A Virtual Selling Agent which is Proactive and Adaptive

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Abstract In this paper, we claim that the online selling process can be improved if the experience of the customer is closer to the one in a retailing store. For this purpose, we aim at providing a virtual selling agent that is proactive and adaptive. Our proactive dialogical agent initiates the dialogue, uses marketing strategies and drives the inquiring process for collecting information in order to make relevant proposals. Moreover, our virtual seller is adaptive since she is able to adjust her behaviour according to the buyer profile.

1 Introduction

Within the last twelve years e-commerce has succeeded to pursue a massive number of shoppers to change their idea of buying. Several existing businesses have taken an advantage of this boom by adding a virtual presence to their physical one by means of an e-commerce website, moreover, new companies that exist only through the web have also appeared (e.g., Amazon). Although the online presence of companies is cost-efficient, yet the lack of a persuading salesman affects the transformation ratio (sales vs. visits). Then, several companies have started to embody a virtual assistant to aid potential online shoppers.

Most of the agents available on the e-commerce websites consists of intuitive interfaces for consulting catalogues by using the customer language (cf. Anna on www.ikea.com). The use of natural language and multi-modal virtual agents increase the expectations of customers which are quite often disappointed by the poor linguistic and the poor selling abilities of the agents [7]. This corresponds to the uncanny valley phenomenon. Actually, these agents play the role of interactive FAQ.

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They are purely reactive agents responding in one-shot interactions (i.e. query/inform) with predefined answers.

In this paper, we claim that the online selling process can be improved if the experience of the customer is closer to the one in a retailing store. For this purpose, we aim at providing a virtual selling agent that is proactive, adaptive and that behaves as an adviser. Our **proactive dialogical agent** (`PDA`) initiates the dialogue, deploys marketing strategies and she drives the inquiring process for collecting information in order to make relevant proposals. Additionally, our virtual seller is adaptive since she is able to adjust her behaviour to the buyer profile.

The paper is organized as follows : we first introduce a walk-through example in Section 2 and we explain our approach in Section 3. We present the dialogue framework in Section 4. Section 5 discusses some related works. Section 6 concludes with some directions for future works.

2 Walk-Through Example

We motivate our approach with the following scenario. A buyer is surfing on the website of a sport reseller. He is looking for a bike for his daughter (i.e the user needs). Since he does not find the appropriate product, he spends some time on the website and so, the virtual seller agent is triggered. Then the dialogue presented in Fig. 1 occurs.

1. `PDA`: Do you have any idea about the kind of bike you are looking for ?
2. `Customer`: Not at all.
3. `PDA`: Who will use this bike ?
4. `Customer`: A girl.
5. `PDA`: How old ?
6. `Customer`: 4.
7. `PDA`: May I suggest the 16” PRINCESS.
8. `Customer`: No, thanks.
9. `PDA`: Do you prefer the 16” CAM&LITI?
10. `Customer`: For sure.

Fig. 1 Proactive Dialogical Agent Vs. Human: a Sale Scenario

This specific case run illustrates the main features exhibited by the virtual seller:

- **Initiative.** The virtual seller agent has initiative since she starts the conversation in order to support the customer (cf utterance #1).
- **Adaptability.** The agent reaction depends on the utterance #2. If the customer would reply that he has a limited budget, then the value `bargain-hunter` is assigned to the buyer profile and the following of the dialogue should be different. For instance, we would propose a special offer. Actually, the agent behaviour depends on the buyer profile.

- **Information-seeking.** The agent asks questions to the customer in order to collect information in order to propose relevant products.

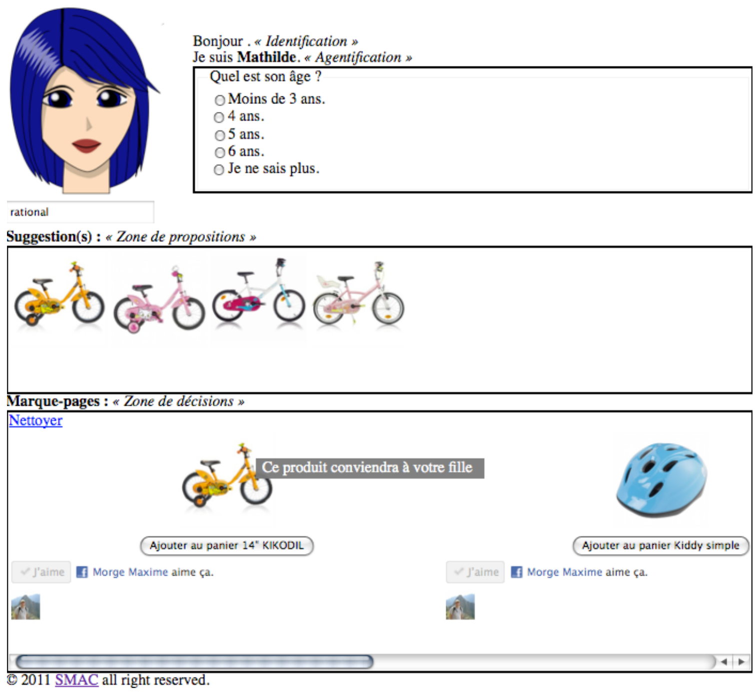

Fig. 2 Web interface with a container for the questions and a container for the proposals.

We prefer a classical web form (cf. Fig. 2) rather than a natural language interface not to increase the expectations of the customer. Therefore, the latter has the choice between several predefined answers for each question asked by the software agent. Moreover, we can focus on the pragmatical aspect of the dialogue. The user interface is written with AJAX technologies. The technological details are described in a companion demonstration within the same proceedings [2].

3 Dialectical approach

Our approach for dialogue modelling considers the exchange of utterances as a process regulated by some normative rules that we call *dialogue-game protocol*. Our approach is based upon the notion of dialogue which is defined by [15] as a coherent and structured sequence of utterances aiming at moving from an initial state to reach the goals of the participants. [15] distinguish five main categories of dialogues depending on the initial situation and the goals (cf. Table 1). For instance, an **infor-**

mation seeking appears when a participant aims at catching knowledge from its interlocutor. A **deliberation** begins with an open problem. The discussion is about a future action. It is worth noticing that, in real world, the nature of dialogues can be mixed, as in our example. Actually, we distinguish in our scenario two dialogues. Firstly, the need identification is performed with the help of an information seeking dialogue about the buyer requirements where the virtual seller agent asks discriminatory questions (cf utterances #1 - #6 in Fig. 1). Secondly, the sale is performed by a dialogue where the aim is to "*make a deal*". In this deliberation dialogue, the virtual seller agent makes offers and the customer accepts or refuses these proposals (cf utterances #7 - #10 in Fig. 1).

Table 1 Systemic overview of dialogue categories [15]

Initial situation → Goal ↓	Conflict	Open problem	Ignorance of a participant
Stable agreement i.e., Resolution	persuasion	inquiry	information seeking
Practical settlement i.e., Decision	negotiation	deliberation	∅

4 Dialogue Framework

This section will present our formal framework and we will show how the previous example can be formalized.

4.1 Communication layer

In order to communicate, the participants must understand each other. They must share the same **knowledge representation language** and the same **agent communication language**. We will present both of them.

A dialogue involves a set of agents Ω: a software agent and a customer agent in our example. In order to formalize this kind of dialogue, we need first to consider that the agents exchange knowledge which are represented in a logical language (denoted $\mathscr{L}$). Moreover, agents communicate by exchanging messages. For this purpose, we define an agent communication language (denoted $\mathscr{ACL}$). Each dialogical move has a unique id $M_k \in \mathscr{ACL}$.

Definition 1 (Dialogical move). Let Ω be a set of agents and $\mathscr{L}$ be a knowledge representation language. A **(dialogical) move** $M_k \in \mathscr{ACL}$ is defined as $M_k = \langle S_k, H_k, P_k, R_k, A_k \rangle$ s.t.:

- $S_k = \texttt{speaker}(M_k) \in \Omega$ is the speaker;

- $H_k = \mathtt{hearer}(M_k) \in \Omega$ is the hearer;
- $P_k = \mathtt{protocol}(M_k)$ is the dialogue-game protocol used;
- $R_k = \mathtt{reply}(M_k) \in \mathscr{ACL}$ is the identifier of the move to which M_k responds. We will use θ to denote that the move do not reply to a previous one;
- $A_k = \mathtt{act}(M_k)$ consists of a speech act, i.e. a locution (denoted $\mathtt{locution}(M_k)$)) and a content (denoted $\mathtt{content}(M_k)$), i.e a sentence of $\mathscr{L}$. The potential locutions are: `query`, `assert`, `unknow`, `propose`, `withdraw`, `accept` and `reject`.

While the speaker generates and sends a move, the hearer receives and interprets it. The example in the previous section can be formalized in the following way:

- $M_1 = \langle \mathtt{PDA}, \mathtt{Customer}, \mathtt{is}, \theta, \mathtt{query}(\mathtt{BuyerProfile}(x)) \rangle$
- $M_2 = \langle \mathtt{Customer}, \mathtt{PDA}, \mathtt{is}, M_1, \mathtt{assert}(\mathtt{BuyerProfile}(\mathtt{rational})) \rangle$
- $M_3 = \langle \mathtt{PDA}, \mathtt{Customer}, \mathtt{is}, \theta, \mathtt{query}(\mathtt{UserSex}(x)) \rangle$
- $M_4 = \langle \mathtt{Customer}, \mathtt{PDA}, \mathtt{is}, M_3, \mathtt{assert}(\mathtt{UserSex}(\mathtt{female})) \rangle$
- $M_5 = \langle \mathtt{PDA}, \mathtt{Customer}, \mathtt{is}, \theta, \mathtt{query}(\mathtt{UserAge}(x)) \rangle$
- $M_6 = \langle \mathtt{Customer}, \mathtt{PDA}, \mathtt{is}, M_5, \mathtt{assert}(\mathtt{UserAge}(4))$
- $M_7 = \langle \mathtt{PDA}, \mathtt{Customer}, \mathtt{del}, \theta, \mathtt{propose}(\mathtt{16princess}) \rangle$
- $M_8 = \langle \mathtt{Customer}, \mathtt{PDA}, \mathtt{del}, M_7, \mathtt{reject}(\mathtt{16princess}) \rangle$
- $M_9 = \langle \mathtt{PDA}, \mathtt{Customer}, \mathtt{del}, \theta, \mathtt{propose}(\mathtt{16cameliti}) \rangle$
- $M_{10} = \langle \mathtt{Customer}, \mathtt{PDA}, \mathtt{del}, M_9, \mathtt{accept}(\mathtt{16cameliti}) \rangle$

`is` stands for information-seeking while `del` stands for deliberation. The knowledge is represented by a logic-based language. For this purpose, we have defined a first-order logic language with unary predicate symbols to represent the product features, the user needs and the buyer profile. For instance,

- $\mathtt{BuyerProfile}(\mathtt{rational})$ is a predicate representing the buyer profile;
- $\mathtt{UserSex}(\mathtt{female})$ and $\mathtt{UserAge}(4)$ represent the user needs;
- $\mathtt{BikeColor}(\mathtt{pink})$ and $\mathtt{BikeSize}(16)$ represent the product features;
- `16princess` and `16cameliti` are proposition symbols representing two different products.

4.2 Dialogue layer

Since we have specified that agents communicate with messages, we need to specify how messages are related to each other. A dialogue is a social interaction amongst parties intended to reach a common goal. In this section, we present how our game-based social model [9] handles the foreseen conversation between a customer and a virtual seller agent.

From this perspective, we define a dialectical system as a formal framework that regulates a dialogue (see [12] for an overview). According to the game metaphor for social interactions, the parties are players which utter moves following social rules.

Definition 2 (Dialectical system). Let $\mathscr{L}$ be a knowledge representation language and $\mathscr{ACL}$ an agent communication language. A **dialectical system** is a tuple $\mathtt{DS}=\langle \mathtt{P},\mathtt{M},\mathtt{H},\mathtt{T},\mathtt{protocol}\rangle$ where:

- $\mathtt{P} = \{\mathtt{init},\mathtt{part}\} \subseteq \Omega$ is a set of participants called players: the initiator and the partner;
- $\mathtt{M} \subseteq \mathscr{ACL}$ is a set of well-formed moves;
- $\mathtt{H}$ is a set of histories, the sequences of well-formed moves s.t. the speaker of a move is determined at each stage by the turn-taking function $\mathtt{T}$ and the moves agree with the dialogue-game $\mathtt{protocol}$;
- $\mathtt{T}$: $\mathtt{H} \rightarrow \mathtt{P}$ is the turn-taking function. If the length of the history is null or even then $T(h) = \mathtt{init}$ else $T(h) = \mathtt{part}$;
- $\mathtt{protocol}$: $\mathtt{H} \rightarrow 2^{\mathtt{M}}$ is the function determining the legal moves which are allowed to expand an history.

Here, DS reflects the formalization of social interactions between two players uttering moves during a dialogue. Each dialogue is a maximally long sequence of moves ($d \in \mathtt{H}$ with $\mathtt{protocol}(d) = \emptyset$).

Later to that, we specify informally the elements of DS for our two dialogue examples. In our scenario, there are two players: the PDA is the initiator since she is proactive and so, the partner is the Customer. The protocol is defined by the function protocol and it can be summarized by the deterministic finite-state automaton represented in Fig. 3. An information-seeking dialogue begins with a query. The legal responding speech acts are assert and unknow. Such a dialogue consists in an arbitrary number of questions. Additionally, two questions cannot be built on the same predicate.The dialogue is closed by an assert or an unknow. A deliberation dialogue begins with an offer from the init through the speech act propose. The legal responding speech acts are accept and reject. Such a dialogue consists in an arbitrary number of different proposals. The dialogue is closed by an accept or a withdraw when init has no more proposals.

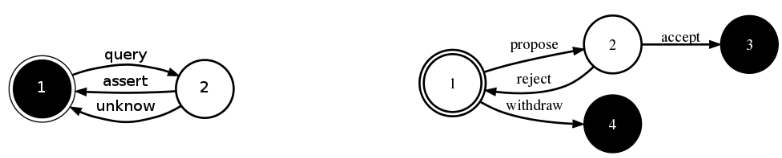

Fig. 3 Dialogue-game protocol for information-seeking (on the left), and deliberation (on the right). An information-seeking dialogue ends with an assertion or an admission of ignorance while a deliberation dialogue ends with an acceptance or a withdrawal.

4.3 Strategic layer

The strategy interfaces with the dialogue-game protocol through the condition mechanism of utterances for a move. For example, at a certain point in the deliberation dialogue `init` is able to send `propose` or `withdraw`. The choice of which locution and which content to send is depending on the strategy. Obviously, we will focus on the strategy of the initiator.

A strategy depends on the set of potential contents and their relative importance.

Definition 3 (Strategy). Let $\mathscr{L}$ be a knowledge representation language, $\mathscr{ACL}$ an agent communication language and $\mathtt{DS}=\langle \mathtt{P}, \mathtt{M}, \mathtt{H}, \mathtt{T}, \mathtt{protocol}\rangle$ a dialectical system where `protocol` enforces an information-seeking dialogue (resp. deliberation dialogue). The **information-seeking strategy** (resp. deliberation strategy) of the initiator is a couple $\langle \mathtt{topics}, \succ\rangle$ where:

- $\mathtt{topics} \subseteq \mathscr{L}$, is the set of literals that could be in the content of the speech acts uttered by the initiator during the dialogue;
- $\succ$ is preorder (reflexive and transitive) over `topics`.

The strategy is implemented in an history iff for all $l_1, l_2 \in \mathtt{topics}$ with $l_1 \succ l_2$, l_1 appears before l_2.

It is worth noticing the strategy can be defined dynamically. The `PDA` is **adaptive** in the information-seeking dialogue represented in Fig. 1 since she asks questions according to the strategy associated to the buyer profile as defined by the marketing rules. In our example, she applies the following strategies:

- if the buyer is `rational`, the `PDA` will only ask questions about the user needs;
- if the buyer is `bargain-hunter`, the `PDA` will first ask a question about the budget;
- if the buyer is `afficionados`, the `PDA` will only ask questions about the product features.

4.4 Reasoning layer

We present here the reasoning mechanism to handle the dialogue strategy.

In order to reason about the domain, we adopt a set of predicate symbols for *beliefs* and a set of *rules*.

Definition 4 (Knowledge base). Let $\mathscr{L}$ be a knowledge representation language. The **knowledge base** is a tuple $\langle \mathscr{R}, \mathscr{B}\rangle$ where:

- $\mathscr{R}$ is a logic program, *i.e* a finite set of **rules** $L_0, \ldots, L_{n-1} \rightarrow L_n$ with $n \geq 1$, each L_i (with $i \leq n$) being a literal (or a negative one) in $\mathscr{L}$. All variables occurring in a rule are implicitly universally quantified over the whole rule. A rule with variables is a scheme standing for all its ground instances;

- $\mathscr{B} \subseteq \mathscr{L}$ is a set of literals called the **beliefs**.

It is worth noticing that $\mathscr{B}$ is dynamically updated during the dialogue, while $\mathscr{R}$ is static. In order to illustrate the previous notions, the knowledge base of the PDA after M_n is $\langle \mathscr{R}, \mathscr{B}_n \rangle$. In our example:

- $\mathscr{R} = \{\texttt{UserAge}(4) \rightarrow \texttt{BikeSize}(16), \texttt{UserAge}(3) \rightarrow \texttt{BikeSize}(14), \texttt{UserSex}(\texttt{female}) \rightarrow \texttt{BikeColor}(\texttt{pink}), \texttt{UserSex}(\texttt{male}) \rightarrow \texttt{BikeColor}(\texttt{blue}), \texttt{BikeColor}(\texttt{pink}) \wedge \texttt{BikeSize}(16) \rightarrow \texttt{16princess}, \texttt{BikeColor}(\texttt{pink}) \wedge \texttt{BikeSize}(16) \rightarrow \texttt{16cameliti}, \ldots\}$;
- $\mathscr{B}_4 = \{\texttt{BuyerProfile}(\texttt{rational}), \texttt{UserSex}(\texttt{female}), \texttt{BikeColor}(\texttt{pink})\}$;
- $\mathscr{B}_{10} = \mathscr{B}_4 \cup \{\texttt{UserAge}(4), \texttt{BikeSize}(16), \texttt{Rejected}(\texttt{16princess}), \texttt{Accepted}(\texttt{16cameliti})\}$

4.5 Behaviour layer

Since our agent is able to reason in order to drive a dialogue, her proactive behaviour must be able to select the dialogues and to initiate them. For this purpose, we consider a set of goals. Each goal can be reached by a specific dialogue.

Definition 5 (Behaviour). Let $\mathscr{G}$ be a set of goals. A **behaviour** is a couple $\langle G, \succ \rangle$ where:

- $G \subseteq \mathscr{G}$ a set of goals;
- $\succ$ is a preorder (reflexive and transitive) over G.

In our example, the PDA considers three goals : the profile identification, the needs identification (which both requires information-seeking) and the agreement (which requires deliberation). In our example, the PDA is **benevolent** since she first attempts to identify the buyer profile, then the user needs and then she continues by proposing some products. An **aggressive** agent would consider the sale prior whether the before-sale tasks have been performed or not.

5 Related Works

In the field of ECAs, the term ”proactive” could be used with different manners. For L’Abbate and *al.*, proactivity is a state of the agent [4]. A chatterbot can, when he has the required information, go from a reactive state to a proactive one. Once, it uses the available information to adapt its behaviour to the current situation. For Semaro and *al.* [14], a proactive agent is able to pursue some goals in a conversation, e.g. products recommendation. In their approach, the agent considers prior information about the user needs and the buyer profile rather than collecting information during the conversation as we have done. Most of existing recommender systems focus on how to use information rather than how to obtain this information [8]. Our PDA does not require prior data, she dynamically models the user. Our user modelling is still limited since it is an explicit representation which is canonical, static and for short term [6]: we model the preferences of the customer (does he prefer a cheap product or a good one) and his expertise level (will he be able to answer to domain-specific questions).

The user modelling allows the PDA to personalize the interaction, i.e. be adaptive. As stated in [11], the adaptation requires (in our case) to: collect input data (the customer's answers), interpret data (the interpretation of the customer's utterances), model the current state of the world (the update of the beliefs), decide upon adaptation (the selection of the offers) and apply adaptation (the goal priority depending on the buyer profile).

[5] presents the challenges and current state-of-the-art of automated solutions for proficient negotiations with humans. They observe that research in AI has neglected this issue, at the expense of designing automated agents aimed to negotiate with perfect rational agents. In this perspective, different approaches to automated negotiation have been investigated, including game-theoretic approaches [13] (which usually assume complete information and unlimited computation capabilities), heuristic-based approaches [3] (which try to cope with these limitations) and argumentation-based approaches [1] (which allow for more sophisticated forms of interaction). Moreover, [5] suggests that adopting non-classical methods of decision making and learning mechanism for modelling the opponent may allow to achieve greater flexibility and effective outcomes. This is the case for our `PDA` which is adaptive.

In the field of Artificial Intelligence, dialectical argumentation has been put forward as a very general approach allowing to support decision-making. Thus, the decision aiding process can be modelled by a dialogue between an analyst and a decision maker where the preference statements of the former are elaborated using some methodology by the latter (see [10] for a survey).

6 Conclusion

Synthesis. In this paper we have proposed a proactive dialogical agent which initiates the dialogue and drives it in order to collect information for making relevant proposals. Furthermore, our agent is adaptive since the strategies can be dynamically defined. Our agent can be defined by her knowledge (a set of rules), the dialogical context (i.e. her beliefs before the dialogue, $\mathscr{B}_0$), her dialogue strategies (for deliberation and information-seeking) and her behaviour (i.e. the preferences between the goals). We have applied our framework to provide a virtual selling agent for e-commerce.

Work-in-progress. We are working with some experts and researchers in marketing who are quite enthusiastic with this approach [7]. They aim at evaluating our proposal with a panel of buyers. For this purpose, we are currently populating our prototype with real world data from a retailing company: product database, knowledge base, marketing strategies and natural language query/inform (see [2] for more details). From a computer science perspective, we plan to allow the selling agent to argue the proposals such that the arguments are adaptive with respect to the buyer profile. Additionally, we plan to express the agent reasoning with probabilistic rules in order to use machine learning techniques for improving the agent behaviour in the long run.

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