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A case based reasoning model for multilingual language generation in dialogues

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ABSTRACT

The process of Natural Language Generation for a Conversational Agent translates some semantic language to its surface form expressed in natural language. In this paper, we are going to show a Case Based Reasoning technique which is easily extensible and adaptable to multiple domains and languages, that generates coherent phrases and produces a natural outcome in the context of a Conversational Agent that maintains a dialogue with the user.

1. Introduction

The industry has got a growing interest in natural language interfaces which make possible that users easily interact in a natural way with the devices they use. These interfaces are usually Embodied Conversational Agents (ECAs) or, in general, Conversational Systems. In the educational field, there are many opportunities where these systems could be employed, e.g. tutoring systems which give curricular advice or lessons about a particular matter (Graesser, Chipman, Haynes, & Olney, 2005), conversational games testing emotional abilities (Rehm & Wissner, 2005), embodied agents to simulate different roles in a professional environment (Kopp, Gesellensetter, Kramer, & Wachsmuth, 2005). These agents carry out, in a broad view, three big tasks: Natural Language Understanding, Dialogue Management, and Natural Language Generation (NLG). For the last one, although there is an agreement between the global subtasks that a NLG process should carry out (Reiter & R, 1997), there is not a standard technique to do it because it depends in many ways on the selected problem domain. Basically, there are three approaches to tackle the NLG problem; which are in ascending order of complexity and generality: canned text, templates, and symbolic approaches employing knowledge representations at different linguistic levels and rules to manipulate them. Canned text has the advantage of being a simple approach; it only needs the final text to be generated, but has the drawback that it is not reusable. Templates have got a more abstract view generating Natural Language (NL), mixing fixed text with variable text. An example of a classical system using this approach is ELIZA (Weizenbaum, 1966), which inserts part of the user input in the system answers to simulate the process of a psychotherapist doing a therapy. This is a more general NLG technique, because it does not need to pre-generate all the system answers, although these templates could not be reused in other situations that those for which they have been initially created. The last approach usually employs linguistic knowledge as grammars or rhetorical operators (Mann & Thompson, 2005) to describe the part of the language used by the system making it more generic, although this leads to raising the complexity of the system.

Conversational agents usually focus their NLG methodology on the use of templates. A well known language to develop conversational agents is AIML (Wallace, 2000). It is based on stimulus–response scheme for answer generation, using pattern matching for recognizing the user input and templates for natural language generation. The semantics of the contents of the agent's answer could be specified as two simple string tags, by the "topic" and "that" tags. This scheme is clearly insufficient to establish the contents of the answer, because the agent cannot say what he wants but only the matching answer to a user input.

One proposal developing this scheme is given by Kimura and Kitamura (2006) which extends the AIML language allowing to incorporate SPARQL queries to extract sentences from web pages annotated with RDF, making the agent more dynamic. Lim and Cho (2005) use a genetic programming algorithm to make the answers of a conversational agent more varied using Sentence Plan Trees (SPT) elements which contain the structure of the answer. SPT are binary trees containing templates in their leaves and joint operators joining these sentences in their parent nodes. The algorithm works crossing and mutating these operators, creating new sentences.

ProtoPropp (Gervas, Diaz-Agudo, Peinado, & Hervas, 2005) is a story plot generation program which uses a CBR technique to build a story from an initial description of its plot, using Propp functions to organize the tale and an ontology to capture the domain entities and to set all the relevant entities for the generation task. Cases are complete plot tales composed by related movements. A movement is a kind of procedure related to several Propp functions that allows

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following the history until a certain point, i.e. until an objective in the plot has been reached. The CBR module retrieves a similar case from the input query which contains a partial description of the tale and the retrieved case is adapted doing substitutions with the restrictions of the input query, searching for compatible movements in the ontology to adapt the case. Later, the resulting structure is passed to an NLG module which selects the content to be included in the tale discarding the already presented information, structures the discourse establishing a presentation order between the facts of the tale based on priorities, makes an aggregation of facts talking about the same subject or the same action, selects the word to represent the salient entities of the tale, and expresses the plot in a natural language instantiating the templates.

Mairesse and Walker (2010) describe PERSONAGE as a psychologically motivated, parameterizable natural language generator able to produce texts with different styles associated with aspects of personality. The system is composed by several modules: a content planner which selects the content of the sentences and structures the discourse using rhetorical operators, a sentence planner which specifies how the sentences have to be arranged and a realization module which produces the final text. Each of these modules holds parameters controlling some aspects of the type of text to generate, e.g. for the content planning, twelve parameters influence the size of the content plan, the content ordering, the used rhetorical relations, and the polarity of the expressed propositions.

There have been more approaches related with the automatic generation of the language. Daniel S. Paiva carries out a survey of 19 NLG systems (Paiva, 1998), most of them using symbolic language representations. From this survey and the other revised literature, we can state the following:

- Symbolic conversational systems must have a semantic level, like the entities of the ontology describing the domain of tales in the ProtoPropp system and a lexical level describing the domain entities in natural language.
- A symbolic view of NLG using linguistic knowledge, e.g. grammars or any other knowledge representation about some linguistic level like rhetorical operators to structure the discourse, is hard to adapt from one domain to another because the operators used in one linguistic level for a given domain could not be applicable to this same level of another domain.
- A symbolic view of an NLG system requires an appreciable theoretic knowledge about linguistics and some methodology to make it successfully applicable.
- If grammatical rules are employed in any level to capture syntactic structure, it is necessary to adapt the rules for each required language.
- Usually, although not always, symbolic approaches based in transformations or grammars produce texts having a very closed style, turning these techniques hard to use in conversational agents employed for dialogues that must be believable.

In many cases, the desirable objectives for NLG in a conversational agent are to keep the employed methodology as simple as possible, without having a deep linguistic knowledge embedded into the system while maintaining an acceptable generality degree, i.e., the conversational agent should use some kind of predefined answers and variations of them, when the contents of the answer and the intentions of the agent were similar to those of a human being in the same situation. Usually, computational linguistics human experts are expensive or unavailable resources and the effort of building an NLG module for a conversational agent should be minimized. If the employed technique is generic enough, this module could be reused in other agents devoted to different domains and languages without developing another specific NLG system for each domain and language.

We are interested in developing an NLG system used for dialogues which does not need a deep linguistic knowledge and which could be reused in many domains without changing the system functionality. Our work takes the ideas by Searle about speech acts (Searle, 1969), that have been later implemented and derived in several theories and conversational systems (Stent, 2002, 1995). Speech acts are of interest to classify the possible kinds of sentences that a conversational agent could use in a dialogue, establishing a relationship between the semantic content of the utterance and the intentionality of the agent.

In the following section, we describe a Case Based Reasoning (CBR) methodology for the NLG process explaining in detail the knowledge representation and each of the CBR stages, starting from the indexation and retrieving of cases from the semantic input, to the adaptation of the cases to get the final natural language answer. Section 3 will show the tests made to the system in the context of a virtual simulated patient that maintains dialogues in several languages and will discuss the results of these tests. Finally, the conclusions are drawn in Section 4.

2. Material and methods

Many authors agree on a high level architecture that stands for a group of high level tasks which are necessary for NLG. However, developed conversational systems do not keep either the order or the functions that each one carries out (Bateman & Zock, 2003; Reiter & R, 1997):

Macro-planning tasks select the relevant information from a knowledge source (content determination) and organize it to build a text plan (discourse planning). This generally produces a tree composed of a set of leaves, messages to be expressed, generally clauses or sentences, and a set of nodes and arcs expressing the rhetoric relation type and the textual status of the segment.

Micro-planning tasks decide how to describe an entity, i.e., they give enough information to allow the entity to be discriminated from other alternatives (reference); they group together related material, removing redundant elements to build better integrated and more concise text (aggregation) and select the correct words to express the chosen content and to achieve the necessary cohesion degree (lexicalization, pronominalization, and keywords selection).

Surface Realization tasks impose the chosen grammatical constructions, as the linear order, the sentence complexity, insert function words, and select the final form of the words.

Although these are general tasks in an NLG process, the language requirements are different whether the task is writing a discourse or maintaining a conversation. In the former, macro planning tasks are very important because usually, the writer must follow an argumentation to come to a conclusion and the produced text is usually large. However, if the task is to maintain a conversation, then keeping track of the intentions and beliefs of the hearer and our own ones becomes more important so Micro-planning tasks are the primary tasks and the type of text produced is shorter. These stages in NLG for a dialogue language generation task could be realized combining some knowledge structures to describe the entities of the domain and the necessary structures to support a CBR process, assimilating the cases with a sort of template.

Communicative Objective.
This expresses the communicative intention of the sentence, like “Greeting” or “Answer”. It has a priority indicating the order between objectives.