Corpus-based Discourse Understanding in Spoken Dialogue Systems

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Overview

- A new discourse understanding method in spoken dialogue systems
  - discourse understanding means utterance understanding taking the context into account
  - retains the ambiguity of a user utterance and resolves it by subsequent utterances
  - uses statistical information derived from dialogue corpora

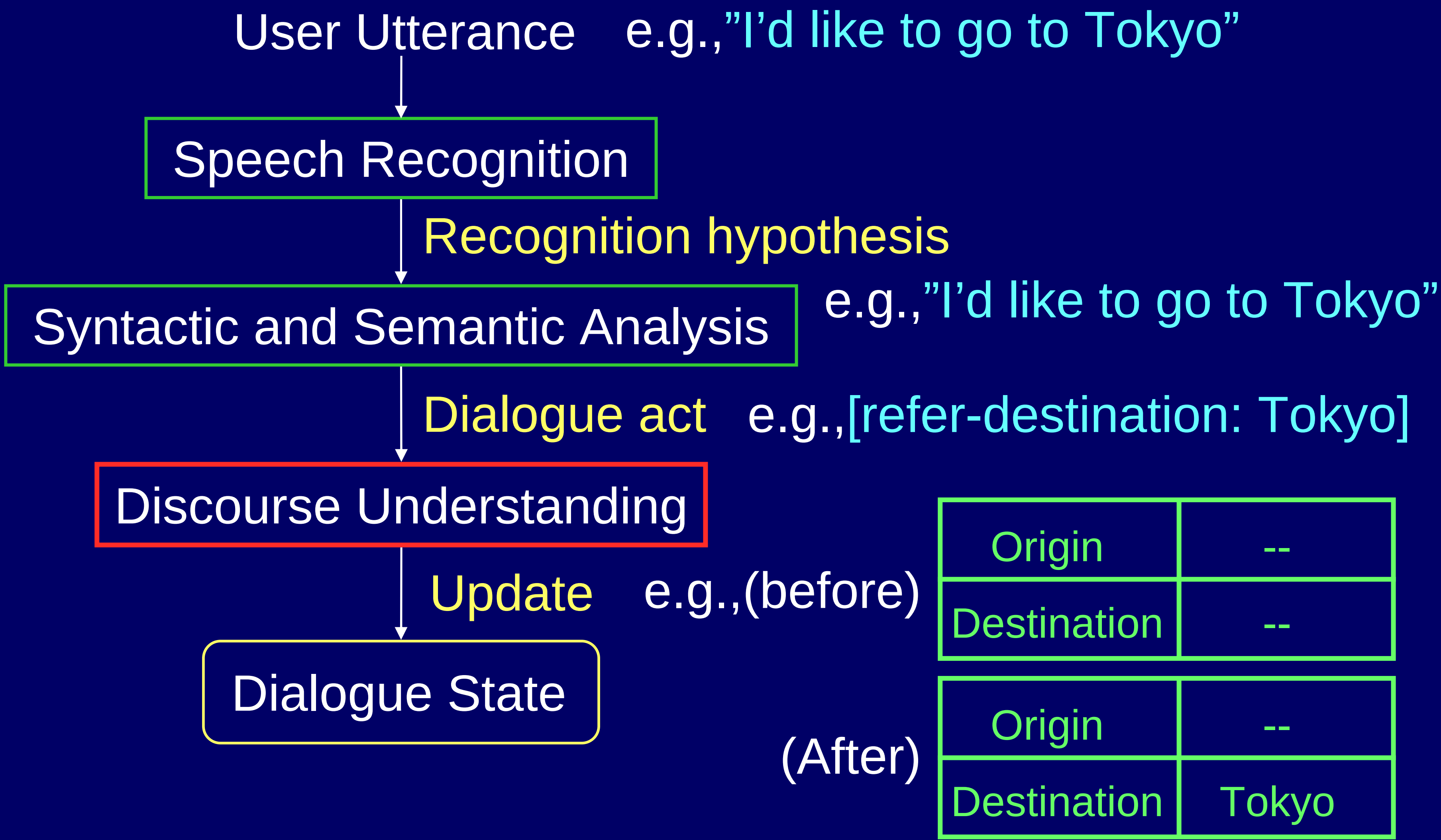
Objective

- Spoken dialogue systems that can
  - accurately understand user intention using the context of a dialogue

Benefits:

- more efficient dialogue
- robust to misrecognitions

Discourse Understanding



Problem

- Ambiguities in discourse understanding
  - Speech recognizer outputs multiple recognition hypotheses (N-best)
  - Syntactic and semantic analysis produce multiple parsing results

→ multiple dialogue act candidates and thus multiple dialogue state candidates are derived from a user utterance

System has to appropriately rank the dialogue state candidates to obtain the most plausible user intention

Problem: an example

Example dialogue:
(Flight reservation domain)

User : "To Sapporo"
System: "uh-huh"
User : "From Tokyo"

Origin	--
Destination	--

"To Sapporo"
[refer-origin: Sapporo]

"To Sapporo"
[refer-destination: Sapporo]

Origin	Sapporo
Destination	--

Which one is more plausible?

"uh-huh"
[sys:backchannel]

Origin	--
Destination	Sapporo

"From Tokyo"
[refer-origin: Tokyo]

"From Tokyo"
[refer-origin: Tokyo]

Origin	Tokyo
Destination	--

Which one is more plausible?

Origin	Tokyo
Destination	Sapporo

Related Work

- ISSS Method (Nakano et al.,1999)
  - rank multiple dialogue states by hand-crafted scoring rules

  → creating rules by hand is costly
- Estimation of dialogue act type (Nagata et al. 1994)
  - estimate the most probable dialogue act from previous dialogue act sequences

  → mainly aims at improving recognition accuracy; not applied to dialogue systems

Approach

- Use of statistical information derived from dialogue corpora to score the dialogue states
- Keep the low-ranked dialogue states to allow possible understanding in the future

Statistical Information

- N-gram probability of a dialogue act type sequence (as Nagata et al.)
  - represents brief (superficial) flow of a dialogue
- Collocation probability of a dialogue state and the next dialogue act
  - deals with more detailed information about the dialogue
  - such as dialogue state changes including grounding information

Dialogue State Scoring

- Update the score of dialogue states by the following formula

Score of the updated dialogue state =

Score of the dialogue state before update

$+ \alpha \cdot$ Score of a dialogue act
(from Speech Recognition and the Syntactic and Semantic Analysis)

$+ \beta \cdot$ N-gram probability score of dialogue act type sequences

$+ \gamma \cdot$ Collocation probability score of a dialogue state and the next dialogue act

(α, β, and γ are weighting factors)

Progress of Understanding

Example dialogue: (Flight reservation domain)

User : "To Sapporo"
System: "uh-huh"
User : "From Tokyo"

Origin	--
Destination	--

"To Sapporo"
[refer-origin: Sapporo]

Origin	Sapporo
Destination	--

"To Sapporo"
[refer-destination: Sapporo]

Origin	--
Destination	Sapporo

Score : **X** **>** Score : **Y**

←**plausible**

"uh-huh"
[sys:backchannel]

"From Tokyo"
[refer-origin: Tokyo]

Origin	Tokyo
Destination	--

"From Tokyo"
[refer-origin: Tokyo]

Origin	Tokyo
Destination	Sapporo

Score : **Z** **<** Score : **W**

plausible→

Data Collection

- Corpus
  - 240 dialogues collected in the meeting room reservation domain
  - 26 dialogue act types
  - Vocabulary of 168 words
  - All the utterances transcribed and converted to dialogue acts
- Extraction of statistical information
  - Trigram probability of dialogue act types
  - Collocation probability
    - Classify the way of collocation into 64 classes
    - Use occurrence probability of each class
    - 17 classes found in the corpus

Implementation

- Scoring formula

  Score of the updated dialogue state =

  Score of the dialogue state before update

  $+ \boldsymbol{\alpha} \cdot \log(1 / \text{N-best-rank})$

  $+ \boldsymbol{\beta} \cdot \log(\text{dialogue act type trigram probability})$

  $+ \boldsymbol{\gamma} \cdot \log(\text{collocation probability}) \quad (\boldsymbol{\alpha} = \boldsymbol{\beta} = \boldsymbol{\gamma} = 1)$

- Maximum number of dialogue states
  - Enables real-time processing by avoiding explosion of dialogue states
- Response generation
  - Rule-based response generation based on the highest-ranked dialogue state

Experiment (1)

- Verification of our approach
  - Collected 256 dialogues with the implemented system
  - 5-best recognition hypotheses as input
  - Maximum number of dialogue states: 15
  - Task completion rate: 88.3% (succeed in reservation within 5 minutes)

→ Sufficiently high percentage of task completion rate suggests that system based on our approach works sufficiently

Experiment (2)

- Effectiveness of holding multiple dialogue states
  - System1 (maximum number of dialogue states: **1**)
    VS.
    System30 (maximum number of dialogue states: **30**)
  - 224 dialogues collected with each system
  - System30 outperformed System1 both in task completion rate and task completion time
  - Average task completion time of System30 (95.86 sec.) was significantly shorter than that of System1 (107.66 sec.)

→ Holding multiple dialogue states is effective

Conclusion

- A new discourse understanding method that
  - retains the ambiguity of a user utterance and resolves it by subsequent utterances
  - uses statistical information derived from dialogue corpora
- Experimental results show the validity of our approach