Exploiting Social Graph Networks for Emotion Prediction

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1 Additional Results

Figure 1: (S) Distribution of the stress and happiness prediction model root mean square error (RMSE). Normalized histogram is shown in blue bars and a kernel density function is fitted to it.

|                             | Average stress score | Standard deviation in stress score |
|-----------------------------|----------------------|-----------------------------------|
|                             | Coefficient | P-Value  | Coefficient | P_Value |
| Eigenvalue centrality       | -9          | 0.004    | 3.5         | 0.01    |
| Small Degree (D<4)          | 0.5         | 0.8      | -1.2        | 0.13    |
| Large Degree (D>4)          | -2          | 0.4      | -2          | 0.17    |
| Closeness Centrality        | 1.5         | 0.8      | -0.3        | 0.9     |
| Pagerank Centrality         | 0.01        | 0.8      | -0.01       | 0.49    |

Table 1: (S) GEE results with true happiness score as dependent variable and graph centrality metrics as independent variables.
Figure 2: (S) Impact of temporal memory on happiness prediction

Figure 3: (S) Impact of graph size on root mean squared error
2 Descriptive Statistics

2.1 Emotion labels distribution

The distribution of self-reported scores for participants across multiple days that they were part of the study is presented through boxplots in Figure. 4 and 5. The x-axis represents a unique user and the corresponding boxplot on the y-axis represents the spread of the corresponding emotion label for that user across multiple days. Each box presents five statistics. The width of the colored box corresponds to the interquartile range (IQR) and the black line inside the box represents the median value. The lower and upper ends of the whiskers show the minimum and maximum values while the black scatter points outside the whisker boundaries correspond to the outliers.

It can be observed from all four plots that there is a huge variation across the median value of emotion scores across users. Not only that, but the IQR also varies a lot. Some participants have a small IQR, meaning their emotion values are not changing a lot on a day-to-day basis. While another large proportion of participants has a large variation in the score. This highlights the dynamic nature of emotion and the need for customized emotion models for each participant. We integrate this customization through rich multi-modal sensor data.

2.2 Network Statistics

The distribution plots of degree and edge strength are presented in Figure.6,7 and 8.

2.3 Phone Data Statistics

The statics of data collected from phones are presented in Table. 2.

| Variable                                        | Mean  | Median | 25th Percentile | 75th Percentile | Standard deviation |
|-------------------------------------------------|-------|--------|-----------------|-----------------|--------------------|
| Daily total call duration (in seconds)          | 756.42| 49     | 507             | 2750.7          |
| Daily total number of calls                    | 4.4   | 2      | 5               | 12.3            |
| Daily total number of SMS                      | 41.7  | 18     | 50              | 70.8            |
| Daily screen usage duration (in seconds)       | 7826.7| 6997.8 | 11899.7         | 41185.7         |
| Daily number of times screen unlocked/used     | 119   | 95     | 165             | 121.2           |

Table 2: Descriptive statistics for metadata collected from mobile phone

2.4 Mobile sensing data description and statistics

The wearable device worn by the participants on their wrists collected Electrodermal Activity (EDA), Skin Temperature (ST), and 3-axis Accelerometer at 8 GHz. The units of EDA, ST, and Accelerometer are microsiemens (µS), Celsius (°C), and gravity (G) respectively. The data for one 24-hr day (0-24) is divided into three 7-hour and one 3-hr windows from 3-10H, 10-17H, 17-24H, and 0-3H. For each window, multiple features from EDA peaks, Skin Conductance Level (SCL), accelerometer, and temperature are computed. For EDA Peak features, the first peaks and artifacts were detected. Then, features listed in Table 3 were computed for both, all detected peaks, and only non-artifact peaks. The statistics for these features for each window (3-10H, 10-17H, 17-24H, and 0-3H) are presented in table 4.
Figure 4: (S) Distribution of self-reported happiness score over the study period for each participant. For better visualization, each participant is assigned a different color.

Furthermore, multiple features about the weather are extracted from DarkSky’s weather API [1]. The weather data contained information about temperature, sunlight, Barometric pressure, and the difference between today’s weather, and the rolling average and wind. The details of features and their statistics are provided in Table 5 and 6 respectively.
Figure 5: (S) Distribution of self-reported stress score over the study period for each participant.
Figure 6: (S) Histogram of the number of direct friends in call and SMS graph networks

Figure 7: (S) Histogram of the edge strength (duration of calls in seconds during the study period) in call graph networks

Figure 8: (S) Histogram of the edge strength (weighted sum of the number of SMS exchanged during the study period) in SMS graph networks
| **Electrodermal activity (EDA) Peak Features** |  |
| --- | --- |
| Sum AUC | the sum of the AUC of all peaks for this period where the amplitude of the peak is calculated as the difference from base tonic signal |
| Sum AUC Full | sum of AUC of peaks where amplitude is calculated as difference from 0 |
| Median RiseTime | median rise time of peaks (seconds) |
| Median Amplitude | median amplitude of peaks (μS) |
| Count Peaks | number of peaks detected |
| SD Peaks 30 min | compute # of peaks per 30 minute epoch, take standard deviation of this signal |
| Med Peaks 30 min | compute # of peaks per 30 minute epoch, take median of this signal |
| Percent Med Peak | percentage of signal containing 1 minute epochs with greater than 5 peaks |
| Percent High Peak | same as percent Med Peak |

| **Skin Conductance Level (SCL) Features** |  |
| --- | --- |
| Percent Off | percentage of period where sensor was off |
| MaxUnnorm | maximum level of un normalized EDA signal |
| MedUnnorm | median of normalized EDA signal |
| MeanUnnorm | mean of unnormalized EDA signal |
| Median Norm | median of z score normalized EDA signal |
| SD Norm | Standard Deviation of z score normalized EDA signal |
| Mean Deriv | mean derivative of z score normalized EDA signal (μS/second) |

| **Accelerometer Features** |  |
| --- | --- |
| Step Count | number of steps detected |
| Mean Movement Step Time | average number of samples (at 8Hz) between two steps (aggregated first to 1 minute, then we take the mean of only the parts of this signal occurring during movement) |
| Stillness Percent | Percentage of time the person spent nearly motionless |
| Sum Stillness Weighted AUC | weight the peak AUC signal by how still the user was every 5 minutes and sum |
| Sum Steps Weighted AUC | weight the peak AUC signal by the step count over every 5 minutes and sum |
| Sum Stillness Weighted Peaks | Multiply the number of peaks every 5 minutes by the amount of stillness during that period |
| Max Stillness Weighted Peaks | the max value for the # peaks * stillness for any five minute period |
| Sum Steps Weighted Peaks | divide number of peaks every five minutes by step count and sum |
| Med Steps Weighted Peaks | average value for the number of peaks / step count every 5 mins |

| **Skin Temperature(ST) Features** |  |
| --- | --- |
| Max Raw Temp | the maximum of the raw temperature signal (°C) |
| Min Raw Temp | the minimum of the raw temperature signal (°C) |
| SD Raw Temp | the standard deviation of the raw temperature signal |
| Med Raw Temp | median of the same |
| Sum Temp Weighted AUC | sum of peak AUC divided by the average temp every 5 mins |
| Sum Temp Weighted Peaks | number of peaks divided by the average temp every 5 mins |
| Max Temp Weighted Peaks | the maximum number of peaks in any 5 minute period divided by the average temp |
| SD Stillness Temp | std dev of the temperature recorded during periods when the person was still |
| Med Stillness Temp | median of the temperature when the person was still |

Table 3: Description of features extracted from wearable device
| Feature                          | Mean  | Median | 25th Percentile | 75th Percentile | Standard deviation |
|---------------------------------|-------|--------|-----------------|-----------------|--------------------|
| 0H-3H:sumAUC                   | 58.96 | 8.07   | 1.27            | 39.98           | 147.19             |
| 0H-3H:sumAUCFull               | 342.93| 16.93  | 1.59            | 126.1           | 1036.55            |
| 0H-3H:countPeaks               | 34.15 | 7      | 2               | 27              | 71.28              |
| 0H-3H:sdPeaks30min             | 6.35  | 1.37   | 0.75            | 5.64            | 11.92              |
| 0H-3H:medPeaks30min            | 3.31  | 0.5    | 0               | 2               | 9.64               |
| 0H-3H:percentMedPeak           | 0.84  | 0      | 0               | 0               | 2.69               |
| 0H-3H:percentHighPeak          | 0.84  | 0      | 0               | 0               | 2.69               |
| 0H-3H:sumAUCNoArtifact         | 33.37 | 5.92   | 0.5             | 25.21           | 73.81              |
| 0H-3H:sumAUCFullNoArtifact     | 216.88| 11.69  | 0.93            | 75.45           | 624.42             |
| 0H-3H:countPeaksNoArtifact     | 18.84 | 4      | 1               | 16              | 38.02              |
| 0H-3H:sdPeaks30minNoArtifact   | 3.63  | 0.76   | 0.37            | 3.09            | 7.11               |
| 0H-3H:medPeaks30minNoArtifact  | 1.7   | 0      | 0               | 1               | 4.63               |
| 0H-3H:percentMedPeakNoArtifact | 0.19  | 0      | 0               | 0               | 0.78               |
| 0H-3H:percentHighPeakNoArtifact| 0.19  | 0      | 0               | 0               | 0.78               |
| 0H-3H:sclPercentOff            | 12.12 | 0      | 0               | 14.45           | 23.75              |
| 0H-3H:sclMaxUnnorm             | 1.05  | 0.61   | 0.27            | 1.35            | 1.24               |
| 0H-3H:sclMedUnnorm             | 0.32  | 0.21   | 0.07            | 0.44            | 0.4                |
| 0H-3H:sclMeanUnnorm            | 0.37  | 0.25   | 0.09            | 0.51            | 0.43               |
| 0H-3H:sclMedianNorm            | 0.14  | 0.09   | -0.19           | 0.4             | 0.48               |
| 0H-3H:sclSDnorm                | 0.36  | 0.22   | 0.1             | 0.48            | 0.38               |
| 0H-3H:sclMeanDeriv             | 0     | 0      | 0               | 0               | 0                  |
| 0H-3H:stepCount                | 575.58| 380    | 142.5           | 768.8           | 636.92             |
| 0H-3H:stillnessPercent         | 0.73  | 0.76   | 0.59            | 0.91            | 0.21               |
| 0H-3H:sumStillnessWeightedAUC  | 26.66 | 3.79   | 0.41            | 17.93           | 65.15              |
| 0H-3H:sumStepsWeightedAUC      | 16.97 | 1.23   | 0.12            | 7.95            | 48.45              |
| 0H-3H:sumStillnessWeightedPeaks| 16.23 | 3.6    | 1.4             | 12              | 34.38              |
| 0H-3H:maxStillnessWeightedPeaks| 4.17  | 2      | 0.8             | 4               | 6.46               |
| 0H-3H:sumStepsWeightedPeaks    | 10.41 | 1.14   | 0.33            | 5.52            | 27.48              |
| 0H-3H:medStepsWeightedPeaks    | 0.02  | 0      | 0               | 0               | 0.12               |
| 0H-3H:sumTempWeightedAUC       | -20.76| -1.22  | -10.91          | 0               | 65.87              |
| 0H-3H:sumTempWeightedPeaks     | -10   | -0.68  | -6.41           | 0.91            | 34.1               |
| Feature                          | Mean  | Median | 25th Percentile | 75th Percentile | Standard deviation |
|---------------------------------|-------|--------|-----------------|-----------------|--------------------|
| 0H-3H:maxTemp WeightedPeaks    | 2.29  | 0.07   | 0               | 2.62            | 4.45               |
| 0H-3H:maxRawTemp               | 35.32 | 35.44  | 33.9            | 36.9            | 2.28               |
| 0H-3H:minRawTemp               | 29.29 | 29.7   | 27.6            | 31.6            | 3.16               |
| 0H-3H:sdRawTemp                | 1.35  | 1.24   | 0.82            | 1.72            | 0.73               |
| 0H-3H:medRawTemp               | 32.65 | 32.88  | 31.4            | 34.1            | 2.09               |
| 0H-3H:sd StillnessTemp         | 1.22  | 1.13   | 0.73            | 1.55            | 0.66               |
| 0H-3H:med StillnessTemp        | 32.94 | 33.1   | 31.62           | 34.3            | 2.1                |
| 3H-10H:sumAUC                  | 113.76| 25.41  | 5.36            | 109.07          | 216.26             |
| 3H-10H:sumAUCFull              | 819.19| 69.37  | 12.41           | 515.77          | 1942.99            |
| 3H-10H:countPeaks              | 67.13 | 20     | 6               | 76              | 110.94             |
| 3H-10H:sd Peaks30min           | 7.62  | 2.2    | 0.8             | 9.03            | 11.65              |
| 3H-10H:med Peaks30min          | 1.52  | 0      | 0               | 1               | 3.75               |
| 3H-10H:percent MedPeak         | 0.7   | 0      | 0               | 0.48            | 1.72               |
| 3H-10H:percent HighPeak        | 0.7   | 0      | 0               | 0.48            | 1.72               |
| 3H-10H:sumAUC NoArtifact       | 82.66 | 16.83  | 3.78            | 69.55           | 168.01             |
| 3H-10H:sumAUC FullNoArtifact   | 681.46| 45.78  | 8.6             | 357.79          | 1707.21            |
| 3H-10H:count PeaksNoArtifact   | 47.93 | 11     | 3               | 42.9            | 90.56              |
| 3H-10H:sdPeaks30minNoArtifact  | 5.69  | 1.25   | 0.48            | 5.51            | 10.02              |
| 3H-10H:medPeaks30minNoArtifact | 0.88  | 0      | 0               | 1               | 2.52               |
| 3H-10H:percentMedPeakNoArtifact| 0.41  | 0      | 0               | 0               | 1.28               |
| 3H-10H:percentHighPeakNoArtifact| 0.41 | 0      | 0               | 0               | 1.28               |
| 3H-10H:percentOff              | 11.69 | 0      | 0               | 11.47           | 22.56              |
| 3H-10H:scl MaxUnnorm           | 1.55  | 1.08   | 0.55            | 2               | 1.56               |
| 3H-10H:scl MedUnnorm           | 0.38  | 0.3    | 0.14            | 0.54            | 0.37               |
| 3H-10H:scl MeanUnnorm          | 0.45  | 0.36   | 0.19            | 0.63            | 0.41               |
| 3H-10H:scl MedianNorm          | 0.26  | 0.27   | -0.01           | 0.54            | 0.41               |
| 3H-10H:sclSDnorm               | 0.49  | 0.4    | 0.2             | 0.7             | 0.38               |
| 3H-10H:sclMeanDeriv            | 0     | 0      | 0               | 0               | 0                  |
| 3H-10H:stepCount               | 581.22| 388    | 127             | 839.5           | 603.91             |
| Feature                                      | Mean  | Median | 25th Percentile | 75th Percentile | Standard deviation |
|----------------------------------------------|-------|--------|-----------------|-----------------|--------------------|
| 3H-10H:mean MovementStepTime                 | 876.28| 485.01 | 250.78          | 990.57          | 1168.21            |
| 3H-10H:stillness Percent                     | 0.9   | 0.92   | 0.86            | 0.97            | 0.08               |
| 3H-10H:sum StillnessWeightedAUC              | 89.47 | 16.46  | 3.44            | 71.39           | 187.42             |
| 3H-10H:sum StepsWeightedAUC                  | 71.26 | 8.83   | 1.47            | 50.37           | 161.09             |
| 3H-10H:sum StillnessWeightedPeaks            | 52.68 | 13.2   | 3.8             | 48.9            | 98.02              |
| 3H-10H:sum StillnessWeightedPeaks            | 7.52  | 3      | 1.6             | 9               | 9.76               |
| 3H-10H:sum StepsWeightedPeaks                | 41.83 | 6.67   | 1.49            | 31.56           | 86.42              |
| 3H-10H:max StepsWeightedPeaks                | 0.02  | 0      | 0               | 0               | 0.14               |
| 3H-10H:sum TempWeightedAUC                   | -62.85| -8.53  | -47.08          | -0.59           | 153.22             |
| 3H-10H:sum TempWeightedPeaks                 | -33.68| -5.07  | -28.76          | 0               | 78.8               |
| 3H-10H:max TempWeightedPeaks                 | 2.99  | 0.38   | 0               | 3.64            | 5.6                |
| 3H-10H:max RawTemp                           | 37.02 | 37.2   | 36              | 38.1            | 1.73               |
| 3H-10H:min RawTemp                           | 29.05 | 29.5   | 27.38           | 31.4            | 3.25               |
| 3H-10H:sd RawTemp                            | 1.63  | 1.55   | 1.2             | 1.96            | 0.61               |
| 3H-10H:med RawTemp                           | 33.95 | 34.1   | 32.9            | 35.2            | 1.77               |
| 3H-10H:sd StillnessTemp                      | 1.45  | 1.39   | 1.1             | 1.72            | 0.51               |
| 3H-10H:med StillnessTemp                     | 34.14 | 34.3   | 33.1            | 35.4            | 1.74               |
| 10H-17H:sum AUC                              | 149.92| 37.05  | 6.17            | 150.23          | 293.19             |
| 10H-17H:sum AUCFull                          | 870.43| 105.47 | 12.51           | 635.51          | 2158.79            |
| 10H-17H:median RiseTime                      | 1.93  | 1.92   | 1.88            | 2               | 0.21               |
| 10H-17H:median Amplitude                     | 0.2   | 0.19   | 0.16            | 0.23            | 0.08               |
| 10H-17H:countPeaks                           | 85.88 | 30     | 8               | 102             | 134.41             |
| 10H-17H:sd Peaks30min                        | 10.16 | 3.47   | 1.03            | 12.96           | 15.22              |
| 10H-17H:med Peaks30min                       | 1.81  | 0      | 0               | 1.5             | 4.44               |
| Feature                                      | Mean | Median | 25th Percentile | 75th Percentile | Standard deviation |
|----------------------------------------------|------|--------|-----------------|-----------------|--------------------|
| 10H-17H:percent MedPeak                      | 1.07 | 0      | 0               | 0.95            | 2.27               |
| 10H-17H:percent HighPeak                     | 1.07 | 0      | 0               | 0.95            | 2.27               |
| 10H-17H:sum AUCNoArtifact                    | 58.79| 19.75  | 3.63            | 69.39           | 95.58              |
| 10H-17H:sum AUCFullNoArtifact                | 370.7| 54.81  | 7.19            | 319.68          | 817.64             |
| 10H-17H:count PeaksNoArtifact                | 34.88| 15     | 3               | 44              | 49.77              |
| 10H-17H:scl Peaks30minNoArtifact             | 3.81 | 1.68   | 0.52            | 5.17            | 5.09               |
| 10H-17H:med Peaks30minNoArtifact             | 0.88 | 0      | 0               | 1               | 2.03               |
| 10H-17H:percent MedPeakNoArtifact            | 0.09 | 0      | 0               | 0               | 0.31               |
| 10H-17H:percent HighPeakNoArtifact           | 0.09 | 0      | 0               | 0               | 0.31               |
| 10H-17H:sclPercentOff                       | 12.45| 2.3    | 0               | 14.24           | 22.08              |
| 10H-17H:scl MaxUnnorm                       | 1.72 | 1.08   | 0.45            | 2.29            | 1.95               |
| 10H-17H:scl MedUnnorm                       | 0.24 | 0.16   | 0.05            | 0.34            | 0.3                |
| 10H-17H:scl MeanUnnorm                      | 0.32 | 0.22   | 0.09            | 0.45            | 0.35               |
| 10H-17H:scl MedianNorm                      | -0.02| -0.05  | -0.26           | 0.19            | 0.35               |
| 10H-17H:sclSDnorm                           | 0.48 | 0.37   | 0.18            | 0.69            | 0.4                |
| 10H-17H:scl MeanDeriv                       | 0    | 0      | 0               | 0               | 0                  |
| 10H-17H:stepCount                           | 3040.2| 2831  | 1768.7          | 4097            | 1805.32            |
| 10H-17H:mean MovementStepTime               | 253.45| 218.13| 160.57          | 302.54          | 143.27             |
| 10H-17H:stillness Percent                   | 0.6  | 0.6    | 0.48            | 0.71            | 0.18               |
| 10H-17H:sum StillnessWeightedAUC            | 33.98| 9.13   | 1.67            | 35.57           | 63.48              |
| 10H-17H:sum StepsWeightedAUC                | 15.31| 3.1    | 0.47            | 12.91           | 33.66              |
| 10H-17H:sum StillnessWeightedPeaks          | 21.66| 8.4    | 2.6             | 25.8            | 33.26              |
| 10H-17H:max StillnessWeightedPeaks          | 5.13 | 2.4    | 1.2             | 7               | 6.22               |
| 10H-17H:sum StepsWeightedPeaks              | 9.9  | 2.85   | 0.7             | 9.35            | 18.97              |
| 10H-17H:med StepsWeightedPeaks              | 0    | 0      | 0               | 0               | 0.02               |
| Feature                        | Mean  | Median | 25th Percentile | 75th Percentile | Standard deviation |
|-------------------------------|-------|--------|-----------------|-----------------|--------------------|
| 10H-17H:sum TempWeightedAUC   | -10.47| -0.09  | -13             | 4.36            | 121.89             |
| 10H-17H:sum TempWeightedPeaks | -3.27 | 0      | -7.96           | 8.88            | 58.33              |
| 10H-17H:max TempWeightedPeaks | 6.63  | 2.7    | 0.29            | 7.57            | 10.98              |
| 10H-17H:max RawTemp           | 35.5  | 35.4   | 34.1            | 37              | 2.33               |
| 10H-17H:min RawTemp           | 26.22 | 26.6   | 24.3            | 28.5            | 3.28               |
| 10H-17H:sd RawTemp            | 1.77  | 1.66   | 1.27            | 2.17            | 0.68               |
| 10H-17H:med RawTemp           | 31.54 | 31.6   | 30.4            | 32.6            | 1.75               |
| 10H-17H:sd StillnessTemp      | 1.55  | 1.44   | 1.11            | 1.9             | 0.63               |
| 10H-17H:med StillnessTemp     | 31.94 | 32     | 30.8            | 33.22           | 1.84               |
| 17H+:sumAUC                   | 205.12| 34.88  | 5.34            | 180.86          | 457.92             |
| 17H+:sumAUCFull               | 1276.89| 93.33  | 10.18           | 812.79          | 3370.56            |
| 17H+:countPeaks               | 107.94| 29     | 7               | 120             | 187.48             |
| 17H+:sdPeaks 30min            | 11.99 | 3.05   | 0.84            | 13.84           | 19.65              |
| 17H+:med Peaks30min           | 2.21  | 0      | 0               | 1               | 6.35               |
| 17H+:percent MedPeak          | 1.48  | 0      | 0               | 1.19            | 3.36               |
| 17H+:percent HighPeak         | 1.48  | 0      | 0               | 1.19            | 3.36               |
| 17H+:sum AUCNoArtifact        | 71.45 | 19.32  | 2.97            | 80.46           | 124.16             |
| 17H+:sum AUCFullNoArtifact    | 477.88| 50.83  | 5.8             | 344.79          | 1102.34            |
| 17H+:count PeaksNoArtifact    | 40.38 | 14     | 3               | 50.9            | 61.92              |
| 17H+:sd Peaks30minNoArtifact  | 4.16  | 1.6    | 0.42            | 5.41            | 5.9                |
| 17H+:med Peaks30minNoArtifact | 1.04  | 0      | 0               | 1               | 2.65               |
| 17H+:percent MedPeakNoArtifact| 0.1   | 0      | 0               | 0               | 0.35               |
| 17H+:percent HighPeakNoArtifact| 0.1  | 0      | 0               | 0               | 0.35               |
| 17H+:sclPercentOff            | 11.7  | 0      | 0               | 14.58           | 21.15              |
| 17H+:sclMaxUnnorm             | 1.8   | 0.98   | 0.36            | 2.31            | 2.21               |
| 17H+:sclMedUnnorm             | 0.25  | 0.15   | 0.04            | 0.33            | 0.32               |
| 17H+:sclMeanUnnorm            | 0.34  | 0.22   | 0.08            | 0.46            | 0.4                |
| Feature                          | Mean   | Median  | 25th Percentile | 75th Percentile | Standard deviation |
|---------------------------------|--------|---------|-----------------|-----------------|--------------------|
| 17H+:sclMedianNorm             | -0.01  | -0.05   | -0.27           | 0.21            | 0.38               |
| 17H+:sclSDnorm                 | 0.49   | 0.34    | 0.15            | 0.72            | 0.45               |
| 17H+:sclMeanDeriv              | 0      | 0       | 0               | 0               | 0                  |
| 17H+:stepCount                 | 3082.07| 2711    | 1646            | 4082            | 1977.16            |
| 17H+:mean MovementStepTime     | 264.79 | 229.02  | 165.32          | 317.35          | 161.34             |
| 17H+:stillnessPercent          | 0.54   | 0.53    | 0.4             | 0.67            | 0.19               |
| 17H+:sum StillnessWeightedAUC  | 33.78  | 7.18    | 1.14            | 31.48           | 70.11              |
| 17H+:sum StepsWeightedAUC      | 15.1   | 2.33    | 0.29            | 11.59           | 36.6               |
| 17H+:sum StillnessWeightedPeaks| 20.61  | 6.61    | 2.01            | 22.22           | 35.2               |
| 17H+:max StillnessWeightedPeaks| 4.69   | 2.14    | 1               | 6.13            | 5.99               |
| 17H+:sum StepsWeightedPeaks    | 9.23   | 2.17    | 0.46            | 8.22            | 19.22              |
| 17H+:med StepsWeightedPeaks    | 0.01   | 0       | 0               | 0               | 0.03               |
| 17H+:sum TempWeightedAUC       | -19.96 | 0       | -12.27          | 3.61            | 194.27             |
| 17H+:sum TempWeightedPeaks     | -7.71  | 0       | -7.66           | 7               | 82.94              |
| 17H+:maxTemp WeightedPeaks     | 6.28   | 2.21    | 0.15            | 7.05            | 10.88              |
| 17H+:maxRawTemp                | 34.77  | 34.7    | 33.3            | 36              | 2.34               |
| 17H+:minRawTemp                | 25.61  | 26      | 23.7            | 28.3            | 3.65               |
| 17H+:sdRawTemp                 | 1.73   | 1.59    | 1.19            | 2.17            | 0.76               |
| 17H+:medRawTemp                | 31.17  | 31.2    | 29.9            | 32.4            | 1.82               |
| 17H+:sdStillnessTemp           | 1.46   | 1.33    | 0.99            | 1.79            | 0.67               |
| 17H+:medStillnessTemp          | 31.51  | 31.6    | 30.4            | 32.9            | 1.92               |

Table 4: Descriptive statistics for physiological features extracted from the wearable device. The feature name is preceded by the time window over which the feature value was extracted.
| Weather Feature                          | Description                                                                 |
|-----------------------------------------|-----------------------------------------------------------------------------|
| Sunrise                                 | Sunrise time UTC                                                            |
| Moon_phase                              | The moon phase value on a scale of 0 – 1 (new moon-full moon)               |
| Apparent_temp_max                       | Maximum apparent temperature of the day in Fahrenheit                       |
| Apparent_temp_min                       | Minimum apparent temperature of the day in Fahrenheit                       |
| Temperature_max                         | Maximum temperature of the day in Fahrenheit                                 |
| Temperature_min                         | Minimum temperature of the day in Fahrenheit                                 |
| avg_cloud_cover                         | Percentage of sky covered by cloud on a scale of 0-1                        |
| avg_dew_point                           | Average dew point temperature                                               |
| avg_humidity                            | Daily average value of humidity on a scale of 0-1                           |
| avg_pressure                            | Average atmospheric pressure on the sea level in hPa                        |
| Morning_pressure_change                 | Trinary value of pressure difference between midnight and noon                |
| Evening_pressure_change                 | Trinary value of pressure difference between noon and midnight               |
| avg_visibility                          | Average visibility in meters                                                |
| weather_precip_probability              | Precipitation probability                                                   |
| Temperature_rolling_mean               | Rolling average of temperature                                              |
| Temperature_rolling_std                | Rolling standard deviation in temperature                                    |
| Temperature_today_vs_avg_past           | Difference between today’s temperature and its rolling average              |
| apparentTemperature_rolling_mean      | Rolling average of apparent temperature                                     |
| apparentTemperature_rolling_std        | Rolling standard deviation in apparent temperature                           |
| apparentTemperature_today_vs_avg_past  | Difference in today’s apparent temperature and its rolling average          |
| pressure_rolling_mean                  | Rolling average of pressure                                                  |
| pressure_rolling_std                   | Rolling standard deviation of pressure                                       |
| pressure_today_vs_avg_past             | Difference between today’s pressure and its rolling average                 |
| cloudCover_rolling_mean                | Rolling average of cloud cover                                              |
| cloudCover_rolling_std                 | Rolling standard deviation in cloud cover                                    |
| cloudCover_today_vs_avg_past           | Difference between today’s cloud cover and its rolling average              |
| humidity_rolling_mean                  | Rolling average of humidity                                                  |
| humidity_rolling_std                   | Rolling standard deviation in humidity                                       |
| humidity_today_vs_avg_past             | Difference between today’s humidity and its rolling average                 |
| windSpeed_rolling_mean                 | Rolling average of wind speed                                               |
| windSpeed_rolling_std                  | Rolling standard deviation in wind speed                                     |
| windSpeed_today_vs_avg_past            | Difference between today’s wind speed and its rolling average               |
| precipProbability_rolling_mean        | Rolling average of precipitation probability                                |
| precipProbability_rolling_std          | Rolling standard deviation in precipitation probability                      |
| precipProbability_today_vs_avg_past    | Difference between current precipitation probability and its rolling average |
| sunlight                               | Duration of sunlight in seconds                                              |
| quality_of_day                         | Quality of the day defined in terms of 8 categories in the range {-4, 4}: clear= 4, partly-cloudy= 3, cloudy= 2, wind=1, fog=-1, rain=-2, sleet=-3, snow=-4 |
| avg_quality_of_day                     | Average value for quality_of_day                                            |
| precipType                             | Type of precipitation as integer;                                           |
| max_precip_intensity                   | Maximum Precipitation volume in mm                                           |
| median_wind_speed                      | Median wind speed of the day in meter/sec                                    |
| median_wind_bearing                    | Median wind bearing of the day in degrees                                   |

Table 5: Description of features extracted from weather API
| Feature                     | Mean       | Median      | 25th Percentile | 75th Percentile | Standard Deviation |
|-----------------------------|------------|-------------|-----------------|-----------------|--------------------|
| weather_sunrise             | 23743.66   | 23800       | 22788           | 25061           | 1596.66            |
| weather_moon_phase          | 0.51       | 0.53        | 0.28            | 0.75            | 0.28               |
| weather_apparent_temp_max   | 44.24      | 44.84       | 26.66           | 60.35           | 19.71              |
| weather_apparent_temp_min   | 25.58      | 26.18       | 10.27           | 42.15           | 20.47              |
| weather_temperature_max     | 47.69      | 47.9        | 34.16           | 60.35           | 16.1               |
| weather_temperature_min     | 32.4       | 32.91       | 19.84           | 45.43           | 15.76              |
| weather_avg_cloud_cover     | 0.37       | 0.26        | 0.17            | 0.5             | 0.28               |
| weather_avg_dew_point       | 27.18      | 28.01       | 12.78           | 41.05           | 18.06              |
| weather_avg_humidity        | 0.63       | 0.61        | 0.5             | 0.73            | 0.15               |
| weather_avg_pressure        | 1015.85    | 1016.23     | 1010.24         | 1021.42         | 9.07               |
| weather_morning_pressure_change | 0.16    | 1           | -1              | 1               | 0.91               |
| weather_evening_pressure_change | 0.04  | 0           | -1              | 1               | 0.94               |
| weather_avg_visibility      | 9.1        | 9.73        | 8.92            | 10              | 1.4                |
| weather_precip_probability  | 0.25       | 0           | 0               | 0.6             | 0.33               |
| weather_temperature_rolling_mean | 39.91  | 39.99       | 26.29           | 52.41           | 14.26              |
| weather_temperature_rolling_std | 7.23    | 6.98        | 5.54            | 8.57            | 2.35               |
| weather_temperature_today_vs_avg_past | 0.14  | 0.38        | -5.38           | 5.94            | 8.73               |
| weather_apparent_Temperature_rolling_mean | 35.01 | 34.79       | 19.5            | 51.56           | 17.99              |
| weather_apparent_Temperature_rolling_std | 8.94  | 8.45        | 6.8             | 11.05           | 2.94               |
| weather_apparent_Temperature_today_vs_avg_past | 0.12 | 0.33        | -6.96           | 7.54            | 10.85              |
| weather_pressure_rolling_mean | 1015.55 | 1015.96     | 1010.68         | 1020.79         | 6.83               |
| weather_pressure_rolling_std | 6.18      | 5.72        | 3.8             | 7.86            | 2.99               |
| weather_pressure_today_vs_avg_past | 0.29 | 0.61        | -5.49           | 6.62            | 9.61               |
| weather_cloudCover_rolling_mean | 0.37  | 0.32        | 0.22            | 0.47            | 0.18               |
| weather_cloudCover_rolling_std | 0.22  | 0.17        | 0.1             | 0.33            | 0.14               |
| Feature                                      | Mean | Median | 25th Percentile | 75th Percentile | Standard Deviation |
|----------------------------------------------|------|--------|-----------------|-----------------|-------------------|
| weather_cloudCover_today vs avg_past        | 0    | -0.02  | -0.12           | 0.12            | 0.22              |
| weather_humidity_rolling_mean               | 0.64 | 0.63   | 0.54            | 0.72            | 0.12              |
| weather_humidity_rolling_std                | 0.16 | 0.17   | 0.13            | 0.19            | 0.04              |
| weather_humidity_today vs avg_past          | -0.01| -0.01  | -0.13           | 0.11            | 0.16              |
| weather_windSpeed_rolling_mean              | 8.91 | 9.56   | 7.57            | 11.11           | 3.65              |
| weather_windSpeed_rolling_std               | 3.49 | 3.35   | 2.42            | 4.4             | 1.49              |
| weather_windSpeed_today vs avg_past         | -0.04| -0.34  | -1.75           | 1.55            | 3.47              |
| weather_precipProbability_rolling_mean      | 0.06 | 0.03   | 0               | 0.09            | 0.09              |
| weather_precipProbability_rolling_std       | 0.13 | 0.11   | 0.01            | 0.21            | 0.11              |
| weather_precipProbability_today vs avg_past | -0.01| -0.01  | -0.06           | 0.03            | 0.13              |
| weather_sunlight                             | 40908.49 | 40127 | 38595           | 41641           | 3726.93           |
| weather_quality_of_day                      | 1.49 | 3      | -2              | 4               | 2.83              |
| weather_precipType                          | 0.88 | 0      | 0               | 1               | 1.37              |
| weather_avg_quality_of_day                  | 3.02 | 3.52   | 2.54            | 3.75            | 1.1               |
| weather_max_precip_intensity                | 0.02 | 0      | 0               | 0.02            | 0.04              |
| weather_median_wind_speed                   | 8.8  | 8.78   | 6.3             | 11.23           | 4.36              |
| weather_median_wind_bearing                 | 240.78 | 267   | 209             | 300             | 89.61             |

Table 6: Descriptive statistics for weather features obtained from Darksy API.

3 Graph Convolutional Networks

In this section, we provide a brief derivation of GCN forward propagation rule which incorporated the graph degree and laplacian matrix. The normalized graph Laplacian \( L \) is a symmetric matrix defined as,

\[
L = I_N - D^{-1/2}AD^{-1/2}
\]

where \( I_N \) is \( N \times N \) identity matrix. The spectral convolution on a graph is simply fourier domain multiplication of node feature signal \( x \) (assume scalar for ease of understanding) with a filter \( h_\theta \) parametrized by \( \theta \)[2],

\[
h(\theta) * x = Uh_\theta(\Lambda)U^T x
\]

where \( U \) and \( \Lambda \) are the eigenvector and eigenvalue matrix of \( L \): \( L = U\Lambda U^T \). To avoid the expensive computational cost of eigenvalue decomposition of \( L \), a truncated Chebychev polynomial expansion
of \( h_\theta(\Lambda) \) is utilized to obtain the following simplified expression\[3\],

\[
h(\theta) \ast x = L_\theta x
\]  

The details are skipped in the interest of space. For the detailed derivation, please refer to \[2\] \[3\]. The expression in eq. (2) can be generalized for any signal \( X \in \mathbb{R}^{N \times C} \) for graph size \( N \) and channels \( C \),

\[
h(\theta) \ast x = \tilde{D}^{-1/2} \tilde{A} \tilde{D}^{-1/2} X \Theta
\]  

where \( \tilde{A} = A + I_N \) is the adjacency matrix with added self-loops and \( \tilde{D}_{ii} = \sum_j \tilde{A}_{ij} \). \( \Theta \) represents the network parameters to be learned.

References

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[3] D. K. Hammond, P. Vandergheynst, and R. Gribonval, “Wavelets on graphs via spectral graph theory,” Applied and Computational Harmonic Analysis, vol. 30, no. 2, pp. 129–150, 2011.