Exploration of a Two Sided Rendezvous Search Problem Using Genetic Algorithms

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Abstract. The problem of searching for a walker that wants to be found, when the walker moves toward the helicopter when it can hear it, is an example of a two sided search problem which is intrinsically difficult to solve. Thomas et al [1] considered the effectiveness of three standard NATO search paths [2] for this type of problem. In this paper a genetic algorithm is used to show that more effective search paths exist. In addition it is shown that genetic algorithms can be effective in finding a near optimal path of length 196 when searching a 14×14 cell area, that is a search space of 10^{100}. . . .

1 Problem Description

Rendezvous search, or looking for someone who wants to be found, such as a walker lost in the desert was recently considered by Thomas and Hulme [1]. The basic problem is as follows, the lost walker is searched for by a helicopter. The speed of the walker is 3 m.p.h. and that of the helicopter 60 m.p.h.. If the walker hears the helicopter it moves towards it, if not it stays still. The walker can detect the helicopter to a radius of 1 mile, and the helicopter can detect the walker to a radius of 0.11 miles. The search region is broken up into 196 cells in a 14×14 grid. The helicopter takes 9 seconds to transit between cells and spends 10 seconds searching each cell. The walker could move freely in the search space but the helicopter was constrained to move up and down but not diagonally between adjacent cells. The cell size was the largest square that could be inscribed within the circle of detection of the helicopter, and it was assumed that detection could only occur if the walker and helicopter were in the same cell at the same time. This problem is hard to solve analytically.

If detection in the simulation (occurring with probability 0.78) is determined by the throw of a dice, this causes fluctuations in the values of the fitness function. The GA was found to not converge unless up to $1,000$ trials were averaged for each fitness value. This then makes the problem computationally intractable.

To overcome this, for each search path and starting location of the walker, a simulation was done to determine at what times the walker and helicopter were in the same cell. This information was used to construct a theoretical cumulative

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probability curve, as a function of time. These results were then averaged over all possible walker starting locations to give a cumulative probability distribution which characterized the effectiveness of the path. These distributions have no random fluctuations and can be used to construct a noise free fitness function for the GA. The fitness function was a weighted sum of the maximum probability at the end of the search and the area under the curve. Including the area under the curve ensured that higher fitness values were given to paths that had higher probabilities of early detection.

2 Results

The three NATO search paths are the decreasing square (DESQ) starting in cell one (at one corner) and spiraling in to the centre, the expansion square (EXSQ) covering the same path in reverse, and the scan search (SCAN) a path which zig zags across the area with strips parallel to the boundaries. The path found by the GA was compared with the three NATO paths, results for which are shown in Fig. 1.

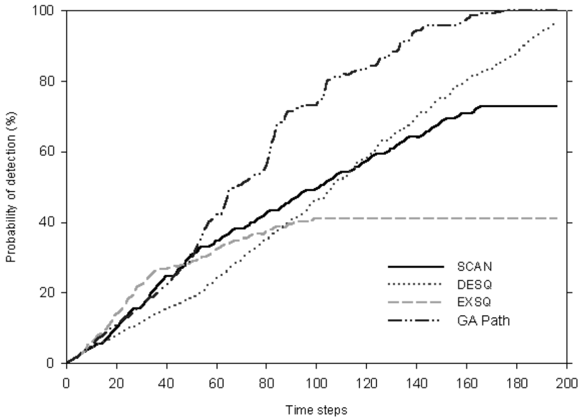

Fig. 1. 14×14 region, velocity of walker 3 m.p.h.

References

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