Dan King
Thomas Young
Yinyuan (Sean) Zheng

10

Title: Escape the room! – An escape room system using spatial and commonsense reasoning

Abstract

CogSketch, a sketch understanding system, encodes object representations and spatial relations for two-dimension images based on OpenCyc and supports further knowledge-based reasoning. The current proposal uses CogSketch as a platform to develop an Escape Room game-playing system open to user customization. Built-in levels will be provided as games but users are welcomed in designing their own stages, which are processed under the spatial representation system of CogSketch.

Introduction

Suppose you wake up and find yourself locked in a strange room. You hear wailing and ghastly screams coming through the walls, and you quickly decide that you wish to escape from the room as soon as possible. You rush to the door, but it's locked. Fortunately, under the dim green light you spot a key in a glass jar hanging below the ceiling fan beyond your reach. What would you do?

A reasoning system faced with this predicament needs to be able to execute a series of goal-oriented actions, but this requires an accurate and flexible representation of the scene and objects at hand. The system needs to be able to reason about spatial relationships and use commonsense knowledge in order to achieve the goal of escape - e.g., *the key is in the bottle, so I have to get it out of the bottle before I can use it*.

Dan King
Thomas Young
Yinyuan (Sean) Zheng

For our project we would like to develop a KRR system that can play an "Escape the Room" game and find its way out of a locked room by using reasoning to obtain a key that is in the room. The project will incorporate both built-in levels with the possibility of user-designed levels as well. For the built-in levels, the system is provided a simple scene and needs to reason with the available objects and their spatial relationships (e.g., a key inside container needs to be taken out first) to unlock the door and escape the room. For customization, possible stretch objectives would be to achieve other goals besides opening the door such as simple fetching or solving spatial puzzles, all involving object representations and spatial reasoning.

Knowledge Sources

CogSketch & NextKB - We will use CogSketch to generate the representations for the objects and relations in our scene. This provides an automatic way of representing both entities and relations using preexisting knowledge available in NextKB and helps avoid tailorability that can come with excessive hand-coding. CogSketch has been used for both research and education purposes and found consistent and predictive with human's representations of spatial structures [4, 5]. It is also argued to enhance student's spatial learning and classroom efficiency [6]. Since we anticipate that our reasoner will operate over mostly common household objects and simple spatial relationships, we believe that NextKB will be sufficient to provide most of the entity and relational knowledge that we will need.

One area where it might be lacking is commonsense knowledge and causal knowledge. Our reasoner will need to be capable of understanding things like, *if you remove an object, any object on top of it will fall*. In addition, typical affordances, or telic roles, associated with artifacts need to be known - e.g., hammers are used for hitting, hammers can break glass, etc. There are

commonsense microtheories available within NextKB but it's not clear how extensive they are. Therefore we may need to look for commonsense ontologies, web scraping etc.

Reasoning

Broadly, the two main types of reasoning involved will be spatial and commonsense. For example, it will need to understand that if a key is inside something else, it must be removed from that object for it to be used. If the container has an opening, it should try to open the container. If it doesn't, it must break the container. Hammers are good for breaking containers, and apples aren't - etc. commonsense reasoning is hard. How will you make this tractable?

The system will also need to be able to engage in planning / goal-directed behavior. It may be that multiple steps are needed to obtain the key. It must be able to understand that multiple steps are necessary and the proper order in which they must executed in (e.g., open the container before reaching for the key).

Possible further reasoning requirements, such as pattern matches or analogical retrieval, could make use of tools such as SME [2,3].

Tools

it's ok if it doesn't. That was just a suggestion in case you wanted to stay closer to research

As mentioned above, we will use CogSketch as the primary means for generating spatial representations, and some reasoning may involve SME. In order to develop an intelligent system that will solve spatial and commonsense reasoning problems, we will need to create an agent that can perform actions. We will build this agent using Python. Python is a well-documented, easy to read language, and there are several libraries that interact with different components of the CogSketch architecture. We will utilize the Pythonian module to interact with Companions, and the PyNextKB module to query NextKB directly. Additionally, we will use CogSketch

consider staying inside Companions to start

integration to extract facts using rbrowse and queries. Finally, Python will form the backend of the Escape the Room game's command line interface.

Steps & Responsibilities

First, we will decide on appropriate constraints for our domain. What objects we will include (i.e., what objects the system will have to have adequate knowledge about) and how complex to make the puzzles will have to be decided on. The goal of this project is to design it so that we can start with very basic puzzles and then, given that the system can handle those, design more difficult challenges for it.

After deciding on our domain, we will investigate CogSketch and NextKB to see what knowledge areas are adequately represented, and what may need to be added by us.

Then we will begin designing our system!

At this point, we are not sure of the exact breakdown of responsibilities.

Possible Obstacles

The hardest thing about this project will likely be the commonsense reasoning aspect of it. Commonsense knowledge and reasoning is obviously a huge problem for AI systems in general, and this project will be no exception. We hope that by intelligently constraining our domain, we can limit this potential trouble.

References

Dan King
Thomas Young
Yinyuan (Sean) Zheng

[1] Forbus, K., Usher, J., Lovett, A., Lockwood, K., & Wetzel, J. (2008). CogSketch: Open-Domain Sketch Under- standing for Cognitive Science Research and for Education. In: Proceedings of the Fifth Eurographics Work- shop on SBIM.

[2] Falkenhainer, B., Forbus, K. D., & Gentner, D. (1989). The structure-mapping engine: Algorithm and examples. Artificial Intelligence, 41, 1–63.

[3] Gentner, D., & Forbus, K. D. (2011). Computational models of analogy. *Wiley Interdisciplinary Reviews: Cognitive Science*, 2(3), 266-276.

[4] Sagi, E., Gentner, D., & Lovett, A. (2012). What difference reveals about similarity. *Cognitive science*, *36*(6), 1019-1050.

[5] Jee, B. D., Gentner, D., Uttal, D. H., Sageman, B., Forbus, K., Manduca, C. A., ... & Tikoff, B. (2014). Drawing on experience: How domain knowledge is reflected in sketches of scientific structures and processes. *Research in Science Education*, *44*(6), 859-883.

[6] Marko, W. T. (2019). Qualitative Assessment of CogSketch Worksheets in Introductory Geoscience Laboratory Courses: An Argument for Expanded Use. In *Inspiring Students with Digital Ink* (pp. 67-77). Springer, Cham.