Developing 3D-Route Planning using ArcGIS Engine

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Abstract
This theme illustrates the implementation of the 3D-Router Planning System using ArcGIS Engine. Our system supposes that each aircraft has its facilities, like flight altitude, speed, oil usage, fly distance and turn angle. Not only do we define the start and destination where the aircraft take off and land, but we also plan the positions it must come over when it flies.

In the meanwhile, we set all kinds of the alert area including the range of radar, weapon, weather etc and those the aircraft are not allowed to pass through. Our system can automatically analysis the routes according to either inner capabilities of all kinds of aircrafts or outer range all kinds of alert areas. Moreover, it can also smooth the path to display the optimal route and eliminate the impossible route as the aircraft flies.

I. Introduce
We use ArcGIS Engine to develop a system for aircraft in order to provide an optimized route planning. This implementation has used axMapControl, axToolBarControl, and Carto, Geometry, display and analysisTool of namespace. And it is fully applied functions ArcGIS Engine provided. The Figure1 states the processes of this subsystem. We divided into three parts of this study containing Mission Plan, Threat Analysis and Automatic Plan. And we can see Figure1, Mission Plan includes set mission plan, editing existing mission; Threat Analysis includes Set Threat Type, Display Threat and Display the result after threat analysis; Automatic Plan includes Display grids, Select the optimized and Display final result.
II. Mission Plan

First, we built a customized tool which provided capabilities to create new mission, edit mission, delete mission, create new route, copy existing route, delete all legs in a route, select leg, move leg, and insert leg. In our system, the mission is an aircraft’s flight path will be followed by aviator and the leg is waypoint seen in Figure 2.

For instance, the result according to customized tool by our initial planning is like the Figure 2. We also can edit the position of leg or other functions again if the need is changed seen in Figure 3.
Next, we can display the threat according to threat type and threat location. Threat type can set color, drawing style of line, and radius or altitude of weapon or radar showed in Figure 4. The threat can be weapon or radar depending on our setting.

Next we can show the threat on the map according to threat locations seen in Figure 5. We also can set the property of threat including the location.
III. Threat Analysis

With display of the threat, we must analyze the threat range using Digital Elevation Model (DEM) seen in Figure 6 which provides altitudes of the surface to calculate the range weapon can attack or radar can detect by our method seen. DEM contains many grids and each has its height and we must define the height of threat and aircraft to analyze which grid can be threatened.

We use 3D Analyst of ArcGIS Engine to analyze if the each grid of DEM is threatened. It is resulted from the Figure5 and DEM and can be seen many grids on the map. The grids represents this area is be threatened with weapon or radar. The blank of origin threat means this area is not threatened so it is allowed to pass through seen in Figure7.
IV. Automatic Plan

The route we planned before must be avoided the range of the threat location according to threat type. With the more threat locations overlay, the more complicated the route plans. It needs more time to analyze the safe areas and threatened areas by 3DAnalyst of ArcGIS Engine. In the beginning of this, we set squired grids (9×9) to choose the candidates of the result of automatic plan seen in Figure 8.

We use $V = \{V_{e1}, V_{e2}, \ldots, V_{p1}, V_{p2}, \ldots, V_{pp}\}$ to represent the squired grids. Greedy algorithm is used for calculate the all possible
traces from the start to the end of this route as the following algorithm.

Begin
  Vstart, Vend,Vt,Vts;
  Vt = Vstart
  While Vts is not including Vend
    if v is not in threat area
      Vts = Vt+ findAdjacentOfVstartAndNoThreat(Vt)
    if Vts are closed
      Vts = Vts – Vt
    end if
  end if
end While
end Begin

This implementation also finds the shortest path for this route to optimize the path which is seen in Figure 9.

![Figure 9 Select the optimized path](image)

V. Conclusion

This implementation has complete mission from the manual mission plan, analyzing by DEM using 3DAnalyer and automatic plan by our method. The enhancement can be more improved to reinforce our algorithm to reduce the calculate time. They may not produced the result owing to the condition of candidates are closed in some cases. It strongly depends on the output of the analyzing by DEM.