2D Log Cutting Problem

Michał Okulewicz

Faculty of Mathematics and Information Science

Presentation Plan

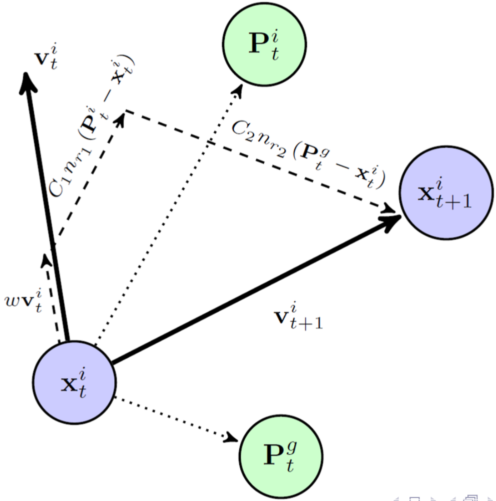
Packing and Cutting Problems

- Both problems consider a set of source material and a set of product types
- In packing problems:
  - product types are characterized by their value
  - the goal is to maximize the value
- In cutting problems:
  - product types are characterized by their demand
  - the goal is to fulfill the demand (get as close as possible)

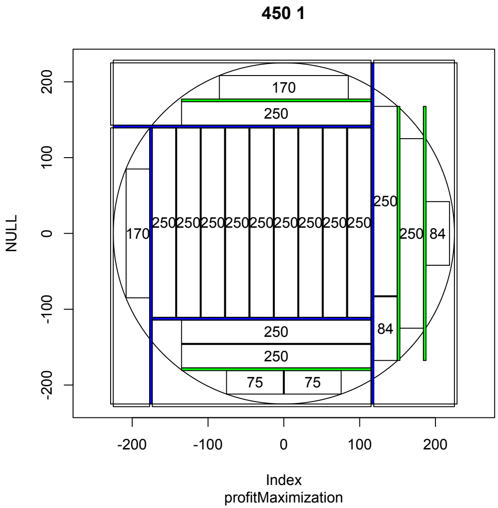
2D Log Cutting Problem

- Material is a set of tree logs (circles)
- Products is a set of sawn timber/planks (rectangles)
- Products are cut from material by guillotine cuts
- Material may be rotated by 90 degrees after each cut
- Number of rotations should be limited
- Each sawn timber size has a different value per m^3

Particle Swarm Optimization (for presentation consistency)



Continuous Search Space for LCP



- Search space is formed by the coordinates of subsequent cuts after which clockwise rotation is performed (blue cuts)
- $[110, 140, -180, -110]$ in this case

Quality functions I

- Quality function is computed as a sum of product values in each shape
- Solutions for each shape are created by a fast heuristic algorithm
- n - number of products, w,h - width and height of product, v - value of product, d - demand for product, m - number of logs, P - placement of products

- Waste minimization

$$f_{waste}(P) = \sum_{j=1}^{|Logs|} m_j \left(\pi {r_j}^2 - \sum_{i=1}^{|Placed \quad timber|} n_{i,j} w_i h_i \right) \quad (1)$$

Quality functions II

- Profit maximization

$$f_{profit}(P) = \sum_{j=1}^{|Logs|} m_j \left(\sum_{i=1}^{|Placed \quad timber|} n_{i,j} v_i \right) \tag{2}$$

- Demand fulfillment maximization

$$f_{demand}(P) = \min_{i=1}^{|Placed \quad timber|} \frac{\sum_{j=1}^{|Logs|} m_j n_{i,j}}{d_i} \tag{3}$$

Placing products within a single shape

- 1-D solution dictionary
- 2-D greedy heuristic
- The stripes from the dictionary are tested horizontally and vertically
- Stripes are placed starting from the center of the log
- The inner shape is considered first
- Coordinates of the shape are tightened in order to fit the stripes (local optimization)

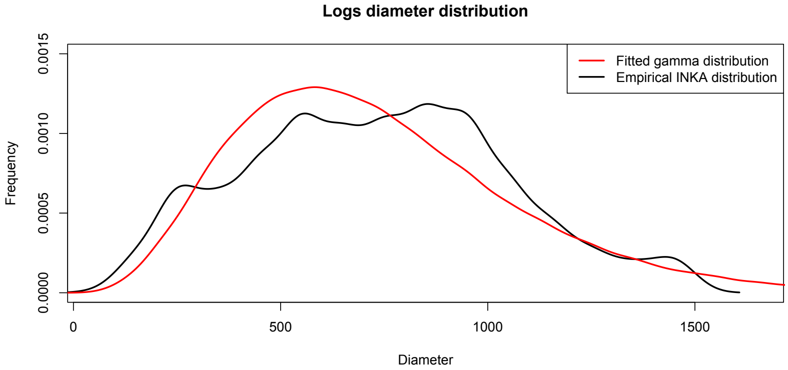
Placing products within a single shape

- 1-D solution dictionary
- 2-D greedy heuristic
- The stripes from the dictionary are tested horizontally and vertically
- Stripes are placed starting from the center of the log
- The inner shape is considered first
- Coordinates of the shape are tightened in order to fit the stripes (local optimization)

Placing products within a single shape

- 1-D solution dictionary
- 2-D greedy heuristic
- The stripes from the dictionary are tested horizontally and vertically
- Stripes are placed starting from the center of the log
- The inner shape is considered first
- Coordinates of the shape are tightened in order to fit the stripes (local optimization)

Artificial data set

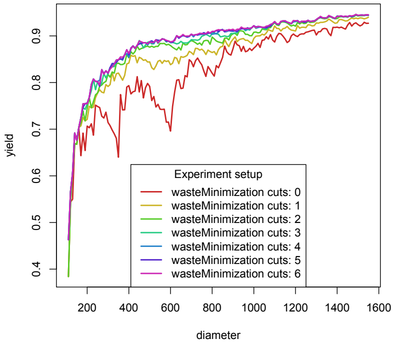


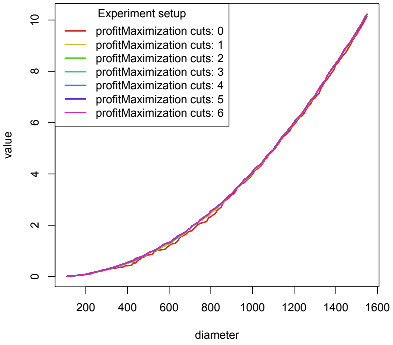
Artificial data set

Table: Artificial products

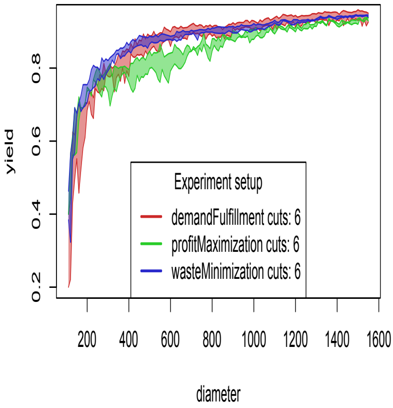
	Thickness	Width	Length	Value m^3	Demand
1	19	100	2000	1.00	500000
2	25	100	2000	1.15	500000
3	32	100	2000	1.30	500000
4	38	100	2000	1.41	500000
5	38	125	2000	1.58	500000
6	50	73	2000	1.39	500000
7	50	100	2000	1.62	500000
8	50	125	2000	1.81	500000
9	50	150	2000	1.99	500000
10	50	175	2000	2.15	500000
11	50	200	2000	2.29	500000
12	75	200	2000	2.81	500000
13	75	225	2000	2.98	500000

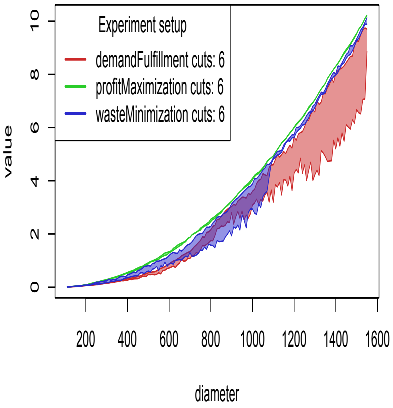
Number of cuts analysis





Solutions distribution analysis





Conclusions

- Proposed approach allowed for creating a stable optimization results (at least within the optimization criterion)
- Having a greedy heuristic inside may lead to unexpected results (yield in demand fulfillment better than in yield maximization)
- Having more than 3 cuts is probably economically unwise
- With random algorithms special care should be put to
  - maintaining the best result over subsequent calls for the same set of input parameters
  - presentation of the solutions (despite their numerical quality)

Literature

- M.Okulewicz, Benchmark dataset, http://www.mini.pw.edu.pl/~okuleviczm/downloads/lcp
- M.Okulewicz, 2-Dimensional Rectangles-in-Circles Packing and Stock Cutting with Particle Swarm Optimization, 2017 IEEE Symposium on Computational Intelligence in Production and Logistics Systems (CIPLS'17), http://www.mini.pw.edu.pl/~okuleviczm/downloads/badania/2dPackingAndStockCutting.pdf