A STATE LOGIC FOR, THE REPPESENTATION OF NATURAL LANGUAGE BASED INTELLIGENT SYSTEMS

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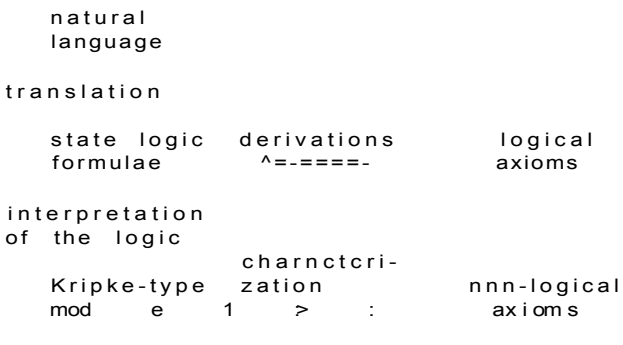
Summary

Tho work described herein introduces a general logic based formalism for the actions of an intelligent system understandinn natural language sentences, executing comnands and answering questions.



The heart of this formal system is a state (or tense) lonic containing special operators for immediately next and preceding states (+,--) as well as for all future states (F) and all past states (P).

Natural language texts are analysed syntactically and transduced into state logic formulae by an attributed grammar (in the same way as described by Sehwind).

The state logic is formalized by a set of logical axioms and derivation rules for which completeness has been proven. Similar systems have also been mentioned by Rescher. But in usual tense logic systems, the structure of tense has been studied only as to its "pure logical" properties. In intelligent systems however, wo *nood* theorems about the non-logical properties of state changes. The tense structure of a world is determined by changes within the world which affect the non-logical symbols of the world, i.e. the functions or predicates: If a robot takes a block "a" lying on a block "b", then this causes a change of the world (i.e. a state transition) with the meaning of the predicate symbol ON changing. Such non-logical change descriptions are incorporated into our formal system. A model for the state logic is given by a set of classical structures M and a binary relation P on M where s P s' means that the state of the world s immediately precedes the state s^1. Truth values are assigned to formulae depending on the state of the v/orld in which the formula is evaluated. And the state operators take into account the truth value of a formula in some other states which can be "reached" from the actual state. To represent the knowledge incorporated in an intelligent system by such Kripkc-type models we assign a non-logical interpretation to state transitions. The very general model of Kripke-structures is used in such a way that the relation P bears a non-logical meaning. For two structures A_o and A , s P s' holds iff the ''v/orld" ° A , is obtained from the world $A_„$ as the'result of an action which can be executed within A . V7hat actions can be executed within a v/orld depend on the extensions of the non-logical symbols. On natural language level actions are verbs. The execution of an action has consequences on the extensions of the non-logical symbols of the v/orld, i.e. a structure is subject to some change whenever the action described by the verb is executed in it. If somebody takes a thing the position of that thin^ changes, i.e. the extension of the predicate symbols ON, BEHIND etc. and the extension of the verb predicate symbol HOLD changes, because the person holds the thing now. There are also preconditions for the execution of an action; "a takes b[:] is only possible if "a" does not yet hold anything and if "b" has a POsition such that it can be ta*):*on, i.e. there is nothing on "b". We describe both the Preconditions and the consequences of an action by non-logical axioms. And the appropriate structure must have the property that in whatever state all the conditions of an action hold there must be some following state in which its consequences are realized.

Example: Action verb "take"
Precondition axiom (PA)
TAKE x y^HANO x ,-[m]HING y-\ 1H0LU $_x$ z -> $-^1$ ON z y This means: x can take y iff x is a hand and y is a thing and x does not hold any other object and there is nothing on y.
Execution axiom (FA)
TAKE x y-*g+I[HOT,D x y_A~ION y *z]* This means: If x takes y then there is an immediately following state such that x holds y and y is not lying on anything.
We could only describe a small part of the possibilities of our formalism here. Wo actually develop application examples of very different types: one for the analysis of tales and one for traffic.

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