

# Recognizing Topics through the Use of Interaction Structures

TAKESHITA, Atsushi

NTT Human Interface Laboratories  
1-2356 Take Yokosuka-Shi Kanagawa 238-03 Japan  
E-mail: take@nthli.ntt.jp

## Abstract

A crucial problem in topic recognition is how to identify topic continuation. Domain knowledge is generally indispensable for this. However, knowledge-based approaches are impractical because not all domain knowledge needed for the identification can be prepared in advance.

This paper presents a topic recognition model using dialogue interaction structures. The model can deal with both task-oriented and non-task-oriented dialogues in any language. Topic continuation is identified without domain knowledge because utterances of relevant topics are indicated by certain interaction structures. The model avoids the weak point of knowledge-based approaches. The model is validated by the result of a topic recognition experiment.

## 1 Introduction

An aggregation of sentences having local coherence is called a "discourse segment". Such a structure must be recognized to understand discourse including dialogues. The structure constrains candidates, for example, referents for anaphora resolution and plans for plan recognition. A topic is a kind of local coherence. Segments can be recognized in both task-oriented and non-task-oriented dialogues because most dialogues have explicit topics.

Recognized topics can also be used in a topic-oriented video retrieval support system. The system recognizes the topic structures of video sequences such as documentaries, and shows a topic list. Topic nests are expressed by indentation. Users can survey the contents of a video library, and play back sequences connected to an interesting topic.

This paper describes how to recognize top-

ics of both task-oriented and non-task-oriented dialogues without domain knowledge. First, a basic topic recognition mechanism is discussed. Second, identifying topic continuation through the interaction structure is presented. Finally, coverage of the interaction structure approach is discussed.

## 2 A Topic Recognition Mechanism

### 2.1 What Is a Topic?

Topics are discourse referents shared by dialogue participants. They are things described by noun phrases and events described by verb phrases. However, these referents are topic candidates not topics. Those referents recognized as topics by persons must be shared by participants for a while; presented as topics again, or referred to by pronouns or zero pronouns.

A set of utterances having topic coherence is called a "topic segment". Topic structures consist of topic segments, topics in the segment and relations between the segments: nests or conjunctions. Post Office Dialogue in Fig.1 can be segmented into topic segments as follows:

(A-1 B-1 (A-2 B-2 A-3 B-3 A-4 B-4)) (A-5).

郵便の配達 (Mail delivery) is talked about from utterance A-1 to B-4, 速達 (express) from A-2 to B-4 and so on.

There are various types of relations between topics. In Post Office Dialogue in Fig.1, the topic "速達 (express)" in utterance A-2 is a subtopic of the topic "郵便の配達 (mail delivery)" in A-1 because 速達 is a subcategory of 郵便 (mail). In another example where a certain person *Taro* had moved to Kyoto recently, Kyoto may be a subtopic of *Taro*. Non-task-oriented dialogues may include various topic relations.

- A-1 郵便の配達についてお伺いしたいのですが。  
I'd like to ask you a question about mail delivery.
- B-1 はい、どうぞ。  
Yes, sir.
- A-2 速達を出したいのですが。  
I want to send a letter by express.
- B-2 速達便ですか？  
Special delivery?
- A-3 京都に明日までに届きますか？  
Will the letter reach Kyoto by tomorrow?
- B-3 次に郵便物を回収するのは正午ですから、届くと思いますか。  
I think it will because the next letter collection is at noon.
- A-4 そのポストに入れておけばいいですか？  
Can I drop the letter into that mailbox?
- B-4 はい。  
Yes.
- A-5 次に郵便貯金をしたいのですが。  
The next question is about a postal deposit.

Figure 1: Post Office Dialogue

This variety of topic relations makes it difficult to identify topic relevance by domain knowledge prepared in advance. Thus, the weak point should be avoided by a new approach.

## 2.2 Topic Markers and Clue Words

There are many topic marker expressions in Japanese. For example, expressions in Table 1 indicate topics explicitly. English expressions such as “concerning ...” and “as regards ...” are similar to these expressions.

Japanese expression	pronunciation
TOPIC に関して	(ni kanshi te)
TOPIC について	(ni tsuite)
TOPIC というのは	(to iu no wa)
TOPIC は	(wa)

“TOPIC” means an indicated topic.

Table 1: topic marker expressions

Focus candidate priority in Japanese has been proposed[1] [4]:

*TOPIC* > *EMPATHY* > *subject*  
> *object* > *others*

*TOPIC* is a noun phrase marked by the postpositional particle “は (wa)”. In the sentence “東京 (Tokyo) は 日本の (Japanese) 首都 (capital) です (is)”, 東京 (Tokyo) is *TOPIC*. *EMPATHY* includes the subject of mental verbs such as 喜ぶ (yorokobu, be glad), the source of 行く (iku, go), etc.. These verbs indicate the speaker's perspective. The subject markers include “が (ga)”, and the object markers “を (wo)”.

These candidates can be used for topic markers. The candidate priority of topics is the same as that of focus; if *TOPIC* exists, it is a topic. If *TOPIC* does not exist but *EMPATHY* does, *EMPATHY* is a topic.

Examples of Japanese clue words indicating a topic change are shown in Table 2. Corresponding English clue words are also shown.

Japanese	pronunciation	English
まず第一に	(mazu daiichi ni)	first
次に	(tsugi ni)	next
それから	(sorekara)	then
ところで	(tokorode)	now

Table 2: clue words

## 2.3 A Topic Stack

A stack is used to handle discourse segments in the discourse model by B.J.Grosz[2]. A stack element corresponds to a segment, and is called a “focus space”. Discourse entities such as objects are maintained in focus spaces. The top stack element holds the most salient entities. Discourse segment structures are related to the intentional structure. The “dominance” and “satisfaction precedence” relation between intentions decides pushing and popping of focus spaces.

A “topic segment” is a discourse segment of large size, and “topic stack” is used to handle topics. However, pushing and popping of topics cannot be determined by the intentional structure in our approach because both topic-oriented and non-topic-oriented dialogues are treated, and the intentional structure may be ill-formed.

Instead of the intentional structure, only clue words are allowed to determine the pushing

and popping. For example, “まず第一に (first)” indicates pushing, and “次に (next)” popping. To recognize local topic structures, a simple mechanism is used. Each element of a topic stack is treated as a stack called an “inner stack”. Topics are pushed onto the inner stack. If an explicit topic indicated by makers in Table.1 is recognized, non-explicit topics are popped from the stack.

### 3 Identifying Topic Continuation

#### 3.1 The Basic Idea

In dialogues, topics can be changed naturally at some utterances, but not at others. For example, topics unfold naturally in the dialogue in Fig. 1. On the other hand, topic expansion is not natural in the dialogue in Fig. 2.

- P-1 Will the letter reach Kyoto by tomorrow?  
 Q-1 The next question is about a postal deposit.

Figure 2: unnatural topic expansion

#### 3.2 Topic Expansion and Speech Acts

The unnatural topic expansion in Fig.2 is related to speech act purposes called illocutionary points. Classification of the illocutionary points was proposed by J.R.Searle[3]: The “assertive point” tells how the world is, e.g. to state and to predict. The “commissive point” commits the speaker to doing something. A promise is an example. The “directive point” tries to have the hearer do things. Making a request is an example. The “declarative point” changes the world by saying so, e.g. to declare and to name. The “expressive point” expresses the speaker’s feeling, e.g. to apologize.

A hypothesis is built: *if a current utterance follows a directive utterance, the current topic is relevant to the topic in the directive utterance.* This is called “topic forwarding”. The unnatural topic expansion in Fig.2 can be explained by this hypothesis. The topic of utterance Q-1 must be relevant to one topic of P-1 because the utterance P-1 is directive. However, “次に (next)”

Speech Acts	Japanese Expressions
ask	～ですか (desu ka), ～ますか (masu ka)
request	～頂けますか (itadake masu ka)
confirm	～ね (ne)

Table 3: Examples of Topic-Binding Speech Acts

Speech Acts	Japanese Expressions
inform	～ですけど (desu kedo), ～です (desu ga)
acknowledge	はい (hai), ええ (ee)

Table 4: Examples of Topic-Nonbinding Speech Acts

indicates a topic change. This contradiction causes unnatural topic expansion.

Utterance pairs such as “requesting – accepting” and “asking – informing” will retain a topic even if the pairs are nested. For example, in the following, R-1 – S-2 have the topic of “restaurant” and S-1 and R-2 have the topic of “money for restaurant”.

- R-1 Do you know a good restaurant?  
 S-1 How much money do you have?  
 R-2 My salary is low.  
 S-2 That restaurant is cheap and good.

However, pairs are not always so formed. In Post Office Dialogue in Fig.1, utterance A-3 performs two speech acts: informing-if and asking. Deeper dialogue understanding is needed for correct pair identification. Therefore, in this work, the pairs are not identified and a directive utterance is regarded as forwarding a topic only to the next utterance.

#### 3.3 Utterance Types

“Topic forwarding” classifies utterances into two types: *topic-binding* and *topic-nonbinding* utterances. Topic-binding utterances have the directive point but topic-nonbinding ones do not. Topic-binding utterance speech acts include to ask, to request and to confirm. Topic-nonbinding utterance speech acts include to inform and to acknowledge.

In Japanese, the utterance type can be identified by pattern matching with expressions such as those shown in Table 3 and 4.

### 3.4 Topic Recognition

A set of consecutive utterances in which the same topics continue is called a "topic unit". A topic unit can be identified by using "topic forwarding" instead of domain knowledge:

1. The current utterance belongs to the same topic unit as the previous utterance if the previous utterance is topic-binding, or there is no topic candidate indicated by a topic marker in the current utterance.
2. Otherwise, a new topic unit is created.

The unit is used to validate candidate of topics and topic changes, and has no effect on the topic and the inner stack.

Noun phrases indicated by topic markers are regarded as *topic candidates*, and utterances with clue words are detected as *topic change candidates*. Some of them are recognized as topics. Topic candidates are preserved in a "candidate list". Recognized topics are pushed onto the inner stack of the topic stack described in 2.3. Topics can be identified by using the topic unit:

- a) A topic candidate indicated by a topic marker such as those listed in Table 1 is immediately recognized as a topic, and pushed onto the inner stack. This is because such markers indicate topics explicitly. These markers are called "explicit topic markers", and the topics "explicit topics".
- b) A topic candidate indicated by other markers such as "が (ga)" and "を (wo)" is preserved in the candidate list. It is recognized as a topic only when the candidate continues for  $n$  utterances. If recognized as a topic, it is removed from the candidate list, and pushed onto the inner stack. The optimum value of  $n$  is 4 according to the results of a manual topic recognition experiment.
- c) If a new topic unit is generated, the candidate list is reset to an empty list.
- d) A topic change candidate is recognized as a topic change only when the candidate is in the first utterance in a topic unit.

If a topic change is recognized, the candidate list is reset to an empty list and the inner stack is pushed onto or popped from the topic stack according to clue words.

This topic recognition algorithm can be used for any language because "topic forwarding" is not language-specific. Only dictionaries for the topic markers, the clue words and the utterance type identification are unique for each language.

### 3.5 An Example of Topic Recognition

In utterance *A-1* in Post Office Dialogue in Fig. 1, "郵便の配達 (yuubin no haitatsu, mail delivery)" is identified as a topic candidate by the topic marker "について (ni tsuite)". This candidate is immediately recognized as a topic because of the explicit marker. Utterance *A-1* and *B-1* belong to the same topic unit because *B-1* has no topic candidate. The system state after processing *B-1* is the following. Each element of the topic stack is an inner stack. The right-most element of the topic and the inner stack is the top stack element.

$$\begin{aligned} \text{TopicStack} &= [[\text{郵便の配達}]] \\ \text{CandidateList} &= \{\} \end{aligned}$$

From utterance *A-2* to *B-3*, a topic marker "を (wo)" is detected in *A-2* and *B-3*, and "に (ni)" in *A-3*. Therefore, "速達 (sokutatsu, express)" in *A-2*, "京都 (Kyoto)" in *A-3* and "郵便物 (yuubin butsu, mail)" in *B-3* are identified as topic candidates. Furthermore, *B-3* is detected as a topic change candidate because of the clue word "次に (tsugi ni, next)". *A-2* generates a new topic unit because *B-1* is topic-nonbinding and there is a topic candidate in *A-2*. As a result of the unit generation, the candidate list is reset. Utterances from *B-2* to *B-3* belong to the second topic unit. This is because there is no topic candidate in *B-2*, and *B-2* and *A-3* are topic-binding. Therefore, the candidate "速達" continues for 4 utterances in the second topic unit and is recognized as a topic. The topic change candidate in *B-3* is dismissed correctly because it is not in the first utterance in the topic unit. The system state after processing *B-3* is:

$$\begin{aligned} \text{TopicStack} &= [[\text{郵便の配達}, \text{速達}]] \\ \text{CandidateList} &= \{\text{京都}, \text{郵便物}\}. \end{aligned}$$

Utterance *A-4* generates a new topic unit and the candidate list is reset to an empty set. In *A-4*, "ポスト (posuto, a mailbox)" is detected as a topic candidate. *B-4* belongs to the unit. The state of the inner stack does not change.

In utterance A-5, a topic candidate “郵便貯金 (yuubin chokin, a postal deposit)” is identified. A-5 is detected as a topic change candidate because of the clue word “次々 (tsugini, next)”. The change candidate is recognized as a topic change correctly because A-5 is the first utterance of a new topic unit. As a result, the inner stack is popped from the topic stack. The system state after processing A-5 is:

$$\begin{aligned} \text{TopicStack} &= [[]] \\ \text{CandidateList} &= \{\text{郵便貯金}\}. \end{aligned}$$

## 4 Discussion

The results from a topic recognition experiment using 207 utterances taken from dialogue transcripts is shown in Table 5. Topics recognized by our system are compared with the manually recognized topics.

Recognition and dismissal of topic change candidates was performed correctly. This correctness has the beneficial effect that wrong popping of the topic stack and the reset of the candidate list can be avoided.

2 noun phrases were wrongly recognized as topics by the system. These errors occurred when current topic *T-1* returned to past topic *T-2*, and *T-2* was not described explicitly at that time. Although a topic change has occurred, *T-1* is regarded as a current topic because no topic candidate was presented.

3 topics were not recognized as topics but were wrongly dismissed. This error occurred when the current topic was rephrased; “topic forwarding” fails in this case. Synonyms such as a fridge and a refrigerator are often used.

Topic recognition accuracy is sufficient for a topic-oriented video retrieval support system. The recognition method is effective especially in dialogues with interaction structures such as “asking – asking” and “requesting – asking”. The experimental results show that such structures are included in many dialogues. Mixed-initiative dialogues may form the structures.

To improve topic recognition accuracy, other approaches such as a knowledge-based approach can be added. For example, a synonym list and a thesaurus would contribute to topic continuation identification.

	Recognized		Dismissed	
	correctly	wrongly	correctly	wrongly
Changes	2	0	2	0
Topics				
explicit	15	3	—	—
other	7	2	5	3

Table 5: The Number of Recognized and Dismissed Candidates

## 5 Conclusion

A topic recognition model has been proposed. The model identifies topic continuation by using dialogue interaction structures instead of domain knowledge. This is based on the hypothesis that a directive utterance repeats the same topic until the next utterance. The model has been validated by the results of a topic recognition experiment.

## References

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