"Cognitive User Interface" Laboratory

GMD - IPSI

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THE LABORATORY

The Integrated Information and Publication Systems Institute (IPSI) was established at the beginning of 1987 as the fourth research institute of the German National Research Center for Computer Science (Gesellschaft fuer Mathematik und Datenverarbeitung - GMD). It currently comprises four major research areas, concerned in turn with database systems, user interfaces, natural language, and publication systems.

The second area, Cognitive User Interface (CUI), deals with the application of theories and methods of cognitive science to the conceptualization and implementation of user interfaces to integrated publication and information systems, currently focusing on the retrieval and manipulation of information stored in large data bases.

Three disciplines of cognitive science play an important role in CUI: artificial intelligence, formal linguistics and pragmatics, and cognitive psychology. Artificial intelligence contributes sophisticated knowledge representation and processing mechanisms. Formal grammars are used to model planning processes and user behavior, while linguistic pragmatics provides the basis for modeling system-user dialogues. Cognitive psychology is particularly relevant for user modelling and the individualized presentation of information.

Primary application areas include information retrieval, in which the role of the information specialist is formally modeled, as well as the manipulation and presentation of information from very large databases. While these are in line with the general objectives of IPSI, research in CUI is directed at developing interface components, methods, and theoretical models that are at least in part transferable to other application domains.

The approach taken in CUI is deliberately interdisciplinary. This is manifested in the various disciplines the members of the lab come from: computer science, mathematics, linguistics, psychology, and sociology. Domain expertise in documentation and information retrieval is provided by documentation specialists.

PROJECT DESCRIPTIONS

In CUI, a user interface to a complex information system is seen as consisting of several communicating components which may have different internal structures. In general, these components have the function of conducting a dialogue with the user, displaying information to the user in a form in which he/she can best process it, supporting the user in query and browsing activities, determining the user's plans and longer-range goals, and providing the user with active help and tutorial information. The user interface will be both adaptable and adaptive. Therefore, it must have facilities for the automatic acquisition of knowledge about user characteristics and tasks.

These components can be roughly separated into two groups: those concerned with the object semantics of complex systems, and those concerned with operational aspects. This division corresponds to the existence in CUI of two separate research projects which nevertheless have numerous points of contact and which eventually are to contribute to an integrated system. The presentation and manipulation of information is dealt with in project COGITO (COGnitive Interaction TOols), which draws on linguistic pragmatics as well as cognitive psychology as its theoretical basis; project TOSS (Task-oriented and Operative Support Systems) is devoted to research on plan recognition and learning techniques for adaptive systems, particularly in the area of information retrieval.

The COGITO Project
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Three types of user interface components are currently being developed in project COGITO: a knowledge explorer, with which the user may 'browse' in an information base, pose queries, and manipulate the information itself or its representation; a dialogue manager, which accepts multimodal input from the user, translating the user's requests, etc. into a form usable by the knowledge explorer; and a presentation manager, which is concerned with the presentation of information to the

user in a form which can be most effectively processed by the user's cognitive and perceptual faculties.

The knowledge explorer is being developed in close collaboration with the database projects. It is to be knowledge-based, incorporating sophisticated retrieval methods, e.g. by the generation of multiple views, combined with inference techniques which make use of knowledge bases (including thesauri) concerned with the structure and content of the information source involved.

The dialogue manager is conceptualized on the model of human-human communication, where the primary medium is natural language; but the nature of the interaction between system and user is fundamentally conceived to allow (simultaneously) multiple modes of interaction, by no means limited or specialized to natural language. A particular problem for the dialogue manager is the interpretation of the user's elementary actions in the absence of complete information.

Current research work on the presentation manager is concerned with information typologies and cognitive/ perceptual models, in particular natural categorization/ prototype theory and spreading activation approaches.

The long-term goal of project COGITO is the development of a personalized information system, which the user can call upon to extract information from external databases in a form which corresponds to his/her conceptual categorizations. That is, the user should be able to "pre-structure" information for his/her own purposes. A first prototypical development in this direction is being pursued, using a hybrid development tool.

The TOSS Project

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The TOSS project aims at supporting users on the task level by means of providing intelligent user interfaces with task knowledge. These interfaces will offer different kinds of support such as context dependent active and passive help, (semi-) automatic macro construction, explanations, or intelligent tutoring.

As the notion of task plays a central role in the TOSS project, decisions on how to represent, process, and acquire task knowledge are essential. For the representation and processing of task knowledge, much of the AI work on planning and plan recognition is directly applicable to these problems. On the representational level, operator-oriented as well as state-oriented descriptions capture important aspects of task knowledge, but have different relevance depending on the purposes of modeling.

Operational descriptions of task knowledge are well suited for purposes like task completion, diagnosis of operational error patterns, and macro generation. A par-

ticularly interesting aspect of state-oriented representations is their possible use as generic task concepts from which specific operationalizations can be derived. This is a promising way to acquire specialized operational knowledge.

Amongst the three basic issues of acquiring, representing, and processing task knowledge, acquisition is clearly the one which is least supported by computational or sufficiently formalized methods. This is a crucial bottleneck in the practical application of intelligent user interfaces. We are currently experimenting with different machine learning techniques in order to develop (semi-) automatic methods for the acquisition of system-specific task knowledge.

The initial test environment for these methods was an advisory system for UNIX file management. Our twofold approach to representing tasks as declaratively described global concepts on the one hand and as operational methods on the other hand, seems to be well suited to the modelling of strategies and tactics in information retrieval. In order to achieve our mid-term goal of implementing an intelligent assistant for information retrieval tasks, we will furthermore have to provide an enriched thesaurus which encodes the semantics of the domain.

PERSPECTIVES

COGITO and TOSS are both mid-range projects, with an expected lifetime of five years. During this time it is expected that fundamental research results will be achieved in the fields of multimodal dialogues, information manipulation and presentation, plan recognition and adaptable/adaptive systems. The user interface components developed in CUI will be integrated with results from other projects at IPSI.

COOPERATION

No small part of CUI's research will be done in cooperation with other research institutes. Currently, CUI is collaborating with the LILOG project (IBM Germany) and with different universities in West Germany. Joint projects are planned with industry partners as well. Furthermore, IPSI has a cooperation agreement with the University of Colorado at Boulder (Institute for Cognitive Science) and is a member in the Human-Computer Interaction Consortium.

IPSI offers excellent facilities for visiting scholars and students (sufficient office space, advanced workstations such as SUN 3, SUN 4, Symbolics, Macintosh II, etc. and software tools for rapid prototyping) in a stimulating interdisciplinary environment.