Infiltration Route Analysis using Genetic Algorithm

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ABSTRACT: The remote sensor’s performance improvement has been gradually expanding the application areas of GIS. The infiltration route analysis is one of them. The result of analysis can be used not only to find optimal infiltration route, but also to estimate optimal location of surveillance equipment by simulation. Most path planning algorithms were developed based on network data, but infiltration route analysis should be done based on raster data. In this study, the genetic algorithm was applied to find optimal infiltration route based on raster data. Existing 2D binary array and suggested 2D array were tested as the expression of gene. Results indicate that 2D binary array shows better performance, but suggested 2D array can significantly reduce computation time. Therefore, if crossover operator is improved, 2D array will be able to be more efficient expression of gene.

1. Introduction

Geospatial Information Systems(GIS) play a pivotal role in military application, and mainly used for the field of flight-related, such as mission planning, terrain tracking, simulation, and LOS analysis. However, the sensor’s performance improvement has been gradually expanding the application areas. The infiltration route analysis is one of them. The result of analysis can be used not only to find optimal infiltration route, but also to estimate optimal location of surveillance equipment by simulation.

Most path planning algorithms were developed based on network data. However infiltration route analysis should be done based on raster data, because there is no fixed path or node. Therefore, It is difficult to apply network-based algorithms, such as Dijkstra’s algorithm. Network-based algorithm can be applied by treating each pixel as a node, however, it requires intensive computation tasks.

Marti et al.(1994), Kwok(1999), and Howard(2002) analyzed optimal routes by applying their suggested algorithms to raster-based map. Bang et al.(2011) used genetic algorithm to determine optimal path, and suggested 2D binary array genes. In this study, we suggest and apply more efficient genetic algorithm.

2. Methodology

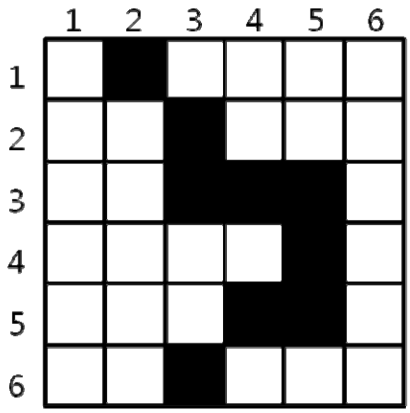
2.1 Detection Probability Map

The optimal infiltration route can be defined the path that minimize the cost function, summation of detection probability. In order to calculate cost, detection probability map was generated. The detection probability was created from the concealment probability map and the TOD detection probability map. The concealment probability was related to the covering rate of vegetation and terrain occlusions. TOD detection probability map was generated by merging the TOD detection probability and result of viewshed analysis. TOD detection probability was inversely proportional to the distance from TOD locations. Each entity was extracted from VITD, which was defined by the National Geospatial-Intelligence Agency (NGA) military standard, and DEM, which was created from contour lines on the 1:5000 digital map, were used.

2.2 Genetic Algorithm

A genetic algorithm is a heuristic optimization method that mimics the process of natural evolution. The genetic algorithm has shown great outcomes in various optimization problems. In general, genetic algorithm consists of 4 steps; initialization, selection, crossover, and mutation. Initialization, the first step of genetic algorithm, is procedure which makes a set of possible solutions. After initialization, other steps are repeated. In selection, more fit solutions are selected with higher probability, and selected solutions reproduce next generation through crossover and mutation.

In this study, each solution is possible route, and objective function is to minimize cumulative detection probability. Each route can be represented by raster format or 2D binary array. However 2D binary array is sparse matrix, which has a lot of 0 value, and it makes to waste computation. If backward direction movement was ignored, it can be more simply represented by start and end point of each row (Figure 1). Whereas 2D array was used by gene instead of string, which is used in most application of genetic algorithm, crossover and mutation also should be redefined. Redefined crossover is similar to conventional one point crossover. Crossover row was randomly selected then the chromosomes were interchanged at crossover row. Each start and end points of crossover row inherit end point of above row and start point of bellow row because of connectivity. Mutation procedure is similar to crossover. Mutation row was randomly selected, above or below values are inherited and other side were randomly generate mutation route.



(a) Raster

	1	2	3	4	5	6
1	0	1	0	0	0	0
2	0	0	1	0	0	0
3	0	0	1	1	1	0
4	0	0	0	0	1	0
5	0	0	0	1	1	0
6	0	0	1	0	0	0

(b) 2D Binary Array

	S	E
1	2	2
2	3	3
3	3	5
4	5	5
5	5	4
6	3	3

(c) 2D array

Figure 1. Representation of Route

3. Results and Conclusion

In the result of applying both the 2D binary array and the 2D array, 2D binary array shows better performance than 2D array. The cumulative detection probability was increased about 20 to 40. It is due to that crossover and non-crossover case was distinguished and apply different crossover operator when 2D binary array was used. However computing time was significantly reduced when using suggested 2D array. Computing time was reduced from about 10 minutes to 10 seconds using same parameter, 1000 population and 50 generations. 2D binary array and 2D array can be freely changed, and operators can be designed to do exactly same work. Therefore, if crossover operator is improved, 2D array will be able to find optimal path more efficiently than 2D binary array.

4. References

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