E3_Exercises

Kwon do yun

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차 례

Preparation (P. 7)

```
import numpy as np
import pandas as pd
gamma = 1
states = np.arange(0,80,10).astype(str)
P_normal=pd.DataFrame(np.matrix([[0,1,0,0,0,0,0,0],
                    [0,0,1,0,0,0,0,0],
                    [0,0,0,1,0,0,0,0],
                    [0,0,0,0,1,0,0,0],
                    [0,0,0,0,0,1,0,0],
                    [0,0,0,0,0,0,1,0],
                    [0,0,0,0,0,0,0,1],
                    [0,0,0,0,0,0,0,1]]), index=states,columns=states)
P_speed=pd.DataFrame(np.matrix([[.1,0,.9,0,0,0,0,0],
                   [.1,0,0,.9,0,0,0,0],
                   [0,.1,0,0,.9,0,0,0],
                   [0,0,.1,0,0,.9,0,0],
                   [0,0,0,.1,0,0,.9,0],
                   [0,0,0,0,.1,0,0,.9],
                   [0,0,0,0,0,.1,0,.9],
                   [0,0,0,0,0,0,0,1]]), index=states, columns=states)
R_s_a=np.matrix([[-1,-1,-1,-1,0,-1,-1,0],
                 [-1.5,-1.5,-1.5,-1.5,-0.5,-1.5,-1.5,0]]).T
R_s_a=pd.DataFrame(R_s_a,columns=["normal","speed"],index=states)
```

Implementation (P. 8)

```
# 1 Intialize V
V_old=pd.DataFrame(np.repeat(0,len(states)).reshape(len(states),1),index=states)
V_old.T
```

```
##    0  10  20  30  40  50  60  70
## 0  0   0   0   0   0   0   0   0
```

```
# 2. Evaluate the Q-function
q_s_a = R_s_a+np.c_[gamma*np.dot(P_normal,V_old), gamma*np.dot(P_speed,V_old)]
q_s_a
```

```
##     normal  speed
## 0     -1.0   -1.5
```

```
## 10    -1.0   -1.5
## 20    -1.0   -1.5
## 30    -1.0   -1.5
## 40     0.0   -0.5
## 50    -1.0   -1.5
## 60    -1.0   -1.5
## 70     0.0    0.0
```

```
# 3. Find the best action for each state
V_new=np.matrix(q_s_a.apply(max,axis=1)).reshape(len(states),1)
V_new.T
```

```
## matrix([[-1., -1., -1., -1.,  0., -1., -1.,  0.]])
```

Implementation (P. 11)

```
cnt=0
epsilon=10**(-8)
V_old=pd.DataFrame(np.repeat(0,len(states)).reshape(len(states),1),index=states)
results=V_old.T
while 1:
    q_s_a=R_s_a+np.c_[np.dot(gamma*P_normal,V_old),np.dot(gamma*P_speed,V_old)]
    V_new=np.matrix(q_s_a.apply(max,axis=1)).reshape(len(states),1)

    if np.max(np.abs(V_new-V_old)).item() < epsilon :
        break

    results=np.r_[results, V_new.T]
    V_old=V_new

    cnt+=1
```

```
value_iter_process = results
results = pd.DataFrame(results, columns=states)
results.head()
```

```
##      0   10   20   30   40    50   60   70
## 0  0.0  0.0  0.0  0.0  0.0  0.00  0.0  0.0
## 1 -1.0 -1.0 -1.0 -1.0  0.0 -1.00 -1.0  0.0
## 2 -2.0 -2.0 -1.6 -1.0 -1.0 -1.50 -1.0  0.0
```

```
## 3 -3.0 -2.6 -2.0 -2.0 -1.5 -1.60 -1.0  0.0
## 4 -3.6 -3.0 -3.0 -2.5 -1.6 -1.65 -1.0  0.0
```

```
results.tail()
```

```
##            0        10        20        30        40        50   60   70
## 17 -5.107743 -4.410774 -3.441077 -2.666667 -1.666667 -1.666667 -1.0  0.0
## 18 -5.107744 -4.410774 -3.441077 -2.666667 -1.666667 -1.666667 -1.0  0.0
## 19 -5.107744 -4.410774 -3.441077 -2.666667 -1.666667 -1.666667 -1.0  0.0
## 20 -5.107744 -4.410774 -3.441077 -2.666667 -1.666667 -1.666667 -1.0  0.0
## 21 -5.107744 -4.410774 -3.441077 -2.666667 -1.666667 -1.666667 -1.0  0.0
```

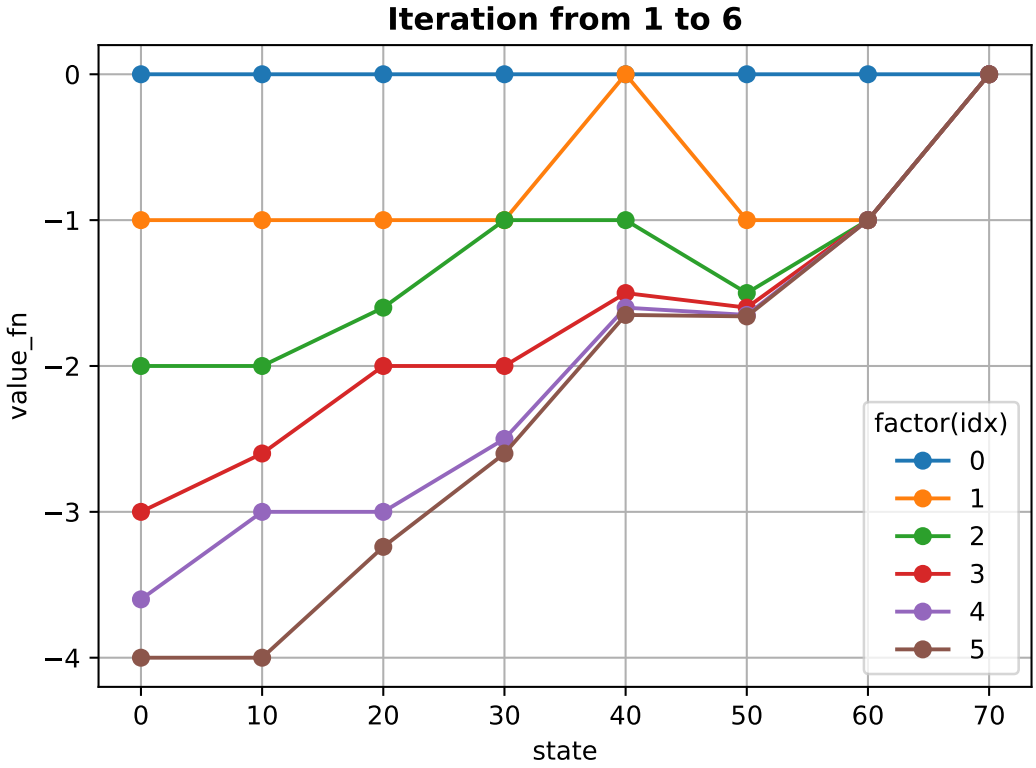
Visualization (P. 13)

```
import matplotlib.pyplot as plt
for i in range(6):
    plt.plot(results.columns,results.iloc[i], label=i,marker='o')

plt.grid(True)
plt.legend(title='factor(idx)')
plt.xlabel('state')
plt.ylabel('value_fn')
plt.title('Iteration from 1 to 6', fontweight='bold')
plt.yticks([0,-1,-2,-3,-4])
```

```
## ([<matplotlib.axis.YTick object at 0x000000002848F438>, <matplotlib.axis.YTick object at 0x000000002847CFD0>,
```

```
plt.show()
```

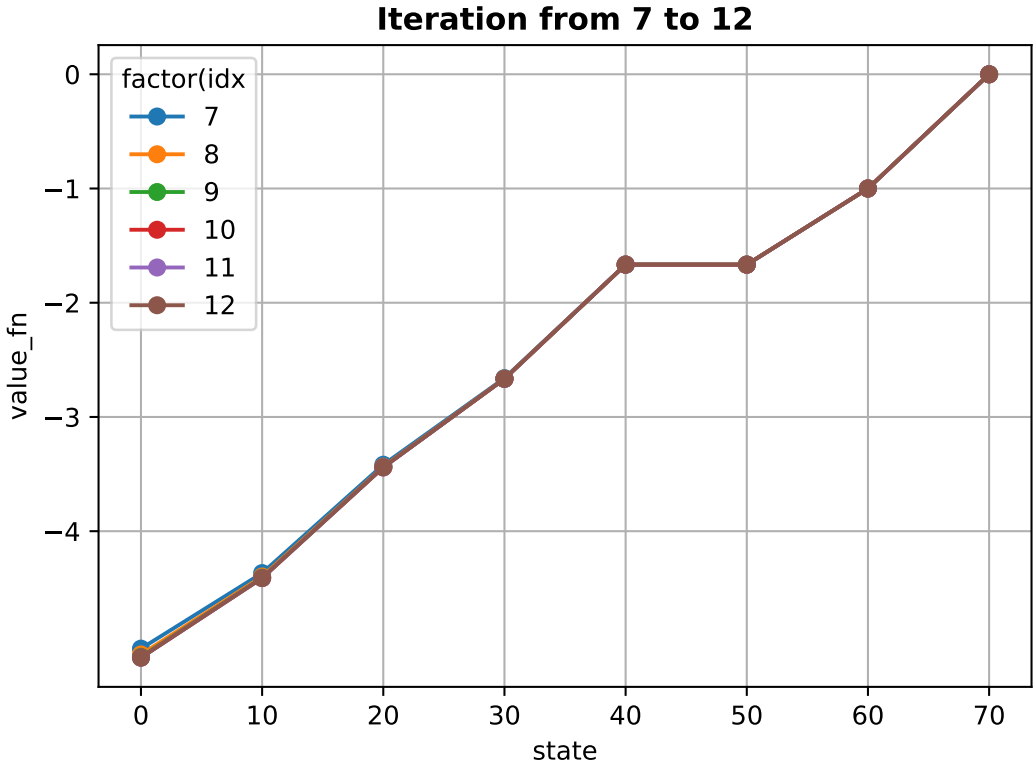



```
for i in range(7,13):
    plt.plot(results.columns,results.iloc[i], label=i,marker='o')

plt.grid(True)
plt.legend(title='factor(idx')
plt.xlabel('state')
plt.ylabel('value_fn')
plt.title('Iteration from 7 to 12', fontweight='bold')
plt.yticks([0,-1,-2,-3,-4])
```

```
## ([<matplotlib.axis.YTick object at 0x00000000295A1BA8>, <matplotlib.axis.YTick object at 0x00000000295A1780>,
```

```
plt.show()
```

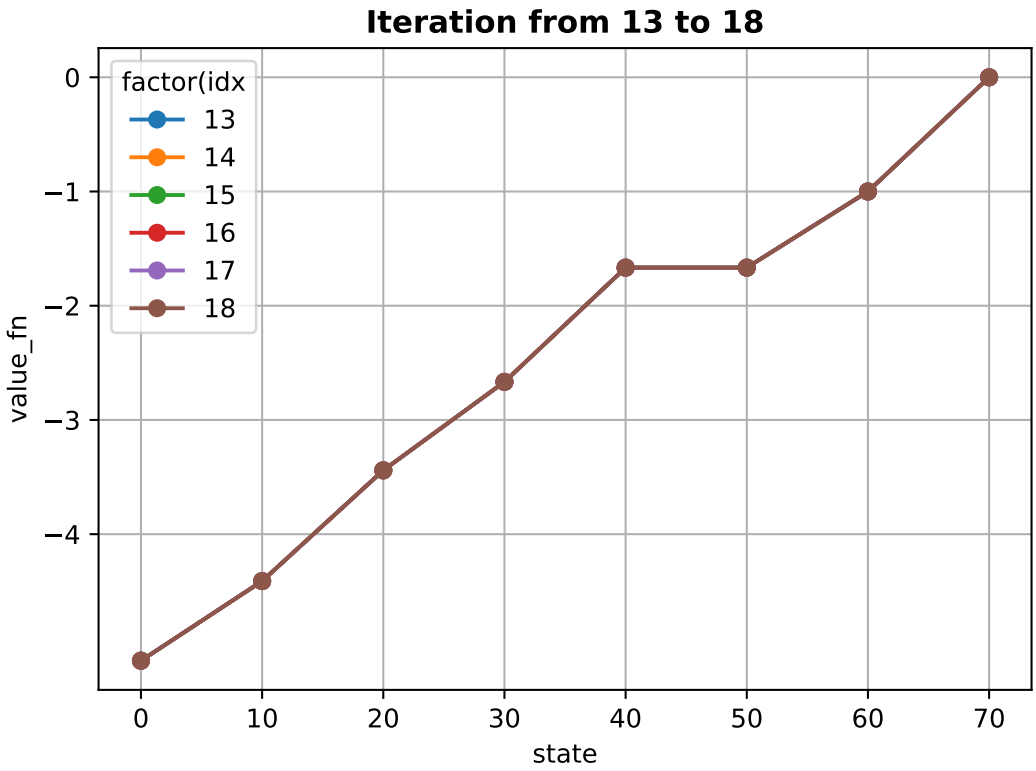



```
for i in range(13,19):
    plt.plot(results.columns,results.iloc[i], label=i,marker='o')

plt.grid(True)
plt.legend(title='factor(idx')
plt.xlabel('state')
plt.ylabel('value_fn')
plt.title('Iteration from 13 to 18', fontweight='bold')
plt.yticks([0,-1,-2,-3,-4])
```

```
## ([<matplotlib.axis.YTick object at 0x000000002849BF60>, <matplotlib.axis.YTick object at 0x000000002849B518>,
```

```
plt.show()
```



Optimal value function (P. 18)

```
V_opt = pd.DataFrame(value_iter_process).tail(1).T
V_opt.T
```

```
##            0         1         2         3         4         5    6    7
## 21 -5.107744 -4.410774 -3.441077 -2.666667 -1.666667 -1.666667 -1.0  0.0
```

```
q_s_a = R_s_a + np.c_[np.dot(gamma*P_normal,V_opt),np.dot(gamma*P_speed,V_opt)]
q_s_a
```

```
##       normal     speed
## 0  -5.410774 -5.107744
## 10 -4.441077 -4.410774
## 20 -3.666667 -3.441077
## 30 -2.666667 -3.344108
## 40 -1.666667 -1.666667
## 50 -2.000000 -1.666667
## 60 -1.000000 -1.666667
## 70  0.000000  0.000000
```

```
pi_opt_vec=pd.DataFrame(np.matrix(q_s_a.idxmax(axis=1)).reshape(len(states),1).T,columns=states)
pi_opt_vec
```

```
##        0     10     20      30      40     50      60      70
## 0  speed  speed  speed  normal  normal  speed  normal  normal
```

```
pi_opt=pd.DataFrame(np.repeat(0,len(states)*2).reshape(len(states),2),index=states, columns=["normal","speed"

for i in states :
  pi_opt.loc[i][pi_opt_vec.loc[0][i]] = 1

pi_opt.T
```

```
##         0  10  20  30  40  50  60  70
## normal  0   0   0   1   1   0   1   1
## speed   1   1   1   0   0   1   0   0
```

```
"E3_Exercises"
```