ds-employee-salary-prediction

November 22, 2023

[4]:
```
import pandas as pd
import seaborn as sns
import matplotlib.pyplot as plt
import numpy as np
sns.set_theme(color_codes=True)
```

[5]:
```
df= pd.read_csv('ds_salaries.csv')
df.head()
```

[5]:
```
   work_year experience_level employment_type                 job_title  \
0       2023               SE              FT  Principal Data Scientist
1       2023               MI              CT             ML Engineer
2       2023               MI              CT             ML Engineer
3       2023               SE              FT           Data Scientist
4       2023               SE              FT           Data Scientist

   salary salary_currency  salary_in_usd employee_residence  remote_ratio  \
0   80000             EUR          85847                 ES           100
1   30000             USD          30000                 US           100
2   25500             USD          25500                 US           100
3  175000             USD         175000                 CA           100
4  120000             USD         120000                 CA           100

  company_location company_size
0               ES            L
1               US            S
2               US            S
3               CA            M
4               CA            M
```

1 DATA PREPROCESSING PART 1

[6]:
```
df.drop(columns=['salary','salary_currency'],inplace=True)                #drop␣
 ↪salary and salary column and make usd universal
df.head()
```

[6]:
```
   work_year experience_level employment_type                 job_title  \
0       2023               SE              FT  Principal Data Scientist
1       2023               MI              CT               ML Engineer
2       2023               MI              CT               ML Engineer
3       2023               SE              FT            Data Scientist
4       2023               SE              FT            Data Scientist

   salary_in_usd employee_residence  remote_ratio company_location  \
0          85847                 ES           100               ES
1          30000                 US           100               US
2          25500                 US           100               US
3         175000                 CA           100               CA
4         120000                 CA           100               CA

  company_size
0            L
1            S
2            S
3            M
4            M
```

[7]:
```
check_missing=df.isnull().sum()*100/df.shape[0]                                #check
 ↪the missing value
check_missing[check_missing>0].sort_values(ascending=False)
```

[7]:
```
Series([], dtype: float64)
```

[8]:
```
df.select_dtypes(include='object').nunique()       #check the number of unique
 ↪value in an object datatype
```

[8]:
```
experience_level       4
employment_type        4
job_title             93
employee_residence    78
company_location      72
company_size           3
dtype: int64
```

2 CATEGORIZE THE JOB TITLE

[9]:
```
df.job_title.unique()
```

[9]:
```
array(['Principal Data Scientist', 'ML Engineer', 'Data Scientist',
       'Applied Scientist', 'Data Analyst', 'Data Modeler',
       'Research Engineer', 'Analytics Engineer',
       'Business Intelligence Engineer', 'Machine Learning Engineer',
```

```
       'Data Strategist', 'Data Engineer', 'Computer Vision Engineer',
       'Data Quality Analyst', 'Compliance Data Analyst',
       'Data Architect', 'Applied Machine Learning Engineer',
       'AI Developer', 'Research Scientist', 'Data Analytics Manager',
       'Business Data Analyst', 'Applied Data Scientist',
       'Staff Data Analyst', 'ETL Engineer', 'Data DevOps Engineer',
       'Head of Data', 'Data Science Manager', 'Data Manager',
       'Machine Learning Researcher', 'Big Data Engineer',
       'Data Specialist', 'Lead Data Analyst', 'BI Data Engineer',
       'Director of Data Science', 'Machine Learning Scientist',
       'MLOps Engineer', 'AI Scientist', 'Autonomous Vehicle Technician',
       'Applied Machine Learning Scientist', 'Lead Data Scientist',
       'Cloud Database Engineer', 'Financial Data Analyst',
       'Data Infrastructure Engineer', 'Software Data Engineer',
       'AI Programmer', 'Data Operations Engineer', 'BI Developer',
       'Data Science Lead', 'Deep Learning Researcher', 'BI Analyst',
       'Data Science Consultant', 'Data Analytics Specialist',
       'Machine Learning Infrastructure Engineer', 'BI Data Analyst',
       'Head of Data Science', 'Insight Analyst',
       'Deep Learning Engineer', 'Machine Learning Software Engineer',
       'Big Data Architect', 'Product Data Analyst',
       'Computer Vision Software Engineer', 'Azure Data Engineer',
       'Marketing Data Engineer', 'Data Analytics Lead', 'Data Lead',
       'Data Science Engineer', 'Machine Learning Research Engineer',
       'NLP Engineer', 'Manager Data Management',
       'Machine Learning Developer', '3D Computer Vision Researcher',
       'Principal Machine Learning Engineer', 'Data Analytics Engineer',
       'Data Analytics Consultant', 'Data Management Specialist',
       'Data Science Tech Lead', 'Data Scientist Lead',
       'Cloud Data Engineer', 'Data Operations Analyst',
       'Marketing Data Analyst', 'Power BI Developer',
       'Product Data Scientist', 'Principal Data Architect',
       'Machine Learning Manager', 'Lead Machine Learning Engineer',
       'ETL Developer', 'Cloud Data Architect', 'Lead Data Engineer',
       'Head of Machine Learning', 'Principal Data Analyst',
       'Principal Data Engineer', 'Staff Data Scientist',
       'Finance Data Analyst'], dtype=object)
```

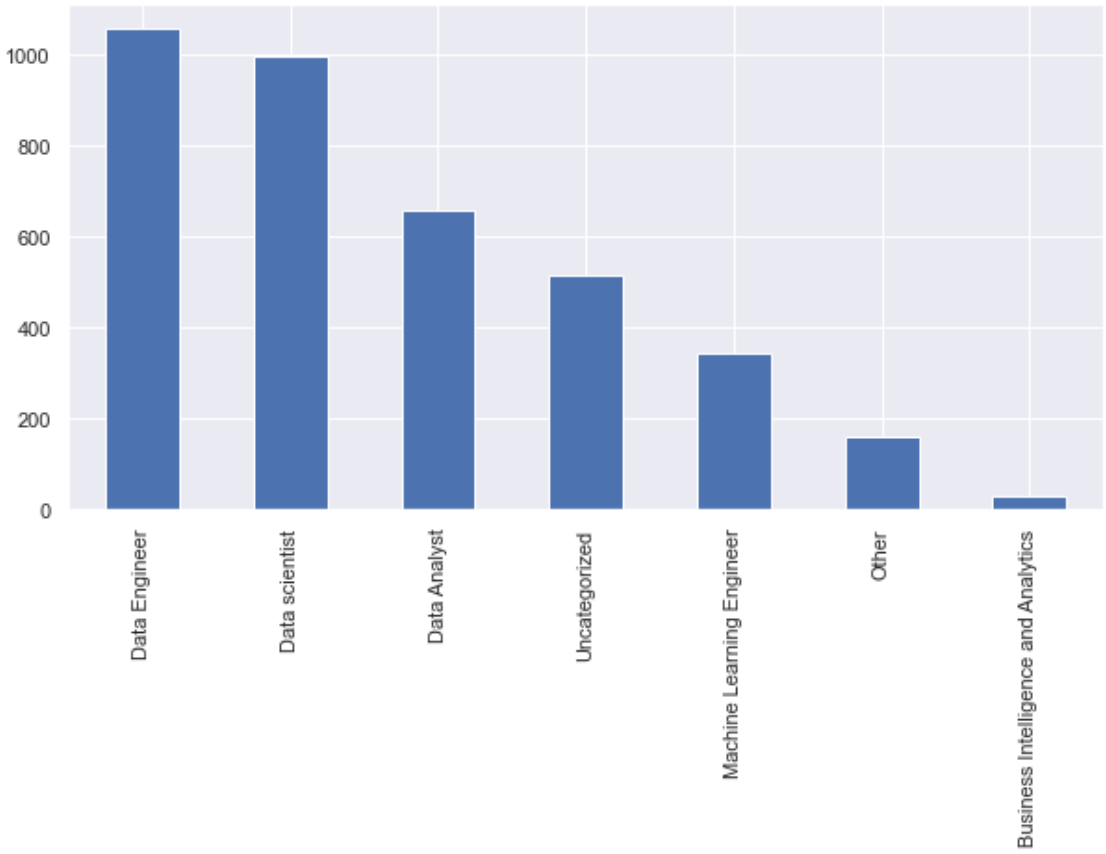
[10]:
```
def segment_job_title(job_title):
    Data_scientist_titles=['Principal Data Scientist','Data Scientist','Applied␣
 ↪Scientist','Research Scientist','Applied Data Scientist']
    Machine_learning_titles=['ML Engineer','Machine Learning Engineer','Applied␣
 ↪Machine Learning Engineer','Machine Learning Software Engineer','NLP␣
 ↪Engineer']
    Data_analyst_titles=['Data Analyst', 'Data Quality Analyst','Compliance␣
 ↪Data Analyst', 'Business Data Analyst','Data Analytics Manager']
```

```
    Data_engineer_titles=['Data Modeler', 'Data Engineer','ETL Engineer','Data␣
↪DevOps Engineer','Data Science Engineer','Data Infrastructure Engineer']
    Bi_analytics_titles=['Data Analytics Manager','Computer Vision␣
↪Engineer','AI Developer','Big Data Architect''Head of Data Science']
    Other_titles=['BI Data Engineer','Director of Data Science', 'Machine␣
↪Learning Scientist','MLOps Engineer', 'AI Scientist', 'Autonomous Vehicle␣
↪Technician','Applied Machine Learning Scientist', 'Lead Data␣
↪Scientist','Cloud Database Engineer', 'Financial Data Analyst','Data␣
↪Infrastructure Engineer', 'Software Data Engineer','AI Programmer', 'Data␣
↪Operations Engineer', 'BI Developer','Data Science Lead', 'Deep Learning␣
↪Researcher', 'BI Analyst','Data Science Consultant', 'Data Analytics␣
↪Specialist']

    if job_title in Data_scientist_titles:
        return 'Data scientist'
    elif job_title in Machine_learning_titles:
        return 'Machine Learning Engineer'
    elif job_title in Data_analyst_titles:
        return 'Data Analyst'
    elif job_title in Data_engineer_titles:
        return 'Data Engineer'
    elif job_title in Bi_analytics_titles:
        return 'Business Intelligence and Analytics'
    elif job_title in Other_titles:
        return 'Other'
    else:
        return 'Uncategorized'
```

[11]:
```
df['job_title']=df['job_title'].apply(segment_job_title)
```

[12]:
```
plt.figure(figsize=(10,5))
df['job_title'].value_counts().plot(kind='bar')
```

[12]: <AxesSubplot:>



3 CATEGORIZE THE EMPLOYEE RESIDENCE

[13]:
```
df.employee_residence.unique()
```

[13]:
```
array(['ES', 'US', 'CA', 'DE', 'GB', 'NG', 'IN', 'HK', 'PT', 'NL', 'CH',
       'CF', 'FR', 'AU', 'FI', 'UA', 'IE', 'IL', 'GH', 'AT', 'CO', 'SG',
       'SE', 'SI', 'MX', 'UZ', 'BR', 'TH', 'HR', 'PL', 'KW', 'VN', 'CY',
       'AR', 'AM', 'BA', 'KE', 'GR', 'MK', 'LV', 'RO', 'PK', 'IT', 'MA',
       'LT', 'BE', 'AS', 'IR', 'HU', 'SK', 'CN', 'CZ', 'CR', 'TR', 'CL',
       'PR', 'DK', 'BO', 'PH', 'DO', 'EG', 'ID', 'AE', 'MY', 'JP', 'EE',
       'HN', 'TN', 'RU', 'DZ', 'IQ', 'BG', 'JE', 'RS', 'NZ', 'MD', 'LU',
       'MT'], dtype=object)
```

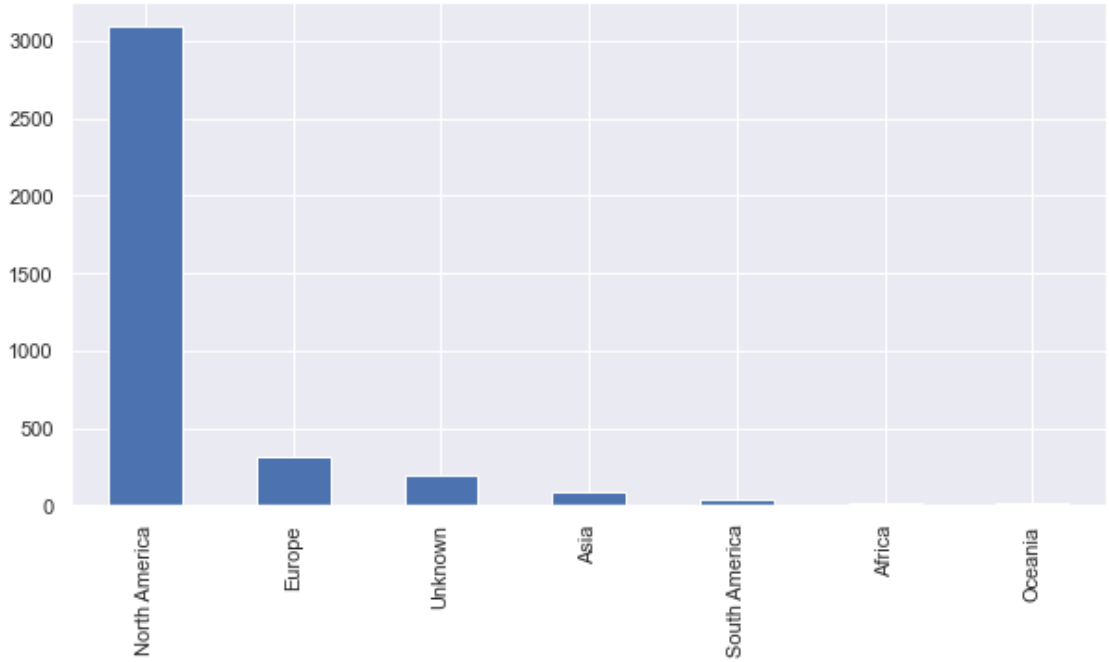
[14]:
```
def categorize_region(country):
    if country in ['DE','GB','PT','NL','CH','CF','FR','FI','UA','IE','AT']:
        return 'Europe'
    elif country in ['US','CA','MX']:
        return 'North America'
    elif country in ['BR','AR','CL','BO','CR','DO','PR','HN','UV']:
```

```
        return 'South America'
    elif country in ['NG','GH','KE','TN','DZ']:
        return 'Africa'
    elif country in ['HK','IN','CN','JP','KR','BD','VN','PH','MY','ID','AE']:
        return 'Asia'
    elif country in ['AU','NZ']:
        return 'Oceania'
    else :
        return 'Unknown'
```

[15]:
```
df['employee_residence']=df['employee_residence'].apply(categorize_region)
```

[16]:
```
plt.figure(figsize=(10,5))
df['employee_residence'].value_counts().plot(kind='bar')
```

[16]: <AxesSubplot:>



4 CATEGORIZE THE COMPANY LOCATION

[17]:
```
df.company_location.unique()
```

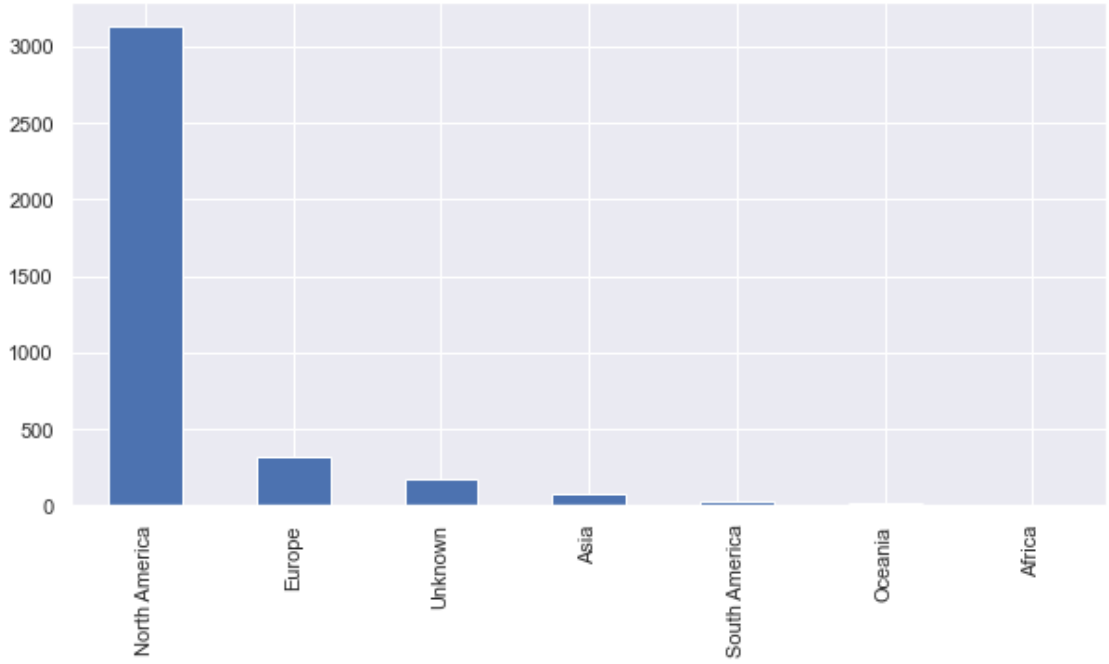
[17]:
```
array(['ES', 'US', 'CA', 'DE', 'GB', 'NG', 'IN', 'HK', 'NL', 'CH', 'CF',
       'FR', 'FI', 'UA', 'IE', 'IL', 'GH', 'CO', 'SG', 'AU', 'SE', 'SI',
       'MX', 'BR', 'PT', 'RU', 'TH', 'HR', 'VN', 'EE', 'AM', 'BA', 'KE',
```

```
'GR', 'MK', 'LV', 'RO', 'PK', 'IT', 'MA', 'PL', 'AL', 'AR', 'LT',
'AS', 'CR', 'IR', 'BS', 'HU', 'AT', 'SK', 'CZ', 'TR', 'PR', 'DK',
'BO', 'PH', 'BE', 'ID', 'EG', 'AE', 'LU', 'MY', 'HN', 'JP', 'DZ',
'IQ', 'CN', 'NZ', 'CL', 'MD', 'MT'], dtype=object)
```

[18]:
```
df['company_location']=df['company_location'].apply(categorize_region)
```

[19]:
```
plt.figure(figsize=(10,5))
df['company_location'].value_counts().plot(kind='bar')
```

[19]:
```
<AxesSubplot:>
```



[20]:
```
#check the number of unique values on object datatype
df.select_dtypes(include='object').nunique()
```

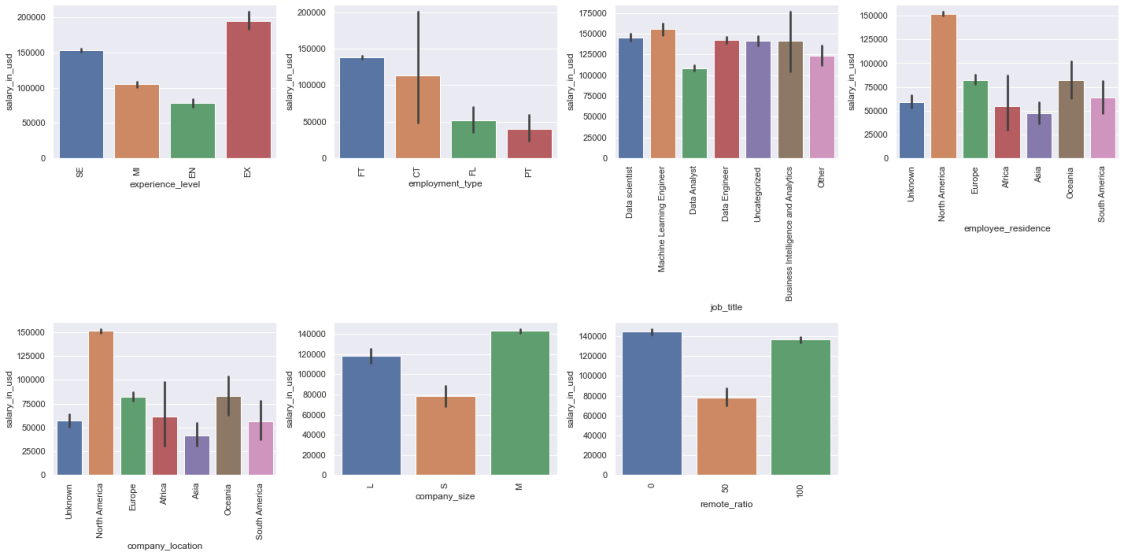
[20]:
```
experience_level      4
employment_type       4
job_title             7
employee_residence    7
company_location      7
company_size          3
dtype: int64
```

5 EXPLORATORY DATA ANALYSIS

[21]:
```
df.remote_ratio.unique()
```

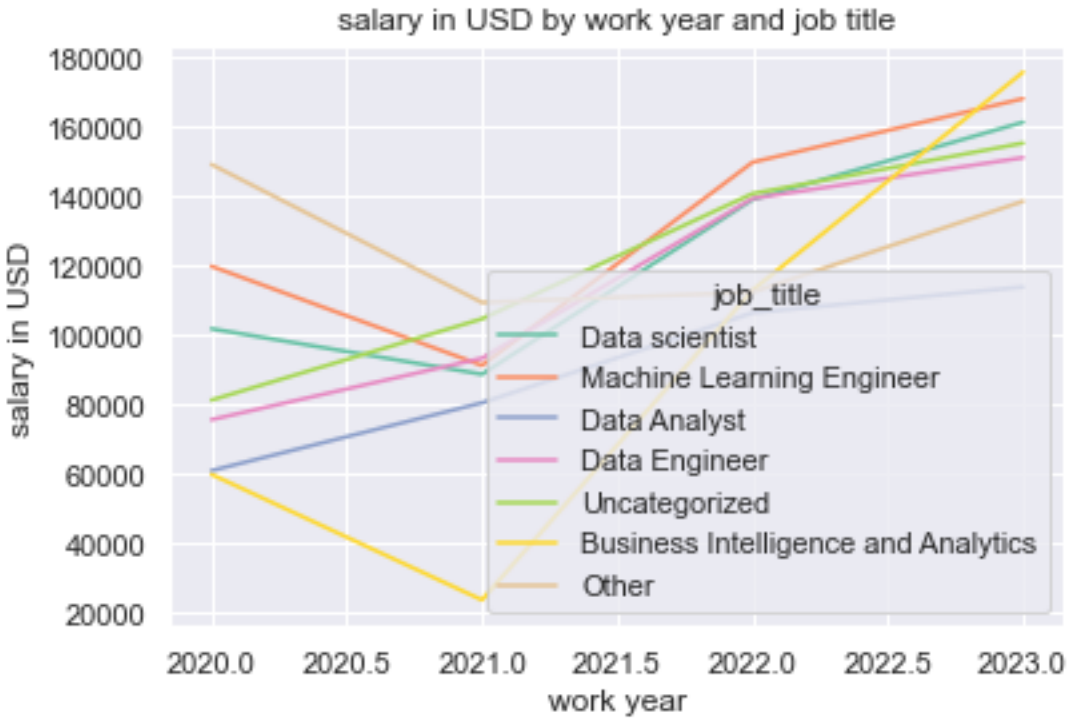
[21]:
```
array([100,   0,  50], dtype=int64)
```

[22]:
```
#list of categorical variables to plot
cat_vars=['experience_level','employment_type','job_title','employee_residence',
          'company_location','company_size','remote_ratio']

#create figure with subplots
fig,axs=plt.subplots(nrows=2,ncols=4,figsize=(20,10))
axs=axs.flatten()

#create barplot for each categroical variable
for i,var in enumerate(cat_vars):
    sns.barplot(x=var,y='salary_in_usd',data=df,ax=axs[i],estimator=np.mean)
    axs[i].set_xticklabels(axs[i].get_xticklabels(),rotation=90)

#remove the eighth subplot
fig.delaxes(axs[7])

#adjust spacing between subplots
fig.tight_layout()

#show plot
plt.show()
```



[23]:
```
sns.set_style("darkgrid")

sns.set_palette("Set2")

sns.
 ↪lineplot(x='work_year',y='salary_in_usd',hue='job_title',data=df,ci=None,estimator=np.
 ↪mean)

plt.title("salary in USD by work year and job title")

plt.xlabel("work year")

plt.ylabel("salary in USD")

plt.show
```

[23]:
```
<function matplotlib.pyplot.show(close=None, block=None)>
```



6 DATA PREPROCESSING PART 2

7 LABEL ENCODING FOR OBJECT DATATYPE

[24]:
```
#LOOP FOR EACH COLUMN IN THE DATAFRAME WHERE DTYPE IS OBJECT
for col in df.select_dtypes(include=['object']).columns:

    #print the column name and unique values
    print(f"{col}:{df[col].unique()}")
```

```
experience_level:['SE' 'MI' 'EN' 'EX']
employment_type:['FT' 'CT' 'FL' 'PT']
job_title:['Data scientist' 'Machine Learning Engineer' 'Data Analyst'
 'Data Engineer' 'Uncategorized' 'Business Intelligence and Analytics'
 'Other']
employee_residence:['Unknown' 'North America' 'Europe' 'Africa' 'Asia' 'Oceania'
 'South America']
company_location:['Unknown' 'North America' 'Europe' 'Africa' 'Asia' 'Oceania'
 'South America']
company_size:['L' 'S' 'M']
```

[25]:
```
from sklearn import preprocessing

#loop over each column in the dataframe where dtype is object
for col in df.select_dtypes(include=['object']).columns:

    #initialize a label encoder object
    label_encoder=preprocessing.LabelEncoder()

    #fit the encoder to the unique values in column
    label_encoder.fit(df[col].unique())

    #transform the column using encoder
    df[col]=label_encoder.transform(df[col])

    #print the column name and the unique encoded value
    print(f"{col}:{df[col].unique()}")
```

```
experience_level:[3 2 0 1]
employment_type:[2 0 1 3]
job_title:[3 4 1 2 6 0 5]
employee_residence:[6 3 2 0 1 4 5]
company_location:[6 3 2 0 1 4 5]
company_size:[0 2 1]
```

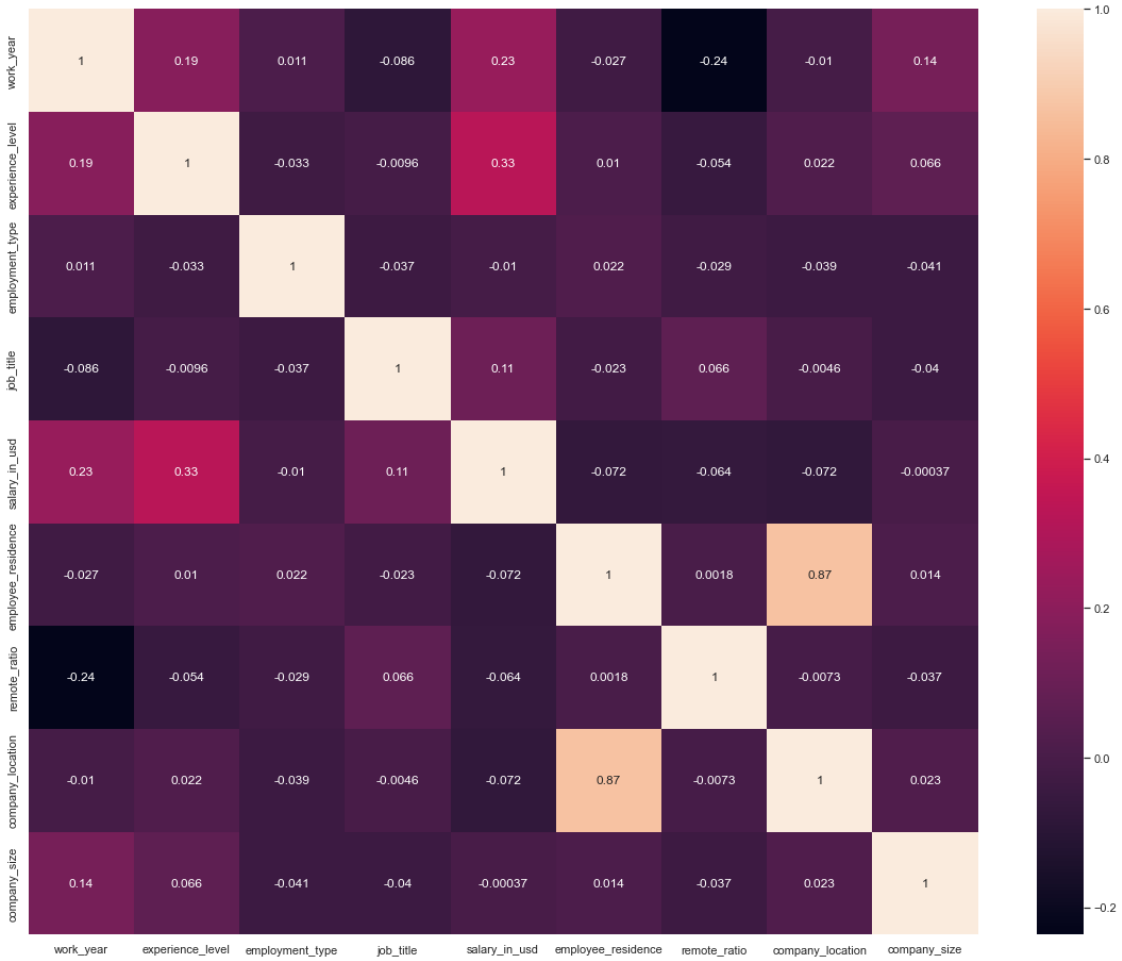
[26]:
```
df.dtypes
```

[26]:
```
work_year              int64
experience_level       int32
employment_type        int32
job_title              int32
salary_in_usd          int64
employee_residence     int32
remote_ratio           int64
company_location       int32
company_size           int32
dtype: object
```

8 ALL OF THE DATA ARE CATEGORICAL SO IT MEANS NO OUTLIERS

[27]:
```
#CORRELATION HEATMAP
plt.figure(figsize=(20,16))
sns.heatmap(df.corr(),fmt='.2g',annot=True)
```

[27]: <AxesSubplot:>



9 TRAIN TEST SPLIT

[28]:
```
x=df.drop('salary_in_usd',axis=1)
y=df['salary_in_usd']
```

[29]:
```
#test size 20% and train size 80%
from sklearn.model_selection import train_test_split
from sklearn.metrics import accuracy_score
x_train,x_test,y_train,y_test=train_test_split(x,y,test_size=0.2,random_state=0)
```

10 DECSION TREE REGRESSOR

[30]:
```
from sklearn.tree import DecisionTreeRegressor
from sklearn.model_selection import GridSearchCV
from sklearn.datasets import load_boston

#create a DecesionTreeRegressor object
dtree=DecisionTreeRegressor()

#define the hyperparameters to tune and their values
param_grid={
    'max_depth':[2,4,6,8],
    'min_samples_split':[2,4,6,8],
    'min_samples_leaf':[1,2,3,4],
    'max_features':['auto','sqrt','log2']
}

#create a gridsearchCV object
grid_search=GridSearchCV(dtree,param_grid,cv=5,scoring='neg_mean_squared_error')

#fit the grid SearchCV object to the data
grid_search.fit(x_train,y_train)

#print the best hyperparameters
print(grid_search.best_params_)
```

```
{'max_depth': 6, 'max_features': 'auto', 'min_samples_leaf': 4,
'min_samples_split': 2}
```

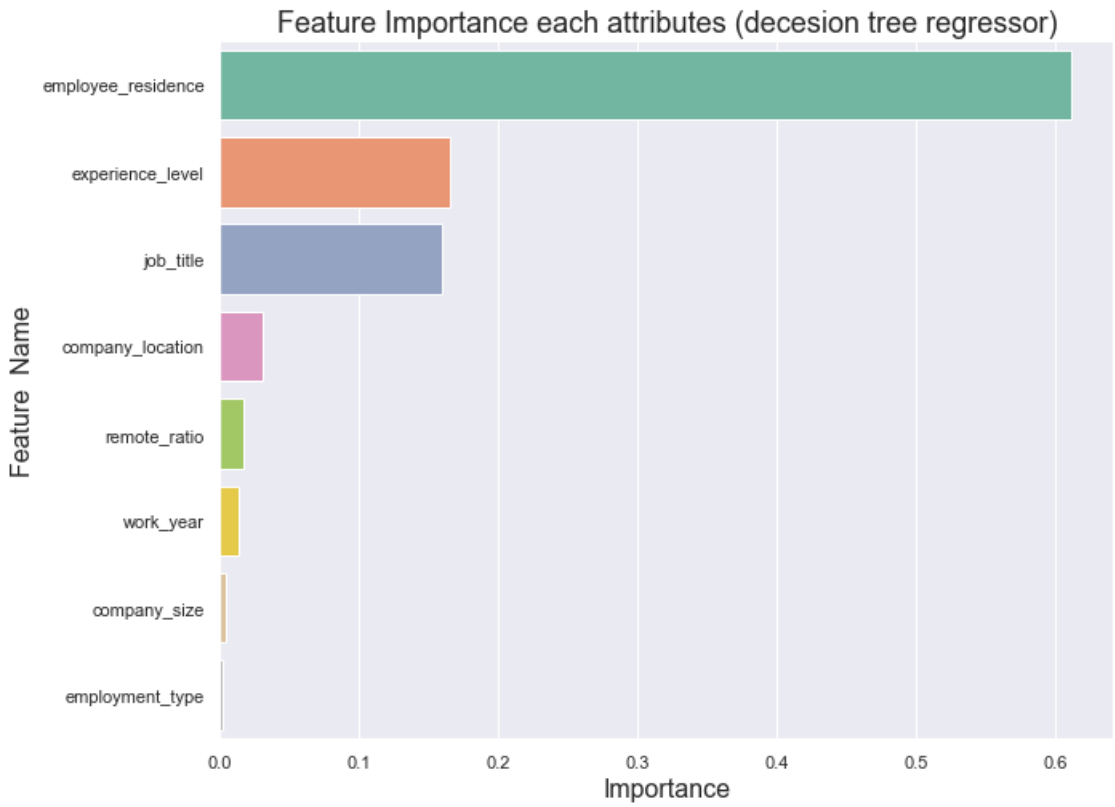
[31]:
```
from sklearn.tree import DecisionTreeRegressor
dtree=DecisionTreeRegressor(random_state=0,max_depth=6,max_features='auto',min_samples_leaf=3,
                            min_samples_split=4)
dtree.fit(x_train,y_train)
```

[31]:
```
DecisionTreeRegressor(max_depth=6, max_features='auto', min_samples_leaf=3,
                      min_samples_split=4, random_state=0)
```

[32]:
```
from sklearn import metrics
from sklearn.metrics import mean_absolute_percentage_error
import math
y_pred=dtree.predict(x_test)
mae=metrics.mean_absolute_error(y_test,y_pred)
mape=mean_absolute_percentage_error(y_test,y_pred)
mse=metrics.mean_squared_error(y_test,y_pred)
r2=metrics.r2_score(y_test,y_pred)
rmse=math.sqrt(mse)

print('MAE is {}'.format(mae))
print('MAPE is {}'.format(mape))
print('MSE is {}'.format(mse))
print('R2 is {}'.format(r2))
print('RMSE is {}'.format(rmse))
```

```
MAE is 39199.20449153232
MAPE is 0.3788760851914734
MSE is 2791704843.838858
R2 is 0.34567613253704854
RMSE is 52836.586224309176
```

[33]:
```
imp_df=pd.DataFrame({
    "Feature Name":x_train.columns,
    "Importance":dtree.feature_importances_
})
fi=imp_df.sort_values(by="Importance",ascending=False)
fi2=fi.head(10)
plt.figure(figsize=(10,8))
sns.barplot(data=fi2,x='Importance',y='Feature Name')
plt.title('Feature Importance each attributes (decesion tree␣
 ↪regressor)',fontsize=18)
plt.xlabel('Importance',fontsize=16)
plt.ylabel('Feature  Name',fontsize=16)
plt.show()
```

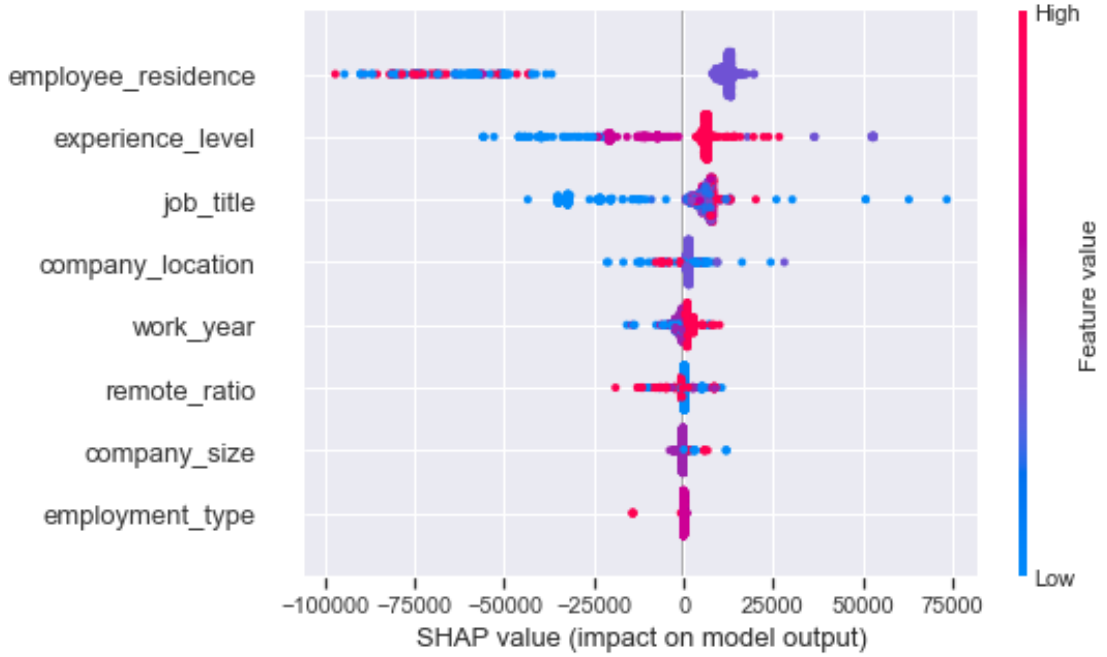


[34]:
```
pip install shap #The SHAP used to calculate the SHAP values of a model␣
↪efficiently
```

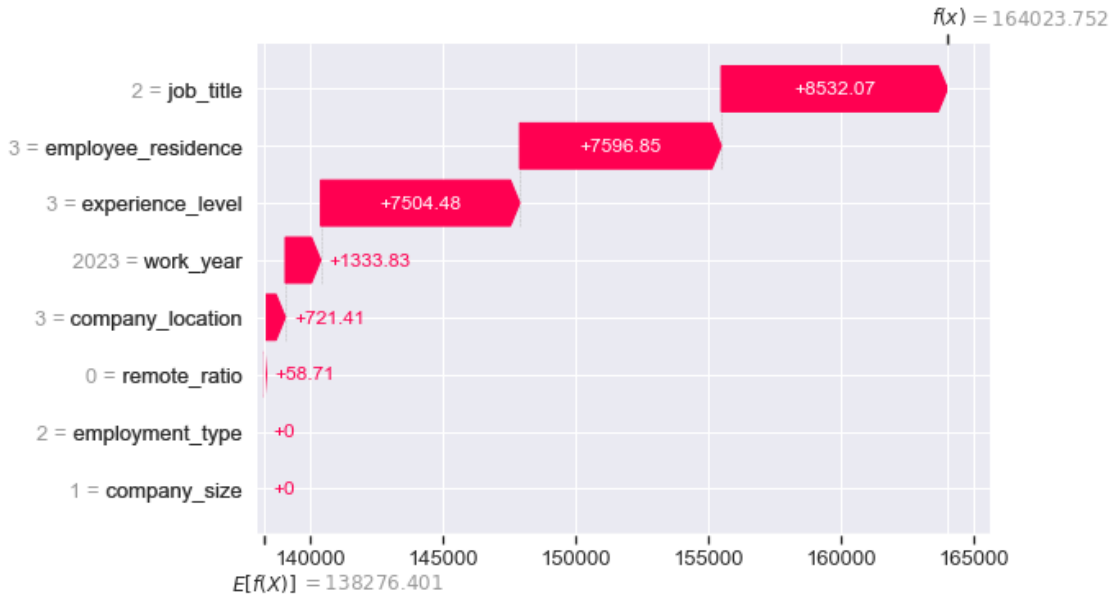
```
Requirement already satisfied: shap in c:\brm\lib\site-packages (0.41.0)
Requirement already satisfied: cloudpickle in c:\brm\lib\site-packages (from
shap) (2.0.0)
Requirement already satisfied: slicer==0.0.7 in c:\brm\lib\site-packages (from
shap) (0.0.7)
Requirement already satisfied: pandas in c:\brm\lib\site-packages (from shap)
(1.4.2)
Requirement already satisfied: tqdm>4.25.0 in c:\brm\lib\site-packages (from
shap) (4.64.0)
Requirement already satisfied: scipy in c:\brm\lib\site-packages (from shap)
(1.7.3)
Requirement already satisfied: numba in c:\brm\lib\site-packages (from shap)
(0.55.1)
Requirement already satisfied: numpy in c:\brm\lib\site-packages (from shap)
(1.21.5)
Requirement already satisfied: packaging>20.9 in c:\brm\lib\site-packages (from
shap) (21.3)
Requirement already satisfied: scikit-learn in c:\brm\lib\site-packages (from
shap) (1.0.2)
```

```
Requirement already satisfied: pyparsing!=3.0.5,>=2.0.2 in c:\brm\lib\site-
packages (from packaging>20.9->shap) (3.0.4)
Requirement already satisfied: colorama in c:\brm\lib\site-packages (from
tqdm>4.25.0->shap) (0.4.4)
Requirement already satisfied: llvmlite<0.39,>=0.38.0rc1 in c:\brm\lib\site-
packages (from numba->shap) (0.38.0)
Requirement already satisfied: setuptools in c:\brm\lib\site-packages (from
numba->shap) (61.2.0)
Requirement already satisfied: python-dateutil>=2.8.1 in c:\brm\lib\site-
packages (from pandas->shap) (2.8.2)
Requirement already satisfied: pytz>=2020.1 in c:\brm\lib\site-packages (from
pandas->shap) (2021.3)
Requirement already satisfied: six>=1.5 in c:\brm\lib\site-packages (from
python-dateutil>=2.8.1->pandas->shap) (1.16.0)
Requirement already satisfied: joblib>=0.11 in c:\brm\lib\site-packages (from
scikit-learn->shap) (1.1.0)
Requirement already satisfied: threadpoolctl>=2.0.0 in c:\brm\lib\site-packages
(from scikit-learn->shap) (2.2.0)
Note: you may need to restart the kernel to use updated packages.
```

[35]:
```
import shap
explainer=shap.TreeExplainer(dtree)
shap_values=explainer.shap_values(x_test)
shap.summary_plot(shap_values,(x_test))
```



[36]:
```
explainer=shap.TreeExplainer(dtree,x_test)
shap_values=explainer(x_test)
shap.plots.waterfall(shap_values[0])
```



11 RANDOM FOREST REGRESSOR

[38]:
```
from sklearn.ensemble import RandomForestRegressor
from sklearn.model_selection import GridSearchCV


#create a RandomForestRegressor object
rf=RandomForestRegressor()

#define the hyperparameters grid
param_grid={
    'max_depth':[3,5,7,9],
    'min_samples_split':[2,5,10],
    'min_samples_leaf':[1,2,4],
    'max_features':['auto','sqrt']
}

#create a gridsearchCV object
grid_search=GridSearchCV(rf,param_grid,cv=5,scoring='r2')

#fit the grid SearchCV object to the training data
grid_search.fit(x_train,y_train)
```

```
#print the best hyperparameters
print("Best Hyper parameters:",grid_search.best_params_)
```

```
Best Hyper parameters: {'max_depth': 7, 'max_features': 'auto',
'min_samples_leaf': 4, 'min_samples_split': 5}
```

[39]:
```
from sklearn.ensemble import RandomForestRegressor
rf=RandomForestRegressor(random_state=0,max_depth=7,min_samples_split=10,min_samples_leaf=2,ma
rf.fit(x_train,y_train)
```

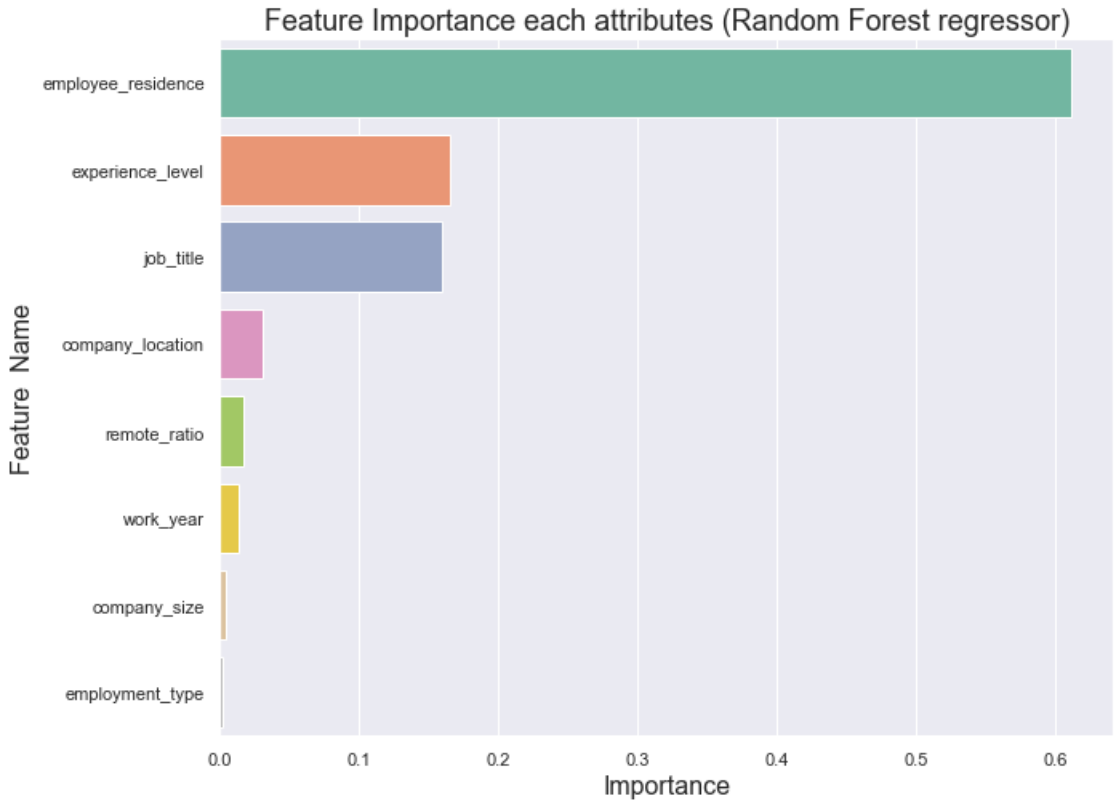
[39]:
```
RandomForestRegressor(max_depth=7, min_samples_leaf=2, min_samples_split=10,
                      random_state=0)
```

[40]:
```
from sklearn import metrics
from sklearn.metrics import mean_absolute_percentage_error
import math
y_pred=rf.predict(x_test)
mae=metrics.mean_absolute_percentage_error(y_test,y_pred)
mape=mean_absolute_percentage_error(y_test,y_pred)
mse=metrics.mean_squared_error(y_test,y_pred)
r2=metrics.r2_score(y_test,y_pred)
rmse=math.sqrt(mse)

print('MAE is{}'.format(mae))
print('MAPE is {}'.format(mape))
print('MSE is {}'.format(mse))
print('R2  score is {}'.format(r2))
print('RMSE score is {}'.format(rmse))
```

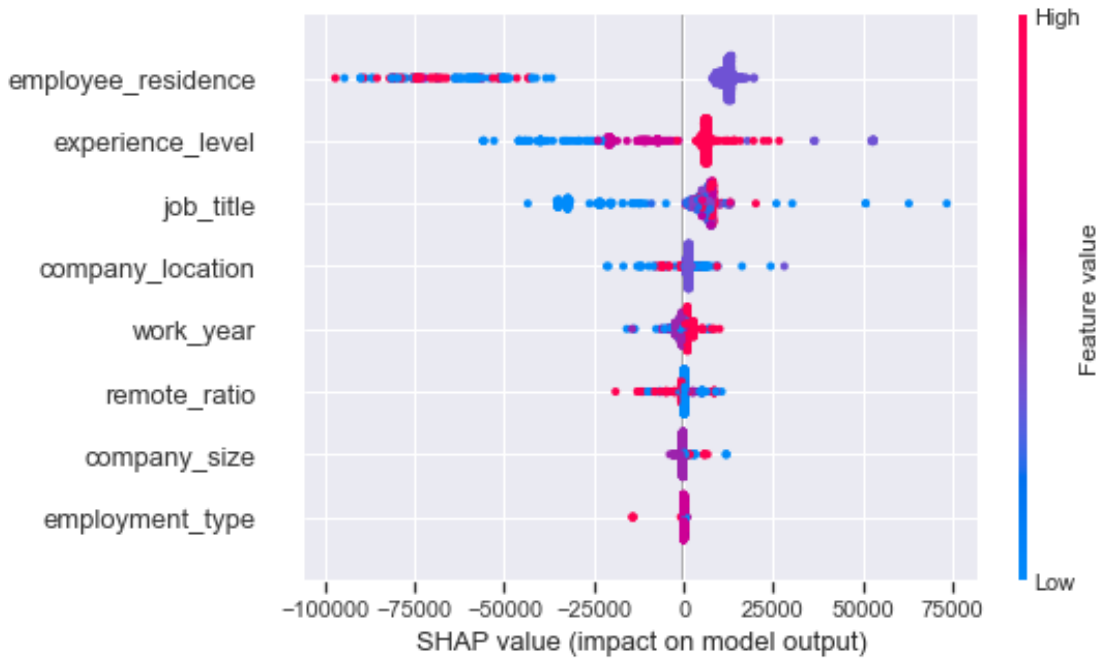
```
MAE is0.3622058931721429
MAPE is 0.3622058931721429
MSE is 2710975143.538173
R2  score is 0.3645976778560128
RMSE score is 52067.02549155438
```

[41]:
```
imp_df=pd.DataFrame({
    "Feature Name":x_train.columns,
    "Importance":dtree.feature_importances_
})
fi=imp_df.sort_values(by="Importance",ascending=False)
fi2=fi.head(10)
plt.figure(figsize=(10,8))
sns.barplot(data=fi2,x='Importance',y='Feature Name')
plt.title('Feature Importance each attributes (Random Forest␣
 ↪regressor)',fontsize=18)
plt.xlabel('Importance',fontsize=16)
```

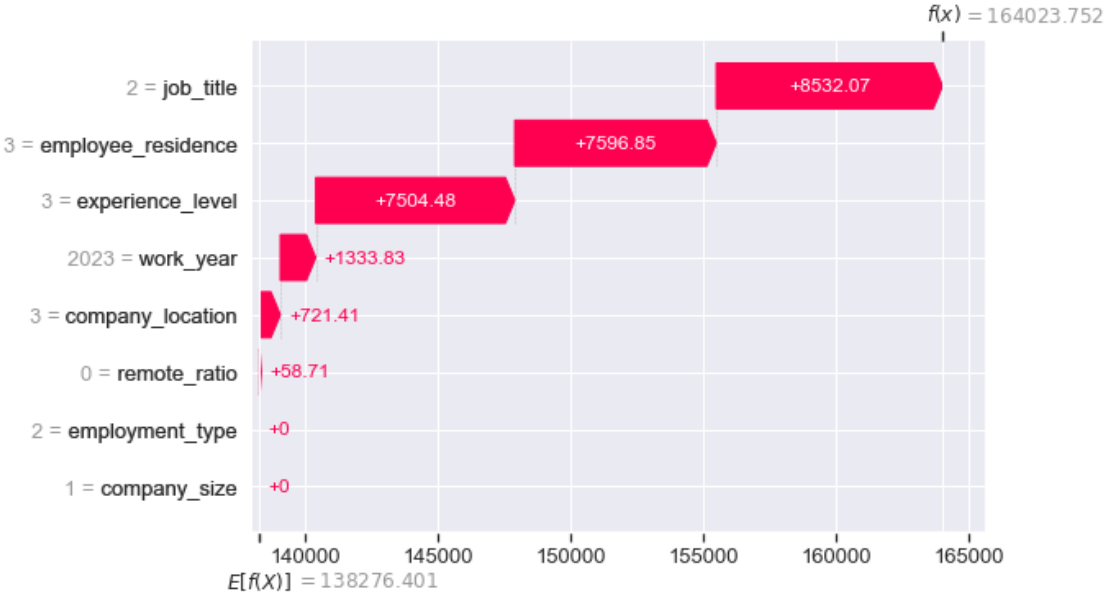
```
plt.ylabel('Feature  Name',fontsize=16)
plt.show()
```



[42]:
```
import shap
explainer=shap.TreeExplainer(dtree)
shap_values=explainer.shap_values(x_test)
shap.summary_plot(shap_values,(x_test))
```



[43]:
```
explainer=shap.TreeExplainer(dtree,x_test)
shap_values=explainer(x_test)
shap.plots.waterfall(shap_values[0])
```



[ ]: