

Machine Learning to Predict if COVID-19 Cases will Increase or Decrease Tomorrow

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Abstract— Recent outbreaks in COVID-19 cases has caused a global crisis. An emphasis on “flattening the curve” has been placed on policies so that the number of current cases a region has does not exceed that region’s capability to handle them. It is thus important to forecast how the number of cases will change. There is a large amount of variability that contributes to the number of cases a region will record. However, there are clear trends which machine learning can learn and use to predict how the number of cases will change in subsequent days. This study creates a rudimentary artificial intelligence to predict if the number of cases will increase or decrease in the following day. Subsequent studies will improve capabilities, studying how the machine learning algorithms can be adapted to possibly predict both further into the future and quantify the degree of change.

Keywords— COVID-19, machine learning, artificial intelligence, time series, forecasting

I. INTRODUCTION

Since the outbreak of COVID-19, regional policies have been in a state of flux in attempts to slow the spread of the virus. It is thus important to create a model capable of forecasting how the number of cases will change in subsequent days. This way, after days of data collection, policy makers can use this information to enact new policies; and doctors, suppliers, and others can prepare for possible large surges in cases.

Machine learning is an ideal candidate for such a forecaster, since the variables that contribute to the number of cases are not fully understood at this time. However, by analysing trends from other countries in the number of cases they encounter, machine learning algorithms can be trained to predict how the number of cases will change for a country given their record of cases over a previous number of days. This is a statistical estimation, based on empirical results expressed as time-series data. This is not a study into the contributors to the number of daily cases.

The simplest case that machine learning can handle is predicting if either the number of cases will increase or decrease tomorrow. How well an artificial intelligence can accomplish this creates a foundation for future algorithms that can possibly predict further into the future, and even estimate the number of cases that may arise in the future.

II. RELATED WORK

Models have been developed to generally estimate the spread of infection diseases, and specifically the number of COVID-19 cases in the USA as recently presented in [1]. Such models are multivariate and consider factors such as exponential spreading, mild cases that become severe, lag time for mild cases to become serious, unconfirmed cases, and domain expertise.

Artificial Intelligence (AI) has recently been used to assist in the COVID-19 crisis in other ways. Reference [2] used AI to identify current positive cases using a mobile phone-based web survey. Machine learning algorithms were used to test patients for COVID-19 with the use of Computed Tomography (CT) images in [3] and designing assays in [4]. Candidates for vaccines were explored with machine learning in [5]. Classifying COVID-19 genomic signatures with machine learning is done in [6].

Eureqa, a modelling software was used in [7] to predict peaks in cases and future trends for world data. Gradient boosted trees were used in [8] to estimate survivors among patients infected with COVID-19.

The literature is rich in similar studies as those mentioned from above. To my knowledge, lacking from the literature is a comparative study of state-of-

the-art machine learning algorithms for univariate predictions of future number of cases trained on empirical data unique to COVID-19. This study seeks to fill that gap and show that statistical models can be created by using empirical data of other countries' trends in number of daily COVID-19 cases. Further, an online tool is missing that can actively deploy such models.

III. DATA

Data was collected from the European Centre for Disease Control (ECDC)¹. Figure 1 shows a plot of raw data taken from the five countries with the highest daily number of cases as of March 28, 2020. Day 1 is the first day recorded in that country with at least 1 positive case. The countries used were only ones which have recorded cases for at least 20 days since day 1, and have had at least 100 cases on a single day.

A. Moving Window Sum

The number of recorded positives shows just that, as opposed to the actual number of newly infected people for that day. There is some variability in day to day recordings. These include, but are not limited to, availability of testing and latency in receiving on-site test results to those results being recorded by the ECDC. One way to mitigate these variances, is to take a moving sum that looks at the n number of previous days and simply adds up the total number of cases. Figure 2 illustrated an 8-day moving window, which shows smoother curves than figure 1.

B. First Derivative

The first derivative, to measure the number of increase or decrease from the previous day, was tested to see if would improve results over using the absolute number of cases for a day. This is common practice in time-series analysis to make the series approximately stationary.

C. Standardizing

Standardizing by subtracting the mean and reducing to unit variance is common practice in machine learning to create a common range of values in data. We standardized data for each day number.

For a given datapoint at a given day and country, the mean and standard deviation was calculated over all other countries at that given day number. Then the mean was subtracted from that datapoint, and the datapoint was divided by the standard deviation. Doing it in this iterative manner, rather than calculating the total mean and standard deviation from all countries once, removed some bias during training since novel cases which will be introduced to the algorithms will not have been used to calculate the mean and standard deviations used to train the algorithms.

D. Chunking

Data was then chunked, into several feature vectors and labels. The number of lags refers to the number of previous data points used in a feature vector. Labels were simply either a '1' if the subsequent day increased in number of cases or '0' otherwise. If the time series of a country consists of N days, and n number lags were used, then there would be $(N - n - 1)$ number of chunks from that country. If there was a day missing in a chunk, it was invalid and not used in either training or testing.

IV. MACHINE LEARNING

Multiple models were tested for robustness. The baseline classification accuracy was 62.75% because this was the percent of chunks which had a label of '1'. Meaning that the simplest model would just predict every tomorrow would increase in number of cases, and this would be 62.75% accurate.

Auto Regressive Integrated Moving Average (ARIMA) was the first algorithm tested. This is a basic algorithm used to make forecasts in time series. It only considers data from the same time series. Meaning, each country used the first 66% of its chunks to train an ARIMA model that was then used to predict the last 33% of the chunks. An ARIMA model is a good starting point but lacks the ability to robustly use other time series since each model is built exclusively for that country.

Multiple machine learning algorithms (MLA) were then tested by using 5-fold cross-validation. This split the data into 5 random sets of chunks.

¹ <https://www.ecdc.europa.eu/en/publications-data/download-todays-data-geographic-distribution-covid-19-cases-worldwide>

Iteratively, one chunk was left out and the other 4 chunks were used to train an MLA. The fifth chunk was then tested on by the trained MLA to measure accuracy. This process was repeated 100 times. The MLA tested were: Multi-Layer Perceptron (MLP) with one hidden layer with number of nodes equal to half of the number of lags, Decision Tree (DTr), Random Forest (RFo), Extra Trees (ETr), Support

Vector Machine (SVM), Naïve Bayes (NBa), and K-Nearest Neighbours (KNN).

V. RESULTS

All code was ran using python on a Jupyter notebook. We used the following libraries: pandas, numpy, datetime, matplotlib, statsmodels for ARIMA, math, tabulate, and sklearn for MLA. The

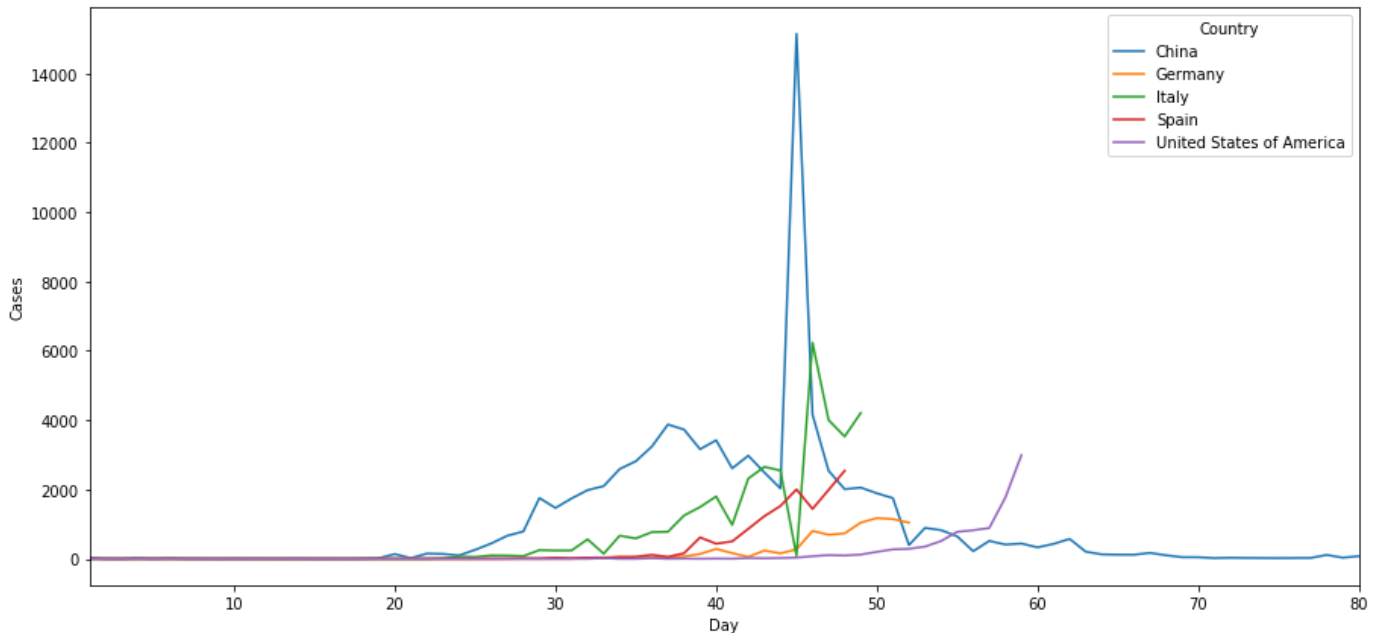


Figure 1: Raw data showing the daily-recorded number of positive cases for the COVID-19 virus, from five countries with highest daily number of positive cases as of March 28, 2020. Day 1 starts from first occurrence in that country.

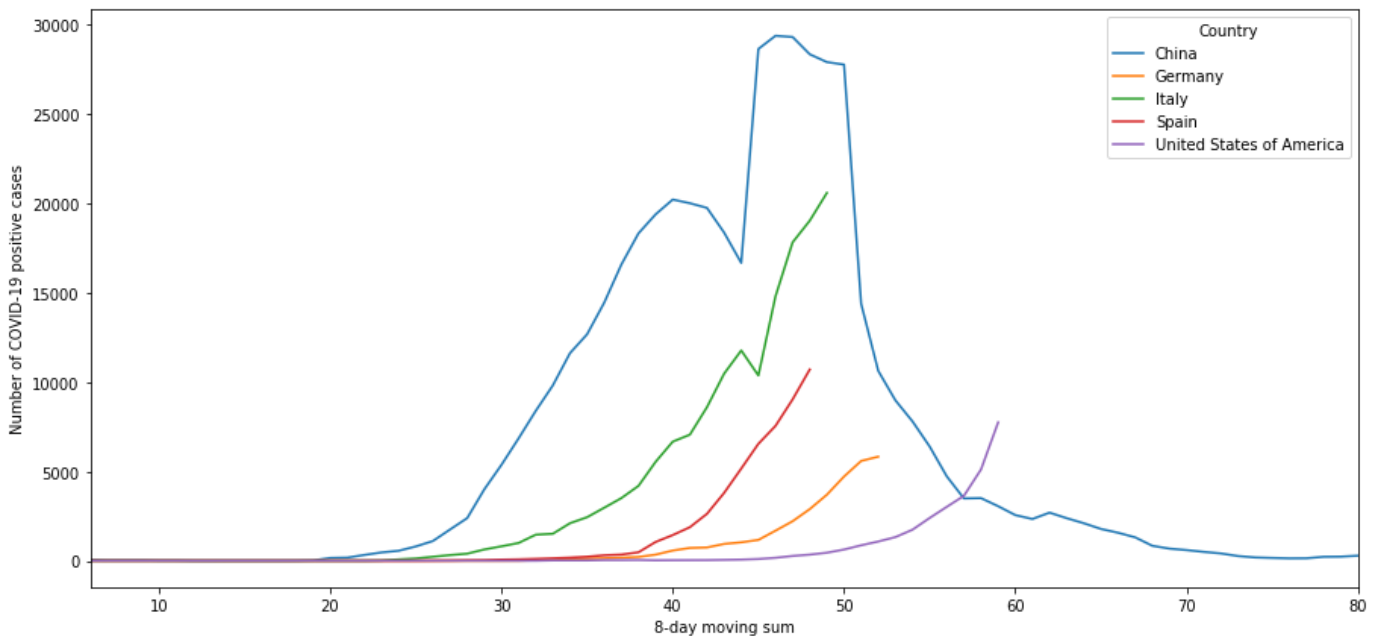


Figure 2: Smoothed data from the same countries in figure 1. This uses a moving window of 8 previous days, to sum the total number of cases over those days. For example, day 8 is the sum of cases recorded in days 1-8.

Jupyter notebook was ran on my desktop on Windows 10 pro 64-bit, with 32 GB RAM and an Intel i5-3570k quad-core processor clocked at 3.4 GHz.

The number of lags used, degree of derivative, and moving window was altered to measure accuracy of the ARIMA models. Accuracy can obtain a deceptively high value, sometimes as high as 100%. This is because cases where error was not able to converge were discarded. The percent of converged data chunks is shown along with other results in appendix A. Root Mean Squared Error (RMSE) shows the deviated error in predicting the absolute number of cases that will occur tomorrow for a given country. Appendix A took approximately 30 minutes to compute in series.

Figure 3 warrants Random Forests (Rfo) and Extra Trees (ETr) are the most robust. They have both relatively high accuracies and low variance (the bars in the figure are tighter together). Figure 3 took approximately 10 minutes to compute in series. Random forests were selected to optimize pre-processing.

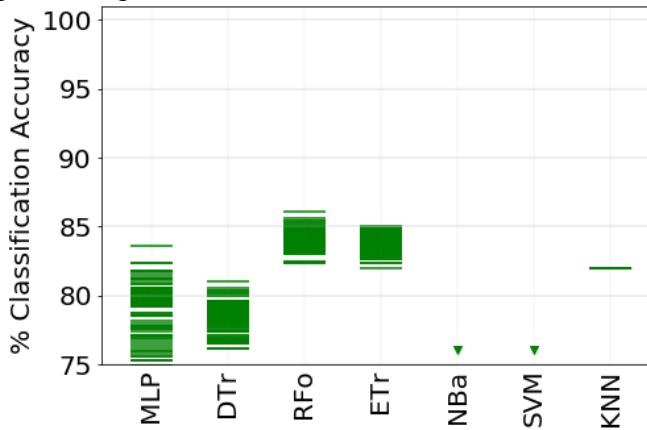


Figure 3: Initial MLA results using 5-fold cross-validation and an initial guess at pre-processing: 12 day moving sum, 8 lags, first derivative, and no standardization. Each green bar shows average accuracy from one run of 5-fold cross-validation. There were 100 total random runs for each MLA. A triangle indicates results were below 75% accuracy.

Appendix B shows the results from empirically testing the number of lags and size of moving window used, as well as testing if the first derivative was taken and if standardizing was done. All results were measured using 100 runs of 5-fold cross-validation and a Random Forest. The displayed accuracy is the average of all 100 runs. Appendix B

took approximately 17 hours to compute in series. The results show the models become more robust when introduced larger viewing windows, more lags, using first derivative, and not using standardization.

Figure 4 is the same test done in figure 3, except using the optimized pre-processing: 13 viewing window size, 12 lags, using first derivative, and not standardizing data. Random Forests appear to still be the most robust MLA, though there is a visible overall improvement in all MLA. Figure 4 took approximately 10 minutes to compute in series.

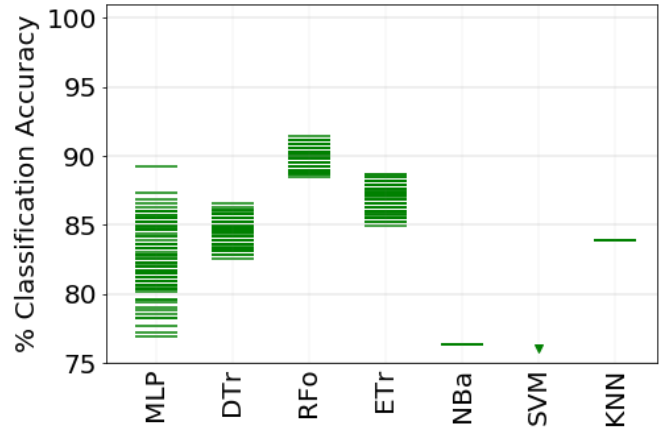


Figure 1: Second MLA results using 5-fold cross-validation and optimized pre-processing: 13 day moving sum, 12 lags, first derivative, and no standardization. Each green bar shows average accuracy from one run of 5-fold cross-validation. There were 100 total random runs for each MLA. A triangle indicates results were below 75%

A random forest was then trained using the optimized pre-processing parameters with data up until March 28, 2020. It was then tested with data from each country from dates between March 29, 2020 and March 31, 2020 (this was new data collected after the models were created. Table 1 shows the predictions compared to ground truths of each country and day, along with the confidence percent in each prediction (the percent of predictors in the random forest that voted for that classification). The total accuracy on the test data was ???.

VI. CONCLUSIONS

Random Forests show to be a robust means for predicting if the number of COVID-19 cases in each region will either increase or decrease tomorrow, yielding an average 5-fold cross-validation accuracy from 100 random runs of 89.82%, and testing accuracy of ???.

Future work will improve the presented methods and attempt to predict further into the future and estimate the number of cases that are likely to occur in the coming days. Future work will also create an online tool for real-time predictions. View my GitHub for active updates and code used to invoke methods², along with future links to an online tool. The tool is advised to be used as one piece of information used by policy makers, medical professionals, suppliers, and others to help in decision making.

ACKNOWLEDGMENT

I wish to acknowledge all the people who have dedicated countless hours to fight the spread of and treat patients infected with the COVID-19 virus. Their heroic dedication has saved countless lives.

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APPENDIX A

Appendix A: ARIMA results. 'p' is number of lags, 'd' is degree of derivative, and 'q' is number of terms used in moving average.

p	d	q	RMSE	%Accuracy	%Converged
1	0	0	22.79	92.41	7.93
2	0	0	39.18	80.65	6.42
3	0	0	83.38	70.45	4.70
4	0	0	63.43	73.91	2.54

5	0	0	97.35	75.00	1.83
6	0	0	75.03	71.43	0.83
7	0	0	201.86	71.43	0.86
8	0	0	83.92	40.00	0.64
9	0	0	70.42	66.67	0.79
10	0	0	189.36	50.00	0.55
11	0	0	63.1	66.67	0.43
12	0	0	157.91	100.00	0.30
1	1	0	53.3	23.29	7.56
2	1	0	97.15	30.51	6.30
3	1	0	85.5	34.78	5.08
4	1	0	146.51	37.50	3.65
5	1	0	145.12	40.74	3.19
6	1	0	153.86	36.84	2.33
7	1	0	63.46	41.67	1.52
8	1	0	88.95	30.00	1.32
9	1	0	177.33	22.22	1.23
10	1	0	112.28	25.00	1.14
11	1	0	456.19	50.00	0.60
12	1	0	343.31	33.33	0.47
13	1	0	474.1	0.00	0.16
14	1	0	47.78	66.67	0.51
1	0	1	83.71	90.91	1.10
2	0	1	107.83	44.44	0.93
3	0	1	92.14	70.00	1.07
4	0	1	97.54	16.67	0.66
5	0	1	213.09	100.00	0.11
6	0	1	119.56	33.33	0.71
7	0	1	135.14	66.67	0.74
8	0	1	118.03	0.00	0.13
9	0	1	162.53	25.00	0.53
11	0	1	125.1	0.00	0.29
12	0	1	46.51	0.00	0.15
1	1	1	80.33	20.00	1.55
2	1	1	129.89	14.29	1.50
3	1	1	117.93	30.77	1.43
4	1	1	101.42	27.27	1.26
5	1	1	243.16	25.00	0.95
6	1	1	121.02	0.00	0.86
7	1	1	128.05	0.00	0.76
8	1	1	181.44	0.00	0.66
9	1	1	249.19	0.00	0.55

² <https://github.com/WreckItTim/COVID19-Predictions>

10	1	1	76.06	0.00	0.14	7	0	5	491.87	0.00	0.12
11	1	1	387.85	0.00	0.15	10	0	5	29.03	100.00	0.14
14	1	1	588.82	0.00	0.17	1	1	5	12.68	0.00	0.21
1	0	2	5610.65	16.67	0.60	2	1	5	170.2	25.00	0.43
2	0	2	282.96	42.86	0.72	3	1	5	184.99	50.00	0.22
3	0	2	45.31	0.00	0.53	4	1	5	99.32	33.33	0.34
4	0	2	461.94	0.00	0.22	5	1	5	35.4	100.00	0.12
1	1	2	100.11	25.00	0.83	6	1	5	18.26	100.00	0.12
2	1	2	152.83	11.11	0.96	7	1	5	145.93	0.00	0.25
3	1	2	164.72	14.29	0.77	8	1	5	233.89	50.00	0.26
4	1	2	110.86	28.57	0.80	10	1	5	661.87	0.00	0.14
5	1	2	92.77	66.67	0.35	1	0	6	837.41	33.33	0.60
6	1	2	144.94	20.00	0.61	2	0	6	273.85	25.00	0.41
7	1	2	150.45	0.00	0.51	8	0	6	204.78	100.00	0.13
8	1	2	191.81	0.00	0.53	4	1	6	189.84	0.00	0.23
9	1	2	252.9	0.00	0.27	5	1	6	78.67	0.00	0.24
10	1	2	124.59	0.00	0.14	9	1	6	108.21	0.00	0.14
14	1	2	568.99	0.00	0.17	2	1	7	329.42	0.00	0.11
1	0	3	4283.02	0.00	0.60	3	1	7	53.53	0.00	0.11
8	0	3	129.44	100.00	0.13	4	1	7	251.59	0.00	0.11
1	1	3	127.13	0.00	0.21	4	1	8	489	0.00	0.11
2	1	3	133.75	0.00	0.21	1	0	9	34.73	100.00	0.10
3	1	3	45.89	0.00	0.22	3	0	9	20	0.00	0.11
4	1	3	94.93	40.00	0.57	5	0	9	178.84	100.00	0.11
5	1	3	80.93	50.00	0.24	4	1	9	40.27	100.00	0.11
6	1	3	113.98	0.00	0.12	5	1	9	60.84	100.00	0.12
7	1	3	141.46	0.00	0.13	6	1	9	185.42	0.00	0.12
10	1	3	114.68	0.00	0.29	7	1	10	286.46	100.00	0.13
1	0	4	2228.38	0.00	0.50	5	0	11	692.28	100.00	0.11
2	0	4	154.78	100.00	0.31	1	0	12	75.32	0.00	0.10
4	0	4	4740.18	0.00	0.11						
8	0	4	161.4	100.00	0.13						
1	1	4	91.2	20.00	0.52						
2	1	4	101.85	25.00	0.43						
3	1	4	240.37	0.00	0.33						
4	1	4	112.67	66.67	0.34						
5	1	4	129.49	50.00	0.71						
6	1	4	219.15	0.00	0.25						
7	1	4	61.54	0.00	0.13						
9	1	4	379.51	0.00	0.14						
1	0	5	1557.14	0.00	0.50						
2	0	5	256.34	0.00	0.21						
3	0	5	673.41	33.33	0.32						
4	0	5	632.14	0.00	0.22						

APPENDIX B

Appendix B: Results from using a random forest with varying pre-processing: ‘Wind’ is the window size used for moving sum, ‘Lags’ is the number of previous data points used in feature vector, ‘Deriv’ is true if first derivative was used or false otherwise, ‘Standard’ is true if data was standardized by day or false otherwise, and ‘Accur%’ is the average percent accuracy of 100 runs of 5-fold cross-validation using a random forest.

Wind	Lags	Deriv	Standard	Accur%
13	12	TRUE	FALSE	89.82
13	5	TRUE	FALSE	89.75
13	9	TRUE	FALSE	89.51
13	10	TRUE	FALSE	89.39

13	11	TRUE	FALSE	89.05	9	8	TRUE	FALSE	86.65
14	11	TRUE	FALSE	88.83	11	14	TRUE	FALSE	86.65
13	6	TRUE	FALSE	88.79	7	10	TRUE	FALSE	86.60
14	13	TRUE	FALSE	88.78	14	5	TRUE	FALSE	86.60
10	6	TRUE	FALSE	88.54	14	7	TRUE	FALSE	86.60
13	2	TRUE	FALSE	88.48	14	6	TRUE	FALSE	86.56
8	9	TRUE	FALSE	88.29	10	3	TRUE	FALSE	86.56
13	4	TRUE	FALSE	88.26	14	13	TRUE	TRUE	86.55
13	8	TRUE	FALSE	88.18	13	3	TRUE	FALSE	86.54
10	5	TRUE	FALSE	88.00	7	9	TRUE	FALSE	86.53
8	8	TRUE	FALSE	87.85	9	9	TRUE	FALSE	86.52
14	4	TRUE	FALSE	87.83	8	12	TRUE	FALSE	86.51
13	13	TRUE	FALSE	87.82	12	2	TRUE	FALSE	86.50
12	13	TRUE	FALSE	87.76	7	6	TRUE	FALSE	86.49
10	7	TRUE	FALSE	87.76	8	10	TRUE	TRUE	86.45
12	12	TRUE	FALSE	87.70	8	11	TRUE	TRUE	86.43
12	3	TRUE	FALSE	87.61	14	2	TRUE	FALSE	86.35
14	12	TRUE	TRUE	87.59	10	8	TRUE	FALSE	86.31
14	14	TRUE	FALSE	87.57	11	10	TRUE	FALSE	86.30
12	11	TRUE	FALSE	87.56	7	11	TRUE	FALSE	86.28
13	14	TRUE	FALSE	87.54	7	8	TRUE	FALSE	86.21
12	9	TRUE	FALSE	87.54	10	4	TRUE	FALSE	86.21
8	10	TRUE	FALSE	87.53	8	9	TRUE	TRUE	86.19
11	12	TRUE	FALSE	87.49	14	9	TRUE	FALSE	86.15
14	12	TRUE	FALSE	87.48	13	1	TRUE	FALSE	86.14
8	7	TRUE	FALSE	87.44	10	5	TRUE	TRUE	86.12
8	11	TRUE	FALSE	87.42	10	2	TRUE	FALSE	86.11
14	3	TRUE	FALSE	87.41	14	10	TRUE	TRUE	86.09
14	11	TRUE	TRUE	87.38	9	6	TRUE	FALSE	86.08
8	6	TRUE	FALSE	87.35	7	5	TRUE	FALSE	86.08
13	7	TRUE	FALSE	87.33	10	11	TRUE	FALSE	86.02
14	10	TRUE	FALSE	87.24	11	7	TRUE	FALSE	86.02
12	7	TRUE	FALSE	87.22	11	8	TRUE	FALSE	85.94
12	5	TRUE	FALSE	87.19	12	14	TRUE	FALSE	85.93
12	8	TRUE	FALSE	87.16	9	5	TRUE	FALSE	85.88
11	13	TRUE	FALSE	87.09	14	14	TRUE	TRUE	85.85
12	4	TRUE	FALSE	87.07	8	14	TRUE	FALSE	85.80
12	10	TRUE	FALSE	87.06	12	1	TRUE	FALSE	85.77
11	11	TRUE	FALSE	86.95	11	9	TRUE	FALSE	85.73
8	5	TRUE	FALSE	86.91	10	9	TRUE	FALSE	85.73
9	7	TRUE	FALSE	86.80	8	13	TRUE	FALSE	85.70
12	6	TRUE	FALSE	86.77	9	10	TRUE	FALSE	85.69
14	8	TRUE	FALSE	86.76	9	12	TRUE	FALSE	85.69
7	7	TRUE	FALSE	86.70	11	3	TRUE	FALSE	85.65

8	7	TRUE	TRUE	85.61	9	11	TRUE	TRUE	84.82
8	6	TRUE	TRUE	85.57	8	13	TRUE	TRUE	84.80
10	10	TRUE	TRUE	85.57	8	7	FALSE	FALSE	84.78
11	2	TRUE	FALSE	85.51	11	6	TRUE	FALSE	84.77
10	10	TRUE	FALSE	85.51	10	9	TRUE	TRUE	84.74
10	4	TRUE	TRUE	85.44	13	4	TRUE	TRUE	84.74
8	12	TRUE	TRUE	85.42	9	8	TRUE	TRUE	84.73
11	14	TRUE	TRUE	85.40	9	13	TRUE	FALSE	84.70
10	12	TRUE	FALSE	85.35	14	1	TRUE	FALSE	84.70
11	5	TRUE	FALSE	85.33	8	8	TRUE	TRUE	84.68
8	3	TRUE	FALSE	85.32	12	5	TRUE	TRUE	84.68
9	10	TRUE	TRUE	85.29	11	6	TRUE	TRUE	84.65
8	4	TRUE	FALSE	85.29	7	9	TRUE	TRUE	84.62
11	5	TRUE	TRUE	85.28	13	11	TRUE	TRUE	84.62
9	11	TRUE	FALSE	85.27	12	13	TRUE	TRUE	84.58
10	14	TRUE	TRUE	85.26	6	11	TRUE	FALSE	84.53
14	4	TRUE	TRUE	85.22	10	7	TRUE	TRUE	84.44
14	14	FALSE	FALSE	85.20	10	12	TRUE	TRUE	84.42
9	9	TRUE	TRUE	85.17	7	10	TRUE	TRUE	84.40
9	7	TRUE	TRUE	85.13	6	9	TRUE	FALSE	84.39
13	12	TRUE	TRUE	85.13	9	5	TRUE	TRUE	84.36
13	10	TRUE	TRUE	85.12	9	14	TRUE	FALSE	84.35
14	5	TRUE	TRUE	85.10	12	4	TRUE	TRUE	84.33
8	2	TRUE	FALSE	85.07	9	3	TRUE	FALSE	84.31
8	5	TRUE	TRUE	85.05	14	6	TRUE	TRUE	84.31
13	14	TRUE	TRUE	85.05	8	6	FALSE	FALSE	84.30
10	6	TRUE	TRUE	85.02	10	8	TRUE	TRUE	84.30
11	10	TRUE	TRUE	85.00	7	11	TRUE	TRUE	84.27
10	13	TRUE	TRUE	84.97	11	4	TRUE	TRUE	84.26
10	13	TRUE	FALSE	84.97	12	6	TRUE	TRUE	84.26
13	5	TRUE	TRUE	84.96	12	9	TRUE	TRUE	84.22
11	9	TRUE	TRUE	84.95	9	6	TRUE	TRUE	84.21
13	9	TRUE	TRUE	84.94	11	13	TRUE	TRUE	84.20
11	4	TRUE	FALSE	84.94	12	11	TRUE	TRUE	84.19
13	13	TRUE	TRUE	84.93	12	14	TRUE	TRUE	84.17
6	10	TRUE	FALSE	84.91	12	12	TRUE	TRUE	84.15
6	8	TRUE	FALSE	84.90	8	5	FALSE	FALSE	84.11
9	4	TRUE	FALSE	84.88	11	12	TRUE	TRUE	84.11
11	11	TRUE	TRUE	84.88	6	12	TRUE	FALSE	84.06
13	3	TRUE	TRUE	84.86	11	7	TRUE	TRUE	84.04
10	11	TRUE	TRUE	84.84	9	4	TRUE	TRUE	84.04
10	14	TRUE	FALSE	84.84	8	4	TRUE	TRUE	84.02
13	8	TRUE	TRUE	84.83	11	8	TRUE	TRUE	84.01
7	4	TRUE	FALSE	84.82	14	9	TRUE	TRUE	83.99

6	7	TRUE	FALSE	83.97	8	11	FALSE	FALSE	83.01
7	7	TRUE	TRUE	83.97	6	4	TRUE	FALSE	83.00
7	7	FALSE	FALSE	83.93	6	5	TRUE	FALSE	82.98
12	10	TRUE	TRUE	83.92	7	4	FALSE	FALSE	82.95
13	6	TRUE	TRUE	83.89	7	12	TRUE	TRUE	82.94
8	10	FALSE	FALSE	83.87	10	3	FALSE	FALSE	82.93
7	8	TRUE	TRUE	83.86	6	8	FALSE	FALSE	82.93
7	6	TRUE	TRUE	83.80	9	4	FALSE	FALSE	82.92
7	12	TRUE	FALSE	83.79	5	7	TRUE	FALSE	82.91
5	9	TRUE	FALSE	83.75	7	5	FALSE	FALSE	82.90
5	12	TRUE	FALSE	83.70	7	3	TRUE	FALSE	82.90
7	6	FALSE	FALSE	83.70	10	3	TRUE	TRUE	82.90
10	8	FALSE	FALSE	83.69	10	6	FALSE	FALSE	82.86
8	14	TRUE	TRUE	83.66	7	9	FALSE	FALSE	82.84
9	5	FALSE	FALSE	83.65	10	9	FALSE	FALSE	82.84
14	7	TRUE	TRUE	83.64	9	6	FALSE	FALSE	82.83
10	5	FALSE	FALSE	83.64	9	8	FALSE	FALSE	82.72
6	6	TRUE	FALSE	83.58	6	9	FALSE	FALSE	82.68
5	10	TRUE	FALSE	83.57	11	3	TRUE	TRUE	82.67
14	3	TRUE	TRUE	83.54	6	7	FALSE	FALSE	82.62
9	1	TRUE	FALSE	83.51	13	2	TRUE	TRUE	82.60
5	13	TRUE	FALSE	83.50	9	9	FALSE	FALSE	82.59
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10	1	TRUE	FALSE	83.46	9	14	TRUE	TRUE	82.56
12	7	TRUE	TRUE	83.43	6	3	TRUE	FALSE	82.56
13	7	TRUE	TRUE	83.42	12	4	FALSE	FALSE	82.53
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14	8	TRUE	TRUE	83.36	6	14	TRUE	FALSE	82.49
8	8	FALSE	FALSE	83.34	11	6	FALSE	FALSE	82.45
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5	11	TRUE	FALSE	83.33	11	1	TRUE	FALSE	82.39
9	12	TRUE	TRUE	83.31	9	7	FALSE	FALSE	82.37
9	13	TRUE	TRUE	83.31	5	6	TRUE	FALSE	82.37
10	4	FALSE	FALSE	83.30	8	3	FALSE	FALSE	82.29
7	5	TRUE	TRUE	83.28	12	14	FALSE	FALSE	82.27
12	3	TRUE	TRUE	83.26	6	1	TRUE	FALSE	82.25
7	13	TRUE	FALSE	83.26	13	5	FALSE	FALSE	82.21
12	8	TRUE	TRUE	83.25	11	5	FALSE	FALSE	82.20
8	9	FALSE	FALSE	83.15	13	4	FALSE	FALSE	82.15
13	14	FALSE	FALSE	83.12	7	10	FALSE	FALSE	82.11
12	5	FALSE	FALSE	83.10	12	2	FALSE	FALSE	82.10
14	2	TRUE	TRUE	83.09	6	2	TRUE	FALSE	82.10
9	2	TRUE	FALSE	83.07	4	9	TRUE	FALSE	82.10
7	8	FALSE	FALSE	83.04	6	10	FALSE	FALSE	82.09

14	13	FALSE	FALSE	82.09	12	13	FALSE	FALSE	80.82
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8	4	FALSE	FALSE	82.01	6	8	TRUE	TRUE	80.79
12	9	FALSE	FALSE	81.99	11	7	FALSE	TRUE	80.76
10	10	FALSE	FALSE	81.95	11	10	FALSE	FALSE	80.76
13	3	FALSE	FALSE	81.92	11	2	TRUE	TRUE	80.72
4	10	TRUE	FALSE	81.88	6	2	FALSE	FALSE	80.70
6	9	TRUE	TRUE	81.86	10	12	FALSE	FALSE	80.70
6	10	TRUE	TRUE	81.79	9	8	FALSE	TRUE	80.68
11	9	FALSE	FALSE	81.73	14	2	FALSE	FALSE	80.67
7	13	TRUE	TRUE	81.69	13	5	FALSE	TRUE	80.65
8	3	TRUE	TRUE	81.66	8	2	TRUE	TRUE	80.61
5	5	TRUE	FALSE	81.66	6	7	TRUE	TRUE	80.60
12	3	FALSE	FALSE	81.66	10	2	FALSE	FALSE	80.50
12	6	FALSE	FALSE	81.65	10	11	FALSE	FALSE	80.49
7	3	FALSE	FALSE	81.64	4	13	TRUE	FALSE	80.40
11	3	FALSE	FALSE	81.60	13	6	FALSE	FALSE	80.39
8	12	FALSE	FALSE	81.50	4	14	TRUE	FALSE	80.39
6	3	FALSE	FALSE	81.45	12	11	FALSE	FALSE	80.36
5	3	TRUE	FALSE	81.43	6	4	FALSE	FALSE	80.34
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7	11	FALSE	FALSE	81.35	12	7	FALSE	FALSE	80.29
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6	6	FALSE	FALSE	81.13	5	4	TRUE	FALSE	80.21
9	7	FALSE	TRUE	81.13	9	2	FALSE	FALSE	80.16
4	11	TRUE	FALSE	81.12	4	7	TRUE	FALSE	80.15
12	10	FALSE	FALSE	81.11	13	8	FALSE	FALSE	80.10
8	2	FALSE	FALSE	81.06	6	6	TRUE	TRUE	80.09
9	10	FALSE	FALSE	81.05	7	3	TRUE	TRUE	80.07
7	4	TRUE	TRUE	81.05	14	4	FALSE	TRUE	80.06
11	7	FALSE	FALSE	81.05	9	10	FALSE	TRUE	80.03
11	4	FALSE	FALSE	81.04	7	2	FALSE	FALSE	79.97
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6	11	FALSE	FALSE	80.99	5	10	TRUE	TRUE	79.95
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7	14	TRUE	TRUE	80.90	14	1	TRUE	TRUE	79.89
7	1	TRUE	FALSE	80.88	11	13	FALSE	FALSE	79.87
8	1	TRUE	FALSE	80.86	12	6	FALSE	TRUE	79.86

8	10	FALSE	TRUE	79.86	5	9	TRUE	TRUE	78.97
9	9	FALSE	TRUE	79.81	8	8	FALSE	TRUE	78.97
11	8	FALSE	TRUE	79.81	11	9	FALSE	TRUE	78.95
13	9	FALSE	FALSE	79.81	12	5	FALSE	TRUE	78.95
9	11	FALSE	FALSE	79.79	6	12	FALSE	FALSE	78.95
10	13	FALSE	FALSE	79.78	11	12	FALSE	FALSE	78.88
9	6	FALSE	TRUE	79.77	14	5	FALSE	TRUE	78.87
6	5	TRUE	TRUE	79.75	10	6	FALSE	TRUE	78.84
14	5	FALSE	FALSE	79.71	4	2	TRUE	FALSE	78.83
5	2	TRUE	FALSE	79.70	8	12	FALSE	TRUE	78.82
11	14	FALSE	FALSE	79.63	14	13	FALSE	TRUE	78.80
5	9	FALSE	FALSE	79.63	14	14	FALSE	TRUE	78.64
5	10	FALSE	FALSE	79.63	14	8	FALSE	FALSE	78.63
9	13	FALSE	FALSE	79.62	9	11	FALSE	TRUE	78.61
5	8	FALSE	FALSE	79.62	5	4	FALSE	FALSE	78.59
14	7	FALSE	FALSE	79.56	4	5	TRUE	FALSE	78.56
13	7	FALSE	FALSE	79.55	7	2	TRUE	TRUE	78.54
11	11	FALSE	FALSE	79.52	10	10	FALSE	TRUE	78.49
10	14	FALSE	FALSE	79.51	10	7	FALSE	TRUE	78.47
13	4	FALSE	TRUE	79.42	14	4	FALSE	FALSE	78.46
11	5	FALSE	TRUE	79.41	5	14	FALSE	FALSE	78.46
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13	12	FALSE	FALSE	79.26	6	2	TRUE	TRUE	78.30
11	2	FALSE	FALSE	79.26	9	1	TRUE	TRUE	78.23
7	13	FALSE	FALSE	79.26	12	2	TRUE	TRUE	78.21
6	13	TRUE	TRUE	79.23	13	3	FALSE	TRUE	78.20
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14	3	FALSE	FALSE	79.15	8	5	FALSE	TRUE	77.95
7	14	FALSE	FALSE	79.14	13	8	FALSE	TRUE	77.93
14	12	FALSE	FALSE	79.14	4	11	FALSE	FALSE	77.92
11	6	FALSE	TRUE	79.13	11	10	FALSE	TRUE	77.91
5	11	TRUE	TRUE	79.13	14	2	FALSE	TRUE	77.91
4	3	TRUE	FALSE	79.11	4	14	FALSE	FALSE	77.91
8	9	FALSE	TRUE	79.08	6	14	TRUE	TRUE	77.90
5	11	FALSE	FALSE	79.07	14	12	FALSE	TRUE	77.90
10	8	FALSE	TRUE	79.00	6	14	FALSE	FALSE	77.87
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4	9	TRUE	TRUE	77.80	9	12	FALSE	TRUE	76.67
6	4	TRUE	TRUE	77.79	4	5	FALSE	FALSE	76.63
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4	12	FALSE	FALSE	77.75	3	11	TRUE	FALSE	76.59
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4	10	TRUE	TRUE	77.73	8	4	FALSE	TRUE	76.58
7	10	FALSE	TRUE	77.72	13	2	FALSE	TRUE	76.48
7	7	FALSE	TRUE	77.71	7	3	FALSE	TRUE	76.41
5	14	TRUE	TRUE	77.69	4	12	TRUE	TRUE	76.37
12	4	FALSE	TRUE	77.67	14	10	FALSE	FALSE	76.36
7	8	FALSE	TRUE	77.64	5	1	TRUE	FALSE	76.33
5	12	TRUE	TRUE	77.55	7	4	FALSE	TRUE	76.32
14	11	FALSE	FALSE	77.50	8	14	FALSE	TRUE	76.28
12	3	FALSE	TRUE	77.49	8	1	TRUE	TRUE	76.26
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12	9	FALSE	TRUE	77.46	14	7	FALSE	TRUE	76.24
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11	3	FALSE	TRUE	77.45	4	13	TRUE	TRUE	76.21
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14	6	FALSE	TRUE	77.41	3	8	TRUE	FALSE	76.07
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7	11	FALSE	TRUE	77.19	7	13	FALSE	TRUE	75.87
14	9	FALSE	FALSE	77.17	13	12	FALSE	TRUE	75.80
5	13	TRUE	TRUE	77.10	5	2	FALSE	FALSE	75.78
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9	4	FALSE	TRUE	77.03	7	5	FALSE	TRUE	75.75
7	12	FALSE	TRUE	77.01	4	1	TRUE	FALSE	75.74
11	11	FALSE	TRUE	76.98	3	12	TRUE	FALSE	75.73
6	3	TRUE	TRUE	76.98	12	2	FALSE	TRUE	75.73
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4	6	FALSE	FALSE	76.88	3	2	TRUE	FALSE	75.70
13	9	FALSE	TRUE	76.87	12	1	TRUE	TRUE	75.69
7	6	FALSE	TRUE	76.82	4	4	FALSE	FALSE	75.65
3	10	TRUE	FALSE	76.81	4	5	TRUE	TRUE	75.63
4	8	TRUE	TRUE	76.79	10	12	FALSE	TRUE	75.59
9	14	FALSE	FALSE	76.73	6	10	FALSE	TRUE	75.53

13	1	FALSE	FALSE	75.47	3	8	FALSE	FALSE	73.98
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4	14	TRUE	TRUE	75.41	3	6	FALSE	FALSE	73.94
5	4	TRUE	TRUE	75.38	14	9	FALSE	TRUE	73.94
5	5	TRUE	TRUE	75.37	6	5	FALSE	TRUE	73.92
9	3	FALSE	TRUE	75.28	3	5	TRUE	FALSE	73.86
3	7	TRUE	FALSE	75.26	3	13	FALSE	FALSE	73.80
13	10	FALSE	TRUE	75.25	12	12	FALSE	TRUE	73.79
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12	11	FALSE	TRUE	75.20	5	6	FALSE	TRUE	73.67
9	13	FALSE	TRUE	75.17	3	10	TRUE	TRUE	73.62
6	11	FALSE	TRUE	75.17	3	7	FALSE	FALSE	73.59
3	14	TRUE	FALSE	75.12	6	7	FALSE	TRUE	73.58
11	12	FALSE	TRUE	75.06	3	9	FALSE	FALSE	73.55
4	4	TRUE	TRUE	75.02	4	2	TRUE	TRUE	73.36
3	12	FALSE	FALSE	74.95	3	3	FALSE	FALSE	73.35
7	14	FALSE	TRUE	74.95	14	10	FALSE	TRUE	73.34
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13	11	FALSE	TRUE	74.88	3	14	FALSE	FALSE	73.31
10	1	FALSE	FALSE	74.84	6	1	TRUE	TRUE	73.20
6	8	FALSE	TRUE	74.83	3	3	TRUE	FALSE	73.18
11	1	FALSE	FALSE	74.83	6	1	FALSE	FALSE	73.10
11	14	FALSE	TRUE	74.80	3	6	TRUE	FALSE	73.03
4	3	FALSE	FALSE	74.79	5	12	FALSE	TRUE	72.91
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12	13	FALSE	TRUE	74.55	14	1	FALSE	FALSE	72.73
7	2	FALSE	TRUE	74.40	3	4	FALSE	FALSE	72.71
6	3	FALSE	TRUE	74.37	6	12	FALSE	TRUE	72.64
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3	5	FALSE	FALSE	74.33	4	3	TRUE	TRUE	72.50
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11	13	FALSE	TRUE	74.25	5	8	FALSE	TRUE	72.45
7	1	FALSE	FALSE	74.25	3	11	TRUE	TRUE	72.40
3	11	FALSE	FALSE	74.19	3	9	TRUE	TRUE	72.32
6	4	FALSE	TRUE	74.18	2	12	TRUE	FALSE	72.30
9	1	FALSE	FALSE	74.14	5	7	FALSE	TRUE	72.22
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9	14	FALSE	TRUE	74.09	10	1	FALSE	TRUE	72.19
8	1	FALSE	FALSE	74.01	4	7	FALSE	TRUE	72.15
4	2	FALSE	FALSE	73.99	13	1	FALSE	TRUE	72.14
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3	5	TRUE	TRUE	71.92	4	2	FALSE	TRUE	69.37
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2	12	FALSE	FALSE	71.86	2	6	FALSE	FALSE	69.24
2	14	TRUE	FALSE	71.84	2	6	TRUE	FALSE	69.18
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4	1	TRUE	TRUE	71.49	2	4	FALSE	FALSE	68.60
4	9	FALSE	TRUE	71.48	3	6	FALSE	TRUE	68.22
11	1	FALSE	TRUE	71.42	12	1	FALSE	TRUE	68.22
5	13	FALSE	TRUE	71.40	2	5	TRUE	FALSE	67.87
6	2	FALSE	TRUE	71.39	3	4	FALSE	TRUE	67.52
2	10	TRUE	FALSE	71.37	3	7	FALSE	TRUE	67.48
4	11	FALSE	TRUE	71.28	3	1	FALSE	FALSE	67.47
2	13	TRUE	FALSE	71.15	2	3	TRUE	FALSE	67.38
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5	14	FALSE	TRUE	70.90	3	8	FALSE	TRUE	67.35
2	9	FALSE	FALSE	70.89	3	5	FALSE	TRUE	67.27
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3	3	TRUE	TRUE	70.73	2	11	TRUE	TRUE	66.82
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4	12	FALSE	TRUE	70.52	2	6	TRUE	TRUE	66.71
4	14	FALSE	TRUE	70.46	3	9	FALSE	TRUE	66.59
2	7	TRUE	FALSE	70.46	2	1	FALSE	FALSE	66.34
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3	12	TRUE	TRUE	70.28	3	10	FALSE	TRUE	66.01
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3	2	FALSE	FALSE	70.06	2	1	TRUE	FALSE	65.76
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3	11	FALSE	TRUE	65.04
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1	10	FALSE	FALSE	64.89
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2	8	FALSE	TRUE	64.82
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