

Perceive this as that – Analogies, artificial perception, and category theory

Zippora Arzi-Gonczarowski

Typographics Ltd, 46 Hehalutz st, Jerusalem 96222, Israel

E-mail: zippie@actcom.co.il

This paper formalizes and analyzes cognitive transitions between artificial perceptions that consist of an analogical or metaphorical transference of perception. The formalization is performed within a mathematical framework that has been used before to formalize other aspects of artificial perception and cognition. The mathematical infrastructure consists of a basic category of ‘artificial perceptions’. Each ‘perception’ consists of a set of ‘world elements’, a set of ‘connotations’, and a three valued (true, false, undefined) predicative connection between the two sets. ‘Perception morphisms’ describe structure preserving paths between perceptions. Quite a few artificial cognitive processes can be viewed and formalized as perception morphisms or as other categorical constructs. We show here how analogical transitions can be formalized in a similar way. A factorization of every analogical transition is shown to formalize metaphorical perceptions that are inspired by the analogy. It is further shown how structural aspects of ‘better’ analogies and metaphors can be captured and evaluated by the same categorical setting, as well as generalizations that emerge from analogies. The results of this study are then embedded in the existing mathematical formalization of other artificial cognitive processes within the same premises. A fallout of the rigorous unified mathematical theory is that structured analogies and metaphors share common formal aspects with other perceptually acute cognitive processes.

1. Introduction

Cognitive transitions between settings that are perceived as analogical, in some sense, constitute a salient natural activity of human intelligence. They have been recognized and studied since antiquity. In an AI context the fruitfulness of analogies should typically depend on whether any testable consequences could be deduced from them. Analogizing could sometimes be useful as a cognitive tool for perceptive artificial intelligent agents.

- Analogies may explicate unfamiliar environments and situations in terms of more familiar ones. For example, an intelligent artifact that has been trained to perceive a bookstore environment and interact with (e.g., ‘shop’ in) this environment, can be efficiently taught to do the same in a music store, with the necessary analogs being drawn. Likewise, an intelligent artifact that has been trained to perceive music and interact with (e.g., ‘play on’) the keyboard of a piano can be efficiently taught to do the same with another keyboard instrument, the necessary analogs being drawn.

- In rational thinking, analogies may be used to suggest hypotheses about a more general rule or setting. For example, an analogy between a bookstore environment and a music store environment may suggest to an observant intelligent artifact general patterns of behavior of agents selling and/or shopping in store environments. Consequences could be deduced for general store environments. Likewise, the analogy between a piano and another keyboard instrument may suggest to an observing intelligence general patterns of music playing. Consequences could be deduced for keyboard instruments in general.
- Linguistic translations constitute examples of analogies. One may look at a language as an environment that consists of perceptible audio/visual elements (words, phrases, etc.). A translation is thus a cognitive transition to the respective environment of another language. Analogs are typically being drawn between linguistic elements that have the same semantic properties, but they can also preserve (or consistently map) the audio properties of the linguistic element, (such as measure and rhyme in translations of poetry), cultural insinuations [51], or even visual properties of the linguistic element, if there is, for example, a perceptual sensitive transference of font.
- In their interaction with human agents, intelligent artifacts might need to analogize when they follow a human line of reasoning (e.g., in the process of expert knowledge acquisition). Metonymies, metaphors, tropes and a variety of other expressive tools that are based on analogies have pervaded human cognitive processes to a point that it would be hard to avoid them when communicating with artificial systems. Lakoff [39–41], for example, argues that language is tropological, and that its usage is typically inspired by analogy to bodily experiences, as in ‘*arriving* at a solution’ or ‘*seeing* a point’.

A mathematical theory of artificial perceptions is proposed as a framework for the formalization of cognitive transitions between settings that are analogical in some perceptible sense. It is shown that the theory can naturally formalize analogy-making, often a useful cognitive activity.

The body of research about analogies in thought, science, language, and other cognitive domains and activities is so vast that it is hard to say anything new, that has not already been said before, about analogies. This paper neither competes with existing theories (some of them will be briefly sketched in the next section), nor does it take sides in debates among various philosophical stances (e.g., traditional comparison theories, interactionist theories, and others). The force of a categorical approach is in avoiding over determination [48], and hence the paper will also not deal with various semantic distinctions between analogies, similes, models and other related phenomena. The novelty and the goal of the proposed approach is the introduction of a rigorous mathematical categorical framework, where no such framework already exists. In addition to meticulous mathematical rigor, this approach opens the way for the integration of analogy making with other cognitive processes that are based on the same mathematical formalism.