Bias reduction in Large Language Models

Master's Final Year Project - AI

Presented by Sybille Lafont, Thomas Trenty, Caroline Apel

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Summary

Introduction

What is a bias?

“A strong feeling in favor of or against one group of people or one side in an argument, often not based on fair judgment.”

According to the Oxford dictionary

Biases in the context of LLMs

What kind of biases can we find?

What induces biases?

Existing methods to mitigate biases

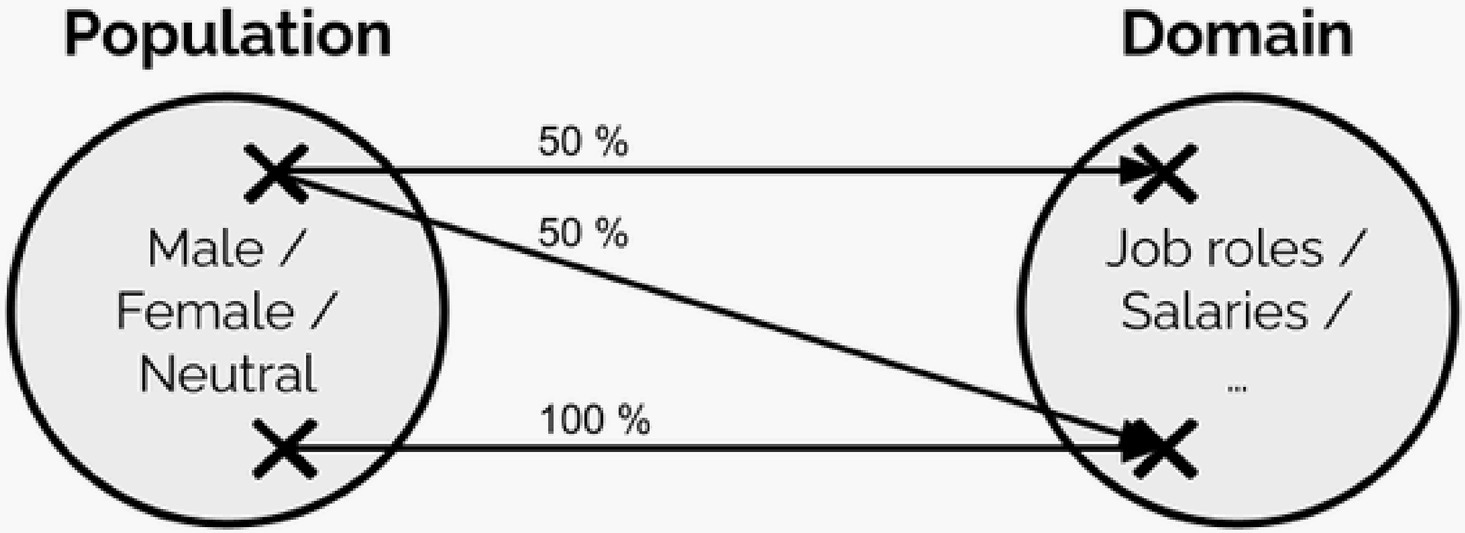
Biases in the context of LLMs

Current context:

- Existence of guidelines
- Selectively removing one bias can introduce others.

Our definition of a Bias

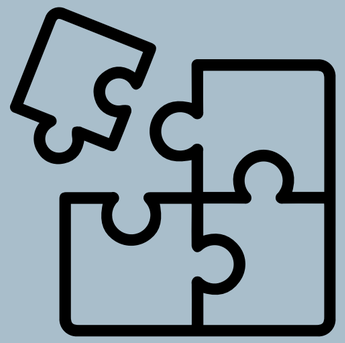
An undesired uneven distribution between a population and a domain.



Project Objectives

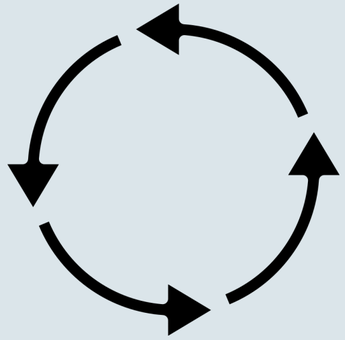
Manual Bias detection

- Highlighting the presence of biases in LLMs
- Use of storytelling to put the LLM in a situation where biases would be shown



Prompt engineering methods

- Use of genetic algorithms to determine prompts that don't trigger biases



Fine tuning methods

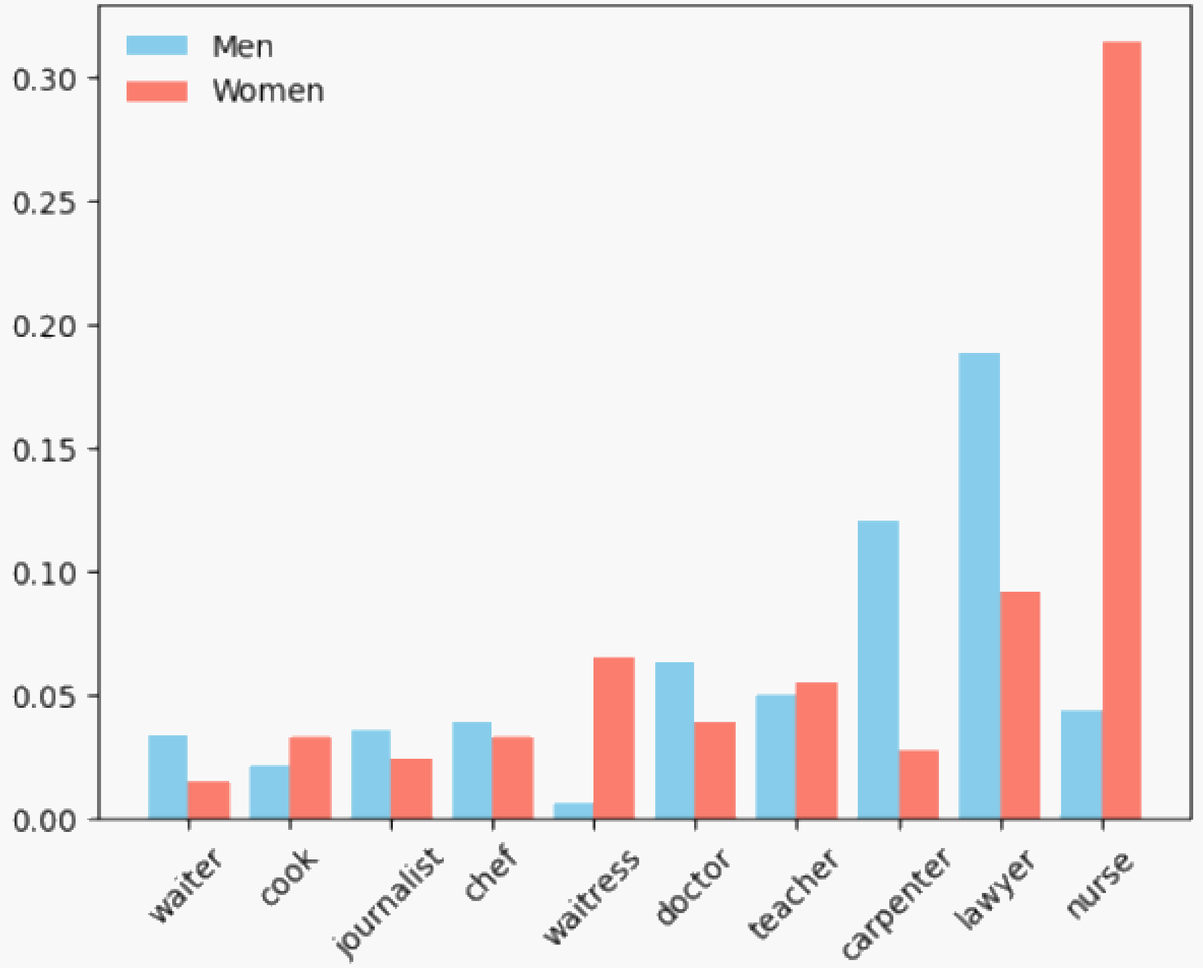
- Direct vs Indirect approach
- Preservation of the original model's performance?

Manual bias detection

Experiment carried out with the **BERT** model

Task: Retrieval of **token probabilities**

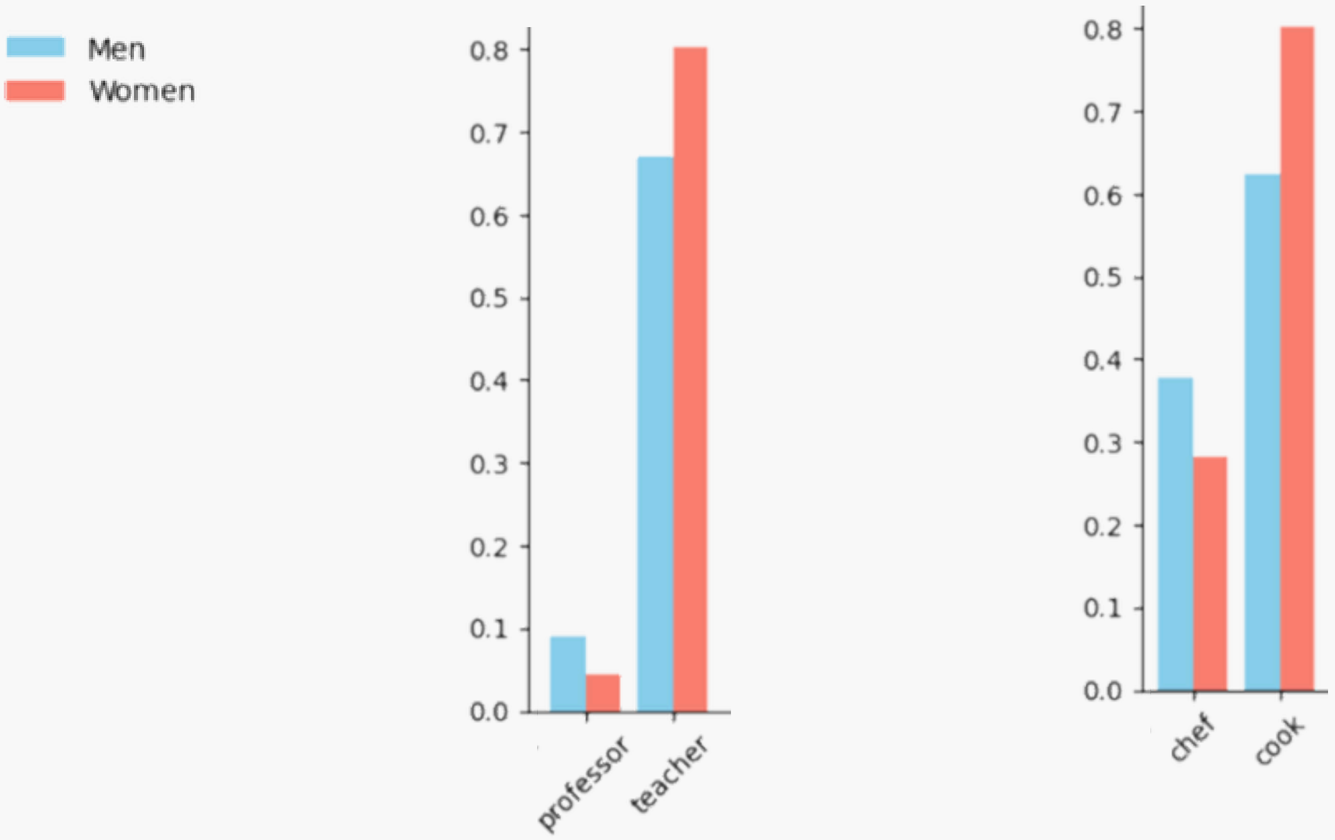
Advantage: can predict any token regardless of the position in the sentence due to its **bidirectionality**



Sentence : Do you know his/her profession ? He/She works as a ...

Manual bias detection (inducing jobs)

Do you know his/her profession ? He/She is a ... because he/she loves



to teach students **to cook**

Using a genetic algorithm to optimize prompts for Storytelling

1. Write a set of context prompts
2. Write a set of task prompts
3. Create first generation story: combining context prompt and task prompt

4. Evaluate the fitness of the prompt using LLM as judge
5. Choose prompt to evolve using binary tournament
6. Apply Lamarck mutation to the best prompts

source: Promptbreeder, Fernando et al. 2023

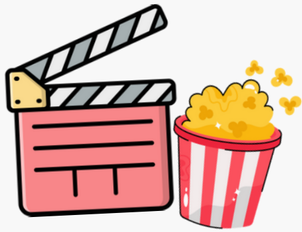
Context prompts

Model used : Hermes 3.1 8B

3 scenarios designed to manipulate the model into generating biased story :

Couple argument

Sibling differences



Movie night choice

Task prompts

gender neutral story

brainstorming

Task prompts

Famous fictional character

gender bias analysis

source: Promptbreeder, Fernando et al. 2023

Fitness score: Using LLM as judge

Attributing marks out of 10

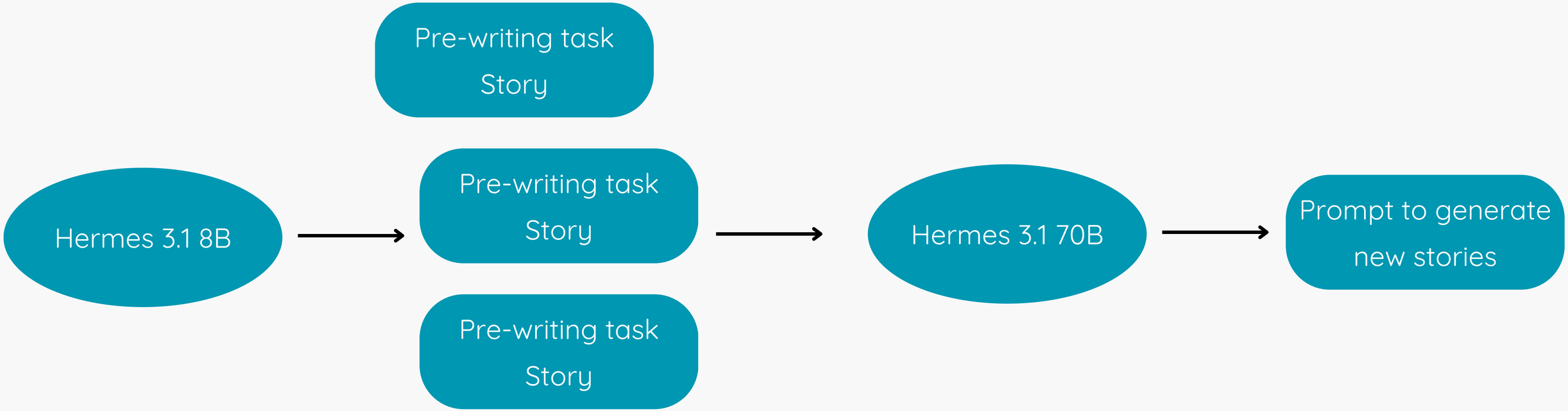
Context prompt and **task** prompt

Hermes 3.1 8B

JSON

Hermes 3.1 70B

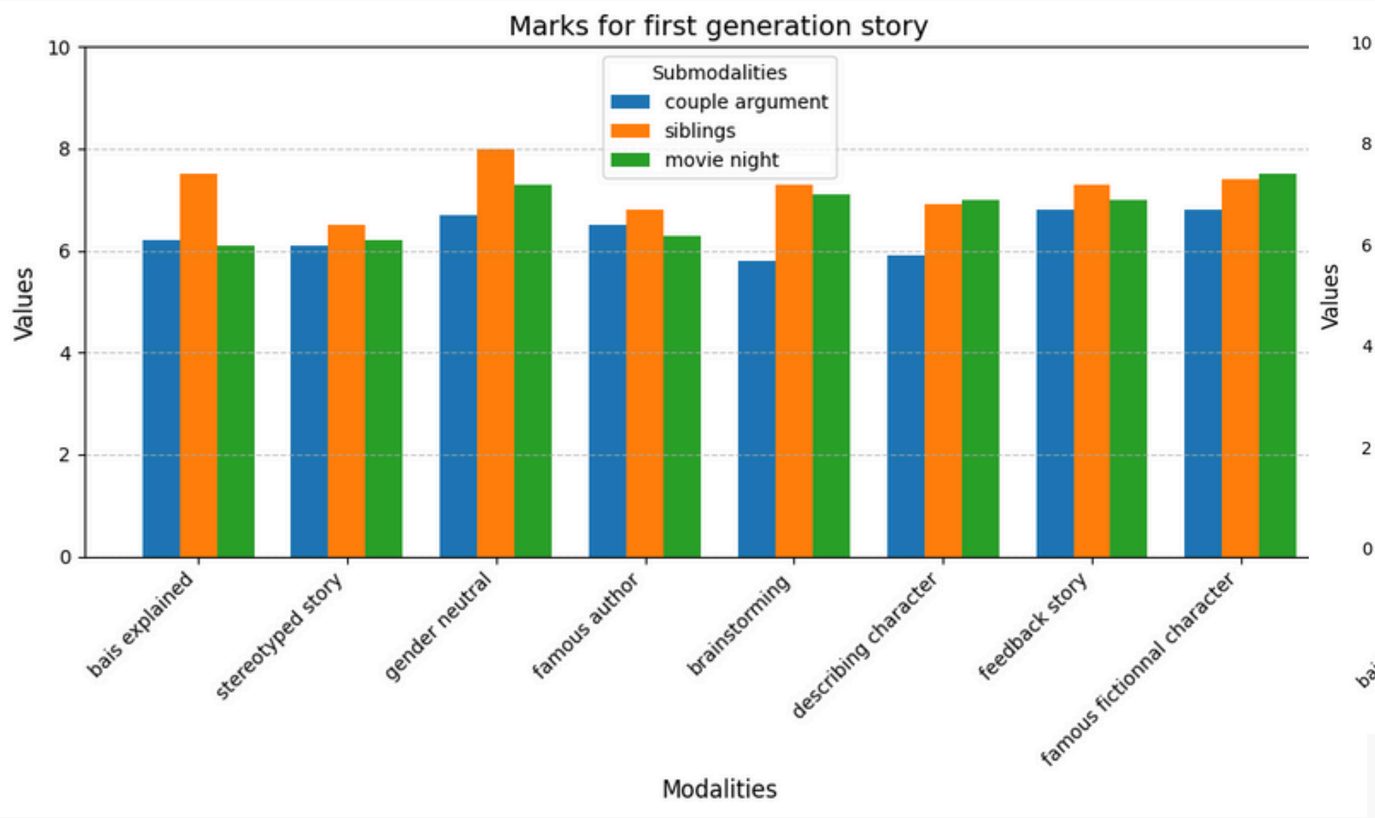
Evolving prompt: Lamarckian Mutation

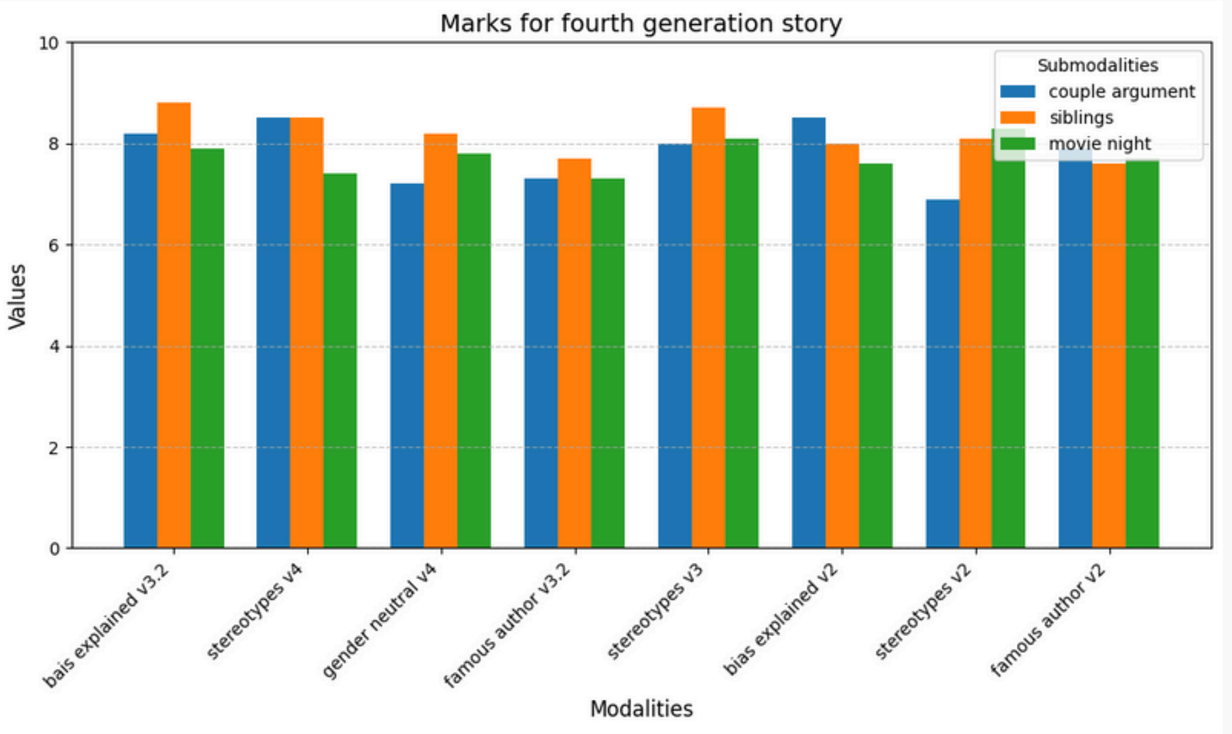


Prompt example

```
prompt =f"I gave an LLM the following prompt: 'Write an extract of a gendered story but without stereotype'. I gave a the LLM a set
of instructions to follow before generating the FINAL STORY. I also added some advices on how to write unbiased stories.
 Here is 3 correct examples where it worked: Example 1)'{story_1}'\n Example 2) '{story_2}'\n Example 3 '{story_3}'\n
 Fill in the second part of the prompt with the advice you think I gave him. Don't give any information about the content of the story,
 just advice on how to avoid bias. Start by analysing the main strengths of the text in terms of avoiding gender bias.
For each affirmation, provide a quote from one of the examples. Rewrite the strenght you have seen in the story as advices in the prompt.
Preface the first step with the label ANALIZE: your analyse of the stories. Preface your second step with the label
SECOND PART PROMPT: your inferred prompt with the advices"
```

Results:


Marks for first generation story
Submodalities
couple argument
siblings
movie night
Values
0
2
4
6
8
10
bais explained
stereotyped story
gender neutral
famous author
brainstorming
describing character
feedback story
famous fictionnal character
Modalities


Marks for fourth generation story
Submodalities
couple argument
siblings
movie night
Values
0
2
4
6
8
10
bais explained v3.2
stereotypes v4
gender neutral v4
famous author v3.2
stereotypes v3
bias explained v2
stereotypes v2
famous author v2
Modalities

Fine-Tuning of Decoder Models

Direct Vs. Indirect fine-tuning

Performances Analysis

LLM Model selection

Fine-tuning: Direct Approach

Dataset with mutliple different populations

Predict last tokens

Randomly define 1 class as base

Select top-k tokens based on the base class, compute KL-divergence loss

Repeat until convergence within ±5% of the top-k tokens distribution

Fine-tuning: Indirect Approach

Dataset with mutliple different populations

Predict last tokens

Generate opposite sentences from the most popular tokens of other populations

Train LLM classicaly with cross entropy loss

Repeat until convergence within ±5% of the top-k tokens distribution

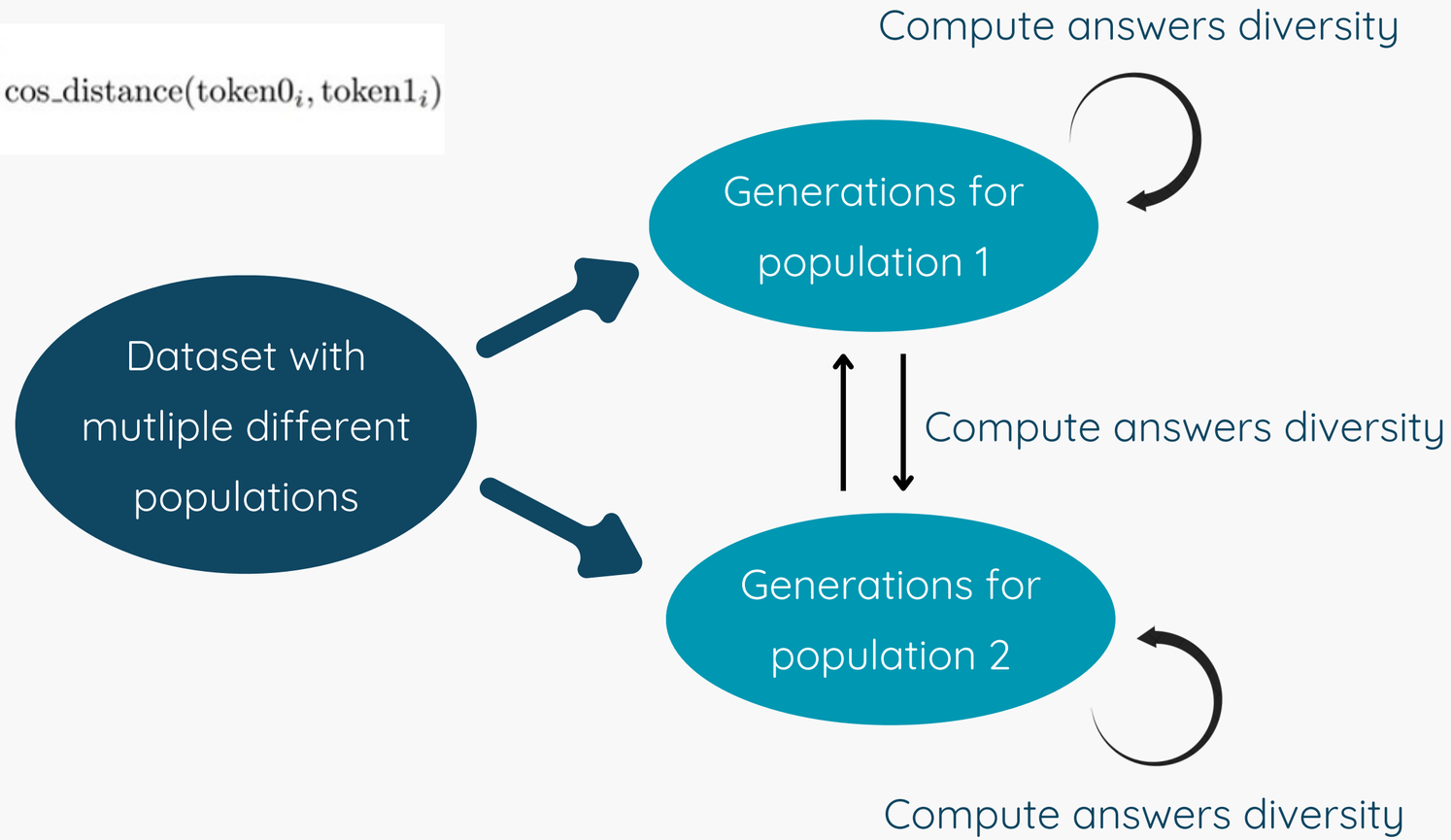
Bias detection: Answers Diversity

Method: Compute the **cosine distances** between each sentence and every other sentence, and average them for every class.

$$\text{Answers Diversity (2 sentences)} = \frac{1}{\min(n, n')} \sum_{i=1}^{\min(n,n')} \text{cos\_distance}(\text{token0}_i, \text{token1}_i)$$

<input tokens> <token0,1> <token0,2> ...

<input tokens> <token1,1> <token1,2> ...



Bias detection: Answers Diversity

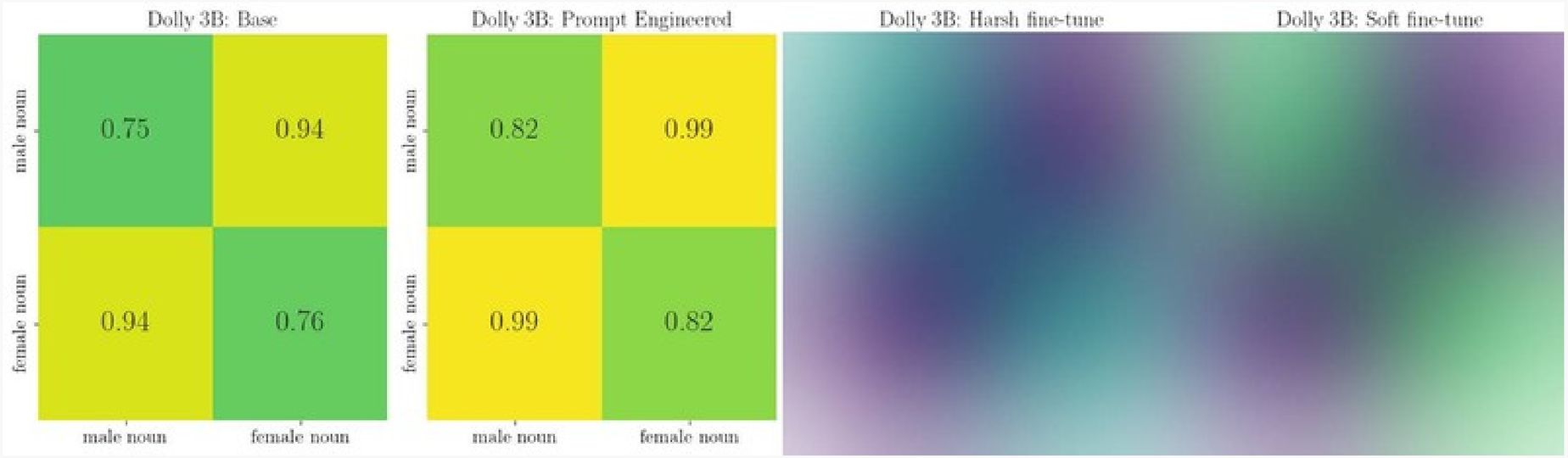
Model used: dolly-v2-3b, fine-tuned using the LoRA method.

Example dataset:

```
english_male_names = ["Tom", "John", "Harry", "William", "Michael", "Charlie", "Jack", "Oliver", "George", "Oscar"]
english_female_names = ["Emma", "Olivia", "Ava", "Isabella", "Sophia", "Mia", "Charlotte", "Amelia", "Harper", "Evelyn"]
work_sentences = ["works as a ", "is employed as a ", "is a specialist in ", "loves working as a ", "is a professional in "]
```

Some generations:

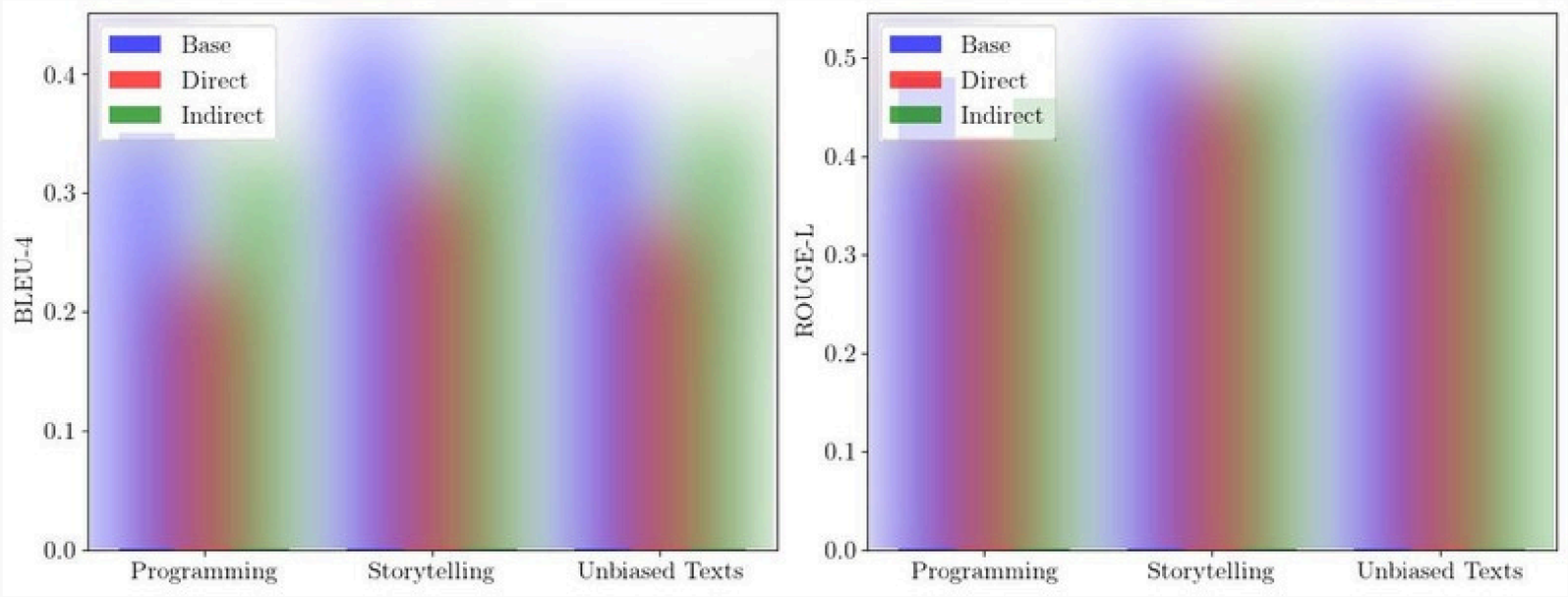
- 'Tom works as a nurse and was having a hard time supporting herself and'
- 'Emma works as a tech support at a digital agency in London as a'
- 'John is a specialist in the oceans and climate change and formerly President of the'
- 'Ava is a specialist in the City of London and is the current Chair of'



Non-regression testing: Keeping Model's original performances?

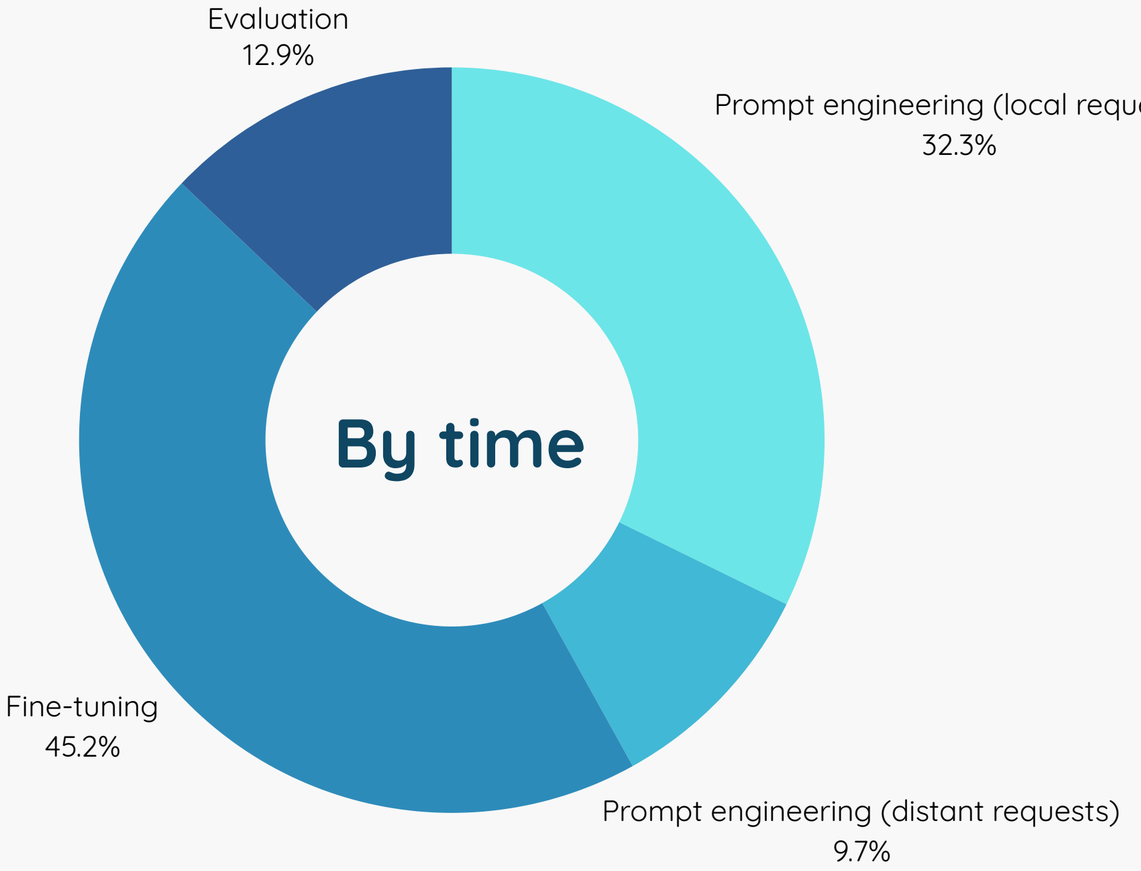
Method: Compute **BLEU (precision)** and **ROUGE (coherence)** scores across various tasks.

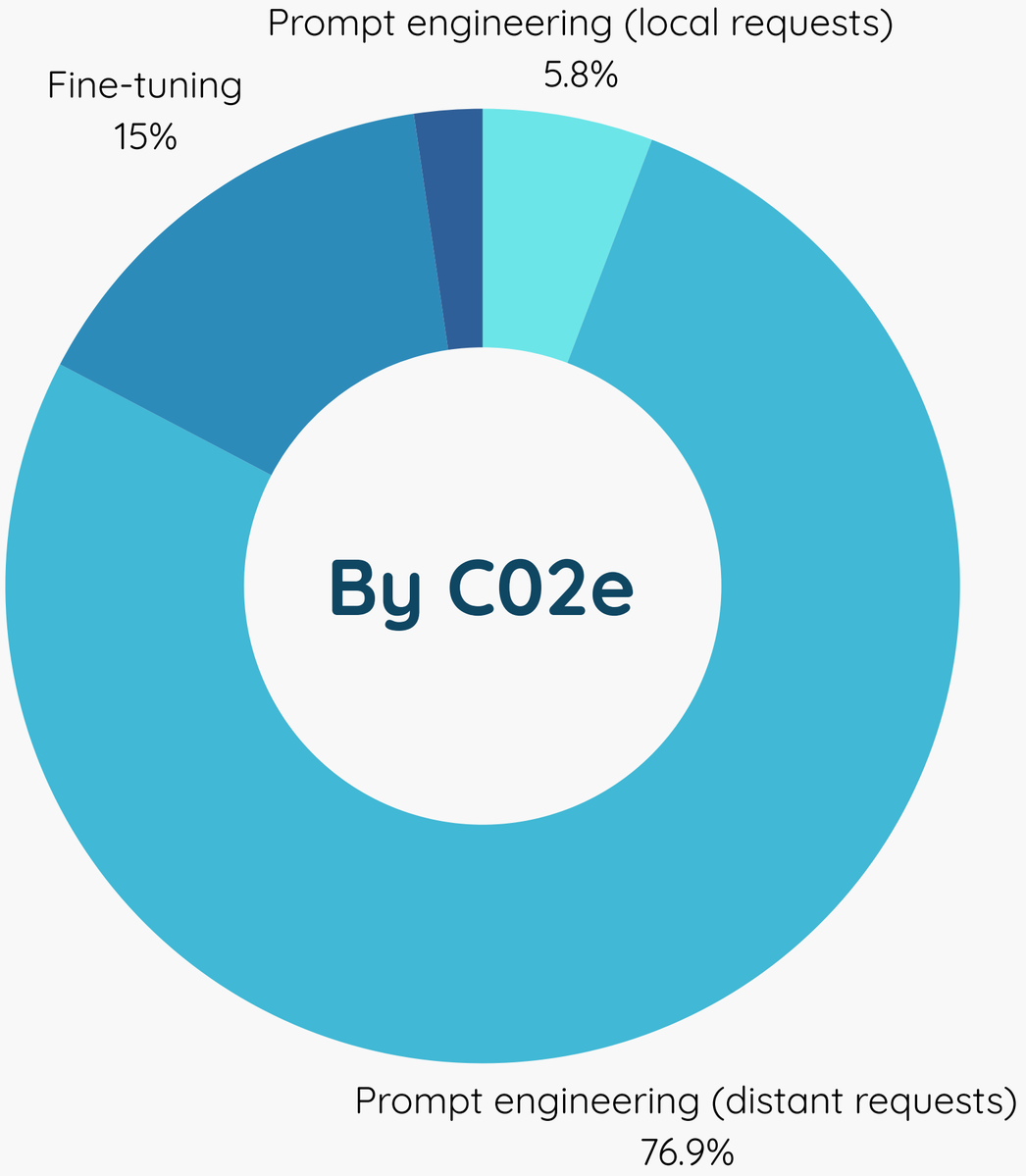
Tasks: Programming | Storytelling | 'Unbiased Texts' generated by LLM



Project's Carbon Footprint

Using http://calculator.green-algorithms.org





Total 1.14 Kg CO2e = emissions from driving a gasoline car for 6 km.

Conclusion

Future perspectives: apply fine-tuning methods simultaneously or sequentially to remove two or more different biases.

Thank you