Heuristic Solutions for the Forest Planning Problem

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1 Introduction

The goal of the forest planning (FP) problem is to maximize timber harvest in a forest over a given number of time periods [1]. The forest consists of a finite number of stands (non-overlapping regions), and a solution to the problem consists of a harvest schedule over these stands. In other words, given a target harvest for each time period, we want to assign a time slot to each of the stands such that our harvest in each time period is closest to the target. Specifically, we seek to find a schedule that minimizes the following equation:

$$\sum_{t=1}^{nPeriods} (H_t - T)^2 \tag{1}$$

where H_t is the harvest volume at time period t and T is the target harvest per time period. However, due to the nature of the problem, the schedule must abide by certain constraints. In order to prevent erosion and other land maintenance issues, no two adjacent stands may be scheduled for the same time period. This greatly increases the complexity of the problem. In this paper, we consider two heuristic solutions, one being a genetic algorithm and the other being a particle swarm optimization (PSO) algorithm. The PSO solution is shown to outperform other attempts at using PSO for the FP problem, though it is still inferior to other algorithms for this problem.

	GA	PSO
Average Fitness	1495	17,893,380
Best Fitness	1000	7012137
Worst Fitness	50	30,671,841

Figure 1: Comparison of fitness between GA and PSO techniques over 100 trials.

2 Fitness

Both algorithms attempt to minimize the same fitness function, which is based on Equation 1. In addition, we add a penalty of

$$ln(n+1) * nPeriods * T^2$$

where n is the number of adjacency violations in the schedule (the number of adjacent stands that are scheduled for the same time period. Because $nPeriods * T^2$ is the worst possible fitness of a schedule with no violations, it is not possible for a schedule with violations to have a higher fitness than a schedule without violations. For the GA, this allows positive genetic material to be retained from individuals with violations, while discouraging the propagation of those individuals themselves, and for the PSO, it guides particles away from adjacency violations and towards valid solutions.

3 Experimentation

3.1 Genetic Algorithm Setup

3.2 PSO Setup

The PSO setup for this problem was rather unusual. With normal parameter settings, the algorithm behaved poorly, obtaining solutions with fitness no better than 10^8. However, with some adjustments, performance increased dramatically, so that results were better than those reported in [2]. The key changes were to use a cognitive factor of 3 and a social factor of 1, and to lower the inertia value to 0.1. Velocities were allowed to be between -2 and 2. Results can be found in Figure 1.

	Integer Programming	GA	Standard PSO
Time Period 1	33049.5	1495	32523.75
Time Period 2	32933.6	1000	33259.88
Time Period 3	33399.4	50	33133.29

Figure 2: Harvests per time period for the best result of each search algorithm. The integer solution was taken from [1]. The target harvest per time period was 34,467 MBF (million board feet) for each.

References

[1] Bettinger, Pete, and Zhu, Jianping (2006) A New Heuristic Method for Solving Spatially Constrained Forest Planning Problems Based on Mitigation of Infeasibilities Radiating Outward from a Forced Choice. *Silva Fennica*

[2] Potter, W.D., Drucker, E., et al. (2008) Diagnosis, Configuration, Planning, and Pathfinding: Experiments in Nature-Inspired Optimization. *Natural Intelligence for Scheduling, Planning and Packing Problems* pp. 267-294