



## Winter Optimization

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### Résumé

We look into optimizing the snow removal plan in Montréal city.

### 1 Context

Montréal city annually face snowfalls between october and april. To avoid an economic activity halt, the municipality manages snow removal teams to remove snow from the roads. These operations involve 3000 employes and more than 2000 snowplows, they are assigned to put 200000 tons of salt on the roads, remove the snow or load snow onto trucks to be dumped (300000 trucks loaded per year), depending on snowfalls. All of this endeavour is for 10000Km of roads. The global cost for this operation represent 165M\$ taken from the city budget. You'll find more details in the official city documentation [dM] or in this CBC News article [New18].

In our context we are concerned with snowplowing operations; these are undergone when snowfalls are between 2.5cm to 15cm. It is then necessary to remove the snow from roads and pedestrain networks of the city.



FIGURE 1 – Snowplows for roads.

## 2 Problem

People from Montréal are concerned with snowplowing operations. [Vé20], but increasing the allowed funds is still a delicate point for the city council [Lef19], and it is now an objective to reduce these operations cost, while still providing an efficient snowplow service to the inhabitants. The city tasks your company with a study. The goal is to minimize the cost of a typical snowplowing day. Your team's role is to find a short enough path for the snowplows around the Montréal road network, while still remove snow from the whole given zone.

It is understood that snow levels show great variance around the city. It is not necessary to snowplow around the whole city. Your boss asks you to perform an aerial analysis via drone. This way we can detect what sector needs snowplowing the most.

Your mission is :

1. to find shortest path(s) for the drone aerial check of the road network. It has to check the whole network to have enough data<sup>1</sup>;
2. to find paths for snowplows to remove snow from identified sector (see section 3 Handout constraints), be minful :
  - snowplows respect the direction of traffic ;
  - snowplows go through two-way roads only once to remove snow.
3. to propose a cost model for snow removing operations given the number of snowplows available.

Also, the municipality would like to invest in high performance snowplows, called type II, that can remove snow faster but at a greater cost (see section 4 Data). Simulations are asked to compare the associated cost for different options.

## 3 Handout constraints

Your handout has to fulfill the following constraints and contain :

1. an AUTHORS file with the list of authors ;
2. a README file with all the necessary instructions to install and run your work, as well as a description of your handout structure ;
3. a pdf file of at most 4 pages that synthesises your team thinking and must contain :
  - a summary of used data, as well as the studied perimeter (which constraints are taken into account)
  - hypotheses and model choices,
  - kept solutions, its indicators, comparison between scenarios,
  - identified limits of the model(s)
4. a script running a demo of your solution ;
5. a subtree dealing with the drone flight ;
6. a subtree dealing with the snow removal planning, on the following sectors :
  - Outremont,
  - Verdun,
  - Anjou,
  - Rivière-des-prairies-pointe-aux-trembles,
  - et Le Plateau-Mont-Royal.

## 4 Data

Municipality gives you the following data :

- Super Drone :
  - Fixed cost : 100 \$/day
  - Cost per Km : 0.01 \$/km
- Snowplows :
  - Fixed cost : type I : 500\$/day, type II : 800 \$/day

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1. It is still early to ask an aerial image analysis, patience.

- Cost per Km : type I : 1.1 \$/km, type II : 1.3 \$/km
- Hourly cost for first 8 hours : type I : 1.1 \$/h, type II : 1.3 \$/h
- Hourly cost for after the first 8 hours : type I : 1.3 \$/h, type II : 1.5 \$/h
- Average speed : type I : 10 km/h, type II : 20 km/h

## Références

- [dM] Ville de Montréal. *Tout savoir sur le déneigement dans l'arrondissement*. Opération déneigement.
- [Lef19] Sarah-Maude Lefebvre. *Les prix du déneigement explosent partout au Québec*, 2019. Journal de Montréal.
- [New18] CBC News. *How Montreal takes 300,000 truckloads of snow off the street every winter*, 02 2018. Truckloads of snow.
- [Vé20] Henri Ouellette Vézina. *Métro - Déneigement : "on craint toujours de dépasser le budget"*, 2020. Métro.