Stress Management Considering Sleeping Habits

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Abstract

Considering today's lifestyle, people just sleep forgetting the benefits sleep provides to the human body. Smart-Yoga Pillow (SaYoPillow) is proposed to help in understanding the relationship between stress and sleep and to fully materialize the idea of "Smart-Sleeping" by proposing an edge device. An edge processor with a model analyzing the physiological changes that occur during sleep along with the sleeping habits is proposed. Based on these changes during sleep, stress prediction for the following day is proposed. The secure transfer of the analyzed stress data along with the average physiological changes to the IoT cloud for storage is implemented.

Introduction

Stress is defined as a state of mental or emotional strain due to unavoidable or demanding circumstances, also known as stressors. Stress can also be defined as a specific strain on the human body caused by various stressors. Stressors cause the human body to release stress hormones. Stressors are categorized as physiological, psychological, absolute and relative [1].

Humans develop lack of adaptation when exposed to stress due to various stressors for longer periods of time which can have major impacts on relationships, work, health and on the self by causing emotional breakdowns. Having an ability to build a self-monitoring system to tackle these stressors is very important. The attempt to control and monitor stress variations due to lack of sleep is the focus of this work. The better the quality of sleep, the lower the stress levels [2].

Framing the problem

The main motivation of SaYoPillow is to actualize the phrase "Smart-Sleeping" which can be termed as a sleep that is complete and which meets the ideal body requirements during sleep. The idea is to propose a smart wearable that requires no user input, a fully automated, response control system which does not compromise the user's convenience. It also aims to educate the user about the benefits and importance of good quality sleep and to understand the relationship between sleep and stress.

Solution

Decision trees are powerful and popular tools for classification and prediction. Decision trees represent rules, which can be understood by humans and used in knowledge system such as database. A decision tree is a hierarchical model for supervised learning whereby the local region is identified in a sequence of recursive splits in a smaller number of steps. A decision tree is composed of internal decision nodes decision node and terminal leaves [3]. Decision tree is a classifier in the form of a tree structure which consists of:

- Decision node: specifies a test on a single attribute.
- Leaf node: indicates the value of the target attribute.
- Edge: split of one attribute.
- Path: a disjunction of test to make the final decision.

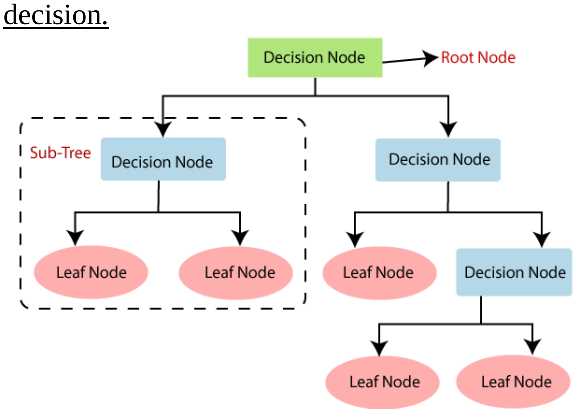

Image 1: Decision Tree diagram (1)

Explaining Data

In this dataset we will se the relationship between the parameters of:

Stress Detection Dataset
Snoring Range
Respiration Rate
Body Temperature
Limb Movement Rate
Blood Oxygen Levels
Eye Movement
Number of Hours of Sleep
Heart Rate
Stress Levels (0-4)

Table 1: Dataset Labels

The relationships between sleep and stress in research made are

1. Sleep can be stated as a state in which the nervous system remains relatively inactive with eyes closed and relaxed muscles.
2. To identify sleep disorders, a sleep study is conducted, known as Polysomnography. This helps in monitoring the sleep stages by performing electroencephalography (EEG) [4].
3. Studies show that the quality od sleep effects the quality of day [5]. Disturbed sleep has been associated with increased instances of sickness, burnout syndrome, persistent psycho-physiological insomnia, weak immune system, PTSD and higher risk of occupational accidents [6].

Data Preparation

The Decision Tree algorithm manages its own data preparation internally. It does not require pretreatment of the data. Before preparing the data, we need to load the data top be processed with its corresponding labels. After this we need to split the dataset into our training data frame and test data frame, we check indexes to make a random test and train set [7].

Decision Tree is not affected by Automatic Data preparation, but in this case, we need to be sure the data we have is pure and the algorithms needs to follow the following diagram [8].

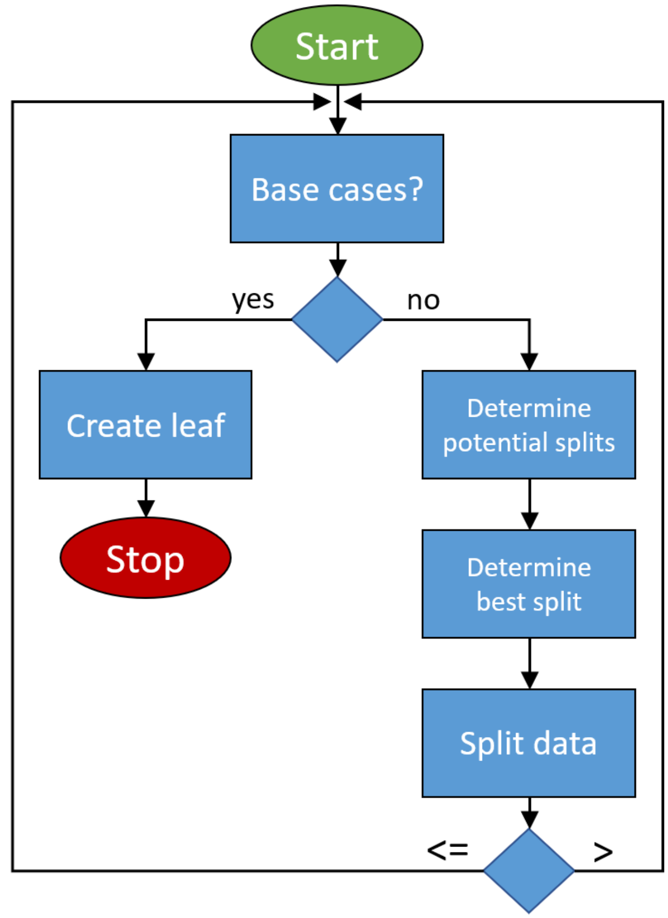

Image 2: Decision Tree diagram (2)

At the beginning of the algorithm, we need to prepare the data and determine the feature type of it in this case we want to separate the values of the sets into categorical and continuous to check which type of data we have.

Entropy and Splits

On our base case, we are checking the purity of the data and if this is correct, we proceed to create a leaf. Otherwise, we proceed with a recursive part which performs the potential splits ad determine the best split for it to split it depending on the metrics of the mean square error if it's a regression task, if it's a classification task we calculate the entropy which can be calculate as follows:

$$H = -\sum p_i(\, log_2(p_i))$$

Where:

H → Entropy

p_i → Event probability

The entropy calculates the impurity or uncertainty present in the data. The split of the dataset involves iterating over each row, checking if the attribute value is below or above the split value and assigning it to the left or right group [9]. By a dataset given, we must check every value on each attribute as a candidate split, evaluate the cost of the split and find the best possible split we could make [10]. Once the split is found, we can use it as a node in our decision tree.

Build a tree recursively until we ger all the leaf nodes based on two criteria: Maximum tree depth and Minimum node record.

Predictive Modelling

In the project developed we compare the variations of the trees by themselves. A code from scratch, using a framework and a technique called random forest which is several trees together to have different result and a better accuracy. According to the tests made the Tree code from scratch was a better performance and accuracy than the framework using scikit learn and the random forest code from scratch.

For the data used on the project the following trees were created using the framework to give us an idea of how a tree works.

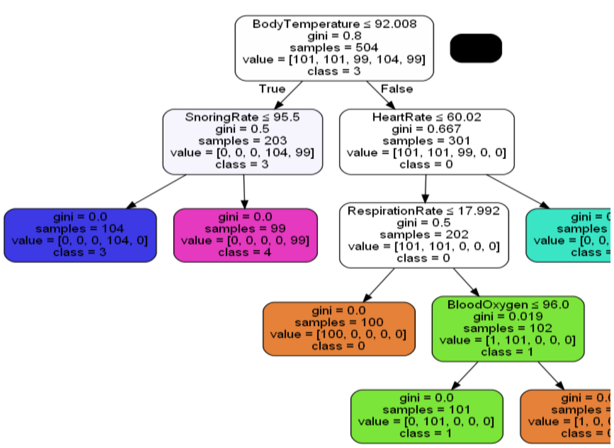

Image 3: Decision Tree example (1)

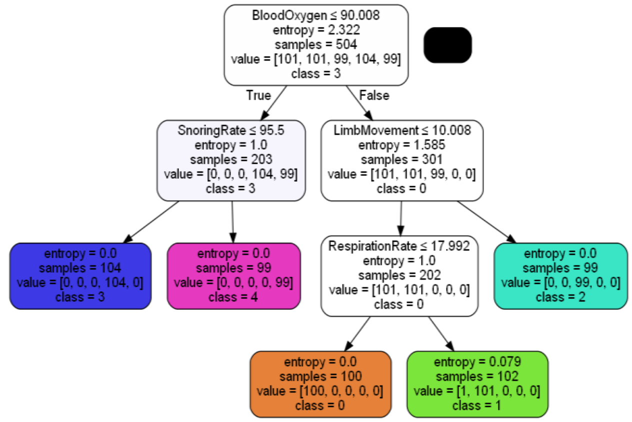

Image 4: Decision Tree example (2)

In this case the tree is interpreted in each node with to detect a pattern and how each data is related with each other. In this case we analyze each node with a true or false depending on some of the features such as blood oxygen, snoring rate, limb movement or any other one to get the data in the correct way.

With these trees performed we can make predictions and start making queries with the model.

Results

In this project the results obtained were good according to the data we have. The main use of trees is the classification of different data depending on different tasks such as classification by itself or regression task. The task performed depends on the data we have and if the data is continuous or categorical. Another point obtained is that in the random forest we split the data in several datasets to haver several classifications of it and different results to have a better result than with one tree. It just depends on the data and how is processed internally.

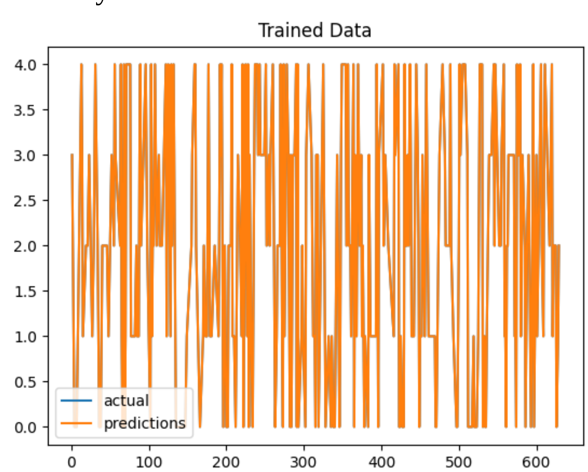

Image 5: Training the dataset.

```
Accuracy: 0.9904761904761905
     SnoringRate  RespirationRate  BodyTemperature  ...  label  Prediction  Correct
142        78.40           21.840           93.840  ...      2         2.0     True
287        89.00           24.400           91.200  ...      3         3.0     True
72         57.68           19.536           95.536  ...      1         1.0     True
356        45.00           16.000           96.000  ...      0         0.0     True
553        49.04           17.616           98.424  ...      0         0.0     True
..           ...              ...              ...  ...    ...         ...      ...
565        54.72           18.944           94.944  ...      1         1.0     True
74         48.68           17.472           98.208  ...      0         0.0     True
570        99.84           29.840           89.800  ...      4         4.0     True
296        69.12           20.912           92.912  ...      2         2.0     True
158        96.32           26.320           85.400  ...      4         4.0     True

[315 rows x 11 columns]
```

Image 6: Results obtained from the Tree program without FW.

```
Accuracy of the model is 99.20634920634922
              precision    recall  f1-score   support

           0       1.00      1.00      1.00        25
           1       1.00      1.00      1.00        25
           2       1.00      0.96      0.98        27
           3       0.96      1.00      0.98        22
           4       1.00      1.00      1.00        27

    accuracy                           0.99       126
   macro avg       0.99      0.99      0.99       126
weighted avg       0.99      0.99      0.99       126
```

Image 7: Results obtained from the Tree FW.

```
0.9886621315192744
{'HeartRate <= 59.96': [{'HeartRate <= 54.88': [0.0, 1.0]},
                        {'HeartRate <= 64.88': [2.0,
                                                {'HeartRate <= 75.0': [3.0,
                                                                       4.0]}]}]}
{'HeartRate <= 60.0': [{'HeartRate <= 54.88': [0.0, 1.0]},
                       {'HeartRate <= 64.96': [2.0,
                                               {'HeartRate <= 75.0': [3.0,
                                                                      4.0]}]}]}
{'HeartRate <= 60.0': [{'HeartRate <= 54.8': [0.0, 1.0]},
                       {'HeartRate <= 64.8': [2.0,
                                              {'HeartRate <= 75.0': [3.0,
                                                                     4.0]}]}]}
{'HeartRate <= 60.0': [{'HeartRate <= 54.88': [0.0, 1.0]},
                       {'HeartRate <= 64.96': [2.0,
                                               {'HeartRate <= 74.84': [3.0,
                                                                       4.0]}]}]
```

Image 8: Trees structures from the Random Forest

```
Accuracy of the model is: 0.9682539682539683
Predictions
     SnoringRate  RespirationRate  BodyTemperature  ...  label  Prediction  Correct
289       64.320           20.432           92.432  ...      2         2.0     True
91        86.600           23.760           90.880  ...      3         3.0     True
590       94.520           25.872           91.936  ...      3         4.0    False
238       83.120           22.832           90.416  ...      3         3.0     True
305       62.560           20.256           92.256  ...      2         2.0     True
..           ...              ...              ...  ...    ...         ...      ...
574       46.160           16.464           96.696  ...      0         0.0     True
437       99.456           29.456           89.320  ...      4         4.0     True
224       80.120           22.032           90.016  ...      3         3.0     True
389       55.040           19.008           95.008  ...      1         1.0     True
276       70.080           21.008           93.008  ...      2         2.0     True
```

Image 9: Random Forest Predictions

Future work

Future exploration on the data preparation step can be included by exploring the change in the depth and by obtaining more data for further predictions and different classification models to have the best accuracy and technique for the problem

Conclusion

References

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