

Exploring a new human-AI co-reasoning system

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Humans have innate capacity to reason about what will happen subsequently based on the knowledge they own and the immediate context they are in, in some words, reasoning is one of the most fundamental and unique abilities that differentiate humans from other animals. Computers, which have been proved to be capable of processing visual and narrative information intelligently, still have trouble on acing the reasoning tasks. Therefore, granting computers substantial reasoning capacity is on top of computer scientists' wishlist.

Current reasoning systems either adopt symbolic representation or data-driven approach. For the former case, knowledge is embodied in the form of symbolic rules, e.g. first logic order language (FOL), with an inclusive library of rules (so called knowledge graph), the reasoning is able to be achieved by starting at a knowledge node and then walking through the graph. However, building such a comprehensive graph is extremely expensive. Furthermore, there is no remedy mechanism when a machine makes an incomplete or incorrect inference. In data-driven method, researchers tend to employ machine learning algorithms to extract knowledge from large scale dataset, meanwhile, a model will be trained upon the dataset to map question into answer, so that the reasoning can be made with this model. The drawbacks of this method is the difficulty of preparing a qualified dataset and corresponding computational resource and

complexity to train the model. Besides, unlike symbolic method, data-driven approach is not self-explanatory, especially the deep neural network, which is known for its black-box property. Finally, currently the AI reasoning system lacks common sense. Deep learning offers more task-specific knowledge, but rarely touches common sense or generalized knowledge. Common sense reasoning with general knowledge is important. Nowadays, most related work focuses either on commonsense reasoning with provided general knowledge or on extracting general knowledge. However, there's a gap between extracting general knowledge and applying learned knowledge directly into commonsense reasoning. Humans can offer general knowledge. Significantly, humans are able to offer general knowledge far better than AI, we, the human, excel at intuitive choice. This introduces the potential for co-reasoning.

Therefore, aiming to overcome the deficiency of current methods, this proposal is going to investigate a Human-AI collaboration framework, where the machine reasoning can be consolidated by human's refinement. Our research questions include: 1) How do humans act and react in co-reasoning scenarios? 2) Does co-reasoning can help AI to produce better "commonsense knowledge?" 3) Does co-reasoning help humans to better understand AI/AI agents and their inner workings.

In order to answer these three research questions, we will conduct two-phase study: In Phase 1 of our study, subjects will assist the AI reasoning system in understanding either one or two short written narratives ("story"/"stories") through modifying graphs

that represent a story's logic. Subsequently, the user and AI reasoning system will collaborate on "generalizing" the commonsense knowledge learned from a story, so that the knowledge gained can be applied to different stories in the future. In this phase, we wish to investigate how humans act and react in co-reasoning scenarios, as well as whether or not the presence of two contrasting stories assists the co-reasoning system in its task of understanding stories and generating commonsense knowledge.

Phase 2 of our study requires a new set of "Turkers" on Amazon Mechanical Turk. These subjects will evaluate the commonsense knowledge created by the human-AI systems in Phase 1, rating them qualitatively and quantitatively. Additionally, evaluators will compare and evaluate the story understanding produced by System A's acquired knowledge versus System B's acquired knowledge when concerning an entirely new story neither system has previously encountered. Our research question in this phase is whether co-reasoning can help AI to produce better "general" and "commonsense knowledge."

This research will be beneficial to both academia and ordinary people. For academia, we in fact offer a new path to implement the machine reasoning. With our framework, the machine can get real-time feedback from real people, such a human-in-a-loop method will enhance machine reasoning capacity without the limitation of the scale of knowledge graph or dataset. And the potential reasoning error can be fixed by human intelligence. For ordinary people, they can have control over the machine reasoning, so

that their trust in the reasoning system will be enhanced. For example, a virtual tutor may lack several common sense knowledge for solving algebra problems, like the inequation formula. With our framework, the student or parents can provide the tutor with essential relevant knowledge, then the tutor will be able to solve the inequation by referring to the complementary knowledge.

To conduct this study, we need a set of high-quality stories to start with. Besides, we will need to recruit a group of workers on Amazon mechanical turk to play with our reasoning system. Besides, we also need to construct an automatic reasoning system with which the participants can work with. After the first phase, another set of workers are required to perform the evaluation task. The computational resource may also be needed to train a contrasting data-driven model. And we also need a video camera to record the interview with real experts for transcribing the talk.