MSIS 638

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Case 3.1b

1. Consider the multi-objective optimization problem discussed in Checkpoint 3.3. The data is given in the following table. Rank the plans according to the weighted average dose to the healthy organs (lowest to greatest). Make sure to include your calculations.

|  |  |  |  |
| --- | --- | --- | --- |
| **Organ** | **Heart** | **Spinal cord** | **Kidney** |
| Weight | 0.6 | 0.3 | 0.1 |
| Plan 1 | 100 Gy | 40 Gy | 50 Gy |
| Plan 2 | 80 Gy | 50 Gy | 30 Gy |
| Plan 3 | 110 Gy | 30 Gy | 10 Gy |

Plan 1: 100\*0.6 + 40\*0.3 + 50\*0.1 / 1 = 77

Plan 2: 48 + 15 + 3 = 66

Plan 3: 66 + 9 + 1 = 76

Then the rank will be - Plan 2 > Plan 3 > Plan 1

We can find that the optimal plan is Plan 2 (having the minimum dose in healthy organs) by using weight average method.

1. The best plan according to the current weights is Plan 2. Change the weights so that Plan 1 becomes the best plan (make sure weights sum to 1)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Organ** | **Heart** | **Spinal cord** | **Kidney** | **Weight Average** |
| Weight | 0.33 | 0.67 | 0 | N/A |
| Plan 1 | 100 | 40 | 50 | 59.8 |
| Plan 2 | 80 | 50 | 30 | 59.9 |
| Plan 3 | 110 | 30 | 10 | 56.4 |

Though the plan 3 is better than plan 1, however, plan 2 is replaced by plan 1.

As the figure shown above, to make Plan 1 the optimal solution.

1. Change the weights so that Plan 3 becomes the best plan (make sure weights sum to 1).

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Organ** | **Heart** | **Spinal cord** | **Kidney** | **Weight Average** |
| Weight | 0.2 | 0.7 | 0.1 | N/A |
| Plan 1 | 100 | 40 | 50 | 53 |
| Plan 2 | 80 | 50 | 30 | 54 |
| Plan 3 | 110 | 30 | 10 | 44 |

As the figure shown above, by changing the weight of Spinal cord and Heart, Plan 3 becomes the best plan (minimum).

1. Reset the weights to the base values in the above table. Assume the weight of kidney must remain at 0.1 (therefore the weights of heart and spinal cord must sum to 0.9). If you gradually reduce the weight of heart and increase the weight of spinal cord, at some point, the best plan will no longer be Plan 2. Find that point at which the best plan switches. (Hint: You can use the Goal Seek tool in Excel as well.)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Organ** | **Heart** | **Spinal cord** | **Kidney** | **Weight Average** |
| Weight | 0.4 | 0.5 | 0.1 | N/A |
| Plan 1 | 100 | 40 | 50 | 65 |
| Plan 2 | 80 | 50 | 30 | 60 |
| Plan 3 | 110 | 30 | 10 | 60 |

When Heart = 0.4, Spinal cord = 0.5, the weight of the plan become the same.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Organ** | **Heart** | **Spinal cord** | **Kidney** | **Weight Average** |
| Weight | 0.39 | 0.51 | 0.1 | N/A |
| Plan 1 | 100 | 40 | 50 | 64.4 |
| Plan 2 | 80 | 50 | 30 | 59.7 |
| Plan 3 | 110 | 30 | 10 | 59.2 |

When Heart become 0.39 and Spinal cord become 0.51. Plan 2 become no longer the optimal solution.