# Imagery in AI
# Assignment 1: Geometric Analogies

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## Introspective Observations

When attempting to solve the geometric analogy problems ourselves, the identification and isolation of different shapes in the image is the first step in our solution process. Identifying shapes is one of the skills we commonly learn as children. We are able to identify distinct shapes even if they are overlapping, as in Problem 11. After identification, we determined that the next step in our problem solving process is the creation of generic logical rules such as "the shape inside of the bigger shape is removed." The rules applied to get from image A to B are then internally applied to our mental image of C. The matching result is then chosen as the correct answer. From these rules we can determine the different operations manipulating the images include: rotation, flipping, moving, adding, and subtracting shapes. Therefore, each of the problems can be divided into subsets of the operations applied to specific or relative shapes. Overall, the process we use to solve these problems involves more abstraction than the mostly visual process we noticeably used during the Raven's test, as discussed in Dawson et al. (2007).

While the isolation of different shapes within one image is easy for us to visually segment, it is a nontrivial task for computers. An algorithm to do so, such as edge detection, must explore every pixel neighboring a non-zero one in order to find the entire boundary of the shape. This will fail when shapes are overlapping, as they will be determined to be one shape together. Due to this complication, the design of our system attempts to find the solution without segmenting the image into individual shapes. This allows for certain operations such as rotation and flipping to occur in our algorithm only when the image has just one individual shape (e.g. Problems 2, 6, 12, 14). Other operations like moving, adding, or subtracting shape(s) are treated differently in our system. As we might visualize the moving of a specific shape from one location to another, to a computer it can be simply identified as subtracting then adding the same shape.

## System Description

Currently, our system starts the problem solving process by isolating the changes made between A and B. This is done by "subtracting" B from A i.e. removing the similar portions, or pixels, between A and B. An example of this can be seen in the section below. Next, the system performs the same subtracting process between C and all the possible answers. This isolates all the changes made between C and the answer options. The idea is that the changes made from A to B and from C to the correct answer will be similar. In order to compare the changes, the system splits the difference images into quadrants and sums the number of pixels that are changed within each. Finally, the number of pixels changed within each quadrant is compared between the subtracted images, i.e. the number of pixels changed in quadrant 1 of difference image A-B is compared to the number of pixels changed in quadrant 1 of difference image C-option. Whichever C-option image has the closest number of quadrant difference on average to the A-B quadrants, is chosen as the correct answer.



## Example Problem

When faced with Problem 1, as seen in Figure 1, the system starts by isolating the changes between A and B which results in a difference image representation as seen in Figure 2.

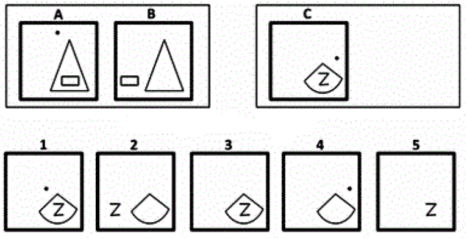


Figure 1: Problem 1

Next, the system isolates the changes between each of the options and C as seen in Figure 3. When comparing Figure 2 and the options in Figure 3, it can be seen that option 2 has the most similar pixel distribution and in fact is the correct answer.

## Results

Currently, without including rotations or flips in our algorithm yet, our system solves 8 out of the 15 problems correctly: 1, 2, 3, 5, 8, 9, 11, and 15

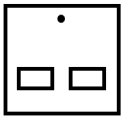

Figure 2: Absolute value difference between A and B

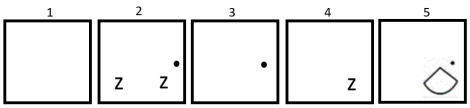


Figure 3: Absolute value differences between C and all the answer options

## References

Dawson, M.; Soulires, I.; Ann Gernsbacher, M.; and Mottron, L. 2007. The Level and Nature of Autistic Intelligence. *Psychological Science.* 18(8): 657662.