Conscious Natural Text Generation

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Abstract

The "Conscious Natural Text Generation" project (CORTEX, grant ref. PID2021-123956OB-I00) investigates how Natural Language Generation (NLG) architectures can be improved so that they can exploit external and commonsense knowledge, and integrate it in a controllable manner (i.e., determining what knowledge to include and how to include it) when generating new text. Our main scientific objective is, therefore, to investigate and propose novel NLG architectures that integrate different types of knowledge to automatically produce reliable, truthful and quality texts, whose information complies with the principles of objectivity and plurality, thereby minimizing bias or manipulated content. The new generation of NLG systems obtained from CORTEX will significantly improve the semantic quality of the generated text, preventing, among other phenomena, the inclusion of invented facts that do not match reality (i.e., hallucination).

Keywords

Human Language Technologies, Natural Language Processing, Natural Language Generation, Commonsense, World Knowledge, Artificial Intelligence

1. Introduction

Natural Language Generation (NLG) oversees the production of text or speech in a coherent and appropriate way for the desired communication objective. NLG encompasses many types of applications — e.g. summarisation, report generation, chatbots— pursuing very different communicative goals and allowing for a wide variety of inputs and outputs.

Significant progress has been made recently in NLG due to the advent of deep neural models and end-to-end architectures and their capacity to produce fluent excerpts of meaningful text together with their capability to capture longer dependencies within the data or even context information, as the architectures based on Transformers (GPT-3 or T5). However, despite their achievements, these approaches face several challenges in that they require huge volumes of data, there is a lack of transparency, and constraining or controlling the algorithms involved is difficult. In fact, among the limitations of these new language models there is one that concerns the unintended consequences related to the generation of distorted text. This can happen when the language model is incapable of understanding or being aware of the text that is being generated. Thus, there are no guarantees that the information generated automatically is accurate and factually correct; it could be distorted in some way. This could lead to the phenomenon known as hallucination [1], a term used to describe the generation of fictitious information that has nothing to do with reality. The potentially dangerous consequences of this are erroneous interpretations, the spreading of false information, manipulation, bias that may result from the exclusion of important facts which are not aligned with a stance, etc.

The "Conscious Natural Text Generation" project, whose acronym is CORTEX, is funded by the Spanish Government with grant reference "PID2021-123956OB-I00" and developed by the GPLSI research group of the University of Alicante. CORTEX is dedicated to researching the improvement of NLG architectures by integrating and injecting external commonsense knowledge. It is expected that the new generation of NLG systems developed by CORTEX will have a degree of consciousness, or at least a degree of common sense, thus making a significant contribution to improving the semantic quality of the generated text, avoiding, among other phenomena, the inclusion of invented facts that are not in accordance with reality. In fact, it is said that "common sense reasoning is the new frontier of Artificial Intelligence (AI)".

2. Hypothesis, Research Question and Objectives

The initial hypothesis of CORTEX is that the effective integration of world and external knowledge in NLG architectures improves the commonsense reasoning capa-

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bilities of NLG systems, which is needed to automatically produce accurate, correct, and reliable texts that will be in line with real facts. Therefore, the research questions that must be asked to validate our hypothesis are the following:

1. What generic language models exist?
2. What information and characteristics must knowledge sources have to enable a NLG system to generate syntactically and semantically correct texts that are also adequate according to the required communicative situation?
3. How effectively would the proposed NLG approaches be able to integrate, use and adapt large generic language models and commonsense knowledge?

The answer to the previous research question embodies the main scientific objective of the project, which can be defined as: "To investigate and propose knowledge-enhanced NLG architectures which integrate different kinds of knowledge to automatically produce reliable, truthful, and quality texts whose information complies with principles of objectivity and plurality, avoiding bias or manipulated content". This main objective is divided into the following specific objectives:

- **OB1**. Gather and analyse the available generic existing language models and knowledge sources (structured and unstructured).
- **OB2**. Determine what kind of knowledge is most appropriate to improve the NLG process, as well as compile, and adapt models that will enable the semantic enrichment of NLG approaches.
- **OB3**. Research, propose and develop novel NLG approaches that can integrate, be guided by, or simply use the obtained knowledge, thus leading to more accurate, flexible, and dynamic common sense and conscious generation approaches.
- **OB4**. Propose and develop various scenarios and use cases that demonstrate the validity and application of the NLG task.
- **OB5**. Evaluate intrinsically and extrinsically each of the proposed techniques and approaches and scenarios with the most suitable standard metrics, or create novel metrics, if necessary.
- **OB6**. Promote and disseminate the results obtained from the project through different national and international media, as well as exploit the potential for transferring this technology to society.

3. Team and Work Plan

The research work addressed in the CORTEX project will have a duration of three years, starting from 1st September 2022.

A gender-balanced (4 women and 5 men) multidisciplinary research team of 7 doctors and 2 PhD students, has been formed. All of them belong to the GPLSI research group and they have Computer Science or Linguistics background.

The methodology has been organised into three main Work Packages (WP) whose tasks and results are interlinked, as shown in Figure 1. An additional transversal fourth WP concerning the management and dissemination of information and resources is also crucial for the effective implementation of the project. Next, each of the WPs and its tasks is explained in more detail.

WP1: *Commonsense, Semantic, World Knowledge and Infrastructures for Natural Language Generation*

The purpose of this work package is to explore multiple and heterogeneous knowledge sources and existing infrastructures. Semantic world knowledge is essential for resolving many deep and complex decisions in natural language understanding and generation. Moreover, to efficiently and effectively manage all existing and potential new knowledge, an appropriate infrastructure is also necessary. Given its importance, objectives OB1 and OB2 will be achieved through the successful completion of the following three tasks.

Task 1.1. Exploration of existing knowledge sources and language infrastructures: The objective of this task is to explore and analyse in-depth so as to compile existing and available knowledge, infrastructures and language models, thereby identifying the potential of these resources as well as their limitations for multilingual NLG. This task will produce a specific computationally appropriate knowledge compilation for NLG. Moreover, it explores to what extent the available large language models and infrastructures can be used as a basis for further research in tasks 1.2, 1.3, as well as the forthcoming work packages.

Task 1.2. Knowledge quality assurance and extraction: Ensuring high knowledge quality and precision is crucial to create NLG models that learn to avoid incorporating societal biases and inaccurate information into further steps [2]. Hence, the aim of this task is to define a methodology and metrics to analyse and detect possible biases in the knowledge sources analysed in Task 1.1 and to extract relevant patterns which may be also used on succeeding tasks.

Task 1.3. Knowledge discovery and representation: The goal of this task is to centralise and represent the obtained knowledge that contains heterogeneous and multilingual information. This will be initially done by exploring available corpora and knowledge graphs that are used for commonsense reasoning, such as CommonsenseQA [3], ConceptNet [4] or AGENDA [5].

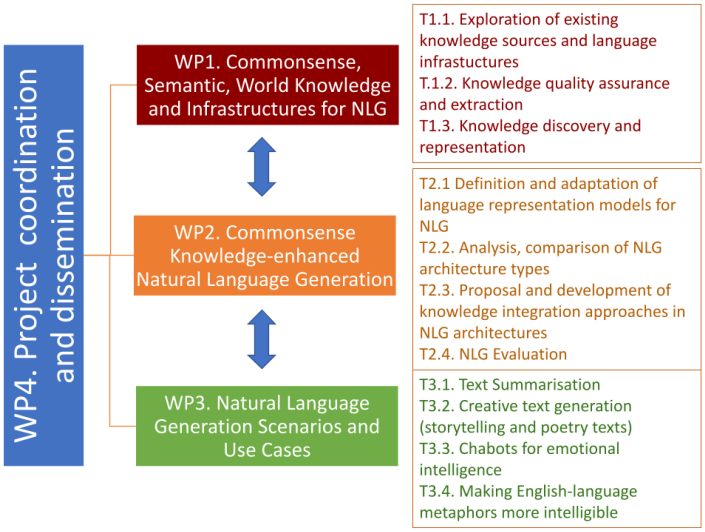

Figure 1: CORTEX work packages and tasks.

WP2: *Commonsense knowledge-enhanced Natural Language Generation*

The main goal of this WP is to analyse and propose novel and cost-effective NLG approaches that integrate commonsense knowledge acquired from WP1 within the generation process, so that a new generation of common sense and conscious NLG systems can be produced. Several tasks related to NLG architectures and how to integrate knowledge has been proposed in order to accomplish objectives OB3 and OB5.

Task 2.1. Definition and adaptation of language representation models for Natural Language Generation: Based on the existing language infrastructure analysis conducted in WP1, the objective here is to determine:

1. Which models are more appropriate and effective for representing human language for the NLG process [6] and its sub-tasks, generally macroplanning, microplanning and surface realisation [7].
2. How they can be adapted to obtain specific language models depending on the targeted NLG tasks to be addressed.

Additionally, some linguistic information such as the communicative intention of the message to be created will also be considered for the comparison of the different models that could be employed in the NLG tasks. This feature would enable the automatic change in form of the generated text depending on the intention to be accomplished. Consequently, this task will also analyse up to which point pragmatic features of language, such as communicative intentions, determine the linguistic elements that the generated text should include. This will enable a narrowing down of the generation process to produce content that is conscious of its pragmatic context, going beyond the lexical, syntactic and semantic features used so far in the state of the art.

Task 2.2. Analysis and comparison of Natural Language Generation architecture types: The goal of this task is to find a flexible but effective and efficient NLG architecture. The architecture of a NLG approach determines how the aforementioned sub-tasks (macroplanning, microplanning and surface realisation) are integrated in the generation process. This task will explore and experiment with different types of architectures. These include: i) sequential architectures, where the different sub-tasks are undertaken in separate modules; ii) integrated architectures, where the whole process is jointly performed at once; and iii) hybrid architectures that benefit from the advantages of both of them.

Task 2.3. Proposal and development of knowledge integration approaches in Natural Language Approaches architectures: The purpose of this task is to analyse how to incorporate commonsense knowledge into downstream NLG models. For this purpose, different options can be explored [8], including the following:

1. Directly encoding commonsense knowledge from structured knowledge bases as additional inputs to a neural network in generation;
2. Indirectly encoding commonsense knowledge into the parameters of neural networks through

pretraining on commonsense knowledge bases or explanations;
3. Using multi-task objectives with common sense relation prediction.

In this task, we first plan to explore the use of knowledge already available in semantic networks, but also including new knowledge obtained from WP1 through the existing corpora. In parallel, our aim is also to determine to what extent neural language models (e.g. Transformers) can be modified and fine-tuned to integrate common sense knowledge during the NLG process.

Task 2.4 Natural Language Generation Evaluation: The purpose of this task is to evaluate every intermediate or final result associated with the previous tasks. These results can be evaluated from different perspectives depending on the goal of the evaluation [9]. Within this context, we can use extrinsic methods (to determine whether the application achieves its objective) and intrinsic methods (to examine the system's performance and the quality of its output). Moreover, existing and new challenges that fit within our scope will also be used as a means of evaluating and comparing our NLG approaches with respect to other methods developed by the research community.

WP3: *Natural Language Generation Scenarios and Use Cases*

This last WP will contribute to fulfilling OB4 and OB5, and its purpose is to apply the proposed and developed knowledge-enhanced NLG approaches into diverse scenarios and use cases to validate and show their appropriateness in real contexts. Each scenario will integrate the findings and outcomes of WP1 and WP2, and they will be evaluated with the specific and standard metrics appropriate for the diverse settings. In particular, the three following scenarios are envisaged.

Task 3.1 Text Summarisation: Text summarisation aims to synthesise information keeping only what is relevant [10]. Although research into extractive approaches is the most predominant, they are limited to literally copying the information from the input and pasting it in the output summary. On the other hand, abstractive summarisation is more powerful, but at the same time more challenging. The goal of this task is to address abstractive summarisation, integrating a strong NLG component from the results of WP2. The integration of a knowledge-enhanced NLG component during the abstractive summarisation process would contribute to producing more human-like summaries, as it will be possible to detect and infer relevant information, even when this is described through complex events in several non-consecutive sentences.

Task 3.2 Creative text generation: One of the most complex NLG scenarios is the production of creative or artistic texts, including storytelling or poetry [11]. In both cases, a NLG system must deal with specific linguistic phenomena such as the type and structure of the narrative events, prosodic devices such as meter and rhythm, among others., or temporal or causal relations between events. During this sub-task, we will analyse and automatically extract literary events, their structures and the temporal or causal relations between them [12, 13]. We also will explore formal analysis of metre and rhythm in a corpus of poetry to introduce more realistic prosody in NLG.

Task 3.3 Chatbots for emotional intelligence: Emotional Intelligence education [14] is a pending issue for society that could potentially contribute to solving many current social problems. Chatbots can be beneficial for helping users to improve their emotional intelligence and to better manage and understand their emotions. Specifically, the chatbot will work on "tales with a message". These folk stories are appropriate in that they represent the millennia-long tradition of homo sapiens to skilfully transmit and understand knowledge. We will apply the research conducted to the text generation techniques of the previous WPs to help users develop social cognition (the ability to identify and understand social situations [15]), as well as to improve their reading comprehension level.

Task 3.4 Making English-language metaphors more intelligible: The study of metaphors in specific domains in the English language is motivated by the desire to promote inclusivity and falls within the area known as English for specific purposes. Indeed, there is a pressing need to process metaphors in a common language for all communities as they are often ambiguous and require up to date global knowledge to understand their meaning and purpose [16]. Thus, the goal of this task is to facilitate the human assimilation of metaphors and to provide an equivalent meaning in a simpler manner.

WP 4: *Project coordination and dissemination*

The goal of this transversal WP is to oversee the internal communication flow throughout the duration of the project to ensure that the objectives are met via the intermediate and final results of each task. This WP will also promote the correct dissemination of the project thereby achieving objective OB6. The main instrument for communicating relevant results will be publications in the most relevant conferences and journals related with the project.

4. Expected Impact

Concerning the scientific and technical impact, our project focuses on theoretical cutting-edge research with

many applied offshoots for NLG. This will lead to several applications designed for facts/data summarisation, storytelling and narrative generation, chatbots for specific purposes, and facilitating the comprehension of complex expressions in specific domains. Tools that achieve these applications are expected to have a great demand in the next decade.

As different types of architectures will be explored for NLG during the execution of the CORTEX project, we will be able to determine which ones maximise the results with minimum computational cost, thereby providing a set of cost-effective NLG methods.

Given the feasibility of incorporating these models and approaches into prototypes or demos, there will be high social and commercial applicability of the research through the proposed scenarios, enabling the promotion of the project's many potential applications to regional, national and international companies and other stakeholders. Knowledge discovery and integration from multimodal, multilingual and heterogeneous information sources, in turn, opens up many unexplored theoretical and applied research avenues for the NLG international community, which are expected to attract interest from the Natural Language Processing and Artificial Intelligence research communities.

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References

[1] Z. Ji, N. Lee, R. Frieske, T. Yu, D. Su, Y. Xu, E. Ishii, Y. J. Bang, A. Madotto, P. Fung, Survey of hallucination in natural language generation, ACM Comput. Surv. 55 (2023). URL: https://doi.org/10.1145/3571730. doi:10.1145/3571730.

[2] E. Sheng, K.-W. Chang, P. Natarajan, N. Peng, Societal biases in language generation: Progress and challenges, arXiv preprint arXiv:2105.04054 (2021).

[3] A. Talmor, J. Herzig, N. Lourie, J. Berant, CommonsenseQA: A question answering challenge targeting commonsense knowledge, in: Proceedings of the 2019 Conference of the North American Chapter of the Association for Computational Linguistics: Human Language Technologies, Volume 1 (Long and Short Papers), Association for Computational Linguistics, Minneapolis, Minnesota, 2019, pp. 4149–4158. URL: https://aclanthology.org/N19-1421. doi:10.18653/v1/N19-1421.

[4] R. Speer, J. Chin, C. Havasi, Conceptnet 5.5: An open multilingual graph of general knowledge, in: Proceedings of the Thirty-First AAAI Conference on Artificial Intelligence, AAAI'17, AAAI Press, 2017, p. 4444–4451.

[5] R. Koncel-Kedziorski, D. Bekal, Y. Luan, M. Lapata, H. Hajishirzi, Text Generation from Knowledge Graphs with Graph Transformers, in: Proceedings of the 2019 Conference of the North American Chapter of the Association for Computational Linguistics: Human Language Technologies, Volume 1 (Long and Short Papers), Association for Computational Linguistics, Minneapolis, Minnesota, 2019, pp. 2284–2293. URL: https://aclanthology.org/N19-1238. doi:10.18653/v1/N19-1238.

[6] C. Dong, Y. Li, H. Gong, M. Chen, J. Li, Y. Shen, M. Yang, A survey of natural language generation, ACM Comput. Surv. 55 (2022). URL: https://doi.org/10.1145/3554727. doi:10.1145/3554727.

[7] A. Gatt, E. Krahmer, Survey of the state of the art in natural language generation: Core tasks, applications and evaluation, J. Artif. Int. Res. 61 (2018) 65–170.

[8] W. Yu, C. Zhu, Z. Li, Z. Hu, Q. Wang, H. Ji, M. Jiang, A survey of knowledge-enhanced text generation, ACM Comput. Surv. 54 (2022). URL: https://doi.org/10.1145/3512467. doi:10.1145/3512467.

[9] A. Celikyilmaz, E. Clark, J. Gao, Evaluation of text generation: A survey, arXiv preprint arXiv:2006.14799 (2020).

[10] A. A. Syed, F. L. Gaol, T. Matsuo, A survey of the state-of-the-art models in neural abstractive text summarization, IEEE Access 9 (2021) 13248–13265.

[11] A. I. Alhussain, A. M. Azmi, Automatic story generation: A survey of approaches, ACM Comput. Surv. 54 (2021). URL: https://doi.org/10.1145/3453156. doi:10.1145/3453156.

[12] M. Sims, J. H. Park, D. Bamman, Literary event detection, in: Proceedings of the 57th Annual Meeting of the Association for Computational Linguistics, 2019, pp. 3623–3634.

[13] A. Feder, N. Oved, U. Shalit, R. Reichart, Causalm: Causal model explanation through counterfactual language models, Computational Linguistics 47 (2021) 333–386.

[14] D. Goleman, Emotional Intelligence, Bantam Books, New York, 1995.

[15] J. Uekermann, M. Kraemer, M. Abdel-Hamid, B. G. Schimmelmann, J. Hebebrand, I. Daum, J. Wiltfang, B. Kis, Social cognition in attention-deficit hyperactivity disorder (adhd), Neuroscience & biobehavioral reviews 34 (2010) 734–743.

[16] S. Rai, S. Chakraverty, A survey on computational metaphor processing, ACM Computing Surveys (CSUR) 53 (2020) 1–37.