A Hybrid Reasoning System with Diagrams and Sentences

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Abstract

Deduction by a computer studied so far has been centered around symbolic reasoning with formulas. Recently, attention has been directed to reasoning with diagrams as well, in order to augment the deficiency of reasoning with symbols only. In this paper, we propose a hybrid reasoning system with diagrams and sentences, called JVenn, having perspicuity of diagrams and strictness of symbols complementarily. JVenn is unique particularly in the points that it has the strategy for proving a chain of syllogisms, allows for an interplay between diagrams and symbols, and guides reasoning with the beauty measure for diagrams.

1 Introduction

We very often visualize objects, using diagrams, graph, chart or table and so on, in our everyday life as well as in scientifc exploration [4][6]. This is because they are not only easier for us to understand than symbolic or linguistic expressions but also allow for conceiving new ideas further. So far, studies of deduction by a computer have been centered around symbolic reasoning with formulas. Recently, attention has been directed to reasoning with diagrams as well, in order to augment the deficiency of reasoning with symbols only [1][7]. In the qualitative comparison of visual reasoning with symbolic one, we, in fact, have observed some advantageous evidences on the proof complexity, similarity and strategy in visual reasoning. Table 1 shows some average figures of them that have seen in proving the validity of the Aristotelian syllogisms (see [5] for the details).

In this paper, we very briefly describe our visual reasoning system called JVenn which is an implementation of Hammer's system [1] and [3] in Java

Table 1. Comparative results [5]

The number of	Hammer's system [1]	Hammer's system [3]	Natural deduction
Proof steps	2.7	5.7	7.5
Formulas and diagrams	4.7	7.7	11.5
Proof patterns	2	2	5

and usable via Internet. In the implementation we incorporated many additional useful and helpful features such as

- an automatic drawing of Venn diagrams
- a deductive method with Venn diagrams [3]
- an automated syllogism with the proof strategy [8]
- a flexible interaction with diagrams and symbols
- an automatic transformation of formulas to diagrams and vice versa [5][8]
- a beauty criteria for diagrams based on the information aesthetics [2][8]
- a user-friendly interface for human reasoners [8]
- a high portability and usability, etc.

2 Some features of the visual reasoning system JVenn

Transformation of diagrams to formulas and vice versa This is accomplished by the relation between labels and regions and the conversion rules between diagrams and formulas [3][5]. So users can input in an either way of digrams or formulas although it is restricted to Aristotellian syllogism.

Beauty measure for diagrams and proof guide based on it The calculus of beauty that Venn diagrams might have is based on the information aesthetics [2], where the beauty measure is defined to be $M_{\ddot{A}} = O/C$ (called Birkoff's quotient), where C stands for the complexity and O the order that a diagram
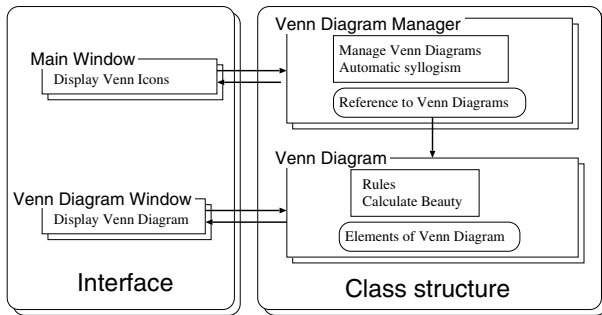
Figure 1. The system configuration of JVenn

Figure 2. A snapshot of JVenn

might have, similarly to the definition of information in information theory. For our purpose, we use the refined version of the following [2]. $M_{\ddot{A}} = K \sum_{i=1}^{m} M_{\ddot{A}_i} = \frac{1}{m} \sum_{i=1}^{m} \frac{\sum_{j=1}^{n_i} E_{ij}}{n_i C_i}$, where m is the number of aesthetic objects (the viewpoints of the beauty measure), $K = \frac{1}{m}$ is a constant, n_i is the number of attributes that determine the order by a specific viewpoint i, and E_{ij} and C_i are the order and the complexity from the viewpoint i. We take into account the following viewpoints for the case of the beauty of Venn diagrams: (1) Kinds of elements in Venn diagrams, and (2) Configurations of elements in Venn diagrams. For each definition of E_{ij} from these two viewpoints ($m = 2$), see [8]. In order to get to an conclusion of the syllogistic form from some assumptions, we had better pay attention to the direction in which the beauty value increases at some proof steps. This can be viewed as sort of a proof guide.

Automated syllogism JVenn automates the chain of syllogistic reasoning from many premises to a conclusion.

3 Implementation of the hybrid reasoning system

The system configuration is shown in Figure 1. It mainly consists of two parts: The interface part of the main window and the Venn diagrams drawing window, through which we can communicate with JVenn, and the processing part consisting of the two classes: the Venn diagram manager and the Venn diagram.

Figure 2 is a snapshot of JVenn running on the Web browser of Macintosh.

4 Concluding remarks

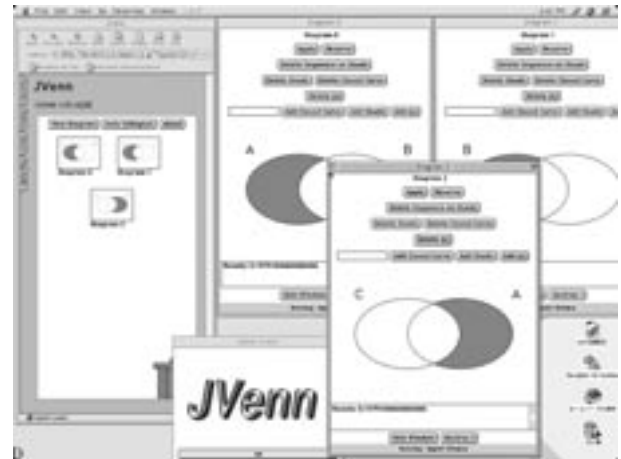In this paper, we proposed a visual reasoning system JVenn which attained a unique amalgamation of the diagrammatic reasoning and the symbolic reasoning, having perspicuity of diagrams and strictness of symbols complementarily. This aspect would be particularly important for human reasoner.

Two logic-based visual reasoning systems have been known so far as far as we know: Venn 2.1 and Hyper-Proof 1.0. Compared with these systems with different design philosophy, JVenn is unique particularly in the realization of (1) the transformation between diagrams and symbols, (2) the automated syllogism under the proof strategy, and (3) the beauty measure for diagrams and its use in guiding proofs.

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