Projection-based planning for draglines

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1 Intro

2 Problem formulation

The aim of this work is to plan a sequence of blocks for a dragline to excavate a strip, and place the overburden into the previous next door strip. The variables in this problem are:

- $y_i : \mathbb{R} \to \mathbb{R}$ which is the deterministic density function for the material along strip i. In practice, this function will only be defined over the subset of the length of the strip, i.e. $[0, L]$, and the evaluated value at each x is the volumetric (i.e. cross sectional area) or mass density at that point.
- $l_1, ..., l_N$ are the sequence of N block lengths. There is a constraint that

$$\sum_{j=1}^{N} l_j = L.$$

  In this formulation N can either be fixed or variable.
- $x_{j,i}$ is the starting position of the block. I am not yet 100% sure how this variable will be incorporated in, but i think i need it

We consider the problem of moving the excavating the material from strip i to the empty next door strip, strip $i-1$. The initial conditions on these two adjacent strips are:

$$y_{0,i}(x) = y_i^{init}(x), \quad x \in [0, L], \tag{1}$$

$$y_{0,i-1}(x) = 0, \quad x \in [0, L], \tag{2}$$

$$x_{0,i} = 0 \tag{3}$$

where the first index of y indicates the terrain after how many blocks have been excavated. In these initial conditions we make the assumptions that (i) the length of the strips are the same, and that the previous strip was completely exhausted down to coal. The terminal conditions after N blocks are removed are that the coal in strip i is uncovered, and the material excavated into strip $i-1$ falls within the constraints. That is,

$$y_{N,i}(x) = 0, \quad x \in [0, L] \tag{4}$$

$$y_{N,i-1}(x) \leq y_{i-1}^{max}(x), \quad x \in [0, L] \tag{5}$$

$$x_{N,i} = L \tag{6}$$

The aim of this problem is to minimize the time taken to excavate the strip, while ensuring that the constraints are satisfied. The constraints to be considered as part of this problem are:

- The minimum and maximum densities of each strip. It is possible that the maximum density will only be applied for the dumping stage. These constraints are given by

$$y_i^{min}(x) \leq y_i(x) \leq y_i^{max}(x), \quad x \in [0, L], \forall i. \tag{7}$$

  It is anticipated that $y_i^{min}(x) = 0$, for all x in $[0, L]$.

- Maximum and minimum block lengths

$$l^{min} \leq l_j \leq l^{max}, \quad \forall j. \tag{8}$$

The key dynamics within this problem is modeling how the material is tranfered from each block in strip i to the spoil pile in strip $i-1$ and how long this transfer application will take. These dynamics must capture:

- The effect of block length on the material transfer rate
- The effect of block length on the density of material that can be transferred to the previous strip. It is known that the density of the material in the spoil pile can be increased by reducing the length of the block. Physically, this decrease results in the spoil pile peaks being closer together.
- The reachability of the material movement from the dragline
- Swell factor.

The key difficulty in posing and solving this problem is in the modelling of the transfer of material and being able to set this up into a tractible optimization problem.