1. Task 2.1: Methodology, Results and Discussion
2. Methodology
3. Results
4. Discussion
5. Task 3: Methodology, Results and Discussion
   1. Methodology

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| In task 3, our goal is to find out the path that has the lowest cost by designing a 16m2 minus cost area. We defined the best minus cost area is that the area is capable to help us greatly reduce the cost or conduct a path that has the lowest cost. We think that design the minus cost area as a line is more effective and more suitable to decline the cost because the PolyU-A380 can has a full use of the minus cost area. Otherwise, the PolyU-A380 cannot has full use of the minus cost area if we make in to square or rectangular. We will conduct this project by using the formula “C = 𝐶𝐹 ∙ ∆𝐹 + 𝐶𝑇 ∙ ∆𝑇 + 𝐶𝑐 + 𝐶𝑃 ∙ ∆P”.  We assume that the minus cost area is placed along the original path because the original path is the path that has the lowest cost calculated by the python A-star. Meanwhile, we try not to increase the total distance that the PolyU-A380 travels, so we think the minus cost area should be placed along the original path in order to cut the cost as much as we can. |
| Figure 1 (The Original Cost Without Minus Cost Area) |
| After that, we will try to figure out the possible minus cost area outside the original path in order to gain all possible results and prevent losing the potential minus cost area that gives us the best cost reduction.  Finally, we will also try to put the minus cost area next to the time consuming area and fuel consuming area in order to find out the path that make the increasing cost to be recovered by the minus cost area. For an exmple, place the minus cost area on the one side of the cost adding areas to recover the cost. It should a method to to gain all possible results. |

* 1. Results

This is the original PolyU-A380 travelling path calculated by Python A-star in Task 1. The cost in this path is 2941.417. The below picture shows the path of PolyU-A380 in Task 1.

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| --- |
| Figure 1 (The Original Cost Without Minus Cost Area) |

* + 1. Designing Minus Cost Along the Original Path

The numbers are the minus cost area locations in the pictures below.

|  |  |
| --- | --- |
| The Location of Minus Cost Area | Cost |
| Location 1 | 2068.832 |
| Location 2 | 1354.041 |
| Location 3 | 1267.332 |
| Location 4 | 1131.498 |
| Location 5 | 355.203 |

Chart 1 (The results of designing minus cost along the original path)

|  |  |  |  |
| --- | --- | --- | --- |
| Figure 2 (Location 1 in Part7.2.1) | | Figure 3 (Location 2 in Part7.2.1) | |
| Figure 4 (Location 3 in Part7.2.1) | | Figure 5 (Location 4 in Part7.2.1) | |
| Figure 6 (Location 5 in Part7.2.1) | |

* + 1. Designing Minus Cost Outside the Original Path

The numbers are the minus cost area locations in the pictures below.

|  |  |
| --- | --- |
| The Locations of Minus Cost Area | Cost |
| Location 1 | 1981.215 |
| Location 2 | 1741.624 |
| Location 3 | 1723.415 |
| Location 4 | 956.830 |
| Location 5 | 1039.791 |
| Location 6 | 792.958 |

Chart 2 (The results of designing minus cost outside the original path)

|  |  |
| --- | --- |
| Figure 7 (Location 1 in Part7.2.2) | Figure 8 (Location 2 in Part7.2.2) |
| Figure 9 (Location 3 in Part7.2.2) | Figure 10 (Location 4 in Part7.2.2) |
| Figure 11 (Location 5 in Part7.2.2) | Figure 11 (Location 6 in Part7.2.2) |

* + 1. Designing Minus Cost Next to the Cost Adding Areas

The numbers are the minus cost area locations in the pictures below.

|  |  |
| --- | --- |
| The Locations of Minus Cost Area | Cost |
| Location 1 | 2038.494 |
| Location 2 | 2382.230 |
| Location 3 | 2382.230 |
| Location 4 | 264.043 |

Chart 3 (The results of designing minus cost next to the cost adding areas)

|  |  |
| --- | --- |
| Figure 12 (Location 3 in Part7.2.3) | Figure 13 (Location 4 in Part7.2.3) |
| Figure 14 (Location 5 in Part7.2.3) | Figure 15 (Location 6 in Part7.2.3) |

* + 1. Sorting the Data from Part 7.2.1 to 7.2.3

|  |  |
| --- | --- |
| The Location of Minus Cost Area | Cost |
| Location 1 in 7.2.1 | 2068.832 |
| Location 2 in 7.2.1 | 1354.041 |
| Location 3 in 7.2.1 | 1267.332 |
| Location 4 in 7.2.1 | 1131.498 |
| Location 5 in 7.2.1 | 355.203 |

Chart 1 (The results of designing minus cost along the original path)

|  |  |
| --- | --- |
| The Locations of Minus Cost Area | Cost |
| Location 1 in 7.2.2 | 1981.215 |
| Location 2 in 7.2.2 | 1741.624 |
| Location 3 in 7.2.2 | 1723.415 |
| Location 4 in 7.2.2 | 956.830 |
| Location 5 in 7.2.2 | 1039.791 |
| Location 6 in 7.2.2 | 792.958 |

Chart 2 (The results of designing minus cost outside the original path)

|  |  |
| --- | --- |
| The Locations of Minus Cost Area | Cost |
| Location 1 in 7.2.3 | 2038.494 |
| Location 2 in 7.2.3 | 2382.230 |
| Location 3 in 7.2.3 | 2382.230 |
| Location 4 in 7.2.3 | 264.043 |

Chart 3 (The results of designing minus cost next to the cost adding areas)

After placing different minus cost area locations into the map, we can get the data above. In order to find the best potential minus cost area location, we decide to place the minus cost area next to the location which is location 4 in 7.2.3 has the minimum cost in the above chart. Hope to find out the minimum cost.

|  |  |
| --- | --- |
| The Locations of Minus Cost Area | Cost |
| Location 1 in 7.2.4 | 320.375 |
| Location 2 in 7.2.4 | 19 |
| Location 3 in 7.2.4 | 94.042 |
| Location 4 in 7.2.4 | 26.042 |

Chart 4 (The results of further designing minus cost area from the location 4 in 7.2.3)

The numbers are the minus cost area locations in the pictures below.

|  |  |
| --- | --- |
| Figure 16 (Location 1 in Part7.2.4) | Figure 17 (Location 2 in Part7.2.4) |
| Figure 18 (Location 3 in Part7.2.4) | Figure 19 (Location 4 in Part7.2.4) |

* 1. Discussion

From the above part, we can observe that the paths having relatively low cost are located nearby the original path. In the above charts, we can see that chart 1 which is the results of designing minus cost area along the original path, its average cost is 1235. In comparison to the average cost in chart 2 and 3, the average cost in chart 1 is 138 lower than the that in chart 2 and 532 lower than that in chart 3. Hence, this reflect that the putting the minus cost area nearby the original path can probably help us get the minimum cost.

Although the minimum cost observed on the above charts is 19 produced in location 2 in part 7.2.4, it could not be considered as the best location to put the minus area. It may be an error data generated by the a-star programme, because the cost should not be that small. After having a discussion, we have our explanation of why the data in part 7.2.4 is considered as error.

The factor of making these error is that the code pattern itself has some weakness that does not show the greatest path. The code used in the project is called AStarPlanner which is a basic path planning model. It calculates the cost by using the equation, “cost fuctionF(x) + HeuristicG(x)”. As the code shown in the file, “open\_set[o].cost + self.calc\_heuristic (self, goal\_node, open-set[o])”, the first function “set[o].cost” is F(x) and the second function “self.calc\_heuristic(self, goal\_node, open-set[o])” is G(x). When too many nodes have the same cost, the codes’ weakness exposed. It does not know which way is the best and the cost calculation become inaccurate. The F(x)+G(x) gives a bigger weighting for heuristic function G(x) in the equation. Eventually, the shorter distance between the minus cost area and the end point, the lower the cost is.

Moreover, all the data conducted in part 7.2.4 should be rejected because of its uncertainty. Now, the data conducted from part 7.2.1 to 7.2.3 should be considered to make further decision.

From the part 7.2.1 to part 7.2.3, the minimum cost can be observed in location 5 in part 7.2.1 in chart 1 which is 355.203 and is decided to be our result on task 3. In figure 6, the minus cost area is placed along the original path. When PolyU-A380 pass through the time-consuming area, then it enters the minus cost area immediately. This result is suitable and reasonable in the situation of figure 6. There are some possible factors that make this result is acceptable and the best.

For the first reason, the chosen result utilizes the shortest distance belong to original path. As the original path calculated by the programme has the shortest travel distance, so we can utilize this characteristic to have further cost reduction by setting the minus cost area along the original path. When the travel distance remains no change, the minus cost area can have a significant effective on total cost reduction. Then, the PolyU-A380 does not travel longer, it means it does not increase any cost by travelling a distance to enter the minus cost area. In this situation, the cost is reduced dramatically. As a result, the cost is reduced dramatically because of the minus cost area.

For the second reason, minus cost area recovers the increase of cost caused by time-consuming area after PolyU-A380 entering the minus cost area. As we can see the time-consuming area increase the cost by 2 per gird and the delta T is 5 per gird, it is a heavy burden on the cost. However, the minus cost area reduces the cost by 2 per grid. Also, the PolyU-A380 travelled 15m2 of the time-consuming area and travelled 16 m2 of minus cost area which is shown in figure 6. Consequently, the reduction on the cost caused by the minus cost area resists the increase on the cost caused by the time-consuming area, and travel one more grid of minus cost area. Both of cost recovery and cost reduction happens during PolyU-A380 is travelling through this path. So, the cost is reduced.

For third reason,

1. Reflective Essay (Franky)

In the beginning, when I knew I can have opportunity to choose project related to aviation, I was excited. Although I was excited, I felt a little bit afraid once I heard that this project requiring programming skills because I have never tried in programming in my whole life. Finally, I found this project is not as difficult as I thought.

During this project, I experienced and learned programming skills, which is important to me because programming skills is one of the fundamental skills towards a person who want to enter aviation industry and it can be applied to many aspects in aviation, like navigation, UAV, flight control system, etc.

I found a way to learn programming effectively which is to observe the combination of each command and test each command incessantly and respectively. By trying type in different commands, I could get instant responses from Python and improve my programming skills.

I got involved in task 3 in this project. As I had no knowledge on programming at the beginning, so I had to guess the meanings and test the results of each command downloaded from professor’s github. I felt difficult on task 3 especially on creating an irregular shape minus cost area. After testing the commands, I realized the logic behind most of the tested commands and started to create the area. I was delighted and satisfied when I found the way to achieve my idea on python. Finally, I learned programming and problem-solving skills during the process.

Meanwhile, I also understood that having a good communication between team members can facilitate the work efficiency. All the members have given their own opinions and suggestions towards each task. For example, our group leader is good at programming, so he gave us numerous of tips in doing our task. As a result, most of our tasks were finished smoothly. Also, we helped each other to check their work. For example, when one of us had finished the responsible part, we helped them to check the answers. Hence, we can probably avoid making mistakes.

Moreover, this project makes me role played as a flight dispatcher to design a path for the aircrafts. During the project, I finally knew that programming can be applied on collaborative path planning towards UAV, separating the aircraft to avoid collision as well as increasing the airworthiness and reliability of aircrafts. These knowledges are what I have learnt during the lecture.

Last but not least, this project is really meaningful that provide a chance to engineering students from different departments to collaborate and share own knowledge with each other. I have learnt several things from this project, including programming skills, problem-solving skills, the importance of having a good communication and the importance of programming in aviation discipline.