

Space to Think as a Common Ground for Human-AI Sensemaking

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Abstract:

We investigate the parallels between human cognition and AI for sensemaking tasks. We focus on the commonality of the concept of Space to Think, the use of external intermediate representations, as important to both human and AI LLM sensemaking processes. Empirical results demonstrate the value of Space to Think for both, and how human-generated Spaces can improve LLM performance. We show how Space to Think can be used as a form of common ground in visual analytics systems to enable interactive human-AI sensemaking that accelerates the overall sensemaking process.

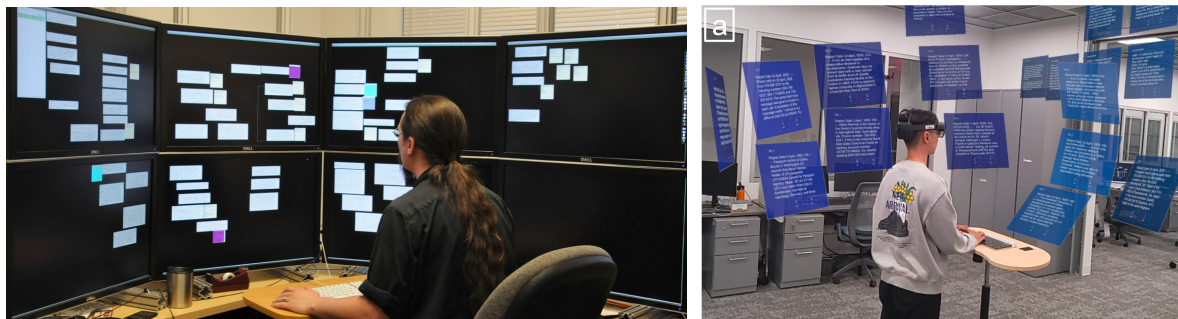
Extended Abstract

Sensemaking

Sensemaking is a challenging task for both humans and AI. The sensemaking loop by Pirolli & Card [8] models the sensemaking process as highly-iterative series of steps, organized into two primary sub-loops: the foraging loop and the synthesis loop. In its simplest form, it begins with a collection of input documents and concludes with an output document that summarizes important latent structure discovered within the inputs. Given that this task of sensemaking is extremely difficult for both humans and AI, we investigate how human and AI can work together to interactively conduct sensemaking.

Cognitive Space to Think

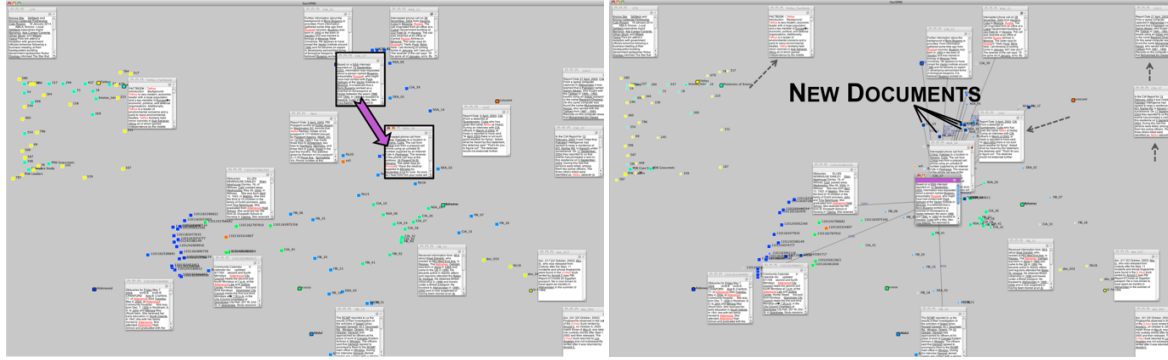
Through numerous human-subjects studies and observations, we investigated how humans conduct sensemaking tasks. A key outcome of our research is the concept of **Space to Think** [6], Human analyst often used a Space to Think to externalize their sensemaking cognition by interactively structuring information in a visual space (e.g. grouping, organizing, annotating, etc.). Analysts exploited Space to Think as an intermediate representation, between input documents and output summary.



Space to Think is based on psychological theories of distributed cognition and embodied cognition. Space to Think provides two important functions: (1) an external memory in which the analyst can offload cognition, and (2) a semantic layer that can easily and flexibly capture meaning from the analyst. For example, Spaces to Think can be 1D or 2D (Analyst Workspace [6], DeepSI [2]), 3D (Immersive Space to Think [3]), graph-structured (Narrative Maps [4]), or other types of structure.

Computing on Space to Think

We then found that the Space to Think representation could serve as an observable window into human cognition. Thus, it can be used as an input and output for AI to support the human sensemaking process. To accelerate triage, we developed Semantic Interaction methods (ForceSpire [1], StarSpire [5]) that augment the space with AI. AI algorithms learn to forage and structure additional relevant information by modeling the analyst's reasoning process through their Space to Think and sensemaking interactions therein (e.g. searching, highlighting, organizing, annotating, etc.). Our experiments showed that these methods accelerated the sensemaking process by helping analysts to more rapidly or more thoroughly construct their Space to Think.

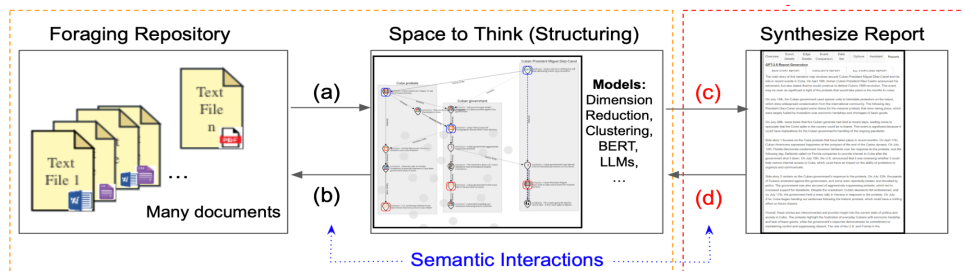


LLM Token Context as a Space to Think

Interestingly, recent lessons from AI large language models LLMs mirror the cognitive phenomenon of Space to Think. LLMs tend to be able to perform sensemaking tasks much better when given intermediate context “space”, in the form of additional tokens (words), on which to compute [7]. For example, chain of thought prompting encourages the LLM to take intermediate steps before producing a final answer. ChatGPT4 now uses python code as an intermediate representation when solving various analytics problems. Retrieval augmented generation (RAG) grounds LLM reasoning with specific retrieved information to avoid hallucinations.

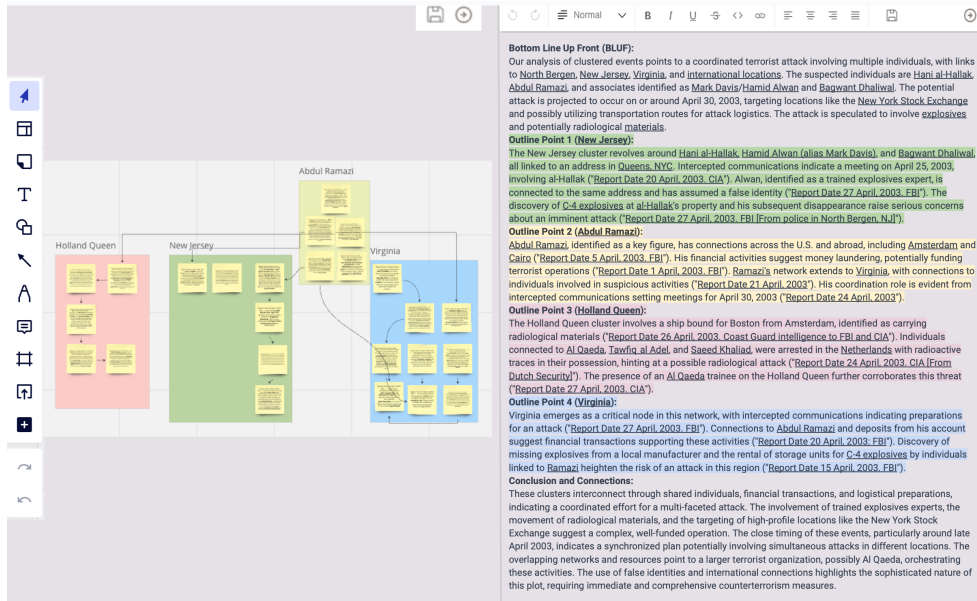
Our experiments on applying LLMs to sensemaking tasks demonstrated how human-generated Spaces to Think can help LLMs complete the sensemaking task. We conducted an experiment in which we tasked an LLM to compute the sensemaking output summary for a given set of input documents, and then we scored the quality of the output summary. LLMs that were also given the contents of a human-generated Space to Think for the given input documents scored much better than LLMs that were given only the input documents alone. We also found that providing additional types of human-generated markup in the Space to Think, such as highlights, labeled groupings, annotations, further improved the LLM summary score.

LLM	Avg Correctness(30)	Avg Quality(60)	Avg Total (90)
Directly from docs	11.0	34.2	45.2
Via Space-to-Think	19.5	49.0	68.5



Common Ground

These results, taken together, lead us to conclude that Space to Think not only represents a commonality between human cognition and AI LLM processing, but could provide a form of common ground between human and AI for interactive sensemaking. That is, a shared Space to Think could enable joint human-AI sensemaking, by providing a common space that each can read & write, and thus communicate and steer each other's process. This points to the potential for a bi-directional human-AI sensemaking loop and future visual analytics sensemaking tools powered by interactive LLMs.



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