Towards a Formal Model of the Deictically Constructed Context of Narratives

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Abstract. This paper proposes an approach to representing the context created by the use of deictic expressions in narrative discourse. It is based on the integration of approaches to formalizing context as first-class objects, the situation calculus for representing actions, text world theory for providing a cognitive model of discourse functioning and the classical linguistic understanding of the functioning of referential indices in language. The result is a representation of the context created by the indexical expressions in the narrative. This is the context needed to interpret each utterance as well as the whole discourse.

1 Introduction

This paper proposes an approach to representing the context created by the use of deictic expressions in narrative discourse. It is based on the integration of approaches to formalizing context as first-class objects [10], the situation calculus [8, 9, 13] for representing actions, text world theory for providing a cognitive model of discourse functioning [19, 20] and the classical linguistic understanding of the functioning of referential indices [5, 15–18] in language, as well as the literature on pragmatics [7]. The result is a representation of the context created by the indexical expressions in a narrative. This is the context needed to interpret each utterance as well as the whole discourse.

The work presented here considers only the target representation of the context created by the discourse. It does not address the issues of automating the construction of the context, and reasoning with the representation. But the particular representation is chosen with the goal of making use of previous work on reasoning with aspects of the representation.

Section 2 describes the representation language and how it combines tools from the theory of context and the situation calculus from within work in artificial intelligence, and the idea of worlds and world creation from within text world theory. Most importantly, new contexts are created within contexts. The representation language is related to the linguistic analysis of deictic expressions in Section 3. It is through the interpretation of deictics that the context is created. An example of the use of the representation is given in Section 4. Finally, Section 5 summarizes the work and situates it within current and future work.

2　The Representation

Following McCarthy and Buvač[10], contexts are *first class objects*. They are terms. To state that a proposition p is true in context c, we write $\text{IST}(c,p)$ meaning that p is true in the context c^1.

The capability to represent (and ultimately reason about) the characteristics of contexts is crucial. Speaking situations will generally have a speaker, a hearer, a time, a place and other features. For example, $\text{SPEAKER}(c) = \text{P}_1$, $\text{TIME}(c) = $ "$4:00PM$", $\text{HEARER}(c) = \text{P}_2$, $\text{PLACE}(c) = $ "$NewJersey$". We can allow multiple values by using predicate notation such as $\text{HEARERS}(c,\text{P}_3)$, $\text{HEARERS}(c,\text{P}_4)$.

The situation calculus (following the presentation in [12]) is a first-order language for representing dynamically changing worlds in which all of the changes are the result of named *actions* performed by some agent. Here, we merge contexts and states. There is no difference.

If α is an action and s a situation or context, the result of performing α in s is represented by $\text{DO}(\alpha,s)$. The constant C_0 is used to denote the initial situation or context. Relations whose truth values vary from situation to situation, called *fluents*, are represented by a predicate symbol taking a situation term as the last argument. For example, $\text{IST}(c,\text{BROKEN}(x))$ means that object x is broken in situation c. Functions whose denotations vary from situation to situation are called *functional fluents*. They are denoted by a function symbol with an extra argument taking a situation term, as in $\text{PHONE-NUMBER}(\text{BILL},c)$. Use of the situation calculus allows one to represent the effect of the different actions on the relevant fluents[8, 9, 13].

The special predicate $\text{CONTEXTCREATION}(t,c_1,c_2)$ captures the world creation notion of text world theory[19, 20]. So, context c_2 is created within context c_1. The t represents the type of creation. This can be "narrative" or "cognitive" or "epistemic", or "intentional, or "hypothetical". Worlds in the sense of text world theory are represented by contexts. There is no difference between world, situation, and context.

The special predicate $\text{REFERS}(s,o)$ is used to indicate that the stretch of speech s is used by some person p (the speaker) to refer to object o. This is an initial approximation of reference having occurred and a more fine grained analysis is planned for the future given the complexity of the notion [1, 15, 17, 18].

3　Deictic Expressions

Deictics are in the terminology of Jakobson[5], analyzed as *shifters*. These are elements of the linguistic code (C), the general meaning of which cannot be defined without reference to the message (M), hence, C/M. The message is being

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[1] The preliminary work presented here is somewhat agnostic as to the exact nature of the operator IST. It may be thought of as a modality, but reasoning along with the embedded contexts may be simpler by treating the arguments to the operator as reified formulas. See [4, 2, 14] for a discussion of the options available here.

spoken by a particular person, at a particular time, at a particular place and in the context of previous and following speech and actions. All of this is located in the context (world/situation) of the representation developed here.

Jakobson distinguishes between the narrated event (symbolized as E^n), the speech event E^s, a participant of the narrated event P^n, and a participant of the speech event P^n. In the representation developed here, E^s is the context created by the action of speaking, while E^n is the context (text world) created by the speech. It is in this context that the actions being talked about actually occur. The participants of the speech event P^s are people who exist in the context in which speaking takes place, while the participants of the narrated event E^n are people who exist in the narrated context, created as a new context within the context in which speech takes place.

Person deixis P^n/P^s relates the participants of the narrated event to those of the speech event. The use of the first-person (I in English) signals that the participant in the narrated event is identical to the speaker of the speech event. Therefore the first argument to the action SPEAK is identical to the person denoted by I in the context related by the world creation predicate. The second-person (you in English) signals the identity of a participant in the speech event with the hearer in the speaking context.

Tense, symbolized as E^n/E^s relates the time of occurrence of the narrated event to that of the speech event. The present tense may indicate that the speaking occurs at the same time, while the future tense may indicate that the narrated event occurs later than the speech event. The use of tense (along with aspect) in English and in the languages of the world is much more complex [7, 3, 20]. Handling the complexity is beyond the scope of this paper, but part of the larger project.

Mood, symbolized as $P^n E^n/P^n$ "characterizes the relation between the narrated event and its participants with reference to the participants of the speech event[5]." It reflects the speaker's view of the action in the narrated event. This is captured in the representation developed here by the different first arguments to the predicate CONTEXTCREATION(t, c_1, c_2).

There is also *place deixis* [7, 3, 6] that situates an entity in the event of narration spatially with respect to the event of speaking. Examples from English are *here*, or *there*. Background knowledge is needed to calibrate the nature of the space. For example, *there* can refer to the table in view or to some place thousands of miles away. Through the interpretation of deictic expressions, the context is constructed.

4   Example

Here is an example based on one used by Werth[20], which in turn was based on a story reported in *The Guardian* on May 14, 1992.

> I read in today's Guardian, over there on the table, an interesting story. A Naples man who kept cocaine in his mother's tomb was arrested

yesterday by drug agents posing as cemetery workers, police said. The known dealer was caught red-handed as he lifted the marble slab and reached inside for two envelopes containing cocaine.

Let s_1 represent the first sentence from the above account, s_2 the second sentence, and s_3 the third sentence.

The term c_0 is used to denote the initial context. This is the context of what Werth [19, 20] calls the *discourse world*. The speaker says the above paragraph. Assume that the speaker is P_1, then in the discourse world the result of the speaking of the first sentence is the context $\text{DO}(\text{SPEAK}(P_1, S_1), C_0)$, the context resulting from the second sentence is $\text{DO}(\text{SPEAK}(P_1, S_2), \text{DO}(\text{SPEAK}(P_1, S_1), C_0))$, and $\text{DO}(\text{SPEAK}(P_1, S_3), \text{DO}(\text{SPEAK}(P_1, S_2), \text{DO}(\text{SPEAK}(P_1, s_1), C_0)))$ is the result of speaking the final sentence.

A number of things are asserted within context c_0.

$$\text{IST}(C_0, \text{EXISTS}(OBJ_1) \wedge \text{NEWSPAPER}(OBJ_1))$$
$$\text{IST}(C_0, \text{EXISTS}(OBJ_2) \wedge \text{TABLE}(OBJ_2))$$
$$\text{IST}(C_0, \text{ON}(OBJ_1, OBJ_2)) \quad \text{IST}(C_0, \text{EXISTS}(P_1) \wedge \text{PERSON}(P_1))$$
$$\text{IST}(C_0, \text{EXISTS}(P_0) \wedge \text{PERSON}(P_0))$$
$$\text{SPEAKER}(C_0) = P_1 \quad \text{HEARER}(C_0, P_0)$$

There is an initial reference to the newspaper and the table. So, we have

$$\text{IST}(\text{DO}(\text{SPEAK}(P_1, S_1), C_0),$$
$$\text{REFERS}(S_1, OBJ_1) \wedge \text{DISTAL}(P_1, OBJ_1) \wedge$$
$$\text{REFERS}(S_1, OBJ_2) \wedge \text{DISTAL}(OBJ_2)).$$

Here *distal* is used as a rough approximation of the effect of the use of *there* rather than *here*. The speaking of the sentence has created what Werth [19, 20] calls a *text world* where the reading action takes place. This is a new context. So, we have

$$\text{CONTEXTCREATION}(\text{``}narrative\text{''}, \text{DO}(\text{SPEAK}(P_1, S_1), C_0), C_1)$$

indicating that there is a new context created in $\text{DO}(\text{SPEAK}(P_1, S_1), C_0)$ through the process of narration and that context is denoted by c_1. Additionally, because past tense was used, we indicate that $\text{TIME}(C_1) < \text{TIME}(\text{DO}(\text{SPEAK}(P_1, S_1), C_0))$. Since, the act of reading occurred within this text world, there is a new context $\text{DO}(\text{READ}(P_1, OBJ_1), C_1)$.

Within the text world describing the act of saying another text world is established. This is the text world where the police announced the crime and the arrest. We have

$$\text{CONTEXTCREATION}(\text{``}narrative\text{''}, \text{DO}(\text{READ}(P_1, OBJ_1), C_1), C_2)$$

indicating that there is a new context created in $\text{DO}(\text{READ}(P_1, OBJ_1), C_1)$ and that context is denoted by c_2. Additionally, because past tense was used, the relation $\text{TIME}(C_2) < \text{TIME}(C_1)$ is added. It is necessary to specify in c_2:

$$\text{IST}(C_2, \text{EXISTS}(P_5) \wedge \text{POLICE}(P_5))$$

Since, the act of saying by the police, occurred within this text world, we have the new context $\textsc{do}(\textsc{say}(\textsc{p}_5, \textsc{c}_3), \textsc{c}_2)$. As indicated above, the saying describes yet another text world. This is the text world where the criminal carried out his activities and was then arrested. So, we have

$$\textsc{ContextCreation}(\textit{``narrative''}, \textsc{do}(\textsc{say}(\textsc{p}_3, \textsc{c}_3), \textsc{c}_2), \textsc{c}_3)$$

indicating that there is a new context created in $\textsc{do}(\textsc{say}(\textsc{p}_3, \textsc{c}_3), \textsc{c}_2)$ through narration and that context is denoted by $\textsc{c}_3$. Additionally, because past tense was used, $\textsc{time}(\textsc{c}_3) < \textsc{time}(\textsc{c}_2)$ is added.

A number of things are asserted within context $\textsc{c}_3$.

$\textsc{ist}(\textsc{c}_3, \textsc{Exists}(\textsc{p}_3) \wedge \textsc{Man}(\textsc{p}_3) \wedge \textsc{DrugDealer}(\textsc{p}_3) \wedge \textsc{FromNaples}(\textsc{p}_3))$
$\textsc{ist}(\textsc{c}_3, \textsc{Exists}(\textsc{obj}_3) \wedge \textsc{Tomb}(\textsc{obj}_3))$
$\textsc{ist}(\textsc{c}_3, \textsc{Exists}(\textsc{p}_4) \wedge \textsc{TombOf}(\textsc{obj}_3, \textsc{p}_4) \wedge \textsc{MotherOf}(\textsc{p}_4, \textsc{p}_2))$
$\textsc{ist}(\textsc{c}_3, \textsc{Exists}(\textsc{p}_6) \wedge \textsc{DrugAgents}(\textsc{p}_6) \wedge \textsc{PosingAsCemeteryWorkers}(\textsc{p}_6))$
$\textsc{ist}(\textsc{c}_3, \textsc{Exists}(\textsc{obj}_6) \wedge \textsc{CocainePackets}(\textsc{obj}_6))$ $\textsc{place}(\textsc{c}_3) = \textit{``Naples''}$

A number of actions take place in context $\textsc{c}_3$. Here, using an abbreviation for a sequence of actions, we have

$$\textsc{do}([\textsc{hidesIn}(\textsc{p}_3, \textsc{obj}_3, \textsc{obj}_5), \textsc{lifts}(\textsc{p}_3, \textsc{obj}_3),$$
$$\textsc{reachesInside}(\textsc{p}_3, \textsc{obj}_4), \textsc{arrest}(\textsc{p}_6, \textsc{p}_3)], \textsc{c}_3)$$

To complete this example, situation calculus axioms need to be added to represent the effects of all of the actions.

5 Conclusion and Future Work

This paper has proposed an approach to representing the context created by the use of deictic expressions in narrative discourse. The work discussed here is just the beginning of a larger project. The representation of context needs to be expanded to include a wider variety of discourses and world building constructs as discussed in the text world literature [19, 20]. Methods for automatically parsing natural language texts and creating the contexts described here remain to be developed. Certainly the construction of the contexts from natural language texts will need to incorporate reasoning about the context that has been constructed so far. As noted in Werth[20] background information about the activities being described needs to be accessed. The representation needs to be extended to include contexts that are jointly constructed by multiple speakers. This will involve analysis of conversational acts [11]. Additionally, automated reasoning methods for inferring which propositions hold at each context are to be developed from those available for the situation calculus.

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