Inferential and Expressive Capacities of Graphical Representations: Survey and Some Generalizations

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1 Tutorial Topics

Thanks to recent as well as age-old theoretical studies, we now find at least four important concepts that seem to capture the crucial functional traits of varieties of graphical representations. They are, roughly, the following concepts:

1. Free ride properties: expressing a certain set of information in the system always results in the expression of another, consequential piece of information. The concept has been suggested or proposed, under various names, as an explanation of certain automaticity of inference conducted with the help of graphical systems (Lindsay [1]; Sloman [2]; Barwise and Etchemendy [3]; Larkin and Simon [4]; Shimojima [5]).
2. Auto-consistency: incapacity of the system to express a certain range of inconsistent sets of information. The concept has been suggested as an explanation of the ease of consistency inferences done with the help of graphical systems (Barwise and Etchemendy [6]; Barwise and Etchemendy [7]; Stenning and Inder [8]; Gelernter [9]; Lindsay [1]; Shimojima [10]).
3. Specificity: incapacity of the system to express certain sets of information without choosing to express another, non-consequential piece of information. The concept has been suggested or proposed as an explanation of the difficulty of expressing "abstract" information in certain graphical systems. (Berkeley [11]; Dennett [12]; Pylyshyn [13]; Sloman [2]; Stenning and Oberlander [14]; Shimojima [5]).
4. Meaning derivation properties: capacity to express semantic contents not defined in the basic semantic conventions, but only derivable from them. The concept has been offered as an explanation of the richness of semantic contents of graphics in certain systems. (Kosslyn [15]; Shimojima [16]).

The purpose of this tutorial is to give an accurate but accessible summary of these "fruits" of the previous research into graphical representations, formulating their exact contents, exposing their explanatory ranges, and exploring their possible modifications or extensions.

This tutorial is divided into three stages. In the first stage, I will first offer a small running example illustrating all the four concepts in a simple, but accurate manner. To ensure the accuracy of the illustration and to facilitate more

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detailed learning on the part of the audience, I will always refer to the original works that have suggested or proposed the concept in question, sometimes citing their own examples.

After ensuring the intuitive grasp of each concept with these examples, I will offer a more accurate reconstruction of each concept. I need make the reconstructions precise enough to determine the application ranges of the concepts in question, but the logical apparatus used for reconstructions will be kept minimal to ensure the accessibility to those participants with little acquaintance with logic and related mathematics.

In the third stage, we will explore much further examples of graphical systems to see how far these concepts are applicable as explanations, what functional traits of what graphical representations they fail to capture, and what refinements or modifications would be necessary to extend their explanatory ranges. In particular, we will discuss various theoretical works in diagrammatic reasoning, and investigate the relationship between our four concepts with the ideas offered in those works. Depending on time available, we hope to cover such concepts as: "locality" (Larkin and Simon [4]), "analog and digital representation" (Dretske [17]), "perceptual inference" (Larkin and Simon [4]; Narayanan et al. [18]), "mental animation" (Hegarty [19]), "law-encoding diagram" (Cheng [20]), and "spatial transformation" or "hypothetical drawing" (Schwartz [21]; Trafton and Trickett [22]; Shimojima and Fukaya [23]). Examples of graphical systems will be also taken from collections of real-world graphics such as Bertin [24], Tufte [25, 26, 27] and Wildbur and Burke [28].

2 Benefit

The tutorial will serve as an interim report of the theoretical research on the functional traits of graphical representations conducted so far, as well as an impetus of further development. Also, it will end up with a fairly comprehensive survey of the literature in the this theoretical area. Such a survey/tutorial is especially important since the works in this area are typically scattered over diverse fields such as AI, cognitive psychology, philosophy, logic, and information design, conducted in different methods, vocabularies, and degrees of technicality. This prohibits an easy overview of various results, proposals, and suggestions offered in the area. The audience will obtain an accessible summary of these results and ideas, described in a single, systematic conceptual set.

3 Audience

Any researcher interested in theoretical analyses of the inferential and expressive capacities of graphical representations should be interested in the tutorial, no matter what field she or he may ne in, computer science, psychology, philosophy, logic, or AI. Practitioners of information design will also find the summery of theoretical results useful. The exploration of the literature of information design planned for the tutorial will have direct connections with the more practical side of graphics research. The tutorial will be so designed not to require any special background knowledge or mathematical maturity on the part of the audience, except for the willingness to handle a certain level of abstract ideas.

4 Instructor Background

The instructor has been associate professor of the School of Knowledge Science for 5 years. He teaches graduate level courses in logic and cognitive science, and supervises master- and doctorate-level research in related fields. He is also a visiting researcher to ATR Media Information Science Laboratories. His educational background is in philosophy and mathematical logic, and his research is centered around the efficacy of different types of representations in human problem-solving and communication. He publishes mainly in the fields of diagrammatic reasoning and graphics communication, covering both logical and empirical approaches to the issues.

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