

Detecticon: A Prototype Inquiry Dialog System

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Abstract A prototype inquiry dialog system, dubbed Detecticon, demonstrates its ability to handle inquiry dialogs, including presenting reasonable arguments, tracking user beliefs, and refining its arguments. User interaction is supported by using a natural language interface and a graphical user interface.

1 Introduction

In the inquiry dialog framework, two participants cooperate to answer shared questions¹ [15], under the assumption that neither of them has complete domain knowledge. They make up for their lack of knowledge through mutual dialog. This characteristic distinguishes dialogs in this framework from slot-filling dialogs (e.g., [9, 14, 16]) and expert systems' dialogs (e.g., [6]), where one of the participants has complete domain knowledge.

Previous research has basically focused on theoretical aspects of inquiry dialog for autonomous agents [1, 4, 5, 7, 8, 10, 11, 12], while, to the best of our knowledge, only Sklar and Azhar [2, 3, 13] developed dialog systems that can handle inquiry dialogs with a human user. Since inquiry dialogs can occur for various situations, further analysis of human-system inquiry dialogs is needed to realize practical inquiry dialog systems for human users.

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¹ A question that is common to both participants

To promote the realization of practical inquiry dialog systems for human users, we are developing a system called **Detecticon**² for collecting human-system inquiry dialog corpora that can be used for analysis. Detecticon can handle inquiry dialogs with a human user. We explain its abilities in Section 2 and then give examples of actual dialogs between Detecticon and a human user in Section 3.

2 Outline of Detecticon

Inquiry dialogs are a discussion in which the participants (here, Detecticon and a human user) collaborate in order to answer shared questions³. The participants cannot reach an answer without considering the beliefs of both participants⁴ and thus must share their beliefs with the other participant. Detecticon has three features that enable it to handle inquiry dialogs with a human user: (1) it can present reasonable arguments, (2) it can track user beliefs, and (3) it can refine its arguments. It has two additional features that enable it to interact with a human user: a natural language interface and a graphical user interface (GUI). The modular implementation of these features is illustrated in Figure 1.

The **natural language interface** translates the user’s natural language input into a dialog act including beliefs and the system’s dialog act including beliefs into a natural language response. The beliefs are represented by first-order logic. For example, the user’s natural language input “Mr. Yoshida and Mr. Kobayashi are competitors” is translated into a dialog act including the belief *Competitors(Yoshida, Kobayashi)*. Translating the system’s dialog act is the inverse process of translating the user’s input. The “natural language understanding” module translates a user input into a corresponding dialog act, and the “natural language generation” module translates a system dialog act into a corresponding system response. Both modules utilize

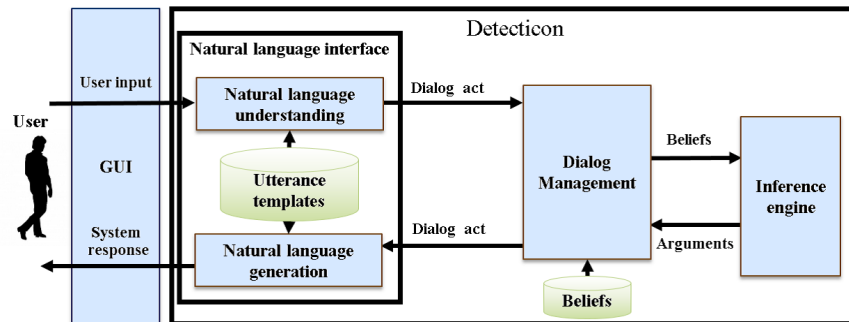


Fig. 1 Modular implementation of Detecticon features.

² Detection is meant to be a text-based inquiry dialog system to act as a detective.

³ More precisely, inquiry dialogs are dialogs arising from an initial situation of “general ignorance” and having the main goal to achieve the “growth of knowledge and agreement.” Each participant in the dialog has the goal to “find a proof or destroy one.” [15]

⁴ See Table 1 and upper part of Table 2 for examples.

utterance templates for their translations. The templates describe two types of mapping of entities; namely, 1) a natural language sentence and a dialog act type (e.g., presenting an argument); 2) a natural language sentence and a semantic content represented as logical formulae. The translations are performed by pattern matching of these templates.

Present reasonable arguments: Detecticon presents reasonable arguments to share what it believes with a human user. An argument consists of a claim and supporting evidence. The claim addresses the given question and be logically derived from the supporting evidence, which is a subset of the system’s beliefs. For example, assume that Detecticon holds the beliefs listed in Table 1 and the question is “Who are competitors? ($\exists?x,y \text{ Competitors}(x,y)$).” Detecticon can presents the following argument:

Claim: Yoshida and Okamoto are competitors. / $\text{Competitors}(\text{Yoshida}, \text{Okamoto})$

Supporting evidence:
$$\left(\begin{array}{c} \text{Work_for_company}(A, \text{Yoshida}) \\ \text{Work_for_company}(B, \text{Okamoto}) \\ \forall x,y \text{ Work_for_company}(A,x) \wedge \text{Work_for_company}(B,y) \\ \rightarrow \text{Competitors}(x,y) \end{array} \right)$$

Detecticon generates an argument as follows. First, the dialog management module reads its holding beliefs (e.g., Table 1), calls the inference engine, and sends the beliefs to the engine. The engine generates possible arguments that are consistent with given beliefs. Finally, the dialog management module chooses one of the possible arguments on the basis of the manually designed policy.

Track user beliefs and refine its arguments: Detecticon refines its arguments to reflect the user’s beliefs. It tracks the beliefs expressed by the user during the dialog and uses them to generate new arguments. It can thus present arguments that are not based solely on its own beliefs. Once the dialog management module receives the user’s dialog act including beliefs from the natural language understanding module, it holds them and uses them for generating arguments.

Detecticon handles dialogs with the user by using the **GUI** shown in Figure 2. The GUI provides a dialog history view, a toggle switch for displaying dialog acts, a user input form, a start/close dialog button, and an agenda tree view. The dialog history view provides the history of the dialog. The toggle switch switches the appearance of dialog acts corresponding to the natural language utterances in the dialog history view. The user input form accepts natural language user utterances and forwards them to the natural language understanding module. The input form

Table 1 Example beliefs

Mr. Yoshida works for company A.	$\text{Work_for_company}(A, \text{Yoshida})$
Mr. Okamoto works for company B.	$\text{Work_for_company}(B, \text{Okamoto})$
Mr. Tanaka works for company C.	$\text{Work_for_company}(C, \text{Tanaka})$
An employee of company A and an employee of company B are competitors.	$\forall x,y \text{ Work_for_company}(A,x) \wedge \text{Work_for_company}(B,y) \rightarrow \text{Competitors}(x,y)$

provides free form and template based form. The latter is provided in order to reduce erroneous novice user input. The start/close dialog buttons are used to start a new dialog or to close an existing dialog. The agenda tree view displays a tree representation of topics, where the nodes represent the topics proposed by the participants, and the edges represent the transitions between topics.

3 Dialog example

As an example within the inquiry dialog domain, we assume a situation in which the participants (Detecticon and a user) address *Compliance Violation Detection* and act as detectives. They are given different information sources (sets of beliefs) and then start a discussion aimed at answering the question, “Is there a compliance violation?” The upper part of Table 2 shows example beliefs. For this example domain, we prepare 542 beliefs (16 domain beliefs and 526 state beliefs⁵) and its natural language transcriptions. Each belief is assigned to Detecticon, its user, or neither of them, so that neither of them have complete set of beliefs.

An example dialog is shown in the lower part of Table 2. The participants set the topics for discussion at id= 2,5. Detecticon sets the topic to discuss “bid rigging” because it believes a compliance violation can be proven if they proof that bid rigging occurred (id= 2). The user sets the topic to discuss bid rigging in more detail (id= 5). Detecticon’s utterances at id= 6, 8, 10, 12, 16 are examples of **pre-**

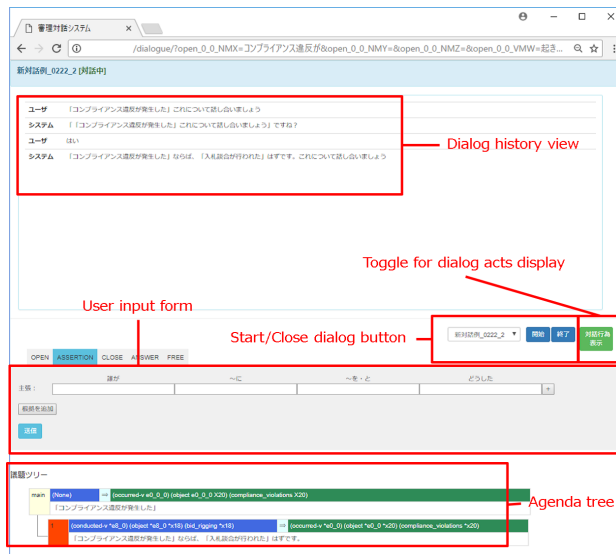


Fig. 2 Graphical user interface of inquiry dialog system.

⁵ The domain belief is an inference rule such that “ $\forall x, y \text{ Work_for_company}(A, x) \wedge \text{Work_for_company}(B, y) \rightarrow \text{Competitors}(x, y)$.” The state belief is an grounded atom such that “ $\text{Competitors}(\text{Yoshida}, \text{Okamoto})$.”

senting reasonable arguments. The utterances at id=5,9,12,16 are examples of **track user beliefs and refine its arguments.** Initially, Detecticon does not know (1) the definition of bid rigging and that (2) “Kobayashi proposed an order price to Yoshida.” As the dialog proceeds, it acquires this information from the user (id=5,9) and reaches the conclusion that there was bid rigging (id= 12) and therefore a compliance violation occurred (id=16).

Table 2 Example inquiry dialog for *Compliance Violation Detection*. Upper table shows example participant beliefs at beginning of dialog. Lower table shows transcription of dialog translated from Japanese.

User	If A and B are competitors, and if A proposed an order price to B and B accepted the proposed price, bid rigging occurred.
	Kobayashi agreed that Yoshida will choose the company from which to take an order.
	Kobayashi proposed an order price to Yoshida.
	Takahashi accepted the order price.
Detecticon	If there was bid rigging, a compliance violation occurred.
	Yoshida and Kobayashi are competitors.
	Yoshida proposed to Kobayashi that he (Yoshida) will choose the company from which to take an order.
	Yoshida accepted Kobayashi's proposed order price.

id	Speaker	Transcription
1	User	Let's talk about whether a compliance violation occurred.
2	Detecticon	If there was a compliance violation, bid rigging might have occurred as well. Let's discuss it.
3	User	Ok.
4	Detecticon	I don't have anything to tell you on the current topic (i.e., "If there was a compliance violation, bid rigging might have occurred as well."). Do you have any relevant information?
5	User	If bid rigging occurred (by suspects), (the suspect) A and (the suspect) B should be competitive with each other, and A should propose order prices to B, and B should accept A's proposal. Let's discuss that.
6	Detecticon	Yoshida and Kobayashi are competitors.
7	User	Kobayashi agreed that Yoshida will choose the company from which to take an order.
8	Detecticon	Yoshida proposed to Kobayashi that he (Yoshida) will choose the company from which to take an order.
9	User	Kobayashi proposed an order price to Yoshida.
10	Detecticon	Yoshida accepted Kobayashi's proposed price.
11	User	Takahashi accepted the order price.
12	Detecticon	Bid rigging occurred because (1) Kobayashi and Yoshida are competitors, (2) Kobayashi proposed an order price, and (3) Yoshida accepted Kobayashi's proposed price.
13	User	I have nothing else to add on the current topic (If bid rigging occurred, A and B should be competitors, and A should propose order prices to B, and B should accept A's proposal).
14	Detecticon	Me neither. Then, let's get back to the previous topic (If there was a compliance violation, bid rigging might have occurred as well). Let's talk about it.
15	User	I don't have anything to tell you on the current topic (If there was a compliance violation, bid rigging might have occurred as well).
16	Detecticon	There was a compliance violation because bid rigging occurred.
Dialog is closed		

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