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NATURAL LANGUAGE PROCESSING FOR ADAPTIVE DIALOGUE SYSTEM

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ABSTRACT

Technological development has made computer interaction more common and also commercially feasible, and the number of interactive systems has grown rapidly. At the same time, the systems should be able to adapt to various situations and various users, so as to provide the most efficient and helpful mode of interaction. The aim of the Interact project is to explore natural human-computer interaction and to develop dialogue models which will allow users to interact with the computer in a natural and robust way. Adaptive systems and user modeling are active research areas with the goal to enhance usability. This paper is help to know how various techniques can be utilized in the process of designing and implementing adaptive dialogue systems.

1. INTRODUCTION

The need for flexible interaction is apparent not only in everyday computer use, but also in various situations and services where interactive systems can diminish routine work on the part of the service provider, and also cater for the users with fast and tailored access to digital information (call centers, help systems, interactive banking and booking facilities, routing systems, information retrieval, etc.). The Human-Computer Interaction (HCI) research community is focused on how to increase the usability of computer systems. Traditionally, graphical user interfaces (GUI) are of considerable interest.

One of the fundamental arguments for natural language (NL) interfaces and dialogue system (DS) research is that such systems would enhance naturalness and ease-of-use in HCI. Naturalness, since humans are using NL when interacting with each other in everyday life (and have done so since we became a species); and ease of-use, since humans require no overhead in learning to master this interaction technique: We are so to speak, already experts in NL communication. The project addresses especially the problem of adaptivity: the users are situated in mobile environments in which their needs, activities and abilities vary. To allow the users to express their wishes in a way characteristic to them and Philadelphia, July 2002, pp. 64-73. Association for Computational Linguistics. Proceedings of the Third SIG dial Workshop on Discourse and Dialogue, the situation, interaction with the system should take place in a robust and efficient manner, enabling rich and flexible communication. Natural language is thus the preferred mode of interaction, compared to graphical interfaces for example. Adaptivity also appears in the techniques and methods used in the modelling of the interaction and the system's processing capabilities. An important aspect in this respect is to combine machine learning techniques with rule-based natural language processing, to investigate limitations and advantages of the two approaches for language technology. In this paper we focus on adaptivity which manifests itself in various system properties:

- Agent-based architecture
- Natural language capability
- Self-organizing topic recognition
- Conversational ability

This paper aims at taking stock of some techniques that can be utilized in the process of designing and implementing adaptive dialogue systems. We first introduce the NLP, dialogue system architecture. We then explain how the modules function and address the specific design decisions that contribute to the systems adaptively. We conclude by discussing the system's capabilities and providing pointers for future work.

2. NLP (NATURAL LANGUAGE PROCESSING)

Natural language processing (NLP) is an integral part of AI, Computer Science, and Linguistics. NLP is all about making computers/machines as intelligent as human beings in the understanding of natural-communication language like text, speech, and so on. It comprises 2 major functionalities. they are Human to machine translation and Machine to Human translation.

Natural Language Processing (NLP) a subset technique of Artificial Intelligence which is used to narrow the communication gap between the Computer and Human. It is originated from the idea of Machine Translation (MT) which came to existence during the second world war. The primary idea was to convert one human language to another human language, for example, turning the Russian language to English language using the brain of the Computers but after that, the thought of conversion of human language to computer language and vice-versa emerged, so that communication with the machine became easy.

In simple words, a language can be understood as a group of rules or symbol. These symbols are integrated and then used for transmitting as well as broadcasting the information. Here rules are applied to suppress the symbols. The area of Natural Language Processing is divided into sub-areas, i.e., Natural Language Generation and Natural Language Understanding which are as the name suggest associated with the generation and understanding the text. The following chart broadly shows these points Don't get confused by these new terms such as Phonology, Pragmatics, Morphology, Syntax, and Semantics. Let's explore these in a very brief manner -

- **Phonology -** This science helps to deal with patterns present in the sound and speeches related to the sound as a physical entity.
- **Pragmatics -** This science studies the different uses of language.
- **Morphology -** This science deals with the structure of the words and the systematic relations between them.
- **Syntax -** This science deal with the structure of the sentences.
- **Semantics -** This science deals with the literal meaning of the words, phrases as well as sentences.

3. DIALOGUE SYSTEM

A dialogue system, or conversational agent (CA), is **a computer system intended to converse with a human**. Dialogue systems employed one or more of text, speech, graphics, haptic , gestures, and other modes for communication on both the input and output channel.

There are several ways to design and implement dialogue systems, some sort of common denominator of what components a dialogue system should consist of will be established for the purpose of this discussion. A generic dialogue system can be viewed as consisting of the components in

There is a natural language understanding (NLU) component responsible for interpreting the user input. In certain systems, this is a combination of speech recognition and text parsing. In multi-modal and multi-platform dialogue systems, this step is preceded by some sort of interaction manager.

There is some sort of dialogue management component which is responsible for keeping track of the dialogue progression. In certain systems, this is a central controller, such as in the LINLIN approach.

There is an application backend, which handles knowledge source requests and other domain-dependent processing. This is usually one or more databases and accompanying reasoning mechanisms for posting queries and retrieving result sets. Finally, there is some sort of output processor that formats responses of various kinds. For example, it might consist of a NL generator and a text-to-speech engine.

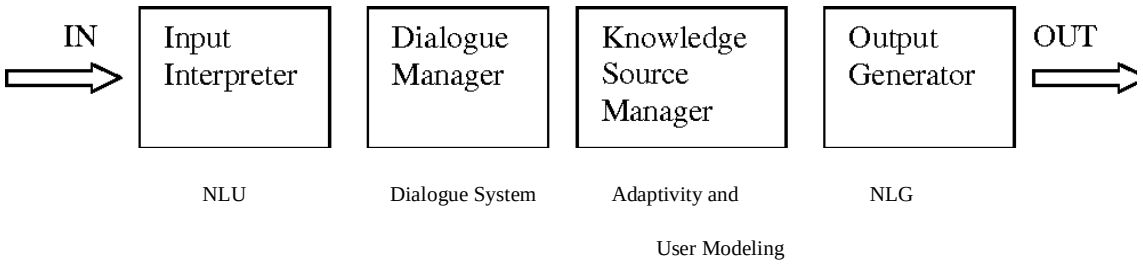

Fig. 1. System flow of dialogue system design

4. ADAPTIVITY AND USER MODELING

A dialogue state and all agents that contribute to a dialogue state.The Dialogue Model is used to classify the current utterance into one of the dialogue act categories (Jokinen et al., 2001), and to predict the next dialogue acts (Expect).

Kass and Finin (1988) present the following dimensions for characterizing user models:

- **Specialization**: The user model may be generic or individual. Typically, the stereotype model (Rich, 1989) can act as a "bridge" between a generic and an individual model.

- **Modifiability**: If the user model is changed during the course of an interaction, it is dynamic. Otherwise, it is static. User models that track goals and plans of the users are dynamic.

- **Temporal extent**: The dimension of temporal extent is defined on a short-term – long-term scale. At the extreme of short-term models, the user model is discarded as soon as the interaction ends. On the other hand, static models (as well as individual models) need to be long-term.

- **Method of use**: User models may be descriptive (i.e. described in a simple database which can be queried), or prescriptive (where the system simulates the user to check the user's interpretation of the response).

- **Number of agents**: Some systems are not limited to a one-to-one relationship between user and system. There might be several agents involved in the interaction, such as in a medical diagnosis system where there is one doctor interacting with the system, and one patient. Both the doctor and the patient can be modeled in separate agent models. The system could also have a model of itself.

- **Number of models**: For each given agent, it is possible to have several models. Separate models for an individual agent correspond to real-life situations where humans can "wear different hats" depending on if they act as a private person, or represent a company etc.

All domains out of the system's capabilities are handled with the help of a special Out Of Domain-agent which informs the user of the relevant tasks and possible topics directly. This allows the system to deal with error situations, such as irrelevant user utterances, efficiently and flexibly without invoking the Dialogue Manager to evaluate appropriate dialogue strategies. The information about error situations and the selected system action is still available for dialogue and task goal management through the shared Information Storage. There are also some agents for internal system interaction, illustrated in the figure with a stack of agents labeled with Agent1. One agent is selected at a time, and the architecture permits us to experiment with various competing agents for the same subtask: the evaluators are responsible for choosing the one that best fits in the particular situation.

5. NATURAL LANGUAGE UNDERSTANDING

Natural language understanding (NLU) is a subfield of natural language processing (NLP), which involves transforming human language into a machine-readable format. NLU analyzes data to determine its meaning by using algorithms to reduce human speech into a structured ontology -- a data model consisting of semantics and pragmatics definitions. Two fundamental concepts of NLU are intent and entity recognition.

For the scope of this paper, I will limit the discussion to written words and syntax, even though a very obvious user modeling connection is to individual training of a speech recognizer (i.e. a personalized language model). First, let us consider individual words. Do we need adaptation at word level? Furnas et al (1987) capture this as:

"People use a surprisingly great variety of words to refer to the same thing. In fact, the data show that no single access word, however well chosen, can be expected to cover more than a small proportion of users' attempts. […] The idea of an 'obvious', 'self-evident' or 'natural' term is a myth! […] Any keyword system capable of providing a high hit rate for unfamiliar users must let them use words of their own choice for objects."

Entity recognition is a specific type of NLU that focuses on identifying the entities in a message, then extracting the most important information about those entities. There are two types of entities: named entities and numeric entities. Named entities are grouped into categories -- such as people, companies and locations. Numeric entities are recognized as numbers, currencies and percentages.

For example, a request for an island camping trip on Vancouver Island on Aug. 18 might be broken down like this: ferry tickets [intent] / need: camping lot reservation [intent] / Vancouver Island [location] / Aug. 18 [date].

6. DIALOGUE MANAGEMENT SYSTEM

Dialog management systems (DMS) are the natural language processing (NLP) components responsible for interpreting and contextualizing human-like conversations between chatbots and live users.

The dialogue manager, the central component of a spoken dialogue system, accepts interpreted input from the ASR and SLU components, interacts with external knowledge sources, produces messages to be output to the user, and generally controls the dialogue flow. The dialogue management process can be viewed in terms of two main tasks:

- Dialogue modeling. Keeping track of the state of the dialogue.

- Dialogue control. Making decisions about the next system action.

Dialogue modeling provides the information used for dialogue control. Dialogue state information may include a record of what has been said so far in the dialogue, such as the propositions and entities that have been discussed (dialogue history). The extent to which this information is shared (or grounded) between the system and the user may also be recorded. Another type of information is the task record, which describes the information to be gathered in the dialogue. This record, often referred to as a form, frame, template, or status graph, is used to determine what information has been acquired by the system and what information is still needed. In simple methods of dialogue control this information may be encoded implicitly in a dialogue graph or in a form consisting of one or more slots to be filled with values elicited in the course of the dialogue.

Dialogue control involves deciding what to do next in the context of the current dialogue state. Decisions may include prompting for more input, clarifying or grounding the previous input, or outputting some information. These decisions may be pre-scripted, with choices based on factors such as the confidence levels associated with the user's input. For example, if the confidence levels are above a certain threshold, the system can assume that it has correctly interpreted the input and can proceed to its next action; if the levels are low, it may first try to verify that it has interpreted the input correctly or even ask the user to repeat her utterance.

7. NATURAL LANGUAGE GENERATION

Natural language generation (NLG) is the use of artificial intelligence (AI) programming to produce written or spoken narratives from a data set. NLG is related to human-to-machine and machine-to-human interaction, including computational linguistics, natural language processing (NLP) and natural language understanding (NLU).

Research about NLG often focuses on building computer programs that provide data points with context. Sophisticated NLG software can mine large quantities of numerical data, identify patterns and share that information in a way that is easy for humans to understand. The speed of NLG software is especially useful for producing news and other time-sensitive stories on the internet. At its best, NLG output can be published verbatim as web content.

Natural Language Generation (NLG) is the inverse of NLU discussed above. While NLU is focused on understanding user's intentions, NLG is concerned with generation responses that fit a specific user. This is done at the following levels:

- Content planning (i.e. deciding what to say)
- Surface generation (i.e. deciding how to express the content in NL)
- Modality considerations (i.e. deciding the 'what' and 'how' for modalities to accompany NL utterances)

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