

experimento 8: rodou com normalização solicitada - 1706ace411

USER

o arquivo dados_50_50.csv anexo possui 4 colunas: IDENTIFICADOR, CARGO, PERCENT_PRI E DISTANCE_KM. A primeira variável é o código que identifica o funcionário, a segunda apresenta os códigos dos cargos, a terceira é um índice que varia de 0 a 1, sendo o 0 o melhor e, por fim, a última variável é a distância em KM entre o funcionário e o cargo que ele poderá assumir, ou seja, quanto maior a distância, pior. Resolva o problema de alocação codificando um algoritmo com o método húngaro de forma a minimizar o PERCENT_PRI ou a DISTANCE_KM ou os dois juntos. E seguida execute o código

BOT

To solve the problem of allocation using the Hungarian method, we need to minimize the cost matrix based on one or both criteria: `PERCENT_PRI` and `DISTANCE_KM`. The Hungarian algorithm is typically used for solving assignment problems where we aim to minimize the total cost of assigning workers to tasks.

Step-by-Step Plan:

- Understand the Problem**:
 - Each employee (`IDENTIFICADOR`) can be assigned to one job (`CARGO`).
 - The cost of assigning an employee to a job can be based on:
 - `PERCENT_PRI` (lower is better).
 - `DISTANCE_KM` (lower is better).
 - A combination of both (e.g., a weighted sum).
- Prepare the Cost Matrix**:
 - Create a matrix where rows represent employees and columns represent jobs.
 - The values in the matrix represent the cost of assigning an employee to a job. This cost can be:
 - Directly `PERCENT_PRI`.
 - Directly `DISTANCE_KM`.
 - A weighted combination of both, e.g., $\text{cost} = w1 * \text{PERCENT_PRI} + w2 * \text{DISTANCE_KM}$.
- Apply the Hungarian Algorithm**:
 - Use the Hungarian algorithm to find the optimal assignment that minimizes the total cost.
 - The algorithm works by transforming the cost matrix and finding the minimum cost assignment.
- Implement the Algorithm**:
 - Use Python's `scipy.optimize.linear_sum_assignment` function, which implements the Hungarian algorithm.
- Execute the Code**:
 - Load the data from the CSV file.
 - Construct the cost matrix.
 - Solve the assignment problem for each criterion (`PERCENT_PRI`, `DISTANCE_KM`, and combined).
 - Output the results.

Implementation in Python

Below is the Python code to solve the problem:

```
```python
import pandas as pd
import numpy as np
from scipy.optimize import linear_sum_assignment

Load the data
file_name = "dados_50_50.csv"
data = pd.read_csv(file_name, sep=";")
```

```
Normalize the columns PERCENT_PRI and DISTANCE_KM to bring them to the same scale
data['PERCENT_PRI'] = data['PERCENT_PRI'].str.replace(',', '.').astype(float)
data['DISTANCE_KM'] = data['DISTANCE_KM'].str.replace(',', '.').astype(float)

Get unique employees and jobs
employees = data['IDENTIFICADOR'].unique()
jobs = data['CARGO'].unique()

Create cost matrices
num_employees = len(employees)
num_jobs = len(jobs)

Initialize cost matrices
cost_percent = np.zeros((num_employees, num_jobs))
cost_distance = np.zeros((num_employees, num_jobs))
cost_combined = np.zeros((num_employees, num_jobs))

Fill the cost matrices
for i, emp in enumerate(employees):
 for j, job in enumerate(jobs):
 row = data[(data['IDENTIFICADOR'] == emp) & (data['CARGO'] == job)]
 if not row.empty:
 cost_percent[i, j] = row['PERCENT_PRI'].values[0]
 cost_distance[i, j] = row['DISTANCE_KM'].values[0]
 # Weighted combination: 50% weight for each criterion
 cost_combined[i, j] = 0.5 * row['PERCENT_PRI'].values[0] + 0.5 * row['DISTANCE_KM'].values[0]
 else:
 # Assign a high cost if no valid assignment exists
 cost_percent[i, j] = cost_distance[i, j] = cost_combined[i, j] = np.inf

Solve the assignment problem for each cost matrix
assignments_percent = linear_sum_assignment(cost_percent)
assignments_distance = linear_sum_assignment(cost_distance)
assignments_combined = linear_sum_assignment(cost_combined)

Output the results
def print_assignments(assignments, cost_matrix, criterion):
 total_cost = cost_matrix[assignments].sum()
 print(f"\nOptimal assignments minimizing {criterion}:")
 for emp, job in zip(assignments[0], assignments[1]):
 print(f"Employee {employees[emp]} -> Job {jobs[job]} (Cost: {cost_matrix[emp, job]:.2f})")
 print(f"Total cost: {total_cost:.2f}")

print_assignments(assignments_percent, cost_percent, "PERCENT_PRI")
print_assignments(assignments_distance, cost_distance, "DISTANCE_KM")
print_assignments(assignments_combined, cost_combined, "Combined Criterion")
```

### ### Explanation of the Code:

### ### Execution

To execute the code:

1. Save the provided data to a file named `dados\_50\_50.csv`.
2. Run the Python script.
3. The output will display the optimal assignments and their total costs for each criterion.

Let me know if you need further assistance!

Execution Result:

Optimal assignments minimizing PERCENT\_PRI:

Employee 1 -> Job 2 (Cost: 0.85)  
Employee 2 -> Job 72 (Cost: 0.58)  
Employee 3 -> Job 4 (Cost: 0.66)  
Employee 4 -> Job 7 (Cost: 0.43)  
Employee 5 -> Job 55 (Cost: 0.64)  
Employee 6 -> Job 56 (Cost: 0.97)  
Employee 7 -> Job 57 (Cost: 0.83)  
Employee 8 -> Job 5 (Cost: 0.98)  
Employee 9 -> Job 58 (Cost: 0.85)  
Employee 10 -> Job 59 (Cost: 0.97)  
Employee 11 -> Job 6 (Cost: 0.40)  
Employee 12 -> Job 8 (Cost: 0.06)  
Employee 13 -> Job 9 (Cost: 0.28)  
Employee 14 -> Job 10 (Cost: 0.97)  
Employee 15 -> Job 60 (Cost: 0.68)  
Employee 16 -> Job 61 (Cost: 0.98)  
Employee 17 -> Job 62 (Cost: 0.98)  
Employee 18 -> Job 11 (Cost: 0.89)  
Employee 19 -> Job 18 (Cost: 0.98)  
Employee 20 -> Job 73 (Cost: 0.52)  
Employee 21 -> Job 63 (Cost: 0.96)  
Employee 22 -> Job 13 (Cost: 0.98)  
Employee 23 -> Job 14 (Cost: 0.95)  
Employee 24 -> Job 15 (Cost: 0.47)  
Employee 25 -> Job 16 (Cost: 0.77)  
Employee 26 -> Job 64 (Cost: 0.09)  
Employee 27 -> Job 17 (Cost: 0.64)  
Employee 28 -> Job 20 (Cost: 0.61)  
Employee 29 -> Job 19 (Cost: 0.89)  
Employee 30 -> Job 21 (Cost: 0.91)  
Employee 31 -> Job 26 (Cost: 0.81)  
Employee 32 -> Job 65 (Cost: 0.96)  
Employee 33 -> Job 66 (Cost: 0.94)  
Employee 34 -> Job 22 (Cost: 0.57)  
Employee 35 -> Job 67 (Cost: 0.98)  
Employee 36 -> Job 23 (Cost: 0.83)  
Employee 37 -> Job 68 (Cost: 0.98)  
Employee 38 -> Job 24 (Cost: 0.60)  
Employee 39 -> Job 25 (Cost: 0.94)  
Employee 40 -> Job 69 (Cost: 0.92)  
Employee 41 -> Job 71 (Cost: 0.71)  
Employee 42 -> Job 27 (Cost: 0.21)  
Employee 43 -> Job 70 (Cost: 0.87)  
Employee 44 -> Job 28 (Cost: 0.81)  
Employee 45 -> Job 29 (Cost: 0.77)  
Employee 46 -> Job 3 (Cost: 0.95)  
Employee 47 -> Job 12 (Cost: 0.72)  
Employee 48 -> Job 1 (Cost: 0.94)  
Employee 49 -> Job 30 (Cost: 0.43)  
Employee 50 -> Job 74 (Cost: 0.77)  
Total cost: 37.45

Optimal assignments minimizing DISTANCE\_KM:

Employee 1 -> Job 1 (Cost: 1414.13)  
Employee 2 -> Job 2 (Cost: 2934.83)  
Employee 3 -> Job 3 (Cost: 3415.07)  
Employee 4 -> Job 4 (Cost: 1758.24)  
Employee 5 -> Job 30 (Cost: 801.75)  
Employee 6 -> Job 5 (Cost: 3355.79)  
Employee 7 -> Job 56 (Cost: 742.76)  
Employee 8 -> Job 6 (Cost: 1604.70)  
Employee 9 -> Job 57 (Cost: 670.80)  
Employee 10 -> Job 7 (Cost: 3590.74)  
Employee 11 -> Job 58 (Cost: 1394.51)  
Employee 12 -> Job 8 (Cost: 93.51)  
Employee 13 -> Job 9 (Cost: 1575.76)  
Employee 14 -> Job 10 (Cost: 3266.16)  
Employee 15 -> Job 59 (Cost: 1487.11)  
Employee 16 -> Job 11 (Cost: 1758.24)  
Employee 17 -> Job 60 (Cost: 1394.51)  
Employee 18 -> Job 12 (Cost: 2991.58)  
Employee 19 -> Job 61 (Cost: 1394.51)  
Employee 20 -> Job 13 (Cost: 2894.83)  
Employee 21 -> Job 14 (Cost: 1898.95)  
Employee 22 -> Job 15 (Cost: 1758.24)  
Employee 23 -> Job 16 (Cost: 3693.04)  
Employee 24 -> Job 17 (Cost: 765.83)  
Employee 25 -> Job 62 (Cost: 1113.01)  
Employee 26 -> Job 63 (Cost: 0.00)  
Employee 27 -> Job 18 (Cost: 1758.24)  
Employee 28 -> Job 19 (Cost: 3590.74)  
Employee 29 -> Job 20 (Cost: 1758.24)  
Employee 30 -> Job 21 (Cost: 579.73)  
Employee 31 -> Job 28 (Cost: 801.75)  
Employee 32 -> Job 65 (Cost: 1394.51)  
Employee 33 -> Job 66 (Cost: 1113.01)  
Employee 34 -> Job 22 (Cost: 1831.83)  
Employee 35 -> Job 67 (Cost: 1394.51)  
Employee 36 -> Job 64 (Cost: 1290.59)  
Employee 37 -> Job 69 (Cost: 1552.73)  
Employee 38 -> Job 23 (Cost: 123.06)  
Employee 39 -> Job 70 (Cost: 1376.11)  
Employee 40 -> Job 71 (Cost: 1472.82)  
Employee 41 -> Job 24 (Cost: 1382.29)  
Employee 42 -> Job 68 (Cost: 1815.15)  
Employee 43 -> Job 73 (Cost: 333.52)  
Employee 44 -> Job 25 (Cost: 765.83)  
Employee 45 -> Job 26 (Cost: 1604.70)  
Employee 46 -> Job 27 (Cost: 2455.42)  
Employee 47 -> Job 74 (Cost: 1113.01)  
Employee 48 -> Job 72 (Cost: 1394.51)  
Employee 49 -> Job 29 (Cost: 1637.95)  
Employee 50 -> Job 55 (Cost: 1394.51)  
Total cost: 81703.36

Optimal assignments minimizing Combined Criterion:

Employee 1 -> Job 1 (Cost: 707.49)  
Employee 2 -> Job 2 (Cost: 1467.70)  
Employee 3 -> Job 3 (Cost: 1707.86)  
Employee 4 -> Job 4 (Cost: 879.33)  
Employee 5 -> Job 30 (Cost: 401.20)  
Employee 6 -> Job 5 (Cost: 1678.39)  
Employee 7 -> Job 56 (Cost: 371.80)  
Employee 8 -> Job 6 (Cost: 802.84)  
Employee 9 -> Job 57 (Cost: 335.83)  
Employee 10 -> Job 7 (Cost: 1795.87)  
Employee 11 -> Job 58 (Cost: 697.47)  
Employee 12 -> Job 8 (Cost: 46.79)  
Employee 13 -> Job 9 (Cost: 788.02)  
Employee 14 -> Job 10 (Cost: 1633.57)  
Employee 15 -> Job 59 (Cost: 743.90)

```
Employee 16 -> Job 11 (Cost: 879.62)
Employee 17 -> Job 60 (Cost: 697.74)
Employee 18 -> Job 12 (Cost: 1496.24)
Employee 19 -> Job 61 (Cost: 697.75)
Employee 20 -> Job 13 (Cost: 1447.66)
Employee 21 -> Job 14 (Cost: 949.98)
Employee 22 -> Job 15 (Cost: 879.61)
Employee 23 -> Job 16 (Cost: 1846.99)
Employee 24 -> Job 17 (Cost: 383.15)
Employee 25 -> Job 62 (Cost: 556.91)
Employee 26 -> Job 63 (Cost: 0.04)
Employee 27 -> Job 18 (Cost: 879.44)
Employee 28 -> Job 19 (Cost: 1795.67)
Employee 29 -> Job 20 (Cost: 879.57)
Employee 30 -> Job 21 (Cost: 290.32)
Employee 31 -> Job 28 (Cost: 401.28)
Employee 32 -> Job 55 (Cost: 697.73)
Employee 33 -> Job 66 (Cost: 556.97)
Employee 34 -> Job 22 (Cost: 916.20)
Employee 35 -> Job 67 (Cost: 697.74)
Employee 36 -> Job 64 (Cost: 645.72)
Employee 37 -> Job 69 (Cost: 776.85)
Employee 38 -> Job 23 (Cost: 61.83)
Employee 39 -> Job 70 (Cost: 688.53)
Employee 40 -> Job 71 (Cost: 736.87)
Employee 41 -> Job 24 (Cost: 691.49)
Employee 42 -> Job 72 (Cost: 907.69)
Employee 43 -> Job 73 (Cost: 167.20)
Employee 44 -> Job 25 (Cost: 383.32)
Employee 45 -> Job 26 (Cost: 802.73)
Employee 46 -> Job 27 (Cost: 1228.18)
Employee 47 -> Job 74 (Cost: 556.88)
Employee 48 -> Job 68 (Cost: 697.73)
Employee 49 -> Job 29 (Cost: 819.19)
Employee 50 -> Job 65 (Cost: 697.64)
Total cost: 40870.54
```
```

USER

ajuste o código para normalizar os dois parâmetros e reexecute o código

BOT

Para ajustar o código e normalizar os dois parâmetros (`PERCENT_PRI` e `DISTANCE_KM`), precisamos garantir que ambos os critérios sejam escalados para o mesmo intervalo (por exemplo, entre 0 e 1). Isso é importante para evitar que um critério tenha mais peso que o outro devido à diferença de escala.

A normalização será feita utilizando a fórmula:

$$\text{normalized_value} = \frac{\text{value} - \text{min}}{\text{max} - \text{min}}$$

Código Ajustado

Aqui está o código atualizado com a normalização dos dois parâmetros:

```
```python
import pandas as pd
import numpy as np
from scipy.optimize import linear_sum_assignment

Carregar os dados
file_name = "dados_50_50.csv"
data = pd.read_csv(file_name, sep=";")
```

```

Converter os valores de PERCENT_PRI e DISTANCE_KM para float
data['PERCENT_PRI'] = data['PERCENT_PRI'].str.replace(',', '.').astype(float)
data['DISTANCE_KM'] = data['DISTANCE_KM'].str.replace(',', '.').astype(float)

Normalizar as colunas PERCENT_PRI e DISTANCE_KM
data['PERCENT_PRI_NORM'] = (data['PERCENT_PRI'] - data['PERCENT_PRI'].min()) / (data['PERCENT_PRI'].max() - data['PERCENT_PRI'].min())
data['DISTANCE_KM_NORM'] = (data['DISTANCE_KM'] - data['DISTANCE_KM'].min()) / (data['DISTANCE_KM'].max() - data['DISTANCE_KM'].min())

Obter os funcionários e cargos únicos
employees = data['IDENTIFICADOR'].unique()
jobs = data['CARGO'].unique()

Criar as matrizes de custo
num_employees = len(employees)
num_jobs = len(jobs)

Inicializar as matrizes de custo
cost_percent = np.zeros((num_employees, num_jobs))
cost_distance = np.zeros((num_employees, num_jobs))
cost_combined = np.zeros((num_employees, num_jobs))

Preencher as matrizes de custo
for i, emp in enumerate(employees):
 for j, job in enumerate(jobs):
 row = data[(data['IDENTIFICADOR'] == emp) & (data['CARGO'] == job)]
 if not row.empty:
 cost_percent[i, j] = row['PERCENT_PRI_NORM'].values[0]
 cost_distance[i, j] = row['DISTANCE_KM_NORM'].values[0]
 # Combinação ponderada: 50% para cada critério
 cost_combined[i, j] = 0.5 * row['PERCENT_PRI_NORM'].values[0] + 0.5 * row['DISTANCE_KM_NORM'].values[0]
 else:
 # Atribuir um custo alto se não houver atribuição válida
 cost_percent[i, j] = cost_distance[i, j] = cost_combined[i, j] = np.inf

Resolver o problema de alocação para cada matriz de custo
assignments_percent = linear_sum_assignment(cost_percent)
assignments_distance = linear_sum_assignment(cost_distance)
assignments_combined = linear_sum_assignment(cost_combined)

Função para imprimir os resultados
def print_assignments(assignments, cost_matrix, criterion):
 total_cost = cost_matrix[assignments].sum()
 print(f"\nAtribuições ótimas minimizando {criterion}:")
 for emp, job in zip(assignments[0], assignments[1]):
 print(f"Funcionário {employees[emp]} -> Cargo {jobs[job]} (Custo: {cost_matrix[emp, job]:.4f})")
 print(f"Custo total: {total_cost:.4f}")

Imprimir os resultados
print_assignments(assignments_percent, cost_percent, "PERCENT_PRI (normalizado)")
print_assignments(assignments_distance, cost_distance, "DISTANCE_KM (normalizado)")
print_assignments(assignments_combined, cost_combined, "Critério combinado (normalizado)")

```

### ### Explicação das Alterações

#### 1. \*\*Normalização\*\*:

- Adicionamos duas novas colunas ao DataFrame: `PERCENT\_PRI\_NORM` e `DISTANCE\_KM\_NORM`, que contêm os valores normalizados de `PERCENT\_PRI` e `DISTANCE\_KM`, respectivamente.
- A normalização é feita para que ambos os critérios fiquem no intervalo [0, 1].

#### 2. \*\*Matrizes de Custo\*\*:

- As matrizes de custo agora utilizam os valores normalizados (`PERCENT\_PRI\_NORM` e

`DISTANCE\_KM\_NORM`).

3. **\*\*Critério Combinado\*\***:

- A matriz de custo combinada utiliza uma média ponderada dos valores normalizados, com pesos iguais (50% para cada critério).

4. **\*\*Resultados\*\***:

- Os resultados são apresentados para cada critério: `PERCENT\_PRI`, `DISTANCE\_KM` e o critério combinado.

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### Como Executar

1. Salve o arquivo CSV com os dados fornecidos como `dados\_50\_50.csv`.
2. Execute o código Python.
3. O programa exibirá as alocações ótimas e os custos totais para cada critério.

Se precisar de mais ajustes ou explicações, é só avisar!

Execution Result:

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Atribuições ótimas minimizando PERCENT\_PRI (normalizado):

Funcionário 1 -> Cargo 1 (Custo: 0.8444)  
Funcionário 2 -> Cargo 73 (Custo: 0.5556)  
Funcionário 3 -> Cargo 3 (Custo: 0.6369)  
Funcionário 4 -> Cargo 18 (Custo: 0.3872)  
Funcionário 5 -> Cargo 55 (Custo: 0.6142)  
Funcionário 6 -> Cargo 56 (Custo: 0.9719)  
Funcionário 7 -> Cargo 57 (Custo: 0.8222)  
Funcionário 8 -> Cargo 5 (Custo: 0.9773)  
Funcionário 9 -> Cargo 58 (Custo: 0.8411)  
Funcionário 10 -> Cargo 59 (Custo: 0.9719)  
Funcionário 11 -> Cargo 12 (Custo: 0.3645)  
Funcionário 12 -> Cargo 7 (Custo: 0.0000)  
Funcionário 13 -> Cargo 8 (Custo: 0.2284)  
Funcionário 14 -> Cargo 9 (Custo: 0.9719)  
Funcionário 15 -> Cargo 60 (Custo: 0.6596)  
Funcionário 16 -> Cargo 61 (Custo: 0.9773)  
Funcionário 17 -> Cargo 62 (Custo: 0.9773)  
Funcionário 18 -> Cargo 10 (Custo: 0.8877)  
Funcionário 19 -> Cargo 11 (Custo: 0.9773)  
Funcionário 20 -> Cargo 72 (Custo: 0.4889)  
Funcionário 21 -> Cargo 63 (Custo: 0.9556)  
Funcionário 22 -> Cargo 13 (Custo: 0.9773)  
Funcionário 23 -> Cargo 14 (Custo: 0.9439)  
Funcionário 24 -> Cargo 15 (Custo: 0.4326)  
Funcionário 25 -> Cargo 16 (Custo: 0.7504)  
Funcionário 26 -> Cargo 64 (Custo: 0.0241)  
Funcionário 27 -> Cargo 17 (Custo: 0.6142)  
Funcionário 28 -> Cargo 19 (Custo: 0.5789)  
Funcionário 29 -> Cargo 21 (Custo: 0.8865)  
Funcionário 30 -> Cargo 20 (Custo: 0.9092)  
Funcionário 31 -> Cargo 23 (Custo: 0.7957)  
Funcionário 32 -> Cargo 65 (Custo: 0.9546)  
Funcionário 33 -> Cargo 66 (Custo: 0.9319)  
Funcionário 34 -> Cargo 22 (Custo: 0.5461)  
Funcionário 35 -> Cargo 67 (Custo: 0.9773)  
Funcionário 36 -> Cargo 26 (Custo: 0.8222)  
Funcionário 37 -> Cargo 68 (Custo: 0.9778)  
Funcionário 38 -> Cargo 24 (Custo: 0.5688)  
Funcionário 39 -> Cargo 25 (Custo: 0.9319)  
Funcionário 40 -> Cargo 69 (Custo: 0.9111)  
Funcionário 41 -> Cargo 71 (Custo: 0.6889)  
Funcionário 42 -> Cargo 27 (Custo: 0.1556)  
Funcionário 43 -> Cargo 70 (Custo: 0.8638)  
Funcionário 44 -> Cargo 28 (Custo: 0.7957)  
Funcionário 45 -> Cargo 29 (Custo: 0.7504)



Funcionário 46 -> Cargo 4 (Custo: 0.9439)  
Funcionário 47 -> Cargo 30 (Custo: 0.7050)  
Funcionário 48 -> Cargo 6 (Custo: 0.9319)  
Funcionário 49 -> Cargo 2 (Custo: 0.3872)  
Funcionário 50 -> Cargo 74 (Custo: 0.7504)  
Custo total: 36.6186

Atribuições ótimas minimizando DISTANCE\_KM (normalizado):

Funcionário 1 -> Cargo 1 (Custo: 0.3640)  
Funcionário 2 -> Cargo 2 (Custo: 0.7553)  
Funcionário 3 -> Cargo 3 (Custo: 0.8789)  
Funcionário 4 -> Cargo 4 (Custo: 0.4525)  
Funcionário 5 -> Cargo 30 (Custo: 0.2063)  
Funcionário 6 -> Cargo 5 (Custo: 0.8637)  
Funcionário 7 -> Cargo 55 (Custo: 0.1912)  
Funcionário 8 -> Cargo 6 (Custo: 0.4130)  
Funcionário 9 -> Cargo 56 (Custo: 0.1726)  
Funcionário 10 -> Cargo 7 (Custo: 0.9242)  
Funcionário 11 -> Cargo 58 (Custo: 0.3589)  
Funcionário 12 -> Cargo 8 (Custo: 0.0241)  
Funcionário 13 -> Cargo 9 (Custo: 0.4056)  
Funcionário 14 -> Cargo 10 (Custo: 0.8406)  
Funcionário 15 -> Cargo 59 (Custo: 0.3827)  
Funcionário 16 -> Cargo 11 (Custo: 0.4525)  
Funcionário 17 -> Cargo 60 (Custo: 0.3589)  
Funcionário 18 -> Cargo 12 (Custo: 0.7700)  
Funcionário 19 -> Cargo 61 (Custo: 0.3589)  
Funcionário 20 -> Cargo 13 (Custo: 0.7451)  
Funcionário 21 -> Cargo 14 (Custo: 0.4887)  
Funcionário 22 -> Cargo 15 (Custo: 0.4525)  
Funcionário 23 -> Cargo 16 (Custo: 0.9505)  
Funcionário 24 -> Cargo 17 (Custo: 0.1971)  
Funcionário 25 -> Cargo 62 (Custo: 0.2865)  
Funcionário 26 -> Cargo 63 (Custo: 0.0000)  
Funcionário 27 -> Cargo 18 (Custo: 0.4525)  
Funcionário 28 -> Cargo 19 (Custo: 0.9242)  
Funcionário 29 -> Cargo 20 (Custo: 0.4525)  
Funcionário 30 -> Cargo 21 (Custo: 0.1492)  
Funcionário 31 -> Cargo 28 (Custo: 0.2063)  
Funcionário 32 -> Cargo 65 (Custo: 0.3589)  
Funcionário 33 -> Cargo 64 (Custo: 0.2865)  
Funcionário 34 -> Cargo 22 (Custo: 0.4715)  
Funcionário 35 -> Cargo 67 (Custo: 0.3589)  
Funcionário 36 -> Cargo 66 (Custo: 0.3322)  
Funcionário 37 -> Cargo 68 (Custo: 0.3996)  
Funcionário 38 -> Cargo 23 (Custo: 0.0317)  
Funcionário 39 -> Cargo 70 (Custo: 0.3542)  
Funcionário 40 -> Cargo 71 (Custo: 0.3791)  
Funcionário 41 -> Cargo 24 (Custo: 0.3558)  
Funcionário 42 -> Cargo 69 (Custo: 0.4672)  
Funcionário 43 -> Cargo 73 (Custo: 0.0858)  
Funcionário 44 -> Cargo 25 (Custo: 0.1971)  
Funcionário 45 -> Cargo 26 (Custo: 0.4130)  
Funcionário 46 -> Cargo 27 (Custo: 0.6320)  
Funcionário 47 -> Cargo 74 (Custo: 0.2865)  
Funcionário 48 -> Cargo 57 (Custo: 0.3589)  
Funcionário 49 -> Cargo 29 (Custo: 0.4216)  
Funcionário 50 -> Cargo 72 (Custo: 0.3589)  
Custo total: 21.0283

Atribuições ótimas minimizando Critério combinado (normalizado):

Funcionário 1 -> Cargo 3 (Custo: 0.6042)  
Funcionário 2 -> Cargo 2 (Custo: 0.6443)  
Funcionário 3 -> Cargo 14 (Custo: 0.7579)  
Funcionário 4 -> Cargo 4 (Custo: 0.4199)  
Funcionário 5 -> Cargo 55 (Custo: 0.4087)  
Funcionário 6 -> Cargo 5 (Custo: 0.9318)  
Funcionário 7 -> Cargo 56 (Custo: 0.5067)



Funcionário 8 -> Cargo 6 (Custo: 0.6952)  
Funcionário 9 -> Cargo 57 (Custo: 0.5069)  
Funcionário 10 -> Cargo 7 (Custo: 0.9621)  
Funcionário 11 -> Cargo 70 (Custo: 0.3731)  
Funcionário 12 -> Cargo 9 (Custo: 0.0120)  
Funcionário 13 -> Cargo 10 (Custo: 0.3170)  
Funcionário 14 -> Cargo 11 (Custo: 0.9063)  
Funcionário 15 -> Cargo 58 (Custo: 0.5212)  
Funcionário 16 -> Cargo 59 (Custo: 0.7242)  
Funcionário 17 -> Cargo 60 (Custo: 0.6681)  
Funcionário 18 -> Cargo 13 (Custo: 0.8288)  
Funcionário 19 -> Cargo 71 (Custo: 0.6795)  
Funcionário 20 -> Cargo 28 (Custo: 0.6059)  
Funcionário 21 -> Cargo 61 (Custo: 0.7247)  
Funcionário 22 -> Cargo 16 (Custo: 0.7149)  
Funcionário 23 -> Cargo 18 (Custo: 0.9472)  
Funcionário 24 -> Cargo 17 (Custo: 0.3149)  
Funcionário 25 -> Cargo 25 (Custo: 0.5215)  
Funcionário 26 -> Cargo 62 (Custo: 0.0121)  
Funcionário 27 -> Cargo 19 (Custo: 0.5334)  
Funcionário 28 -> Cargo 20 (Custo: 0.7516)  
Funcionário 29 -> Cargo 21 (Custo: 0.6695)  
Funcionário 30 -> Cargo 22 (Custo: 0.5292)  
Funcionário 31 -> Cargo 23 (Custo: 0.5010)  
Funcionário 32 -> Cargo 63 (Custo: 0.6568)  
Funcionário 33 -> Cargo 64 (Custo: 0.6092)  
Funcionário 34 -> Cargo 24 (Custo: 0.5088)  
Funcionário 35 -> Cargo 65 (Custo: 0.6681)  
Funcionário 36 -> Cargo 73 (Custo: 0.5883)  
Funcionário 37 -> Cargo 66 (Custo: 0.6887)  
Funcionário 38 -> Cargo 26 (Custo: 0.3002)  
Funcionário 39 -> Cargo 27 (Custo: 0.6451)  
Funcionário 40 -> Cargo 67 (Custo: 0.6451)  
Funcionário 41 -> Cargo 29 (Custo: 0.5112)  
Funcionário 42 -> Cargo 69 (Custo: 0.3225)  
Funcionário 43 -> Cargo 68 (Custo: 0.4748)  
Funcionário 44 -> Cargo 30 (Custo: 0.4964)  
Funcionário 45 -> Cargo 15 (Custo: 0.5817)  
Funcionário 46 -> Cargo 8 (Custo: 0.7879)  
Funcionário 47 -> Cargo 12 (Custo: 0.4988)  
Funcionário 48 -> Cargo 72 (Custo: 0.6568)  
Funcionário 49 -> Cargo 1 (Custo: 0.4044)  
Funcionário 50 -> Cargo 74 (Custo: 0.5546)  
Custo total: 28.8931  
'''