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Literature Review

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1. WHY DO WE NEED MACHINES THAT USE LANGUAGE

Development of agents that are capable of communication and flexible language use is one of the long-standing and most ambitious challenges that the field of artificial intelligence faces. In a context where humans and machines are leading to work as a collective, agents will need some language capacity if they are to interact and productively collaborate or make decisions that are interpretable by humans.

Recent years have seen substantial progresses in practical natural language applications such as machine translation (1), sentiment analysis (2), document summarization (3), and domain-specific dialogue (4). Much of this success is a result of intelligently designed statistical models based on static, passive, and mainly supervised regimes that are ultimately trained on large static datasets. While this is a great way to learn general statistical associations, it is very far from interactive communication, which proceeds by an active and incremental updating of the speakers' knowledge states. Those approaches that learn to plausibly imitate language from examples of human language do not learn why language exists. They do not capture its functional aspects, or that language happens for purposes of successful coordination between humans.

Developing a sophisticated language system is crucial for machines to become truly intelligent and gain the ability to learn like humans. If such a capacity were to arise artificially, it could also offer important insights into questions surrounding development of human language and cognition.

2. WHAT FORM OF LANGUAGE WOULD BETTER FIT HUMAN/MACHINE INTERACTION

2.1 Logic and Interpretations

There is a divergence between formal communication devices, as used by machines or in programming, and their counterparts in natural human “day-to-day” language (5).
For some, this divergence is the result of unwanted elements in the meaning of the natural ones, which they do not share with the formal devices (5). Those elements are at the cause of multiple possible meanings to a statement and therefore, philosophically and logically speaking, would render them useless because not fully intelligible.
For others though, those elements of meaning obey to an unsimplified and unsystematic logic that cannot be supplanted by the reduce meaning of the formal analogs (5). The proof reside in that we use natural language everyday without the need of an analysis or formal devices to be understood.

Since the restructuration of natural language seems impossible and that the goal is to facilitate the understanding of language between humans and machine, it is needed to take special precautions in the handling of those communication devices. We hope that our method naturally teaches the machine the unsimplified and unsystematic rules that we, as humans, take for granted.

2.2 Optimizing the Exchange of Information

A conversation isn’t a succession of disconnected remarks, even if the latitude of possible answers is considerably large at each stage, at least some possible conversational moves would be excluded (5). Hence appears a Cooperative Principle between the participants.
We can define 4 categories, in which appear certain maxims, to clarify this principle.

1. Quantity of information	2. Quality	3. Relation	4. Manner
As informative as required for the current purpose Not more informative than required	Try to make your contribution one that is true Do not say what you believe is false Do not say that for which you lack adequate evidence	Be relevant (this one is hard to theorize)	Avoid obscurity of expression Avoid ambiguity Be brief Be orderly

Those maxims are made to maximally exchange informations between participants, as it is a good (although simplified and incomplete) theorization of a conversation. It is needed to integrate such principle in the learning process of a machine to ensure the best possible transmission of information when it communicates.

3. HOW TO TEACH A MACHINE ACCORDINGLY

3.1 The Paradigm

It is primordial to apply a set of rules to ensure a utilitarian definition of language understanding. That is : we say an agent “understands” language only when it is able to use language productively to accomplish these goals. Under this definition, an agent’s communication success is reduced to its success on tasks within its environment (6). Their goals are grounded non-linguistic objectives: for example, to reach a desired location, manipulate objects in the environment, or transmit a piece of information. Our agents crucially need to be grounded in a world which is not only linguistic.

Importantly, the agents start in a tabula rasa state (7). They do not possess any form of language or understanding. They have no prior notion of the semantics of words. Meanings are assigned to words by playing the game and are reinforced by communication success. Thus, agents can agree to any sort of conceptualization and assign to any word any kind of interpretation that help them effectively solve the tasks. This essentially aligns with the view of Wittgenstein that language meaning is derived from usage.

3.2 Multiagent Communication

If we wish to arrive at formation of communication from first principles, it must form out of necessity. New researches are proposing a radically different program, namely multi-agent communication-based language learning within a multimodal environment that bring about emergence of a basic compositional language (7,8). The essence of this proposal is to let computational agents co-exist, so that their co-existence constitutes the interactive environment. In this multi-agent environment, agents need to collaborate to perform a task, and it is hypothesize that (with the right priors and constraints) developing language production and understanding will be prerequisites to successful communication.

Several points make this proposal attractive. First of all, this framework requires minimum human intervention for designing agents, the environment and its physics. Computational agents will co-exist and self-organize freely, interacting with each other and being encouraged to learn in order to achieve communication. The sort of learning taking place in such setup is based on active request for information, and it fosters incremental agreement by interaction.

3.3 Zero-shot learning ability

Language semantics, when grounded in perception experience, can encode knowledge about perceiving the world. This knowledge is transferred from task to task, which empowers the machine with generalization ability. Humans are good at transferring past knowledge to new tasks by using language, whereas a machine must try millions of times before figuring out the right moves if not pre-programmed with rules.

Research in creating a framework that demonstrates the zero-shot learning ability of an agent in a specific task, namely, learning to navigate in a 2D maze-like environment has been conducted in order to answer this problematic (9). This means that even for a completely new command that was not previously seen, it is still able to correctly execute the task if enough sentences of a similar form were seen before. In other words, the agent is able to understand a new sentence assembled with known words in a known way (grammar). This allows a faster learning by the machine but also provide a more generative comprehension of language.

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