Commonsense Knowledge Representation I

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INTRODUCTION

Significant advances in artificial intelligence, including machines that play master level chess, or make medical diagnoses, highlight an intriguing paradox. While systems can compete with highly qualified experts in many fields, there has been much less progress in constructing machines that exhibit simple commonsense, the kind expected of any normally intelligent child. As a result, commonsense has been identified as one of the most difficult and important problems in AI (Doyle, 1984; Waltz, 1982).

BACKGROUND

The Importance of Commonsense[1]

It may be useful to begin by listing a number of reasons why Commonsense is so important:

1. Any general natural language processor must possess the commonsense that is assumed in the text.
2. In building computerized systems, many assumptions are made about the way in which they will be used and the users' background knowledge. The more commonsense that can explicitly be built into systems, the less will depend on the implicit concurrence of the designer's commonsense with that of the user.
3. Many expert systems have some commonsense knowledge built into them, much of it reformulated time and again for similar systems. It would be advantageous if commonsense knowledge could be standardized for use in different systems.
4. Commonsense has a large element that is environment and culture specific. A study and formalization of commonsense knowledge may permit people of different cultures to better understand one another's assumptions.

Defining Commonsense

No attempt will be made here to define commonsense rigorously. Intuitively, however, commonsense is generally meant to include the following capabilities, as defined for any given culture:

a. knowing the generally known facts about the world,
b. knowing, and being able to perform, generally performed behaviors, and to predict their outcomes,
c. being able to interpret or identify commonly occurring situations in terms of the generally known facts – i.e. to understand what happens,
d. the ability to relate causes and effects,
e. the ability to recognize inconsistencies in descriptions of common situations and behaviors and between behaviors and their situational contexts,
f. the ability to solve everyday problems.

In summary, commonsense is the knowledge that any participant in a culture expects any other participant in that culture to possess, as distinct from specialized knowledge that is possessed only by specialists.

The necessary conditions for a formalization to lay claim to representing commonsense are implicit in the above definition; a formalism must exhibit at least one of the attributes listed there. Virtually all work in the field has attempted to satisfy only some subset of the commonsense criteria.

COMMONSENSE REPRESENTATION FORMALISMS

In AI research, work on common sense is generally subsumed under the heading of Knowledge Representation. The objective of this article is to survey the various formalisms that have been suggested for representing commonsense knowledge.

Four major knowledge representation schemes are discussed in the literature - production rules, semantic nets, frames, and logic. Production systems are frequently adopted in building expert systems. Virtually all the discussions of commonsense representations, however, are in terms of semantic net, frame-like, or logic systems. These schemes are applied within three main paradigms for commonsense representation—propositional, truth maintenance, and dispositional (see Figure 1). Very briefly, propositional models are descriptions of representations of things or concrete facts. When the knowledge represented is imprecise or variable, propositional formalisms are no longer sufficient and one needs to consider the beliefs about the world engendered by the system's current state of knowledge, and to allow for changes in those beliefs as circumstances dictate; this is the nature of belief or truth maintenance systems. Finally, when the knowledge is both imprecise and not factual, but relates rather to feelings, insights and understandings, the dispositional representations are evoked.

Within each representational paradigm, there are a number of specific formalisms. Figure 1 indicates the existence of eight different knowledge representation formalisms. Each of these formalisms is presented via discussion of one or more representatives.

The need for different types of formalisms, the difficulty in representing multiple domain knowledge, psychological theories of various levels of consciousness, the physiological evidence of different levels of the brain and their association with specific functions, the functional specialization of specific areas of the brain, and similar evidence concerning the two sides of the brain all support the view of the mind, or self, as composed of a considerable number of cooperating subagents, to which Minsky (1981) refers as a society of mind. It is useful to keep this concept in mind while studying the variety of representation schemes; it suggests that a number of such formalisms may coexist in any rational agent and little can be gained by attempts to choose the "right" formalism in any general sense.

PROPOSITIONAL MODELS

Virtually all the propositional models of commonsense knowledge are perceived as consisting of nodes that are associated with words or tokens representing concepts. The nodes are hierarchically structured, with lower level nodes elaborating or representing instantiations of higher-level nodes; the higher-level nodes impart their properties to those below them, which are said to inherit those properties. Thus, all the propositional models are hierarchically structured networks consisting of nodes and arcs joining the nodes. From this point, the representational structures begin to diverge according to the distribution of information between the arcs and the nodes. At one extreme, nodes are self-contained

Figure 1. Commonsense knowledge representation formalisms