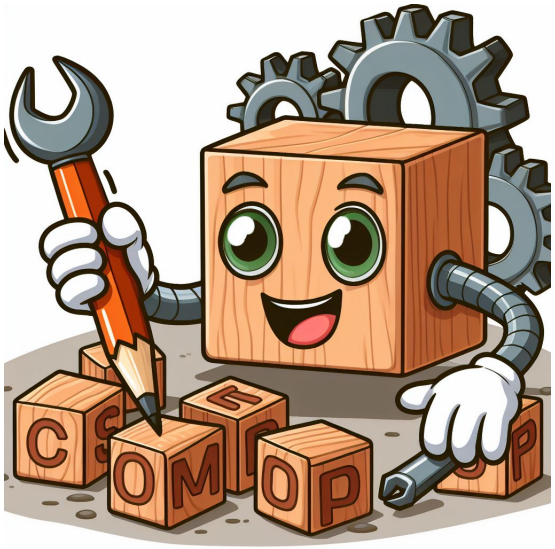
COMPO

Inductive Biases for Compositionality-capable Deep Learning Models of Natural Language

January 2024



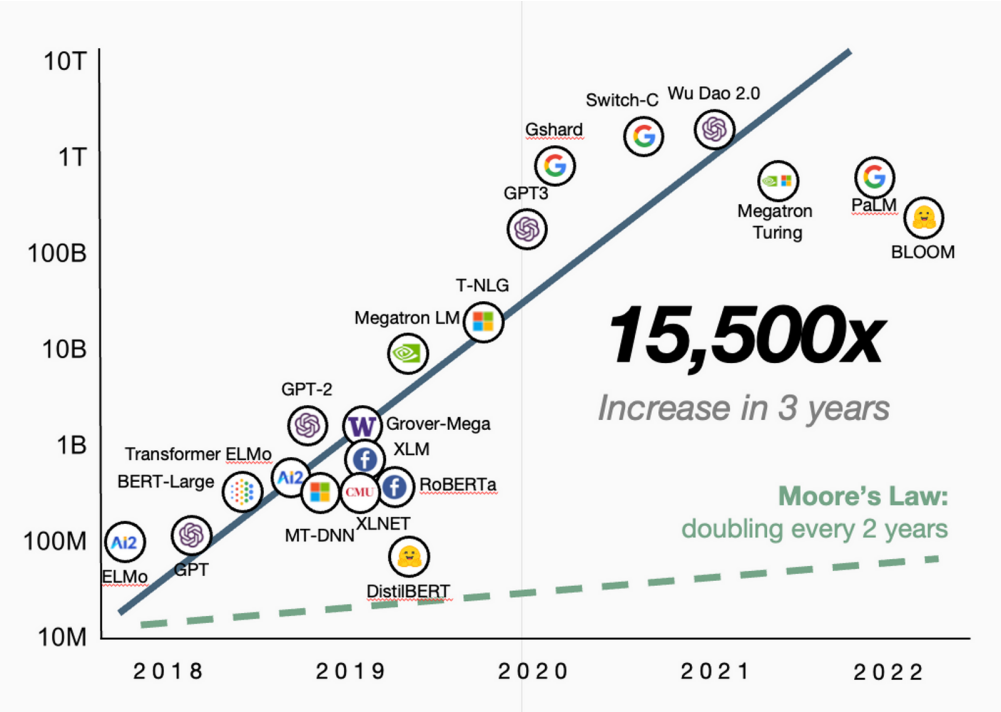
Consortium

The consortium involves labs and teams with a focus on Natural Language Processing or language modeling, each coming with its own perspective: computer science, applied mathematics, linguistics, cognitive science

- Laboratoire Informatique de Grenoble (LIG, Grenoble, E. Gaussier)
- Laboratoire Informatique et Systèmes (LIS, Marseille, A. Nasr)
- Laboratoire de Linguistique Formelle (LLF, Paris, B. Crabbé)
- Laboratoire de Psychologie Cognitive (LPC, Marseille, A. Rey)

Evolution of Large Language Models (LLMs)

- Outstanding successes on most NLP benchmarks have been substantially improved since 2018 and the birth of **transformers**
- The current trend amounts to increase the amount of parameters and the amount of training data the transformer language models are trained on



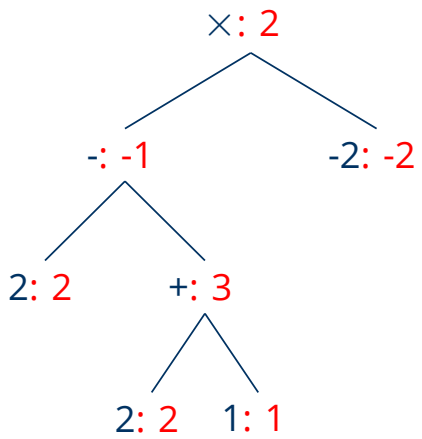
Position of the project

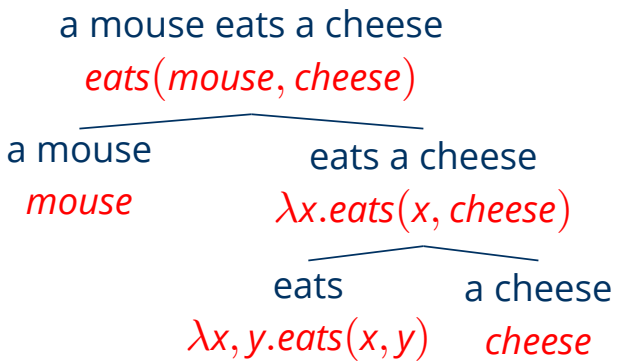
Natural language is compositional

- The amount of training data and the amount of computing resources required by current models is unrealistic
- Current language models fail to acquire generalizations that are thought to be central to the human language competence

Compositionality

Compositionality relies on the hypothesis that the function mapping form to meaning of natural language is not entirely arbitrary, this mapping is compositional and the meaning of the whole is a function of the meaning of its parts





Position of the project

Compositionality is a consequence of human cognitive limitations

- Recall that a language model computes

$$P(\mathrm{x}) = \prod_{i=1}^{n} P(x_i | x_1 \ldots x_{i-1})$$
$$\approx \prod_{i=1}^{n} P(x_i | x_{i-k} \ldots x_{i-1})$$

- k was around 3, 4, 5 a few years ago, it is now enormous: 1024, 2048, 4096 in a typical LLM (e.g. GPT-X)

Human memory is limited

- Cognitive science agrees that Humans do not have access to a large photographic context. Rather the amount of chunks we can store in memory is bounded: Miller (1951) sets this constant to 7
- **Hypothesis** Rather than storing the long list $x_{i-k} \ldots x_{i-1}$, humans have approximate memory and compose these items

Scientific questions and workpackages

- Which biases are already built-in in current LLMs ? in particular wrt compositionality, non compositionality **(WP 1)**
- Can we enforce compositionality-based biases in language models ? how do these biases relate to natural language parsers models ? Can language models do more than memorizing their training set and acquire generalizations ? **(WP 2)**
- How do language models encode non compositionality, idiomaticity ? **WP 3** explores comparisons between cognitively motivated segmentation methods simulating human memory limitations biases and current segmentation methods used in LLMs
- Can cognitively inspired memory limitations biases help to improve compositional generalisations ? **(WP 4)**

Evaluation

On Cogs/Slog (NLP typical setup) but also on behavioral data (Reading times)

Training	**Generalization**
A hedgehog ate the cake $*\texttt{cake}(x_4); \texttt{hedgehog}(x_1)$ $\wedge \texttt{eat.agent}(x_2, x_1) \wedge \texttt{eat.theme}(x_2, x_4)$	The baby liked the hedgehog $*\texttt{baby}(x_1); \texttt{hedgehog}(x_4)$ $\wedge \texttt{like.agent}(x_2, x_1) \wedge \texttt{like.theme}(x_2, x_4)$
Ava saw a ball in a bowl on the table $*\texttt{table}(x_9); \texttt{ball}(x_3) \wedge \texttt{bowl}(x_6)$ $\texttt{see.agent}(x_1, \texttt{ava}) \wedge \texttt{see.theme}(x_1, x_3)$ $\texttt{ball.nmod.in}(x_3, x_6) \wedge \texttt{ball.nmod.on}(x_6, x_9)$	Ava saw a ball in a bowl on the table on the floor $*\texttt{table}(x_9); *\texttt{floor}(x_{12}); \texttt{ball}(x_3) \wedge \texttt{bowl}(x_6)$ $\texttt{see.agent}(x_1, \texttt{ava}) \wedge \texttt{see.theme}(x_1, x_3)$ $\texttt{ball.nmod.in}(x_3, x_6) \wedge \texttt{ball.nmod.on}(x_6, x_9)$ $\texttt{table.nmod.on}(x_9, x_{12})$

Organisation

- Website, possibilité LLF:
  - `http://pages.llf-paris.fr/~deeptypo/`
  - `http://pages.llf-paris.fr/~project_austrils/`
- gitlab/github
  - Stockage de données ? de modèles ?
  - Site web sur le github directement ?
- Mailing list: llf ? slack ?
- Accès Jean Zay/Adastra pour le projet ?

Name	task	language	nature	Reference
Cogs	sentence to logical form	English	artificial	kim-linzen-2020-cogs
Cogs+idioms	entence to logical form	English	artificial	WP **??**
Memory	memory bias analysis	Artificial	artificial	WP **??**
Geoquery	sentence to database query	English	natural	Zelle1996LearningTP
Cfq	sentence to sparql	English	artificial	CFQ
childes	lexical acquisition	English	natural	macwhinney2000childes
orfeo	lexical acquisition	French	natural	benzitoun2016projet
parseme	multi word Expressions	French and English	natural	savary2018parseme
Nat. Stories	reading times	English	semi natural	futrell-2018

Scientific animation

- Reading group: fréquence ?
- Workshop: date prévisionnelle / format / invités / appel à contributions ?
- Internship/thesis supervision/co-supervisions