

# VISVESVARAYA TECHNOLOGICAL UNIVERSITY

JNANA SANGAMA, BELAGAVI – 590 018



**A Mini Project Report on**

## ***“MEDICAL EXPENDITURE PREDICTION SYSTEM”***

*Submitted in partial fulfillment of the requirements as a part of the*

**AI/ML INTERNSHIP**

**(NASTECH)**

*For the award of degree of*

**Bachelor of Engineering  
in  
Information Science and Engineering**

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**2020 -2021**

# RNS Institute of Technology

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## DEPARTMENT OF INFORMATION SCIENCE & ENGINEERING



### CERTIFICATE

This is to certify that the mini project report entitled **MEDICAL EXPENDITURE PREDICTION SYSTEM** has been successfully completed by **SAMARTH AITHAL** bearing USN **1RN18IS091** and **SANDESH A RAM** bearing USN **1RN18IS093**, presently VII semester students of **RNS Institute of Technology** in partial fulfillment of the requirements as a part of the **AI/ML Internship (NASTECH)** for the award of the degree of **Bachelor of Engineering in Information Science and Engineering** under **Visvesvaraya Technological University, Belagavi** during academic year **2021 – 2022**. It is certified that all corrections/suggestions indicated for Internal Assessment have been incorporated in the report and deposited in the departmental library. The mini project report has been approved as it satisfies the academic requirements as a part of Internship.

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# ABSTRACT

The medical sector is one of the most important industries with many stakeholders ranging from regulatory bodies to private companies and investors. Among these stakeholders, there is a high demand for a better understanding of the industry operational mechanism and driving factors. Today there is a large amount of data available on relevant statistics as well as on additional contextual factors, and it is natural to try to make use of these in order to improve efficiency of working in this industry.

Medical Expenditure prediction project focuses on providing an estimate on the health insurance for a particular person. By analyzing certain conditions such as a person's age, bmi, sex, number of children, whether the person smokes or not, speculated prices will be estimated for the health insurance of that person. The motive of this project is to help the customers to estimate the health insurance price for their family. Some of the related factors that impact the cost were also taken into considerations such as physical conditions, concept and location etc.

Medical expenditure price prediction on a data set has been done by using gradient booster regression technique. Moreover, this project can be considered as a further step towards more evidence-based decision making for the benefit of these stakeholders. The aim of our project is to build a predictive model for estimating the cost of insurance for a family so that the family can be prepared in advance to get insured.

# ACKNOWLEDGMENT

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## Chapter 1

# INTRODUCTION

## 1.1 ORGANIZATION/INDUSTRY

### 1.1.1 COMPANY PROFILE

NASTECH is formed with the purpose of bridging the gap between Academia and Industry. Nastech is one of the leading Global Certification and Training service providers for technical and management programs for educational institutions. We collaborate with educational institutes to understand their requirements and form a strategy in consultation with all stakeholders to fulfill those by skilling, reskilling and upskilling the students and faculties on new age skills and technologies.

### 1.1.2 DOMAIN/TECHNOLOGY

The domain chosen for our project is AI/ML. Machine learning, the fundamental driver of AI, is possible through algorithms that can learn themselves from data and identify patterns to make predictions and achieve your predefined goals, rather than blindly following detailed programmed instructions, like in traditional computer programming. This technology allows the machine to perceive, learn, reason and communicate through observation of data, like a child that grows up and acquires knowledge from examples. Machines also have the advantage of not being limited by our inherent biological limitations. With machine learning, manufacturing companies have increased production capacity up to 20%, while lowering material consumption rates by 4%.

Nowadays, the revolutionary AI technology evolved from rule-based expert systems to machine learning and more advanced subcomponents such as deep learning (learning representations instead of tasks), artificial neural networks (inspired by animal brains) and reinforcement learning (virtual agents rewarded if they made good decisions).

The AI can master the complexity of the intertwining industrial processes to enhance the whole flow of production instead of isolated processes. This enormous cognitive capacity gives the AI the ability to consider the spatial organization of plants and the timing constraints of live production. Another key advantage is the capability of AI algorithms to think probabilistically, with all the subtlety this allows in edge cases, instead of traditional rule-based methods that require rigid theories and a full comprehension of problems.

### **1.1.3 Department**

R.N.Shetty Institute of Technology (RNSIT) established in the year 2001, is the brain-child of the Group Chairman, Dr. R. N. Shetty. The Murudeshwar Group of Companies headed by Sri. R. N. Shetty is a leading player in many industries viz construction, manufacturing, hotel, automobile, power & IT services and education. The group has contributed significantly to the field of education. A number of educational institutions are run by the R. N. Shetty Trust, RNSIT being one amongst them. With a continuous desire to provide quality education to the society, the group has established RNSIT, an institution to nourish and produce the best of engineering talents in the country. RNSIT is one of the best and top accredited engineering colleges in Bengaluru.

## **1.2 PROBLEM STATEMENT**

### **1.2.1 Existing System and their Limitations**

A manual method is currently used in the market to predict the insurance price. The problem with this is that it is very time consuming and tedious process for the insurance company to manually provide this for every customer. To overcome this, insurance companies tend to hire an agent which again increases the cost of the process.

Moreover, there is a chance that the agent might be prone to manual error or bribery.

### **1.2.2 Proposed Solution**

To eliminate the drawback of manual method, Machine learning algorithms can be used by insurance companies to provide a fast, easy and customer friendly approach for the problem. Also, the new system will be cost and time efficient. This will have simple operations.

### **1.2.3 Program formulation**

The proposed system works on Gradient Boosting Regression Algorithm. This algorithm takes into account all the different conditions on which the insurance can be provided and gives a highly accurate estimate.



## **Chapter 2**

### **REQUIREMENT ANALYSIS, TOOLS & TECHNOLOGIES**

#### **2.1 Hardware and Software Requirements**

##### **2.1.1 Hardware Requirements:**

- Processor: Pentium IV or above
- RAM: 4 GB or more
- Hard Disk: 2GB or more

##### **2.1.2 Software Requirements:**

- Operating System: Windows 7 or above
- IDE: Google Colab

#### **2.2 Tools/Languages/Platforms**

- Python

## DESIGN AND IMPLIMENTATION

### 3.1 Architecture/ DFD/Sequence diagram/Class diagrams /Flowchart

**Gradient boosting** is a machine learning technique used in regression and classification tasks, among others. It gives a prediction model in the form of an ensemble of weak prediction models, which are typically decision trees. When a decision tree is the weak learner, the resulting algorithm is called gradient-boosted trees; it usually outperforms random forest. A gradient-boosted trees model is built in a stage-wise fashion as in other boosting methods, but it generalizes the other methods by allowing optimization of an arbitrary differentiable loss function.

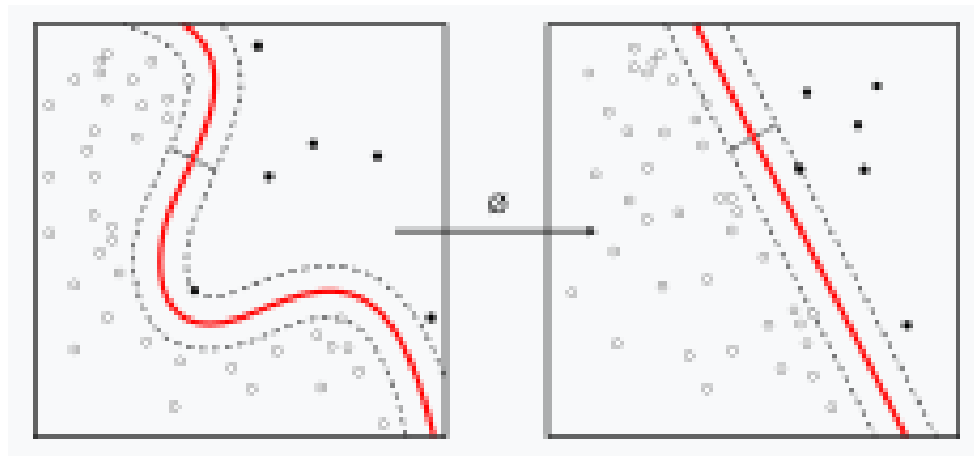


Figure 3.1 Gradient boosting regression Model

### 3.2 Problem Statement

The goal of this statistical analysis is to help us understand the relationship between insurance prices and how these variables are used to predict insurance price.

Gradient boosting regression Model has been used in terms of minimizing the difference between predicted and actual rating.

The following features have been used:

1. **Age:** Describes the age of the individual who is applying for the medical insurance policy. The older a person gets, the less healthy he becomes and therefore a higher premium will be required to get a health insurance.
2. **Sex:** Describes the sex of the individual who is applying for the medical insurance policy. Statistically males are more likely to get into accidents and therefore have a higher premium rates on the insurance policy.
3. **BMI:** Body mass index (BMI) is a measure of body fat based on height and weight that applies to adult men and women. A good BMI number for the person's height and weight indicates that the person is healthy therefore a lesser premium would be ideal. The normal BMI values can range anywhere between 19.5 and 24.9 for both adult males and females for average height and weight.
4. **Children:** Indicates the number of children a person has. More the number of children, higher will be the premium as the insurance covers the entire family of the person which includes the spouse and their children.
5. **Smoking:** Indicates whether a person smokes or not. Smokers generally tend to have higher risk of health issues. Smoking contributes majorly in the hiking up of premiums for health insurance.
6. **Region:** Indicates the locality in which a person stays. This has a profound effect as some areas are safer to live in due to the lower accident rates, crime rates etcetera. Therefore such safer areas will have lower insurance premiums while the riskier parts of the city will have a higher premium.

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 1338 entries, 0 to 1337
Data columns (total 7 columns):
#   Column      Non-Null Count  Dtype
---  -
0   age         1338 non-null   int64
1   sex         1338 non-null   object
2   bmi         1338 non-null   float64
3   children    1338 non-null   int64
4   smoker      1338 non-null   object
5   region      1338 non-null   object
6   charges     1338 non-null   float64
dtypes: float64(2), int64(2), object(3)
memory usage: 73.3+ KB
```

Figure 3.2 Description of the Dataset

The above fig3.2, shows the description of the dataset.

### 3.3 Algorithm

Input: training set  $\{(x_i, y_i)\}_{i=1}^n$ , a differentiable loss function  $L(y, F(x))$ , number of iterations  $M$ .

Algorithm:

1. Initialize model with a constant value:

$$F_0(x) = \arg \min_{\gamma} \sum_{i=1}^n L(y_i, \gamma).$$

2. For  $m = 1$  to  $M$ :

1. Compute so-called *pseudo-residuals*:

$$r_{im} = - \left[ \frac{\partial L(y_i, F(x_i))}{\partial F(x_i)} \right]_{F(x)=F_{m-1}(x)} \quad \text{for } i = 1, \dots, n.$$

2. Fit a base learner (or weak learner, e.g. tree) closed under scaling  $h_m(x)$  to pseudo-residuals, i.e. train it using the training set  $\{(x_i, r_{im})\}_{i=1}^n$ .
  3. Compute multiplier  $\gamma_m$  by solving the following [one-dimensional optimization](#) problem:

$$\gamma_m = \arg \min_{\gamma} \sum_{i=1}^n L(y_i, F_{m-1}(x_i) + \gamma h_m(x_i)).$$

4. Update the model:

$$F_m(x) = F_{m-1}(x) + \gamma_m h_m(x).$$

3. Output  $F_M(x)$ .

### 3.4 Libraries

- Pandas
- Numpy
- Plotly
- sklearn
- Seaborn
- Matplotlib

## Chapter 4

### OBSERVATION AND RESULTS

#### 4.1 Testing

##### Evaluation on Test Data

```
from sklearn.ensemble import GradientBoostingRegressor
gb = GradientBoostingRegressor(random_state=0)
gb.fit(x_train,y_train)
grad_train_pred = gb.predict(x_train)
grad_test_pred = gb.predict(x_test)
GbMae = metrics.mean_absolute_error(y_test, grad_test_pred)
GbMse = metrics.mean_squared_error(y_test, grad_test_pred)
GbRmse = np.sqrt(metrics.mean_squared_error(y_test, grad_test_pred))
GbVar = metrics.explained_variance_score(y_test,grad_test_pred)
##Evaluating the performance of the algorithm
print('Mean Absolute Error:%.2f %GbMae )
print('Mean Squared Error:%.2f %GbMse )
print('Root Mean Squared Error:%.2f %GbRmse )
print('Varscore:%.2f %GbVar)
```

##### Visualizing Our predictions based on different algorithms

```
predict = pd.DataFrame(data = models, columns=['Model','MAE', 'MSE', 'RMSE', 'Variance Score'])
```

##### Perfect predictions

```
new_gb = GradientBoostingRegressor(learning_rate=0.01,n_estimators=400) new_gb.fit(x_train,y_train)
```

#### 4.2 Results & Snapshots

##### Importing Libraries

```
In [36]: import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import seaborn as sns
import plotly.express as px
%matplotlib inline
import warnings
warnings.filterwarnings('ignore')

from sklearn import metrics
from sklearn.linear_model import LinearRegression
from sklearn.model_selection import train_test_split
from sklearn.preprocessing import PolynomialFeatures
from sklearn.metrics import r2_score, mean_squared_error, accuracy_score, confusion_matrix
from sklearn.ensemble import RandomForestRegressor
from sklearn.model_selection import cross_val_score, RandomizedSearchCV, GridSearchCV
```

##### Loading Data

```
In [37]: data = pd.read_csv("medical_cost.csv")

In [38]: data.shape
Out[38]: (1338, 7)

In [39]: data.head()
```

Figure 4.1 Reading CSV File

In the above fig 4.1, we are first importing all the modules required and then reading the dataset.csv file.

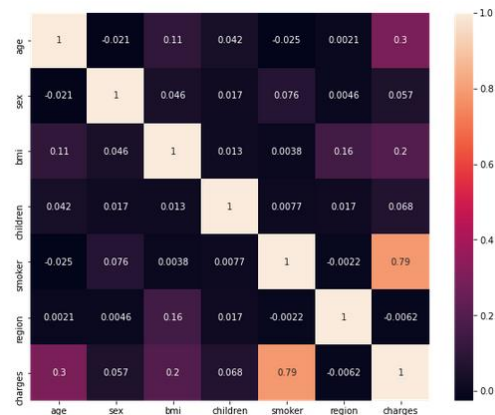


Figure 4.2 Price prediction model

In the above fig4.2, we are visualizing the categories and how much each category affects the price of the insurance policy. With distribution plot of price, we can visualize all the conditions that affect the price and by how much each condition affects the price.

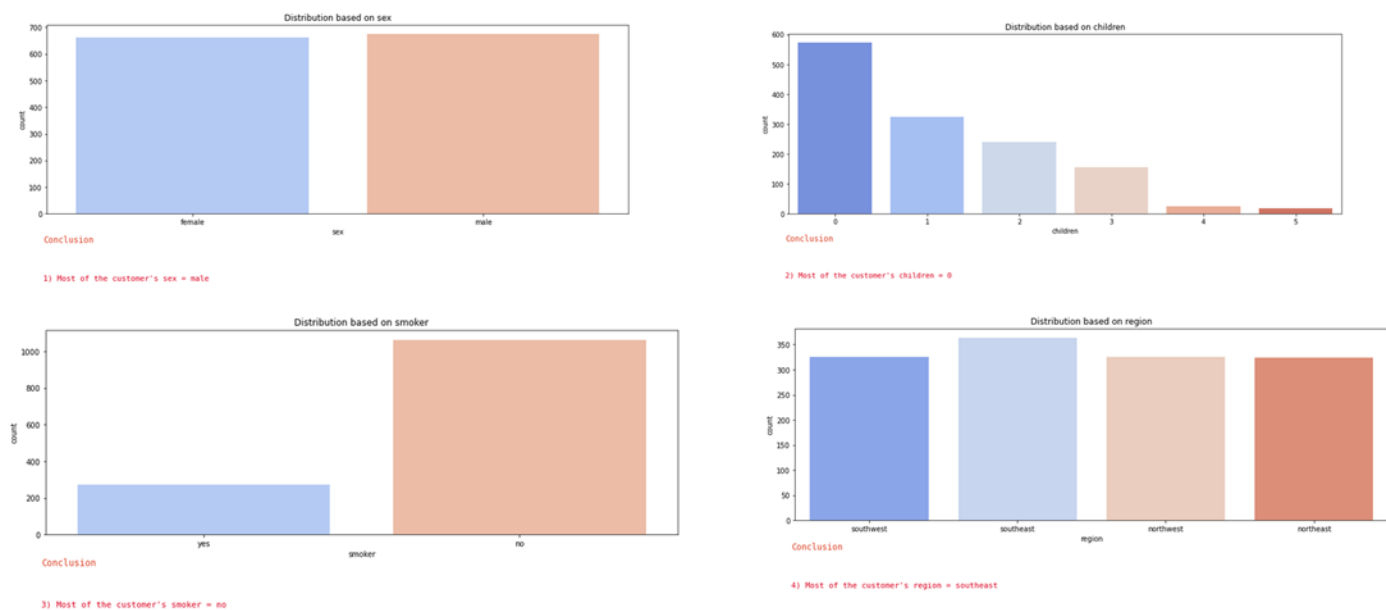
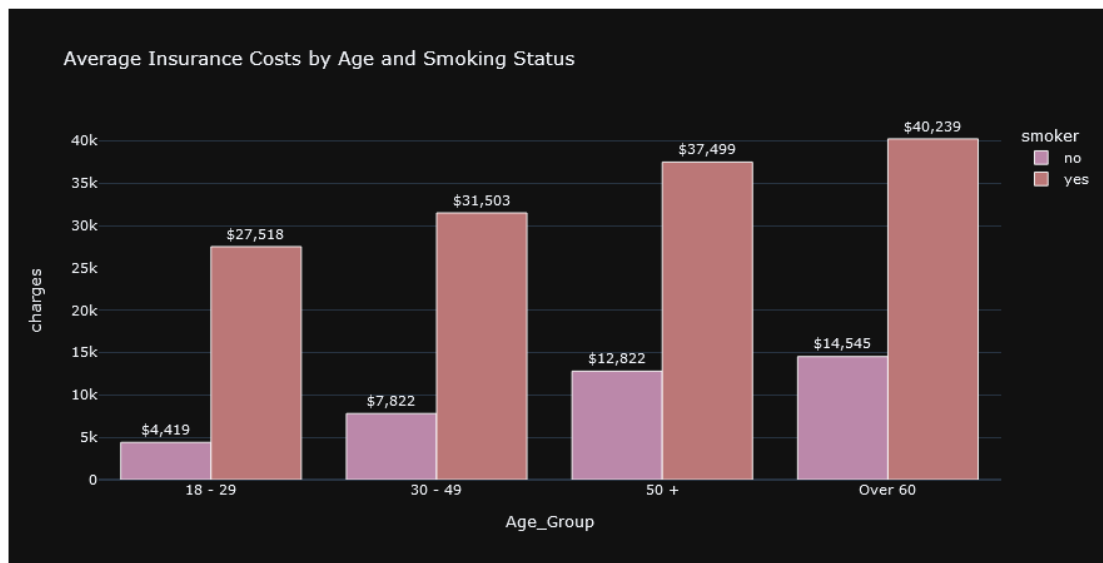


Figure 4.3 Data Analysis

In the above fig4.3, we are visualizing how the data is organized based on sex, number of children, region and if the individual smokes or not. And based on this organization it is determined that majority customers are male, non-smokers with no children living in southwest region. This helps the insurance company to have a standard to compare to.



From the above graph we can say that due to increasing age and if the person is a Smoker than charges are Increasing

Figure 4.4 Price range for smokers vs non-smokers

In the above fig4.4, we are viewing the price change that is happening for people of a certain age group based on whether they smoke or not. Likewise each condition is examined against each other and 4 different algorithms are implemented to predict the price. In this the algorithm with the highest varscore is used in our project.

```
x = data.drop(['charges'], axis = 1)
y = data.charges

x_train,x_test,y_train,y_test = train_test_split(x,y, random_state = 0)
lr = LinearRegression().fit(x_train,y_train)

y_train_pred = lr.predict(x_train)
y_test_pred = lr.predict(x_test)

LrMae = metrics.mean_absolute_error(y_test, y_test_pred)
LrMse = metrics.mean_squared_error(y_test, y_test_pred)
LrRmse = np.sqrt(metrics.mean_squared_error(y_test, y_test_pred))
LrVar = metrics.explained_variance_score(y_test,y_test_pred)

print('Mean Absolute Error: %.2f' %LrMae )
print('Mean Squared Error:%.2f'%LrMse )
print('Root Mean Squared Error:%.2f' %LrRmse)
print('Varscore:%.2f'%LrVar)
```

Mean Absolute Error: 3998.27  
Mean Squared Error:32073628.56  
Root Mean Squared Error:5663.36  
Varscore:0.80

Figure 4.5 Linear Regression model

In the above fig4.5, we use the linear regression model to predict the prices for insurance and we end up getting an accuracy of 80%.



```

X = data.drop(['charges','region'], axis = 1)
Y = data.charges

quad = PolynomialFeatures (degree = 2)
x_quad = quad.fit_transform(X)

X_train,X_test,Y_train,Y_test = train_test_split(x_quad,Y, random_state = 0)

plr = LinearRegression().fit(X_train,Y_train)

Y_train_pred = plr.predict(X_train)|
Y_test_pred = plr.predict(X_test)

PrMae = metrics.mean_absolute_error(Y_test, Y_test_pred)
PrMse = metrics.mean_squared_error(Y_test, Y_test_pred)
PrRmse = np.sqrt(metrics.mean_squared_error(Y_test, Y_test_pred))
PrVar = metrics.explained_variance_score(Y_test,Y_test_pred)
print('Mean Absolute Error: %.2f' %PrMae)
print('Mean Squared Error: %.2f' %PrMse )
print('Root Mean Squared Error: %.2f'%PrRmse)
print('Varscore: %.2f' %PrVar)

Mean Absolute Error:2761.13
Mean Squared Error:18117605.54
Root Mean Squared Error:4256.48
Varscore:0.89

```

Figure 4.6 Polynomial Regression model

In the above fig4.5, we use the Polynomial Regression model to predict the prices for insurance and we end up getting an accuracy of 89%.

```

forest = RandomForestRegressor(n_estimators = 100,
                              criterion = 'mse',
                              random_state = 1,
                              n_jobs = -1)

forest.fit(x_train,y_train)
forest_train_pred = forest.predict(x_train)
forest_test_pred = forest.predict(x_test)

RfMae = metrics.mean_absolute_error(y_test, forest_test_pred)
RfMse = metrics.mean_squared_error(y_test, forest_test_pred)
RfRmse = np.sqrt(metrics.mean_squared_error(y_test, forest_test_pred))
RfVar = metrics.explained_variance_score(y_test,forest_test_pred)
##Evaluating the performance of the algorithm
print('Mean Absolute Error: %.2f' %RfMae )
print('Mean Squared Error: %.2f' %RfMse )|
print('Root Mean Squared Error: %.2f' %RfRmse )
print('Varscore: %.2f' %RfVar)

Mean Absolute Error:2705.78
Mean Squared Error:19965476.41
Root Mean Squared Error:4468.27
Varscore:0.88

```

Figure 4.7 Random Forest Regression model

In the above fig4.7, we use the Random Forest regression model to predict the prices for insurance and we end up getting an accuracy of 88%.

```

from sklearn.ensemble import GradientBoostingRegressor
gb = GradientBoostingRegressor(random_state=0)
gb.fit(x_train,y_train)

grad_train_pred = gb.predict(x_train)
grad_test_pred = gb.predict(x_test)

GbMae = metrics.mean_absolute_error(y_test, grad_test_pred)
GbMse = metrics.mean_squared_error(y_test, grad_test_pred)
GbRmse = np.sqrt(metrics.mean_squared_error(y_test, grad_test_pred))
GbVar = metrics.explained_variance_score(y_test,grad_test_pred)
##Evaluating the performance of the algorithm
print('Mean Absolute Error:%.2f' %GbMae )
print('Mean Squared Error:%.2f' %GbMse )
print('Root Mean Squared Error:%.2f' %GbRmse )
print('Varscore:%.2f' %GbVar)

Mean Absolute Error:2433.88|
Mean Squared Error:16012531.39
Root Mean Squared Error:4001.57
Varscore:0.90

```

Figure 4.8 Gradient boosting regression model

In the above fig4.7, we use the Gradient boosting regression model to predict the prices for insurance and we end up getting an accuracy of 90%.

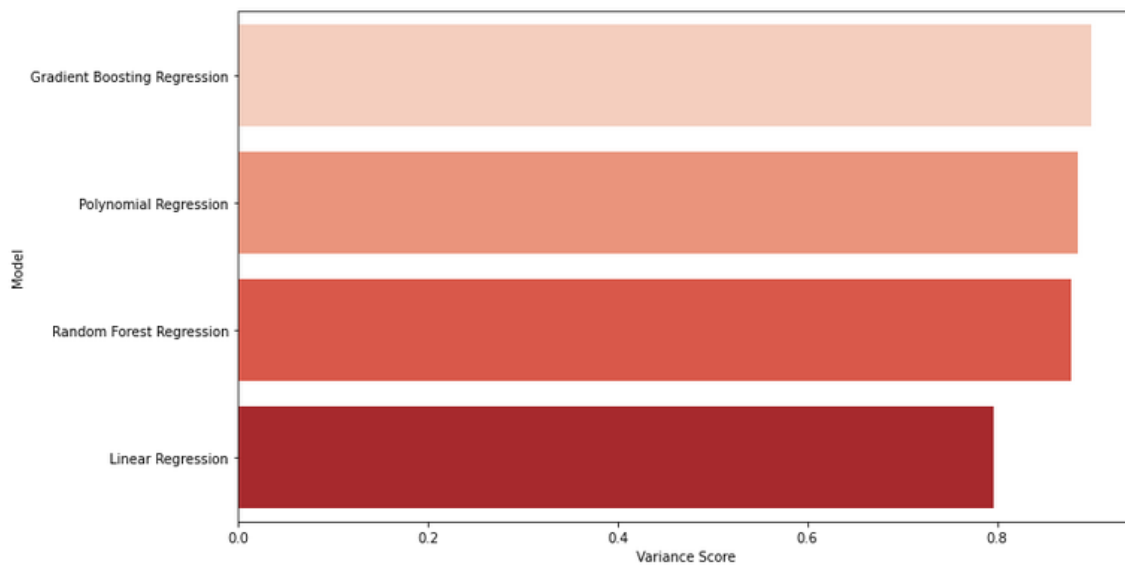


Figure 4.9 Visualizing Accuracies of different algorithms

In the above fig4.9, we compare the algorithms that predict the price of insurance based on the different conditions provided. It is evident that the gradient booster regression algorithm has the highest accuracy of 90%. Since this model provides the highest accuracy for price prediction, we use this algorithm to determine the final output.

## Total Medical Cost Prediction

Age:

Body mass index(Bmi):

Number of children covered by health insurance:

Residential area:

Gender:

Smoker:

Total individual medical costs billed by health insurance:

**\$18912.1**

Figure 4.9.1 Result

In the above fig4.9.1, we are calculating the actual cost for a person to get health insurance based on his age, bmi, no.of children, area, sex and smoking status. For the values of 21, 17500, 0, southeast, male and yes, we get an estimated price of 18,912.1\$ to get health insurance for that person. This value has an accuracy of 90% being the final insurance value.

## Chapter 5

# CONCLUSION AND FUTURE ENHANCEMENT

### 5.1 Conclusion

The proposed model is the best substitute for the manual method where a third party is involved as the middleman and is potentially vulnerable along with it being cheaper for the end customers.

Based on the results, it can be concluded that such ML-driven predictions are easily comprehensible and significant from a data-analytics point of view.

When correctly implemented, a high rate of accuracy can be achieved.

### 5.2 Future Enhancement

- To make the interface more informative and user-friendly by implementing better GUI designs.
- Using bigger training data sets to get a more accurate estimate of the prices.
- Implementing other machine learning algorithms which can improve the accuracy of the model.

**Chapter 6****REFERENCE**

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XIANLONG ZENG 1, SIMON LIN2, AND CHANG LIU 3 (Member, IEEE)  
**DOI:** 10.1109/OJCS.2021.3052518
- 2) Medicine Expenditure Prediction via a VarianceBased Generative Adversarial  
Network SHRUTI KAUSHIK 1 , (Member, IEEE), ABHINAV CHOUDHURY1 ,  
SAYEE NATARAJAN2 , LARRY A. PICKETT, JR.2 , AND VARUN DUTT1 ,  
(Senior Member, IEEE) **DOI:** 10.1109/ACCESS.2020.3002346
- 3) Medicine Expenditure Prediction via a Variance- Based Generative Adversarial  
Network by Abhinav Choudhury; Sayee Natarajan; Larry A. Pickett; Varun Dutt  
**DOI:** 10.1109/ACCESS.2020.3002346