Knowledge Based A.I. to the ARC Price Challenge

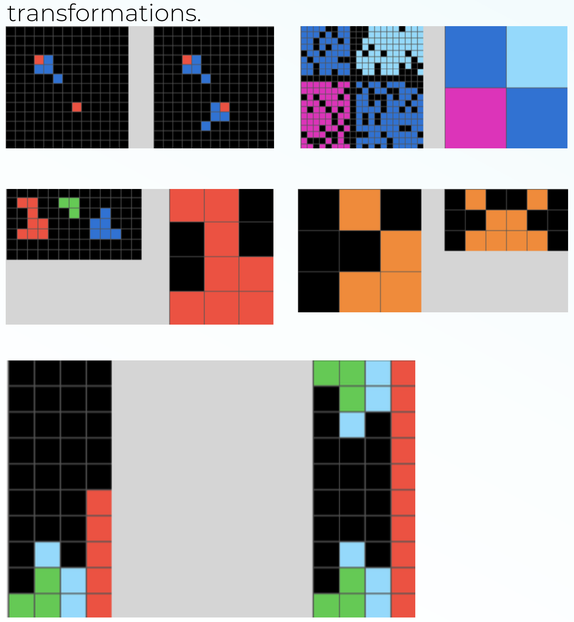
Junseo Ha
Georgia Institute of Technology

Abstract

This project explores the application of Knowledge-Based AI methods to the ARC Prize Challenge, demonstrating how symbolic reasoning, rule-based systems, and domain-specific knowledge can address the challenge of generalization and abstract reasoning in solving visually complex tasks.

Introduction

The ARC (Abstract and Reasoning Corpus) Prize Challenge is a benchmark for evaluating AI's capabilities in abstraction and reasoning. ARC tasks requires a system to generalize across tasks with minimal training data, unlike traditional AI tasks rooted in pattern recognition. ARC emphasizes human-like problem-solving skills, including identifying abstract patterns like symmetry, mirroring, and object relationships. This project examines the potential of Knowledge-Based AI to address the ARC challenge by employing symbolic reasoning and rule-based transformations.



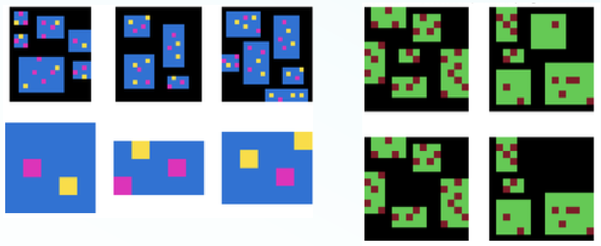
Methodology

The methodology employs a rule-based framework operating on grid representations, structured around three key components below.

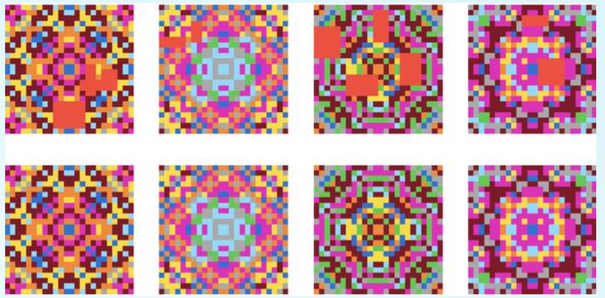
- **Representation Structures:** Grids serve as the core data structure, capturing the spatial and color relationships within tasks.
- **Transformational Primitives:** Modular operations applied to grids to perform specific transformations, ranging from basic (e.g., rotation, mirroring) to advanced (e.g., noise correction).
- **Rule-Based System:** A heuristic-driven framework prioritizing transformations based on grid properties, such as symmetry, color variety, and object relationships.

Transformational Primitives

- **Basic Transformations –** Includes transformations like retrieving top half or bottom half, rotating, horizontal or vertical mirroring, color inverting, etc. Transformations that can be applied to nearly all tasks.
- **Object Related Primitives –** Includes object recognizing methods like extracting biggest object, smallest object, most complex object, etc. Useful when dealing with object-related tasks.



- **Advanced Primitives –** Includes noise handling and dynamic color transformation. Noise handling method identifies the repetitive pattern and removes noise when a pixel doesn't align with other pixel values.

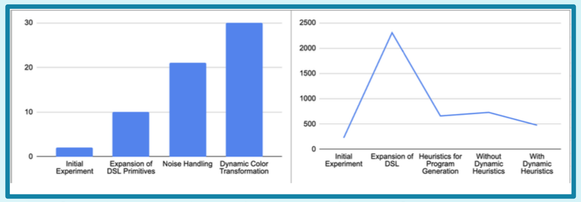


- Dynamic color transformation learns color matches from training data and apply color transformations when corresponding colors are found.

Heuristics

- **Avoiding Redundant Transformations –** Eliminates meaningless combinations like rotating 90 degrees and 270 degrees again.
- **Prioritizing Grid-Specific Operations –** Skips object related primitives when object count is small, skips noise handling when pattern isn't detected, etc.

Results



- After increasing the number of transformational primitives, accuracy was scored 6.0 out of 400.0, with 3206s of running time.
- After adding object-based primitives and basic heuristics, accuracy increased to 10.0 with 660s of running time.
- With noise handling logic implemented, the score increased to 21.0 but runtime also increased to 730s.
- After implementing dynamic heuristics and dynamic color transformations, score was recorded 30.0, with 477s of running time.

Conclusion

This project illustrates the potential of KBAI in solving visually complex tasks by leveraging symbolic reasoning and domain-specific transformations. The results emphasizes the importance of diverse rule-based methods and heuristic-driven optimization in achieving robust generalization when there's lack of training data. Future work includes expanding the library of primitives, integrating perceptual reasoning, and exploring hybrid methods that combine symbolic and data-driven techniques to improve adaptability and resilience.