Université de Montréal

Environnement et Changement climatique Canada | Environment and Climate Change Canada

ENVIRONMENT & CLIMATE CHANGE CANADA

Development of a weather text generator

11th Montreal Industrial Problem Solving Workshop

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DIRO

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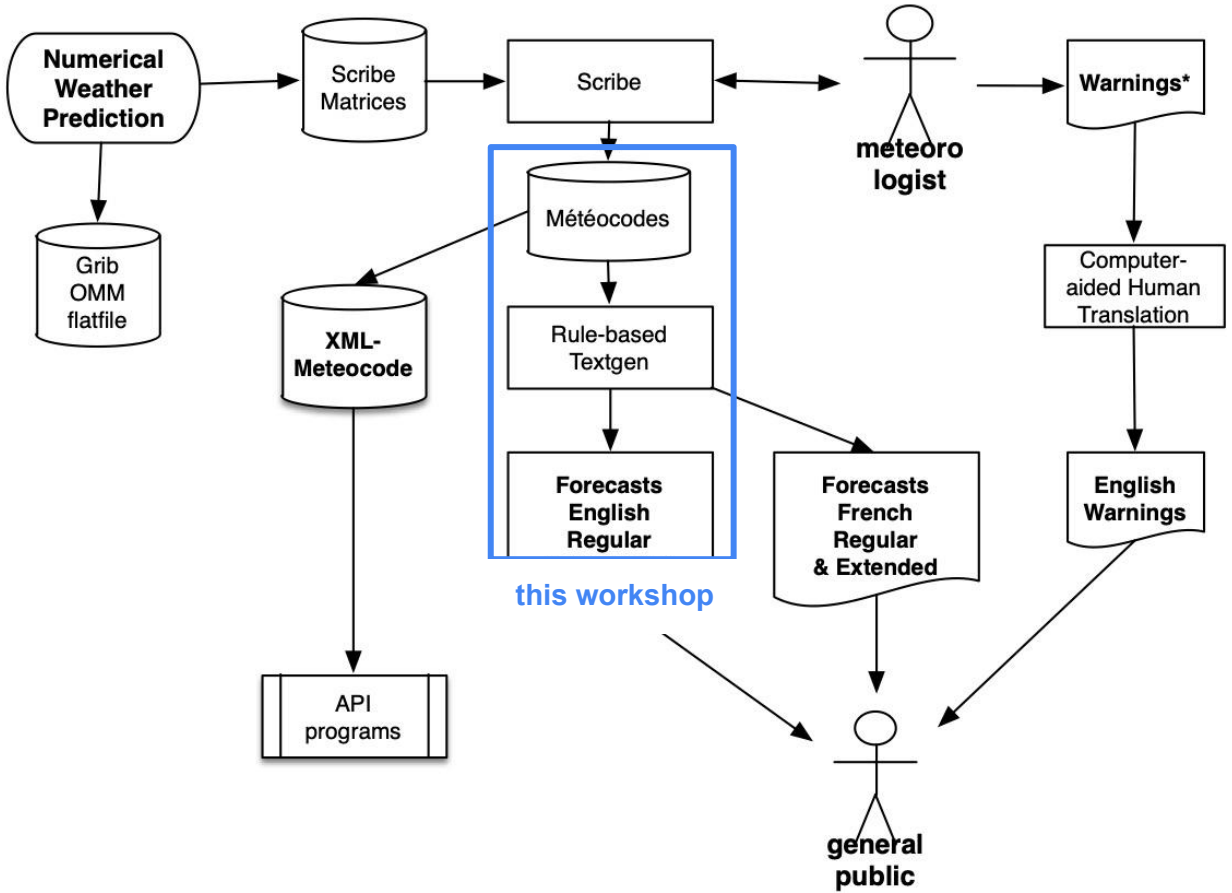
Natural Language Generation (NLG)

- Create readable text from data
- Input : numbers, texts, logical formulas,...
- Output : text, graphics, conversations
- Two classic processes usually pipelined:
  - What to say ?
  - How to say it ?
- Contrarily to parsing:
  - Fuzzy starting point
  - Easy for a human to appreciate the result

Weather Bulletins in Canada

- Canada is a *wide* country
- Thousands of forecast bulletins each day
  - 3 times a day : ~5h, ~11h, ~16h00
  - Regular (today, tomorrow), Extended (7 days)
  - French and English
- All times in data are in *Coordinated Universal Time* (UTC)
  - 6 time zones in Canada
  - daylight saving or standard

Context of the data



Data sources

- Meteocode
  - possibly human edited
- Bulletins
  - generated by Scribe in English and French
- Data for the workshop
  - Ontario and Québec English bulletins
  - 2018 and 2019
  - Timezone shift is given (-5h EST, -6 EDT)

Météocode for a bulletin

{*Field*: {"("start_h end_h ...other infos...")")}";"} "."

Documentation of the fields

```
entete: (FPCN71 CWUL EST5EDT regulier  2018 06 03 0900 00
         prochaine_prevision 2018 06 03 1530 30);

regions: (r71.1);
...
regions: (r71.15);
accum:  (-49 -46  pluie totale pres_de 4 6)
...      (69 72  pluie totale pres_de 2);
ciel:  (-53 -24 9 9 9) (-24 -21 9 1 9) (-21 24 1 1)
...    (180 186 5 5 9) (186 213 5 5 9) (213 228 1 1);
climat_temp:  (-52 -38 min 5.0) (-38 -28 max 18.0)
       (-28 -14 min 5.0) (-14 -4 max 18.0)
...    (212 226 min 7.0) (226 236 max 20.0);
indice_qa:  (-39 -38 1.6) (-38 -37 1.3) (-37 -36 1.0)
...    (33 34 1.2) (34 35 1.1) (35 36 1.1);
indice_uv:  (-32 -30 7.0) (-8 -6 6.9)
            (16 18 7.2) (40 42 7.2);
pcpn:  (-52 -44 certain debut_fin pluie nil continuel)
..     (135 144 possible debut_fin averses nil frequent);
prob: (seuil 0.2  (-54 -31 80) (-31 32 0) (32 46 80)
       (46 48 100) (48 60 90) (60 72 100)
..     (216 228 10)     );
rosee:  (-51 -48 point_intermediaire 18) (-48 -45 point_inter
...     (225 228 point_intermediaire 7);
temp:  (-51 -48 point_intermediaire 20) (-48 -45 point_interm
...    (225 228 point_intermediaire 14);
vents:  (-49 -42 sw  vitesse 20 (-49 -42 rafales 40)) (-42 -3
40))
...     (216 228 w  vitesse 10);

regions: (r71.16);
```

JSON


```
{"header":["FPCN71","CWUL","EST5EDT","regulier",2018,6,3,900,0,
  "prochaine_prevision",2018,6,3,1530,30],
 "names-en":["Matagami"],
 "names-fr":["Matagami"],
 "regions":["r71.15"],
 "accum":[[-49,-46,"pluie","totale","pres_de",4,6],
          [69,72,"pluie","totale","pres_de",2]],

 "ciel":[[-53,-24,9,9,9],
         [213,228,1,1]],

 "climat_temp":[[-52,-38,"min",5.0],
                [226,236,"max",20.0]],

 "indice_uv":[[-32,-30,7.0],
              [40,42,7.2]],

 "pcpn":[[-52,-44,"certain","debut_fin","pluie","nil","continuel"],

         [135,144,"possible","debut_fin","averses","nil","frequent"]],
 "prob":[["seuil", 0.2, -54,-31,80],
          [216,228,10]]],

 "rosee":[[-51,-48,"pi",18],
          [225,228,"pi",7]],

 "temp":[[-51,-48,"pi",20],
         [-42,-39,"min",3],
         [-30,-27,"max",5],
         [225,228,"pi",14]],

 "vents":[[-49,-42, "sw", "vitesse",20,
           [-49,-42,"rafales",40]],
          [216,228,"w","vitesse",10]],
```

JSON


```
{"header":["FPCN71","CWUL","EST5EDT","regulier",2018,6,3,900,0,
  "prochaine_prevision",2018,6,3,1530,30],
 "names-en":["Matagami"],
 "names-fr":["Matagami"],
 "regions":["r71.15"],
 "accum":[[-49,-46,"pluie","totale","pres_de",4,6],

          [69,72,"pluie","totale","pres_de",2]],
 "ciel":[[-53,-24,9,9,9],

         [213,228,1,1]],
 "climat_temp":[[-52,-38,"min",5.0],

                [226,236,"max",20.0]],
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              [40,42,7.2]],
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         [135,144,"possible","debut_fin","averses","nil","freq
 "prob":[["seuil",
          0.2,
          [-54,-31,80],

          [216,228,10]]],
 "rosee":[[-51,-48,"pi",18],

          [225,228,"pi",7]],
 "temp":[[-51,-48,"pi",20],

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         [-30,-27,"max",5],
         [225,228,"pi",14]],
 "vents":[[-49,-42, "sw", "vitesse",20,
           [-49,-42,"rafales",40]],
          [216,228,"w","vitesse",10]],
```


Generated English bulletin

FPCN11 CWUL 030900
Forecasts for Western Quebec issued by Environment Canada at 5:00 a.m. EDT Sunday 3 June 2018 for today and Monday.
The next scheduled forecast will be issued at 11:30 a.m. EDT.

Metro Montréal - Laval.
...
Vaudreuil - Soulanges - Huntingdon.
...

Matagami.
Today..Sunny. Wind becoming southeast 20 km/h this morning. High 23. UV index 8 or very high.
Tonight..Increasing cloudiness. Rain beginning before morning. Wind east 20 km/h gusting to 40. Low 9.
Monday..Rain. Wind east 20 km/h gusting to 40. Temperature steady near 10. UV index 2 or low.

Waskaganish.
....

Some challenges

- Identify the appropriate data for a given *period* (today, tonight, tomorrow)
  - e.g. **today** : between 5h and 18h local time
  - data is in Universal Time (i.e. Greenwich) so must subtract 4 or 5 depending on the date
  - data is given as ranges [start end values…]
  - must find the data ranges that intersect with the start and end time of the period
  - possibly expand the data values for each hour
- Some values (e.g UV index or Wind chill) depend on many types of values

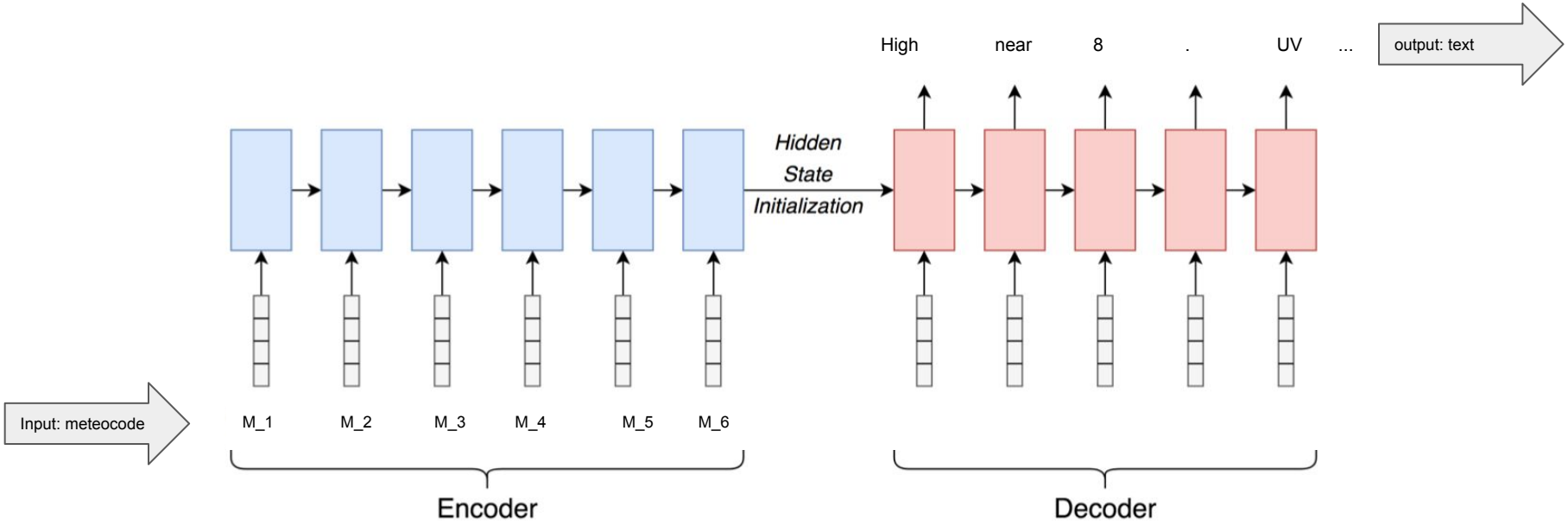
Remarks

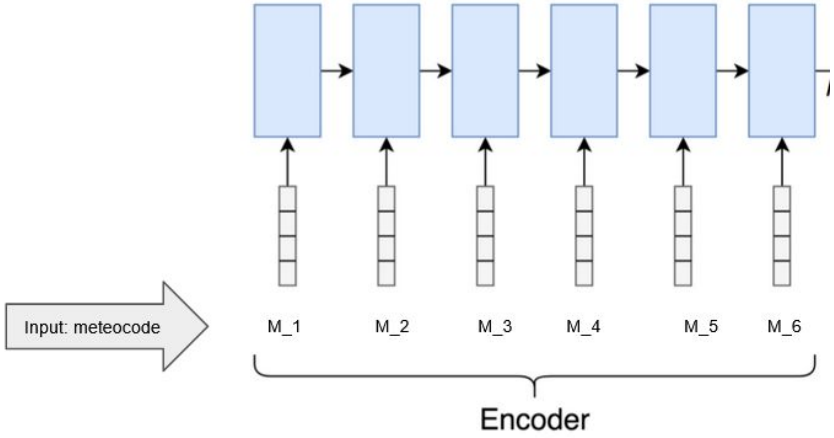
- Input is data generated by a mathematical process, not data created by humans (e.g. sales, click rate…)
- The job is to try to reproduce with a neural approach the output of a symbolic system

Compromises given the time allotted and the difficulty encountered:

- temperatures only (`temp` field)
- separate the generation by period of the day
- train: ~200k, valid: ~10k, test: ~10k bulletins, but subset of train used

Strategy: seq2seq architecture






```
temp:
  0:
    0:  -51
    1:  -48
    2:  "pi"
    3:  -17
  1:
    0:  -48
    1:  -45
    2:  "pi"
    3:  -17
  2:
    0:  -45
    1:  -42
    2:  "pi"
    3:  -18
```

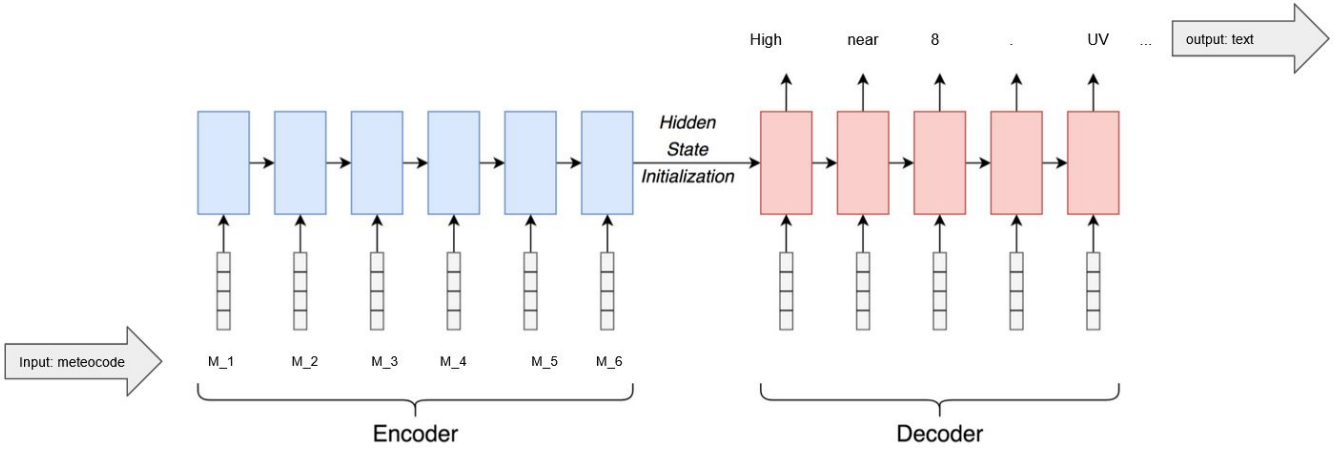

rules

M_0: <start_hour , one-hot(category), temperature>

M_1: <start_hour + 1, one-hot(category), temperature>

M_2: <start_hour + 2, one-hot(category), temperature>

...



- no word embeddings in input, we build meteocode embeddings instead
- small vocabulary of ~100 words for temperature
- meteocode temperature embeddings of size 8 only

- … so modest architecture (38k parameters), faster to train, 1 epoch = 10 minutes on GPU, 3 epochs give good results

Results: convincing

- BLEU score of 76% (100% = perfect)

reference	generation
Low 10 .	Low 10 .
High 26 .	High 26 .
Low 9 .	Low 8 .
Low 12 .	Low 12 .
High 28 .	High 27 .
Low 12 .	Low 12 .
Low 14 .	Low 14 .
High 28 .	High 26 .
Low 14 .	Low 14 .
Temperature steady near minus 1 .	Temperature steady near zero .
Low minus 8 .	Low minus 8 .
High minus 5 .	High minus 5 .
High minus 8 .	High minus 8 .
Temperature rising to minus 3 by morning .	Temperature rising to minus 3 by morning .
High plus 1 .	High plus 1 .
High minus 1 .	High minus 1 .
Low minus 2 .	Low minus 2 .
High plus 2 .	High plus 2 .
High minus 3 .	High minus 3 .
Temperature steady near minus 3 .	Temperature steady near minus 3 .
High minus 1 .	High minus 1 .
Temperature steady near minus 1 .	Temperature steady near minus 1 .
Low minus 9 .	Low minus 9 .
High minus 7 .	High minus 7 .

… but beware of “revisionist” seq2seq

reference	generation
High 28 .	High 27 .
Low 12 .	Low 12 .
Low 14 .	Low 14 .
High 28 .	High 26 .
Low 14 .	Low 14 .
Temperature steady near minus 1 .	Temperature steady near zero .
Low minus 8 .	Low minus 8 .
High minus 5 .	High minus 5 .
High minus 8 .	High minus 8 .
Temperature rising to minus 3 by morning .	Temperature rising to minus 3 by morning .
High plus 1 .	High plus 1 .
High minus 1 .	High minus 1 .
Low minus 2 .	Low minus 2 .

Materials & methods

- All written in Python
- Data processing: custom-made parser, JSON technologies
- The usual deep learning libraries: pytorch, torchtext
- Interesting starting point: NLP From Scratch: Translation with a Sequence to Sequence Network and Attention — PyTorch Tutorials 1.9.0+cu102 documentation
- About 3 person-weeks of work, ~2k lines of (sometimes hurried) code
- GPU for fast training and inference

Conclusions

- As usual, data is a very time-consuming element (extraction, format, documentation, interpretation, etc.)
- seq2seq seems to be a good start for temp field
- Whether it works with other fields remains to be seen...
- Rarer meteocode phenomena will create difficulties, because of scarcity of examples
- In NLG, evaluation is a recurring challenge, and BLEU is a very coarse metric