Exploring the use of Controlled English for communication with ACT-R agents

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***Abstract*— Research is being undertaken into sense-making by collaborative agents, based upon a cognitive framework of human behaviour, ACT-R, together with communication between the agents. We explore the use of Controlled English for this purpose.**

Keywords- ACT-R, Controlled Natural Language, cognition

I. INTRODUCTION

Research is being undertaken into sense-making by collaborative agents, based upon a cognitive framework of human behaviour, ACT-R [1], together with communication between the simulated agents. It is of benefit to include other collaborating agents, such as real humans and agents providing services such as Natural Language processing (Task4.2) and asset tasking (Task4.3). Several considerations pertain to the characteristics of the language used to communicate between agents: communication is a cognitive task and choice of language may affect the nature of the agent's cognition; inclusion of external agents would be facilitated by a language that is already used and understood by the other tasks; communications need to be understood by researchers, and benefit from being easily readable. These suggest that Controlled English (CE) [2,3] may be suitable for the communication language and this paper explores this possibility. We consider how transformations may occur between representational structures in ACT-R and representation in CE. We consider how semantics of ACT-R map onto semantics of CE, and whether the use of a Natural Language (albeit controlled) in communication could provide insights into the relationship between language and cognition.

II. COMMUNICATING WITH ACT-R VIA CE

To communicate between agents using CE as the communication language, it is necessary to design two mappings:

- between the concepts used in an ACT-R model and the concepts used in the CE sentences
- between the syntactic representation of ACT-R concepts and the CE language

Usually in applying CE to reasoning tasks, we take the first mapping to be implicit and 1-1, i.e. concepts used in the application are exactly the concepts expressed in the CE, indeed that is a strength of CE. If so, the only consideration is the syntactic mapping. However, we have separated out the first mapping to allow for the possibility that concepts in CE and concepts in ACT-R are not 1-1, and that cognition is required to perform the conceptual transformation. For now we assume that the first mapping is 1-1, and will concentrate only on the second.

In ACT-R, information is expressed as "chunks", each chunk being of a certain type, and having properties defined as "slots" with values. For example, a person may be represented as:

(PaulSmith isa person age 21 gender male common_name paul father JohnSmith)

Here the chunk type is "person" and this may be defined as:

(chunk-type person age gender common_name father)

It is reasonable to view the chunk type as equivalent to a "concept" that is expressed as a CE "conceptualise" sentence. Further equivalences are: a chunk is an instance of a CE concept, a slot is a CE attribute, and the value is the value of the CE attribute. These equivalences can be used to transform between ACT-R and CE syntactic representations. For example the equivalent CE specification of the person PaulSmith is:

there is a person named PaulSmith that has 21 as age and has male as gender and has paul as common name and has the person JohnSmith as father.

This is based upon a CE conceptualisation, which is equivalent to the chunk-type:

conceptualise a ~ person ~ P that has the value A as ~ age ~ and has the value G as ~ gender ~ and has the value CN as ~ common name ~ and has the person O as ~ father ~.

However there is a significant difference between the expression of information in ACT-R chunks and CE sentences, as in CE there are alternative ways to express information, and a decision must be made as to the style in which this is done.

For example, the possession of an attribute may be better expressed as being of a certain type:

the person PaulSmith is a male.

or as being in a certain relationship (note the order reversal):

the person JohnSmith is the father of the person PaulSmith.

Different conceptualise statements are needed to allow these expressions, but they are logically equivalent, differing only in style. Style is important in CE as we are concerned with human readability, and different styles of expression, whilst conveying the same logical information, may affect readability and communication of the information with humans.

Given these equivalences, it is possible to define a mapping between CE and chunks, allowing CE to be used as the means of input and output with an ACT-R agent, and hence permit communication between a community of ACT-R agents and humans. Each slot of each chunk-type must be associated with the name of the CE concept representing that slot, together with the CE concept type of the value that is to be placed in the slot.

It may be not be possible to assume that an attribute style is always used, and is therefore necessary to include as part of the mapping, information about the style of CE representation to be used for each slot (e.g. attribute, relation or type) in each chunk type. This assumption may be invalid for two reasons. Firstly, an existing CE model may be being used as the basis for communication, and the design of this model may already have specified a non-attribute style for expression of certain concepts. The second reason is taken up below.

III. Some Thoughts on Cognition and Language

A key consideration of the nature of the communication between ACT-R agents is whether the language for communication is defined in the same concepts as used by the ACT-R agent (in which case the simple mapping mechanisms described above are sufficient) or whether some additional cognition is required by the ACT-R to interpret the input sentences or to construct the output sentences.

One reason for requiring cognition in communication is the concern over the use of style for readability, as exemplified by the alternative ways to express the same logical propositions in CE. Cognition may be required to determine the best style for writing the CE sentences, and may require consideration of the nature of the recipient, the context in which the communication occurs and the overall style of the communications being undertaken. Cognition may also required on reading sentences, if pragmatic information is encoded by expressive style; for example the alternative ways to express the "father" relation given above (attributive v.s. relational) alters the relative prominence of the entities involved. Of course such considerations would only be relevant if more subtle aspects of communication are to be addressed in the modeling of agent communication and its effects. It may be noted that if no cognition is being modeled in ACT-R in the transformation between CE sentences and chunks, then CE stylistic distinctions are not visible to ACT-R.

The motivation for using cognition in handling style in the communication of CE sentences is relevant even if concepts are the same in CE and ACT-R, since style is a syntactic property. However, the need for a "first mapping" was noted above, if the concepts in CE are different to those in the ACT-R models, if agents have different conceptual models. In this case cognition may be required to interpret CE sentences into ACT-R chunk-types. Such mapping may be an ontology mapping task, or if complex, may have some of the characteristics of Natural Language processing [4].

Other more complex issues arise when considering the mapping between CE and ACT-R models: if an entity is mentioned in a CE sentence (such as JohnSmith in the "father" attribute/relation), does this imply its existence, and if so, in the real world, or an abstract world to be constructed as part of the dialog? CE allows the expression of statements that do not define the absolute truth of the contained proposition (e.g. as assumptions or uncertainties), are these to be interpreted as "possible worlds", how is the ACT-R model constructed to represent such information, and how is cognition able to use such information? For now we put aside these deeper questions, but note that they may require answers in the future.

Although these issues are more of a philosophical nature we suspect that they arise because CE is a (subset of a) real natural language and would have been hidden if a completely formal computational representation such as XML were to be used as the means of communication. We speculate that the linguistic nature of CE may be leading to a certain type of cognitive thinking that leads to deeper analysis of communication issues.

IV. Discussion

A basic transformation between CE and ACT-R structures is easy to construct and allows CE to be used for communication between humans and ACT-R agents. However, using CE instead of a computational representation such as XML raises potentially interesting questions about the need for modeling ACT-R cognition as part of the communication process itself and about other philosophical issues relating to world modeling.

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