In [1]:
```
import pandas as pd

url = "modified_property_data.csv"
data = pd.read_csv(url)
data
```

Out[1]:

	SquareFeet	Density	City	price
0	850	low	CityA	425000
1	779	medium	CityB	467040
2	990	medium	CityA	693000
3	665	medium	CityC	399000
4	550	medium	CityC	330000
5	880	medium	CityB	528000
6	567	low	CityB	283500
7	1020	low	CityB	408000
8	2067	high	CityC	1447830
9	577	high	CityA	462400
10	989	medium	CityA	692300
11	720	low	CityC	216000
12	585	high	CityA	468000
13	656	medium	CityC	393600
14	788	high	CityC	551600
15	1222	high	CityB	977600
16	565	high	CityA	452000
17	844	high	CityC	590800
18	744	low	CityA	372000
19	1356	high	CityB	1084800
20	1555	low	CityB	622000
21	2000	high	CityC	1400000
22	647	low	CityA	323500
23	769	low	CityC	230700
24	855	medium	CityB	513000
25	900	medium	CityA	630000
26	456	medium	CityC	273600
27	669	low	CityB	334500
28	1899	high	CityA	1519200
29	633	low	CityC	189900

	SquareFeet	Density	City	price
30	890	medium	CityB	534000
31	946	low	CityC	283800
32	1235	low	CityA	617500

In [2]:
```
#pre-data processing
#convert sqft to m^2
#convert price to k

data["SquareFeet"] = data["SquareFeet"] * 0.092903
data['price'] = data['price'] / 1000
```

In [3]:
```
data["Density"] = data["Density"].map({"low": 0, "medium": 1, "high" : 2})
data
```

Out[3]:

	SquareFeet	Density	City	price
0	78.967550	0	CityA	425.00
1	72.371437	1	CityB	467.04
2	91.973970	1	CityA	693.00
3	61.780495	1	CityC	399.00
4	51.096650	1	CityC	330.00
5	81.754640	1	CityB	528.00
6	52.676001	0	CityB	283.50
7	94.761060	0	CityB	408.00
8	192.030501	2	CityC	1447.83
9	53.605031	2	CityA	462.40
10	91.881067	1	CityA	692.30
11	66.890160	0	CityC	216.00
12	54.348255	2	CityA	468.00
13	60.944368	1	CityC	393.60
14	73.207564	2	CityC	551.60
15	113.527466	2	CityB	977.60
16	52.490195	2	CityA	452.00
17	78.410132	2	CityC	590.80
18	69.119832	0	CityA	372.00
19	125.976468	2	CityB	1084.80
20	144.464165	0	CityB	622.00
21	185.806000	2	CityC	1400.00
22	60.108241	0	CityA	323.50
23	71.442407	0	CityC	230.70
24	79.432065	1	CityB	513.00
25	83.612700	1	CityA	630.00
26	42.363768	1	CityC	273.60
27	62.152107	0	CityB	334.50
28	176.422797	2	CityA	1519.20
29	58.807599	0	CityC	189.90

	SquareFeet	Density	City	price
30	82.683670	1	CityB	534.00
31	87.886238	0	CityC	283.80
32	114.735205	0	CityA	617.50

One Hot Encoding

In [4]:
```
#Convert City to CityA, CityB, CityC
#drop CityC is because if CityA and CityB are 0. it means it is CityC
```

In [5]:
```
from sklearn.preprocessing import OneHotEncoder

onehot_encoder = OneHotEncoder()
onehot_encoder.fit(data[["City"]])
city_encoded = onehot_encoder.transform(data[["City"]]).toarray()

data[["CityA","CityB","CityC"]] = city_encoded
data = data.drop(["City","CityC"],axis=1)
data
```

Out[5]:

	SquareFeet	Density	price	CityA	CityB
0	78.967550	0	425.00	1.0	0.0
1	72.371437	1	467.04	0.0	1.0
2	91.973970	1	693.00	1.0	0.0
3	61.780495	1	399.00	0.0	0.0
4	51.096650	1	330.00	0.0	0.0
5	81.754640	1	528.00	0.0	1.0
6	52.676001	0	283.50	0.0	1.0
7	94.761060	0	408.00	0.0	1.0
8	192.030501	2	1447.83	0.0	0.0
9	53.605031	2	462.40	1.0	0.0
10	91.881067	1	692.30	1.0	0.0
11	66.890160	0	216.00	0.0	0.0
12	54.348255	2	468.00	1.0	0.0
13	60.944368	1	393.60	0.0	0.0
14	73.207564	2	551.60	0.0	0.0
15	113.527466	2	977.60	0.0	1.0
16	52.490195	2	452.00	1.0	0.0
17	78.410132	2	590.80	0.0	0.0
18	69.119832	0	372.00	1.0	0.0
19	125.976468	2	1084.80	0.0	1.0
20	144.464165	0	622.00	0.0	1.0
21	185.806000	2	1400.00	0.0	0.0
22	60.108241	0	323.50	1.0	0.0
23	71.442407	0	230.70	0.0	0.0
24	79.432065	1	513.00	0.0	1.0
25	83.612700	1	630.00	1.0	0.0
26	42.363768	1	273.60	0.0	0.0
27	62.152107	0	334.50	0.0	1.0
28	176.422797	2	1519.20	1.0	0.0
29	58.807599	0	189.90	0.0	0.0

	SquareFeet	Density	price	CityA	CityB
30	82.683670	1	534.00	0.0	1.0
31	87.886238	0	283.80	0.0	0.0
32	114.735205	0	617.50	1.0	0.0

In [6]:
```
from sklearn.model_selection import train_test_split

x = data[["SquareFeet","Density","CityA","CityB"]]
y = data["price"]

x_train, x_test, y_train, y_test = train_test_split(x,y,test_size=0.2,random_state=
x_train = x_train.to_numpy()
x_test = x_test.to_numpy()
y_train = y_train.to_numpy()
y_test = y_test.to_numpy()
```

Standardization

In [7]:
```
from sklearn.preprocessing import StandardScaler

scaler = StandardScaler()
scaler.fit(x_train)
x_train = scaler.transform(x_train)
x_test = scaler.transform(x_test)
```

In [8]:
```
import torch

device = "cuda" if torch.cuda.is_available() else "cpu"
device
```

Out[8]: 'cuda'

In [9]:
```
from torch import nn

class MultiRegressionModel(nn.Module):
    def __init__(self):
        super().__init__()
        self.linear_layer = nn.Linear(in_features = 4, out_features = 1,dtype = tor

    def forward(self,x):
        return self.linear_layer(x)
```

In [10]:
```
torch.manual_seed(87)
model = MultiRegressionModel()
model.to(device)
model.state_dict()
```

Out[10]:
```
OrderedDict([('linear_layer.weight',
              tensor([[-0.4710,  0.1380, -0.1459, -0.1397]], device='cuda:0',
                     dtype=torch.float64)),
             ('linear_layer.bias',
              tensor([-0.4544], device='cuda:0', dtype=torch.float64))])
```

In [11]:
```
x_train = torch.from_numpy(x_train)
x_test = torch.from_numpy(x_test)
y_train = torch.from_numpy(y_train)
y_test = torch.from_numpy(y_test)
```

In [12]:
```
x_train = x_train.to(device)
x_test = x_test.to(device)
y_train = y_train.to(device)
y_test = y_test.to(device)
```

In [13]:
```
y_train = y_train.reshape(-1,1)
y_test = y_test.reshape(-1,1)
```

In [14]:
```
cost_fn = nn.MSELoss()
```

In [15]:
```
y_pred = model(x_train)
cost = cost_fn(y_pred,y_train)
print(model.state_dict()) #before
print(cost) #before

optimizer = torch.optim.SGD(params=model.parameters(),lr=0.00005,momentum=0.9,weigh
optimizer.zero_grad()
cost.backward()
optimizer.step()

y_pred = model(x_train)
cost = cost_fn(y_pred,y_train)
print(model.state_dict()) #after
print(cost) #after
```

```
OrderedDict([('linear_layer.weight', tensor([[-0.4710,  0.1380, -0.1459, -0.1397]],
device='cuda:0',
       dtype=torch.float64)), ('linear_layer.bias', tensor([-0.4544], device='cuda:
0', dtype=torch.float64))])
tensor(421352.7562, device='cuda:0', dtype=torch.float64,
       grad_fn=<MseLossBackward0>)
OrderedDict([('linear_layer.weight', tensor([[-0.4423,  0.1580, -0.1496, -0.1349]],
device='cuda:0',
       dtype=torch.float64)), ('linear_layer.bias', tensor([-0.3981], device='cuda:
0', dtype=torch.float64))])
tensor(421264.1937, device='cuda:0', dtype=torch.float64,
       grad_fn=<MseLossBackward0>)
```

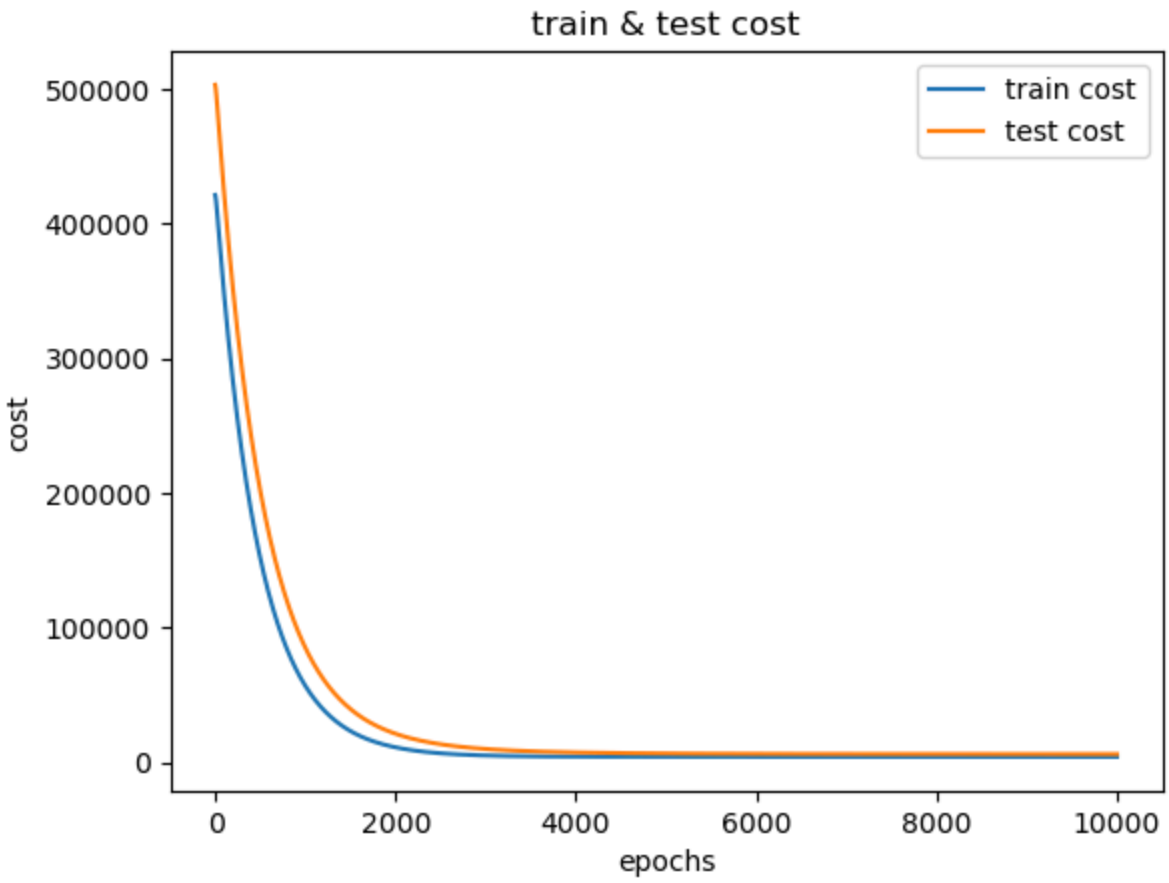
In [16]:
```
#Loop
epochs = 10000

train_cost_hist = []
test_cost_hist = []
```

```
for epoch in range(epochs):
    model.train() # to indicate now is in train phase
    #model.eval() # to indicate in test phase

    y_pred = model(x_train)
    train_cost = cost_fn(y_pred, y_train)
    train_cost_hist.append(train_cost.cpu().detach().numpy()) # .detach().numpy() i

    optimizer.zero_grad()
    train_cost.backward()
    optimizer.step()

    model.eval() #test phase
    with torch.inference_mode():   #no need to run gradient descent because it is i
        test_pred = model(x_test)
        test_cost = cost_fn(test_pred,y_test)
        test_cost_hist.append(test_cost.cpu())

    if epoch%1000==0:
        print(f"{epoch:5} - train_cost : {train_cost: .4e} : test_cost : {test_cost
```

```
   0 - train_cost :  4.2126e+05 : test_cost :  5.0313e+05
1000 - train_cost :  5.6669e+04 : test_cost :  8.4981e+04
2000 - train_cost :  1.1009e+04 : test_cost :  2.1097e+04
3000 - train_cost :  4.9465e+03 : test_cost :  9.7820e+03
4000 - train_cost :  4.0993e+03 : test_cost :  7.2088e+03
5000 - train_cost :  3.9743e+03 : test_cost :  6.4408e+03
6000 - train_cost :  3.9546e+03 : test_cost :  6.1621e+03
7000 - train_cost :  3.9512e+03 : test_cost :  6.0497e+03
8000 - train_cost :  3.9505e+03 : test_cost :  6.0019e+03
9000 - train_cost :  3.9504e+03 : test_cost :  5.9810e+03
```

In [17]:

```
import matplotlib.pyplot as plt

plt.plot(range(0,10000), train_cost_hist, label = "train cost")
plt.plot(range(0,10000), test_cost_hist, label = "test cost")
plt.title("train & test cost")
plt.xlabel("epochs")
plt.ylabel("cost")
plt.legend()
plt.show()
```



In [18]:
```
model.eval()
with torch.inference_mode():
    y_pred = model(x_test)
y_pred,y_test
```

Out[18]:
```
(tensor([[ 554.7380],
         [ 474.6778],
         [ 229.7757],
         [ 522.1014],
         [ 173.0035],
         [ 594.3884],
         [1387.1462]], device='cuda:0', dtype=torch.float64),
 tensor([[ 452.0000],
         [ 467.0400],
         [ 216.0000],
         [ 513.0000],
         [ 283.5000],
         [ 630.0000],
         [1519.2000]], device='cuda:0', dtype=torch.float64))
```

In [19]:
```
# sq = 80.5
# density = 1
# checkdensity = "high" if density == 1 else "low"
# cityA = 0
# cityB = 1

# x_realData = np.array([[sq,density,cityA,cityB]])
# x_realData = scaler.transform(x_realData)
```

```
# y_realData = (x_realData * w_final).sum(axis=1) + b_final
# price = round(y_realData[0],2)

# print(f'Square feet(m^2): {sq} : Density: {checkdensity} : cityA : {cityA}: cityB
```

In [20]:
```
sq = 80.5
density = 1
checkdensity = "high" if density == 1 else "low"
cityA = 0
cityB = 1

with torch.inference_mode():
    x_realData = torch.tensor(scaler.transform([[sq, density, cityA, cityB]]),dtype
    x_realData = x_realData.to(device)
    price = round(model(x_realData).item(), 2)

# m^2 to sq ft → multiply by 10.7639
# sq ft to m^2 → multiply by 0.092903

print(f'Square feet: {round((sq * 10.7639),0)} : Density: {checkdensity} : cityA :
```

```
Square feet: 866.0 : Density: high : cityA : 0: cityB: 1: The price is: 529.27 k
```

In [ ]:
```

```