A Hybrid Heuristic Algorithm for Harvesting Decision of Mixed Species Stand under Price Uncertainty

Fadian Lu
Department of Forest Economics
Swedish University of Agricultural Science

Motivation

In our previous study, we use the following two equations to calculate the optimal stocking level of the pine and spruce to guide the thinning decision:

\[ \ln v_1^* = \alpha_1 + \alpha_2 \ln t + \alpha_3 \ln p_1 + \alpha_4 \ln p_2 \]
\[ \ln v_2^* = \alpha_5 + \alpha_6 \ln t + \alpha_7 \ln p_2 + \alpha_8 \ln p_1 \]
And use the following reservation function to guide the final cutting decision:

\[ p^*(t,v_t) = c - \frac{(1-\rho)(L-C_F)}{v_t} + \frac{\rho^\alpha_{t+1}}{v_t} (E[p_{t+1}] - c + \alpha_9(T-1-t)^{\alpha_0}) \]

Then, through simulation to optimize the values of the ten variables \(\alpha_1\) to \(\alpha_{10}\) in order to maximize the expected net present value. The optimization method used is Powell Search.
Objective of this study

Find more efficient algorithm than Powell Search

Methods

In this study, Genetic Algorithm (GA) and GA based Hybrid algorithm were tested.
Implementation of GA

GA is work on a population of solutions, that is, after creating a certain number of initial solutions (generation 0), the evolution process is started by apply three operations: selection, crossover and mutation at each generation, in hoping that the solutions could be improved from generation to generation.

Basic GA search approach

1. Creation of initial population (generation 0)
2. Selection
3. Cross over
4. Mutation
5. Compute the fitness values. Stop if the stop criterion is met, otherwise go to 2 (next generation)
Coding of the ten variables

The binary coding was used in this study, for any variable, the map between the cod and real value is as following:

\[
\underbrace{000\ldots0}_{l} \rightarrow U_{\text{min}}
\]

\[
\underbrace{111\ldots1}_{l} \rightarrow U_{\text{max}}
\]

The precision of this mapped coding is:

\[
\pi = \frac{U_{\text{max}} - U_{\text{min}}}{2^l - 1}
\]

When \(U_{\text{min}}\) and \(U_{\text{max}}\) is fixed, the precision could be controlled by choosing different value of \(l\). We set the value of \(l\) as 7. The total length of a string would be 70
The initial search scope $U_{\text{min}}, U_{\text{max}}$ was predetermined. The search process was divided into different stages, except that of first stage, the search scope of every stage is 50% narrower than previous stage.

**Creation of initial population**

Randomly generate 100 binary strings, each string with length 70 and correspond to a solution of the problem. On each position of every string, it has equal probability to be 1 or 0.
Selection

The principle is the strings (individual solution) with good performance (high objective function value) will be selected with high probability

\[ P(i) = \frac{ob(i)}{\sum_{j=1}^{100} ob(j)} \]

\[ Ob(i) = (r)^{100 - or(i)} \]

\( or(i) \) is the position of string \( i \) in the ordered 100 strings according to their \( ob \) value.

\( r: \) selection rate, 1.01

Cross over

four points cross over was used in this study

Parent 1: 000000000000000000000000000000
Parent 2: 111111111111111111111111111111

Child 1: 011111000111111111110000000000
Child 2: 100000111000000000001111111111
**Mutation**

With a very small probability, each binary number in every string will be changed, from 0 to 1, or from 1 to 0.

Mutation rate is 0.01

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**Stop criterion**

- For each stage, stop criterion is certain number of generations without improvement.
- For the whole process, stop criterion is that a predetermined precision is met.
Hybrid algorithm 1 (HB1)
GA + Random search

Hybrid algorithm 2 (HB2)
HB1 + Hooke & Jeeve (HJ)

HB1 was used to create qualified initial solution (find the mountain);
then HJ was used to climb the top of the mountain
When switch GA to HJ?

HB1 was stopped after generation 50, and HJ was started using the results from HB1 as initial solutions.

Which results from GA should be used?

The following ten results are tested:

• 1 to 5: the five best solutions in the population
• 6: the average of the five best solutions
• 7: the average of the ten best solutions
• 8: the average of the twenty best solutions
• 9: the average of the fifty best solutions
• 10: the average of all the solutions (100)
Results

Instead of using absolute objective function value (ENPV), relative deviation index (RDI) is used in the results:

\[ \text{RDI}(i) = \frac{(T_i - T_w)}{(T_b - T_w)} \]

in which:
- \( T_i \): ENPV of result \( i \)
- \( T_b \): ENPV of the best result
- \( T_w \): ENPV of the worst result

<table>
<thead>
<tr>
<th>algorithm</th>
<th>RM</th>
<th>PW</th>
<th>HJ</th>
<th>GA</th>
<th>HB1</th>
<th>HB2</th>
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<tbody>
<tr>
<td>Ten best</td>
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Results from different initial solutions

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<th>6</th>
<th>7</th>
<th>8</th>
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<td>6</td>
<td>4</td>
<td>10</td>
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<td>Percentage (%)</td>
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<td>14</td>
<td>4</td>
<td>3</td>
<td>7</td>
<td>5</td>
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Conclusion and discussion

• the hybrid heuristic algorithms developed in this study work better compare with some traditional algorithms (random search, Powell Search, Hooke & Jeeve)
• to develop the hybrid heuristic algorithm need much more work.
• the more complicated the problem is, the advantage of the heuristic algorithm is more obvious