CoRA - Interactive Communication with Smart Products

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Abstract The concept of interactive natural language communication between users and products within a physical environment holds the capability for a redesign and extension of communication at the point of sale. After considering specific requirements of ambient environments, we present the model of a Conversational Recommendation Agent (CoRA), a domain-specific web-based dialogue system based on semantic knowledge representations (OWL-DL), which enables a product-centered communication between customers and smart products within ambient environments.

Keywords Smart product · dialogue system · Question-Answer · Natural Language Processing · semantic representations · OWL-DL

1 Introduction

By increasing informational complexity of consumer products, communication needs of customers regarding products at the point of sale rise intensely. Products possess a lot of different information, such as user guides, service and support features or user generated or professional reviews. Furthermore, consumers look for information about products that are alternatives or complements. For satisfying these consumers’s communication needs, we investigate how Natural Language services can be embedded into products that support consumer-product communication. A Natural Language based communication within a physical shopping environment enables an improved filtering and an intuitive representing of product information [1]. The direct embedding of communication services into the product, resuming the idea of Ubiquitous Computing [2], forms the basis for communication between users and physical products in ambient environments. The linkage of physical products with communicative functions requires the integration of value-added mobile services and digital product descriptions [3] and represents the concept of a smart product [4]. In order to realize Natural Language communication within physical environments, dialogue systems and appropriate knowledge representations are necessary that meet the specific requirements of ambient environments. In this article, we introduce the concept of a web-based dialogue system for Natural Language consumer-product communication in ambient retail environments. Therefore, we adopt a design science methodology [5]. Our results will be presented in the sense of a “proof by construction” [6]. In Section 2 we will outline the main research issues and works in the context of this article. Following, Section 3 describes the requirements on a dialogue system in ambient environments. After that, we introduce the architecture of our dialogue system that meets the identified requirements (Section 4). In Section 5 we exemplify our approach of Natural Language Processing through an example. Finally we discuss our current results and future work (Section 6).

2 Related Work

Interactive communication with smart products contacts two fields of research - Ambient Intelligence and Natural Language Processing (NLP). Through the in-
tegration of concepts of the NLP into ambient environments, the two scientific fields as yet separated are merged and exciting research issues are opened [1]. Ambient Intelligence (AmI) is close to Ubiquitous Computing that describes the disappearing of information technology within physical things of the daily use and the opportunity to communicate with them [2]. In continuation, Ambient Intelligence “implies a seamless environment of computing, advanced networking technology and specific interfaces” [1]. An AmI system generally cope with large amounts of unstructured information from heterogeneous sources. These have to be selected and prepared to satisfy user information needs [1]. At this point, NLP technologies become relevant, because they enable interpretation, transformation and filtering of information and therefore enhance the quality of AmI systems. The more natural a communication with a physical entity the higher is the acceptance of services and information [7], [8], [9]. Natural Language is a means for increased adaptation of communication to the needs of consumers which is important for more effective marketing models [4].

We assume that the appliance of Natural Language interfaces is attractive especially for creating human computer interfaces in tangible shopping environments. Such ambient environments hold specific characteristics, for instance, the prevalent embedding of an AmI system into mobile devices or their distribution among multiple components [1]. This means that Ambient Intelligence places high demands on a NLP approach for the realization of an interaction in form of discourses within physical environments. Within the NLP, there are four dominant discourse theories of Hobbs [10], Grosz & Sidner [11], Mann & Thompson [12] and McKeown [13]. What they have in common is the aspect that discourses are purpose-driven, i.e. communication is driven by user intentions to achieve a communicative goal. Furthermore, there exist two perspectives to consider the planning of discourses: functionalist and formalist perspective [14]. Whereas the former focuses on communicative intents of a speaker and their reflection within the discourse structure, the latter capitalizes on formalisms of the linguistic structure of discourse segments. We assume that a combination of a functionalist and a viable formalist perspective constitutes an approach for interactive communication with smart products in ambient environments [14], [15].

3 Interactive Communication between Customers and Smart Products

The concept of interactive communication with smart products encompasses the capability for a redesign and extension of communication interfaces between customers, retailers and manufacturers at the point of sale. Imagine, a customer is situated within a fashion shop. She is interested in a brown jacket and wants to know weather there is a blue variant of the product. In line with an interactive communication with the smart product, she is able to ask: "Is this jacket available in blue?". The jacket could answer the question: "Yes, you can find it on the second floor." In order to realize the embedding of natural language communication functions into physical products, dialogue systems and semantic product representations are required [3]. The former presents information in an optimal, goal-driven and intuitive way. We assume that natural language output enlarges the competitive advantage of products within several domains. Furthermore, the relationship between the manufacturer and the consumer is deepened. "Great salespeople understand that customer relationships are built, maintained, and expanded through dialogues, which take place one after another over time." [16]

3.1 Requirements on Natural Language Processing in Physical Environments

A dialogue system within the scenario of a communication between physical products and customers in physical environments has to fulfill specific requirements:

- **Processing of applied dialogues in shopping situations** - a dialogue system processes applied dialogues in shopping situations.
- **Two-dimensional resolution of intentions** - In order to realize product-centered communication between manufacturer and customer, dialogue systems need to resolve several, in part oppositional communicative intentions. On the one hand, the dialogue system adopts a supportive function concerning the informational needs of the customer. On the other hand, it has to pursue specific economic interests according to concerns of manufacturers or retailers.
- **Differentiated output of answers** - Subject to the course of a dialogue and changing economic intentions of manufacturers, a dialogue system is obliged to generate messages in diverse form at different times.
- **Efficient Natural Language Processing (NLP)** - To assure an efficient Natural Language Processing on a mobile device within physical environments, the
input opportunities of the customer in line with the Natural Language Understanding have to be channeled and restricted, for instance, through the proposal of constituent options. Thereby the usability of the dialogue system is improved. “We believe that, for many purposes, a suitable natural language subset will be much preferred, on grounds of conciseness and ease of typing alone [...]. It is fair to say that our objective is to so constrain natural language that it becomes a formal, but user-friendly, query language” [17].

4 Architecture of the Conversational Recommendation Agent

According to the requirements of Natural Language Processing in physical environments, we present a model of a domain-specific dialogue system that constitutes a communicative interface between customers and smart products. We propose the model of a Conversational Recommendation Agent (CoRA) that consists of three components: discourse intentions, the knowledge base and the processing layer (cf. Fig. 1).

4.1 Question Schemata

After analyzing a text corpus of sales conversations and consulting talks within the product domain of consumer electronics and fashion that was collected previously, we identified 19 question schemata that appear frequently within sales dialogues [13].

1. Definition Pure Definition, e.g. What means Lycra®? What means TMC?
2. Definition Functionality, e.g. How does Bluetooth work?
3. Equation Difference, e.g. Whereby trouser A differs from trouser B?
4. Equation Equity, e.g. Are the materials of the jackets equal? Are jacket A and jacket B equal?
5. Description Survey Average, e.g. What is the average price of navigation systems?
6. Description Survey NumberOfProducts, e.g. Which navigation systems are available in the color red? Which skirts are priced less than €80?
7. Description Survey NumberOfProperties, e.g. Which colors are available? Which materials are available?
8. Description Decision Comparison, e.g. Is there a smaller navigation system?
9. Description Decision Existence Property, e.g. Does product A possess Bluetooth?
10. Description Decision Existence Product, e.g. Is this jacket available in blue? Is there a navigation system in red?
11. Description Information Price, e.g. How much does product A cost?
12. Description Information Property, e.g. Which software is used? Which special features does the product have?
13. Description Information Usage, e.g. How can product A be used?
14. Description Information Person, e.g. Who is the manufacturer?
15. Description Information Modality, e.g. How tall is product A? How large is the memory? How long is the guarantee issued?
16. AdditiveProduct Survey Matching, e.g. Which product matches with product A? Which colors match with product A?
17. AdditiveProduct Bundle Price, e.g. How much does the bundle of product A and product B costs?
18. AdditiveProduct Decision Matching, e.g. Does product A matches with product B?
19. AdditiveProduct Discount, e.g. Is there a discount on the purchase of product A and product B?

4.2 Discourse Intentions

The discourse intention component covers linguistic intentions, user-centered and vendor-centered intents for participating in a sales conversation. We derived the communicative intentions of the customer from the question schemata mentioned above. The results were transferred to the taxonomy of communicative top-level-intentions of the customer [13] and integrated into the phases of the Simplified Consumer Choice Model (SCCM), which represents the course of a shopping situation [18] (cf. Fig. 2).

Furthermore, vendor’s and retailer’s intentions are pre-defined. Along with derived communicative inten-
tions of a consumer, vendor-retailer-centered intents compose the model of a two-dimensional goal resolution, i.e. the processing of differentiated partly oppositional intentions of several participants within a discourse. Consequently, there are three sorts of discourse intentions in CoRA:

1. Linguistic intentions - Basically, CoRA pursues linguistic intentions that represent the conversational maxims of Grice, e.g. the dialogue system has the intent to generate syntactical correct messages without redundant information [19].

2. User-centered intentions - User-centered intents compromise the communicative intentions of a customer during the discourse.

3. Vendor-centered intentions - For instance, satisfaction of a consumer’s information needs and increase of profitability and revenue.

In our configuration vendor-centered intentions are subordinated to linguistic and user-centered intentions [20].

![Fig. 2 Taxonomy of communicative goals in line with the SCCM [13], [18]]

4.4 Processing Layer

On the Processing Layer all courses of the Natural Language Processing in CoRA are controlled and managed. The Interpretation Manager represents the Natural Language Understanding, whereas the scope of the Natural Language Generation is constituted through the Generation Manager. The Behavioural Agent is the central controlling component that possesses a static discourse model that maps the discourse intentions, and the dynamic discourse management. The latter holds the process management, the discourse history and the focus stack for storing the subjects of interest during the dialogue. The trichotomy enables a plain disjunction of the components interpretation, generation and planning. Based on this, the handling of more complex domains and the portability of the dialogue system is improved [23].

The approach of the NLP in CoRA covers the demands of both domains of the NLP in dialogues understanding of questions and generation of answers. Natural Language Understanding in CoRA uses a schema based approach [13]. Each schema consists of a consumer’s communicative intention, a linguistic goal, constraints, keywords (cue-words) [24] and a schematic composition of a question.

The approach of the Natural Language Generation in CoRA is represented through a combination of text planning technologies [25]; rhetorical relations [10], [12], [14]; text schemas [13] and focus of attention [11]. The linkage of goal-driven planning technologies with the light-weight constitution of linguistic structures within the schemas enables the conjunction of the formalist and functionalist perspective of discourse planning [14]. Furthermore, the application of planning technologies allows an improved mapping of intentional structures [15] and provides a basis for realization of a two-dimensional goal resolution. Text plans are represented by plan operators [25], which are defined based on an analysis of a text corpus and assigned to schemas for question understanding. A plan operator defines a text plan for achieving an effect that satisfies a consumer’s communicative intention(s). It consists of a compulsive part that provides information requested by a consumer, and optional parts, which conduce to the satisfaction of vendor-retailer-centered intentions. A further component, the library of rhetorical relations, interlinks the parts of a plan operator [10], [12], [14]. The model of the Natural Language Generation in CoRA is completed by the focus of attention that represents the salient concepts of a discourse [13], [11].
4.5 Course of a NLP cycle in CoRA

At the beginning of a NLP cycle in CoRA, a consumer approaches a product in focus with a particular communicative intention and selects the first segment of her desired question (cf. Fig. 3). In the course of incremental selection of question segments by the consumer, CoRA analyses the question and processes question schemas of the Semantic QA Structure Model for identifying a consumers communicative goal. The question is deemed to be understood in CoRA, if the communicative intention of the user and the appropriate question schema was detected. In addition, CoRA derives a linguistic goal from the detected question schema and translates it into an effect that constitutes a key concept between a domain of a question understanding and an answer generation.

Meanwhile, the consumer can approve the completed question. Thus, the process of the answer generation is started. The Behavioural Agent checks the pool of plan operators based on the identified effect and selects the appropriate operator. Within the processing of the plan operator, the text plan of the answer is generated with regard to the vendor-retailer-centered intentions (called Macroplanning [26]). Each part of the plan operator is expanded; and resulting linguistic material is allocated (called Microplanning [26]). After checking the focus stack, CoRA decides which parts of an expanded plan operator are integrated into the final answer. Simultaneously, the foci of processed fragments of a plan operator are stored within the focus stack.

Finally, the generated answer is displayed and the Behavioural Agent saves the discourse act consisting of question, answer, effect and timestamp within the discourse history of the SPDO for building up a product memory.

4.6 Implementation of CoRA

On implementation level, CoRA constitutes a module of the Tip ’n Tell framework [4] and is implemented in form of a Java web service. The Tip ’n Tell client on a mobile device can communicate with the CoRA web service based on SOAP\(^1\). The implementation of the dialogue system in form of a web service enables the plain enclosure of the NLP module from the remaining framework and the realization of a performant dialogue system on mobile devices within physical environments.

To realize the handling of the semantic representations, more precisely the SPDO and the Semantic QA Structure Model, we use the Jena Semantic Web Framework\(^2\). This allows the use of SPARQL-based queries for retrieving product information from distributed semantic knowledge bases [27] and the processing of data within the application. Furthermore, each part of the knowledge base is formalized by semantic representations (currently in OWL-DL\(^3\)).

5 Exemplary NLP cycle on CoRA

The customer is situated in a physical shopping environment and poses a question to a product in focus. After identification of this product via RFID-based communication [3], the mobile client displays the dialogue interface to the consumer. By means of the client, the consumer is able to compose a question step-by-step.

In the course of question composition, the CoRA web service returns potential question segments of the next step according to consumer selections. At this point,

\(^1\) http://www.w3.org/TR/2007/REC-soap12-part1-20070427/

\(^2\) http://jena.sourceforge.net/

\(^3\) http://www.w3.org/TR/owl-features/
the CoRA web service processes the information retrieved from the knowledge base - the schematic linguistic structures as well as the non-linguistic product information of the SPDO (cf. Fig. 4). After completion of a question by a consumer, CoRA identifies the assigned question schema; the linguistic goal and the resulting effect (cf. Fig. 4).

Then, CoRA starts to generate an answer to the question (in this example "Wieviel kostet das Etuikleid?")4) by means of the effect. Based on the effect, an adequate plan operator is retrieved from the Semantic QA Structure Model. The plan operator is used for controlling further requests of the linguistic and non-linguistic knowledge base (cf. Fig. 5).

Fig. 5 Exemplary generation of an answer in CoRA

Product-comprehensive information, for instance, product matching or product bundle results, are generated via reasoning based on standardized web-based rules that are applied to SPDO instantiations of products [28], [29]. When linguistic and informational structures of an answer are completed, the CoRA web service sends a response to the mobile client: "Das Etuikleid kostet €89,95. Das Etuikleid passt zu den Ballerinas Sunshine. Die Produkte kosten im Bündel nur €119,95."5)

6 Conclusion and Future Work

An interactive communication between customers and products in physical environments implies the integration of technologies of the Natural Language Processing (NLP) into ambient environments. Such an embedding of interactive communication functions into physical products requires the assignment of dialogue systems and semantic product representations [3] (cf. Section 1 & 2).

In Section 3, we identified specific requirements for such a dialogue system within an ambient environment. Then, we presented with the Conversational Recommendation Agent (CoRA) a model of a dialogue system that realizes the communication between consumers and smart products based on questions and answers [22] (cf. Section 4). It was shown how CoRA fulfills the requirements of an ambient environment. It enables a distribution of the dialogue system among multiple components, embedding into mobile devices and processing of web-based semantic knowledge representations. Furthermore, CoRA affords two-dimensional goal resolution according to communicative intentions of a consumer and economic intents of manufacturers and retailers. We exemplified our approach within an example in Section 5.

Our current version of CoRA uses a rough set of restrictions within the expansion of plan operators. To achieve more improved results, the integration of further specific restrictions is targeted. Furthermore, the processing of economic intentions of manufacturer and retailers mainly proceeds on the basis of the focus stack in a streamlined way. In addition to that, NLP-oriented SPARQL requests are rather complex and therefore affect flexibility of operating on the semantic data.

In our future work, we will focus on three issues: (1) A more differentiated processing of dynamically changing intentions of different stakeholders within the generation of answers in real-time, (2) representation of courses of conversations and those integration into the discourse model of CoRA based on scripts [30] or tasks [31], and (3) improving the flexibility of answer generation through integration of user models [32], [33], [34].

References


