Development alternatives to improve Optitek computing capabilities

Jean-Marc Frayret, Reza Hosseinirad, Odile Marcotte,
Vilmar Jefte Rodrigues de Sousa, Michael David de Souza Dutra

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Problem statement

Optitek is a softwood and hardwood ***lumber production simulator***. It simulates precisely the various physical transformations of logs, work-in-process, and lumber pieces.

In order to do so it must ***simulate how every machining centre is programmed*** to carry out its sawing operations.

In particular it must replicate how these machining centres ***optimize the relative positions of their blades with respect to the wood***.

This implies that ***Optitek must compute the revenue associated to each position within a huge set of such positions***, many of which are inferior.

Future manufacturing developments include even ***more detailed information*** that will have to be incorporated (e.g., internal log defects).

Problem statement

How do we reduce the number of relative positions to be investigated (i.e., the so-called search space), thereby reducing the computation time?

Initial thoughts

Two general directions should be investigated:

1. Replacing the true shapes of logs by simplified shapes, s***o as to introduce symmetries.***

   This enables the reduction of the search space (i.e., many solutions become identical).

   This idea is being tested by FPInnovations.

2. ***Start the optimization for a given log (within the simulation) with a near-optimal first solution***:

   This enables the pruning of a large number of inferior solutions. This is the focus of our work.

Find a good initial position for a log

Again, two specific directions can be investigated:

1. ***Finding the best position for a specific log by maximizing the volume of a shape that approximates the sawing operation.***

   This implies the development of an algorithm optimizing the dimension and position of the shape (to be defined) with respect to shape constraints and the true dimensions of the log.

2. ***Learning the log position that maximizes the actual sawing output.***

   This implies the development of machine learning algorithms and the use of a large database of Optitek simulation results describing how logs characteristics and position influence the lumber output.

Learn the log position that maximizes the lumber output

We propose a work plan to carry out such a complex project.

Defining objectives	1. Identify the problem statement, the objectives, and a detailed research methodology.	1. Description of the current situation and a detailed research method.
Data collection and experiments	2. Collect the data, the model variables and parameters; design the data base.	2. Data base, preprocessed data, design of experiments, simulation results.
Design machine learning	3. Design and implement machine learning algorithms.	3. implemented machine learning algorithms.

Learn the log position that maximizes the lumber output

We propose a work plan to carry out such a complex project.

Test, analyze results	4. Train the machine learning algorithm and compare the results with other approaches (including with the maximal volume one)	4. Comparative study, recommendations
Improve Optitek	5. Add algorithm to Optitek	5. Efficient Optitek

Maximizing the Volume of a Structured Shape Within a Log

Jean-Marc Frayret [1] Reza Hosseinirad [1] Odile Marcotte [2]
Vilmar Jefte Rodrigues de Sousa [1] Michael David de Souza Dutra [1]

[1]École Polytechnique de Montréal [2]Centre de recherches mathématiques

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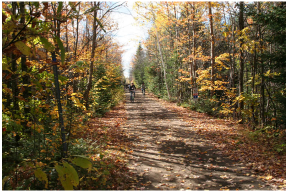

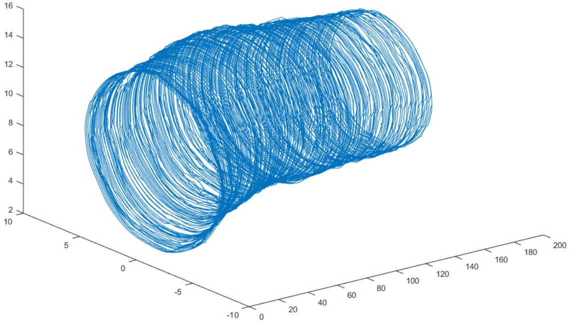
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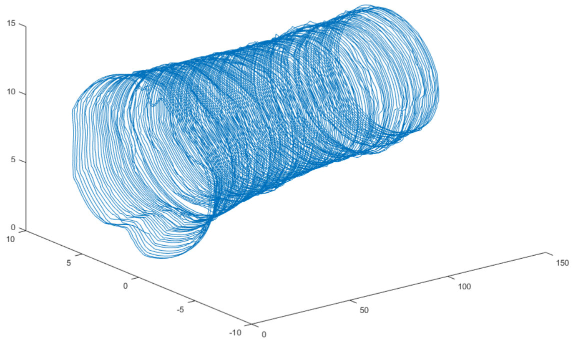
Diverse log shapes



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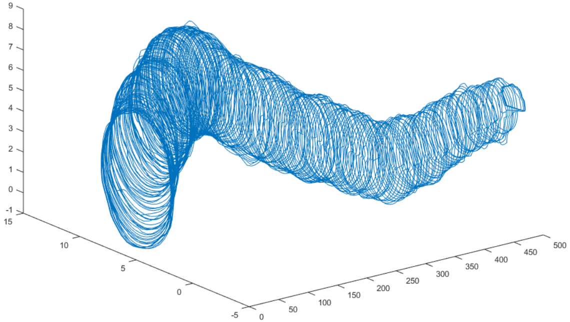

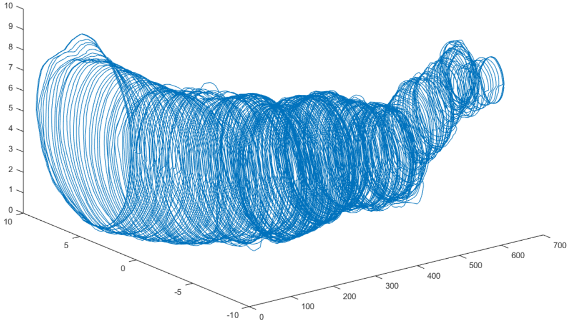
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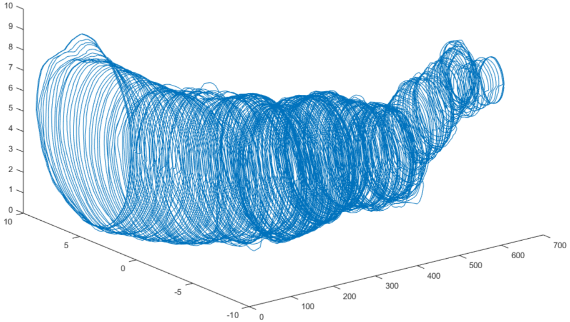
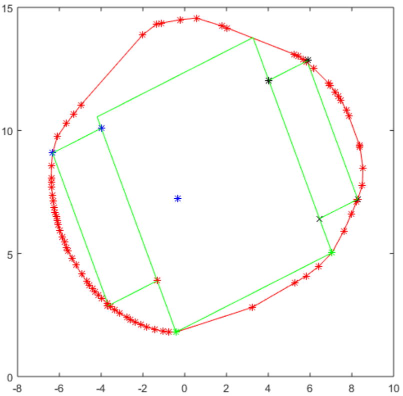
Diverse log shapes



Idea underlying the algorithm (in the 2D case)



Pseudocode of the algorithm

- Select the largest slice of the log.
- Consider each pair of vertices $\{p_1, p_2\}$ on the polygon (such that the line segment joining those two points is entirely contained within the slice).
- Build the largest rectangle $\{p_1, p_2, p_4, p_3\}$ defined by p_1 and p_2 and contained within the slice. (At least one of p_3 and p_4 is on the boundary of the polygon).
- Let the saw cut the log along p_1p_3 and along p_2p_4.
- Build a rectangle of maximal area with one side included in p_1p_3 and such that its interior is disjoint from the rectangle $\{p_1, p_2, p_4, p_3\}$.
- Build a rectangle of maximal area with one side included in p_2p_4 and such that its interior is disjoint from the rectangle $\{p_1, p_2, p_4, p_3\}$.

Remarks

- The algorithm considers every partition into three rectangles, one for each pair of points, and chooses the partition yielding the maximum sum of the three rectangle areas.
- This is better than considering all combinations of positions and angles.
- Finding the optimal solution enables one to select the orientation of the log in the machine centre.

Future work

- Extend the algorithm to the 3D case.
- Introduce dynamic programming to save time.
- Take the wane into account.
- Propose a mathematical model (?).

Thanks

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