Filter(方差、卡方、相关系数),Wrapper（递归）,Embedding（L1正则、特征重要性）

In [1]:

```
import pandas as pd
import numpy as np
import warnings
warnings.filterwarnings("ignore")
from  sklearn.model_selection import train_test_split
```

In [5]:

```
data=pd.read_csv("d:/datasets/Heart.csv",index_col="Unnamed: 0")
```

In [6]:

```
data.head()
```

Out[6]:

	Age	Sex	ChestPain	RestBP	Chol	Fbs	RestECG	MaxHR	ExAng	Oldpeak	Slope	Ca
1	63	1	typical	145	233	1	2	150	0	2.3	3	0.0
2	67	1	asymptomatic	160	286	0	2	108	1	1.5	2	3.0
3	67	1	asymptomatic	120	229	0	2	129	1	2.6	2	2.0
4	37	1	nonanginal	130	250	0	0	187	0	3.5	3	0.0
5	41	0	nontypical	130	204	0	2	172	0	1.4	1	0.0

In [7]:

```
data.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 303 entries, 1 to 303
Data columns (total 14 columns):
 #   Column     Non-Null Count  Dtype  
---  ------     --------------  -----  
 0   Age        303 non-null    int64  
 1   Sex        303 non-null    int64  
 2   ChestPain  303 non-null    object 
 3   RestBP     303 non-null    int64  
 4   Chol       303 non-null    int64  
 5   Fbs        303 non-null    int64  
 6   RestECG    303 non-null    int64  
 7   MaxHR      303 non-null    int64  
 8   ExAng      303 non-null    int64  
 9   Oldpeak    303 non-null    float64
 10  Slope      303 non-null    int64  
 11  Ca         299 non-null    float64
 12  Thal       301 non-null    object 
 13  AHD        303 non-null    object 
dtypes: float64(2), int64(9), object(3)
memory usage: 35.5+ KB
```

In [8]:

```
data=data.dropna()
```

In [9]:

```
data.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 297 entries, 1 to 302
Data columns (total 14 columns):
 #   Column     Non-Null Count  Dtype  
---  ------     --------------  -----  
 0   Age        297 non-null    int64  
 1   Sex        297 non-null    int64  
 2   ChestPain  297 non-null    object 
 3   RestBP     297 non-null    int64  
 4   Chol       297 non-null    int64  
 5   Fbs        297 non-null    int64  
 6   RestECG    297 non-null    int64  
 7   MaxHR      297 non-null    int64  
 8   ExAng      297 non-null    int64  
 9   Oldpeak    297 non-null    float64
 10  Slope      297 non-null    int64  
 11  Ca         297 non-null    float64
 12  Thal       297 non-null    object 
 13  AHD        297 non-null    object 
dtypes: float64(2), int64(9), object(3)
memory usage: 34.8+ KB
```

In [10]:

```
data.columns
```

Out[10]:

```
Index(['Age', 'Sex', 'ChestPain', 'RestBP', 'Chol', 'Fbs', 'RestECG', 'MaxHR',
       'ExAng', 'Oldpeak', 'Slope', 'Ca', 'Thal', 'AHD'],
      dtype='object')
```

In [11]:

```
data["ChestPain"].value_counts()
```

Out[11]:

```
asymptomatic    142
nonanginal       83
nontypical       49
typical          23
Name: ChestPain, dtype: int64
```

In [12]:

```
data["ChestPain"]=data["ChestPain"].map(
    {"asymptomatic":0,"nonanginal":1,"nontypical":2,"typical":3})
```

In [13]:

```
data.columns
```

Out[13]:

```
Index(['Age', 'Sex', 'ChestPain', 'RestBP', 'Chol', 'Fbs', 'RestECG', 'MaxHR',
       'ExAng', 'Oldpeak', 'Slope', 'Ca', 'Thal', 'AHD'],
      dtype='object')
```

In [14]:

```
data.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 297 entries, 1 to 302
Data columns (total 14 columns):
 #   Column     Non-Null Count  Dtype  
---  ------     --------------  -----  
 0   Age        297 non-null    int64  
 1   Sex        297 non-null    int64  
 2   ChestPain  297 non-null    int64  
 3   RestBP     297 non-null    int64  
 4   Chol       297 non-null    int64  
 5   Fbs        297 non-null    int64  
 6   RestECG    297 non-null    int64  
 7   MaxHR      297 non-null    int64  
 8   ExAng      297 non-null    int64  
 9   Oldpeak    297 non-null    float64
 10  Slope      297 non-null    int64  
 11  Ca         297 non-null    float64
 12  Thal       297 non-null    object 
 13  AHD        297 non-null    object 
dtypes: float64(2), int64(10), object(2)
memory usage: 34.8+ KB
```

In [15]:

```
data["Thal"].value_counts()
```

Out[15]:

```
normal        164
reversable    115
fixed          18
Name: Thal, dtype: int64
```

In [16]:

```
data["Thal"]=data["Thal"].map({"normal":0,"reversable":1,"fixed":2})
```

In [17]:

```
data.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 297 entries, 1 to 302
Data columns (total 14 columns):
 #   Column     Non-Null Count  Dtype  
---  ------     --------------  -----  
 0   Age        297 non-null    int64  
 1   Sex        297 non-null    int64  
 2   ChestPain  297 non-null    int64  
 3   RestBP     297 non-null    int64  
 4   Chol       297 non-null    int64  
 5   Fbs        297 non-null    int64  
 6   RestECG    297 non-null    int64  
 7   MaxHR      297 non-null    int64  
 8   ExAng      297 non-null    int64  
 9   Oldpeak    297 non-null    float64
 10  Slope      297 non-null    int64  
 11  Ca         297 non-null    float64
 12  Thal       297 non-null    int64  
 13  AHD        297 non-null    object 
dtypes: float64(2), int64(11), object(1)
memory usage: 34.8+ KB
```

In [18]:

```
data.AHD.value_counts()
```

Out[18]:

```
No     160
Yes    137
Name: AHD, dtype: int64
```

In [19]:

```
data
```

Out[19]:

Sex	ChestPain	RestBP	Chol	Fbs	RestECG	MaxHR	ExAng	Oldpeak	Slope	Ca	Thal	AHD
1	3	145	233	1	2	150	0	2.3	3	0.0	2	No
1	0	160	286	0	2	108	1	1.5	2	3.0	0	Yes
1	0	120	229	0	2	129	1	2.6	2	2.0	1	Yes
1	1	130	250	0	0	187	0	3.5	3	0.0	0	No
0	2	130	204	0	2	172	0	1.4	1	0.0	0	No
...	...	...	...	...	...	...	...	...	...	...	...	...
0	0	140	241	0	0	123	1	0.2	2	0.0	1	Yes
1	3	110	264	0	0	132	0	1.2	2	0.0	1	Yes
1	0	144	193	1	0	141	0	3.4	2	2.0	1	Yes
1	0	130	131	0	0	115	1	1.2	2	1.0	1	Yes
0	2	130	236	0	2	174	0	0.0	2	1.0	0	Yes

14 columns

In [20]:

```
X=data.drop(columns=["AHD"])
y=data.AHD.map({"Yes":1,"No":0})
```

In [21]:

```
y
```

Out[21]:

```
1      0
2      1
3      1
4      0
5      0
      ..
298    1
299    1
300    1
301    1
302    1
Name: AHD, Length: 297, dtype: int64
```

In [22]:

```
X.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 297 entries, 1 to 302
Data columns (total 13 columns):
 #   Column     Non-Null Count  Dtype  
---  ------     --------------  -----  
 0   Age        297 non-null    int64  
 1   Sex        297 non-null    int64  
 2   ChestPain  297 non-null    int64  
 3   RestBP     297 non-null    int64  
 4   Chol       297 non-null    int64  
 5   Fbs        297 non-null    int64  
 6   RestECG    297 non-null    int64  
 7   MaxHR      297 non-null    int64  
 8   ExAng      297 non-null    int64  
 9   Oldpeak    297 non-null    float64
 10  Slope      297 non-null    int64  
 11  Ca         297 non-null    float64
 12  Thal       297 non-null    int64  
dtypes: float64(2), int64(11)
memory usage: 32.5 KB
```

In [23]:

```
X_train,X_test,y_train,y_test=train_test_split(X,y,test_size=0.2,random_state=10)
```

过滤式（Filter）

方差选择法

In [24]:

```
from sklearn.feature_selection import VarianceThreshold
sel_var=VarianceThreshold(threshold=0.5)  #设定方差阈值0.5
```

In [25]:

```
sel_var_x=sel_var.fit_transform(X_train)    #fit and transform
```

In [26]:

```
sel_var_x.shape
```

Out[26]:

(237, 8)

In [27]:

```
#输出选择的情况  True为选中的特征
print(pd.Series(sel_var.get_support(),index=X_train.columns).sort_values())
```

```
Sex          False
Fbs          False
ExAng        False
Slope        False
Thal         False
Age           True
ChestPain     True
RestBP        True
Chol          True
RestECG       True
MaxHR         True
Oldpeak       True
Ca            True
dtype: bool
```

卡方选择法

In [31]:

```
from sklearn.feature_selection import SelectPercentile
from sklearn.feature_selection import chi2
sel_p_chi=SelectPercentile(chi2,percentile=60).fit(X,y)  #选择60%
print(sel_p_chi.scores_)
print(pd.Series(sel_p_chi.get_support(),index=X.columns).sort_values())
```

```
[2.29176975e+01 7.44419531e+00 5.47476352e+01 1.67074632e+01
 2.08550836e+01 2.54731794e-03 8.13465196e+00 1.87053104e+02
 3.55080899e+01 6.85705327e+01 7.82883557e+00 8.27306134e+01
 4.77899553e+01]
Sex          False
RestBP       False
Fbs          False
RestECG      False
Slope        False
Age           True
ChestPain     True
Chol          True
MaxHR         True
ExAng         True
Oldpeak       True
Ca            True
Thal          True
dtype: bool
```

In [ ]:

In [37]:

```
from sklearn.feature_selection import SelectKBest
from sklearn.feature_selection import chi2
sel_b_chi=SelectKBest(chi2,k=8).fit(X,y)  #卡方选择法，选择8个特征
print(sel_b_chi.scores_)
print(pd.Series(sel_b_chi.get_support(),index=X.columns).sort_values())
```

```
[2.29176975e+01 7.44419531e+00 5.47476352e+01 1.67074632e+01
 2.08550836e+01 2.54731794e-03 8.13465196e+00 1.87053104e+02
 3.55080899e+01 6.85705327e+01 7.82883557e+00 8.27306134e+01
 4.77899553e+01]
Sex          False
RestBP       False
Fbs          False
RestECG      False
Slope        False
Age           True
ChestPain     True
Chol          True
MaxHR         True
ExAng         True
Oldpeak       True
Ca            True
Thal          True
dtype: bool
```

相关系数选择法（不合适）

每个特征 X 单独和 Y 计算相关系数, 并排序. 特征选择就是基于 X 和 Y 的相关程度.

In [33]:

```
from sklearn.feature_selection import f_regression
sel_bf_chi=SelectKBest(f_regression,k=8).fit(X,y)  #卡方选择法，选择8个特征
print(sel_bf_chi.scores_)
print(pd.Series(sel_bf_chi.get_support(),index=X.columns).sort_values())
```

```
[1.60380965e+01 2.47983475e+01 5.92419147e+01 7.11764643e+00
 1.91379983e+00 2.95852886e-03 8.39498663e+00 6.45898547e+01
 6.36802533e+01 6.46772084e+01 3.68042999e+01 8.05778659e+01
 8.34114563e+01]
Age          False
RestBP       False
Chol         False
Fbs          False
RestECG      False
Sex           True
ChestPain     True
MaxHR         True
ExAng         True
Oldpeak       True
Slope         True
Ca            True
Thal          True
dtype: bool
```

In [34]:

```
from sklearn.feature_selection import f_regression    #相关系数选择法
sel_pf_chi=SelectPercentile(f_regression,percentile=60).fit(X,y)
print(sel_pf_chi.scores_)
print(pd.Series(sel_pf_chi.get_support(),index=X.columns).sort_values())
```

```
[1.60380965e+01 2.47983475e+01 5.92419147e+01 7.11764643e+00
 1.91379983e+00 2.95852886e-03 8.39498663e+00 6.45898547e+01
 6.36802533e+01 6.46772084e+01 3.68042999e+01 8.05778659e+01
 8.34114563e+01]
Age          False
RestBP       False
Chol         False
Fbs          False
RestECG      False
Sex           True
ChestPain     True
MaxHR         True
ExAng         True
Oldpeak       True
Slope         True
Ca            True
Thal          True
dtype: bool
```

In [35]:

```
import matplotlib.pyplot as plt
%matplotlib inline
```

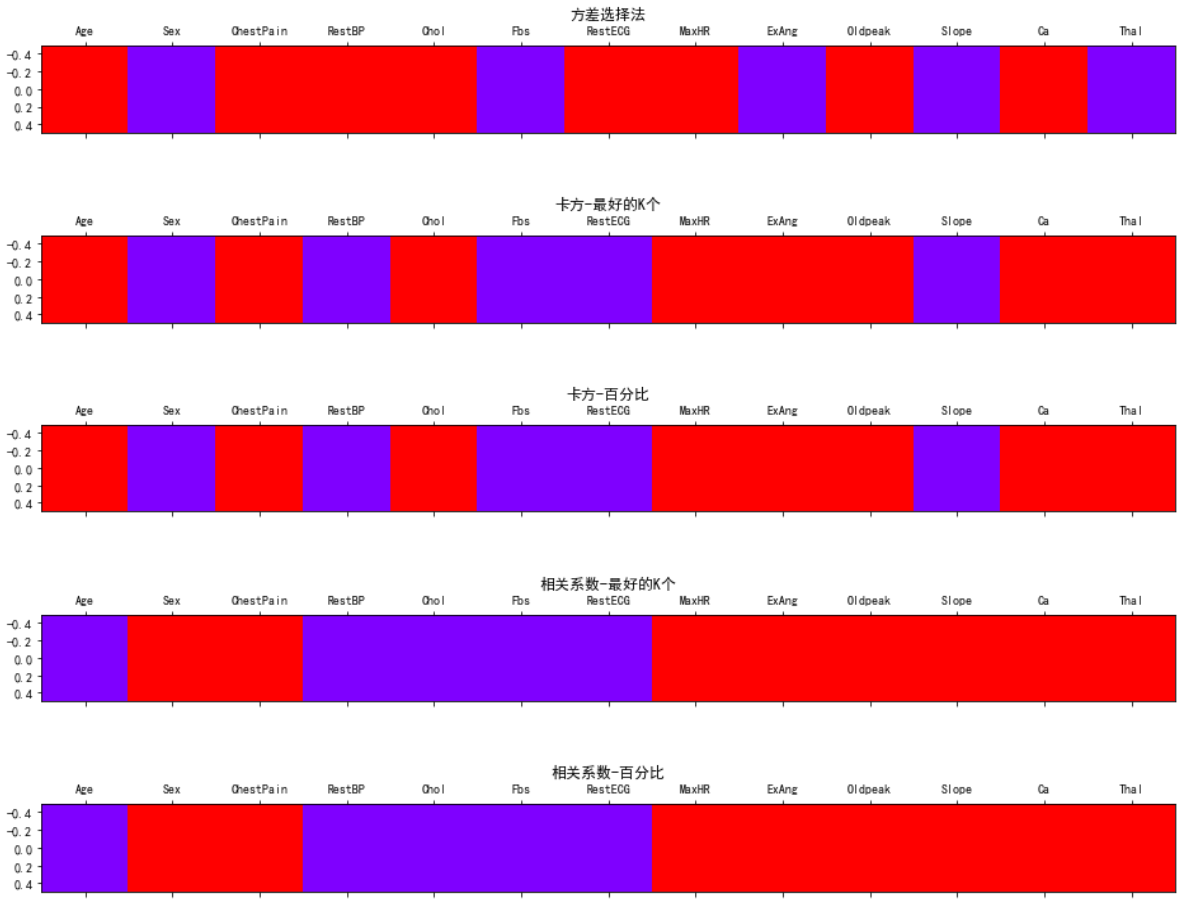
In [38]:

```
#可视化选择的结果
plt.rcParams["font.sans-serif"]=["SimHei"]
plt.rcParams["axes.unicode_minus"] = False
plt.figure(figsize=(8,6))
#plt.xticks(range(13),X.columns)
plt.matshow(sel_var.get_support().reshape(1,-1),cmap="rainbow")
plt.xticks(range(13),X.columns)
plt.title("方差选择法")
plt.matshow(sel_b_chi.get_support().reshape(1,-1),cmap="rainbow",)
plt.xticks(range(13),X.columns)
plt.title("卡方-最好的K个")
plt.matshow(sel_p_chi.get_support().reshape(1,-1),cmap="rainbow")
plt.xticks(range(13),X.columns)
plt.title("卡方-百分比")
plt.matshow(sel_bf_chi.get_support().reshape(1,-1),cmap="rainbow",)
plt.xticks(range(13),X.columns)
plt.title("相关系数-最好的K个")
plt.matshow(sel_pf_chi.get_support().reshape(1,-1),cmap="rainbow")
plt.xticks(range(13),X.columns)
plt.title("相关系数-百分比")
```

Out[38]:

Text(0.5, 1.0, '相关系数-百分比')

<Figure size 576x432 with 0 Axes>



In [ ]:

```
```

RFE 递归 Wrapper

单个模型

In [39]:

```
from sklearn.feature_selection import RFE
from sklearn.tree import DecisionTreeClassifier
from sklearn.metrics import accuracy_score
from sklearn.metrics import classification_report
```

In [40]:

```
rfe=RFE(DecisionTreeClassifier(random_state=10),n_features_to_select=8)
rfe_x=rfe.fit_transform(X_train,y_train)
```

In [41]:

```
rfe_x.shape
```

Out[41]:

```
(237, 8)
```

In [44]:

```
X_test.shape
```

Out[44]:

```
(60, 13)
```

In [42]:

```
rfe.score(X_test,y_test)  #使用原始全部特征，使用时自动去除
```

Out[42]:

```
0.85
```

In [43]:

```
rfe.score(X_train,y_train)
```

Out[43]:

1.0

In [48]:

```
#rfe.estimator_.score(X_train,y_train)
```

In [49]:

```
rfe.estimator_.score(rfe_x,y_train)  #需要用选择好的特征
```

Out[49]:

1.0

In [73]:

```
rfe_X_test=rfe.transform(X_test)
```

In [74]:

```
rfe.estimator_.score(rfe_X_test,y_test)
```

Out[74]:

0.85

In [50]:

```
y_pred=rfe.predict(X_test)
```

In [51]:

```
accuracy_score(y_test,y_pred)
```

Out[51]:

0.85

In [52]:

```
print(classification_report(y_test,y_pred))
```

```
              precision    recall  f1-score   support

           0       0.93      0.80      0.86        35
           1       0.77      0.92      0.84        25

    accuracy                           0.85        60
   macro avg       0.85      0.86      0.85        60
weighted avg       0.86      0.85      0.85        60
```

In [53]:

```
rfe.ranking_
```

Out[53]:

```
array([1, 2, 1, 1, 1, 6, 5, 1, 4, 1, 3, 1, 1])
```

In [54]:

```
rfe.support_
```

Out[54]:

```
array([ True, False,  True,  True,  True, False, False,  True, False,
        True, False,  True,  True])
```

In [55]:

```
print(pd.Series(rfe.support_,index=X.columns).sort_values())
```

```
Sex          False
Fbs          False
RestECG      False
ExAng        False
Slope        False
Age           True
ChestPain     True
RestBP        True
Chol          True
MaxHR         True
Oldpeak       True
Ca            True
Thal          True
dtype: bool
```

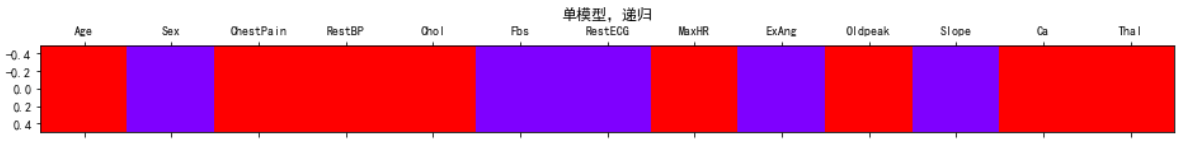
In [56]:

```
plt.figure(figsize=(8,6))
plt.matshow(rfe.support_.reshape(1,-1),cmap="rainbow")
plt.xticks(range(13),X.columns)
plt.title("单模型，递归")
```

Out[56]:

```
Text(0.5, 1.0, '单模型，递归')

<Figure size 576x432 with 0 Axes>
```



单个模型 K折交叉检验

In [57]:

```
from sklearn.feature_selection import RFECV
#单个模型 K折交叉检验
rfeCV=RFECV(DecisionTreeClassifier(random_state=0),cv=5,min_features_to_select=8)
rfeCV.fit(X_train,y_train)
```

Out[57]:

```
RFECV(cv=5, estimator=DecisionTreeClassifier(random_state=0),
      min_features_to_select=8)
```

In [58]:

```
print(pd.Series(rfeCV.ranking_,index=X_train.columns))
```

```
Age          1
Sex          1
ChestPain    1
RestBP       1
Chol         1
Fbs          3
RestECG      4
MaxHR        1
ExAng        2
Oldpeak      1
Slope        1
Ca           1
Thal         1
dtype: int32
```

In [59]:

```
rfeCV.get_support()
```

Out[59]:

```
array([ True,  True,  True,  True,  True, False, False,  True, False,
        True,  True,  True,  True])
```

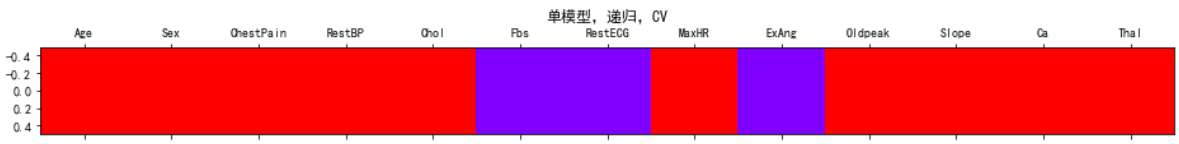
In [60]:

```
plt.figure(figsize=(8,6))
plt.matshow(rfeCV.get_support().reshape(1,-1),cmap="rainbow")
plt.xticks(range(13),X.columns)
plt.title("单模型，递归，CV")
#红色被选中
```

Out[60]:

```
Text(0.5, 1.0, '单模型，递归，CV')
```

```
<Figure size 576x432 with 0 Axes>
```



集成模型

In [62]:

```
from sklearn.feature_selection import RFECV
from sklearn.ensemble import GradientBoostingClassifier
```

In [63]:

```
rfeCV_rf=RFECV(GradientBoostingClassifier(n_estimators=50,random_state=0),
               min_features_to_select=8,cv=5)
rfeCV_rf.fit(X_train,y_train)
```

Out[63]:

```
RFECV(cv=5,
      estimator=GradientBoostingClassifier(n_estimators=50, random_state=0),
      min_features_to_select=8)
```

In [64]:

```
rfeCV_rf.transform(X_train)
```

Out[64]:

```
array([[66.,  1.,  0., ...,  1.,  0.,  2.],
       [53.,  0.,  0., ...,  1.,  0.,  0.],
       [49.,  1.,  2., ...,  1.,  0.,  0.],
       ...,
       [57.,  1.,  1., ...,  1.,  0.,  0.],
       [56.,  0.,  0., ...,  3.,  2.,  1.],
       [42.,  1.,  1., ...,  1.,  0.,  0.]])
```

In [65]:

```
rfeCV_rf.score(X_test,y_test)
```

Out[65]:

```
0.8833333333333333
```

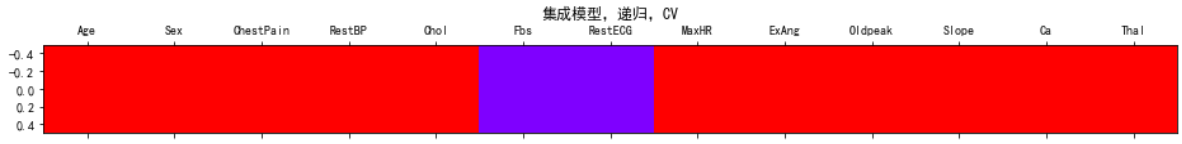
In [66]:

```
plt.figure(figsize=(8,6))
plt.matshow(rfeCV_rf.get_support().reshape(1,-1),cmap="rainbow")
plt.xticks(range(13),X.columns)
plt.title("集成模型，递归，CV")
#红色被选中
```

Out[66]:

```
Text(0.5, 1.0, '集成模型，递归，CV')

<Figure size 576x432 with 0 Axes>
```



Embedding

单个模型

In [67]:

```
from sklearn.feature_selection import SelectFromModel
select=SelectFromModel(DecisionTreeClassifier(random_state=10),threshold="mean")
select.fit(X_train,y_train)
```

Out[67]:

```
SelectFromModel(estimator=DecisionTreeClassifier(random_state=10),
                threshold='mean')
```

In [70]:

```
select_X1=select.transform(X_train)
```

In [71]:

```
select_X1.shape
```

Out[71]:

```
(237, 7)
```

#embedding 调用训练好的模型的方法(不能直接调用，通过属性estimator_调用训练好的模型)

In [75]:

```
select.estimator_.predict(X_test)
```

Out[75]:

```
array([1, 1, 0, 1, 0, 0, 0, 1, 0, 0, 0, 0, 1, 0, 1, 1, 1, 1, 0, 1, 1, 1,
       0, 1, 0, 1, 1, 1, 1, 0, 1, 0, 0, 0, 1, 0, 0, 1, 1, 1, 1, 0, 1, 1,
       1, 0, 1, 1, 1, 1, 0, 0, 1, 1, 0, 1, 1, 0, 0, 0], dtype=int64)
```

In [76]:

```
select.estimator_.score(X_train,y_train)
```

Out[76]:

```
1.0
```

In [77]:

```
select.get_support()
```

Out[77]:

```
array([ True, False,  True,  True,  True, False, False,  True, False,
       False, False,  True,  True])
```

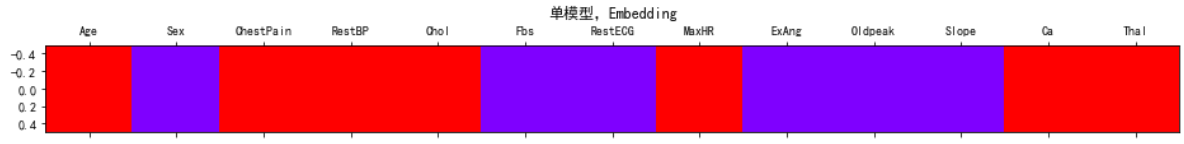
In [79]:

```
plt.figure(figsize=(8,6))
plt.matshow(select.get_support().reshape(1,-1),cmap="rainbow")
plt.xticks(range(13),X.columns)
plt.title("单模型，Embedding")
```

Out[79]:

```
Text(0.5, 1.0, '单模型，Embedding')
```

```
<Figure size 576x432 with 0 Axes>
```



集成模型

In [80]:

```
from sklearn.feature_selection import SelectFromModel
from sklearn.ensemble import RandomForestClassifier
select_rf=SelectFromModel(RandomForestClassifier(n_estimators=200,random_state=10),threshold="mean")
select_X=select_rf.fit_transform(X_train,y_train)
```

In [81]:

```
select_rf.get_support()
```

Out[81]:

```
array([ True, False,  True, False,  True, False, False,  True, False,
        True, False,  True,  True])
```

In [ ]:

In [82]:

```
select_rf.estimator_.predict(X_test)
```

Out[82]:

```
array([1, 1, 0, 1, 0, 0, 0, 1, 0, 0, 0, 0, 1, 0, 0, 0, 1, 1, 0, 1, 0, 0,
       0, 0, 0, 0, 1, 1, 1, 0, 1, 1, 0, 0, 0, 0, 0, 0, 0, 1, 1, 0, 0, 1,
       1, 0, 1, 1, 1, 0, 0, 0, 1, 0, 0, 1, 1, 0, 0, 0], dtype=int64)
```

In [83]:

```
select_rf.estimator_.score(X_test,y_test)
```

Out[83]:

```
0.8333333333333334
```

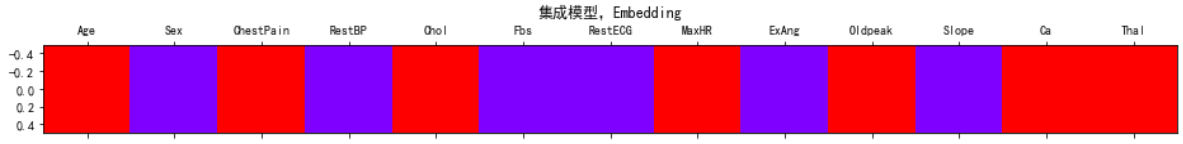
In [86]:

```
plt.figure(figsize=(8,6))
plt.matshow(select_rf.get_support().reshape(1,-1),cmap="rainbow")
plt.xticks(range(13),X.columns)
plt.title("集成模型，Embedding")
```

Out[86]:

```
Text(0.5, 1.0, '集成模型，Embedding')

<Figure size 576x432 with 0 Axes>
```



In [ ]:

In [ ]: