Bridging Worlds: The Splicing of MDD and GPT for Constrained Text Generation

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Bridging Worlds: The Splicing of MDD and GPT for Constrained Text Generation

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Constrained text : Standardized…

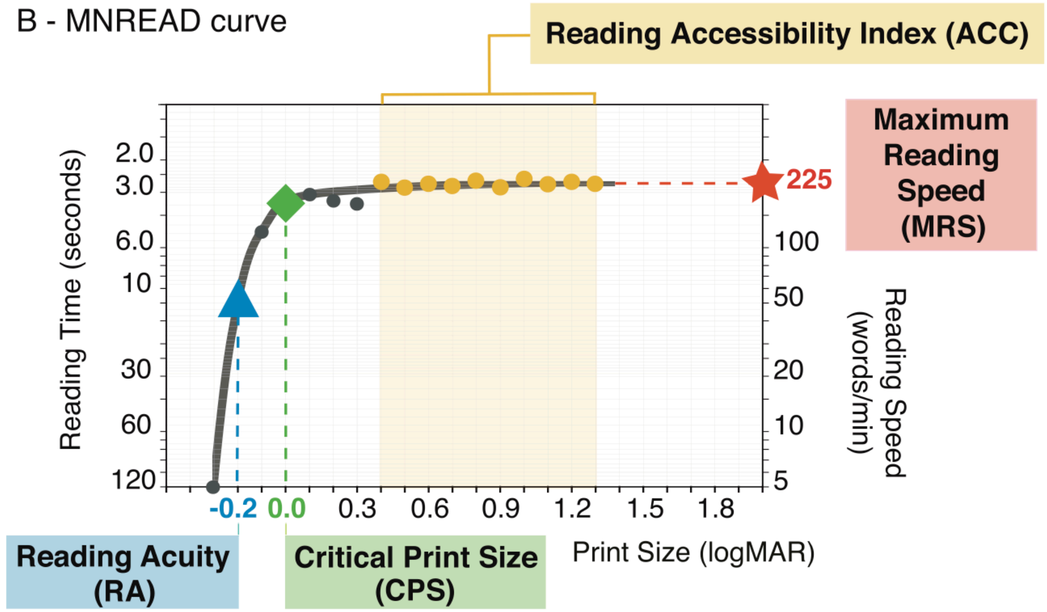
- **Standardized text** : sentences read at the same speed
- **Goal**: assess reading performance
- **How to** : obey a set of strict rules

Nous pouvons faire
une centaine de pas
dans cette direction

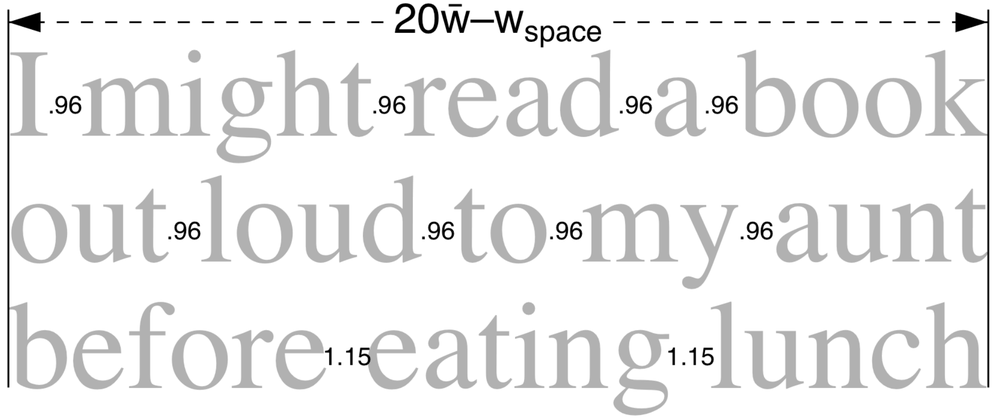
A standardized sentence (FR)

(Test MNREAD)

(Mansfield et al., 1993)

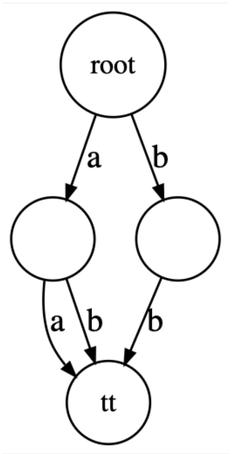


Constrained text generation



Strict text rules

+

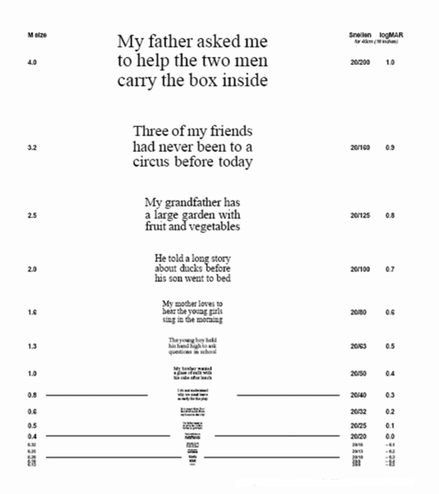


Multi-Valued Decision Diagram

(MDD)

=

Test MNREAD



(Mansfield et al., 1993)

MDDs have already been successfully used to generate **music** and **poetry**.

It's a problem dominated by rules (**constraints**)

Focus on MNREAD phrases

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MNREAD Rules

Grammatical rules

E.g. no punctuation

Length rules

E.g. 60 characters, between 9 and 15 words.

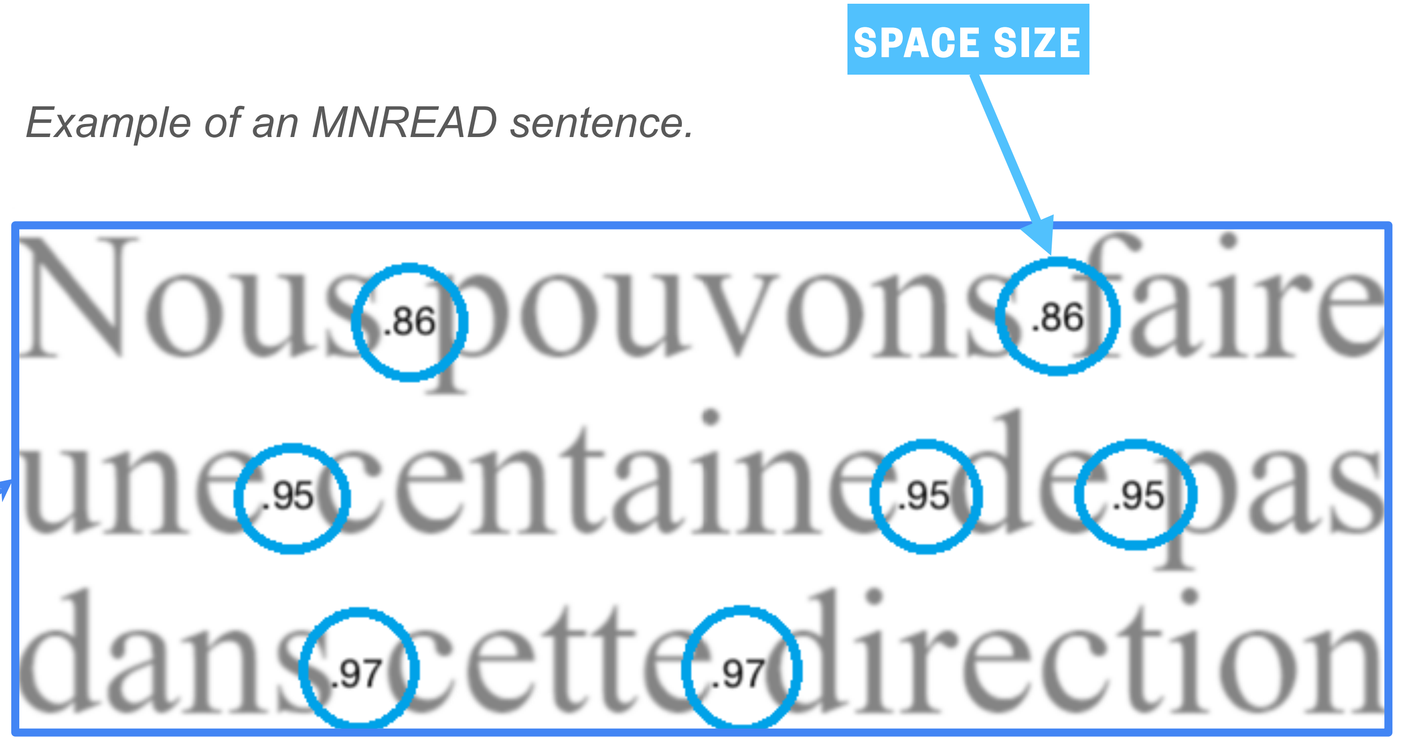
Display rules

E.g. Entering the rectangle

Lexical rules

3000 words from CE2 textbooks

Example of an MNREAD sentence.



There are 38 MNREAD phrases in French

Questions :

There are 38 MNREAD phrases in French.

Are there enough sentences?

No, a few thousand sentences are needed to detect and monitor visual pathology throughout life.

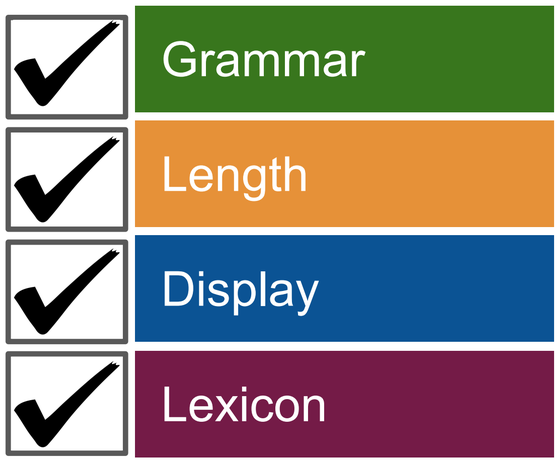
Is it really difficult to have more sentences that respect the rules ?

Naive method
Search for MNREAD type sentences in books.

2300 books → 10 000 000 sentences → 3 sentences

Problem : This method does not scale up

Solution : We have to generate them, but how ?

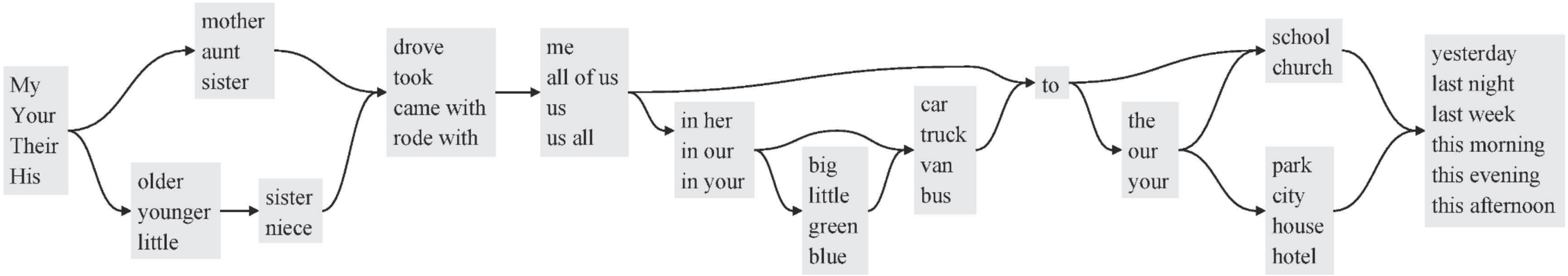


How to generate standardized sentences?

3 method classes

LLM-based approach (GPT, BERT) + SEARCH := good text quality, but unlikely to find in an instance that satisfies the constraints.

Ad hoc method: a recent method proposed by the creators of MNREAD and based on hand-defined models (Mansfield et al., 2019).



- One "good" sentence out of 8000 (only)
- A semi-automatic method for the English language
- Non-trivial extension to Latin languages! (e.g. French?)

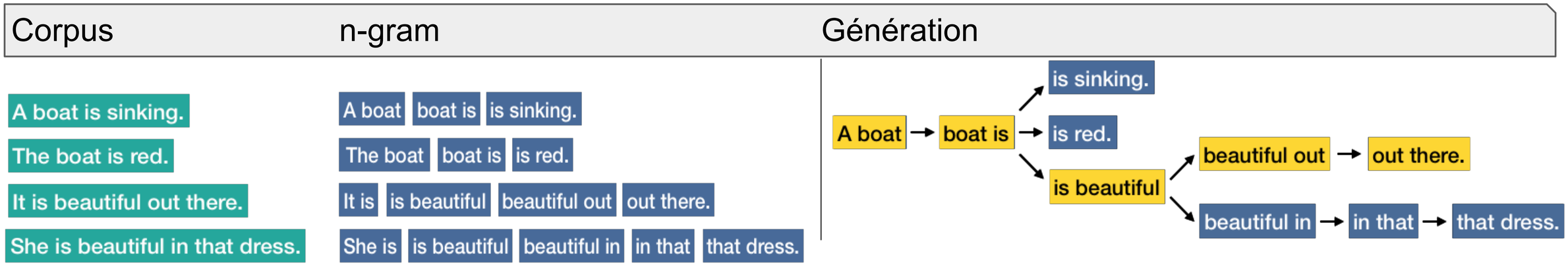
How to generate standardized sentences?

3 method classes

LLM-based approach (GPT, BERT) good text quality, but unlikely to result in an instance that satisfies the constraints.

Ad hoc method: a recent method proposed by the creators of MNREAD and based on hand-defined models (Mansfield et al., 2019).

Combinatorial optimization (n-grams based) (Papadopoulos et al., 2015)



How to integrate constraint in this scheme ?

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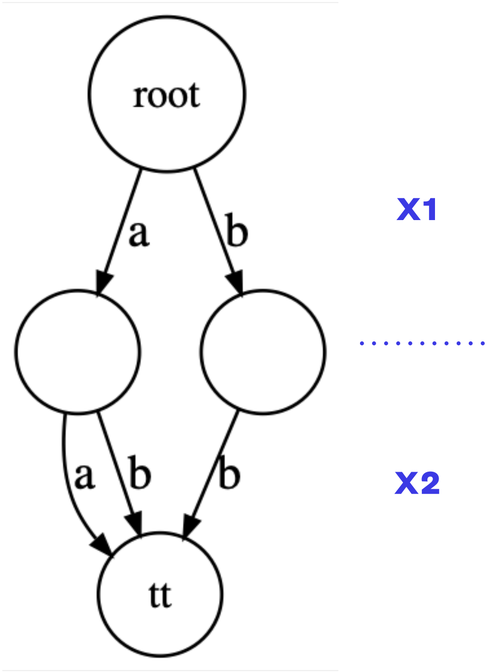
Multi-Valued Decision Diagram (MDD)

- A generalization of Binary Decision Diagrams (BDD)
- Each layer represents a variable
- Each path between root and tt is a valid assignment of the variables
- An MDD models all tuples that satisfy a constraint

Take Home message:

- Data structures for calculating and storing problem solutions in a compressed form using an acyclic directed graph



MDD which contains three solutions :

(a,b) (a,a) (b,b)

4 IDEAS

- N-gram
- MDD to handle N-gram
- Integrate constraints in MDD
- Select best sentences

Idea 0
N-gram as an implicit constraint

Ngram : An implicit constraint

- Avoiding *generate & test*
- Taking account of meaning and grammar
- Reducing combinatorics

General Remark :

N of n-grams ↗

Quality of sentence ↗

Number of sentence ↘

Idea (n-gram)

Step 1 : Corpus

Il est beau.

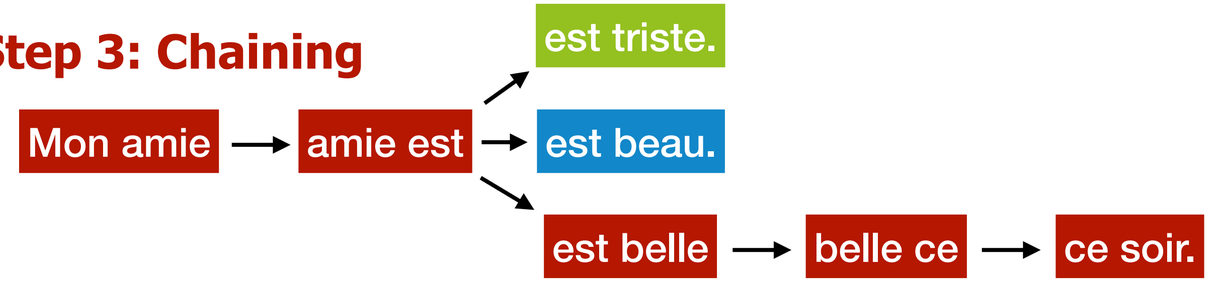
Mon amie est triste.

Elle est belle ce soir.

Step 2: set of 2-grams

est belle | amie est | est beau. | ce soir. | Il est | Mon amie | belle ce | Elle est | est triste.

Step 3: Chaining

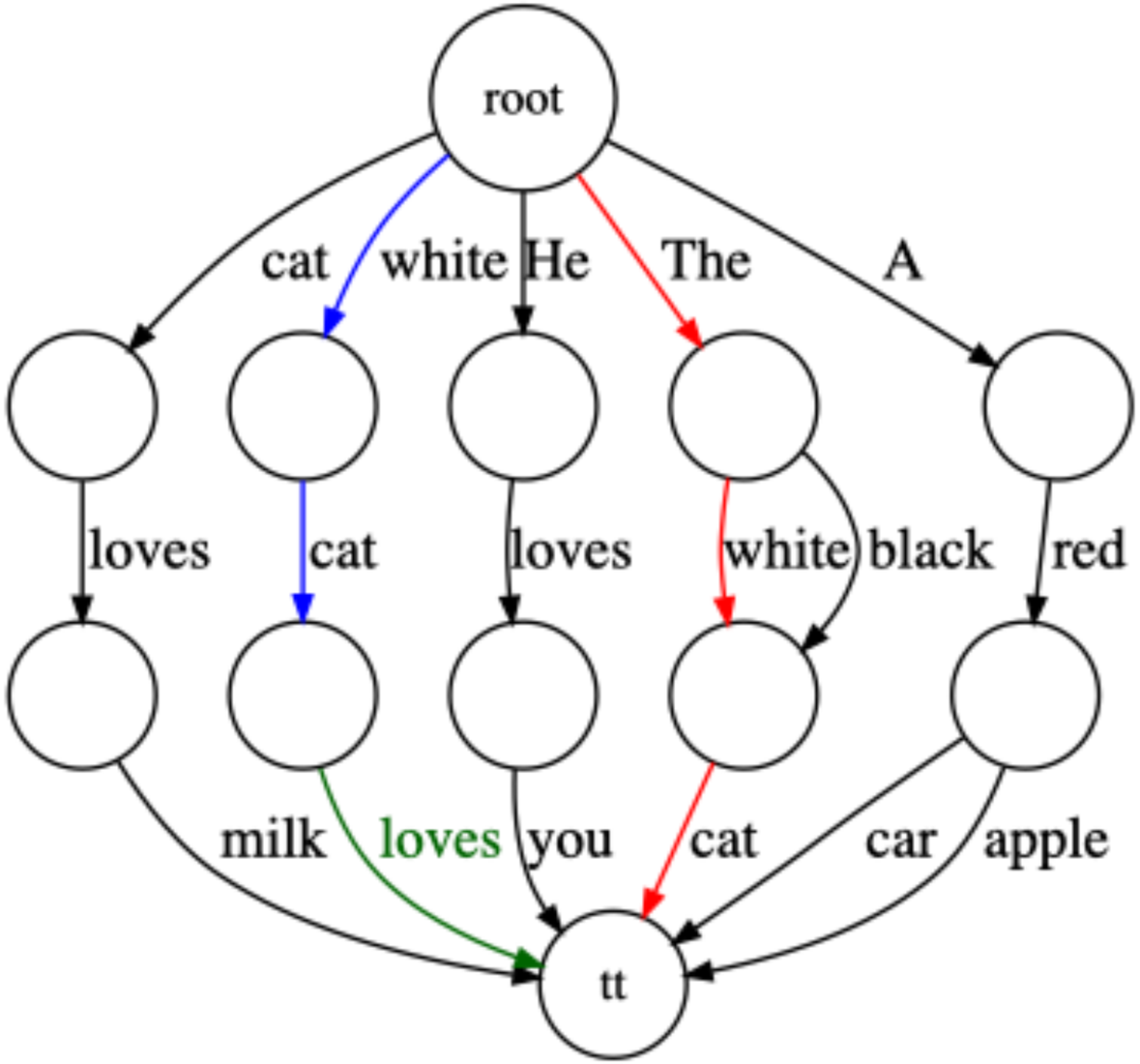


First idea

store and re**trie**ve n-grams efficiently

Successions Constraint

- Assuming all n-grams are inserted in the MDD as solutions.
- MDD as a TRIE
- To store and reTRIEve n-grams.

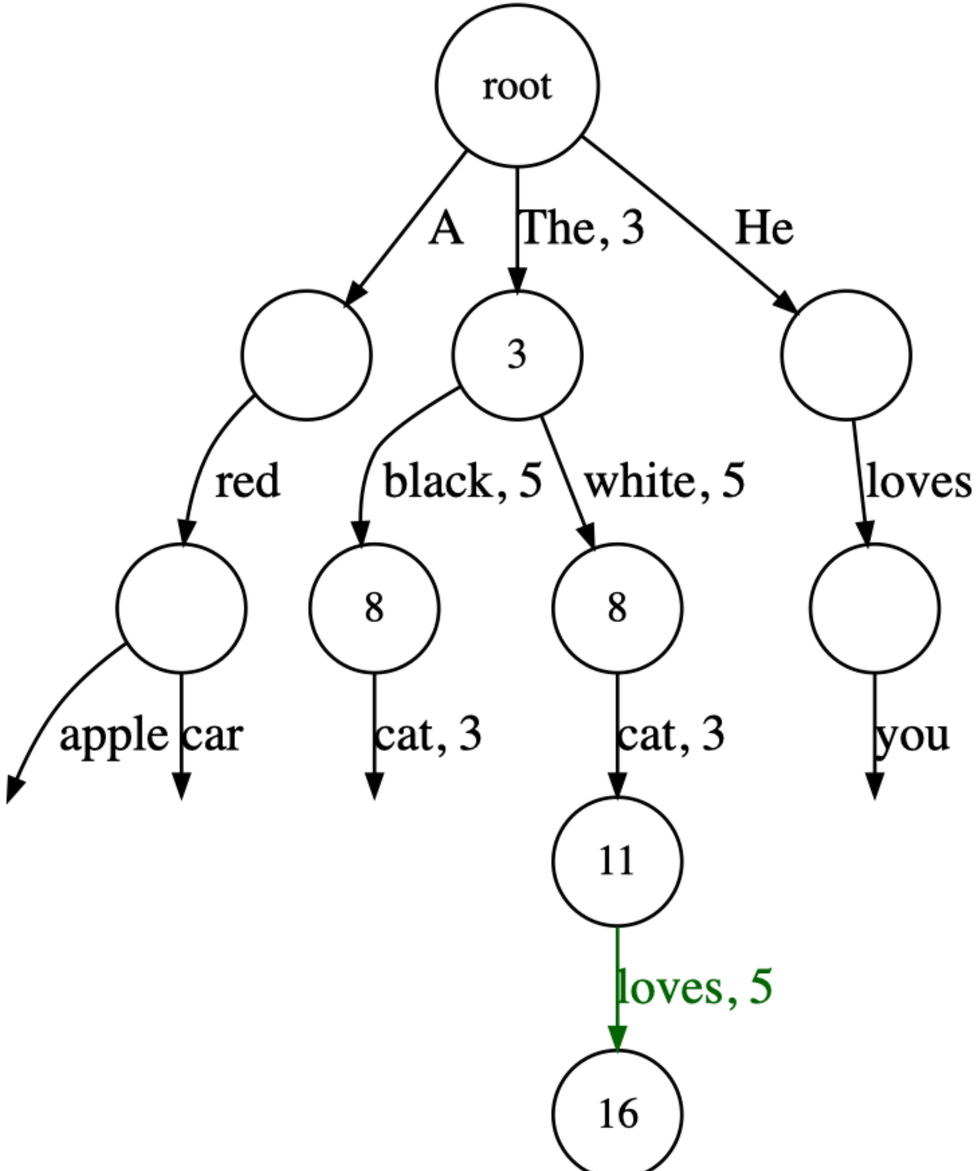


What is the next word of **The white cat** ?

Second idea
Integrate constraints on-the-fly

MDD Unfolding (top-down)

- Using the first MDD (successions)
- We compile the second one
  - Constraint are checked on-the-fly



OK, but what we obtain so far ?

J'aimerais bien que le soleil commence à se rendre au salon

Mes yeux se posent sur le nom qui lui a dit que vous croyez

Aucun de ses pieds nus sur les yeux de ce qui ne se passera

Y en a pas de nous préparer à tout bout de sa petite bouche
J'en ai dit que si je vous en emparez et vous ne pouvez pas
Entrez là et tu as de ma part de sa main dans le monde voit
Bien que je ne veux pas que les yeux de ce que ça me plaira

- Ces phrases ne sont **pas admissible.**
- En 3-grammes on produit une grande majorité de phrase ayant des problèmes de sens et de syntaxes

Can we do better ?
Increase the n of n-gram !

Je ne m'attends pas à ce que ses efforts soient récompensés

Une femme sort de la maison et je n'ai pas le temps de fuir
Une fille se tenait à quelques mètres de son pire cauchemar
Ils vont dire à mon père que je n'ai pas envie de me marier

Il ne comprend pas ce que tu es et tout ce que tu as décidé

L'homme tourna la tête en direction de la voiture de police
Son compagnon lui jeta un coup d'œil à travers les carreaux
Une catastrophe est en train de m'aider à réaliser mon rêve
Allez le dire à mon père que je n'ai pas envie de me marier

Les images sont de plus en plus vers le cœur de la sorcière

- En 5-grammes, problème syntaxe et sens moins fréquent mais toujours présent

Third idea

Use an LLM to select best sentences

LLM sentences scoring : Perplexity

- Transformers (good for generation (chatGPT), but also to rank text):

Hugging Face is a startup based in New York City and Paris

p(word)

$$P(X_1 ... X_n) = \prod_{i=1}^{n} P(X_i | X_1 ... X_{i-1})$$

$$PPL(S_n) = \sqrt[n]{\frac{1}{P(w_1 w_2 w_3 ... w_n)}}$$

- Perplexity is derived from Shannon entropy.
  - It quantify the uncertainty of a model with respect to a sample
  - Lower the better, range is [1 ; + inf[

Example of PPL ranking

	PPL
Je ne m'attends pas à ce que ses efforts soient récompensés	9
Les images sont de plus en plus vers le cœur de la sorcière	60
Aucun de ses pieds nus sur les yeux de ce qui ne se passera	160
Il est tombé dans le vide avec une sorte de douceur absente	80

@

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Experimental conditions

- **Input** : 443 books belonging to the youth category (FR)
- **Input** : 75 books belonging to the fiction category (EN)
- **Evaluation** :
  - MNREAD **candidate** sentence set (syntax and meaning correct)
  - **Ineligible** set of sentences (syntax and/or meaning problems)
- **Software & Hardware** :
  - The model is implemented in Java 17 in an MDD solver (MDDLib) @I3S.
  - The LLM use to rank sentences is GPT-2
  - Machine: Ubuntu 18.04 using an Intel(R) Xeon(R) Gold 5222 @ 3.80GHz CPU and 256 GB RAM.

Questions:

Are MNREAD sentences generated?

What is their quality ?

Are MNREAD sentences generated?

- YES ! In **5-grams** , with **443** books , we generate thousands of sentences (7028).

French Generated Sentences	PPL
Assise à la table de la salle à manger il y a un bon moment	6.23
Elle se pencha vers elle et lui donna un grand coup de pied	6.62
Et il y a des choses dont on ne peut pas dire la même chose	6.82
Nous avons à peine le temps de faire un tour dans la maison	6.83
Ses parents ne sont pas au courant de la maladie de sa mère	6.94
....	...
Il frappa à nouveau dans ses yeux et de voir la grue bouger	230
La poupée finit par tomber sur le sol et préparai mon bâton	241
Une hache reposait près de lui et de ne pas jouer aux héros	241
Quand le bout de la salle et frappa dans ses mains en coupe	242
Une hache reposait près de lui et de ne pas sortir ensemble	291

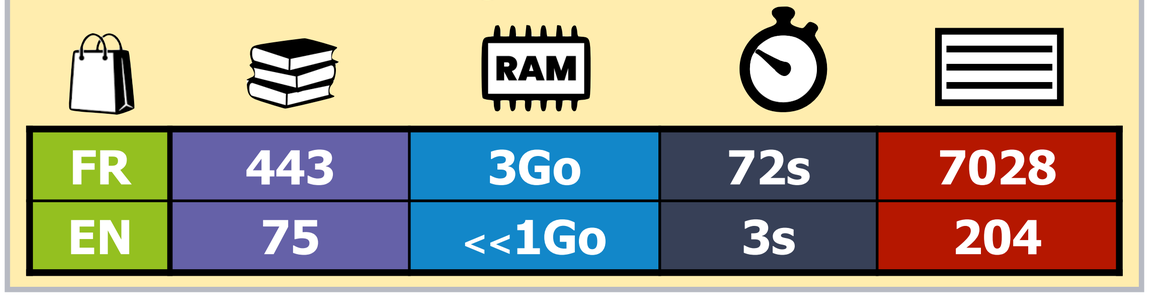
Are MNREAD sentences generated?

- YES ! In **5-grams** , with **75** books , we generate hundreds of sentences (204).

English Generated Sentences	PPL
And he had no idea what to do with the fact that she was in	17.9
It made me wonder if it was going to be able to do the work	20.1
You should be able to get out of bed to get out of the room	20.2
You need to get out of bed to get out of the room right now	21.2
No one will be able to get in and out of the room right now	21.4
....	...
The family in front of the double doors and into the branch	109
She paused outside the door to the back of my left shoulder	123
The difference here was now she had to deal with in my life	160
She hesitated at the door to the back of her nose and mouth	189
So strange to be on the edge of my chin between his fingers	224

Performances analysis

MNREAD sentence generation



FR	443	3Go	72s	7028
EN	75	<<1Go	3s	204

- Scoring takes roughly 1 hours for 7000 sentences. GPT-2 (lab server no GPU)
- Scoring takes roughly 30 mins for 7000 sentences. GPT-3 (OpenAI cloud)

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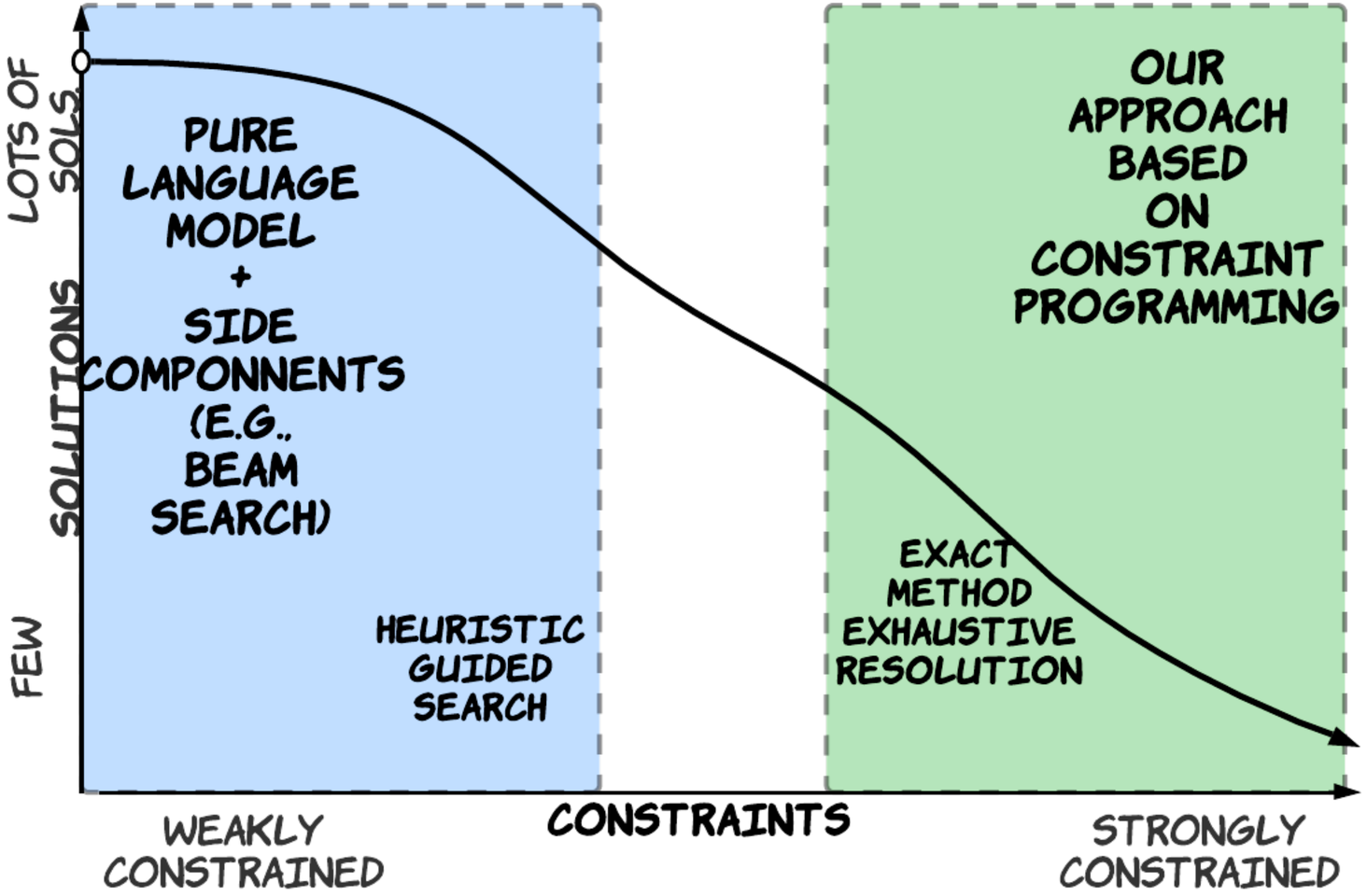
Conclusion

- Novel and creative approach that solves **constraints first** and then **select**
- Method: more suitable than generic methods for managing constraints (e.g., GPT, Bert) and more **flexible** than the ad-hoc method of Mansfield et al.
- Advantages: **modularity** (easy to add and/or remove rules), constraints taken into account at **generation stage**, applicable to **other languages**.

- Perspectives:
  - Constraint Programming - Machine Learning Bridge.

Overview


LOTS OF SOLS.
SOLUTIONS
FEW
PURE LANGUAGE MODEL + SIDE COMPONNENTS (E.G., BEAM SEARCH)
HEURISTIC GUIDED SEARCH
OUR APPROACH BASED ON CONSTRAINT PROGRAMMING
EXACT METHOD EXHAUSTIVE RESOLUTION
WEAKLY CONSTRAINED
CONSTRAINTS
STRONGLY CONSTRAINED

Thanks for your attention.

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Paper :

Constraint First: A New MDD-based model to generate sentences under constraints.

Aknowledgement :

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