Languages Network Models: from Wittgenstein to Deep-Learning Systems

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Extended abstract of a position paper

During the last years, we witnessed remarkable progress in the development of Natural Language Processing (NLP) systems. These are neural networks implemented with self-supervised deep learning methodologies which learn concept representation from rough data and are very effective in targeting tasks such as question answering, textual entailment, and translation (Devlin et al., 2019; Kitaev et al., 2019, Wang et al., 2020). As in other relevant research topics, the deep learning system's output comes out from what is usually labeled the "black box". Moreover, it is well known how Wittgenstein's works contributed to the progress of NLP. Famous and crucial concepts such as Satzsysteme and language game, Sprachspiele, or meaning-as-use are still implied at the basis of NLP systems. The same concepts are implemented in models of language acquisition, following the Wittgenstein rejection of symbols and rules approach and accepting a connectionist or neural-network approach (Lowney et al., 2020). But there is, indeed, a subsidiary concept that I want to analyse here, which is the private-language argument, expressed via the beetle-in-the-box argument (§293 Philosophical Investigation), with specific importance for NPL deep learning and language acquisition and mastery (LAM) models. Skelac and Jandrić (2020) analysed the concept of meaning as-use from Wittgenstein to Google's Word2vec, a word vector representation developed by Google in a machine translation model. They emphasize the relevance of context concerning word meaning in Wittgenstein and Word2vec and focus on the scope differences of context in each case. The Beetle in the box argument shows the rejection of a private language construed only through an internal process the individual of the thought experiment calls the "beetle", but which does not refer to humans as an actual "beetle" would. First, I claim that Wittgenstein's beetle-in-the-box argument is relevant for NPL systems and LAM models. Second, it follows the analysis of the language game concept in NLP and LAM, how it is embedded, and what role it plays in inductive systems development. It seems that there is a correlation between Wittgenstein's invitation to look, which is an invitation to dismiss the aim of theorizing about languages, and the absence of theory-ladenness

in deep learning technologies involved in NLP. Third, I argue that even if we can distinguish a strong and a weak definition of a private language, Wittgenstein's argument holds also for deep-learning models and his worries are still a good guide for NLP developers and LAM modelers. In recent times both Natural Language Processing (NPL) systems and Language Acquisition and Mastery (LAM) models have been implemented on the base of deep learning neural networks which learn concepts representation from rough data being nonetheless very effective in tasks such as question answering, textual entailment, and translation (Devlin et al., 2019; Kitaev et al., 2019, Wang et al., 2020). Since deep learning neural networks have been refined to accomplish even more complex tasks and their application widened, the philosophical relevance of cognitive science, AI, and also the General AI program has proportionally increased. NPL systems and LAM models are relevant ways of discovering new insights about language through models recently developed by cognitive science and data science. Between the 60s and the mid-90s, two main approaches concerning LAM were settled, namely the connectionist and the symbols and rule approach. The first conceives cognition as an ability that could be explained through the aid of a neural network, while the symbolic or rule-based approach conceives the mind as an information processing system similar to a computer, hence the language is understood as a set of symbols governed by rules like the computer programming languages. It was when the symbols and rule approach dominated that Stephen Mills (1993) stated some important similarities between Wittgenstein's later philosophy and connectionism. Following this complementarity, Lowney et al. (2020) specify the affinity between Paul Smolensky's (1991) distributed representation connectionist approach and Wittgenstein's main philosophical notions, such as symbol constitution, language-games, family resemblance, rule following, logic, and language learning. According to them, there is a possible path connecting Wittgenstein and connectionism. In the first part of the paper, I will recap the similarities between Wittgenstein's ideas and the main tenets of connectionism, then it follows the analysis of the role of the Beetle in the box argument to connectionist ends as used by Lowney et al. (2020). This argument showed an unpredicted relevance not only for the philosophy of language but also for NPL and LAM modelers. It will follow in the analysis of the language game concept in NLP and LA, how it is embedded, and what role it plays in inductive systems development. This main concept in Wittgenstein's work is relevant to describing the role of context in the understanding of the words meaning and I argue that the connectionist theoretical framework can better catch the context dependency. It seems that there is a correlation between Wittgenstein's invitation to look, which is an invitation to dismiss the aim of theorizing about languages, and the absence of theory-ladenness in deep learning technologies involved in NLP. Third, I argue that even if we can distinguish a strong and a weak definition of a private language, Wittgenstein's argument holds also for deep-learning models and his worries are

still a good guide for NLP developers and LAM modelers. In the last decades, there has been an upswing in the debate between the classical approach and connectionism and there has been an important effort by many scholars to disentangle the Wittgensteinian root of connectionism and more recently deep-learning models. According to Stern (1991), Mills (1993), Goldstein and Slater (1998), and Elman (2014) connectionism provides an understanding of mind and language use that traces back to the so-called later Wittgenstein. Connectionism states that cognition is an emergent property relying on associations and activation of patterns following parallel processing. Dating back to Skinner's work, Chomsky, Fodor, and Pinker proposed an alternative to connectionism with the renewed classical symbolic approach. Now we could recast connectionism as a cognitive science movement working on deep-learning models. Recently it has been noticed the importance of Wittgenstein's work for both Natural Language Processing systems and connectionist theoretical frameworks, in particular deep-learning neural networks. There are NPL and LAM models that in both cases rely on deep-learning neural networks. The analysis of the Wittgensteinian concepts embedded in both NPL and LAM using deep-learning models provides a philosophical inquiry helpful to tidying up the assumptions leading to connectionism nowadays. Given that understanding and mastery of a language is a practice and that the meaning of the words is the use we make of them, as Wittgenstein stated in the Philosophical Investigations, it follows that the contexts of specific situations in which we learn, use, and understand the language, is a key item in the analysis of NPL and LAM. According to Wittgenstein, the contexts in question have public features and are crucial for his description of language games. Hence it is not possible to develop linguistic abilities in a private context, such as described in the case of the beetle in the box. The conceptual role of contexts is crucial for both NPL and LAM. On the first side, looking at the shallow neural network of Word2vec, which is a word vector representation (WVR) applied in a translation model built by Google, the concept of context is of recognized importance given the output the network has required to give. Moreover, in the case of LAM, Lowney et al. (2020) showed how Vector Symbolic Architectures (VSA) can resolve some limitations encountered by the previous connectionist approach, also concerning the private language. Even if we distinguish a strong and a weak sense of the argument of the private language, the concept of meaning as occurring within a public context is assumed by NPL and LAM models. In conclusion, WVR and VSA neural networks are built with different purposes, the former for translation, the latter to explain language acquisition and mastery, but both are grounded on the assumption that the meaning of linguistic signs could change accordingly with the contexts in which they are used.

References:

Devlin et al., BERT: Pre-training of deep bidirectional transformers for language understanding. In Proceedings of the Conference of the North American Chapter of the Association for Computational Linguistics: Human Language Technologies (NAACL-HLT). Association for Computational Linguistics, 2019, arXiv:1810.04805.

Elman, J. (2014). Systematicity in the lexicon: Having your cake and eating it too. Calvo & Symons, 2014, 115–146.

Fodor, J., & Pylyshyn, Z. (1988). Connectionism and cognitive architecture: A critical analysis. In C. MacDonald & G. MacDonald (Eds.), (1995). Connectionism: Debates on psychological explanation (Vol. 2). Oxford: Blackwell (pp. 90–163). New York: Springer

Gayler, R. (2003). Vector symbolic architectures answer Jackendoff's challenges for cognitive neuroscience. In P. Slezak (Ed.), ICCS/ASCS international conference on cognitive science (pp. 133–138). Sydney, Australia, University of New South Wales: CogPrints.

Goldstein, L., & Slater, H. (1998). Wittgenstein, semantics and connectionism. Philosophical Investigations, 21(4), 293–314.

Hacker, P. M. S. (2001). Wittgenstein: Connections and controversies. Oxford: Clarendon Press. Kitaev et al., Multilingual constituency parsing with self-attention and pre-training. In Proceedings of the 57th Annual Meeting of the Association for Computational Linguistics, pages 3499–3505, Florence, Italy, July 2019. Association for Computational Linguistics. doi: 10.18653/v1/P19-1340. URL https://www.aclweb.org/anthology/P19-1340.

Lowney, C.W., Levy, S.D., Meroney, W. et al. Connecting Twenty-First Century Connectionism and Wittgenstein. Philosophia 48, 643–671, 2020.

Mills, S. (1993). Wittgenstein and connectionism: A significant complementarity? Royal Institute of Philosophy Supplement, 34, 137–157.

Pietsch W., On the Epistemology of Data Science, Springer, 2022.

Skelac I., and Jandrić A., Meaning as Use: From Wittgenstein to Google's Word2vec, in Guide to Deep Learning Basics. Logical, Historical and Philosophical Perspective, S. Skansi ed., Springer, 2020.

Smolensky, P. (1991). Connectionism, constituency and the language of thought. In C. MacDonald & G. MacDonald (Eds.), (1995). Connectionism: Debates on psychological explanation (Vol. 2). Oxford: Blackwell (pp. 164–198). New York: Springer.

Stern, D. (1991). Models of memory. Philosophical Psychology, 4(2), 203–217.

Wang et al. SuperGLUE: A Stickier Benchmark for General-Purpose Language Understanding Systems, 2020, arXiv:1905.00537v3.

Wittgenstein L., Tractatus Logico-Philosophicus, 1961, D. F. Pears and B. F. McGuinness (trans.), New York: Humanities Press.

Wittgenstein L., Philosophical Investigations (PI), 4th edition, 2009, P.M.S. Hacker and Joachim Schulte (eds. and trans.), Oxford: Wiley-Blackwell