# Medical Insurance Cost Personal, Linear Machine Learning Model

August 17, 2023

[51]:
```
import pandas as pd
import numpy as np
import seaborn as sns
import matplotlib.pyplot as plt
%matplotlib inline
import warnings
warnings.filterwarnings("ignore")
```

Columns

age: age of primary beneficiary

sex: insurance contractor gender, female, male

bmi: Body mass index, providing an understanding of body, weights that are relatively high or low relative to height, objective index of body weight (kg / m ^ 2) using the ratio of height to weight, ideally 18.5 to 24.9

children: Number of children covered by health insurance / Number of dependents

smoker: Smoking

region: the beneficiary's residential area in the US, northeast, southeast, southwest, northwest.

charges: Individual medical costs billed by health insurance

[132]:
```
#To load the dataset
df = pd.read_csv(r"C:\Users\Aaditya Adyot\Downloads\Medical Cost Personal␣
↪Datasets\insurance.csv")
```

[53]:
```
# to see top 5 entries
df.head(5)
```

[53]:

| | age | sex | bmi | children | smoker | region | charges |
|---|---|---|---|---|---|---|---|
| 0 | 19 | female | 27.900 | 0 | yes | southwest | 16884.92400 |
| 1 | 18 | male | 33.770 | 1 | no | southeast | 1725.55230 |
| 2 | 28 | male | 33.000 | 3 | no | southeast | 4449.46200 |
| 3 | 33 | male | 22.705 | 0 | no | northwest | 21984.47061 |
| 4 | 32 | male | 28.880 | 0 | no | northwest | 3866.85520 |

[54]:
```
# to see last 5 entries
df.tail(5)
```

[54]:

| | age | sex | bmi | children | smoker | region | charges |
|---|---|---|---|---|---|---|---|
| 1333 | 50 | male | 30.97 | 3 | no | northwest | 10600.5483 |
| 1334 | 18 | female | 31.92 | 0 | no | northeast | 2205.9808 |
| 1335 | 18 | female | 36.85 | 0 | no | southeast | 1629.8335 |
| 1336 | 21 | female | 25.80 | 0 | no | southwest | 2007.9450 |
| 1337 | 61 | female | 29.07 | 0 | yes | northwest | 29141.3603 |

[55]:
```
#to see the random sample in the dataset
df.sample(5)
```

[55]:

| | age | sex | bmi | children | smoker | region | charges |
|---|---|---|---|---|---|---|---|
| 1187 | 62 | female | 32.680 | 0 | no | northwest | 13844.79720 |
| 575 | 58 | female | 27.170 | 0 | no | northwest | 12222.89830 |
| 867 | 57 | male | 43.700 | 1 | no | southwest | 11576.13000 |
| 626 | 36 | male | 28.880 | 3 | no | northeast | 6748.59120 |
| 56 | 58 | female | 31.825 | 2 | no | northeast | 13607.36875 |

[56]:
```
#to check the info of the dataset
df.info()
```

```
<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
```

### 0.0.1 Observation: dtypes: float64(2), int64(2), object(3)

[57]:
```
# to check the null values in the features
df.isna().sum()
```

[57]:
```
age         0
sex         0
bmi         0
children    0
smoker      0
region      0
charges     0
dtype: int64
```

[58]:
```
df[['smoker', 'region']]
```

[58]:
```
     smoker     region
0       yes  southwest
1        no  southeast
2        no  southeast
3        no  northwest
4        no  northwest
…       …          …
1333     no  northwest
1334     no  northeast
1335     no  southeast
1336     no  southwest
1337    yes  northwest

[1338 rows x 2 columns]
```

[59]:
```
# to check the unique values in these feature
df['smoker'].unique()
```

[59]:
```
array(['yes', 'no'], dtype=object)
```

[60]:
```
df['region'].unique()
```

[60]:
```
array(['southwest', 'southeast', 'northwest', 'northeast'], dtype=object)
```

[61]:
```
## for smoker and region, we can perform encoding
```

[62]:
```
df['smoker'] = df['smoker'].map({'yes': 1, "no":0})
```

[66]:
```
df= pd.concat([df, pd.get_dummies(df['region'])], axis =1)
```

[68]:
```
df['sex'].unique()
```

[68]:
```
array(['female', 'male'], dtype=object)
```

[71]:
```
#use label encoder

from sklearn.preprocessing import LabelEncoder
encoder = LabelEncoder()
df['sex']=encoder.fit_transform(df['sex'])
```

[73]:
```
df.drop('region', axis=1, inplace= True)
```

[74]:
```
df
```

[74]:
```
      age  sex     bmi  children  smoker      charges  northeast  northwest  \
0      19    0  27.900         0       1  16884.92400          0          0
```

```
1       18    1  33.770         1        0   1725.55230            0            0
2       28    1  33.000         3        0   4449.46200            0            0
3       33    1  22.705         0        0  21984.47061            0            1
4       32    1  28.880         0        0   3866.85520            0            1
…    …   …     …        …      …          …         …        …
1333    50    1  30.970         3        0  10600.54830            0            1
1334    18    0  31.920         0        0   2205.98080            1            0
1335    18    0  36.850         0        0   1629.83350            0            0
1336    21    0  25.800         0        0   2007.94500            0            0
1337    61    0  29.070         0        1  29141.36030            0            1

      southeast  southwest
0             0          1
1             1          0
2             1          0
3             0          0
4             0          0
…          …         …
1333          0          0
1334          0          0
1335          1          0
1336          0          1
1337          0          0

[1338 rows x 10 columns]
```

[75]:

```
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 1338 entries, 0 to 1337
Data columns (total 10 columns):
 #   Column     Non-Null Count  Dtype
---  ------     --------------  -----
 0   age        1338 non-null   int64
 1   sex        1338 non-null   int32
 2   bmi        1338 non-null   float64
 3   children   1338 non-null   int64
 4   smoker     1338 non-null   int64
 5   charges    1338 non-null   float64
 6   northeast  1338 non-null   uint8
 7   northwest  1338 non-null   uint8
 8   southeast  1338 non-null   uint8
 9   southwest  1338 non-null   uint8
dtypes: float64(2), int32(1), int64(3), uint8(4)
memory usage: 62.8 KB
```

[76]:

```
df.describe().T
```

[76]:

| | count | mean | std | min | 25% |
|---|---|---|---|---|---|
| age | 1338.0 | 39.207025 | 14.049960 | 18.0000 | 27.00000 |
| sex | 1338.0 | 0.505232 | 0.500160 | 0.0000 | 0.00000 |
| bmi | 1338.0 | 30.663397 | 6.098187 | 15.9600 | 26.29625 |
| children | 1338.0 | 1.094918 | 1.205493 | 0.0000 | 0.00000 |
| smoker | 1338.0 | 0.204783 | 0.403694 | 0.0000 | 0.00000 |
| charges | 1338.0 | 13270.422265 | 12110.011237 | 1121.8739 | 4740.28715 |
| northeast | 1338.0 | 0.242152 | 0.428546 | 0.0000 | 0.00000 |
| northwest | 1338.0 | 0.242900 | 0.428995 | 0.0000 | 0.00000 |
| southeast | 1338.0 | 0.272048 | 0.445181 | 0.0000 | 0.00000 |
| southwest | 1338.0 | 0.242900 | 0.428995 | 0.0000 | 0.00000 |

| | 50% | 75% | max |
|---|---|---|---|
| age | 39.000 | 51.000000 | 64.00000 |
| sex | 1.000 | 1.000000 | 1.00000 |
| bmi | 30.400 | 34.693750 | 53.13000 |
| children | 1.000 | 2.000000 | 5.00000 |
| smoker | 0.000 | 0.000000 | 1.00000 |
| charges | 9382.033 | 16639.912515 | 63770.42801 |
| northeast | 0.000 | 0.000000 | 1.00000 |
| northwest | 0.000 | 0.000000 | 1.00000 |
| southeast | 0.000 | 1.000000 | 1.00000 |
| southwest | 0.000 | 0.000000 | 1.00000 |

# 1 Detecting outliers

1. By using standard deviation method

[116]:
```
index_list = []
feature = ['age', 'bmi', 'charges']
for i in feature:
    mean= df[i].mean()
    std = df[i].std()
    cuttoff = std * 3
    index = df[(df[i] < (mean - cuttoff)) | (df[i] > (mean + cuttoff))].index
    index_list.extend(index)
```

[123]:
```
index_list = sorted(set(index_list))
print(f'The no. outlier detected through Standard deviation method is,␣
↪{len(index_list)}')
print(f'The index of the dataset containing outliers are, {index_list}')
```

```
The no. outlier detected through Standard deviation method is, 11
The index of the dataset containing outliers are, [34, 116, 543, 577, 819, 847,
1047, 1146, 1230, 1300, 1317]
```

2. By using IQR

[125]:
```
index_list = []
feature = ['age', 'bmi', 'charges']
for i in feature:
    lower_fence = df[i].quantile(.25)
    higher_fence= df[i].quantile(.75)
    IQR = higher_fence-lower_fence
    q1 = lower_fence - 1.5*IQR
    q2 = higher_fence + 1.5*IQR
    index = df[(df[i] < q1) | (df[i]> q2)].index
    index_list.extend(index)
```

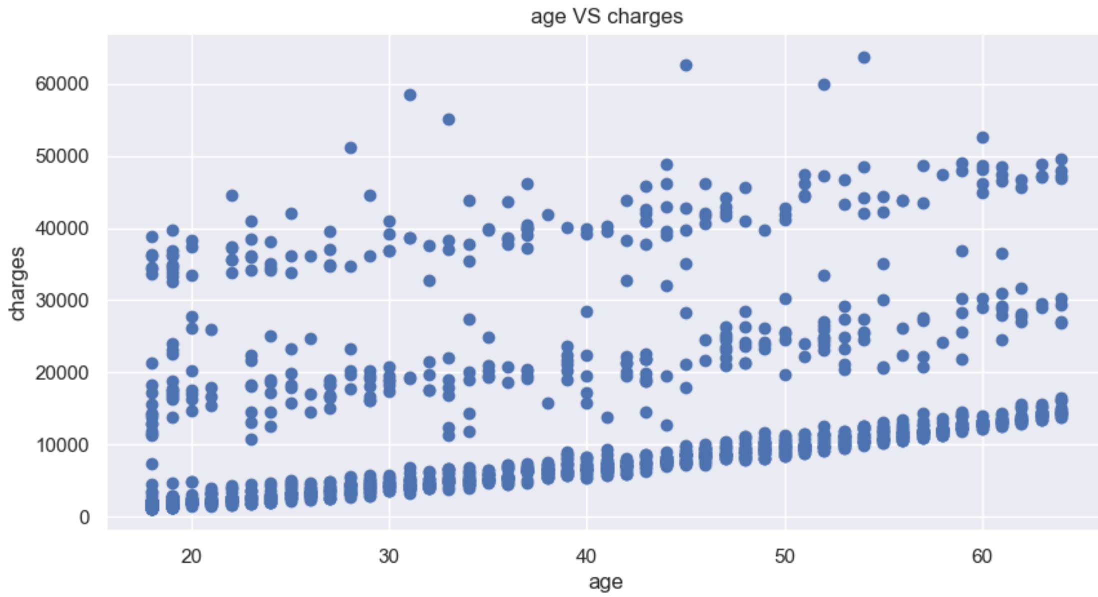
[126]:
```
index_list = sorted(set(index_list))
print(f'The no. outlier detected through Standard deviation method is,␣
↪{len(index_list)}')
print(f'The index of the dataset containing outliers are, {index_list}')
```

```
The no. outlier detected through Standard deviation method is, 145
The index of the dataset containing outliers are, [14, 19, 23, 29, 30, 34, 38,
39, 49, 53, 55, 82, 84, 86, 94, 109, 116, 123, 146, 158, 161, 175, 185, 203,
223, 240, 242, 251, 252, 254, 256, 263, 265, 271, 281, 286, 288, 292, 298, 312,
314, 322, 327, 328, 330, 338, 373, 377, 381, 401, 420, 421, 422, 441, 476, 488,
500, 524, 530, 543, 549, 558, 569, 577, 587, 609, 615, 621, 623, 629, 665, 667,
668, 674, 677, 682, 689, 697, 706, 725, 736, 738, 739, 742, 759, 803, 819, 826,
828, 842, 845, 847, 850, 852, 856, 860, 883, 893, 901, 917, 947, 951, 953, 956,
958, 1012, 1021, 1022, 1031, 1036, 1037, 1047, 1049, 1062, 1070, 1078, 1088,
1090, 1096, 1111, 1117, 1118, 1122, 1124, 1139, 1146, 1152, 1156, 1186, 1206,
1207, 1218, 1230, 1240, 1241, 1249, 1284, 1288, 1291, 1300, 1301, 1303, 1313,
1317, 1323]
```

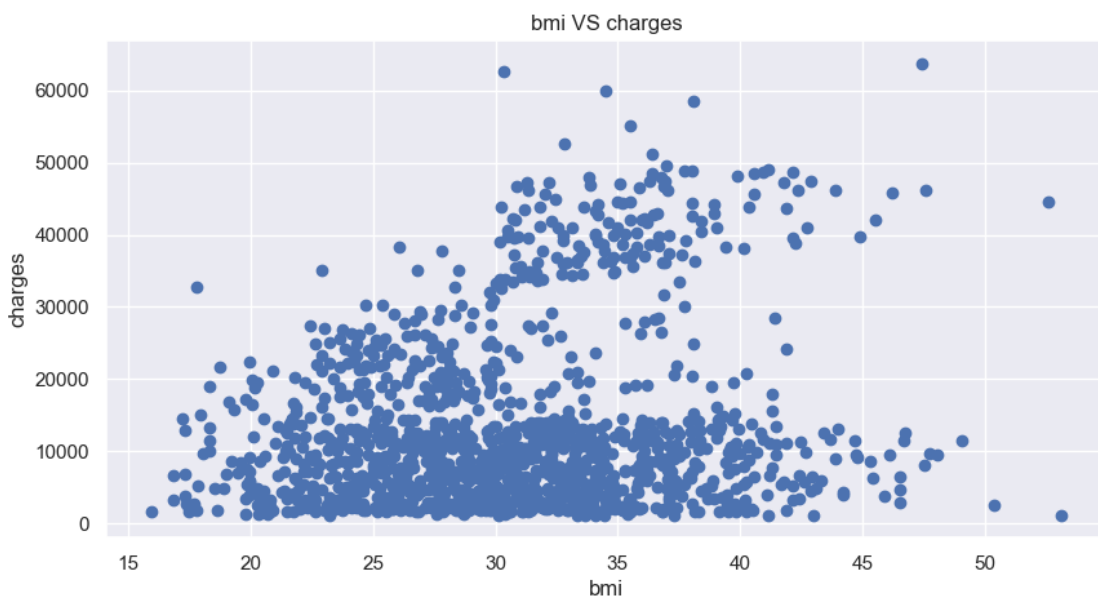
3. using Using scatter for numerical feature and boxplot for categorical features

[127]:
```
numerical_features = ['age', 'bmi', 'charges']
```

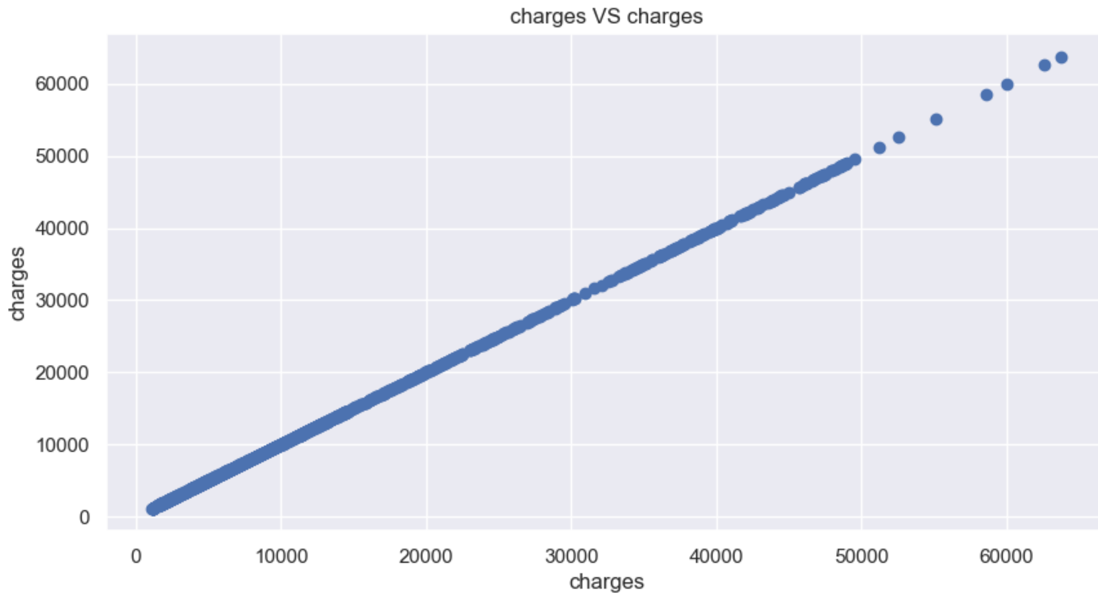
[129]:
```
# numericals
for n in numerical_features :
    plt.figure(figsize=(10,5))
    plt.scatter(df[n], df["charges"])
    plt.title(f"{n} VS charges")
    plt.xlabel(f"{n}")
    plt.ylabel("charges")
    plt.show()
```



age VS charges
charges
age
0
10000
20000
30000
40000
50000
60000
20
30
40
50
60

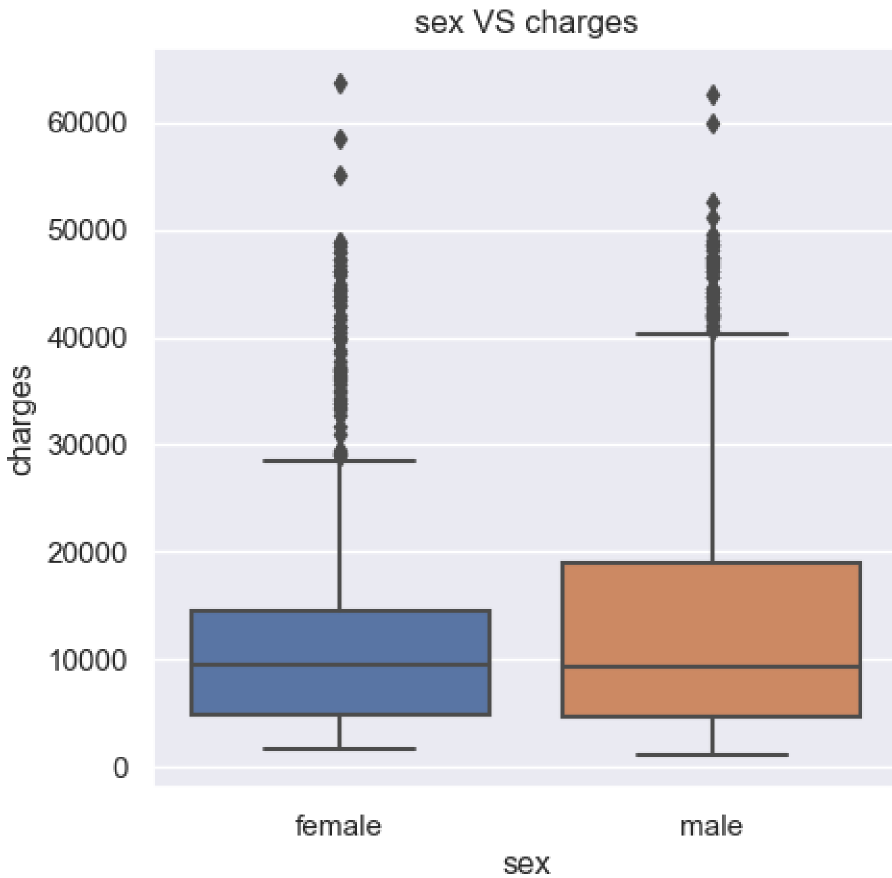



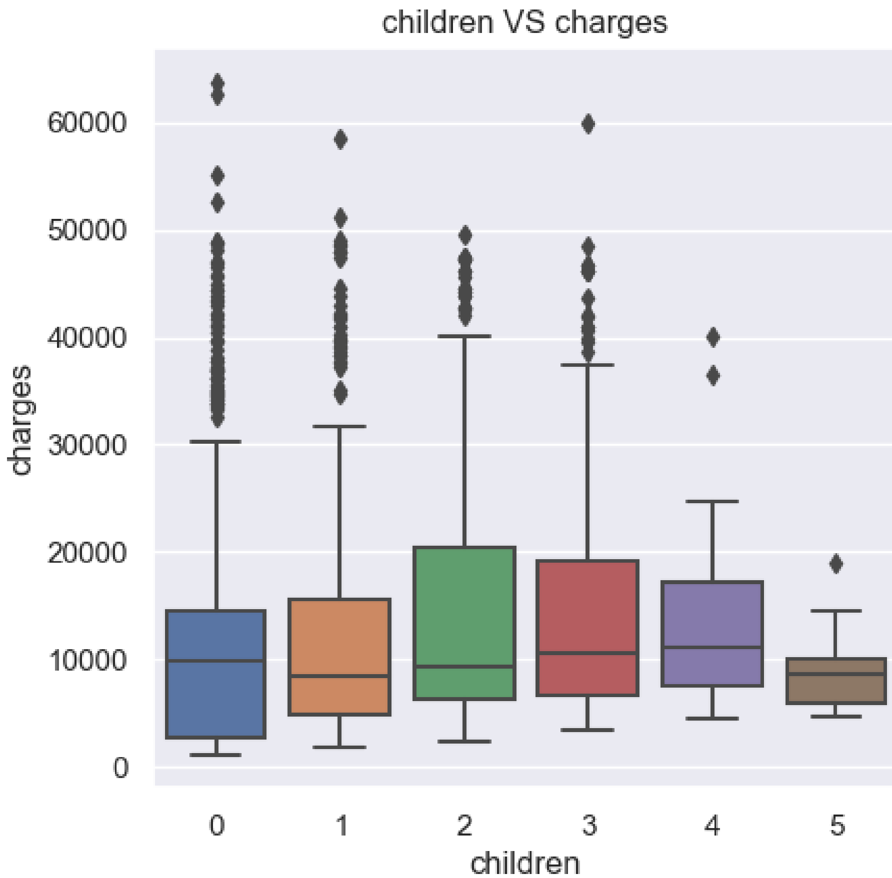
bmi VS charges
charges
bmi
0
10000
20000
30000
40000
50000
60000
15
20
25
30
35
40
45
50

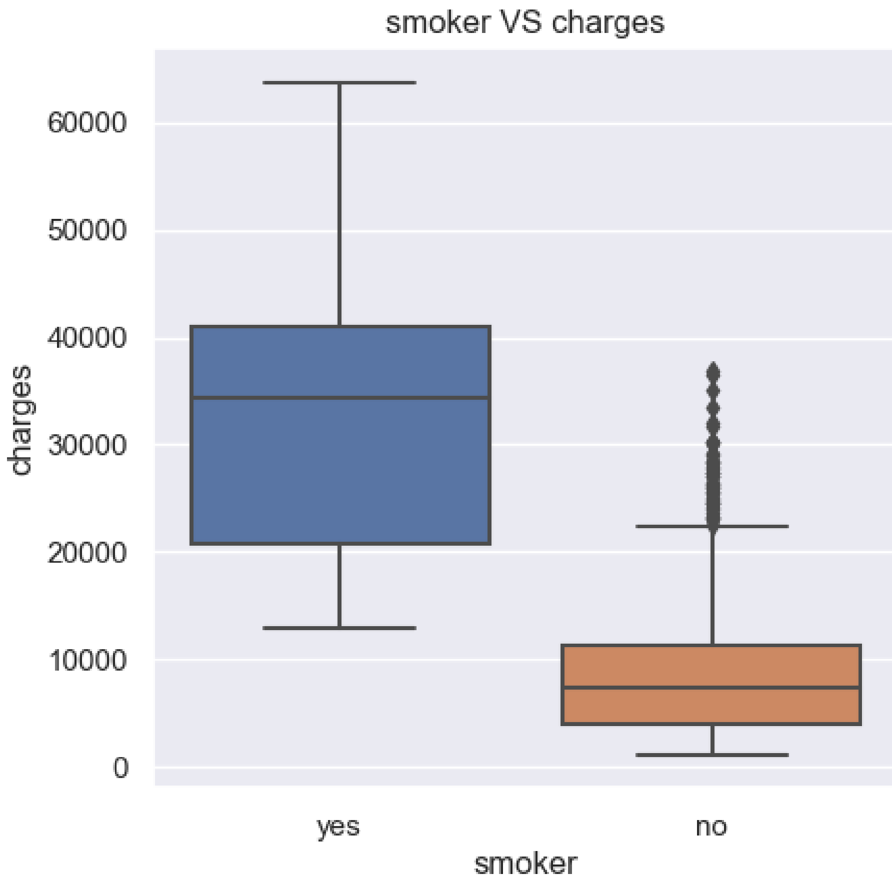


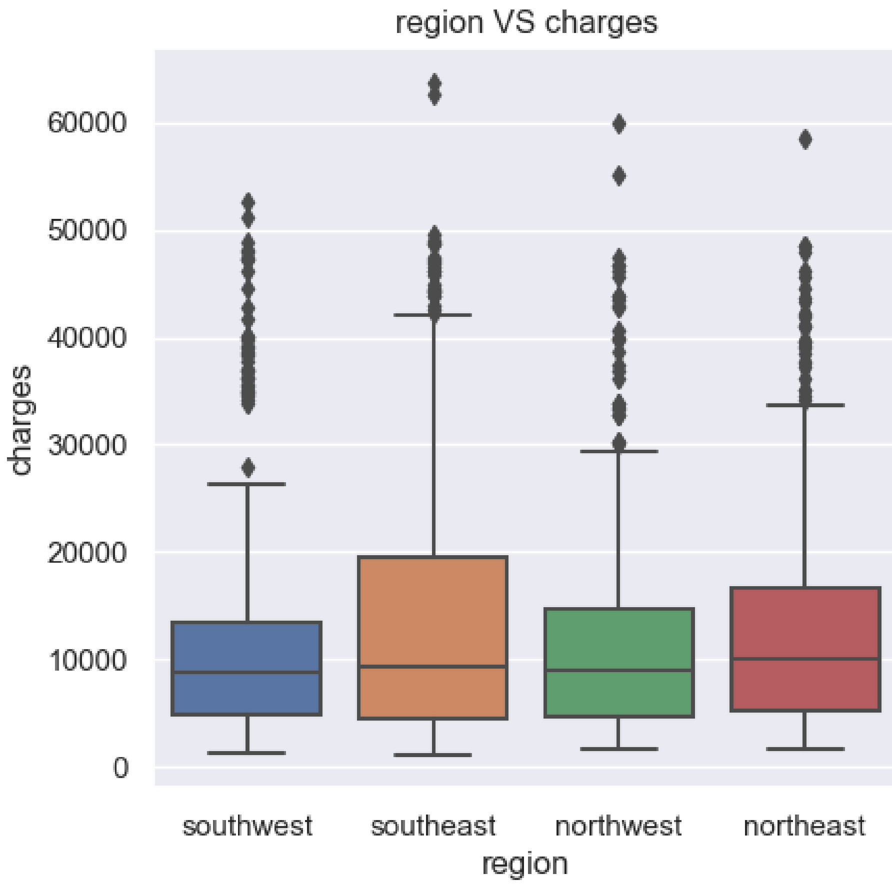

[130]:
```
categorical_features = ["sex", "children", "smoker", "region"]
```

[135]:
```
#categoricals
for n in categorical_features :
    plt.figure(figsize=(5,5))
    sns.boxplot(x=n, y="charges", data=df)
    plt.title(f"{n} VS charges")
    plt.show()
```


sex VS charges
60000
50000
40000
30000
20000
10000
0
charges
female
male
sex


children VS charges
charges
60000
50000
40000
30000
20000
10000
0
0
1
2
3
4
5
children

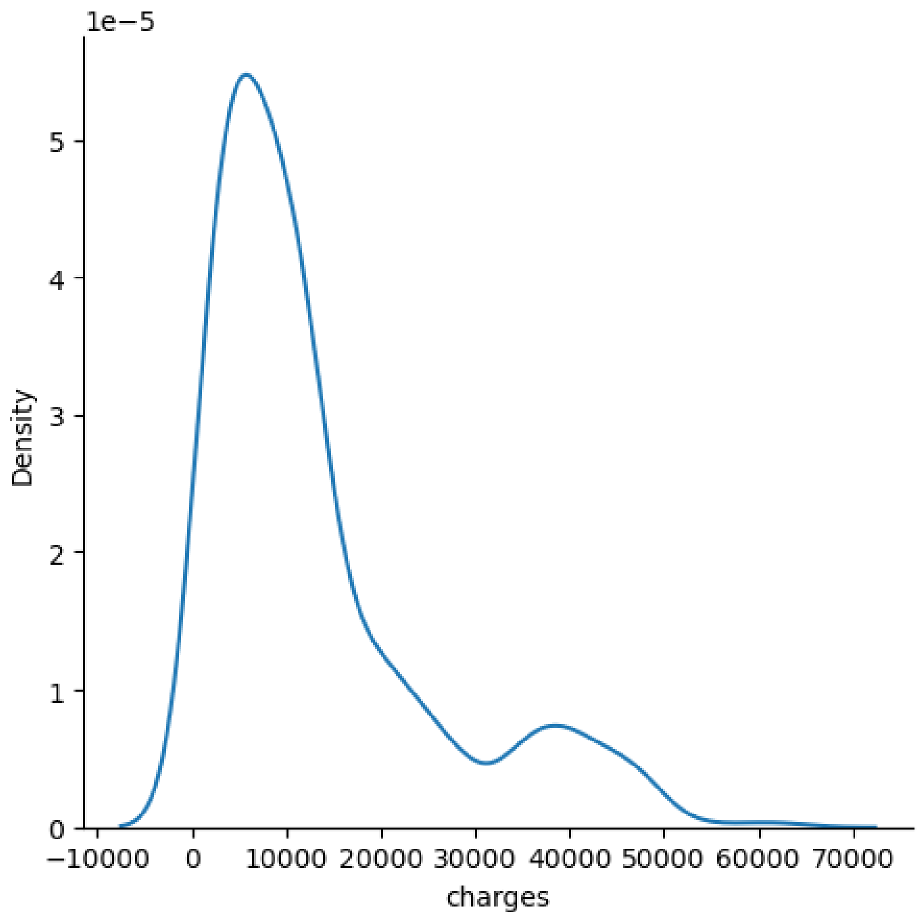

smoker VS charges
60000
50000
40000
30000
20000
10000
0
charges
yes
no
smoker




**There are some outliers in our dataset. But it doesn't mean that they are false values or I should remove them. Also the number of samples are low.**

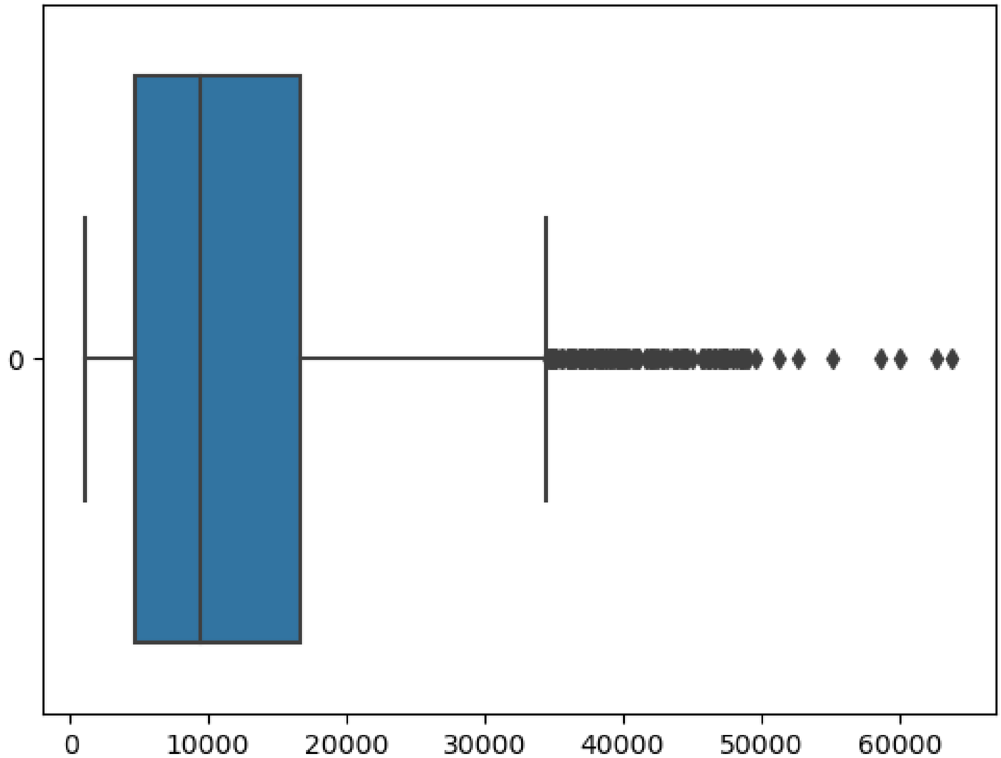
[20]:
```
sns.displot(df['charges'], kind='kde')
```

[20]: <seaborn.axisgrid.FacetGrid at 0x14c1c0e6920>



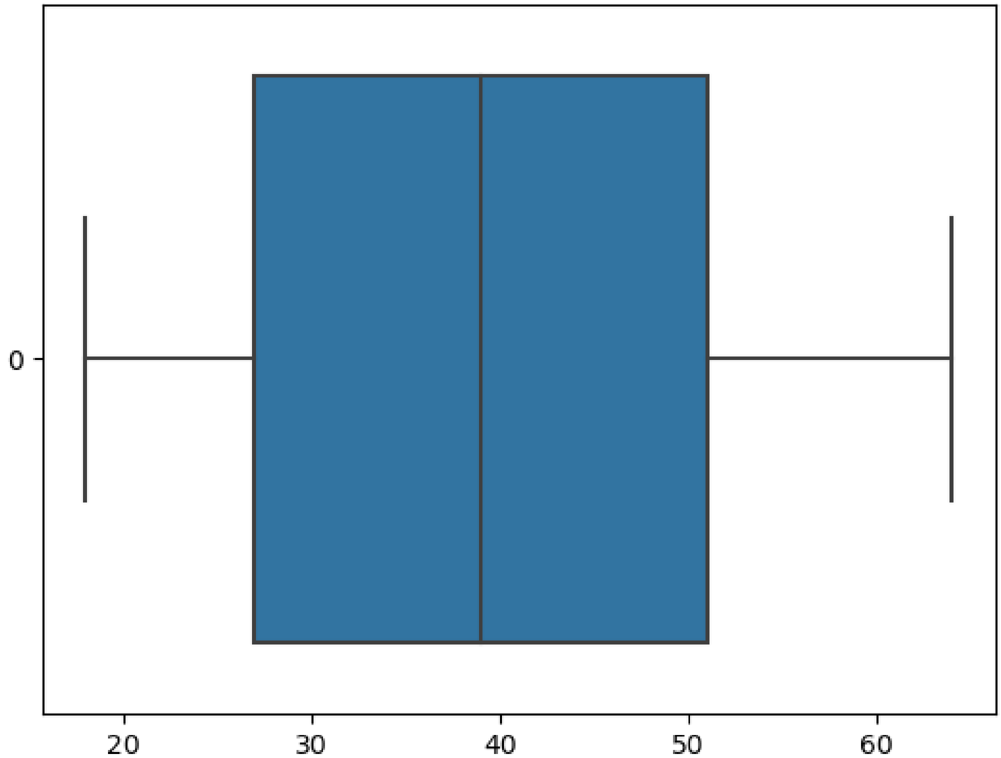

[22]:
```
sns.boxplot(df['charges'], orient='h')
```

[22]: `<Axes: >`



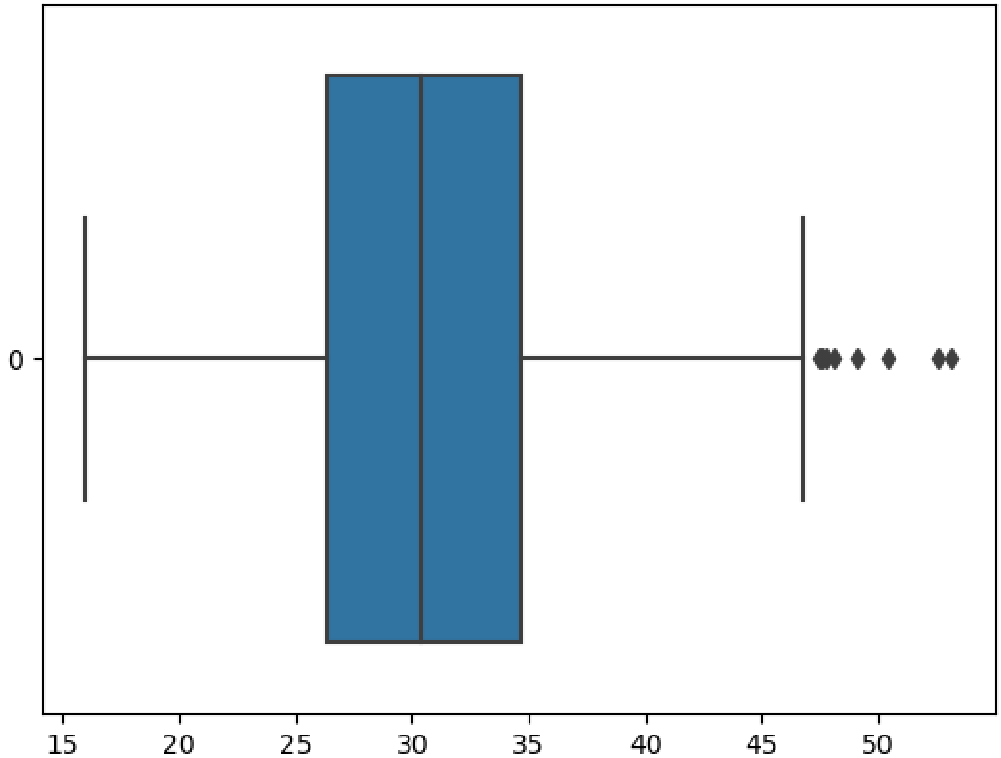

[80]:
```
sns.boxplot(df['age'], orient='h')
```

[80]: <Axes: >



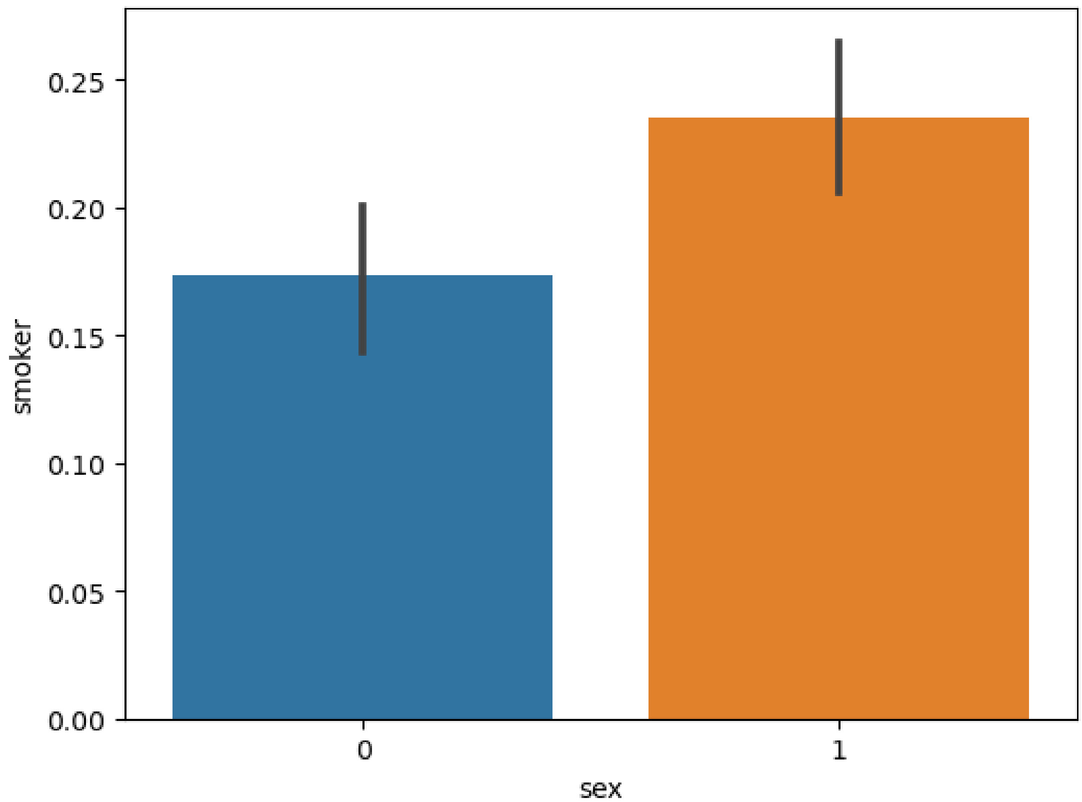

[82]:
```
sns.boxplot(df['bmi'], orient='h')
```

[82]: <Axes: >




[89]:
```
sns.barplot(x='sex', y='smoker', data=df)
```

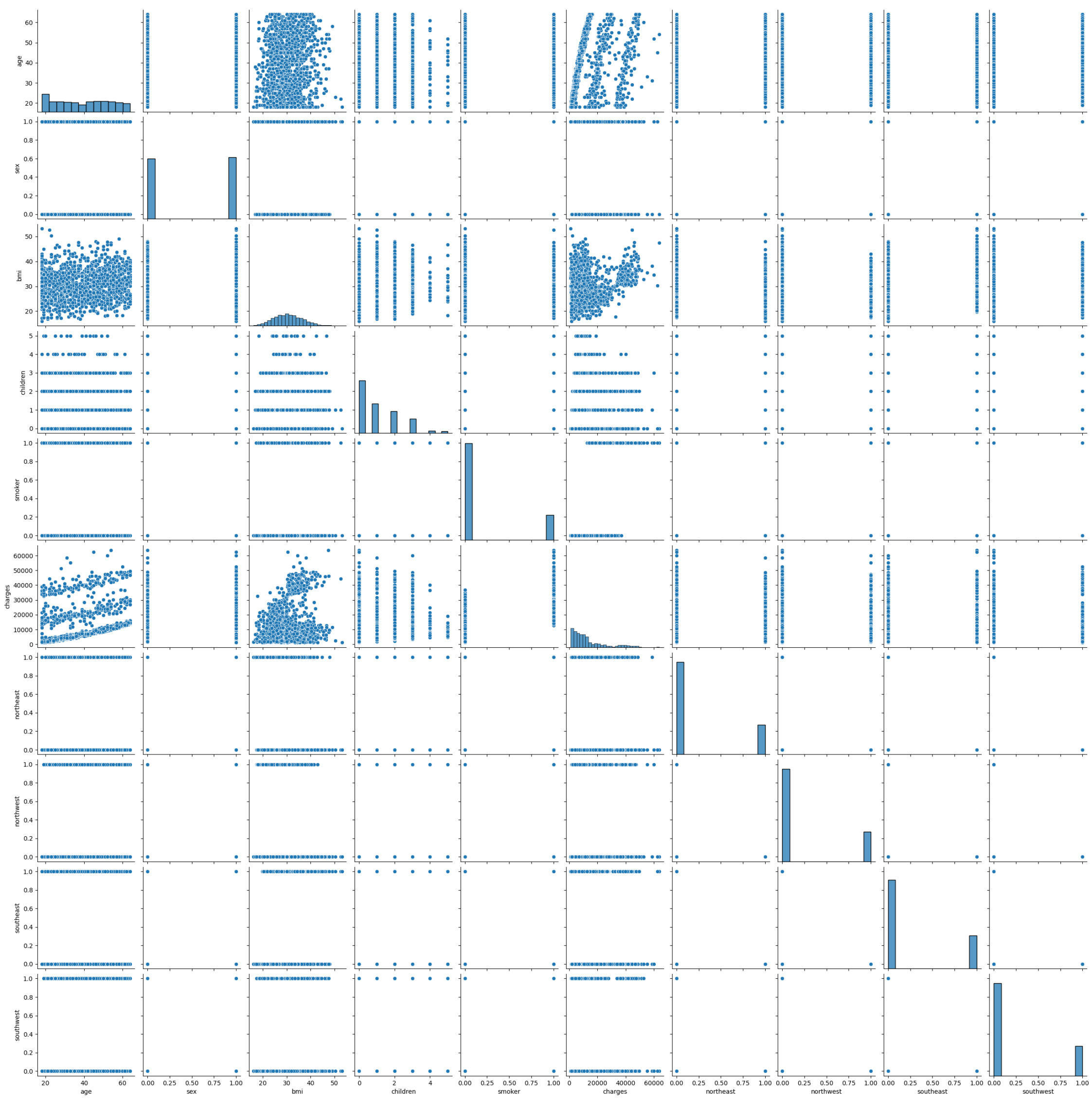
[89]: <Axes: xlabel='sex', ylabel='smoker'>




Observation: Male sex smokes more than the female sex.

[90]:
```
sns.pairplot(df)
```

[90]: <seaborn.axisgrid.PairGrid at 0x14c271f3760>



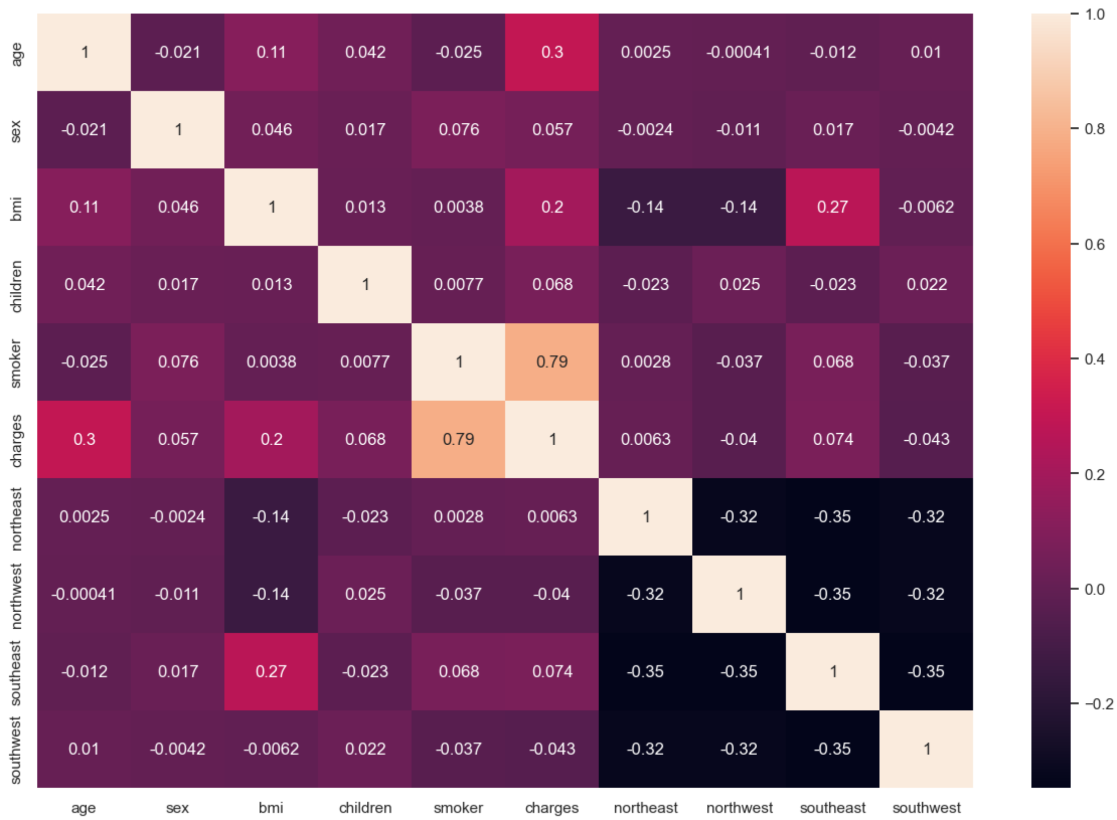

[93]:
```
df.corr()
```

[93]:
```
                age       sex       bmi  children    smoker   charges  \
age        1.000000 -0.020856  0.109272  0.042469 -0.025019  0.299008
sex       -0.020856  1.000000  0.046371  0.017163  0.076185  0.057292
bmi        0.109272  0.046371  1.000000  0.012759  0.003750  0.198341
children   0.042469  0.017163  0.012759  1.000000  0.007673  0.067998
smoker    -0.025019  0.076185  0.003750  0.007673  1.000000  0.787251
charges    0.299008  0.057292  0.198341  0.067998  0.787251  1.000000
northeast  0.002475 -0.002425 -0.138156 -0.022808  0.002811  0.006349
northwest -0.000407 -0.011156 -0.135996  0.024806 -0.036945 -0.039905
southeast -0.011642  0.017117  0.270025 -0.023066  0.068498  0.073982
southwest  0.010016 -0.004184 -0.006205  0.021914 -0.036945 -0.043210
```

```
           northeast  northwest  southeast  southwest
age         0.002475  -0.000407  -0.011642   0.010016
sex        -0.002425  -0.011156   0.017117  -0.004184
bmi        -0.138156  -0.135996   0.270025  -0.006205
children   -0.022808   0.024806  -0.023066   0.021914
smoker      0.002811  -0.036945   0.068498  -0.036945
charges     0.006349  -0.039905   0.073982  -0.043210
northeast   1.000000  -0.320177  -0.345561  -0.320177
northwest  -0.320177   1.000000  -0.346265  -0.320829
southeast  -0.345561  -0.346265   1.000000  -0.346265
southwest  -0.320177  -0.320829  -0.346265   1.000000
```

[92]:
```
sns.set(rc={"figure.figsize": (15,10)})
sns.heatmap(df.corr(), annot= True)
```

[92]: <Axes: >




[94]:
```
# Model building
X = df.drop('charges', axis =1)
y= df['charges']
```

[95]:
```
from sklearn.model_selection import train_test_split
X_train, X_test, y_train, y_test = train_test_split(X, y, random_state=42,␣
↪test_size=0.33)
```

[ ]:
```
#Standardising the daaset
```

[96]:
```
from sklearn.preprocessing import StandardScaler
scaler = StandardScaler()
X_train= scaler.fit_transform(X_train)
X_test= scaler.transform(X_test)
```

## 2 Applying the Liner regression

[97]:
```
from sklearn.linear_model import LinearRegression
regression = LinearRegression()
regression.fit(X_train, y_train)
pred_data= regression.predict(X_test)
```

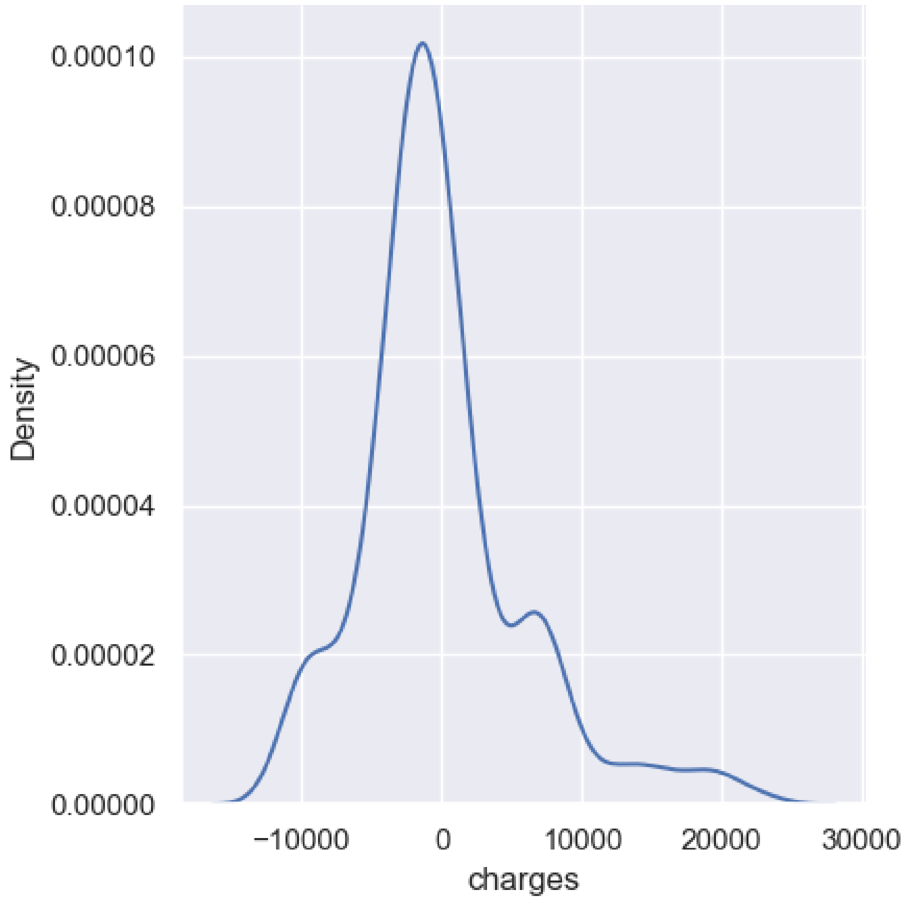
[98]:
```
plt.scatter(y_test, pred_data)
plt.xlabel("actual data")
plt.ylabel("predicted data")
```

[98]: Text(0, 0.5, 'predicted data')

[99]:
```
residuals = y_test - pred_data
```

[100]:
```
sns.displot(residuals, kind= 'kde')
```

[100]:
```
<seaborn.axisgrid.FacetGrid at 0x14c337e37f0>
```




[101]:
```
from sklearn.metrics import mean_absolute_error, mean_squared_error
print(mean_squared_error(y_test, pred_data))
print(mean_absolute_error(y_test, pred_data))
print(np.sqrt(mean_squared_error(y_test, pred_data)))
```

```
35090225.72562568
4193.463021932157
5923.700340633857
```

[102]:
```
from sklearn.metrics import r2_score
score = r2_score(y_test, pred_data)
score
```

[102]: 0.7605492639270064

## 3 Using Ridge (L2 regularisation)

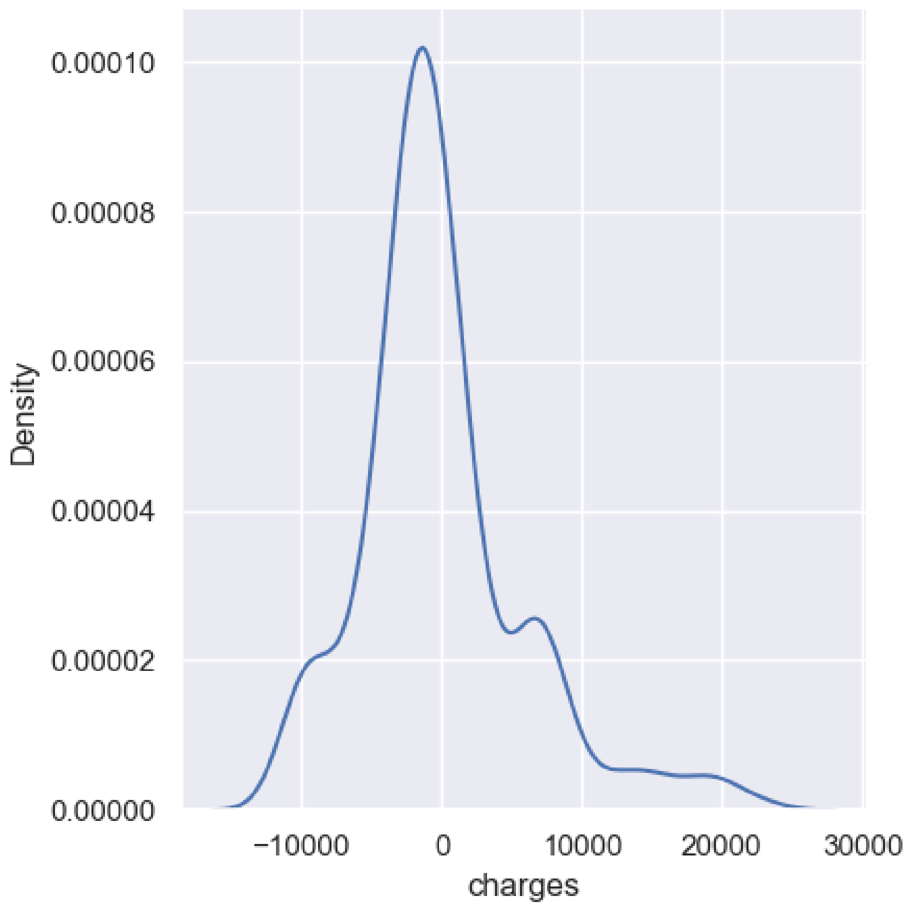
[103]:
```
from sklearn.linear_model import Ridge
ridge = Ridge()
ridge.fit(X_train, y_train)
pred_data= ridge.predict(X_test)
```

[105]:
```
plt.scatter(y_test, pred_data)
plt.xlabel("Actual data output")
plt.ylabel("Predicted data output")
```

[105]: Text(0, 0.5, 'Predicted data output')


[107]:
```
residuals= y_test - pred_data
sns.displot(residuals, kind= 'kde')
```

[107]: <seaborn.axisgrid.FacetGrid at 0x14c3325d8d0>




[108]:
```
from sklearn.metrics import mean_absolute_error, mean_squared_error
print(mean_squared_error(y_test, pred_data))
print(mean_absolute_error(y_test, pred_data))
print(np.sqrt(mean_squared_error(y_test, pred_data)))
```

```
35091586.871670134
4194.950790847867
5923.815229366133
```

[109]:
```
from sklearn.metrics import r2_score
score = r2_score(y_test, pred_data)
score
```

[109]: 0.7605399756589628

# 4 using Lasso (L1 Regularisation)

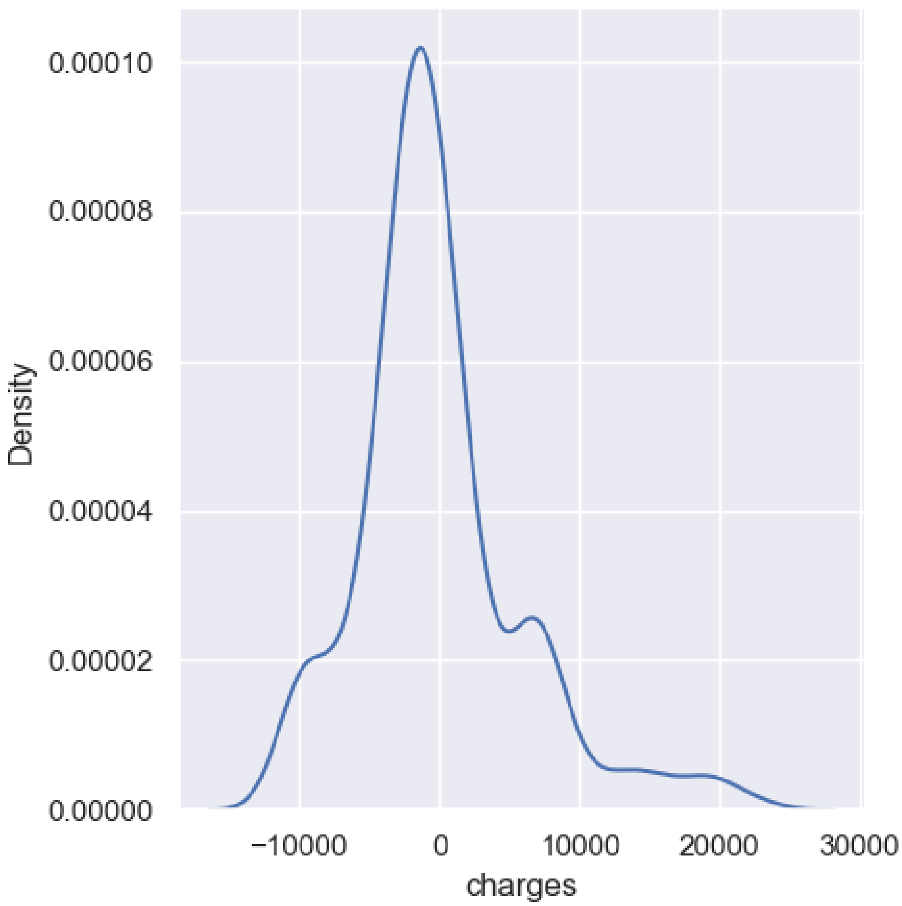
[110]:
```
from sklearn.linear_model import Lasso
lasso = Lasso()
lasso.fit(X_train, y_train)
pred_data= lasso.predict(X_test)
```

[111]:
```
plt.scatter(y_test, pred_data)
plt.xlabel("Actual data output")
plt.ylabel("Predicted data output")
```

[111]: Text(0, 0.5, 'Predicted data output')


[112]:
```
residuals= y_test - pred_data
sns.displot(residuals, kind= 'kde')
```

[112]: <seaborn.axisgrid.FacetGrid at 0x14c33b671f0>




[113]:
```
from sklearn.metrics import mean_absolute_error, mean_squared_error
print(mean_squared_error(y_test, pred_data))
print(mean_absolute_error(y_test, pred_data))
print(np.sqrt(mean_squared_error(y_test, pred_data)))
```

```
35090559.44369504
4193.3943816846895
5923.72850860799
```

[114]:
```
from sklearn.metrics import r2_score
score = r2_score(y_test, pred_data)
score
```

[114]: 0.7605469866821127

# 5 ElasticNet Linear Model

[136]:
```
from sklearn.linear_model import ElasticNet
EN = ElasticNet()
EN.fit(X_train, y_train)
pred_data = EN.predict(X_test)
```

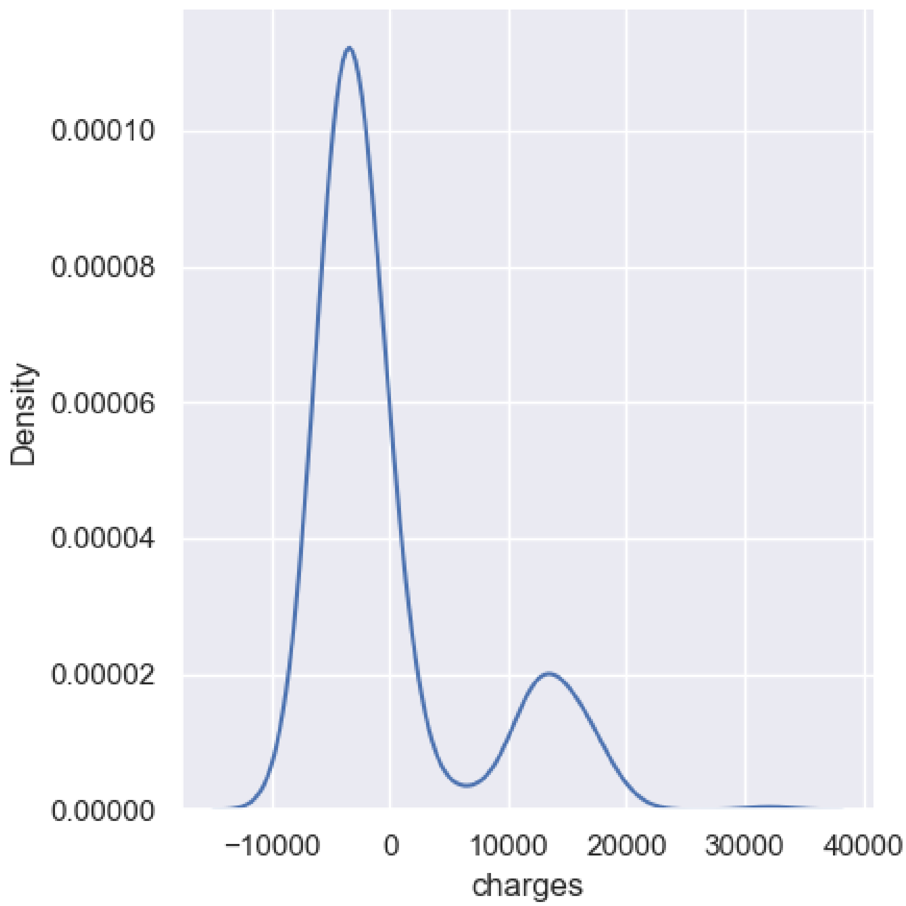
[137]:
```
plt.scatter(y_test, pred_data)
plt.xlabel("Actual test data")
plt.ylabel("predicted test data")
```

[137]: Text(0, 0.5, 'predicted test data')


[138]:
```
residual = y_test - pred_data
```

[139]:
```
sns.displot(residual, kind = 'kde')
```

[139]: <seaborn.axisgrid.FacetGrid at 0x14c33910850>




[140]:
```python
from sklearn.metrics import mean_absolute_error, mean_squared_error
print(mean_squared_error(y_test, pred_data))
print(mean_absolute_error(y_test, pred_data))
print(np.sqrt(mean_squared_error(y_test, pred_data)))
```

```
47985463.21529332
5190.321365611101
6927.154048762978
```

[141]:
```python
from sklearn.metrics import r2_score
score = r2_score(y_test, pred_data)
score
```

[141]: 0.6725539876104439

[146]:
```python
# adjusted r2 score
1-(1-score)*(len(y_test)-1)/ (len(y_test)-X_test.shape[1]-1)
```

[146]: 0.6657321956856616

```
[ ]:
```

```
[ ]:
```

```
[ ]:
```