15-12-2021

Desharnais Software Cost Estimation using Machine Learning Algorithms

Software Project Management
SWE3002

Submitted By
Amit Kumar Sahu
18MIS7250

Contents

Abstract

Making decisions with a highly uncertain level is a critical problem in the area of software engineering. Predicting software quality requires high accurate tools and high-level experience. Otherwise, AI-based predictive models could be a useful tool with an accurate degree that helps in the prediction of software effort based on historical data from software development metrics. In this study, we built a software effort estimation model to predict this effort using a linear regression model. This statistical model was developed using a non-parametric linear regression algorithm based on the K-Nearest Neighbours (KNN). So, our results show the possibility of using AI methods to predict the software engineering effort prediction problem with an coefficient of determination of 76%.

Introduction

Effort estimation is the process of forecasting how much effort is required to develop or maintain a software application. This effort is traditionally measured in the hours worked by a person, or the money needed to pay for this work.

Effort estimation is used to help draft project plans and budgets in the early stages of the software development life cycle. This practice enables a project manager or product owner to accurately predict costs and allocate resources accordingly.

Effort estimation is vital to the software development process as it helps teams to ensure a product is developed and delivered on time. For product owners specifically, effort estimation enables them to manage resources.With the help of machine learning algorithms we can make better decisions with the help of real time data and estimate the effort efficiently.

Background Study

Software cost and effort estimation is truly a very important and elaborate, however a necessary task in the software development procedures. During the last 3 decades, an increasing tendency has been seen in utilizing a number of software estimation techniques in numerous computer companies. In addition to this enormous progress, it is usually made real the essentiality of most such techniques of estimation the software efforts and also making plans quicker or simply in the estimated situations. However lots of investigation hours, or funds has been spent in enhancing precision of the different estimation products, because of the natural risk in software development efforts similar to elaborate and changing communication aspects, inherent software sophistication, stress on standardization and also insufficient software information, it will be not realistic to calculate quite a precise effort estimation of software .

The precision of the specific models chooses their usability in the planned areas, while the accuracy may be described as driven by knowing the calibration of the software information. Because the accuracy and credibility of the software effort estimation is critical to the competitiveness of computer organizations, the analysts have put their fullest energy to create the correct models for estimated cost close to true wrongs. There are a lot of techniques have already been suggested that will be classified based upon their core composition strategies; analogy based estimation , estimation by expert, rule induction techniques , algorithmic techniques with empirical strategies, artificial neural network designed methods , decision tree based strategies , Bayesian network techniques and fuzzy logic based estimation structures . Cost and Effort are tightly relevant, these are not always connected by an easy conversion operation.

The effort is usually calculated in person-months of the managers, analysts and also programmers and so on. Choosing a model while the ideal appears to be not possible due to the fact the efficiency of every model relies on numerous aspects like accessible data, development methods, project characteristics etc. Thus, estimates of software metrics might be more complex versus various other things.

Objective

Predicting the most realistic amount of effort (expressed in terms of person-hours or money) required to develop or maintain software based on incomplete, uncertain and noisy input. Here we are taking the Desharnais dataset.

```
import pandas as pd
df = pd.read_csv('Desharnais.csv',  header=0)
df.head()
```

	id	Project	TeamExp	ManagerExp	YearEnd	Length	Effort	Transactions	Entities	PointsNonAdjust	Adjustment	PointsAjust	Language
0	1	1	1	4	85	12	5152	253	52	305	34	302	1
1	2	2	0	0	86	4	5635	197	124	321	33	315	1
2	3	3	4	4	85	1	805	40	60	100	18	83	1
3	4	4	0	0	86	5	3829	200	119	319	30	303	1
4	5	5	0	0	86	4	2149	140	94	234	24	208	1

Methodology

We are using the following concepts and algorithms for this project:

1. ## Pearson Correlation

   The correlations between attributes of Desharnais dataset and software effort are analyzed and applicability of the regression analysis is examined. The correlation between two variables is a measure of how well the variables are related. The most common measure of correlation in statistics is the Pearson Correlation (or the Pearson Product Moment Correlation - PPMC) which shows the linear relationship between two variables.

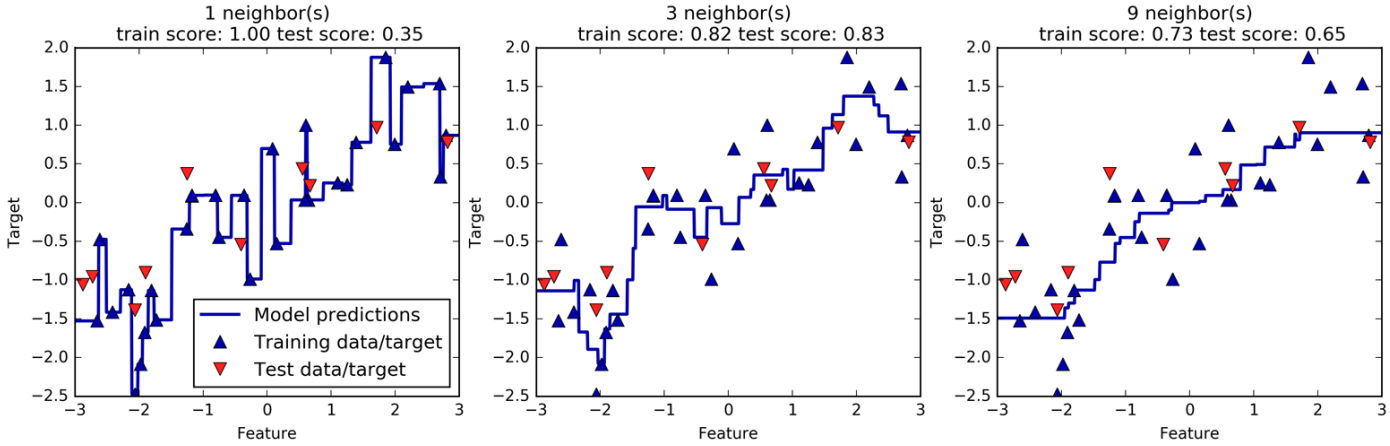
   Pearson correlation coefficient analysis produces a result between -1 and A result of -1 means that there is a perfect negative correlation between the two values at all, while a result of 1 means that there is a perfect positive correlation between the two variables.

   Results between 0.5 and 1.0 indicate high correlation.Correlation coefficients are used in statistics to measure how strong a relationship is between two variables. There are several types of correlation coefficient. Pearson’s correlation (also called Pearson’s R) is a correlation coefficient commonly used in linear regression.

In this study the following algorithms were used: Linear Regression and K-Nearest Neighbors Regression. The training of the regressors models were performed on 67% of the instances

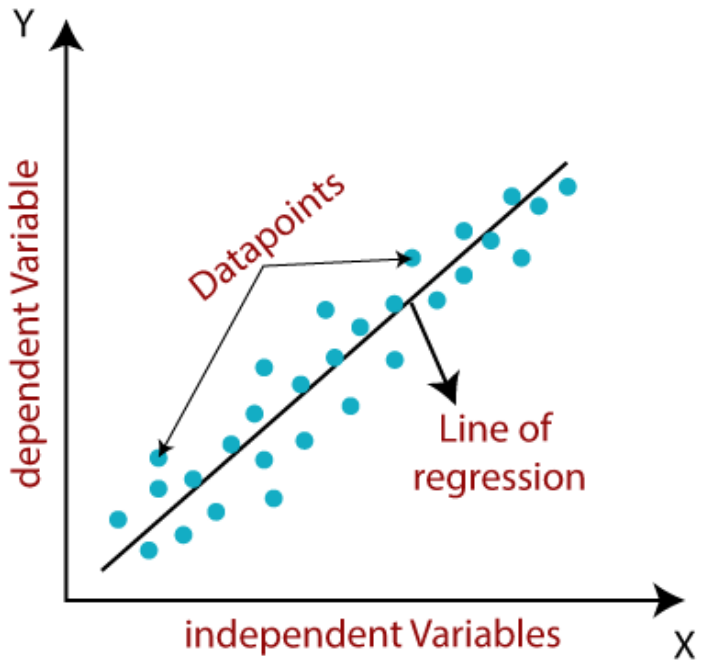
2. Knn Regression

The K-Nearest Neighbor Regression is a simple algorithm that stores all available cases and predict the numerical target based on a similarity measure and it's been used in a statistical estimation and pattern recognition as non-parametric technique classifying correctly unknown cases calculating euclidean distance between data points. In fact our choice by K-Nearest Neighbor Regression was motivated by the absence of a detailed explanation about how effort attribute value is calculated on Desharnais dataset. In the K-Nearest Neighbor Regression we choose to specify only 3 neighbors for k-neighbors queries and uniform weights, that means all points in each neighborhood are weighted equally. [Example Figure]



3. Linear Regression

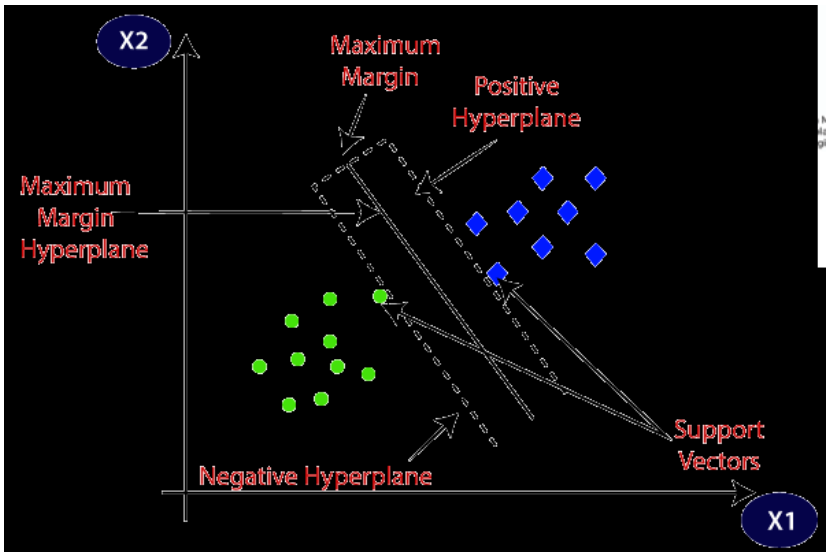
The regression analysis aims to verify the existence of a functional relationship between a variable with one or more variables, obtaining an equation that explains the variation of the dependent variable Y, by the variation of the levels of the independent variables. The training of the Linear Regression model consists of generating a regression for the target variable Y.



4. Support Vector Machine

The goal of the SVM algorithm is to create the best line or decision boundary that can segregate n-dimensional space into classes so that we can easily put the new data point in the correct category in the future. This best decision boundary is called a hyperplane.

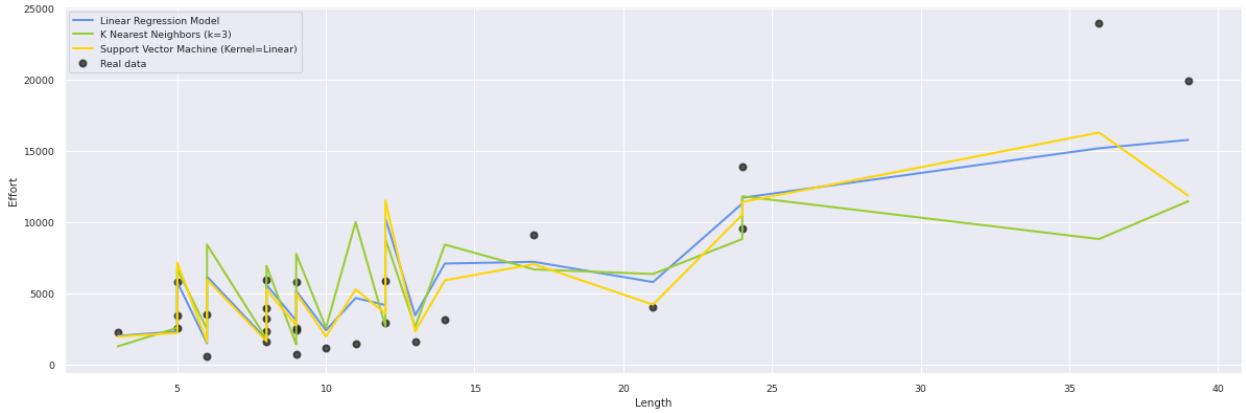
SVM chooses the extreme points/vectors that help in creating the hyperplane. These extreme cases are called as support vectors, and hence algorithm is termed as Support Vector Machine. Consider the below diagram in which there are two different categories that are classified using a decision boundary or hyperplane:

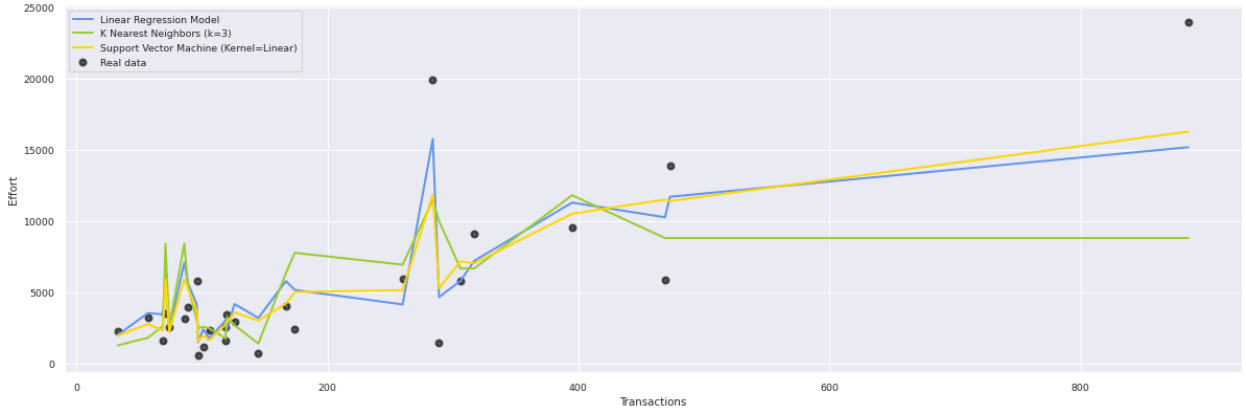


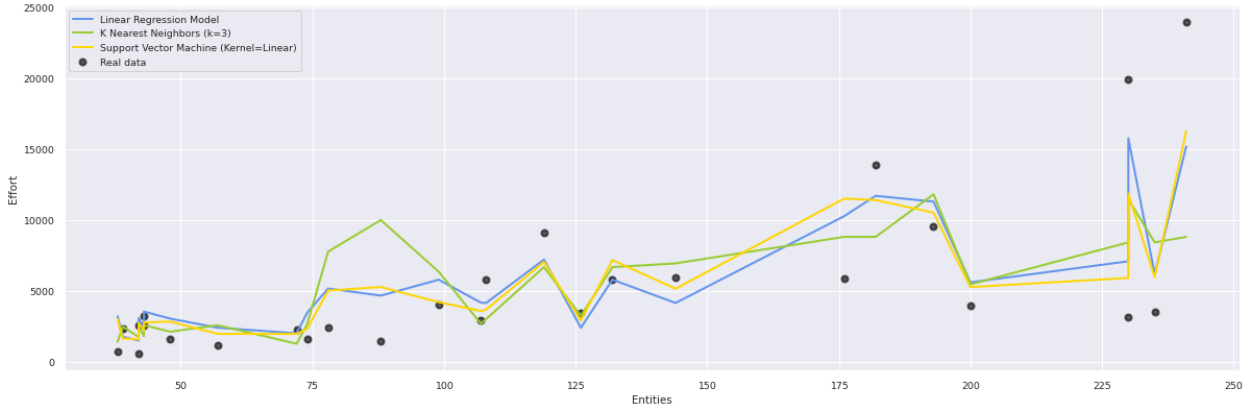
Results

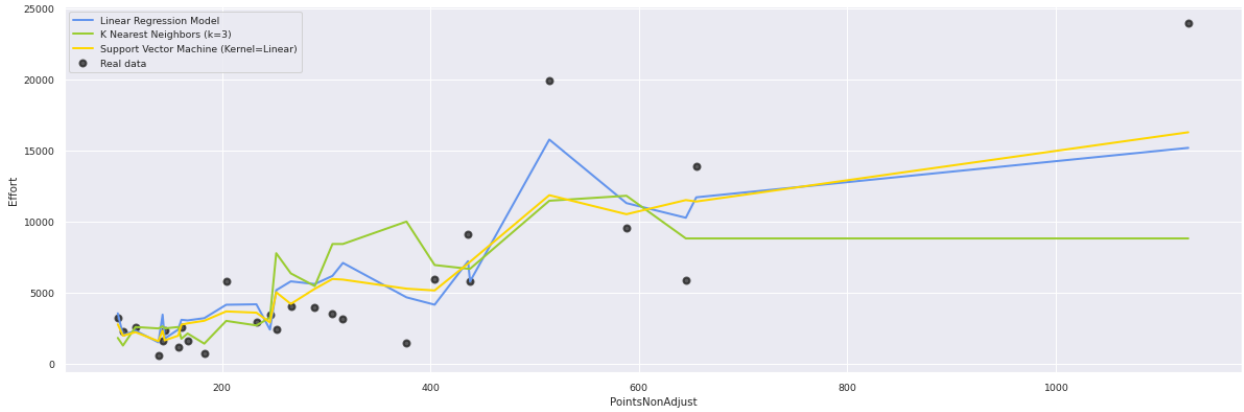
The figure shows the linear model (blue line) prediction is fairly close to Knn model effort prediction (red line), predicting the numerical target based on a similarity measure. According to the plot we observe that Linear Regression model (blue line) presents a

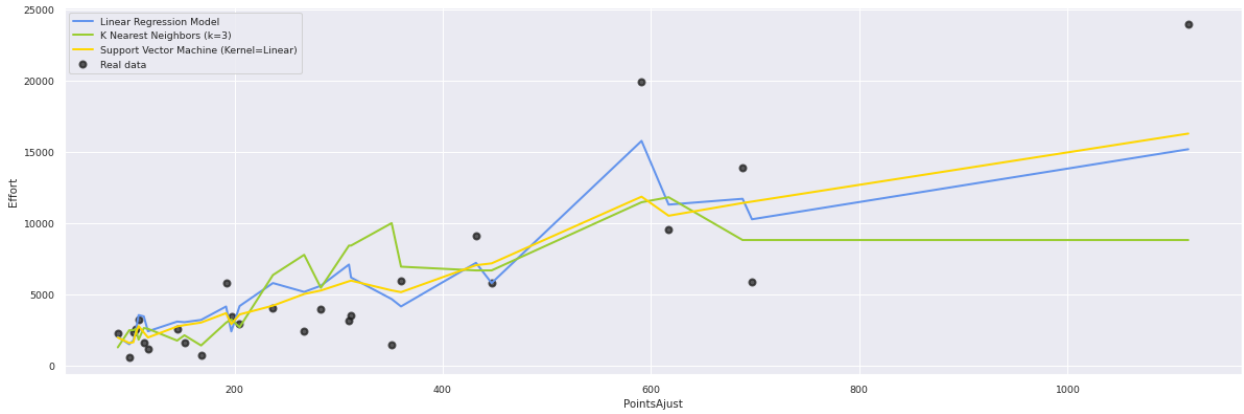
better performance. Although Knn Regression model (red line) is fairly close to data points, the Linear Regression model shows a smaller mean squared error. It is possible to observe that the lines of both models present a slight tendency to rise, which justifies their correlation with the increase in effort. Some metrics are also highlighted by the presence of outliers.











Implementation Code

Code has been uploaded in my github repository

https://github.com/ammy20019/ML-stuff/blob/main/More%20ML%20Algorithms/Software%20Proj%20Mgt%20Project/Software_Effort_Estimation_SPM.ipynb

```
import math
from scipy.io import arff
from scipy.stats.stats import pearsonr
import pandas as pd
import numpy as np

from sklearn.linear_model import LinearRegression
from sklearn.neighbors import KNeighborsRegressor
from sklearn.model_selection import GridSearchCV
from sklearn.svm import SVR
from sklearn.model_selection import train_test_split
import seaborn as sns
import matplotlib.pyplot as plt
```

```
%matplotlib inline
plt.style.use('fivethirtyeight')
plt.rcParams['figure.figsize'] = (15,5)
```

```
import pandas as pd
df = pd.read_csv('Desharnais.csv',  header=0)
df.head()
```

	id	Project	TeamExp	ManagerExp	YearEnd	Length	Effort	Transactions	Entities	PointsNonAdjust	Adjustment	PointsAjust	Language
0	1	1	1	4	85	12	5152	253	52	305	34	302	1
1	2	2	0	0	86	4	5635	197	124	321	33	315	1
2	3	3	4	4	85	1	805	40	60	100	18	83	1
3	4	4	0	0	86	5	3829	200	119	319	30	303	1
4	5	5	0	0	86	4	2149	140	94	234	24	208	1

```
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 81 entries, 0 to 80
Data columns (total 13 columns):
 #   Column           Non-Null Count  Dtype
---  ------           --------------  -----
 0   id               81 non-null     int64
 1   Project          81 non-null     int64
 2   TeamExp          81 non-null     int64
 3   ManagerExp       81 non-null     int64
 4   YearEnd          81 non-null     int64
 5   Length           81 non-null     int64
 6   Effort           81 non-null     int64
 7   Transactions     81 non-null     int64
 8   Entities         81 non-null     int64
 9   PointsNonAdjust  81 non-null     int64
 10  Adjustment       81 non-null     int64
 11  PointsAjust      81 non-null     int64
 12  Language         81 non-null     int64
dtypes: int64(13)
memory usage: 8.4 KB
```

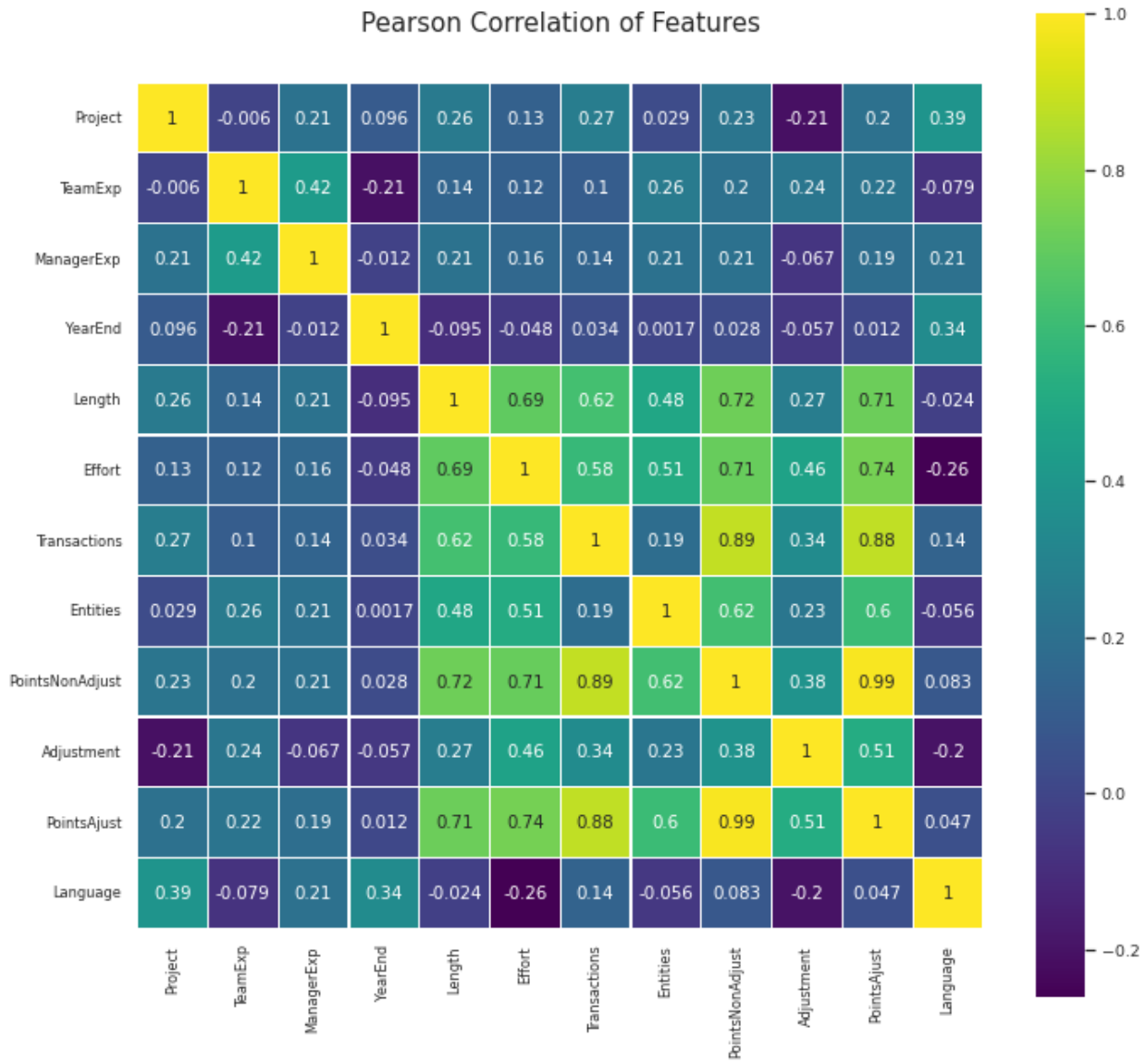
```
df.describe()
```

	id	Project	TeamExp	ManagerExp	YearEnd	Length	Effort	Transactions	Entities	PointsNonAdjust	Adjustment	PointsAjust	Language
count	81.000000	81.000000	81.000000	81.000000	81.000000	81.000000	81.000000	81.000000	81.000000	81.000000	81.000000	81.000000	81.000000
mean	41.000000	41.000000	2.185185	2.530864	85.740741	11.666667	5046.308642	182.123457	122.333333	304.456790	27.629630	289.234568	1.555556
std	23.526581	23.526581	1.415195	1.643825	1.222475	7.424621	4418.767228	144.035098	84.882124	180.210159	10.591795	185.761088	0.707107
min	1.000000	1.000000	-1.000000	-1.000000	82.000000	1.000000	546.000000	9.000000	7.000000	73.000000	5.000000	62.000000	1.000000
25%	21.000000	21.000000	1.000000	1.000000	85.000000	6.000000	2352.000000	88.000000	57.000000	176.000000	20.000000	152.000000	1.000000
50%	41.000000	41.000000	2.000000	3.000000	86.000000	10.000000	3647.000000	140.000000	99.000000	266.000000	28.000000	255.000000	1.000000
75%	61.000000	61.000000	4.000000	4.000000	87.000000	14.000000	5922.000000	224.000000	169.000000	384.000000	35.000000	351.000000	2.000000
max	81.000000	81.000000	4.000000	7.000000	88.000000	39.000000	23940.000000	886.000000	387.000000	1127.000000	52.000000	1116.000000	3.000000

```
df.corr()
```

	id	Project	TeamExp	ManagerExp	YearEnd	Length	Effort	Transactions	Entities	PointsNonAdjust	Adjustment	PointsAjust	Language
id	1.000000	1.000000	-0.006007	0.214294	0.096486	0.255187	0.126153	0.265891	0.028787	0.226076	-0.207774	0.202608	0.391475
Project	1.000000	1.000000	-0.006007	0.214294	0.096486	0.255187	0.126153	0.265891	0.028787	0.226076	-0.207774	0.202608	0.391475
TeamExp	-0.006007	-0.006007	1.000000	0.424687	-0.210335	0.143948	0.119529	0.103768	0.256608	0.203805	0.235629	0.222884	-0.079112
ManagerExp	0.214294	0.214294	0.424687	1.000000	-0.011519	0.211324	0.158303	0.138146	0.206644	0.207748	-0.066821	0.187399	0.205521
YearEnd	0.096486	0.096486	-0.210335	-0.011519	1.000000	-0.095027	-0.048367	0.034331	0.001686	0.028234	-0.056743	0.012106	0.342233
Length	0.255187	0.255187	0.143948	0.211324	-0.095027	1.000000	0.693280	0.620711	0.483504	0.723849	0.266086	0.714092	-0.023810
Effort	0.126153	0.126153	0.119529	0.158303	-0.048367	0.693280	1.000000	0.581881	0.510328	0.705449	0.463865	0.738271	-0.261942
Transactions	0.265891	0.265891	0.103768	0.138146	0.034331	0.620711	0.581881	1.000000	0.185041	0.886419	0.341906	0.880923	0.136778
Entities	0.028787	0.028787	0.256608	0.206644	0.001686	0.483504	0.510328	0.185041	1.000000	0.618913	0.234747	0.598401	-0.056439
PointsNonAdjust	0.226076	0.226076	0.203805	0.207748	0.028234	0.723849	0.705449	0.886419	0.618913	1.000000	0.383842	0.985945	0.082737
Adjustment	-0.207774	-0.207774	0.235629	-0.066821	-0.056743	0.266086	0.463865	0.341906	0.234747	0.383842	1.000000	0.513197	-0.199167
PointsAjust	0.202608	0.202608	0.222884	0.187399	0.012106	0.714092	0.738271	0.880923	0.598401	0.985945	0.513197	1.000000	0.046672
Language	0.391475	0.391475	-0.079112	0.205521	0.342233	-0.023810	-0.261942	0.136778	-0.056439	0.082737	-0.199167	0.046672	1.000000

```
colormap = plt.cm.viridis
plt.figure(figsize=(10,10))
plt.title('Pearson Correlation of Features', y=1.05, size=15)
sns.set(font_scale=0.85)
sns.heatmap(df.drop(['id'],
axis=1).astype(float).corr(),linewidths=0.1,vmax=1.0,
square=True,cmap=colormap, linecolor='white', annot=True)
```




```
features = [ 'TeamExp', 'ManagerExp', 'YearEnd', 'Length', 'Transactions',
'Entities','PointsNonAdjust', 'Adjustment', 'PointsAjust']

max_corr_features = ['Length', 'Transactions',
'Entities','PointsNonAdjust','PointsAjust']

X = df[max_corr_features]
y = df['Effort']
```

K Nearest Neighbor Model

```
#KNN
```

```
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.33,
random_state=30)

neigh = KNeighborsRegressor(n_neighbors=3, weights='uniform')
neigh.fit(X_train, y_train)
print(neigh.score(X_test, y_test))

0.7379861869550943
```

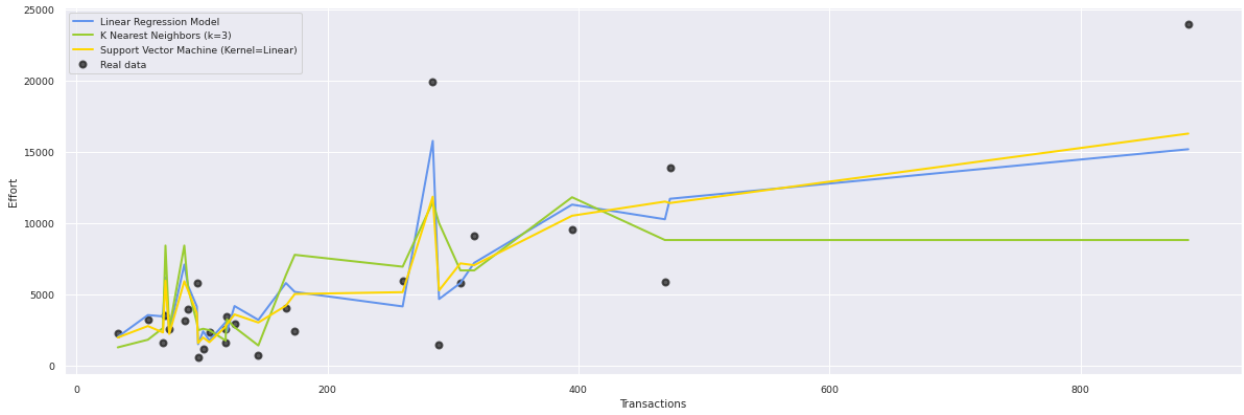
Linear Regression Model

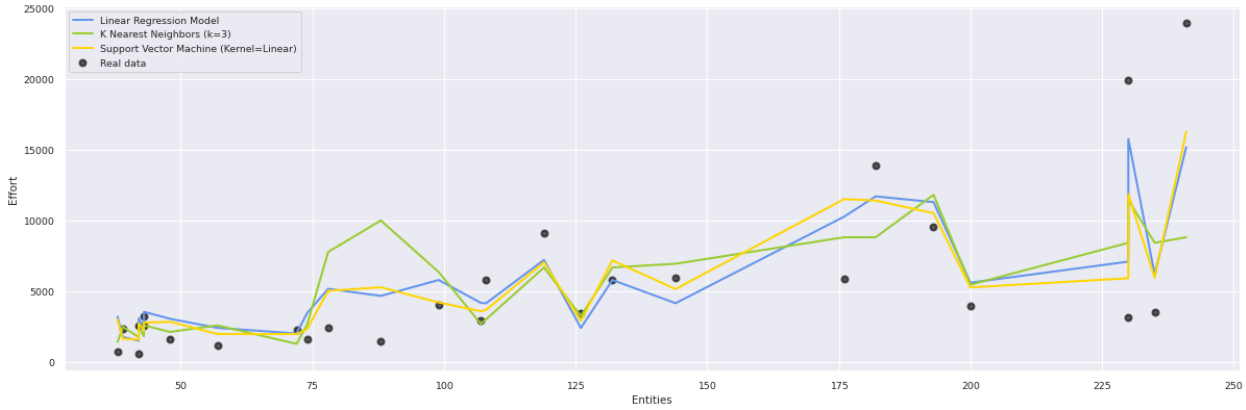
```
#Linear
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.33,
random_state=22)
model = LinearRegression()
model.fit(X_train, y_train)
print(model.score(X_test, y_test)

0.7680074954440715
```

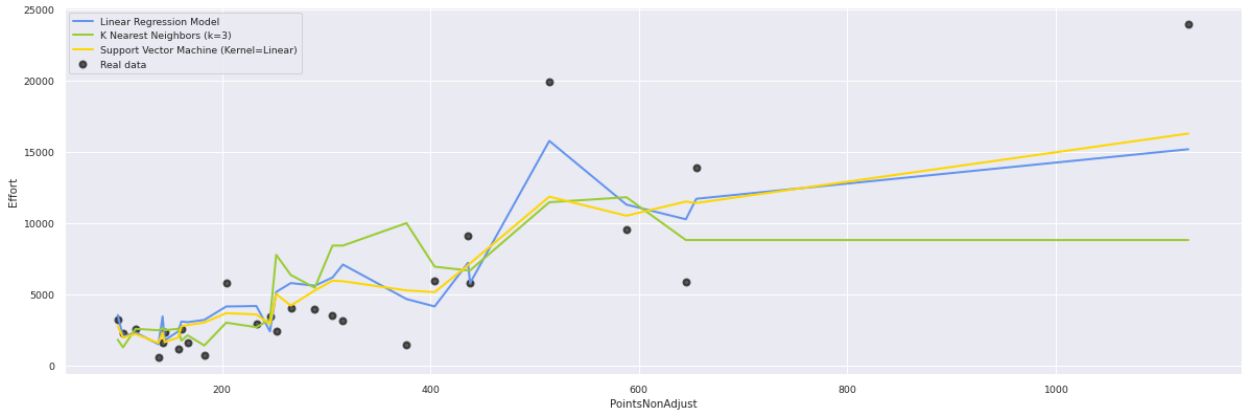
Support Vector Machine Model

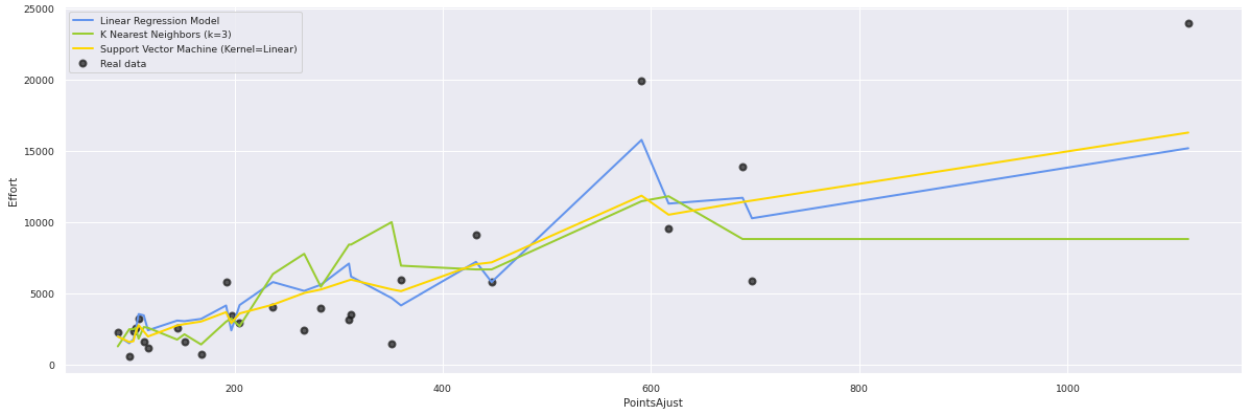
```
#SVM
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.33,
random_state=22)

parameters = {'kernel':('linear', 'rbf'), 'C':[1,2,3,4,5,6,7,8,9,10],
'gamma':('auto', 'scale')}

svr = SVR()
LinearSVC = GridSearchCV(svr, parameters, cv=3)
LinearSVC.fit(X_train, y_train)
print("Best params hash: {}".format(LinearSVC.best_params_))
print(LinearSVC.score(X_test, y_test))

Best params hash: {'C': 1, 'gamma': 'auto', 'kernel': 'linear'}
0.735919788126071
for i, feature in enumerate(max_corr_features):
    plt.figure(figsize=(18,6))

    # Knn Regression Model
```

```
    xs, ys = zip(*sorted(zip(X_test[feature], neigh.fit(X_train,
y_train).predict(X_test))))

    # Linear Regression Model
    model_xs, model_ys = zip(*sorted(zip(X_test[feature],
model.fit(X_train, y_train).predict(X_test))))

    # Support Vector Machine
    svc_model_xs, svc_model_ys = zip(*sorted(zip(X_test[feature],
LinearSVC.fit(X_train, y_train).predict(X_test))))

    plt.scatter(X_test[feature], y_test, label='Real data', lw=2,alpha=
0.7, c='k' )
    plt.plot(model_xs, model_ys , lw=2, label='Linear Regression Model',
c='cornflowerblue')
    plt.plot(xs, ys , lw=2,label='K Nearest Neighbors (k=3)',
c='yellowgreen')
    plt.plot(svc_model_xs, svc_model_ys , lw=2,label='Support Vector
Machine (Kernel=Linear)', c='gold')

    plt.xlabel(feature)
    plt.ylabel('Effort')
    plt.legend()
    plt.show()
```









References

https://www.researchgate.net/figure/Summary-of-variables-in-Desharnais-dataset_tbl1_225561017

http://promise.site.uottawa.ca/SERepository/datasets/desharnais.arff

15-12-2021

https://github.com/ammy20019/ML-stuff/blob/main/More%20ML%20Algorithms/Software%20Proj%20Mgt%20Project/Software_Effort_Estimation_SPM.ipynb