Air Canada Constrained Demand

Ninth Montréal Industrial Problem Solving Workshop

Summer 2019

Agenda

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- Train, Validation, and Test
- Booking Sequences
- Our Approach
- Distance Function
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Team

- Caroline Dietrich (Air Canada)
- Fabian Bastin (Université de Montréal)
- Mohammad Daneshvar (Université du Québec à Montréal)
- Chiyu Ma (Nankai University)
- Daniel Sallier (Saéro)
- Loïc Shi-Garrier (École Nationale d’Aviation Civile)

Problem

- Air Canada: Each flight is open for booking 354 days before the departure.
- We: ok ...!
- Air Canada: We would like to have an estimation on how many of the seats will be booked for each flight.
- We: How many days before the departure you need this estimation?
- Air Canada: Starting 354 days before the departure up to the departure day, every day.
- We: OK! Do you have any measuring parameter for this problem?
- Air Canada: We use Load Factor!
- We: Perfect! :)

Problem

- Load Factor:

$$\frac{\#\textit{booked seats on the departure day}}{\textit{adjusted capacity on the departure day}}$$

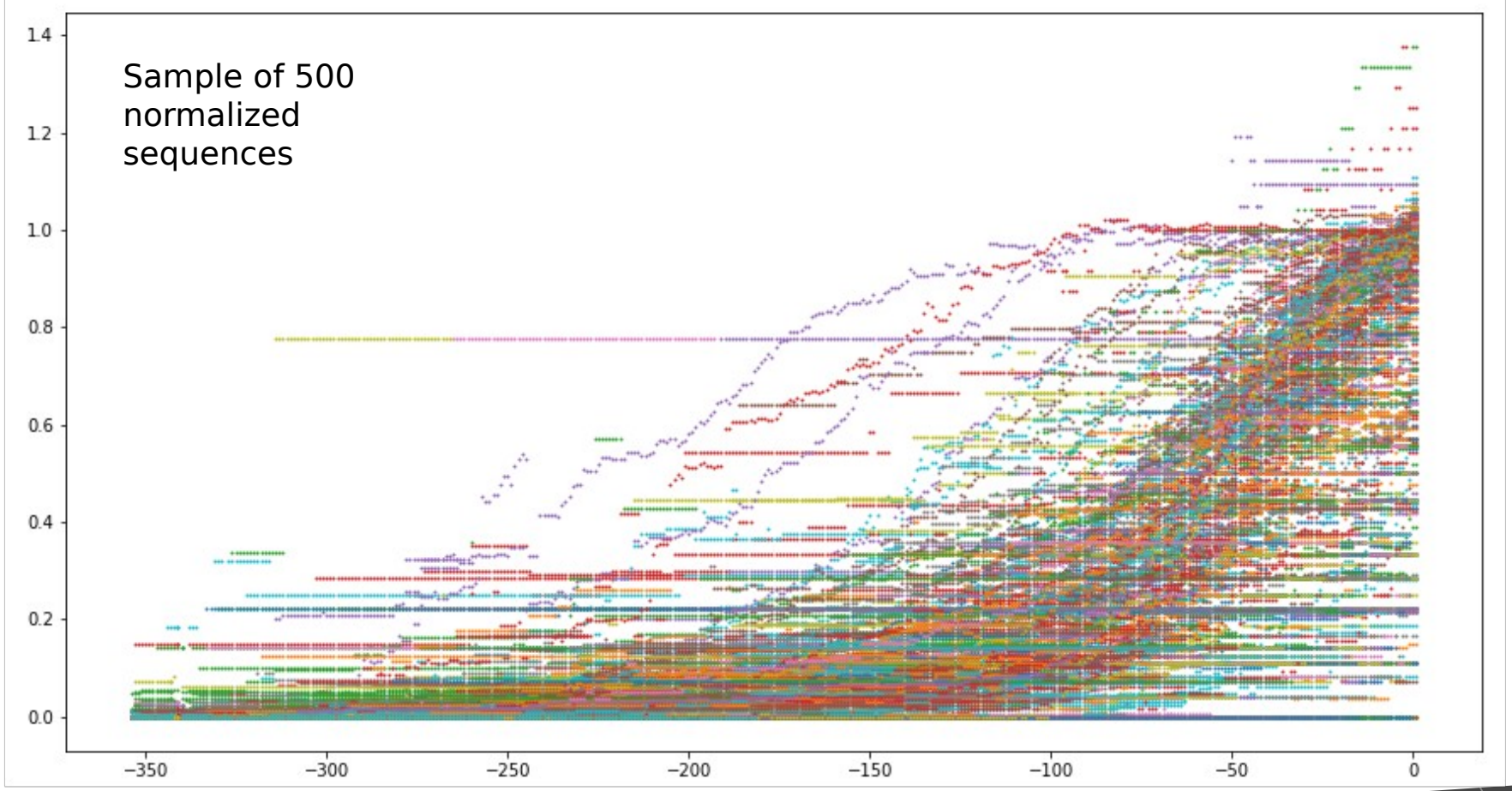
https://upload.wikimedia.org/wikipedia/commons/f/f5/Air_Canada_787_Premium_Economy_20170805.jpg

Air Canada Dataset

- The booking data for each day is recorded.
- The data is separated based on flight number, departure day, cabin type, if it is a group booking or not, ...
- How many records?
  - 60,229,667

Train, Validation, and Test

- Train data (60%): will be used to build or learn a model.
- Validation data (20%): will be used to tune the parameters of the model.
- Test data (20%): will be used to evaluate the performance of the model.



Booking Sequences

- Each flight is open for 354 days; the sequence of daily cumulative bookings can be represented by a vector in N^{355}.
- We normalized the sequences, so a flight at full capacity has a final loading factor equal to 1.

Our Approach

- Compute booking sequence for each flight in the train data dataset.
- For each flight in the validation dataset, compute the booking sequence, then find the similar booking sequences in the train dataset. [**What is a similar sequence?**]
- Estimate the Load Factor for the new flight based on the Load Factor of the similar flights. [**How to estimate the Load Factor?**]

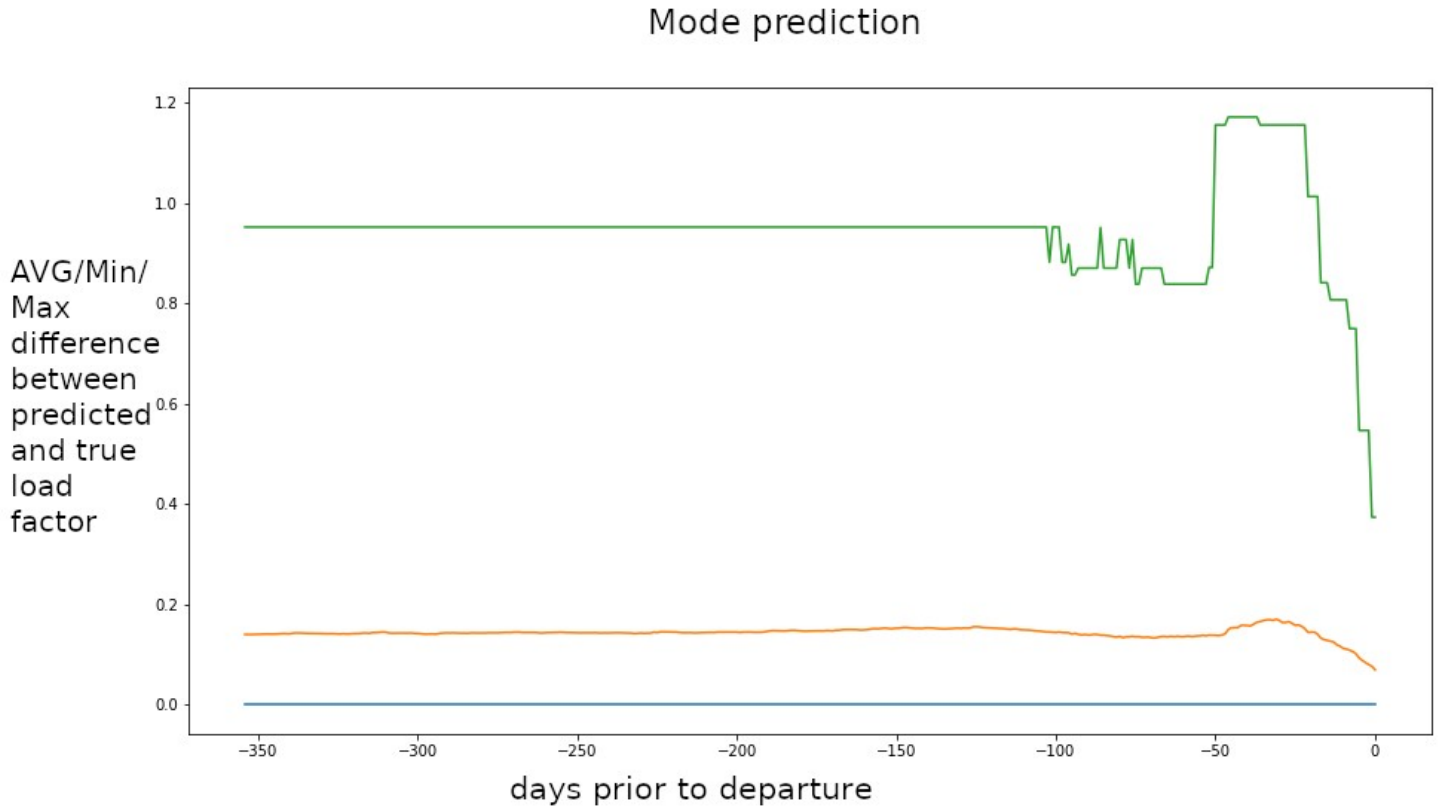
Distance Function

- We use 2-norm

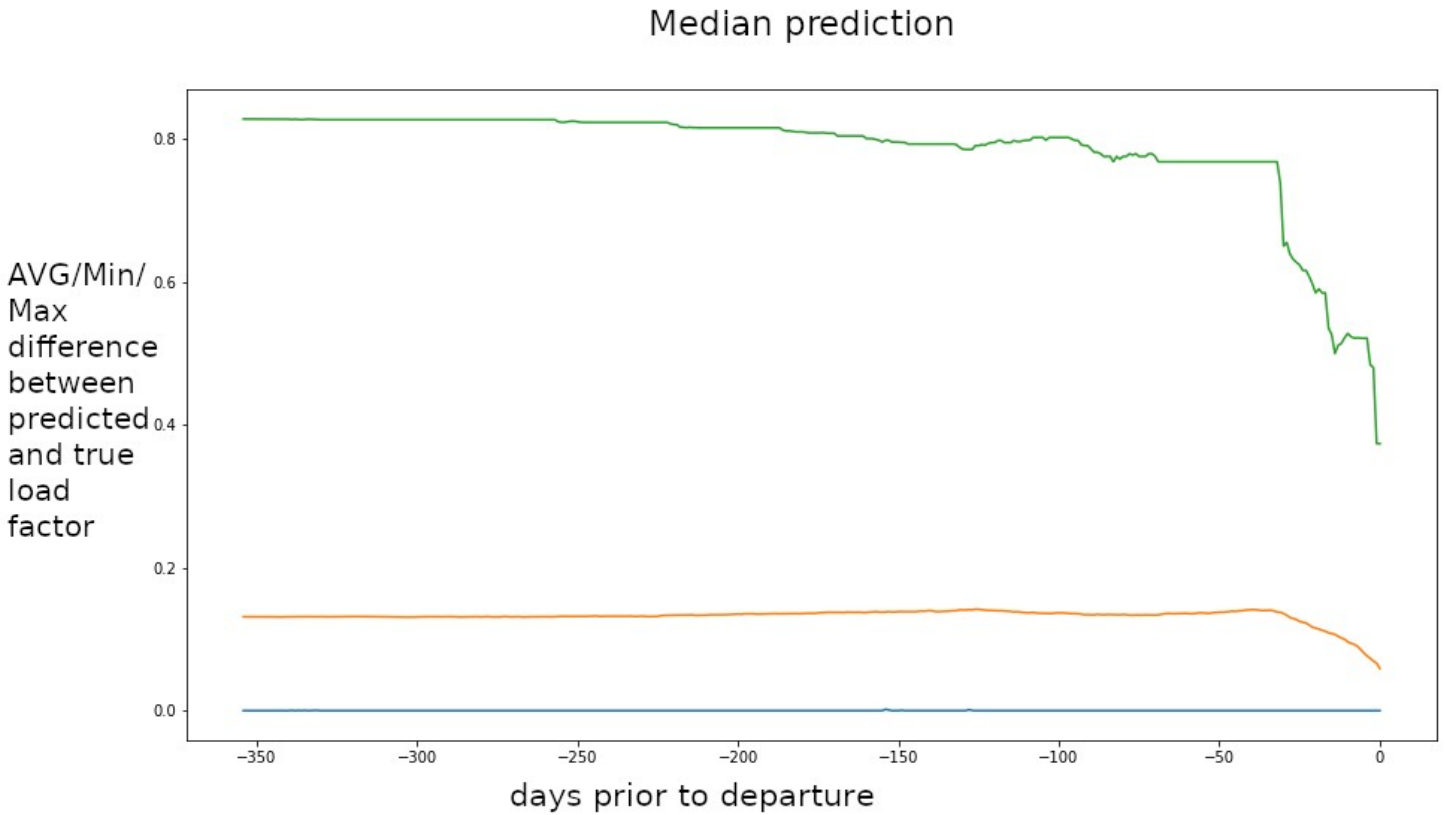
$$||x||_2 = \sqrt{x_1^2 + x_2^2 + \ldots + x_n^2}$$

- We care more about the days that are close to the departure day, so we use discount factor, with a discount rate *r*, to reduce the effect of the days at the beginning of the booking sequence.

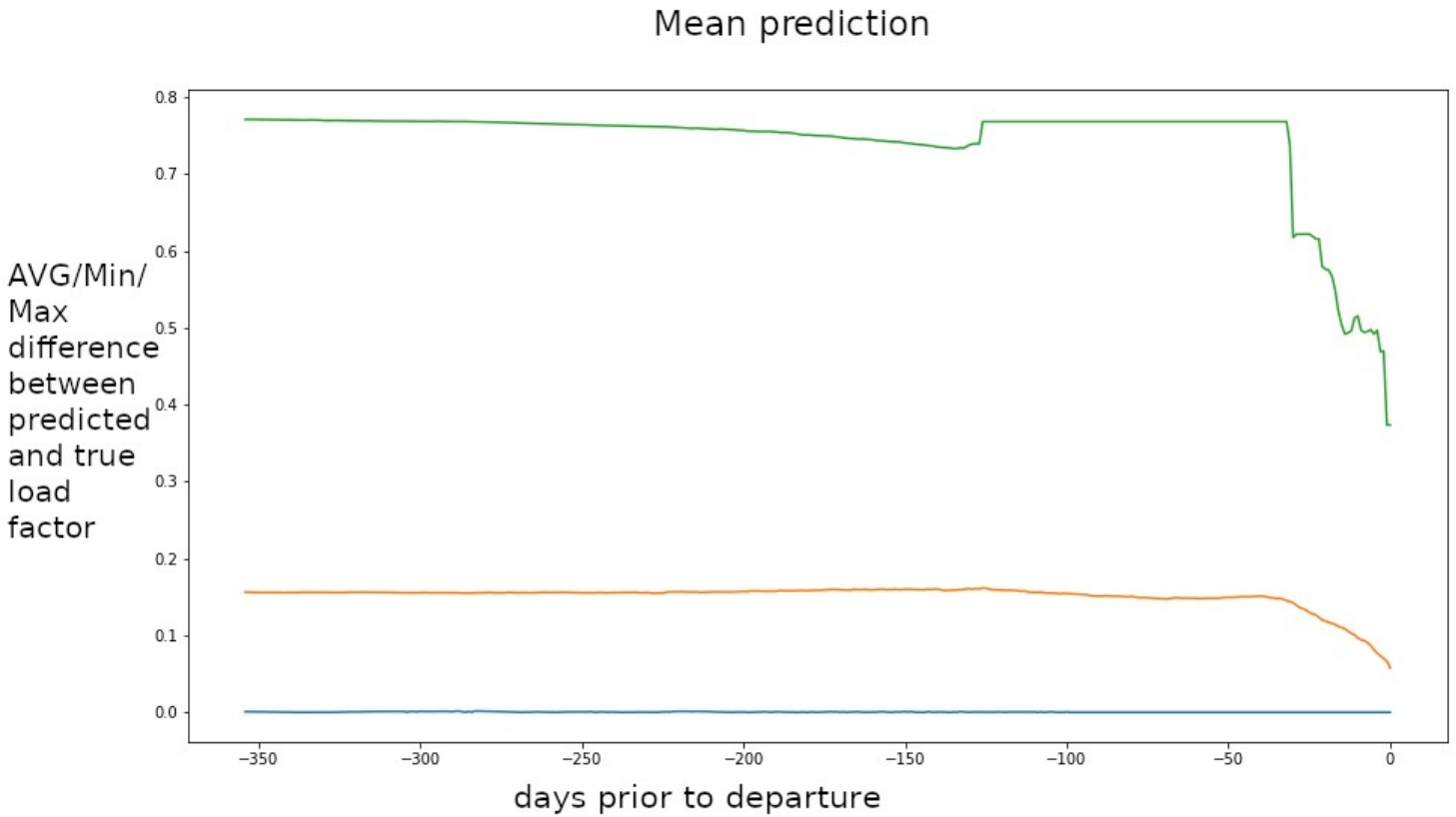
$$\sqrt{\sum_{i=1}^{t} e^{-r(t-i)}(x_i - y_i)^2}$$


Mode prediction
AVG/Min/
Max
difference
between
predicted
and true
load
factor
1.2
1.0
0.8
0.6
0.4
0.2
0.0
−350
−300
−250
−200
−150
−100
−50
0
days prior to departure

Results


Median prediction
AVG/Min/
Max
difference
between
predicted
and true
load
factor
0.8
0.6
0.4
0.2
0.0
−350
−300
−250
−200
−150
−100
−50
0
days prior to departure

Results


Mean prediction
AVG/Min/
Max
difference
between
predicted
and true
load
factor
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
−350
−300
−250
−200
−150
−100
−50
0
days prior to departure

Results

Discount rate	Mean	Mode	Median
0.0	0.05781271	0.0589592	0.06928062
0.05	0.0495158	0.05016554	0.06218065
0.1	0.05387314	0.05500062	0.0661367

AVG difference between predicted and real value of Load Factor one day before departure on the Validation set

Discount rate	Mean	Mode	Median
0.05	?	?	?

AVG difference between predicted and real value of Load Factor one day before departure on the test set

Results

Future Work

- Filter the outiler
- Using weighted load factor prediction
  - Instead of Average:

$$\frac{\frac{seq_1}{d_1} + \ldots + \frac{seq_5}{d_5}}{\sum_i d_i}$$

- Using other distance functions:
  - Inf-Norm

$$||x - y||_\infty = \max_i |x_i - y_i|$$

  - Fréchet distance
- Optimize model parameters as the discount factor
- ...

Thank you!

Questions?

https://en.wikipedia.org/wiki/Air_Canada#/media/File:Air_Canada_Boeing_777-200LR_Toronto_takeoff.jpg