COMMONSENSE REASONING WITH VERBS

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Abstract

KT encodes commonsense knowledge (CK) about entities and relations in a cross-classified Ontology and a database of generic (prototypical and inherent) information. The verb Ontology combines linguistic and psycholinguistic classification. The generic information for verbs encodes typical associations with actions and events. This knowledge base is useful for word-sense disambiguation, inferencing without scripts, discourse reasoning, and post-verbal PP attachment.

1. Introduction

This paper describes adding verbs to the KT system (Dahlgren and McDowell, 1986a, 1986b). KT encodes CK (Hayes 1985) as ontological classifications and generic descriptions of entities and relations. The Ontology is a hierarchy with cross-classification possible at any node. We use the label "the commonsense view" to describe the body of knowledge and belief which the people of a subculture hold of concepts associated with lexical items.

2. The Ontology of Verb Concepts

Nouns in utterances refer to real-world entities and in the lexicon name classes of entities. Verbs describe relations between entities. In using verbs, speakers refer to real-world situations (Barwise & Perry 1983). The entire verbal Ontology attaches to the node TEMPORAL which is a subnode of REAL in the main Ontology.

The TEMPORAL Ontology superimposes the Vendler (1967) classification over a psycholinguistically justified classification scheme of the commonsense view of actions and events. The Ontology and examples of attachments

	Natural			Social		
	Mental	Emotional	Nonmental	Mental	Emotional	Nonmental
Nongoal Achievement	*FORGET*	*PANIC*	*DIE*	*CONFESS*	*DISGRACE*	*FORFEIT*
Nongoal Accomplishment	*UNDERSTAND*	*SOOTHE*	*RECOVER*	*LEARN*	*FALL IN LOVE*	*SUCCEED*
Nongoal Activity	*DREAM*	*SUFFER*	*SLEEP*	*THEORIZE*	*GRIEVE*	*PLAY*
Goal Achievement	*MEMORIZE*	*SURPRISE*	*ARRIVE*	*SAY*	*OSTRACIZE*	*MARRY*
Goal Accomplishment	*EXPLAIN*	*INSPIRE*	*CONSUME*	*TEACH*	*ENTERTAIN*	*BUILD*
Goal Activity	*THINK*	*HOPE*	*RUN*	*STUDY*	*GLOAT*	*EXPLORE*
Stative	*KNOW*	*FEAR*	*BE*	*ADVOCATE*	*MOURN*	*OWN*

Table 1. The Verb Ontology

are shown in Table 1. A verb is SOCIAL iff the relation exists within the domain of a social "institution," understood in the broadest sense, for instance family, government, education, warfare, organized religion, etc.

The division of temporal concepts into stative and nonstative types is standard. All non-states are cross-classified as goal-oriented or not by the distinction GOAL, NONGOAL. The MENTAL, EMOTIONAL, NONMENTAL distinction is made at the highest level because people divide the objects and relations in the world into those which have to do with thinking and those which do not (Gelman & Spelke 1981, Strawson 1953). The Ontology completely covers the 600 verbs in our pilot study.

3. Generic Descriptions of Verb Concepts

For generic descriptions of verbs, we relied heavily on Graesser and Clark (1985). We do not directly encode their representation system but instead have adapted their findings as feature types in generic descriptions for verbs. These are accessible in KT via the following set of questions, where X is some situation. *What caused X? What enabled X? What was the goal of X? What happened next (after X)? What was the consequence of X? What does X imply? When did X happen? Where did X happen? How did X happen?* These are not primitives, but are a framework for representing what people know about some of the implications of relations described by verbs. Trabasso and van den Broek (1985) find that events are best recalled which feature goal states and consequences of goals and that events categorize around settings, initiating events, internal responses, attempts, consequences, and reactions. Huttenlocher and Lui (1979) find that the mental representation of verbs is less hierarchical than that of nouns and uncorrelated with the semantic fields to which the verbs belong. Trabasso and Sperry (1985) find that the salient features of events are goals, antecedents, consequences, implications, enablement, causality, motivation and temporal succession and coexistence. Suppose KT reads sentence (1). KT can then answer questions as in (2).

(1) *John bought a book.*

(2) *Where did John buy the book?*
-Typically in a store.

If John bought a book, what resulted?
—Inherently, John owns the book.

Selectional restrictions (SRs) are also encoded for each sense of a verb. This information is divided into two lists associated with each verb in the lexicon. One list encodes typical features of relations and the other inherent features (those features which the relation has in virtue of being that relation). The richest such description for a particular verb would include a full set of answers in each list.

4. Reasoning with Verbs

The TEMPORAL Ontology and Generic Information can be used for (1) word sense disambiguation, (2) inferencing without resort to scripts, (3) supplying discourse elements not referred to directly in the text, and (4) guiding post-verbal prepositional phrase attachment (Dahlgren & McDowell 1986b).

Word-Sense Disambiguation. We assume that each set of SRs for subject, object, and oblique case identifies one unique sense of a n-ambiguous verb. While this is not true all the time, it is a good working hypothesis. KT has direct access to SR information, which can be used to select among the senses of *run,* for example, as in (3).

(3) *John ran for an hour.*
(LIVING & SENTIENT) run
The car ran roughly.
(NONLIVING & SELFMOVING) run
John ran the machine expertly.
SENTIENT run ARTIFACT
Akers runs IBM.
SENTIENT run INSTITUTION

In (4) the subject is a VEHICLE and KT chooses the "change location" sense of move. In (b) the subject is an INSTITUTION and KT chooses the "progress" sense of move. When SRs fail, KT uses generic information. KT uses the fact that cities are typical domiciles to choose the "change domicile" sense of move in (c) but the "change location" sense in (d).

(4) a. The truck is moving forward.
b. The economy is moving forward.
c. John moved to New York.
d. John moved to the infield.

The same holds for nouns. In (5a) KT chooses the ARTIFACT sense of crane required by the SR on operate. But in (b) KT chooses the "bird" sense because things that fly are typically birds, airplanes, or people.

(5) a. John operated the crane.
b. The crane flew over the rooftop.

Table 2 shows more examples and see Dahlgren (1987).

Inferencing without Scripts. Some inferences can be made directly. Suppose we have the following information on goals coded for the verbs shoot and kill.

(6) shoot: goal, kill(subj,obj)
kill : goal, eliminate(subj,obj)
kill : goal, eat(subj,obj)
kill : goal, inherit(subj,money)
kill : goal, protect(subj,subj)

It is now possible to infer that if A shoots B, then As goal is to eliminate, eat, inherit from, or defend against B. Selectional restrictions then guide the choice among these possible goals for sentences such as (7).

(7) The firing squad shot the prisoner
The hunter shot the deer
The husband shot the heiress
The man shot the burglar

Other inferences will require specific routines to extract, such as the relationship between owning, having, using, and FUNCTION (a feature type). Consider (1) again. The typical function of a book is to read it. A typical sequel to owning something is using it for its function. KT reasons that John reads the book after he buys it.

Discourse. Much of the information needed to understand text is not explicitly mentioned in a text. In order to understand the sentence Many kinds of products come to the markets of Paris, the system must supply the missing information that the products are shipped by an agent in some kind of conveyance. Agentivity of the subject is required by the ontological classification of the verb and the SRs on the verb require that its subject be selfmoving. The problem is that the subject of come, the NP many kinds of products, is neither an agent with a goal nor selfmoving. We can exploit this situation rather than view it as a liability if the system has access to CK. KT supplies an agentive entity and a selfmoving entity to the discourse for later identification from the text or from the generic information.

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