Machine Learning Techniques for Stress Prediction among working IT professionals due to WFH(work from home)

A Thesis Submitted in partial fulfillment of the

requirements for the award of the Degree of

MASTER OF TECHNOLOGY

IN

INFORMATION TECHNOLOGY

BY

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MESRA-835215, RANCHI 2022

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b. The work has not been submitted to any other Institute for any degree or diploma.

c. I have followed the guidelines provided by the Institute in writing the thesis.

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To the best of my/our knowledge, the contents of this thesis did not form a basis for the award of any previous degree to anyone else.

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Affiliation

Signature
Guide:- Dr Subrajeet Mohapatra
Dept. of Computer Science and Engineering

THESIS APPROVAL CERTIFICATE

This is to certify that the work embodied in this thesis entitled "Machine Learning Techniques for Stress Prediction among working IT professionals due to WFH(work from home)" is carried out by Mr./Ms. - Nikesh Kumar (Roll No. MT/ITY/10011/20) is approved for the degree of Master of Technology of Birla Institute of Technology; Mesra, Ranchi.

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Place: Ranchi

Internal Examiner(s)
Name & Signature

External Examiner(s)
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Chairman
(Head of the Department)

Content

ACKNOWLEDGEMENT

Thank you to my guide, Dr Subrajeet Mohapatra and Dr Madhu Gupta, for your patience, guidance, and support. I have benefited greatly from your wealth of knowledge and meticulous editing. I am extremely grateful that you took me on as a student and continued to have faith in me over the years.

Thank you to the interviewees, who so generously took time out of their schedules to participate in my research and make this project possible.

ABSTRACT

Brain, a place that stores and computes each and every aspect of our life, the house of stress is what I would like to call it, hence stress disorders are a common issue among all working IT professionals especially in times such as these. With changing lifestyle and work cultures during the COVID-19 era there is entirely a new phase of lifestyle that has been incorporated in the form of Work From Home (WFH). Though many industries and corporations have their individual mental health related schemes and do try to ease the workplace atmosphere however in times like these the issue is bejoy their reach and control.

Keeping the above nitty-gritty in mind in the following paper, we would like to apply machine learning technique(s) to further analyze stress patterns in working adults and to narrow down the factors that strongly determine the stress levels. Towards this, data was collected in the form of extensive market study and responses of working professionals within the tech-industry was considered. Multiple Machine Learning technique(s) were applied to train the model after complete data cleaning and preprocessing. The accuracy of the all above models was obtained and studied comparatively. Logistic regression had the highest accuracy amongst the models implemented. With results such as these, industries can now narrow down their approach to reduce stress and create a much more comfortable workplace for their employees.

By using Decision Trees, prominent features that influence stress were identified as gender, marital status, the level of stress due to work during WFH and anxiety symptoms.

INTRODUCTION

In the year 2019 the world as we know went through a drastic change, a change that was completely unexpected to say the least, COVID-19 a RNA virus took over the globe and disrupted the general flow of our lives. This phase saw the beginning of countless new things and a complete paradigm shift of work culture was observed. Work From Home (WFH) lifestyle was incorporated as we were in lockdown and this impacted the general flow of everything. Stress-related mental health disorders are not uncommon among the working class, as we entered the phase of WFH culture time spent inside our four walls has increased and this brought around a host of new issues mentally and physically. People were spending time 24/7 at home all 7 days a week, managing their personal and professional lives while living enclosed in a close space is something no one has experienced before, taking caring of their kids, preparing food for their families, attending office calls, keeping in touch with their other family members, going through the loss of close ones due to the pandemic, entertaining their kids in such times and after all this keeping a smile on their face. This surely has in a way affected their mental health and has broten the factor of stress somewhere in our lives.

Several studies in the past have raised concerns over the same. According to a study by the industry association, Assocham, more than forty-two percent of working professionals in the Indian private sector suffer from depression or general anxiety disorder due to long work hours and tight deadlines. This portion of said people is rising as mentioned in the 2018 Economic Times article based on the survey conducted by Optum[1]

that half of its working professionals in India suffer from stress. This has seen an increase during the COVID-19 phase as the working hours are now considered as the entire day. The need for a stress-free workplace should be of utmost importance for greater productivity and well-being of the employees. Numerous steps must be taken to help working professionals cope up with stress for mental well-being like counseling assistance, career guidance, stress management sessions, and health awareness programs. Early identification of employees who will be needing such help will enhance the chances of such measures being productive as well as successful in their individual lives.

We desire to ease this technique through the use of machine learning methods to develop a model to predict if an individual is having stress or not by taking various aspects of the persons professional and personal factors as parameters collected in the form of cautiously drafted surveys. In the end such market research will help the employer to better understand the situation at ground level and accordingly a healthier strategery can be created keeping in mind the mental wellbeing of their employees.

OBJECTIVE

Stress Mechanism is something that humans have always found it difficult to cope up with but there has never been a solution to it since we're not able to identify the gravity in the first place.

Hence, this thesis will embark on the various stresses that an IT professional goes through and how the designed model can validate these situations to have a work around for it. The model is based on Machine Learning predictive analysis wherein each situation is studied, an IT professional has gone through in a Work From Home model.

There is a way to handle this process by the help of Machine Learning methods so that for this model can be developed to predict this risk for stress experienced and also if treatment is needed or not for an individual by considering some of theirs professional and personal factors which are parameters collectively have an impact in the form of drafted surveys form. Such type of approach will help HR managers to understand better about their employees but also helps and proven useful in taking preventive measures to eliminate the case of underperforming and reduce the atriation rate of the company. If a person requires treatment for his mental health or not can be predicted in the early stage.

LITERATURE REVIEW

Serial No.	Author	Paper Title	Publication	Year
1	R Bhattacharaya, S Basu	India Inc looks at to deal with rising stress in employees	Economics Times	2018
2	Van den Broeck, J., Cunningham, S. A., Eeckels, R., & Herbst, K.	Data cleaning: detecting, diagnosing, and editing data abnormalities	PLoS medicine	2005
3	Shwetha, S, Sahil, A, Anant Kumar J	Predictive analysis using classification techniques in healthcare domain	International Journal of Linguistics & Computing Research	2017
4	Tomar, D., & Agarwal,	A survey on Data Mining	International Journal	2013

	S	**approaches for Healthcare**	**of Bio-Science and Bio-Technology**	
5	**Pedregosa, F., Varoquaux, G., Gramfort, A., Michel, V., Thirion, B., Grisel, O., & Vanderplas, J.**	**Scikit-learn: Machine learning in Python.**	**Journal of machine learning research,**	**2011**
6	**Karen Danna and Ricky W. Griffin**	**Health and Well-Being in the Workplace: A Review and Synthesis of the Literature**	**Journal of Management 1999 25: 357**	**1999**

METHODOLOGY

The below figure depicts the flow of the process starting from data collection which was ground 0 up till the final conclusion that was established at the end of extensive market research.

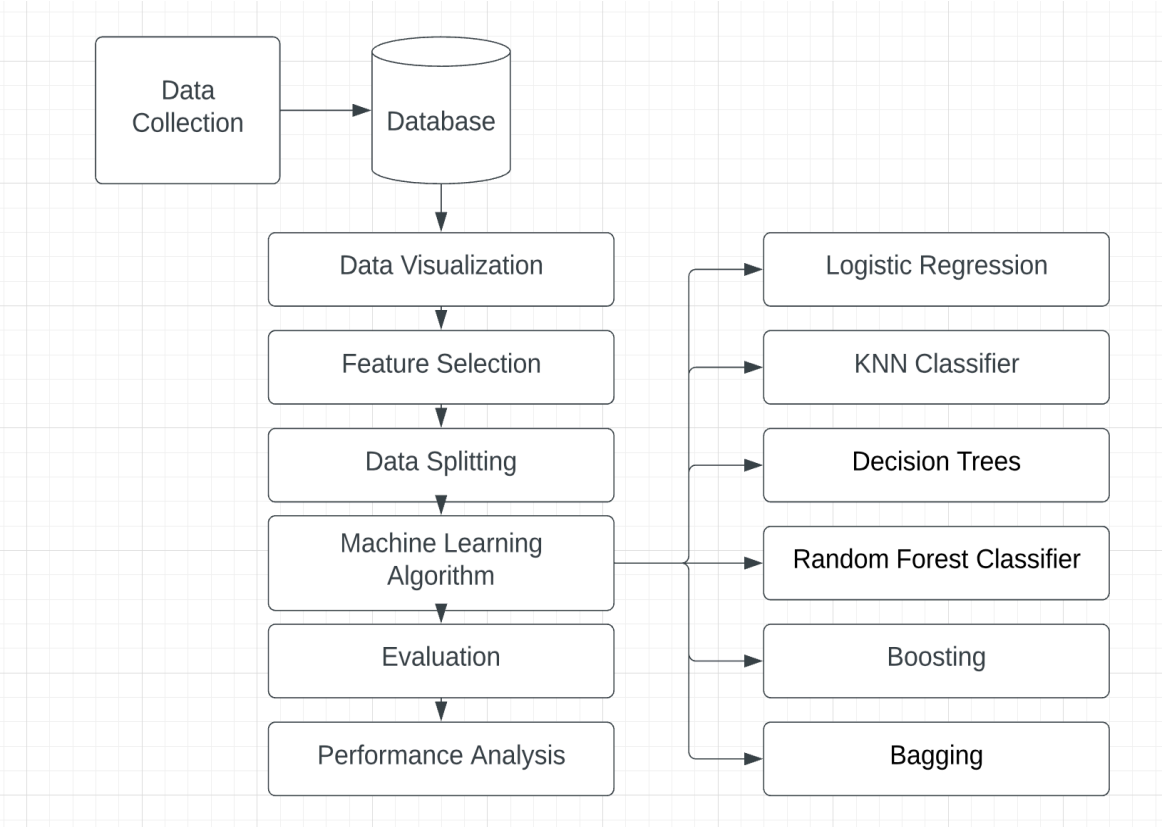


Fig. Flow chart

Data Collection

The data collection was done by extensive market research conducted over a period of 2 months focusing on maining working class professionals from the IT industry. This database comprised 243 individual resonses, across various age groups. A questionnaire of 43 questions in cohesion with personal demography, family related and stress related was prepared keeping in mind the current scenario pertaining to Work From Home.

Dataset and its features

The dataset consisted of 43 features spanning across various fields of study, gathering data of aspects which are in relation to stress levels of these professionals in such times, where mainly WFH is the norm.

Questions were ranging from basic day to day life activities to personal life questions using which an extensive array of data was gathered which became the crucial aspect of the thesis, in addition to this the questions were vetted by a professional over a period of time to better understand the genuineness of the said questions.

Below depicts an actual set of questions from the sheet filled by those individuals, over here we can see that a scale is provided ranging from 0 to 5 in which the street level is being asked in relation with the pandemic and WFH system.

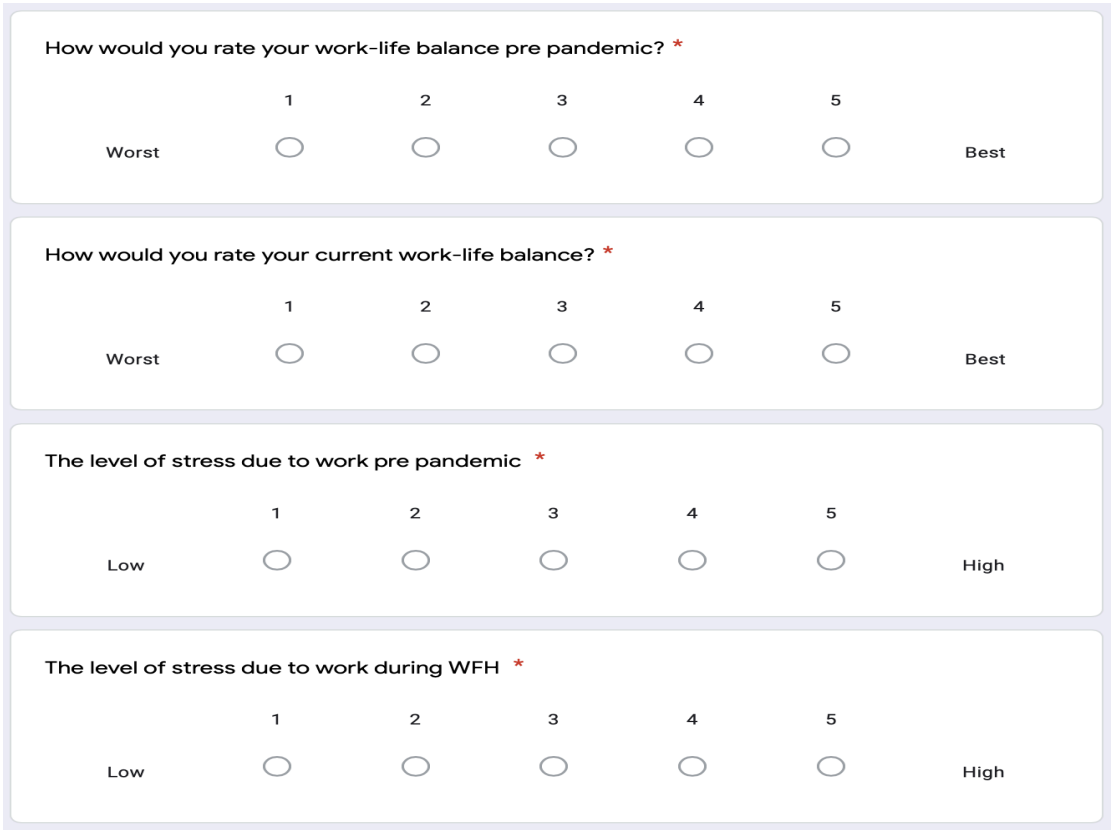


Fig. Sample of questions

Data Head

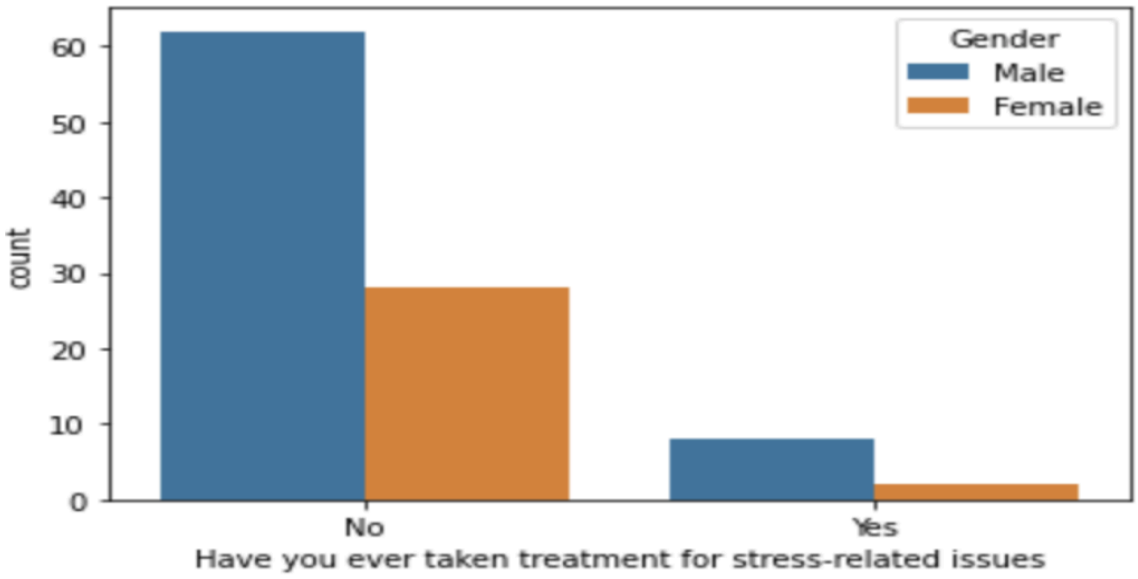
Gender	Age	Your highest educational qualification	Your Marital status	Do you have kids	Did you face any problem while WFH because of kids	Compare to pre pandemic do you now get more time to spend with your family	Do you feel your bond has become stronger with your partner during WFH	...	How do you feel about your mental well-being during WFH	How would you rate your work-life balance pre pandemic?	How would you rate your current work-life balance?	The level of stress due to work pre pandemic	The level of stress due to work during WFH	Have you been stressed out about deadlines during the WFH scenario.	Select the anxiety symptoms you have
Male	24	Graduation	Single	No	No	Yes	Yes	...	2	5	2	2	4	Yes	Feeling nervous;Restless or tense
Male	25	Graduation	Single	No	No	Yes	I'm single	...	3	3	3	3	3	No	Feeling nervous;Restless or tense;Sweating;Bre...
Male	32	Masters/Post Graduation	Married	Yes	No	No	Yes	...	3	4	2	3	5	Yes	No
Female	24	Masters/Post Graduation	Single	No	No	Yes	Yes	...	3	3	3	3	4	Yes	Feeling nervous;Sweating
Female	27	Graduation	Married	No	No	Yes	Yes	...	5	3	4	5	2	No	na

Sample of Dataset

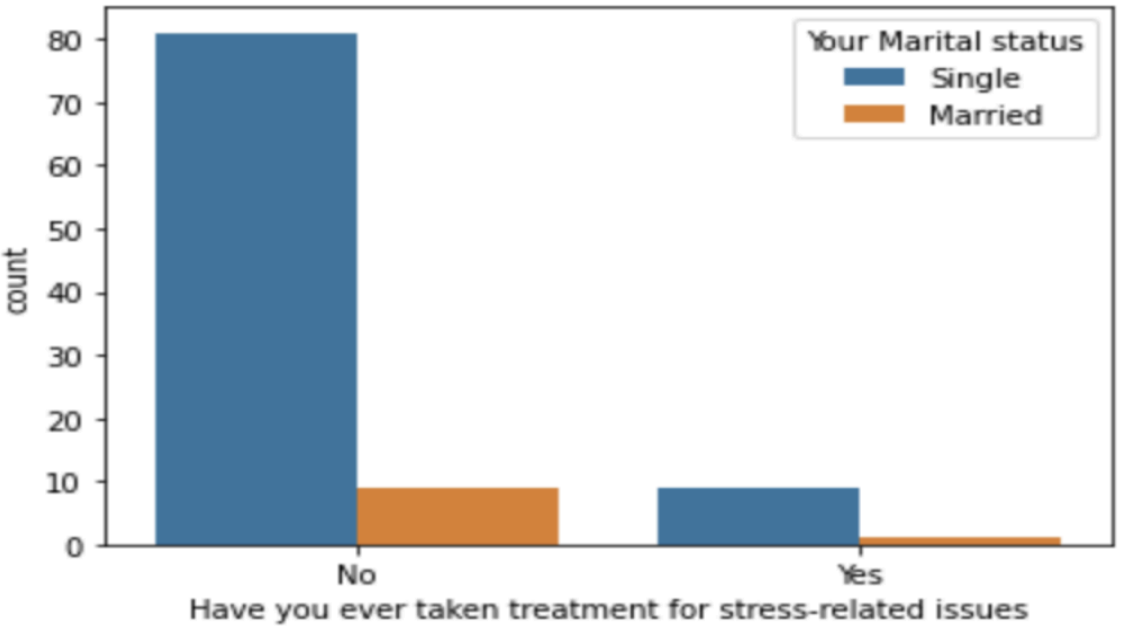
Data Cleaning

A specific model is required as after discarding the irrelevant feature, a total of 15 parameters were taken into consideration as per the requirements of the feature being relevant for conducting the further procedures in the research. For the data to be suitable enough for visualizing, the records with duplicate value or value as NA were dropped from the dataset. [2]

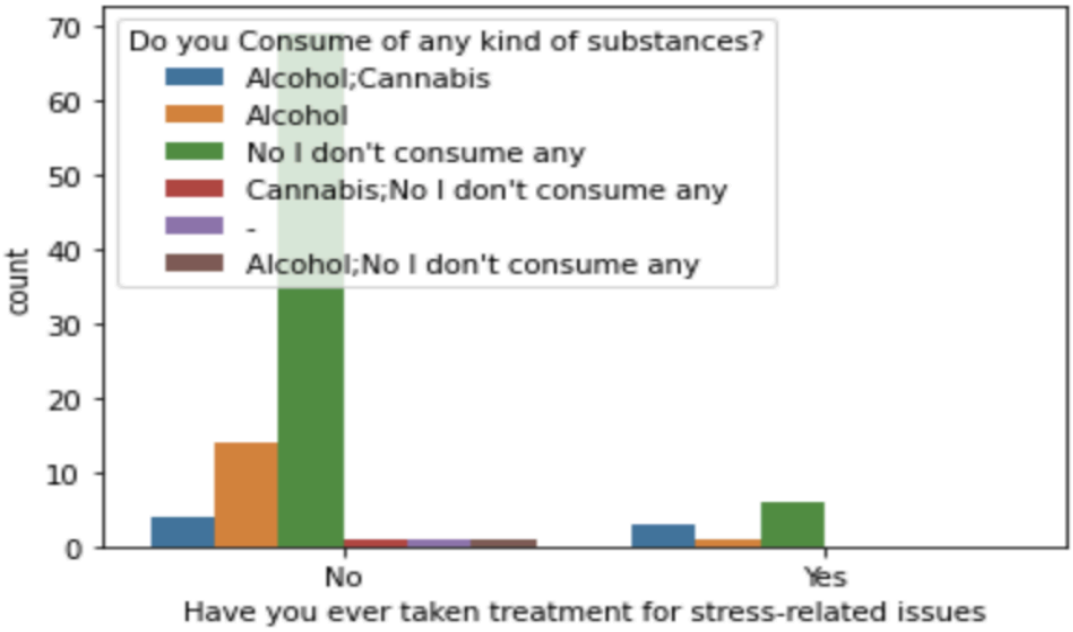
Data Visualization



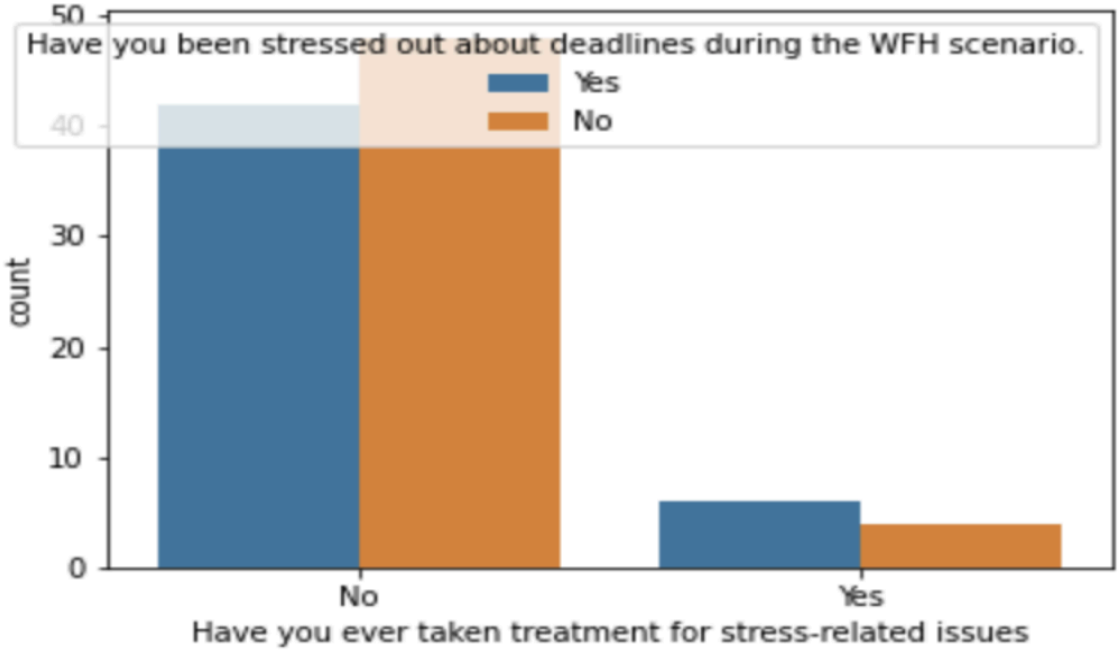
Bar graph showing gender wise past stress-related treatment



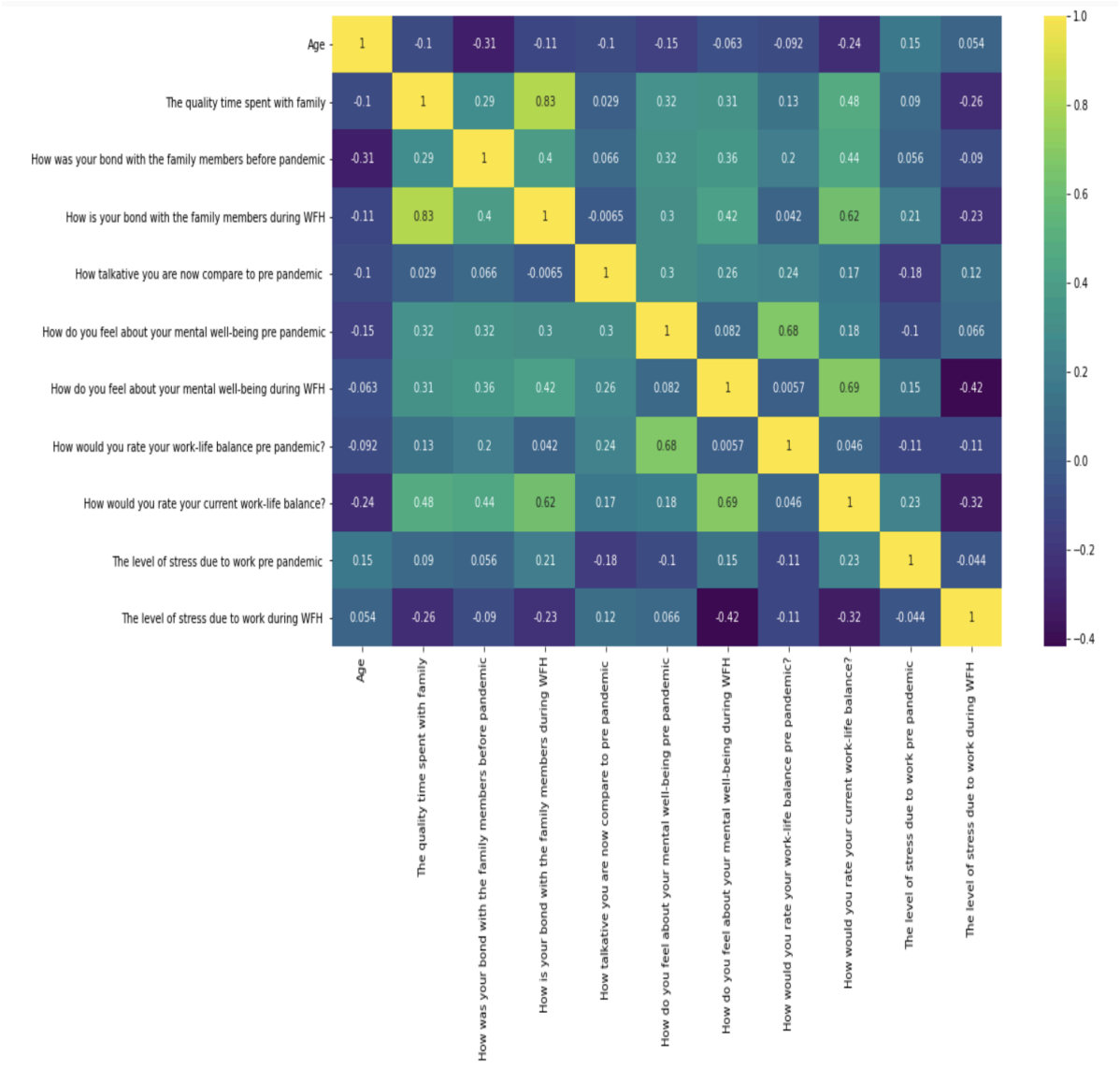
Bar graph showing past stress-related treatment with respect to the marital status



Bar graph showing consumption of additive substances and past stress-related treatment



Bar graph showing stressed out level and past stress-related treatment



SNS Heatmap

Feature Selection

For the complexity of the model prediction to be reduced, features of most relevance for the process are to be selected which is achieved by the process of feature selection

- Among a total of 43 features that constitute the questions framed for the data collection 14 of them found to be of most relevance that serve the purpose of forming the set of independent variables.
- The model after training predicts the dependent variable which is encoded as such that the value depicts the possibility of a person being stressed out or not.

Below table shows the 15 relevant feature considerd.

Feature Description

Description
Age
Gender
Your highest educational qualification
Marital status
Do you have kids?
Did you face any problem while WFH because of kids?
Compared to pre pandemic do you now get more time to spend with your family?
Rate the current work life balance.
Rate the work-life balance during WFH.
Level of stress due to work pre pandemic.
Level of stress due to work during WFH.
Have you been stressed out about deadlines during the WFH scenario?
Currently are you working from home(WFH)?
Are you willing to WFH permanently?
Are you in stress or have you ever taken treatment for stress-related issues?

Splitting Data:

- For running the models on the preprocessed data the data has to be splitted into two sets where the 1st set is used for training the model and other one for the tests to provide the prediction.
- The training data set constitutes 80% of the ratio for data split.
- The testing data set constitutes 20% of the ratio for data split for testing of the model trained and predicting the result.

```
In [81]: from sklearn.model_selection import train_test_split

In [82]: X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.3, random_state=1)
```

Multiple ways to scale.

- Standard Scaler (Standardization): Scale the feature by shifting the mean back to 0 and variance 1, with the use of this way we only shift the mean value to 0 and keep the distribution the same. Furthermore, this way can preserve the outliers in case they can contribute additional information to the problem.
- Min-max Scaler (Normalization): In this we, scales the range of values to between 0 and 1 and also eliminate the outliers.

The train-test split can be thought of as a method for calculating the machine learning algorithm's performance. It can be utilized for classification or regression issues, implying that it can be used for any supervised learning algorithm. The method entails partitioning a dataset into two subsets, the first of which is used to fit the model and is referred to as the training dataset. Instead of using the second of the two subsets to train the model, the input element of the dataset is supplied to the model, predictions are produced, and then the predicted outcome is compared. The test dataset is the second dataset in this collection.

- Trained Dataset is used to fit the machine learning model.
- The fit machine learning model is calculated using the test dataset.

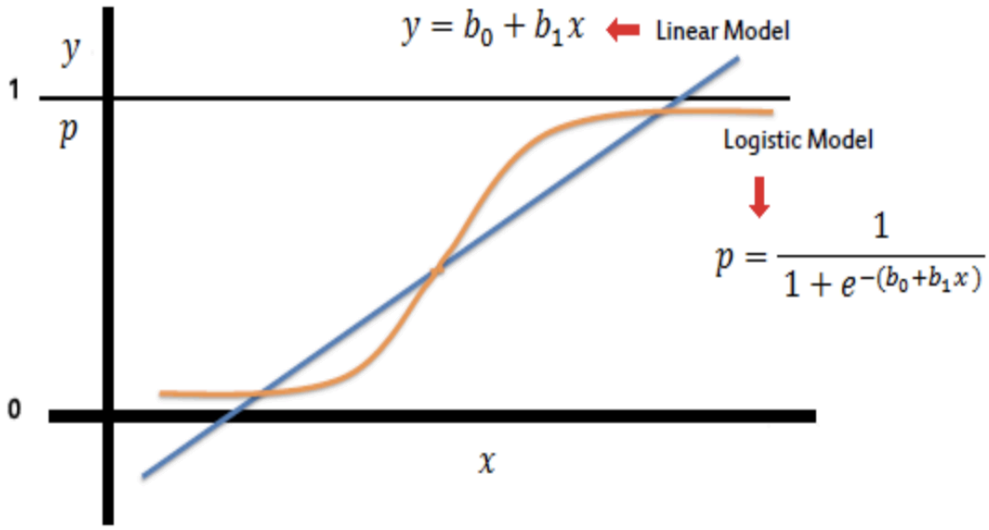
The goal here is to assess the Machine Learning model's performance on new data that was not used to train the model. This is how the model will be used in practice. To put it another way, fit it to existing data with known inputs and outcomes, then generate predictions for fresh cases in the near future where we don't have the expected output or goal outcome. When a sufficiently big dataset is available, the train-test procedure is considered acceptable.

MACHINE LEARNING TECHNIQUES USED

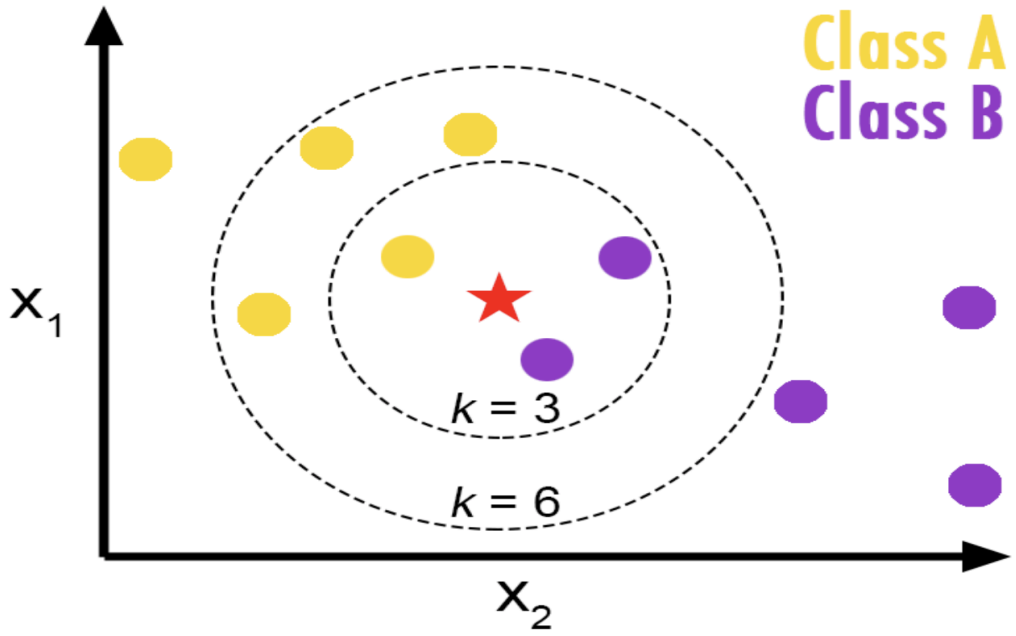
For a specific problem to get the interesting facts out of it without executing customized codes for the same Machine Learning is a robust topic with the concept of giving generic algorithms to do so. The need for writing the customized code for each individual problem becomes obsolete after the conceptualization of Machine Learning that gives the idea of algorithms that are generic and just needs the data to be feeded. For the underlying patterns which are of great value for making complex decisions, Machine Learning provides generic algorithmic techniques for the purpose automatically which the general code writing practice struggles to discover.

All the hidden knowledge and particular patterns regarding a problem have been useful for prediction of futuristic events and performance for all the kinds of too complex and more hardcore decision making. Machine Learning is mostly based on basis of development and research of computing powerful programs that can more precisely retrieve data and also with it learn throughout. It is very effective in different domains which are included in healthcare as there is large amount of data which has been properly fed to the intelligent system and which has been trained and learned accordingly, the result in prediction model will also have been never a perfect match and also which is freely available from human errors and also which can be reduced to the more accurate time required for particular diagnostics. As a result, all of the replies gathered from various websites, forums, articles, and a Google form were utilized to train the following Machine Learning models that have previously been evaluated in the healthcare area for various classification challenges.[3][4]

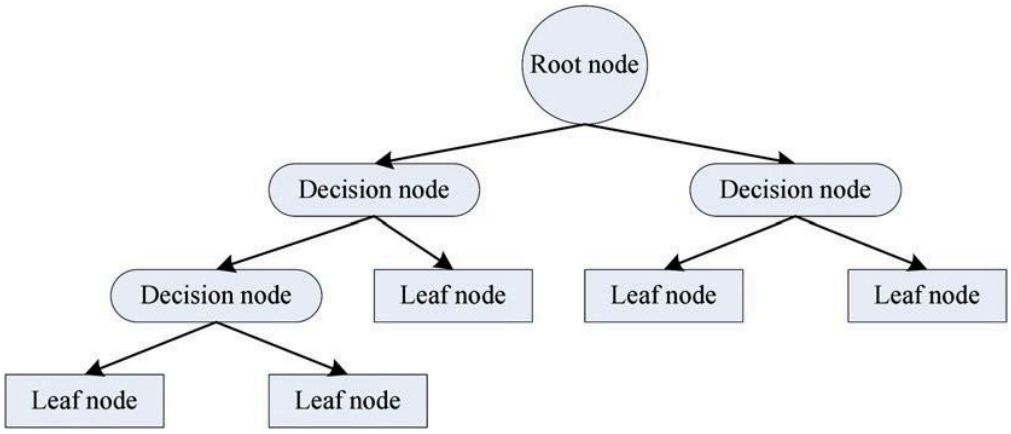
A. **Logistic Regression:**In comparison to all regression models, logistic regression is considered a predictive analysis. Logistic regression is employed when one binary variable is dependent on one or more independent variables. As a result, we consider fourteen pertinent indicators to be independent variables, with the possibility of an individual IT professional experiencing stress-related issues and requiring treatment as the dependent variable, which the trained model will predict.



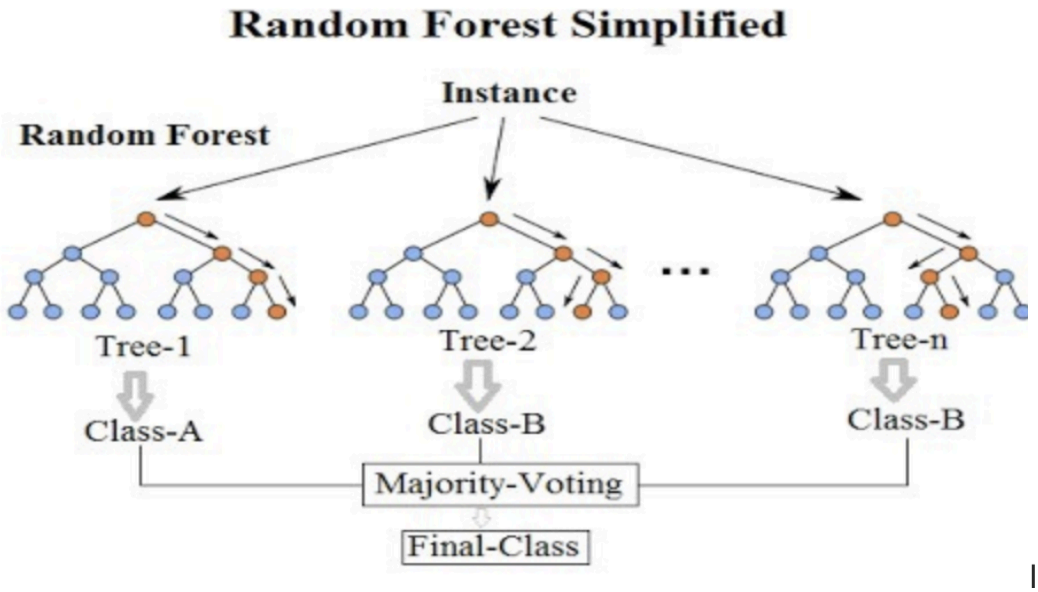
B. KNN Classifier: KNN(KNearest Neighbor) as classified as one type of Supervised Learning algorithm and it can be implemented based on particular labeled data. It has been useful while predicting if a particular person is in an emergency need of treatment or not. KNN is classified on the basis of dependent variables, which is totally a basis of how similar variables which are independent are for a similar instance which is from the data which is has been previously known.



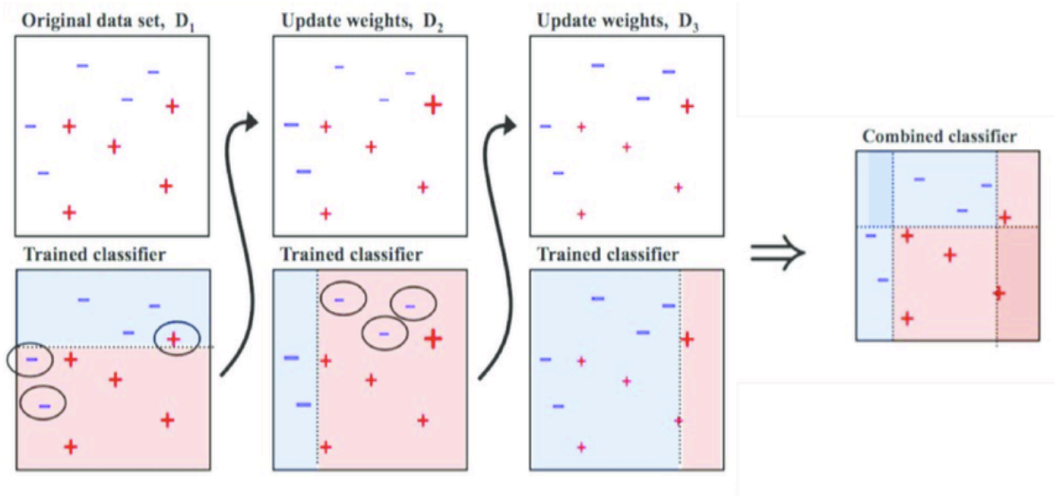
C. **Decision Trees:** A decision tree is a tree where each node represents an attribute, each branch represents a rule, each leaf represents a categorical or continuous value. Therefore, all of them are Decision Trees which are useful for finding out the factors which are contributing among the several 14 features which were useful. It has been very helpful, as most of the attention has been given to particular areas which are required steps which are particularly taken on such lines.



D. Random Forest Classification: The Random Forest mostly contains of clusters with decision trees having cohesion with particularly each other and it's been proven that it is of higher effectiveness than only a single decision tree. Random Forest is mostly flexible and also it is easy to used in Machine Learnig algorithm which is produced as a good result all over persistently, and also it is even without the need of any kind of the hyper tuning.

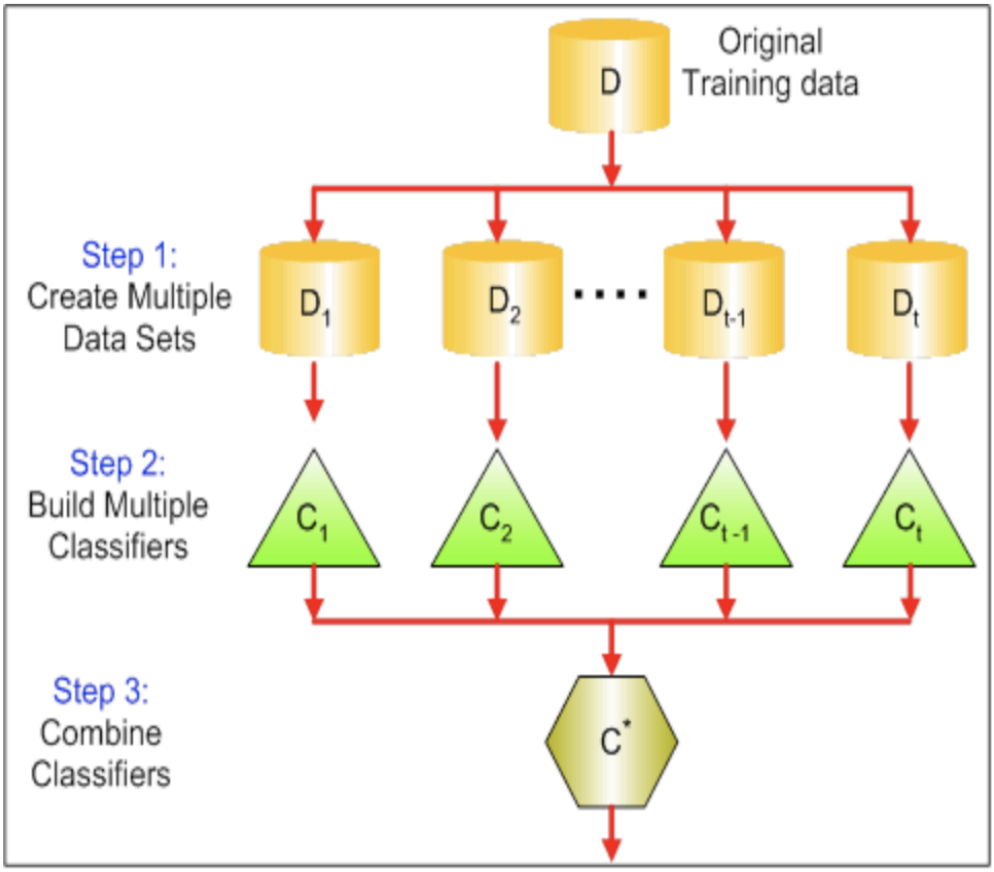


E. Boosting: Here with huge effort different also ensembled methods has been implemented which is augmenting the performance of already existing models. Boosting is also said to be one of the most effective and most commonly used as an ensemble classifier. The most important motive which is for boosting can also be said to reduce biases in the model. The ideology which are in regards to boosting the algorithms is to learn all the weak classifiers which can only slightly correlate with all the true classification here, also they can combine them into proper very strong classifiers that are well-correlated with the true classification.



Working of boosting

F. Bagging- Bagging is one of the most important techniques which is also called bootstrap aggregating which sits over the majority of the most voting principle. These types of samples are bootstrapped with every time and also when the model is trained in a particular domain. All the samples which are chosen, all of them are used and trained to validate the perfect predictions. All samples which are then replaced and again back into particular training set. These samples are basically chosen at random. It entails training and fine-tuning a model while applying the same technique on all various subsets of diverse data from across the dataset. This not only helps to improve the model's overall stability and accuracy, but it also helps to reduce the model's variance.

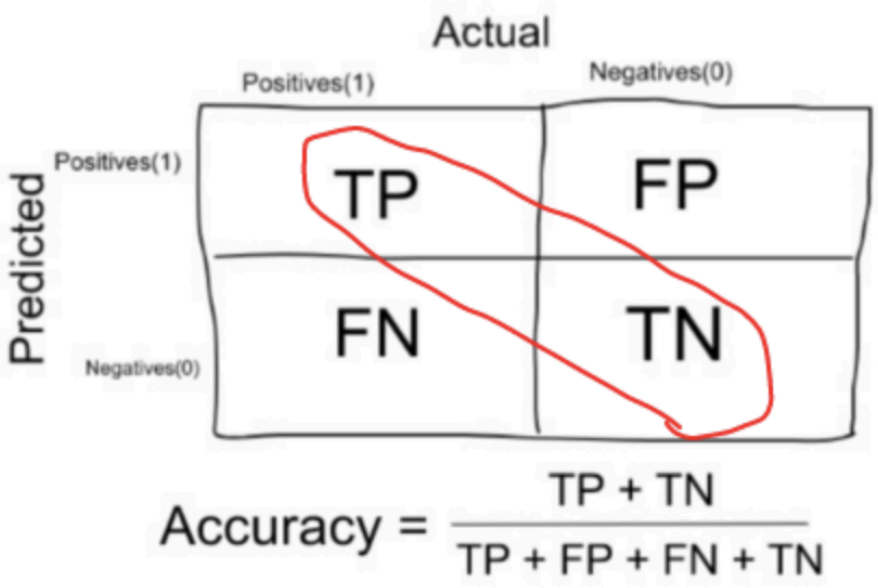


Working of bagging

PERFORMANCE METRICS

For different types of trained models which are used for an evaluation of an accuracy are as follows:

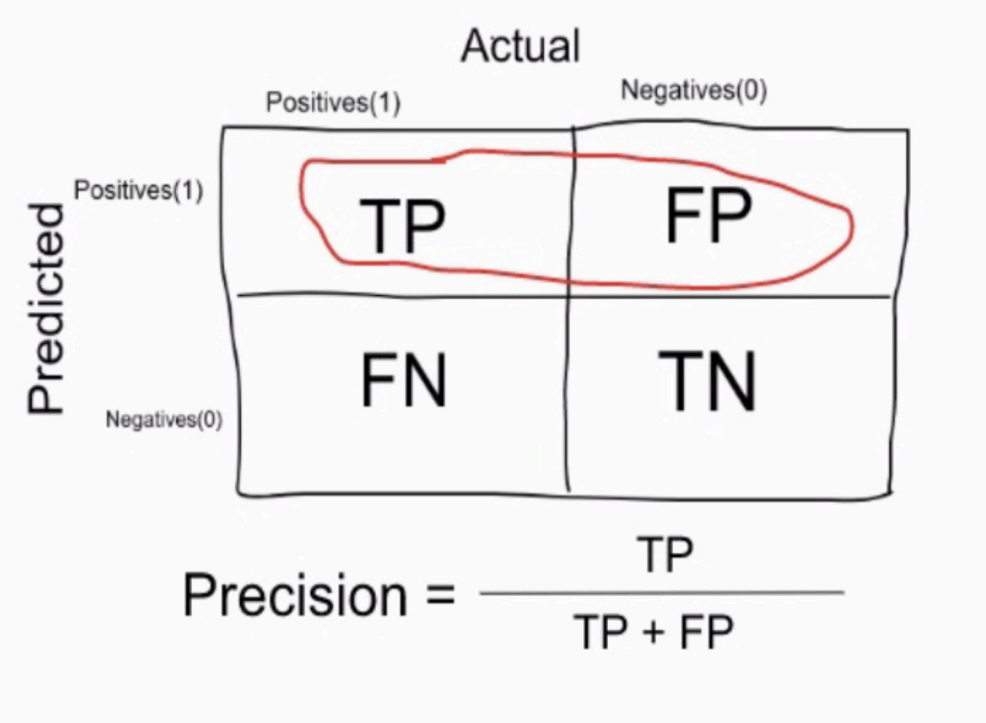
A. **Classification Accuracy:** This factor is said to be a measure which is concerned with all the effectiveness related to classification models. All the classification related accuracy is the percentage(%) of a way to successful prediction which is one of all the predictions made. Hence classification accuracy can also be useful as a rank to measure performance among all of the different models.



Accuracy

B. **False Positive Rate:** It is basically a measure based on how much amount of instances the model classified a negative event as positive. In our current scenario, it would mean that the model classifies a person as needing help, to cope up with stress and mental health related issues although the person in question here feels perfectly alright. Hence we can see that lower the false positive rate, better the model.

C. **Precision:** Precision on a larger scale When it comes to Data Mining, it is defined as a measure of a certain fraction of positive predictions that are actually positive. For example, if an employee is dealing with stress and requires treatment, the model identifies the comparable one. Furthermore, greater precision indicates that the model is performing well in identifying all persons who require treatment.



Precision

D. **AUC Score:** Area Under the Curve which is abbreviated as AUC. It is useful in particular analysis criteria, to measure the performance of different models to determine which model predicts the classes best. Receiver Operating Characteristics (ROCs) is considered a part of AUC and it is here the plot of the true positive rate with the false positive rate. Area under a ROC curve signifies how well the model can predict a positive classification correctly.

E. **Cross-validated AUC:** A factor which is a major aspect for the formation having a prediction model to ensure mainly about the stability. To do so, the Cross-validation approach is used, in which a model uses a portion of the training samples as test data and then fits our model to the outcome.

RESULT AND DISCUSSION

Machine learning models have been constructed using Python and Scikit-learn [5] for validating all predictions and identifying whether or not a person requires therapy. The following is how all of the findings are appropriately visualized and tabulated:

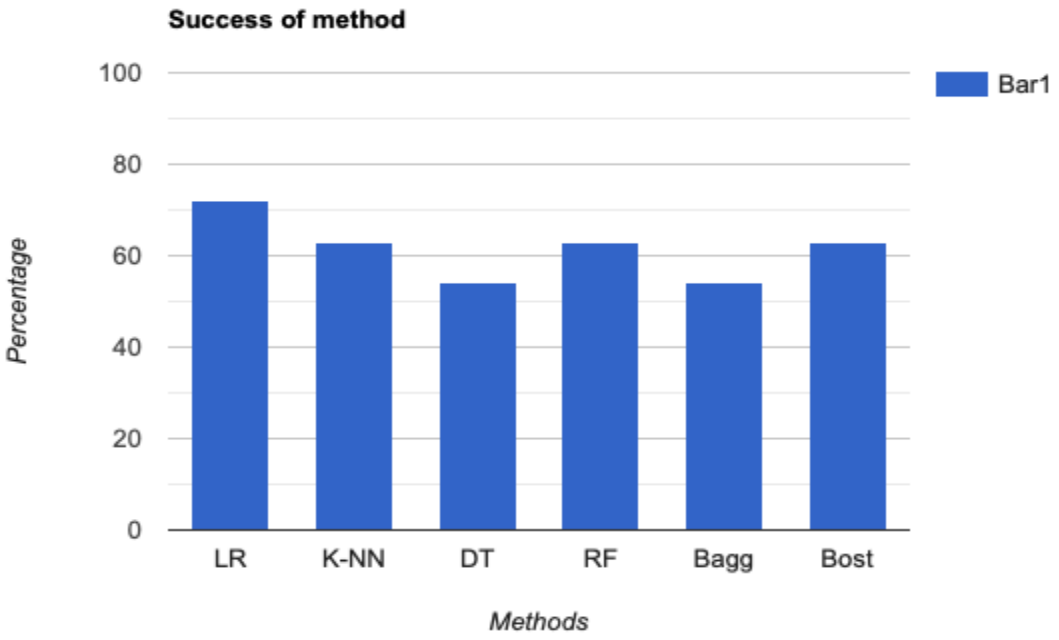


Figure 1

In Figure 1, we can see that all of the trained models performed well in classification when using Logistic Regression, with the maximum accuracy of 72 % and the lowest accuracy of 54 % for bagging and decision tree.

14 attributes were considered while making use of decision tree, it was noticed while performing it that when gender is having the highest influence related to stress as well as mental health which was among all the selected parameters. Which was reflected on the observations that the women which are generally found with highest mental stress as compared to men. This in turn have been directly in supports with the discovery of 2010 paper published by American Psychological Association which as has been mostly focused on all the correlation which is between the gender and the stress.[6]

All the performance here having various trained models was tabulated with proper evaluation Table1. In terms of precision, accuracy, and false positive rate, this model, which was trained using several Machine Learning techniques and from all of them, logistic regression fared considerably better than all of the other models. As a result, all of the Cross-Validation related to AUC score, Random Forest classifier and KNN classifier all have high scores, indicating that all of these models are more stable than the others. The KNN, as well as the Random Forest classifier and the Boosting score, all share the same classification accuracy, but Random Forest surpasses all of the previous models in other parameters.

Method	Classification Accuracy	False Positive Rate	Precision	Cross Validation AUC
Logistic Regression	0.72	0.87	0.78	0.54
K-NN	0.63	0.85	0.75	0.68
Decision Tree	0.55	0.83	0.71	0.62
Random Forest	0.63	0.85	0.75	0.68
Bagging	0.54	0.83	0.73	0.51
Boosting	0.63	0.81	0.75	0.51

Table 1

CONCLUSION

While working on all this predictions models and also by comparing their performance we finally conclude this thesis as the Work From Home concept for IT professionals is proven to be a huge stress reliever as compared to IT professionals working in a company. Also different factors like being with family and working under the same roof whole day has increased the efficiency of IT professionals. The outcome of the experiments and analysis done in this research conducted for thesis conclude that the productivity of the IT professionals has increased in the Work From Home culture due to presence of a supportive environment and the absence of peer pressure in the organizational premises.

Gender, marital status, and an employer who provides mental health benefits to all of their working workers are all more important than other employers who are chosen based on other factors to determine if a person would develop mental health concerns in the future.

In this thesis we have compared the accuracy of different models and found that the accuracy of the Logistic regression model was much better in the prediction of the stress level amongst the IT professionals. We feed data to the model using the questionnaire based approach.

In this study, it has been found that all the people who are working for tech companies most probably have a slightly higher risk of developing stress even it is not dealing with technology . These insights have been very effectively used by different corporations to have a frame which is better to have the HR policies related to their employees.

Also, ensemble methods which are widely used like the Logistic Regression which is produced with the highest Classification accuracy with precision following the Random Forest. A 72.72% accuracy score here also signifies that the application of Machine Learning techniques useful to deal with prediction of stress and mental health conditions has given mostly remarkable results which can be researched further which meets the final result and also the objective taken for this thesis.

Future Work

The problem discussed in this thesis is an open ended problem which deals with the issues that have more dimensions to explore which gives a space for improvement in the current work. Collection of data with more varied parameters is to be done and more complex algorithms like Naive Bayes, Gradient Descent and C-NN can be implemented. In future we may add more detailed descriptions and try to figure out the root causes of a person having stress. In future customization of the survey which is taken in order to achieve the responses in the right format and also there will be an urge and always a challenge to increase the no of attributes to predict the mental stress among IT professionals.

Appendix

This section of the thesis deals with the codes used for the implementation of the work done in the thesis:

1. Libraries used:

```
import pandas as pd
import numpy as np
import seaborn as sns
import matplotlib.pyplot as plt
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import seaborn as sns
import plotly.express as px
import plotly.graph_objects as go
from sklearn import preprocessing
from category_encoders import *
from sklearn.preprocessing import LabelEncoder
%matplotlib inline
from sklearn.neighbors import KNeighborsClassifier
from sklearn.metrics import f1_score
from sklearn.tree import DecisionTreeClassifier
from sklearn.ensemble import AdaBoostClassifier
from sklearn.model_selection import cross_val_score
from sklearn.tree import DecisionTreeClassifier
from sklearn import datasets
from sklearn.model_selection import train_test_split
from sklearn.model_selection import cross_val_score
from sklearn.preprocessing import StandardScaler
from sklearn.preprocessing import PolynomialFeatures
from sklearn.linear_model import LinearRegression
from sklearn.metrics import r2_score,mean_squared_error
from sklearn import datasets, linear_model, metrics
from sklearn.metrics import  confusion_matrix
```

2. Splitting data:

```
In [81]: from sklearn.model_selection import train_test_split

In [82]: X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.3, random_state=1)
```

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