(Semi-)Automatic Analysis of Dialogues

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Abstract: We study human-human and human-computer dialogues with the aim to determine which dialogue acts and communicative strategies do the participants of interaction use, and which structural parts does a dialogue include. We develop software that makes it possible to recognise and annotate the dialogue acts, the dialogue structure and the communicative strategies. In order to recognise dialogue acts, a data-driven method is implemented when determination of the dialogue structure and the strategies is based on rules. The software tool is used by linguists in dialogue studies which further aim is to develop a dialogue system that interacts with a user in natural language following norms and rules of human-human communication. The contribution of the paper consists of integration of the existing approaches within a common platform and adaptation to the Estonian language.

1 INTRODUCTION

The pragmatic analysis of a coherent text usually follows to the morphological, syntactic and semantic analysis of the sentences which form the text. The output of preceding stages of analysis is used as the input of the following stage.

We are studying a special kind of texts – dialogues (transcripts of human-human spoken dialogues and human-computer written dialogues). We try to carry out the pragmatic analysis of dialogue texts without the traditional preceding stages of analysis (morphological, etc.). Therefore, the input of the pragmatic analysis is a plain text. First, we determine the dialogue acts (DA) in a dialogue using a statistical method. After that, recognition of the dialogue structure and dialogue strategies can be carried out using the rules which are based on the DAs.

Our aim is to build a software tool that can be used by linguists for annotating the dialogues in order to study and compare their structure.

Different typologies of DAs have been worked out (e.g. Sinclair and Coulthard, 1975, Stenström, 1994, Bunt et al., 2012). The most well-known typology, DAMSL (Allen and Core, 1997), is proposed as the standard annotation scheme for dialogue tagging by the Discourse Resource Initiative. The main aim of DAMSL is to capture the multiple function utterances can have, as well as the interrelation of different speech acts.

We have worked out our own typology of DAs which is based on the principles of organization of conversation borrowed from the Conversation Analysis, CA (Hutchby and Wooffitt, 1998) which has been our main research method since 1990s. We are using the act typology for annotating our dialogue corpus. However, the main part of our typology coincides with DAMSL.

Several data-driven methods have been used for recognition of DAs: n-grams, Hidden Markov Models, Bayes classifiers, neural networks, decision trees, transformation-based learning, memory-based learning, etc (Reithinger and Maier, 1995, Wright, 1998, Keizer et al., 2002, Grau et al., 2004, Levin et al., 2003, Samuel et al., 1998, Fernandez et al., 2005). We are using Naïve Bayes classifier for recognition of DAs.

The structural parts of a dialogue can be determined using the rules formulated on the basis of DAs. The dialogue manager of a dialogue system uses information about the structure of communication in order to understand the user's utterances and to generate its own responses (Field et al., 2008).

Communicative strategies, or dialogue policies, have been annotated and studied in information seeking dialogues (Jokinen, 1996) and in negotiation dialogues (Georgila et al., 2011). Reinforcement

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learning has been used to recognise argumentation policies in negotiations. We are departing from the notion of communicative strategy as introduced by Jokinen in her Constructive Dialogue Model, CDM (Jokinen, 1996, 2009). We use rules to assign the communicative strategies to utterances.

The paper is organised as follows. In section 2 we introduce our data – the Estonian dialogue corpus and the dialogue act typology. Sections 3 to 5 describe the functionality of the software tool: semi-automatic recognition of dialogue acts, automatic determination of structural parts of dialogue and communicative strategies. In section 6 we draw conclusions.

2 DIALOGUE CORPUS AND THE TYPOLOGY OF DIALOGUE ACTS

2.1 Estonian Dialogue Corpus

The Estonian Dialogue Corpus (Hennoste et al., 2008) currently includes three parts. The first part of the corpus is formed by human-human spoken dialogues recorded in authentic situations and transliterated using the transcription of CA (Hutchby and Wooffitt, 1998). In our corpus, there are telephone calls as well as face-to-face conversations, among them institutional as well as everyday conversations. Most of them are institutional information-seeking dialogues. The number of the dialogues is over 1000. The main aim of recording the dialogues has been the study of human-human conversation. For that reason, the corpus includes various types of dialogues: directory inquiries, calls to travel agencies, bus stations, outpatients' offices, shops, etc. as well as face-to-face dialogues in shops, services, travel agencies, guiding on the street, etc. However, such diversity makes harder the automatic analysis of dialogues. The corpus is open and increasing, new recordings and transliterations will be made and added into the corpus.

The second part of the corpus is collected in Wizard-of-Oz (WOZ) experiments where a human plays the role of the computer (Dahlbäck et al., 1993, Bellucci et al., 2009). Custom software is used for experiments. A user puts in his/her text (request for information) from the keyboard and receives the Wizard's answers on the screen. The number of WOZ dialogues is about 100.

The third part of the corpus is formed by actual interactions with two web-based dialogue systems (DS). One of them gives information about cinema programmes and the other – dental information (www.dialoogid.ee). The user puts in his/her texts in Estonian from the keyboard and receives the computer's answers on the screen, similarly with the WOZ experiments. The number of dialogues is about 100.

Different kinds of dialogues have been collected and used in dialogue studies for comparison. A part of the corpus has been used for development of the software. Still, the software is aimed for the automatic analysis of the whole corpus which is increasing in time.

2.2 The Typology of Dialogue Acts

Our main aim is to support the study of human-human communication. For that reason, we have worked out our own typology of DAs (s. an overview in Appendix). The typology is based on CA. In the typology, the DAs are divided into two groups – adjacency pair (AP) acts where the first pair part expects a certain second pair part like question – answer, and non-AP acts like acknowledgement.

On the other hand, the DAs are divided into communication managing acts (e.g. greeting and thanking), repair acts (e.g. other-initiated repair), and information acts (e.g. different types of questions). The name of a DA consists of two parts separated by a colon (e.g. QU: *Wh*-question, VR: Acknowledgement): the first part indicates the act class (e.g. QU – questions, VR – voluntary responses) and the second part is the proper name of the act (e.g. *Wh*-question, Acknowledgement). The total number of the acts is 126. The full list can be found e.g. in (Hennoste and Rääbis, 2004). Fig. 1 demonstrates the transcript of a spoken dialogue where DAs are annotated (DA tags are placed between vertical strokes, some of the utterances have double DA tags, i.e. they hold more than one function). The transcription of CA is used in the example.

In order to study communication, we annotate the DAs in our corpus. So far, two persons annotated the DAs manually, by using custom software that simplifies to choose dialogues from the corpus and DAs from a list and then a third person (an expert) disambiguated the annotations. Automatic annotation will make the job much easier. Further, we are looking for the structural parts of dialogue which can be simply determined on the basis of adjacency pairs of DAs.

The communication participants use

communicative strategies in order to achieve their communicative goals. Our software is planned, first, to recognise DAs in a dialogue transcript and after that, to determine the dialogue structure and communicative strategies.

```
A : ((summons))            | RIF: Summons |
B: `Estmar=`info,           | RIS: Answer |
                         | RS: Introduction |
Estmar info
`Leenu=kuuleb           | RS: Introduction |
Leenu is hearing
 tere                      | RIF: Greeting |
good morning
A: tere `päevast.         | RIS: Greeting |
good morning
 (.) ee kas te `ütleksite mulle takso num-
`telefoninumbri e `tellimiseks.
                         | QUF: Open yes/no |
could you tell me a phone number for
ordering a taxi
(0.5)
B: neli kaks `null, neli kaks `null on
`Eepee auto.    | QUS: Giving information |
four two zero four two zero is Eepee car
(0.5)
A: jah.     | VR: Neutral acknowledgement |
yes
(.) neli kaks null neli kaks null jah?
| QUF: Offering answer | | RPF: Checking |
four two zero four two zero yes
B: jah?     | QUS: Yes |     | RPS: Repair |
yes
A: no suur `tänu teile.   | RIS: Thanking |
thank you very much
B: palun?                  | RIS: Please |
you are welcome
```

Figure 1: A directory inquiry from the Estonian Dialogue Corpus (*A* – client, *B* – official). Dialogue acts are annotated (s. Appendix).

The next sections 3 to 5 are dedicated to the description of the software tool.

3 RECOGNITION OF DIALOGUE ACTS

3.1 Method

As a result of previous observations, our first aim was to choose a suitable method for automatic recognition of DAs. After the DAs are annotated in dialogues, the rules for recognition of the dialogue structure can be formulated on the basis of DA tags. Further, there exists a close relation between DAs and communicative strategies (in the sense of CDM) therefore rules can be formulated for recognition of communicative strategies on the basis of DAs. In this way, DAs prove to be good indicators for determining the dialogue structure as well as the dialogue strategies.

We have tested several methods for recognition of DAs: multi-layered perceptrons, decision trees, suffix trees, Bayes classifier. An overview of the results can be found in (Koit, 2011, Aller, 2012). No method was considered sufficient for fully automatic recognition of DAs. There are at least two reasons of that – the complexity of the typology of DAs and the diversity of our (relatively small) corpus which does not offer necessary training material. That is why we decided to implement semi-automatic annotation of DAs in our software: the programme finds DAs for every utterance in a dialogue and then a human annotator corrects the annotation errors if needed. We have chosen the most robust and simplest method from the set of the tested methods – Naïve Bayes (Manning and Schütze, 1999).

3.2 Implementation

The semi-automatic annotator splits a dialogue text into utterances and assigns up to five most probable DAs to every utterance. After that, a human can correct mistakes and then to repeat the automatic annotation if needed. The input is a *.txt* file – a dialogue where turns (but not the utterances) are located in separate rows. The output is a *.txt* file where turns are splitted into utterances placed into different rows and DA tags are assigned to every utterance. The annotator implements Naïve Bayes classifier. In the experiments with the classifier, the following features were chosen in order to achieve the best results: the probability of trigrams of words, the length of utterances (number of words) and the geometric mean of the probabilities of the DA tags (Fishel, 2007).

The annotator itself includes two parts: training and annotation. Also cross-validation can precede to the training (Fig. 2). When training, a new session is initiated, a model is created and used for annotation of new data. The classifier is implemented as *Perl* scripts. The annotator was trained on 800 dialogues, ten-fold cross-validation was used. The average recall of 64.7% and precision of 33.0% were received. The calculations were made on the basis of the most probable tag for every utterance but the interface offers up to five tags in decreasing order of the probability. Actually, a human annotator does not need to search a suitable tag from the list of all DA tags but the right tag is mostly located among the five.

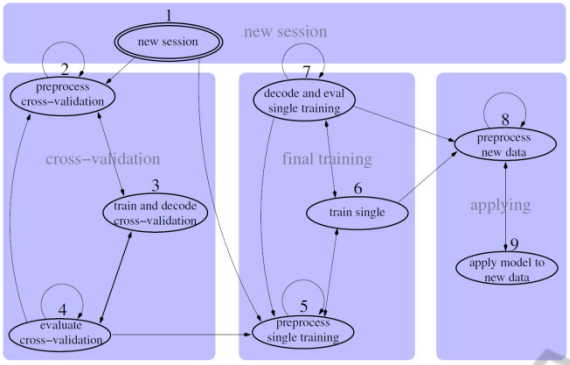

Figure 2: Dialogue act annotator. The numbers indicate different processing states: (1) start of new session, (2 to 4) cross-validation, (5 to 7) training, (8) preprocessing new data, (9) applying model to new data.

A detailed description of the dialogue act annotator can be found in (Aller, 2012).

4 ANNOTATION OF THE DIALOGUE STRUCTURE

A typical dialogue consists of three parts: (1) a conventional beginning, (2) the main information part, and (3) a conventional ending. The kernel of the information part is an adjacency pair directive – grant or question – answer.

Sub-dialogues can occur in the main part after a request (or question) and/or answer, respectively: an adjusting/specifying question is asked and answered, or a repair for solving a communication problem is initiated and performed.

The corpus analysis suggests to use adjacency pairs of DAs as the main cues for recognition of different parts and sub-dialogues of a dialogue.

The conventional opening and closing parts can be recognised looking for APs of rituals and the single conventional act RS: Introduce in the beginning or at the end of a dialogue, respectively.

The main part begins with a request or question immediately after the opening part and continues until the closing part begins. Sub-dialogues in the main part can be recognised by double-tags: information-sharing initiated by the responder before giving information begins with the act tag ACF: Adjusting the conditions of answer and ends with the act tag ACS: Adjusting the conditions of answer. Other-initiated repair begins with the act tag RPF: Reformulation, RPF: Checking or RPF: Non-understanding and ends with RPS: Repair (Fig. 3, cf. Koit, 2012).

[Opening]
A: ((summons)) RIF: Summons
B: RIS: Answer RS: Introduce [*B* introduces the service company]
(RS: Introduce [*B* introduces him/herself])
(RIF: Greeting)
A: RIS: Greeting

[Main part]
A: DIF: Request / QUF: *Wh*-question/ Open yes-no
([information sharing initiated by *B*]
--> *B:* ACF: Adjusting the conditions of answer
<-- *A:* ACS: Adjusting the conditions of answer
)

([other-initiated repair]
--> *B/A:* RPF: Reformulation/ Checking/ Non-understanding
A/B: RPS: Repair
<-- (*B/A:* VR: Repair evaluation)
)
B: (VR: Neutral acknowledgment QUS/DIS: Deferral) DIS/QUS: Giving information
([other-initiated repair]
--> *A/B:* RPF: Checking/ Non-understanding/ Reformulation
B/A: RPS: Repair
<-- (*A/B:* VR: Repair evaluation)
)
(*A:* VR: Neutral acknowledgment / Neutral bounder / Neutral change of state)

[Closing]
A: RIF: Thanking (RIF: Greeting)
(*B:* RIS: Please RIS: Greeting)

Figure 3: The structural parts of information dialogue: opening, main part, closing. *A* – client, *B* – official. Sub-dialogues are marked by '-->' (begin) and '<--' (end). The dialogue acts between '(' and ')' can be missed. An overview of the DA typology is given in Appendix.

The automatic annotator of the dialogue structure (implemented by S. Aller) takes as input the dialogue where DAs are annotated (*.txt* file) and uses rules for recognition of different parts of dialogue. The parts are distinguished by different colors. The output is given in two formats: *.txt* and *.xml*. The programming language is *PHP*.

An example output is presented in Fig. 4. The main part of the dialogue includes a sub-dialogue – repair initiated by the client (participant *A*) and performed by the official (participant *B*).

```
Opening
A : ((summons))              | RIF: Summons |
B: Estmar info
      | RIS: Answer |   | RS: Introduction |

Leenu is hearing        | RS: Introduction |
good morning              | RIF: Greeting |
A:  good morning          | RIS: Greeting |
Main part
could you tell me a phone number for
ordering a taxi         | QUF: Open yes/no |

(0.5)
B: four two zero four two zero is Eepee
car             | QUS: Giving information |
(0.5)
A: yes      | VR: Neutral acknowledgement |
    Sub-dialogue: other-initiated repair
    --> four two zero four two zero yes
                  | QUF: Offering answer |
                          | RPF: Checking |

   <-- B: yes | QUS: Yes |     | RPS:
   Repair |
Closing
A: thank you very much    | RIS: Thanking |
B: you are welcome          | RIS: Please |
```

Figure 4: The structural parts of information dialogue: opening, main part, closing (cf. Fig.1).

5 RECOGNITION OF COMMUNICATIVE STRATEGIES

We are using the notion of the communicative strategy, introduced in (Jokinen, 1996) as a part of CDM.

A communicative strategy is used by a participant to build up the next utterance as a reaction to the partner's previous utterance.

Four context factors are used in CDM to determine communicative strategies:

1) expectations – is the partner's turn expected or not

2) the central conception – does the partner's turn keep the topic or not

3) initiatives – has the speaker initiative or not

4) goals – are the speaker's goals fulfilled or not.

All the context factors have binary values in the CDM which results in 16 communicative strategies (e.g. finish/start, follow-up old, somethingelse, etc., Table 1).

Every strategy can be represented as a vector with the values of the coordinates of 0 or 1, e.g. 0000 (strategy *notrelated*) means that the partner's turn is unexpected, does not keep the topic, the speaker does not have the initiative and there are unfulfilled goals (cf. Table 1).

Do not annotate

1. PS: Uninterpretable
2. Rituals, except of
   RIF: Preclosing – **specify-new**
   RIS: Accept – **follow-up-new**
   RIS: Reject – **somethingelse**

Adjacency pair acts

Directives, questions, opinions

First pair part

3. The first A: DIF/QUF – **finish/start**
4. Later A: DIF/QUF (with a single DA tag)
   a. If B: DIS/QUS does not precede then – **backto**
   b. If B: missing information or topic change precedes then – **specify-new**
   c. If B: giving information precedes then – **new-dialogue**
5. B: QUF: Alternative/Open yes/no or DIF: Offer – **new-dialogue**
6. A: DIF+TCF – **specify-new**
7. A: DIF+RP – **specify-new** (self-repair changes topic)
8. OPF: Opinion – **new-dialogue**

Second pair part

9. DIS/QUS: Giving information/Accept – **follow-up-old**
10. DIS/QUS: Missing information/Reject – **continue**
11. DIS: Agreeing no – **continue** (like Missing information)
12. OPS: Other – **continue** (like Reject)

With double tags (the second pair and the first pair parts):

13. QUS+ QUF – **new-question**
14. DIS+DIF – **new-request**

Contact control

15. CCF – **specify-new**
16. CCS – **follow-up-new**

Sub-dialogues

17. ACF and RPF – **subquestion,X**
18. ACS and RPS – **follow-up-old**

Non-adjacency pair acts

Additional information

19. A: AI: Specification – **backto**
20. B: AI: Specification/Explication/Emphasize after giving information by the same participant – **follow-up-new**

Responses

21. A: VR: neutral/evaluative continuer – **continue**
22. All the remaining VR – **somethingelse**, except of
    a. VR: neutral/evaluative bounder
       i. If giving information follows then – **object,X**
       ii. If not then – **specify**
    b. VR: neutral/evaluative change of state – **repeat-new**

Primary single acts

23. SA: giving information – **follow-up-old**
24. SA: other – **somethingelse**

Figure 5: Relations between dialogue acts (s. Appendix) and communicative strategies.

Table 1: Communicative strategies in CDM.

Communicative strategy	Vector
Notrelated	0000
New-st-request	0001
Objekt,X	0010
Specify-new	0011
Continue	0100
Somethingelse	0101
Subquestion,X	0110
New-dialogue	0111
New question	1000
New-request	1001
Repeat-new	1010
Specify	1011
Follow-up-old	1100
Follow-up-new	1101
Backto	1110
Finish/start	1111

	Communicative strategy	Vector
A : ((summons)) | RIF: Summons |	-	-
B: **Estmar info** |RIS: Answer|	-	-
|RS: Introduction| **Leenu is hearing**	-	-
|RS: Introduction| **good morning** |RIF: Greeting|	-	-
A: **good morning** |RIS: Greeting|	-	-
could you tell me a phone number for ordering a taxi |QUF: Open yes/no| (0.5)	**Finish/start**	**1111**
B: **four two zero four two zero is Eepee car** |QUS: Giving information| (0.5)	**Follow-up-old**	**1100**
A: **yes** |VR: Neutral acknowledgement|	**-**	**-**
four two zero four two zero yes |QUF: Offering answer| |RPF: Checking|	**Somethingelse**	**0101**
B: **yes** |QUS: Yes| |RPS: Repair|	**Subquestion,X**	**0110**
A: **thank you very much** |RIS: Thanking|	**Follow-up-old**	**1100**
B: **you are welcome** |RIS: Please|	-	-
	-	-

Figure 6: Communicative strategies in information dialogue (cf. Fig.1).

We have manually annotated the strategies in 60 information dialogues, occasionally taken from the Estonian dialogue corpus. The study of the dialogues has given as a result the following algorithm for determination of communicative strategies on the basis of DAs and the participants signs (Fig. 5, *A* – client, *B* – official). The automatic annotator of communicative strategies takes as input a dialogue file (*.txt*) where DAs are annotated and gives as output a *.txt* file where communicative strategies and the corresponding vectors are assigned to the utterances.

Some of the utterances remain without tags because the strategies in CDM are mainly related to requesting and giving information, i.e. to the main part of dialogue (Fig.6).

The annotator is implemented by S. Aller in *PHP*. A user can choose a dialogue from the corpus and then annotate the DAs, or s/he can choose a dialogue where the DAs are already annotated and then optionally to annotate the dialogue structure and/or communicative strategies.

6 CONCLUSIONS

We have introduced the Estonian dialogue corpus and the dialogue act typology used for annotation of the corpus. Our initial aim was to create software for automatic annotation of DAs in the corpus. No method was found which would give sufficient practical results in the case our complex typology of DAs and the diverse corpus. For that reason, we implemented a semi-automatic annotator of DAs which splits the dialogue text into utterances and assigns up to five most probable DA tags to every utterance using the Naïve Bayes classifier. Then a linguist can confirm the right tags and/or correct annotation errors.

The structural parts of dialogue are determined using the DA tags. Different colours visualize the different parts and make it possible to observe sub-dialogues (information-sharing and other-initiated repair) in the main information part.

Communicative strategies determined on the basis of DAs add a new annotation layer to dialogue. The values of context factors (coordinates of vectors which correspond to different strategies) make it possible to study how the initiative is moving from one participant to another, where and under which conditions the strategies are used which are not topic-related, etc. Taking into account the relation between DAs and communicative strategies, the typical structure of the main information part of a dialogue can be represented also by the strategies (Fig.7, cf. Koit, 2003).

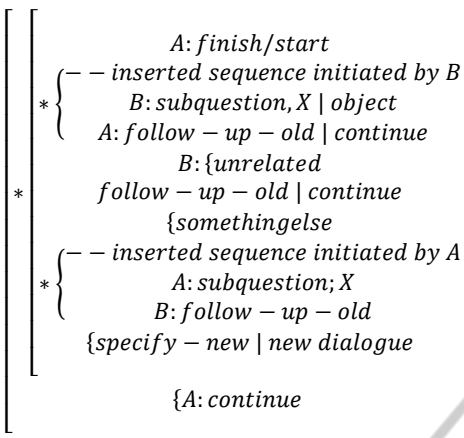

Figure 7: The structure of the main part of information dialogue: communicative strategies. Notations: [− dialogue or its part; { −strategy or sequence which can be missed; * −strategy or sequence which can be repeated; | variants of strategies; − −a comment.

Our further work includes the study of the Estonian conversations by using the software tool. Our further aim is to develop a DS which interacts with a user in Estonian and follows norms of human-human communication.

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APPENDIX: OVERVIEW OF THE DIALOGUE ACT TYPOLOGY

I. Adjacency Pair Acts

DIALOGUE MANAGING ACTS

1. Conventional acts (greeting, thanking, etc.), e.g. RIF: Greeting, RIS: Greeting, RIF: Wish, RIS: Thanking. .
2. Topic change acts **(**are used to start a new topic or sub-topic), e.g. TCF: Initiation, TCS: Accept.
3. Contact control acts (typically occur in phone conversations and are used as formulas which can be presented as lists), e.g. CCF: Initiation, CCS: Confirmation).
4. Adjusting the conditions of answer (ACF: Adjusting the conditions of answer, ACS: Adjusting the conditions of answer).

REPAIR ACTS

5. Repairs initiated and made by different participants, e.g. RPF: Non-understanding, RPS: Repair.

INFORMATION ACTS

6. Directives and grants (request, proposal, offer, etc.), e.g. DIF: Request, DIS: Giving information.
7. Questions and answers, e.g. QUF: Closed yes/no, QUS: Yes, QUS: No.
8. Opinions and responses (assertion, etc.), e.g. OPF: Assertion, OPS: Accept, OPS: Reject.

II. Non-Adjacency Pair Acts

DIALOGUE MANAGING ACTS

1. Conventional (contact, call, etc.), e.g. RS: Introduce.

REPAIR ACTS

2. Repairs initiated and made by the same person, e.g. RP: Self-repair.

INFORMATION ACTS

3. Primary single acts (narration, promise, rhetorical question, etc.), e.g. PS: Promise.
4. Additional information (specification, softening, etc.), e.g. AI: Specification.
5. Responses (continuer, acknowledgement, etc. – acts that traditionally are considered as narrow feedback), e.g. VR: Neutral continuer.