Developing a Formal Model of Conversational Agent

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***Abstract*—Our model of conversational agent is based on the analysis of human-human telemarketing calls. We study negotiations where two participants are presenting arguments for and against of doing an action. The choice of an argument depends, on one hand, on the beliefs of the dialogue participant about the positive and negative aspects of the action and the needed resources, and on the other hand, on the result of reasoning affected by these beliefs. The dialogue initiator is using a partner model—the hypothetical beliefs of the partner who is aimed to do the action. At the same time, the partner operates with own beliefs. Both the models have to be upgraded during a dialogue. The notion of a communicative strategy is included in the model as an algorithm used by a dialogue participant for achieving his or her communicative goal. A limited version of the model is implemented on the computer. The computer attempts to influence the reasoning of the user by its arguments in order to convince the user to make the positive decision about the proposed action.**

Keywords—reasoning; beliefs; communicative strategy; negotiation; argument; conversational agent.

I. INTRODUCTION

This article is an extended version of the conference paper [1]. Our aim is to develop a model of conversational agent that interacts with a user in a natural language and carries out negotiations.

Negotiation is a form of interaction in which a group of agents, with a desire to cooperate but with potentially conflicting interests try to come to a mutually acceptable division of scarce resources [2]. Negotiation is simultaneously a linguistic and a reasoning problem, in which intent must be formulated and then verbally realized. A variety of agents have been created to negotiate with people within a large spectrum of settings including the number of parties, the number of interactions, and the number of issues to be negotiated [3]. Negotiation dialogues contain both cooperative and adversarial elements, and their modelling require agents to understand, plan, and generate utterances to achieve their goals [3][4].

We start with the analysis of human-human negotiation dialogues aiming to model the reasoning processes, which people go through when pursuing their communicative goals and coming to a decision.

The remainder of the paper is organized as follows. Section 2 describes related work. In Section 3, we analyze a kind of human-human negotiation dialogues—telemarketing calls, in order to explain how do people reason and argue when negotiating about doing an action. In Section 4, we introduce our model of conversational agent that takes into account the results of the analysis of human-human negotiations, and an implementation—a simple dialogue system (DS). Section 5 discusses the model and the DS. In Section 6, we draw conclusions and plan future work.

II. RELATED WORK

A conversational agent, or DS, is a computer system intended to interact with a human using text, speech, graphics, gestures and other modes for communication. It will have both dialogue modelling and dialogue management components [5]. A dialogue manager is a component of a DS that controls the conversation. The dialogue manager reads the input modalities, updates the current state of the dialogue, decides what to do next, and generates output [6]. Four kinds of dialogue management architectures are most common—plan-based, finite-state, frame-based, and information-state [7].

One of the earliest models of conversational agent is based on the use of artificial intelligence *planning* techniques. Using plans to generate and interpret sentences require the models of beliefs, desires, and intentions (BDI) [4][5]. Plan-based approaches, though complex and difficult to embed in practical dialogue systems, are seen as more amenable to flexible dialogue behavior [7].

The simplest dialogue manager architecture, used in many practical implementations, is a *finite-state* manager. The states correspond to questions that the dialogue manager asks the user, and the arcs correspond to actions to take depending on what the user responds. Such a system completely controls the conversation with the user. It asks the user a series of questions, ignoring or misinterpreting anything the user says that is not a direct answer to the system's question, and then going on to the next question [7].

Frame-based dialogue managers ask the user questions to fill slots in a frame until there is enough information to perform a data base query, and then return the result to the user. If the user answers more than one question at a time, the system has to fill in these slots and then remember not to ask the user the associated questions for the slots. In this way, the user can also guide the dialogue [5].

More advanced architecture for dialogue management, which allows for sophisticated components is the *information-state* architecture [5][7]. An information-state approach combines the other approaches, using the advantages of each. An information state includes beliefs, assumptions, expectations, goals, preferences and other attitudes of a dialogue participant that may influence the

participant's interpretation and generation of communicative behavior. The functions of the dialogue manager can be formalized in terms of information state update [8]. Update and selection rules provide a more transparent, declarative representation of system behavior.

Rahwan et al. [9] discuss three approaches to automated negotiation—game-theoretic, heuristic-based and argumentation-based.

A dialogue game is a rule-based structure for conversation where arguments are exchanged between two participants reasoning together on a turn-taking basis aimed at a collective goal [10]. *Heuristic methods* offer approximations to the decisions made by participants. Agents exchange proposals (i.e., potential agreements or potential deals). Both game-theoretic and heuristic approaches assume that agents' preferences are fixed. One agent cannot directly influence another agent's preferences, or any of its internal mental attitudes (beliefs, desires, goals, etc.) that generate its preference model. A rational agent only modifies its preferences if it receives new information.

Attitudes are relatively enduring, affectively colored beliefs, preferences, and predispositions towards objects or persons [11]. Attitude is a psychological tendency that is expressed by evaluating a particular entity with some degree of favor or disfavor. Attitude change can mediate the impact of some influence treatment on behavioral compliance [12].

Argumentation-based approaches to negotiation allow agents to 'argue' about their beliefs and other mental attitudes during the negotiation process. Argumentation-based negotiation is the process of decision-making through the exchange of arguments [13].

Hadjinikolis et al. [14] provide an argumentation-based framework for persuasion dialogues, using a logical conception of arguments, that an agent may undertake in a dialogue game, based on its model of its opponents. In negotiation, an argument can be considered as a piece of information that may allow an agent to (a) justify its negotiation state; or (b) influence another agent's negotiation state. Amgoud and Cayrol define an argument as a pair (H, h) where (i) H is a consistent subset of the knowledge base, (ii) H implies h, (iii) H is minimal, so that no subset of H satisfying both (i) and (ii) exists. H is called the support and h the conclusion of the argument [15].

Automated negotiation agents capable of negotiating efficiently with people must rely on a good opponent modelling component to model their counterpart, adapt their behavior to their partner, influencing the partner's opinions and beliefs [16]. NegoChat is the first negotiation agent successfully developed to use a natural chat interface while considering its impact on the agent's negotiation strategy [3]. A virtual human negotiating with a human helps people learn negotiation skills. For virtual agents, the expression of attitudes in groups is a key element to improve the social believability of the virtual worlds that they populate as well as the user's experience, for example in entertainment or training applications [17][18][19]. Argumentation systems can be beneficial for students.

Computers that negotiate on our behalf hold great promise for the future in emerging application domains such as the smart grid and the Internet of Things. An interesting and useful kind of DSs are embodied conversational agents [17][20][21].

III. Analysis of Human-Human Negotiations

Our further aim is to implement a DS, which interacts with a user in a natural language (Estonian) and carries out negotiations like a human does. For that, we are studying human-human negotiations using the Estonian dialogue corpus [22]. All the dialogues in the corpus are recorded in authentic situations and then transliterated by using the transcription of Conversation Analysis [23]. A sub-corpus of telemarketing calls is chosen for the current study. In the dialogues, two official persons are communicating—a sales clerk of an educational company, he is the initiator of a call, and a manager or a personnel officer of another institution—she is here a customer.

The educational company offers training courses (management, sale, etc.), which can be useful for the employees of the customer's institution. The communicative goal of a sales clerk is to convince the customer to decide to order a course.

Several typical phases can be differentiated in telemarketing negotiations [24]: (1) preparing, (2) opening, (3) mapping the customer, (4) argumentation, (5) achieving a decision, (6) following activities. The first (1) and the last (6) phases take place outside of actual negotiation.

Phase 1 is carried out by a sales clerk alone when he is planning his very first call to a pre-selected customer. The clerk, by using different open sources, tries to collect information about the customer's institution—its background, financial situation, the number of employees, etc., in order to be ready to propose and argue for a suitable course. The last phase (6) will be initiated by a sales clerk after the customer has already passed a course. Then the clerk again calls to the customer asking her feedback. Still, our sub-corpus does not include such calls. Therefore, it is possible to recognise only the phases 2 to 5 in the dialogues of our sub-corpus.

As a rule, several calls are needed before a customer makes her decision about the offered course. The decision can be positive (to take the course) or negative (to reject the clerk's proposal). However, no decision is mostly made regarding the courses during a call—the calls usually end with an agreement to continue the negotiation after some time. The reason is that all the telemarketing calls in our corpus belong to the beginning stage of negotiations.

The most important phase of negotiation is *argumentation*. A sales clerk (*A*) presents different arguments that take into account the actual needs of the customer (*B*) explained by him (*A*) before or during the call. *A* tries to bring out the factors that are essential for the customer, in order to convince her to make a positive decision (Example 1). If *B* accepts these factors then *A* will demonstrate how the proposed course will solve *B*'s assumed problems. In an ideal case, the customer will agree with the proof offered by the clerk and she will decide to take the course.

The behaviour of sales clerks and customers is different when they are arguing for/against a course. A sales clerk when having the initiative provides his arguments for taking

the course either asserting something (then a customer typically accepts the assertion, Example 1).

Example 1 (transcription of Conversation Analysis is used in the examples)

A: /---/(1.0) .hh sest loomu`likult et=ee `töökogemuste kaudu: õpib ka: alati aga .hh a `sageli ongi just `see (0.5) mt ee `kursused pakuvad sellise `võimaluse kus saab siis `teiste .hh oma hh `ala `spetsia`listidega samuti `kokku=ja `rääkida nendest `ühistest prob`leemidest ja samas siis ka .hh ee `mõtteid ja `ideid ee hh ee=`Tiritamme poolt sinna `juurde.

because, of course, one can learn from experience but frequently training courses make it possible to meet other specialists in the field and discuss common problems; additional thoughts and ideas come from Tiritamm — argument

(.)

B: £ `jah?

yes — accept

A customer, to the contrary, does not accept assertions/arguments of a sales clerk when arguing against taking a course (Example 2).

Example 2

/---/ *B*: aga jah ei mul on see läbi ´vaadatud=ja (.) ´kahjuks ma pean ütlema=et (.) et ´teie (.) seda meile (.) ´ei suuda ´õpetada (.) mida (.)´mina: (.) tahan.

but I have looked through your catalogue of courses and unfortunately, I have to say that you can't teach what is needed for us — counter argument

/---/

A: .h ja mida kon´kreetselt=ee ´teie tahate.

and what do you want — question

(0.8) mida te ´silmas ´peate. what do you have in view — question

B: noo (0.2) ´meie (.) äri´tegevus on (.) ´ehitamine.

well, our business is house-building — answer

/---/

A: nüüd kas (0.2) näiteks (0.5) ´lepingute ´saamisel (0.5) mt ee ´tegelete te ka: läbi´rääkimistega.

well, do you need to carry out negotiations in order to achieve agreements — question

B: noo ikka.

yes, of course — answer

(0.8)

A: mt et see=on ka üks ´valdkond mida me: (0.2) ´käsitleme.

but that is one of our fields, which we cover — argument

The argumentation continues in a similar way. *A* attempts to convince *B* preparing his new arguments by questions. Either *A* constructs his arguments during the conversation or he chooses suitable arguments from a previously completed set of possible arguments collected in discussions with other customers.

In Example 3, the customer takes over the initiative and explains that no courses are needed because her experience is unique.

Example 3

B: /---/ me ´müüme eksklu´siivset ´kodu´mööblit.

we are selling exclusive home furniture.

/---/

noo siis ´see kauba´märk ka juba ütleb iseendast se=on ´täpselt sama´moodi nagu on Mer´seedes=´Pens ja ´Jaaguar.

this trademark speaks for itself, like Mercedes Benz and Jaguar.

[eksole]

is it not? — counter argument

A: [jaa.]

yes.

seda ´küll?

it is. — accept

A sales clerk always accepts the counter arguments presented by a customer but he also brings out his own arguments for taking the course and tries to take over the initiative. The participants communicate cooperatively in the majority of the analyzed dialogues. The customer similarly can ask questions like the sales clerk does but her aim is rather to get more information about the course(s) than to dispute.

When modelling negotiation, a good way seems to follow the sales clerks' strategy: try to take and hold the initiative and propose 'hard' arguments for the strived action, i.e., the statements that do not provoke the partner's rejection but accept. In order to have such arguments at disposal, it is necessary to know as possible more about the partner in relation to the goal action. That is the reason why mapping (i.e., explanation of the customer's needs) is a necessary phase (3) in our analyzed telemarketing calls.

In summary, telemarketing calls turn out to be good examples of argument-based negotiations.

IV. Modelling Conversational Agent

Our model of conversational agent is motivated by the results of the analysis of human-human negotiations. Let us consider negotiation between two (human or artificial) participants *A* and *B* where *A* is the initiator. Let *A*'s communicative goal be to bring *B* to the decision to do an action *D*. When convincing *B*, he is using a partner model (an image of the communication partner) that gives him grounds to believe that *B* will agree to do the action. *A* starts the dialogue by proposing *B* to do *D*. If *B*, after her reasoning, refuses, then *A* must influence her in the following negotiation, continuously correcting his partner model and trying to guess in which reasoning step *B* reached her negative decision. In this way a dialogue—a

sequence of utterances will be generated together by *A* and *B*.

A. Reasoning Model

The initial version of our reasoning model is introduced in [24]. In general, it follows the ideas realized in the BDI model [25][4][5]. The reasoning process of a subject about doing an action *D* consists of steps where the resources, positive and negative aspects of *D* will be weighed. A communication partner can take part in this process only implicitly by presenting arguments to stress the positive aspects of *D* and downgrade the negative ones.

Our reasoning model includes two parts—(1) a model of (human) motivational sphere that represents the beliefs of a reasoning subject in relation to the aspects of the action under consideration, and (2) reasoning procedures.

1) Model of Motivational Sphere

We represent the model of *motivational sphere* of a communication participant as a vector with (here: numerical) coordinates that express the beliefs of the participant in relation to different aspects of the action *D*:

$\boldsymbol{w}_D$ = ($w(resources_D)$, $w(pleasant_D)$, $w(unpleasant_D)$, $w(useful_D)$, $w(harmful_D)$, $w(obligatory_D)$, $w(prohibited_D)$, $w(punishment\text{-}do_D)$, $w(punishment\text{-}not_D)$).

The value of $w(resources_D)$ is 1 if the reasoning subject has all the resources needed for doing *D*, and 0 if some of them are missing. The value of $w(obligatory_D)$ or $w(prohibited_D)$ is 1 if the action is obligatory or, respectively, prohibited for the subject (otherwise 0). The values of the other coordinates can be numbers on the scale from 0 to 10—$w(pleasant_D)$, $w(unpleasant_D)$, etc, indicate the values of the pleasantness, unpleasantness, etc. of *D* or its consequences; $w(punishment\text{-}do_D)$ is the punishment for doing a prohibited action and $w(punishment\text{-}not_D)$—the punishment for not doing an obligatory action.

2) Reasoning Procedures

The reasoning itself depends on the *determinant* which triggers it. With respect to the used (intuitive) theory, there are three kinds of determinants that can cause humans to reason about an action *D*: wish, need and obligation [26]. Therefore, three different prototypical *reasoning procedures* can be described—WISH, NEEDED, and MUST. Every procedure consists of steps passed by a reasoning subject and it finishes with a decision—do *D* or not. When reasoning, the subject considers his/her resources as well as different positive and negative aspects of doing *D*. If the positive aspects (pleasantness, usefulness, etc.) weigh more than negative (unpleasantness, harmfulness, etc.) then the decision will be "do *D*" otherwise "do not do *D*". The reasoning subject checks primarily his/her wish, thereafter the need and then the obligation and he/she triggers the corresponding reasoning procedures. If no one procedure returns the decision "do *D*" then the reasoning ends with the decision "do not do *D*".

In Figures 1 and 2, we present two reasoning procedures that will be used in the following examples—WISH triggered by the wish of the reasoning subject to do the action *D* (i.e., doing the action is more pleasant than unpleasant for the subject), and NEEDED triggered by the need of the reasoning subject to do the action *D* (i.e., doing the action is more useful than harmful for the subject). The procedures are presented as step-form algorithms. We do not more indicate the action *D*.

Presumption: $w(pleasant) \geq w(unpleasant)$.
1) Is w(resources) = 1? If not then 11.
2) Is w(pleasant) > w(unpleasant) + w(harmful)? If not then go to 6.
3) Is w(prohibited) = 1? If not then go to 10.
4) Is w(pleasant) > w(unpleasant) + w(harmful) + w(punishment_D)? If yes then go to 10.
5) Is w(pleasant) + w(useful) > w(unpleasant)+w(harmful) + w(punishment_D)? If yes then go to 10 else 11.
6) Is w(pleasant) + w(useful) ≤ w(unpleasant) + w(harmful)? If not then go to 9.
7) Is w(obligatory) = 1? If not then go to 11.
8) Is w(pleasant) + w(useful) + w(punishment_not) > w(unpleasant) + w(harmful)? If yes then go to 10 else 11.
9) Is w(prohibited) = 1? If yes then go to 5 else 10.
10) Decide: to do D. End.
11) Decide: not to do D.

Figure 1. Reasoning procedure WISH.

Presumption: $w(useful) \geq w(harmful)$.
1) Is w(resources) = 1? If not then go to 8.
2) Is w(pleasant) > w(unpleasant)? If not then go to 5.
3) Is w(prohibited) = 1? If not then go to 7.
4) Is w(pleasant) + w(useful) > w(unpleasant) + w(harmful) + w(punishment-do)? If yes then go to 7 else 8.
5) Is w(obligatory) = 1? If not then go to 8.
6) Is w(pleasant) + w(useful) + w(punishment-not) > w(unpleasant) + w(harmful)? If not then go to 8.
7) Decide: do D. End.
8) Decide: do not do D.

Figure 2. Reasoning procedure NEEDED.

We use two vectors $\boldsymbol{w}^B$ and $\boldsymbol{w}^{AB}$, which capture the beliefs of communication participants in relation to the action *D* under consideration. Here $\boldsymbol{w}^B$ is the model of motivational sphere of *B* who has to make a decision about doing *D*; the vector includes *B*'s (actual) evaluations (beliefs) of *D*'s aspects. These values are used by *B* when reasoning about doing *D*. The other vector $\boldsymbol{w}^{AB}$ is the partner model that includes *A*'s hypothetical beliefs concerning *B*'s beliefs in relation to the action. It is used by *A* when planning the next turns in dialogue. We suppose that *A* has some preliminary knowledge about *B* in order to compose the initial partner model before making the initial proposal.

Both the models will change as influenced by the arguments presented by both the participants in negotiation. For example, every argument presented by *A* targeting the usefulness of *D* will increase the corresponding values of w^B*(useful)* as well as w^{AB}*(useful)*.

B. Communicative Strategies and Tactics

A communicative strategy is an algorithm used by a participant for achieving his/her goal in communication [27]. The initiator *A* can realize his communicative strategy in different ways—he can entice, persuade or threaten the partner *B* to do (or respectively, not to do) *D*. We call these ways of realization of a communicative strategy *communicative tactics*. If *A*'s communicative goal is "*B* will do *D*" then by *persuading*, *A* tries to trigger *B*'s reasoning by the NEEDED-determinant (i.e., he tries to increase the usefulness of *D* for *B* as compared with its harmfulness). Respectively, when *enticing*, *A* tries to trigger *B*'s reasoning by the WISH-determinant (to increase the pleasantness) and when *threatening*, by the MUST-determinant (to increase the punishment for not doing an *obligatory D*). We call the affected aspect (respectively, usefulness, pleasantness, or punishment) the *title aspect* of the tactics. When choosing the communicative tactics, *A* believes that *B*'s reasoning triggered by this determinant, will give a positive decision in his partner model. Still, the participants can change their communicative tactics during negotiation.

- Determine the initial $\boldsymbol{w}^{AB}$ in relation to *D*
- Choose an input determinant (WISH, NEEDED, or MUST), which determines a reasoning procedure depending on $\boldsymbol{w}^{AB}$
- Choose the communicative tactics with the title aspect *a* (respectively, pleasantness, usefulness or punishment for not doing *D* if it is obligatory for *B*)
- Implement the tactics to generate a proposal to *B* to do *D*

REPEAT

Analyze *B*'s utterance

- - (1) Choose a (counter) argument depending on the aspect of *D* indicated in *B*'s utterance

- - (2) Choose argument(s) to support *a*

Update $\boldsymbol{w}^{AB}$

Run the current reasoning procedure in updated $\boldsymbol{w}^{AB}$

- - Response to *B*

IF the decision generated with the reasoning procedure matches to G^A THEN present the chosen argument(s) to *B* (- - *A* can optionally present both (1) and (2), OR only (2))

Change the communicative tactics? IF yes THEN choose the new tactics (with new *a*)

UNTIL *B* agrees (G^A achieved), OR *B* postpones the decision (G^A not yet achieved), OR *A* decides to abandon G^A, OR *A* does not have unused tactics and/or unused arguments (G^A not achieved)

Figure 3. Communicative strategy of the initiator *A* (G^A *=B will do D).*

Let us present two communicative strategies in Figures 3 and 4, respectively, for *A* and for *B*. It is assumed here that their initial communicative goals are similar—that *B* decides to do *D*. Still, there can be some obstacles for *B* (resources are missing, or *D* is prohibited and its doing will be punished, etc.). In negotiation, *A* has to demonstrate how the obstacles can be crossed over.

Both *A* and *B* can indicate that the finishing conditions are fulfilled: (1) the communicative goal is already achieved, (2) give up regardless of having new arguments or counter arguments, (3) there are no more arguments to continue the fixed tactics but no new tactics will be chosen regardless of having some tactics not implemented so far, (4) all the tactics are already implemented and all the possible arguments are used without achieving the communicative goal. We assume here that the communicative tactics and arguments can be used only once.

- Determine the initial $\boldsymbol{w}^{B}$ in relation to *D*
- Choose an input determinant (WISH, NEEDED, or MUST) which determines a reasoning procedure depending on $\boldsymbol{w}^{B}$

REPEAT

Analyze *A*'s utterance

CASE *A*'s utterance OF

resources: increase resources

pleasantness: increase pleasantness

unpleasantness: decrease unpleasantness

usefulness: increase usefulness

harmfulness: decrease harmfulness

punishment for not doing an obligatory *D*: increase punishment

punishment for doing a prohibited *D*: decrease punishment

END CASE

Update $\boldsymbol{w}^{B}$

Change the reasoning procedure? IF yes THEN choose a new procedure

Run the current reasoning procedure in updated $\boldsymbol{w}^{B}$

Choose and present a new (counter) argument depending on the result of the reasoning procedure

UNTIL *B*'s current reasoning procedure gives the decision, which matches to G^B in the current $\boldsymbol{w}^{B}$ (*A* and *B* achieved their joint goal), OR whether *A* or *B* abandoned their joint goal, OR *B* postpones the decision (*A* and *B* did not yet achieve their joint goal).

Figure 4. Communicative strategy of the partner *B* (G^B*=* G^A*=B will do D).*

If *A or B* gives up then the communicative goal will be not achieved. If *B* postpones her decision at the end of dialogue then there are neither winners nor losers.

Questions can be asked by participants in order to make choices among different propositions that can be used in argumentation.

C. Information States in Negotiation Process

If both *A* and *B* are conversational agents then let us assume the availability of following knowledge [27]:

1) a set *G* of communicative goals where both participants choose their initial goals (G^A and G^B, respectively). In our case, $G^A = G^B$= "*B* decides to do *D*"
2) a set *S* of communicative strategies of the participants. A communicative strategy is an algorithm used by a participant for achieving his/her communicative goal. This algorithm determines the activity of the participant at each communicative step
3) a set *T* of communicative tactics, i.e., methods of influencing the partner when applying a communicative strategy. For example, *A* can entice, persuade, or threaten *B* in order to achieve the goal G^A, i.e., *A* attempts to demonstrate that achieving this goal is, accordingly, more pleasant than unpleasant, more useful than harmful, or obligatory for *B*
4) a set *R* of reasoning procedures, which are used by participants when reasoning (here: about doing an action *D*). A reasoning procedure is an algorithm that returns the positive or negative decision about the reasoning object (the action *D*)
5) a set *P* of participant models, i.e., a participant's depictions of the beliefs of himself/herself and his/her partner in relation to the reasoning object: $P = \{P^A(A), P^A(B), P^B(A), P^B(B)\}$
6) a set of world knowledge
7) a set of linguistic knowledge.

A conversational agent passes several *information states* during interaction starting from the initial state and going to every next state by applying *update rules*. Information states represent cumulative additions from previous actions in the dialogue, motivating future actions. There are two parts of an information state of a conversational agent [8] —private (information accessible only for the agent) and shared (accessible for both participants).

The private part of an information state of the conversational agent *A* (dialogue initiator) consists of the following information: (a) current model of the partner *B*, (b) communicative tactics t_i^A, which *A* has chosen for influencing *B*, (c) the reasoning model r_j, which *A* is trying to trigger in *B* and bring it to the positive decision (it is determined by the chosen tactics, e.g., when persuading, *A* tries to increase *B*'s need to do *D*), (d) a set of dialogue acts $DA=\{d_1^A, d_2^A, \ldots, d_n^A\}$, which *A* can use, (e) a set of utterances for increasing or decreasing the values of *B*'s attitudes in relation to *D* (arguments for/against of doing *D*) $U=\{u_{i1}^A, u_{i2}^A, \ldots, u_{iki}^A\}$.

The shared part of an information state contains (a) a set of reasoning models $R=\{r_1,\ldots,r_k\}$, (b) a set of communicative tactics $T=\{t_1, t_2, \ldots, t_p\}$, and (c) dialogue history $p_1{:}u_1[d_1], p_2{:}u_2[d_2],\ldots, p_i{:}u_i[d_i]$ where p_1=*A*; p_2, etc. are *A* or *B*.

A stack is used keeping (sub-)goals under consideration. In every information state, the stack contains an aspect of *D* under consideration (e.g., when *A* is persuading *B* then the usefulness is on the top).

Two categories of *update rules* are at disposal of conversational agent for moving from current information state into the next one: (1) for interpreting the partner's turns and (2) for generating its own turns. For example, there are the following rules for the initiator *A* in order to *generate* its turns:

1) for the case if the title aspect of the used tactics is located on top of the goal stack (e.g., for the tactics of persuasion, the title aspect is usefulness)
2) for the case if another aspect is located over the title aspect of the used tactics (e.g., if *A* is trying to increase the usefulness of *D* for *B* but *B* argues for unpleasantness, then the unpleasantness lies over the usefulness)
3) for the case if there are no more utterances for continuing the current tactics (and new tactics should be chosen if possible)
4) for the case if *A* has to abandon its goal
5) for the case if *B* has made the positive decision and therefore, *A* has reached the goal.

Special rules exist for updating the initial information state.

D. Implementation

A simple dialogue system is implemented that carries out negotiations with a user in a natural language about doing an action [27]. The participants can have different initial goals: e.g., the initiator (either DS or a user) tries to achieve the decision of the partner to do the action but the partner's goal can be opposite. DS interacts with a user using texts in a natural language. There are two work modes. In one mode, the computer is playing *A*'s and in the other—*B*'s role.

Both *A* and *B* have access to a common set of reasoning procedures. They also use fixed sets of dialogue acts and the corresponding utterances in a natural language which are pre-classified semantically, e.g., the set $P_{missing\_resources}$ for indicating that some resources for doing a certain action *D* are missing (e.g., *I don't have proper dresses*, see Example 4), $P_{increasing\_resources}$ for indicating that there exist resources (e.g., *The company will cover all your expenses*), $P_{increasing\_usefulness}$ for stressing the usefulness of *D* (e.g., *You can be useful for the company*), etc. Therefore, no linguistic analysis or generation will be made during a dialogue in current implementation. The utterances will be accidentally chosen by conversational agent from the suitable semantic classes (in our implementation, every utterance can be used only once). However, these restrictions will bring along that the generated dialogues are not quite coherent.

If *A*'s goal is "*B* will do *D*" then *A*, starting interaction, generates, by using his knowledge, a partner model $\boldsymbol{w}^{AB}$ and determines the communicative tactics *T*, which he will use (e.g., persuasion), i.e., he accordingly fixes the reasoning procedure *R*, which he will try to trigger in *B*'s mind (e.g., NEEDED). *B* (if being another conversational agent) has her own model $\boldsymbol{w}^B$ (which exact values *A* does not know). *B* in her turn determines a reasoning procedure R^B that she

will use in order to make a decision about doing *D*, and her communicative tactics T^B.

When attempting to direct *B*'s reasoning to the positive decision (do *D*), *A* presents several arguments stressing the positive and downgrading the negative aspects of *D*. Preparing an argument, *A* triggers the current reasoning procedure in his partner model $\boldsymbol{w}^{AB}$, in order to be sure that the reasoning will give the positive decision. *B* can use the same or a different reasoning procedure triggering it in the model of herself $\boldsymbol{w}^{B}$. After the changes made by both the participants in the two models during a dialogue, the models will approach each to other but, in general, do not equalise. Although, the results of reasoning in both models can be (or not be) equal.

1) Upgrading the model $\boldsymbol{w}^{AB}$

Let us consider a dialogue with our DS (Example 4). Here *A* is conversational agent playing the role of the boss of a company and *B* is the user playing the role of an employee of the company who is at the same time studying at the university. *A* presents arguments for doing *D* by *B* (*D*=travel to *N.* to conclude a contract). He succeeds to decline *B*'s counter arguments and convince *B* to accept its goal.

Example 4

1.A: The company offers you a trip to N. Our company needs to conclude a contract there.
2.B: I don't have proper dresses.
3.A: The company will pay your executive expenses. You can be useful for the company.
4.B: I can have some problems at my university.
5.A: It's all right–your examinations period will be extended. The company will evaluate your contribution.
6.B: OK, I'll do it.
7.A: I am glad.

Let us examine how the partner model is used in the dialogue. *A* will implement the tactics of *persuasion* and generates a partner model, let it be

$\boldsymbol{w}^{AB}$={w^{AB}*(resources)=1,* w^{AB}*(pleasant)=4,* w^{AB}*(unpleasant)=2,* w^{AB}*(useful)=5,* w^{AB}*(harmful)=2,* w^{AB}*(obligatory)=0,* w^{AB}*(prohibited)=0,* w^{AB}*(punishment-do)=0,* w^{AB}*(punishment-not)=0*}.

The reasoning procedure NEEDED (Figure 2 above) yields a positive decision in this model. *A*'s *initial information state* is as follows.

Private part
•initial partner model $\boldsymbol{w}^{AB}$ = (1, 4, 2, 5, 2, 0, 0, 0, 0)
•the tactics chosen by *A*–persuasion
•*A* will use the reasoning procedure NEEDED, the presumption is fulfilled: w^{AB}*(useful)* > w^{AB}*(harmful)*
•the set of dialogue acts at *A*'s disposal: {proposal; arguments for increasing/decreasing values of different coordinates of $\boldsymbol{w}^{AB}$; accept; reject}
•the set of utterances for expressing the dialogue acts at *A*'s disposal: {*The company offers you a trip to N, You can be useful for the company*, etc.}.

Shared part
•the reasoning procedures WISH, NEEDED, MUST
•the tactics of enticement, persuasion, threatening
•dialogue history–an empty set.

Let us suppose here that every statement (argument) presented in dialogue will increase or respectively, decrease the corresponding value in the model of beliefs by *one unit*. Still, this is a simplification because different arguments might have different weights for different dialogue participants.

Table 1 demonstrates how the partner model is changing during the dialogue.

Conversational agent *A* starts the dialogue with a proposal. Using the tactics of persuasion and attempting to trigger the reasoning procedure NEEDED in *B*, it adds an argument for increasing the usefulness to the proposal (turn 1). At the same time, it increases the initial value of the usefulness in its partner model $\boldsymbol{w}^{AB}$ by 1. The current reasoning procedure NEEDED still gives a positive decision in the updated model. *A* does not know the actual values of attitudes, which *B* has assigned in the model $\boldsymbol{w}^{B}$ of herself. As caused by every counter argument that *B* will present, *A* has to update the partner model $\boldsymbol{w}^{AB}$.

However, *B*'s counter argument (turn 2) demonstrates that *B* actually has resources missing (*I don't have proper dresses*) therefore, *A* has to decrease the value of w^{AB}*(resources)* from 1 to 0 in its partner model. Now *A* must find an argument indicating that the resources are available: it selects an utterance from the set $P_{increasing\_resources}$ (*The company will pay your executive expenses*) and following the tactics of persuasion it adds an argument for increasing the usefulness (*You can be useful for the company*) in turn 3. The value of w^{AB}*(resources)* will now be 1 and the value of w^{AB}*(useful)* will be increased by 1 in the partner model. The reasoning in the updated model gives a positive decision.

Nevertheless, *B* has a new counter argument indicating the harmfulness of the action: *I can have some problems at my university* (turn 4).

Now *A* has to increase the value w^{AB}*(harmful)* in the partner model, it turns out that by 6 not by 1 as was assumed by default. Let us explain why. So far, *A* was supposing that *D* is not prohibited for *B*. This assumption proves to be wrong because otherwise it would be impossible for *B* to indicate the harmfulness of *D* (if she is applying the reasoning procedure NEEDED as *A* supposes, see Figure 2). Therefore, *B* supposedly compares the values of beliefs at the step 4 of the procedure and makes a negative decision. *B* can come to the step 4 only after the step 3 where she detects that *D* is prohibited and doing *D* involves a punishment (turn 4).

Table 1. Updating the partner model w^{AB} by *A* in argumentation dialogue with *B* (*A* implements the reasoning procedure NEEDED)

Dialogue history	**Partner model w^{AB}**									**Comments**
	Re-sour-ces	Pl ea sa nt	Un-plea-sant	Use-ful	Ha rm ful	Obli ga-tory	Proh ibite d	Puni shm ent_ do	Puni shm ent-not	
	1	**4**	**2**	**5**	**2**	**0**	**0**	**0**	**0**	Initial model
1.A: The company offers you a trip to N. Our company needs to conclude an agreement there. statement for usefulness	1	4	2	5+1	2	0	0	0	0	*A* makes a proposal; usefulness increases
2.B: I don't have proper dresses. statement of missing resources	0	4	2	6	2	0	0	0	0	Resources missing
3.A: The company will pay your executive expenses. statement of existence of resources You can be useful for the company. statement for usefulness	1	4	2	6+1	2	0	0	0	0	Resources exist, usefulness increases once more
4.B: I can have some problems at my university. statement for harm-fulness	1	4	2	7	2+ 6	0	1	1	0	Harmfulness has to be increased by 6 because *B*'s reasoning has given a negative decision
5.A: It's all right – your examinations period will be extended. statement against harmfulness The company will evaluate your contribution. state-ment for usefulness	1	4	2	7+1	8- 1	0	1	1	0	Harmfulness decreases, usefulness increases once more
6.B: OK, I'll do it. agreement	**1**	**4**	**2**	**8**	**7**	**0**	**1**	**1**	**0**	Final model
7.A: I am glad. accept										*A* has achieved the goal

Therefore, *A* changes the value of w^{AB}*(prohibited)* from 0 to 1 and increases the value of w^{AB}*(punishment-do)* in the partner model at least by 1. (Being optimistic, *A* increases the value exactly by 1 and not more.) Now *A* checks, how to change the value of the harmfulness in the partner model in order to get the negative decision like *B* did. According to the reasoning procedure NEEDED *A* calculates that the value has to be increased (at least) by 6. Therefore, w^{AB}*(harmful)* will be 2+6=8. Responding to *B*'s counter argument, *A* decreases the value of w^{AB}*(harmful)* by 1 using the utterance *It's all right - your examinations period will be extended*, and increases the value of w^{AB}*(useful)* once more using the utterance *The company will evaluate your contribution* (turn 5). The reasoning procedure NEEDED gives a positive decision in the updated partner model. Now it turns out that *B* has made this same decision (turn 6). *A* has achieved its communicative goal and finishes the dialogue (turn 7). Table 1 demonstrates how *A* is updating the partner model $\boldsymbol{w}^{AB}$ in argumentation dialogue with *B*. As compared with the initial model, the values of four aspects have been increased: *w(usefulness)* from 5 to 8, *w(harmfulness)* from 2 to 7, *w(prohibited)* and *w(punishment-do)* from 0 to 1.

Table 2. Updating the model w^B by *B* in argumentation dialogue with *A* (*B* implements the reasoning procedure WISH).

Dialogue history	**The model w^B**									**Comments**
	Re-sour-ces	Pl ea sa nt	Un-plea-sant	Us e-ful	Ha rm ful	Obli ga-tory	Proh ibite d	Puni shm ent_ do	Pu-nish-ment -not	
	0	**6**	**4**	**3**	**4**	**0**	**1**	**0**	**3**	Initial model; reasoning procedure WISH gives a negative decision
1.A: The company offers you a trip to N in order to conclude a contract. proposal Our company needs to conclude an agreement there.	0	6	4	3+ 1	4	0	1	0	3	*A* makes a proposal; usefulness increases
2.B: I don't have proper dresses. statement of missing resources	0	6	4	4	4	0	1	0	3	Resources mis-sing
3.A: The company will pay your executive expenses. You can be useful for the company.	1	6	4	4+ 1	4	0	1	0	3	Resources exist, usefulness increases once more
4.B: I can have some problems at my university. statement for harmfulness	1	6	4	5	4	0	1	0	3	Harmfulness too big, *B*'s reasoning has given a negative decision
5.A: It's all right – your examinations period will be extended. statement against harmfulness The company evaluates your contribution.	1	6	4	5+ 1	4- 1	0	1	0	3	Harmfulness decreases, usefulness increases once more
6.B: OK, I'll do it. agreement	**1**	**6**	**4**	**6**	**3**	**0**	**1**	**0**	**3**	Final model; WISH gives a positive decision
7.A: I am glad. accept										The common goal is achieved

2) Upgrading the model $\boldsymbol{w}^B$

In argumentation dialogue, *A* is updating his partner model $\boldsymbol{w}^{AB}$. At the same time, *B* has to update the model $\boldsymbol{w}^B$ of herself as caused by the arguments presented by *A*. Similarly with *A*, who does not know the exact values of *B*'s beliefs in $\boldsymbol{w}^B$, also *B* does not know the exact values of beliefs in the model $\boldsymbol{w}^{AB}$. Both participants can make inferences only from arguments presented by the partner.

Does the final model $\boldsymbol{w}^{AB}$ coincide with *B*'s actual model $\boldsymbol{w}^B$, i.e., has *A* correctly guessed all the actual weights of *B*'s beliefs? The answer is "no". Let us discuss why.

Let us again consider Example 4 and Table 1. Let us suppose that *B* also is a conversational agent (not a human user) and that *B*'s actual model is $\boldsymbol{w}^B$ = (0, 6, 4, 3, 4, 0, 1, 0, 3) at the beginning of the dialogue (different from $\boldsymbol{w}^{AB}$ as in Table 1). In addition, let us suppose that *B*'s communicative goal coincides with *A*'s one (is not opposite)—*B* has a wish to do *D* (doing *D* is more pleasant than unpleasant). It triggers a reasoning procedure WISH (Figure 1 above) in its model of beliefs in order to check the resources and other aspects of doing *D* and to make a decision. The decision will be negative because *B* does not have enough resources (*I don't have proper dresses*).

Table 2 demonstrates the updates made by *B* in the model $\boldsymbol{w}^B$ during the dialogue as affected by *A*'s arguments. We suppose here that *A*'s arguments will increase/decrease the corresponding weights by *one unit* (this same assumption was made for *A* in the case of *B*'s counter arguments). *B* uses the reasoning procedure WISH. The initial model $\boldsymbol{w}^B$ gives a

negative decision but the updated final model gives a positive decision.

In this way, *A* is able to convince *B* to do *D* if he has enough arguments for doing *D* and his initial picture of *B* does not radically differentiate from *B*'s actual beliefs. Both the beliefs in the partner model $\boldsymbol{w}^{AB}$ and *B*'s actual beliefs in the model $\boldsymbol{w}^{B}$ of herself (if *B* is a conversational agent similarly with *A*) are changing during the dialogue as influenced by the arguments presented by the participants. Although the models $\boldsymbol{w}^{AB}$ and $\boldsymbol{w}^{B}$ do not necessarily coincide at the end of the dialogue, the proportions of the values of the positive (pleasantness, etc.) and negative aspects of doing *D* (unpleasantness, etc.) will be similar. Still, if *B* (or *A*) is a human user then she (or he) is not obliged to use the models and algorithms.

V. Discussion

Our model of conversational agent is motivated by the analysis of human-human negotiations. We consider the dialogues where two participants *A* and *B* negotiate doing an action *D*. In the analyzed telemarketing calls, the communicative goal of a sales clerk of the educational company is to convince a customer to order and pass a training course offered by the company. The customer can either adopt or not this goal.

If the participants are collaborative and one of them presents his/her argument then the partner mostly accepts it. If the participants are antagonistic then at least one of them does not agree with the opinion of the partner and presents his/her counterargument(s). The more the clerk knows about the customer, the more convincing arguments is he able to choose. Asking questions is a way to learn more about the communication partner.

The most important phase of a telemarketing call is a clerk's *argumentation* for taking a training course. Arguments of sales clerks are presented as assertions and customers can accept or reject them. It is remarkable that the customers usually accept assertions of clerks—it shows that the clerks succeed to choose 'right' arguments. Still, *B*'s accept is usually followed by additional information that can be interpreted as a counter argument. The argumentation chain looks like

A: argument$_1$ – *B*: accept$_1$ + counter argument$_1$
…
A: argument$_n$ – *B*: accept$_n$ + counter argument$_n$.

The situation is different when *B* is steering to a negative decision (one single conversation in the whole analyzed corpus). Then *B* does not accept *A*'s assertion/argument and takes over the initiative starting to present assertions/counter arguments herself. *A* always accepts *B*'s assertions but he provides his arguments as additional information. The argumentation chain looks like

A: argument$_1$ – *B*: reject$_1$ + counter argument$_1$
A: accept$_2$ + argument$_2$ – *B*: reject$_2$ + counter argument$_2$
…
A: accept$_n$ + argument$_n$ – *B*: reject$_n$ + counter argument$_n$.

When reasoning about doing an action, a subject is weighing different aspects of the action (its pleasantness, usefulness, etc.), which are included into his/her model of motivational sphere. In the model presented here, we evaluate these aspects by giving them discrete numerical values on the scale from 0 to 10. Still, people do not use numbers but rather words of a natural language, e.g., *excellent, very pleasant, harm*, etc. Further, when reasoning, people do not operate with exact values of the aspects of an action but they rather make 'fuzzy calculations', for example, they suppose/believe that doing an action is more pleasant than unpleasant and therefore they wish to do it. Another problem is that the aspects of actions considered here do not be fully independent. For example, harmful consequences of an action as a rule are unpleasant. In addition, if the reasoning object is different (not doing an action like in our case) then the beliefs of a reasoning subject can be characterized by a different set of aspects.

When attempting to direct *B*'s reasoning to the desirable decision, *A* presents several arguments stressing the positive and downgrading the negative aspects of *D*. The choice of *A*'s argument is based on one hand, on the partner model, which captures *A*'s knowledge about *B*, and on the other hand, on the (counter) argument presented by *B*. Still, *B* is not obliged to present any counter argument but she can simply refuse (e.g., *I do not do this action*). When choosing the next argument supporting *D*, *A* triggers a reasoning procedure in his partner model depending on the chosen communicative tactics, in order to be sure that the reasoning will give a positive decision after presenting this argument. *B* herself can use the same or a different reasoning procedure triggering it in her own model. After the updates made both by *A* and *B* in the two models during a dialogue, the models will approach each to another but, in general, do not equalize. Nevertheless, the results of reasoning in both models can be similar, as demonstrated in Example 4. Therefore, *A* can convince *B* to do *D* even if not having a perfect picture of her.

Our dialogue model considers only limited kinds of dialogue but nonetheless it illustrates the situation where the dialogue participants are able to change their beliefs related to the negotiation object and bring them closer one to another by using arguments. The initiator *A* does not need to know whether the counter arguments presented by the partner *B* have been caused by *B*'s opposite initial goal or are there simply obstacles before their common goal, which can be eliminated by *A*'s arguments. *A*'s goal, on the contrary is not hidden from *B*. Secondly, the different communicative tactics used by *A* are aimed to trigger different reasoning procedures in *B*'s mind. *A* can fail to trigger the pursued reasoning procedure in *B* but however he can achieve his communicative goal when having a sufficient number of arguments supporting his initial goal.

In our implemented DS, the user interacts with the computer, choosing ready-made, semantically pre-classified sentences as arguments and counter arguments for and against doing a certain action. Nevertheless, we suppose that such kind of software is useful when training the skills of finding arguments for and against of doing an action. The computer can establish certain restrictions on the argument types and on the order in their use. Still, when interacting with the computer, a human user does not use neither a formal partner model, nor a formal model of herself, nor reasoning procedures. However, both implementation modes allow study how the beliefs of the participants are changing in negotiation.

VI. Conclusion and Future Work

We analyse human negotiations in order to explain how arguments are used to convince a dialogue partner. We consider human-human telemarketing calls where a sales clerk of an educational company proposes training courses to a customer who possibly does not want to order any course. When starting a dialogue, the sales clerk determines a certain way to realize his communicative strategy—communicative tactics—and retains them during a dialogue. The customer can change her strategy during conversation.

We study dialogues where one participant (initiator of interaction *A*) has a communicative goal that the partner (*B*) will decide to do an action *D*. *B*'s communicative goal can be similar or opposite ("do not do *D*"). When reasoning about doing *D*, *B* considers different positive and negative aspects of *D*. If the positive aspects weigh more the decision will be "do *D*". If the negative aspects weigh more the decision will be "do not do *D*". The initiator *A* chooses a suitable communicative strategy and tactics in order to influence *B*'s reasoning and achieve the positive decision: he stresses the positive and downgrades the negative aspects of doing *D*. Different arguments are presented in a systematic way, e.g., *A* stresses time and again the usefulness of *D*.

Initial communicative goals of the participants can be similar or opposite. The partners present arguments for and against of doing *D*. The arguments of the initiator *A* are based on his partner model $\boldsymbol{w}^{AB}$ whilst *B*'s arguments—on her model of herself $\boldsymbol{w}^{B}$. Both models include beliefs about the resources, positive and negative aspects of doing *D* that have numerical values in our implementation. Both models are updated during a dialogue.

In our implementation, the user interacts with the computer, choosing ready-made, semantically pre-classified sentences as arguments and counter arguments for and against of performing a certain action. We believe that this kind of software is useful when training the argumentation skills—the programme can establish certain restrictions on the argument types, the order in the use of arguments and counter arguments, etc. It allows study how beliefs of the participants are changing in argumentation dialogue.

Our further aim is to develop the DS concentrating foremost on the reasoning model. So far, we are using an intuitive (naïve) reasoning theory. However, there are several other approaches to model change of a person's opinion, e.g., Elaboration Likelihood Model, Social Judgment Theory, and Social Impact Theory. Some of the theories can be better to model human reasoning. Our further research will explain this. We also plan to add NLP for Estonian in order to achieve more natural communication between DS and the user. The results of the study can be used in various domains of activity, when training people to carry out negotiations.

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