 50
> |
```

```
> all_hours_summary3[[5]] #23
representation approach k w_size avg_acc sdev_acc result_count
1: Raw euclidean distance 20 14 0.5950943 0.03194042 50
2: Raw euclidean distance 25 14 0.5909434 0.03354469 50
3: Raw euclidean distance 15 14 0.5862264 0.03896767 50
4: Raw edr distance 20 14 0.5826415 0.03977728 50
5: Raw edr distance 25 14 0.5822642 0.04441473 50
6: Raw edr distance 15 14 0.5779245 0.04148711 50
7: Raw euclidean distance 10 14 0.5650943 0.03836830 50
8: Raw edr distance 10 14 0.5592453 0.04554538 50
9: Raw euclidean distance 5 14 0.5462264 0.04563343 50
10: Raw edr distance 5 14 0.5339623 0.03555500 50
11: Raw lcass distance 10 14 0.3909434 0.04676996 50
12: Raw lcass distance 5 14 0.3901887 0.05131073 50
13: Raw lcass distance 15 14 0.3854717 0.04404390 50
14: Raw lcass distance 25 14 0.3845283 0.04682430 50
15: Raw lcass distance 20 14 0.3824528 0.04262725 50
> |
```

```

> all_hours_summary3[[5]] #23
  representation approach k w_size avg_acc sdev_acc result_count
1:      Raw euclidean distance 25      7 0.5806948 0.03720574      50
2:      Raw      edr distance 20      7 0.5762123 0.03804359      50
3:      Raw euclidean distance 20      7 0.5718709 0.03774981      50
4:      Raw      edr distance 25      7 0.5717034 0.04383304      50
5:      Raw euclidean distance 15      7 0.5602839 0.03661674      50
6:      Raw euclidean distance 10      7 0.5602680 0.03920157      50
7:      Raw      edr distance 15      7 0.5583918 0.03654111      50
8:      Raw      edr distance 10      7 0.5450979 0.04379050      50
9:      Raw      edr distance  5      7 0.5379545 0.04143597      50
10:     Raw euclidean distance  5      7 0.5284324 0.04282781      50
11:     Raw      lcsc distance 15      7 0.4039534 0.05702257      50
12:     Raw      lcsc distance 10      7 0.3805290 0.03894319      50
13:     Raw      lcsc distance  5      7 0.3786457 0.03551971      50
14:     Raw      lcsc distance 25      7 0.3623364 0.04195523      50
15:     Raw      lcsc distance 20      7 0.3611850 0.03755739      50
> |

```

Best Accuracy: Euclidean distance, k = 20, w\_size = 14

Used Model: Euclidean distance, k = 20, w\_size = 14

## 5. Results

Results are compared with 4 baseline methods.

1. Frequency based method: The sign predicted for each hour is the most frequent sign observed for that hour in the train data.

Overall accuracy is 0.5583721

2. Lagged method 1: Predicted sign is the sign of yesterday same hour (lag24)

Overall accuracy is 0.5533442

3. Lagged method 2: Predicted sign is the sign of prev. week same day same hour (lag168 )

Overall accuracy is 0.4927044

In addition all positive and all negative and all balanced prediction results are evaluated.

All zeros overall accuracy is 0.08468992

All positive overall accuracy is 0.3584109

All negative overall accuracy is 0.5568992

Figure 5 represents the accuracy values for the baseline methods for every hour.

hours	base_freq	base_24lag	base_168lag	all_zeros	all_ones	all_mones
0	0.507906976744186	0.57635009310987	0.466292134831461	0.0623255813953488	0.429767441860465	0.507906976744186
1	0.616744186046512	0.578212290502793	0.49625468164794	0.0762790697674419	0.306976744186047	0.616744186046512
2	0.549767441860465	0.499068901303538	0.440074906367041	0.124651162790698	0.325581395348837	0.549767441860465
3	0.492093023255814	0.513966480446927	0.425093632958801	0.148837209302326	0.35906976744186	0.492093023255814
4	0.434418604651163	0.484171322160149	0.408239700374532	0.167441860465116	0.398139534883721	0.434418604651163
5	0.46046511627907	0.473929236499069	0.424157303370786	0.138604651162791	0.40093023255814	0.46046511627907
6	0.458604651162791	0.478584729981378	0.442883895131086	0.118139534883721	0.458604651162791	0.423255813953488
7	0.476279069767442	0.541899441340782	0.517790262172285	0.067906976744186	0.455813953488372	0.476279069767442
8	0.543255813953488	0.545623836126629	0.559925093632959	0.0474418604651163	0.409302325581395	0.543255813953488
9	0.62046511627907	0.570763500931099	0.587078651685393	0.0734883720930233	0.306046511627907	0.62046511627907
10	0.586046511627907	0.542830540037244	0.538389513108614	0.0632558139534884	0.350697674418605	0.586046511627907
11	0.61953488372093	0.56610800744879	0.526217228464419	0.0734883720930233	0.306976744186047	0.61953488372093
12	0.553488372093023	0.558659217877095	0.497191011235955	0.0688372093023256	0.377674418604651	0.553488372093023
13	0.52093023255814	0.559590316573557	0.4812734082397	0.0641860465116279	0.414883720930233	0.52093023255814
14	0.604651162790698	0.57635009310987	0.482209737827715	0.0995348837209302	0.295813953488372	0.604651162790698
15	0.581395348837209	0.574487895716946	0.465355805243446	0.0902325581395349	0.328372093023256	0.581395348837209
16	0.581395348837209	0.578212290502793	0.471910112359551	0.0716279069767442	0.346976744186047	0.581395348837209
17	0.598139534883721	0.574487895716946	0.49625468164794	0.0772093023255814	0.324651162790698	0.598139534883721
18	0.613023255813953	0.595903165735568	0.530898876404494	0.0688372093023256	0.318139534883721	0.613023255813953
19	0.626046511627907	0.59683426443203	0.539325842696629	0.0586046511627907	0.315348837209302	0.626046511627907
20	0.605581395348837	0.573556797020484	0.526217228464419	0.0632558139534884	0.331162790697674	0.605581395348837
21	0.607441860465116	0.579143389199255	0.523408239700375	0.0762790697674419	0.316279069767442	0.607441860465116
22	0.574883720930233	0.573556797020484	0.50374531835206	0.0725581395348837	0.352558139534884	0.574883720930233
23	0.568372093023256	0.567970204841713	0.474719101123595	0.0595348837209302	0.372093023255814	0.568372093023256

Figure 5. Baseline accuracies for each hour

The table below represent the comparison of the accuracy of the sign predictions of our method (-1, 0, 1) and the baseline methods and the mean accuracy and standard deviation of these methods using 10 fold 5 rep CV.

hours	base_freq	base_24lag	base_168lag	all_zeros	all_ones	all_mones	tuned_method_acc	tuned_method_sd
1	0	0.507906976744186	0.57635009310987	0.466292134831461	0.0623255813953488	0.429767441860465	0.5846464	0.04871745
2	1	0.616744186046512	0.578212290502793	0.49625468164794	0.0762790697674419	0.306976744186047	0.616981	0.02972607
3	2	0.549767441860465	0.499068901303538	0.440074906367041	0.124651162790698	0.325581395348837	0.549767441860465	0.03321166
4	3	0.492093023255814	0.513966480446927	0.425093632958801	0.148837209302326	0.35906976744186	0.492093023255814	0.03928103
5	4	0.434418604651163	0.484171322160149	0.408239700374532	0.167441860465116	0.398139534883721	0.434418604651163	0.04331831
6	5	0.46046511627907	0.473929236499069	0.424157303370786	0.138604651162791	0.40093023255814	0.46046511627907	0.03968951
7	6	0.458604651162791	0.478584729981378	0.442883895131086	0.118139534883721	0.458604651162791	0.423255813953488	0.04043127
8	7	0.476279069767442	0.541899441340782	0.517790262172285	0.067906976744186	0.455813953488372	0.476279069767442	0.03771302
9	8	0.543255813953488	0.545623836126629	0.559925093632959	0.0474418604651163	0.409302325581395	0.543255813953488	0.04237130
10	9	0.62046511627907	0.570763500931099	0.587078651685393	0.0734883720930233	0.306046511627907	0.62046511627907	0.03045047
11	10	0.586046511627907	0.542830540037244	0.538389513108614	0.0632558139534884	0.350697674418605	0.586046511627907	0.03506945
12	11	0.61953488372093	0.56610800744879	0.526217228464419	0.0734883720930233	0.306976744186047	0.61953488372093	0.03310145
13	12	0.553488372093023	0.558659217877095	0.497191011235955	0.0688372093023256	0.377674418604651	0.553488372093023	0.04524128
14	13	0.52093023255814	0.559590316573557	0.4812734082397	0.0641860465116279	0.414883720930233	0.52093023255814	0.04484605
15	14	0.604651162790698	0.57635009310987	0.482209737827715	0.0995348837209302	0.295813953488372	0.604651162790698	0.03217544
16	15	0.581395348837209	0.574487895716946	0.465355805243446	0.0902325581395349	0.328372093023256	0.581395348837209	0.04278376
17	16	0.581395348837209	0.578212290502793	0.471910112359551	0.0716279069767442	0.346976744186047	0.581395348837209	0.03120314
18	17	0.598139534883721	0.574487895716946	0.49625468164794	0.0772093023255814	0.324651162790698	0.598139534883721	0.03743818
19	18	0.613023255813953	0.595903165735568	0.530898876404494	0.0688372093023256	0.318139534883721	0.613023255813953	0.03892103
20	19	0.626046511627907	0.59683426443203	0.539325842696629	0.0586046511627907	0.315348837209302	0.626046511627907	0.02896540
21	20	0.605581395348837	0.573556797020484	0.526217228464419	0.0632558139534884	0.331162790697674	0.605581395348837	0.03302794
22	21	0.607441860465116	0.579143389199255	0.523408239700375	0.0762790697674419	0.316279069767442	0.607441860465116	0.02951206
23	22	0.574883720930233	0.573556797020484	0.50374531835206	0.0725581395348837	0.352558139534884	0.574883720930233	0.03457964
24	23	0.568372093023256	0.567970204841713	0.474719101123595	0.0595348837209302	0.372093023255814	0.568372093023256	0.03194042

Figure 6. Baseline accuracies and average model accuracies

There are 2 problematic hours which are 2 and 11. Selected parameters and method for these hours are worse than two baseline methods. Since differences are small predictions will be made with tuned methods.

## **6. Conclusions and Future Work**

The predictions we have done were for the hours between 12 and 23. Almost every single one of them were positive which means there is excess supply of electricity. Comparing these to the real imbalance signs we have concluded that the model is consistent and adequate.

We did not and could not implement the trend and seasonality effects, which are mentioned in the paper of Alonzo et al. in the literature review, to our model. The implementation of the joint distribution that is described in that paper may result in a model that gives better accuracy values.

## **7. Code**

<https://bu-ie-48b.github.io/fall21-hpinaryildirim/files/IE48B-PROJECT.R>

## **8. References**

Alonzo, B., Drobinski, P., Plougonven, R., & Tankov, P. (2020). Measuring the Risk of Supply and Demand Imbalance at the Monthly to Seasonal Scale in France. *Energies*, 13(18), 4888. <https://doi.org/10.3390/en13184888>

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