INRIA

INSTITUT NATIONAL DE RECHERCHE EN INFORMATIQUE ET EN AUTOMATIQUE

Project-Team MErLIn

Methods for Interactive Software Ergonomics

Lorraine - Rocquencourt

THEME COG

Table of contents

1. Team

Scientific Leaders

Dominique Scapin [Research Director, INRIA Rocquencourt, Scientific Leader]
Noëlle Carbonell [Professor, Henri Poincaré University, LORIA, Scientific Co-leader]

Administrative Assistants

Stéphanie Aubin [Admin. Assistant, INRIA Rocquencourt, part-time]
Danielle Marchand [Admin. Assistant, Henri Poincaré University, LORIA, part-time]

University Staff

Walter Cybis [Invited Professor, École Polytechnique de Montréal, INRIA Rocq., one month]
Suzanne Kieffer [Lecturer, IUFM Nancy-Metz, until Aug. 31, 2005; Henri Poincaré University from Sept. 1, 2005, LORIA]

Junior Technical Staff

Delphine Autard [ACET, INRIA-Rocq., from Sept. 1, 2004 until July 1, 2005]

Post-doctoral fellow

Zhaowu Luo [INRIA-Lorraine, from Sept. 1, 2004 until Aug. 31, 2005]
Mickaël Baron [INRIA-Rocq., from Sept. 1, 2005]
Tristan Blanc-Brude [INRIA-Rocq., from Dec. 1, 2004 until Nov. 30, 2005]

Project technical staff

Marius Hategan [Exp. Eng., INRIA-Lorraine, from Oct. 1, 2005]

Ph.D. Students

Vincent Lucquiaud [INRIA-Rocq. grant, until Jul. 31, 2005, Poitiers University]
Jérôme Simonin [DGA-CNRS grant, Henri Poincaré University, LORIA]
Olivier Christmann [MENESR grant, Henri Poincaré University, LORIA]
Syrine Charfi [Tunisian govt. grant, INRIA-Rocq., since Oct. 1, 2005, Toulouse University]

Student interns

Thomas Sabbadini [M1 Student, Master In Cognitive Science, Nancy 2 University, from Apr. 1, until Aug. 5, 2005, LORIA]
Badr Siala [M2 Student, Master In Computer Science (Research), Nancy 2 University, from Mar. 1, until Jun. 30, 2005, LORIA]
Marius Hategan [M2 Student, Master on Intelligent Systems, Toulouse III University, from Mar. 1, until Sept. 30, 2005, LORIA]

External Collaborator

Daniel Gepner [Dedale SA, Paris, LORIA]

2. Overall Objectives

2.1. Overall Objectives

Keywords: *3D interaction, HCI, ergonomic criteria, ergonomic quality of interactive software, formal task description, gaze interaction, hypermedia, information systems, interaction languages, interface evaluation, mixed-reality, multimodal interaction, online help, software ergonomics, standardization, user testing, virtual environments, visual search, www.*

The goal of the MErLIn project is to contribute to the improvement of the Ergonomic Quality of Interactive Software. Two sub-goals contribute to this general goal:

- Study, through empirical studies[1], users' interactions with software-based systems in order to improve such systems. It is about increasing available knowledge about users' activities and cognitive characteristics as well as about the usability of software systems.
- Study and improve ergonomic design and evaluation methods, thereby contributing to the overall improvement of technical systems by providing software designers with sound methodological elements helping the incorporation of user-centered concerns within the design process life cycle. It is about increasing available knowledge on such processes, together with defining new methods or complementing existing ones.

Considering interactive computing systems for human use, i.e., ergonomic optimization of interactive software, requires to make progress both on fundamental knowledge and on methods in HCI (Human-Computer Interaction), and Ergonomics. The scientific contributions of the MErLIn project include scientific literature on users and task modeling, on empirical studies, on design and evaluation methods, on ergonomics recommendations, as well as software (e.g., mock-ups, test-prototypes, tools supporting design and evaluation methods). These various contributions are aimed at disseminating current ergonomic results, knowledge, and know-how to the national and international scientific community, but also to standards and to technology transfer through industrial contracts, collaborations and consulting activities.

Currently, the MErLIn project investigates two main research directions:

- The study, design, assessment, and set-up of ergonomic methods for designing and evaluating interactive software. This corresponds to the need for integrating available ergonomic results into the computer systems life cycle. The main current topics relate to task-based and criteria-based methods.
- The study of usability issues raised by "new" computer applications: new user populations, new application domains, new forms of interaction (often new technology raises new usability problems). This corresponds to the need for acquiring novel ergonomic results on innovative computer systems, and to further increase current knowledge on usability. The main current topics relate to multimodal interactions, and virtual reality.

3. Scientific Foundations

3.1. Scientific Foundations

The scientific domains characterizing the activities of the MErLIn project are essentially Ergonomics, particulary Software Ergonomics, and HCI. Four definitions apply to the research activities of the MErLIn project:

Ergonomics[2] (or Human Factors) is the scientific discipline concerned with the understanding of interactions among humans and other elements of a system, and the profession that applies theory, principles, data, and methods to design in order to optimize human well being and overall system performance. Ergonomics contributes to the design and evaluation of tasks, jobs, products, environments, and systems in order to make them compatible with the needs, abilities, and limitations of people. Derived from the Greek ergon (work) and nomos (laws) to denote the science of work, ergonomics is a systems-oriented discipline which now extends across all aspects of human activity. Domains of specialization within the discipline of ergonomics are broadly the following:

- Physical ergonomics is concerned with human anatomical, anthropometric, physiological, and biomechanical characteristics as they relate to physical activity (relevant topics include working postures, materials handling, repetitive movements, work related musculoskeletal disorders, workplace layout, safety, and health).

[1] i.e., resulting from experience, through various methods, including controlled experiments.

[2] Definition from IEA (International Ergonomics Association) (http://www.iea.cc/ergonomics/)

- Cognitive ergonomics is concerned with mental processes, such as perception, memory, reasoning, and motor response, as they affect interactions among humans and other elements of a system (relevant topics include mental workload, decision-making, skilled performance, human-computer interaction, human reliability, work stress and training as these may relate to human-system design).

- Organizational ergonomics is concerned with the optimization of sociotechnical systems, including their organizational structures, policies, and processes (relevant topics include communication, crew resource management, work design, design of working times, teamwork, participatory design, community ergonomics, cooperative work, new work paradigms, virtual organizations, telework, and quality management).

Software Ergonomics inherits from the main characteristics of ergonomics. It is a science that contributes to the knowledge necessary to software design, and more generally to computer-based environments, with the overall perspective of human security and well-being, but also with the perspective of effectiveness, efficiency, and productivity, for instance by facilitating users' tasks, limiting learning time, reducing errors and the cost of errors. Software Ergonomics focuses on the improvement of human-computer interactions mainly in terms of cognition, as the main human activity involved with software interactions is mental. However, as novel interaction techniques (e.g., multimodality) and novel environments (e.g., Virtual Reality) arise, some aspects of physical ergonomics are starting to be considered as well.

HCI[3] is also at the center of the MErLIn project research activities: "Human-Computer Interaction can be defined as the set of hardware, software, human and environmental elements that influence the efficiency of systems and products, both from a technological and a human point of view".

In addition, the MErLIn project aiming at the optimization of Software Ergonomics, that is the *Ergonomic Quality of Interactive Software*, the following definition applies as well.

Ergonomic Quality of Interactive Software [42] covers all software aspects which have an influence on the user's task completion: it therefore covers usability in the widest sense, or ease of use, i.e., the extent to which the users can easily reach their interaction goals (presentation and dialogue aspects of the interaction) but also what is sometimes called utility, i.e., the extent to which the users can reach their task goals (functional aspects of the interaction such as functions, objects, data, etc.). From a software engineering perspective (e.g., architecture models), it could be said that *Ergonomic Quality* covers not only the classical presentation, dialogue control and application interface aspects, but also some application kernel aspects: those that have an influence on the users reaching their goals.

Approach: the MErLIn project uses methods from Ergonomics and Computer Science, with a strong background and orientation in experimental approaches and methods (in the sense of experimental sciences, with hypotheses testing and proving).

The project contributes to the rationalization of ergonomic methods, from experimental testing in the laboratory or field simulations, using performance data, analysis of verbal protocols, analysis of preferences. The modeling activities are also centered on the production of computer models.

The appropriateness and accuracy of such models compared to reality also goes through ergonomic evaluations.

Research work starts usually from the observation of real tasks, on selected fields of activity, often in parallel with particular practical problems to be solved. Data gathering is based on activity and interaction analyses, case studies, critical incidents, automatic logs, and records.

Focus: research work at MErLIn has also three additional characteristics. The focus is on methods dedicated to designers that are not necessarily skilled in ergonomics, even though such methods can also improve the activity of the ergonomists themselves. More specifically, the project deals with the integration of ergonomics approaches within the computer system life cycle through sets of recommendations, methods, software support tools, and involvement in standardization, teaching, and consulting.

[3]Definition from AFIHM (Association Francophone d'Interaction Homme-Machine) (http://www.afihm.org)

The focus is on users who are not computer specialists. This user population is the major target of current software developments, whether it is the large public (e.g., interactive booths, electronic commerce, mobile systems) or professional experts in various domains (e.g., nuclear power plants, railways systems, textile design). A particular focus is on accessibility which promotes increased effectiveness, efficiency, and satisfaction for people who have a wide variety of capabilities and preferences.

The focus is not only on “classical” work situations, but also on new computers uses, not yet all well defined, such as: consumer products (e.g., electronic commerce), information retrieval (e.g., tourism), mobility, etc.

4. Application Domains

4.1. Application Domains

This year, the main application domains have been: 3D virtual and mixed reality environments; interaction with visualisations of large sets of multimedia information; personal information management systems, text and picture visual search, 3D interactive visualisation metaphors, picture browsers; regulation activities (railway systems); online help; Embodied Conversational Agents (ECAs); gaze-contingent displays.

See section 5 for specific scientific results with the industrial and academic partners involved.

5. New Results

5.1. Introduction

The research work conducted this year is presented along three main topics: ergonomics methods for the evaluation and design of software interactions; ergonomics of multimodal interactions; interaction with visualizations of large sets of pictures or complex images.

5.2. Ergonomic methods for the evaluation and design of software interactions

5.2.1. Generic issues in ergonomics methods for HCI

Participant: D. L. Scapin.

In a book chapter [20] the attempt has been to introduce various human issues in the design and evaluation of information systems, with an ergonomic perspective. The goal was not thorough, but to provide a survey of the main issues. After a few definitions and a contextual description of the main problems, the chapter describes the major ergonomics requirements to be taken into account. Then, along a classification of methods, a brief description of current ergonomic methods and standards is provided, followed by a set of issues concerning the choice of ergonomic methods depending on the systems lifecycle and other parameters of information system context.

Another book chapter [17] deals mainly with a number of dimensions aimed at promoting usability, from two sets: ISO 9241-Part 10 and the Ergonomic Criteria. The chapter describes first seven principles that can be considered as general guidance for usability, associated with examples and comments; then, after a description of a method usually called ergonomic inspection, this chapter presents the contents of the 20 Ergonomic Criteria recently applied to virtual environments, and its associated approach.

While participating to the European project COST294-MAUSE (see http://www.cost294.org), new classification and description templates have been designed as a support to the critical analysis of usability methods.

The ultimate goal of COST294-MAUSE (« Towards the MAturation of IT USability Evaluation ») is to bring more science to bear on Usability Evaluation Methods (UEMs) development, evaluation, and comparison, aiming for results that can be transferred to industry and educators, thus leading to increased competitiveness of European industry and benefit to the public.

MAUSE comprises four working groups (WGs) each addressing one or more of the three main objectives. The goal of WG1 (Leader : D. L. Scapin) is to build a refined, substantiated and consolidated knowledge-pool about usability evaluation. A database has been created to record the findings, with regard to a set of selected attributes of UEMs, and of individual case studies involved in MAUSE. A critical classification and best practices of existing UEMs, covering operational, organizational and cultural dimensions, should be derived from the records of this database and rendered accessible to researchers and practitioners within and outside the community.

Currently, two templates are available, a template for "generic methods" which consists of a method identification section that deals with name, origin of the method to be described (and the cross-referencing) as well as a method characteristics section describing the method, what it is intended for, when to use it, its pre-requisites and constraints, its advantages, etc.; a "case study" template that has an additional free form part: the case study characteristics section that describes the systems projects to which the methods have been applied to, and the specific, detailed characteristics of the method implementation.

The other WGs in which we are also involved are: WG2: Comparative Studies; WG3: Defect Classification Schemes; WG4: Formalized Concepts and Models.

5.2.2. MAD/MDA task modeling and tool

Participants: V. Lucquiaud, D. Autard, D. L. Scapin.

Initially developed in parallel with a research activity on the identification of potential factors influencing mental workload of human users in charge of controlling railways traffic (project PREDIT, in collaboration with SNCF and RATP; contract deliverable [34]), research work has focused on the improvement of the task analysis model MAD (Méthode Analytique de Description) and the re-design of an associated software tool aimed at facilitating the modelling of field data.

The analysis of user tasks constitutes indeed a critical step in the design process for interactive systems. A number of models and sometimes associated tools aim at supporting that type of activity. They vary a lot in terms of scope, formality, level of development, etc. The critical review of these models and tools led to a number of improvements of both model and tool. The new model (MDA) and tool (N-MDA: Noyau du Modèle de Description de l'Activité, i.e., Kernel for the Activity Description Model) now allow : the formal description of an activity, using the EXPRESS underlying model; the description of the user's environment, including the objects involved; the description of events acting on the activity at hand; the specification of execution constraints on the tasks (prerequisites, iterations), and the consequences on objects and events when a task is executed (objects behaviour, event management). In addition to the modularity and extensibility of the kernel, a software tool has been developped. The tool offers a number of features such as : verification of coherence (i.e., controls on the model rules), integration of taylorable assessment functions (e.g., static functions, for instance to evaluate the frequency of usage of an object, of a task, the objects or tasks associated with a particular user; dynamic functions such as number and type of tasks performed for a specific scenario, number of interruptions, restarts, completions, etc.); an important feature that most other tools do not accomodate is a simulation capability. Overall, the capability of expression of the model has been improved (i.e., its ability to describe what it is intended for), and the tool fully supports all the model features. However, this capability will need to be confirmed on other sets of data; besides, its usability will need some further improvements and testing in real situations.

This work has also resulted in a conference paper [26], and to a Ph.D. dissertation [16].

5.2.3. MDA, NMDA validation and extensions

Participants: M. Baron, D. L. Scapin.

MDA (Modèle de Description de l'Activité), recently modified and improved from a formal point of view from the initial MAD task model, led to the design of a new task modeling tool (MDATool), which provides support for the design and evaluation of user interfaces.

The current research has two goals: validate MDATool and its model from the point of view of : (1) its power of expression (i.e., its capability to model what it is supposed to model); and (2) its usability (i.e. its

capability to be used easily); increase the capabilities of MDATool in terms of services, particularly regarding the interrogation of the task model, as a source of data for the design and the evaluation of user interfaces.

An initial step has been to look for areas of improvement in terms of usability, in order for the tool to be used in real-life situations, by users in charge of describing actual user activities. Mainly the graphic representation of the task model was enriched by incorporating an existing library, already tested for this type of representation (graph visualization and layout). The JGraph library is written in Java; it is based on the model/view pattern and it offers many functionalities which corresponded to the ones in MDATool, for instance: simple or grouped selection tasks; zoom in/out the task model; quick overview; copy/cut/paste and undo/redo; structured printing of related parts of the task model on several pages. Also, with these new functionalities, the tool was tested on various cases studies (e.g. car renting procedures, fire emergency procedures). In addition, the tool has been upgraded to be used in both French and English language.

The next step will be to validate the model and the tool on real activities (administrative activities at INRIA), with real users. The goal is twofold: verify the level of accuracy of the model semantic (power of expression) and assess the level of support provided to the analyst to enter actual data from interviews into the tool (usability). This study should help validate the model and the tool, as well as find out areas for improvement.

Parallel to that research activity, a study will focus on the potential scope of queries on the model in order to identify useful additions to the service capabilities of the MDATool. The approach is to identify sets of query requirements, initially based on the literature on task-based recommendations. The expected outcome is to provide a set of query tools leading supporting a task-based design and evaluation process (e.g. comparison of tasks model, identification of common tasks, of tree depth, of common objets used by certain tasks).

5.2.4. ErgoManager

Participants: W. Cybis, D. L. Scapin.

A collaboration between INRIA and École Polytechnique de Montréal, following a collaboration between INRIA and University of Santa Catarina, led to a study aimed at designing a semi-automatic ergonomics evaluation method for commercial Web sites. Considering the fact that many non-specialists in ergonomics (and sometimes in computer science) can easily design Web sites, one characteristic of the method was that it should accomodate such designers; the other requirements were that it should be fast and low cost, due to the short and low-investment characteristics of the usual Web site design process. The description of the results of that study can be found fully in a technical report [33], as well as in two conference papers [22] and [23]. These papers describes the specification of ErgoManager, a UIMS (User Interface Management System) specifically intended to support the user interface revision phase over changeable Web sites running B2B, ERP or Intranets transactions. This UIMS contains two basic components: ErgoMonitor and ErgoCoIn. ErgoMonitor applies task-oriented analysis and usability oriented processing on interaction traces stored in log files as a way to identify “average” usability levels that have been occurring when users were accomplishing transactional tasks with a Web site. ErgoCoIn is a checklist based CSEE (Computer Supported Ergonomic Evaluation) tool that features automatic services to inquire context of use aspects and to recognize Web page components as a way to conduct inspections of only the context pertinent aspects of a Web page. By integrating these tools, ErgoManager aims to support quality assurance strategies over the revision phase of Web sites lifecycle by confronting, in an iterative way, usability quantitative metrics and qualitative aspects of user interfaces. ErgoMonitor determines the incidence and the duration of these behaviors and uses the data to produce usability measures, which quantify the average productivity of interactions. In addition, a first validation with actual log files of web uses has been performed.

5.2.5. Personal Information Management : an investigation of user’s practice

Participants: T. Blanc-Brude, D. L. Scapin.

The amount of electronic files that we store in our computers through our work activities and in our private life is considerable. A significant problem is the ease and efficiency of retrieving the files of interest that may be lost in the bulk of our hard disks. While basic retrieval tools and various search engines are currently available, there is a need for tools that would allow users to better (effectively and easily) retrieve their files.

To reach such a goal, these tools must be grounded on the knowledge of cognitive processes which underlie the actual process of files retrieval activities. Our hypothesis is that users carry out their file searches based on features they are able to recall about them. In order to find out what these attributes are, a quasi-experiment was designed. Semi-directed interviews were conducted with two groups of participants (7 researchers and 7 members of the administrative staff) in the context of the management of their own working documents (digital and physical ones). Participants were first interviewed about their work, their environment, and about how they manage their files and documents. Then the quasi-experiment, focusing on the users' own documents (paper and/or digital) was conducted in two phases:

- An initial "recall" phase exploring the intuitive characterization of the documents by the users, based on their memory. This phase consisted of two sessions: a "free-recall" session and a "cued-recall" session.

- A "retrieval" phase in which the participants were asked to actually find their documents in their own environment, with their current tools.

The results do not show strong differences in terms of groups, except for the use, in "cued-recall", of the attribute "time of last usage" for which the use by the clerical group was less robust than by the group of researchers. Concerning "free-recall", the main characteristics expressed freely by the participants were: characteristics of the documents content (67.8%) ; file type or document format (21.4%) ; visual elements (25%).

Concerning "cued-recall", results show the types of attributes that were most frequently selected and exemplified from the cued list as potentially characterizing documents. Five attributes (among 11) were recalled in each case: location, file type or document format, time of last usage, keywords and associated events. The other attributes were not always recalled although they were part of the actual document attributes. The comparison of the expressed attributes with the actual attributes of the document(s) showed (in most of cases) that the accurately shared attributes were: "file type or format of paper" and "visual elements". Most other attributes are less robust or partly robust; often, attributes were recalled partially. A number of qualitative results were also obtained on the characteristics and variability of the expressed attributes.

Concerning "retrieval", results show that participants often had difficulties in finding their own document(s) in their ordinary environment, with currently available tools. Four users did not succeed in finding their documents (three paper and one electronic documents). Among the twenty six documents found, eight were not found easily including two paper documents and six electronic ones, in most of the cases because the user sought in the wrong directory or in the bad location.

These findings support the need for better tools for personal document retrieval. The data obtained in this quasi-experiment led to a number of potential recommendations for better support of personal information management tools. These recommendations fall into different categories: selection of appropriate attributes; selection of appropriate formats of attributes; flexibility; extensibility; search mechanisms on file contents; explicit inter-documents relationships; log of past document-based operations; etc. This work has been presented at the PaRISTIC conference [35] and is detailed in a research report [30].

5.2.6. Ergonomic Criteria for Human-Virtual Environments Interactions (HVEIs)

Participants: C. Bach, D. L. Scapin.

Following a 2004 Ph.D. dissertation, and conference papers, a research report [29] provides detailed information on the Ergonomic Criteria applied to HVEIs. The report first summarizes the approach: data gathering, deciphering, and classification studies; analysis of a first validation based on an assignment task; analysis of a second validation based on a comparison, in terms of performance, of the use of Ergonomics Criteria, in a context of ergonomic inspection of actual Virtual Environments (VE), with two other methods : free inspection and user testing. Then, the report describes the 20 Ergonomic Criteria in detail, with definitions, justifications, and examples of associated recommendations. This report is aimed at providing a detailed and practical understanding of the inspection material available for assessing the ergonomics of such environments, together with methodological advice and identification of the method limits.

5.2.7. User centred design and evaluation of mixed systems

Participants: S. Charfi, D. L. Scapin.

User interactions with computer systems are moving away from the classical screen/ mouse/ keyboard context of use. Indeed, recent technological innovations led to new means of communication, devices and interaction components, together with miniaturization. As a consequence, new forms of interactive systems are being developed based on various novel interaction forms (e.g., wearable, tangible interfaces, augmented reality) in which physical and digital worlds are merging: mixed systems. Research work has just started on the various issues associated with the design of such systems. This work originated from a collaboration on such systems between INRIA's past ergonomics work and IRIT's past software engineering work [40]. The goal is to contribute to the facilitation of joined manipulation of usual physical objects (cup, pen, lancet, etc.) together with computer-based objects, to accomodate naturally the capabilities of physical and digital worlds. Several topics are investigated, including a major one: modelling such systems in order to facilitate design and the development of hardware and software components. The approach is usage-centred, particularly in terms of users' tasks in mixed systems. A number of steps are planned: critical review on models and methods for mixed systems; survey of existing mixed systems in terms of underlying models, in terms of context (domains, tasks, objects), and in terms of associated evaluations; definition of evaluation benchmarks; identification of relationships between user tasks and mixed systems components (including the study of task models such as N-MDA (see section 5.2.2.) and mixed systems models, such as ASUR (Dubois et al. 2004, op. cit.); design of a user-centred mixed system model-based platform; survey of ergonomics recommendations; validation on selected application domains (interactive museum, aircraft maintenance, etc.).

5.2.8. Adaptive user support: formative usability assessment

Participants: J. Simonin, M. Hategan, N. Carbonell.

User modelling is an active and fast developing research area. Recent scientific advances make it possible to consider the implementation of effective adaptive user interfaces. However, specific usability issues are yet to be investigated:

- To react predictably is viewed as a major usability requirement for interactive software design. Hence, how will users react to, and accept, user interfaces the behaviour of which evolves in the course of time autonomously?
- Then, should users be made aware or notified explicitly of the evolution of the system behaviour? If the answer is positive, when and how should this information be delivered to the user?
- Should notification strategies (i.e., the design of the content and form of notification messages) vary according to the user characteristics (e.g., knowledge, preferences and interests, etc.) that determine the system evolution?
- What amount of control over the interface evolution should users be given?

A comprehensive survey of published research on adaptive user interfaces has been presented at a national scientific workshop last year. We are currently preparing an experimental study with a view to gaining meaningful information on these issues. This study is focused exclusively on dynamic system adaptation to the evolution of the current user's knowledge and skill in the course of interaction. The application chosen is online help meant to assist novice users in discovering the operation of Flash, a standard software tool for creating animations. Advanced adaptive help strategies and functionalities of the considered help system will be simulated using the Wizard of Oz paradigm. Jérôme Simonin has developed specific software (in Java) for, on the one hand, assisting the Wizard in the simulation of the help system user interface and, on the other hand, recording rich digital traces of participants' interactions with Flash and the simulated help system. Marius Hategan is currently developing software tools for "re-playing" interaction traces and annotating them semi-automatically. 20 volunteer participants (Bac + 1 students) will experiment this help system. Individual experimentation sessions are scheduled to start in January 2006.

5.3. Multimodal interaction design, implementation and evaluation

Spoken natural language may appeal to users in the general public since it is the main modality used, together with pointing gestures or gaze, in face-to-face human communication. Our work on multimodal human-computer interaction is based on the two following observations. On the one hand, speech- and gesture-based multimodality has been extensively studied, both from a software and an ergonomic point of view. However, speech plus graphics as an output form of multimodality has raised fewer research studies, especially regarding the utility and usability of speech as a supplementary modality to graphics.

Besides, pointing hand gestures have the same limited expressive power as gaze in some contexts of use, namely, the selection of objects on very large displays (e.g., electronic blackboards, reality centres or caves, etc.) or in 3D environments. In these interaction environments, both modalities can only specify directions, if used spontaneously as in real life. Our current work on multimodality addresses the three following issues:

- How to design oral messages that help visual search in cluttered displays?
- How to design multimodal command languages that use information on spontaneous or controlled gaze movements to disambiguate oral commands, especially those including deictic phrases?

5.3.1. Oral assistance to visual search

Participants: S. Kieffer, N. Carbonell, J. Simonin.

Concerning the effectiveness of oral support to visual search, the detailed presentation of our first study has been accepted as a chapter in a collective scientific book edited by Kluwer [39]. This study was focused on determining whether oral information on the location of a visual target in a complex, cluttered, display could improve the efficiency of its identification (accuracy and selection times). Targets were either familiar (visual presentation of the isolated target prior to scene display) or unfamiliar (oral characterisation of the target only, prior to scene display), monomodal (visual or oral) or multimodal (visual and oral).

This initial study was followed up, last year, with two more ambitious experimental studies. The first experiment, which involved 24 participants, was focused on investigating the influence of oral help messages on the speed and accuracy of visual target detection activities. Message content merely specified the location of the target in one out of nine pre-defined areas on the screen. The effectiveness of this form of oral assistance was assessed for various display spatial layouts. 3600 photographs of real landscapes, people and objects were selected from a database including over 6000 items, then formatted and divided up into 120 thematically homogeneous collections (30 photographs per collection). These collections were displayed using four spatial layouts (40 collections/scenes per spatial layout): elliptical, radial, matrix-like, random. To refine results on participants' performances (especially target detection accuracy and selection time), we performed a complementary experiment where the eye movements of 5 participants were traced (using an ASL-501 eye tracker) during similar visual tasks to the ones performed during the second experiment save for the presence of oral assistance. Eye movements were analysed using specific software. Results of both studies are detailed in Suzanne Kieffer's PhD [15]; see also [19] for the second study, [27] and [28] for the third one. These results are part of our contribution to the Micromégas Project[4].

5.3.2. Multimodal speech- and gaze-based interaction

Participants: N. Carbonell, D. Gepner.

Concerning speech- and gaze-based multimodal interaction, we are carrying on with the analysis of the corpus collected in 2004 with a view to gaining an insight into users' gaze strategies during oral interaction with 3D virtual environments. The corpus which was collected in 2004 includes realistic data on spontaneous and controlled eye movements using an ASL-501 eye tracker. 10 participants interacted during half an hour with various 3D applications, using first speech, then multimodal (speech and gaze) commands. Applications were created using the ORIS virtual reality development tool, and the user interface was simulated using an

[4]Three year research project (starting July 2003) in collaboration with the In Situ team at UR INRIA-Futurs (Orsay) and the Laboratoire de la Perception et du Mouvement in Marseille; it benefits from national support (ACI "Masses de données", 1st call, 2003).

advanced implementation of the Wizard of Oz technique (i.e., the human wizard benefited from appropriate software assistance). The recorded multimodal interactions are being analysed using a specific software tool that Daniel Gepner developed in 2003 (under Linux). This tool records and "replays" interactions with any ORIS application in two separate windows. One window displays the user's points of gaze superimposed on the successive displays from the application. The other window displays graphical representations of the temporal evolution of the pupil diameter and speech signal. It also displays the names of the graphical application objects looked at by the user together with speech recognition results in both orthographic and phonetic forms[5]. The user's oral commands and utterances can also be listened to simultaneously. All these data are carefully time-synchronized.

The knowledge obtained from the analysis of recorded interaction traces will be used (in 2006) to design and implement a robust real time algorithm capable of:

- separating intentional gaze movements from visual attention shifts (i.e., stimulus driven eye movements) reliably;
- then, interpreting intentional movements and fixations that occur simultaneously with speech commands (loose concomitance) as designation gestures pointing towards the displayed graphical objects that users are currently interested in; and using this information for solving ambiguities and deictic phrases in their speech commands (multimodal fusion).

The next step will be to integrate this algorithm into a software demonstrator with a view to assessing its actual efficiency (accuracy and run time speed) in realistic situations where multimodal speech and gaze commands are used for interacting with various virtual reality applications. Later, the demonstrator will also be evaluated in ambient intelligence environments (see [21]). The software architecture model proposed in [18] for multimodal user interfaces will be used for designing the overall architecture of the demonstrator.

5.3.3. Assessment of the contribution of Embodied Conversational Agents

Participants: D. Gepner, M. Hategan, J. Simonin, N. Carbonell.

Research on the design and implementation of Embodied Conversational Agents (ECAs) is a fast developing area. Numerous prototypes endowed with human-like appearance and behaviour are now available in research laboratories. However, the benefits that may be expected from their integration into user interfaces has motivated a few studies only. In collaboration with France Télécom R&D (CRE, 04/15/05-04/15/06), we are currently preparing an experimental study meant to assess the actual contribution of a human-like ECA, an attractive realistic woman face with talking capabilities and facial expressiveness, to the efficiency and usability of human-computer interaction. The aim is to investigate the effects of ECAs, namely their aspect, and their communicative and expressive behaviour, on users' performances, motivation and subjective satisfaction. The experimental tasks and set-up will be similar to the one used for investigating usability issues relating to adaptive user interfaces (see subsection 5.2.8). The only differences will be the substitution of oral help information for textual messages; synthesized oral messages will be either delivered by the ECA provided by France Télécom R&D (experimental condition), or simply played in the absence of any ECA (reference condition). Participants' eye tracking data will be recorded, and the evolution of the focus of their visual attention in the course of interaction will be analysed, in order to obtain objective information on the actual appeal to the ECA felt by participants, on their engagement in the execution of experimental tasks and the interaction with the simulated help system; using eye tracking data for gaining an insight into the affective reactions of users to an ECA is rather original.

This experiment will involve 32 participants. Individual experimentation sessions will start in January 2006.

5.4. Interaction with visualizations of large sets of pictures or complex images

Entertainement and commercial Web-sites, information kiosks and public terminals tend to display an increasing number of pictures simultaneously: video and movie snapshots, CD sleeves, book covers, etc.

[5] We use a speech recognition system developed by the Parole team for recognizing the user's oral commands.

Personal electronic archives and file directories are increasingly cluttered with unstructured collections of photographs, scanned drawings, videos. The only option offered to users by current software for searching large sets of picture files, such as ACDSee, PhotoSuite of ThumbsPlus, amounts to scrollable 2D arrays of thumbnails or labelled file icons besides ordered lists of directory and file names.

5.4.1. Navigation and search in multi-scale 3D representations of large collections of pictures

Participants: O. Christmann, N. Carbonell.

We have designed and implemented two 3D metaphors for visualizing and searching in, or navigating through, large collections of photographs (e.g., landscapes, portraits, complex objects). Both metaphors visualize a collection in the form of a vertical 3D cylinder. However, in the context of the first metaphor, the representation is an object that users manipulate while, in the context of the second one, they are surrounded by a cylindrical wall (immersive virtual reality). In the case of the "wall" metaphor, moves are ambiguous: users may feel as if they were moving in front of the wall (locomotion), or they may have the impression that the wall itself is moving before them.

These metaphors have been compared regarding their respective efficiency (i.e., task execution times, success and failure rates, spatial orientation effectiveness) and usability (user subjective satisfaction especially). 20 participants carried out two types of realistic visual search tasks: looking for a visually familiar picture, and browsing through a collection of pictures in search of a picture matching a predefined list of criteria specified verbally. Each collection included over 1000 photographs, and 150 photographs or so were displayed simultaneously. Actions on the cylinder included left and right rotations, forward and backward adjustment moves, zooms. This experimental study carried out by Olivier Christmann constitutes another contribution of MerLIn to the Micromégas Project. First results have been presented at the PaRISTIC conference (Panorama des Recherches Incitatives en STIC, Bordeaux, November 21-23, 2005). We are currently considering other visualization metaphors for browsing through large sets of familiar structured multimedia information.

5.4.2. Gaze-contingent displays

Participants: D. Gepner, Z. Luo, N. Carbonell.

The main objective of this project is to tailor displays, especially displays of complex data sets or large 2D and 3D displays, so that the most informative details are generated at the point of gaze and degraded in some way outside the field of foveal vision.

To be efficient, gaze-contingent display algorithms have to rely on knowledge of human vision, both for limiting the amount of information displayed on the screen areas beyond the user's current field of foveal vision, and for reacting to visual attention shifts as fast as possible. In addition, changes of resolution in specific areas of the display should not interfere with the pace and comfort of users' visual exploration. Research on gaze-contingent displays is developing rapidly. See (Duchowski, 2003, pages 211-217 [41]) for a review of current research in this area. Potential application areas include:

- interaction with complex distant visualizations or animations in cases when image compression techniques (without major loss of information) prove insufficient for achieving satisfactory display speed and reactivity;
- interaction with virtual reality environments such as Reality Centers or Caves where viewpoint changes often entail time-consuming computations which preclude interactivity.

This year, we designed and developed a gaze-contingent prototype application using the ASL-501 eye tracker for tracing the user's eye movements (60 Hz sampling rate) and a real time algorithm for computing gaze fixations developed by Daniel Gepner. The prototype is operational and has been experimented on blurred images displayed on a standard 21" screen. However, the delay necessary for detecting fixations is too high (about 80 ms) for ensuring smooth scan paths; users perceive it and resent to be slowed down in their exploration of the progressively de-blurred image. We are currently investigating several strategies for getting round this difficulty, based on the results of an experiment performed by Zhaowu Luo. This experiment was

meant to gain the necessary knowledge on human vision for increasing visual comfort during the exploration of blurred images that are progressively de-blurred according to the user's eye-movements.

We have also developed a demonstrator for an innovative electronic surveillance application in collaboration with researchers at the Centre de Recherche en Automatique de Nancy (Francis Lepage and Fabien Michaut): gaze control of the shooting angle of a distant camera (with 4 DOF) mounted on a mobile robot. This demonstrator uses our real time algorithm for computing the user's fixations. Currently, multimodal remote interaction with this mobile visual surveillance equipment is being considered, namely: speech for controlling the moves of the robot, and gaze for operating the camera.

6. Other Grants and Activities

6.1. National projects

- Participation to the PREDIT program (Ministry of Transportation) together with SNCF (French Railways) and RATP (Paris Subway System): study of mental workload based on task characteristics (V. Lucquiaud, D. L. Scapin).
- Participation to the Working Group CESAME (Conception et Exécution de Systèmes interactifs Adaptables et/ou Mixtes en Évolution) GDR I3 (D. L. Scapin).
- Participation to the Micromégas project, ACI "Masses de Données", since July 2003 (N. Carbonell, O. Christmann, T. Blanc-Brude, D. L. Scapin).
- Collaboration with France Télécom R&D (Contrat de recherche externalisée LORIA-CNRS, from April 2005): Evaluation of the contribution of Embodied Conversational Agents (ECAs) to Human-Computer Interaction: the case of online help (N. Carbonell).
- Participation to the "Pôle Intelligence Logicielle" of the "Contrat de plan État-Région Lorraine", theme "Téléopérations et Assistants Intelligents": projects "Multimodal (speech and gaze) télé-opération of a mobile robot equipped with a camera" and "Visual attention modelling" (N. Carbonell).

6.2. Networks and international working groups

- ERCIM Working Group "UI4ALL" (N. Carbonell member of the Steering Committee).
- WWCS (Work With Computer Systems conference) Group (D. L. Scapin).
- AFNOR X3SE (Ergonomie des Logiciels Interactifs); (Chair: D. L. Scapin).
- ISO/TC 159/SC4/WG5 (Software ergonomics and human-computer dialogues) (D. L. Scapin expert).
- ISO/TC 159/SC4/WG6 (Human-centred design processes for interactive systems) (D. L. Scapin expert).
- CEN/TC 122/G 5 (Software ergonomics and human-computer dialogues) (D. L. Scapin expert).
- Participation to the CNPq/INRIA project EDGE (Evaluation methods, Design Guidelines and Environments for Virtual Reality and Information Visualization Techniques) (D. L. Scapin).
- Participation to the project COST294-MAUSE "Towards the Maturation of IT Usability Evaluation" 2005-2009 (D. L. Scapin).

7. Dissemination

7.1. Animation of the scientific community

7.1.1. Organization of scientific events

- Participation to the organization of a CESAME Workshop (“Conception et Evaluation de Systèmes interactifs Adaptables et/ou MixtEs »), Groupe de Travail du GDR-I3 GT 4.6, at UbiMob’05, deuxièmes Journées Francophones : Mobilité et Ubiquité 2005, 31 mai - 3 juin 2005, Grenoble. (D. L. Scapin).
- Participation to the organization of a MAUSE Workshop at INTERACT, UIQM: International COST294-MAUSE Workshop on User Interface Quality Models, Rome, Italy, September 12-13, 2005. (D. L. Scapin).

7.1.2. Editorial Boards of Journals

- Behaviour and Information Technology. (Member of the Editing Committee: D. L. Scapin; Reviews: N. Carbonell).
- Interacting with Computers, (Member of the Editorial Committee: D. L. Scapin).
- International Journal of HCI. (Member of the Editorial Committee: D. L. Scapin).
- International Journal of Human-Computer Studies. (Member of the Editorial Committee: D. L. Scapin).
- International Journal of Universal Access in the Information Society. (Members of the Editorial Board: N. Carbonell, D. L. Scapin).
- Revue d’Interaction Homme-Machine. (Membre du Comité de Rédaction: D. L. Scapin).
- Le Travail Humain (Membres du Comité de Consultants: N. Carbonell, D. L. Scapin).
- Revue Information, interaction, intelligence. (Membre du Comité de Rédaction: N. Carbonell).

7.1.3. Conference Programme Committees

- IADIS’05, Virtual Multi Conference on Computer Science and Information Systems (MCCSIS 2005), Interfaces and Human-Computer Interaction (IHCI 2005), April 11-22, 2005 (Scientific Committee Member, N. Carbonell)
- IWIPS 2005, 7th Annual International Workshop on Internationalisation of Products and Systems, Amsterdam, July 7-9 (Program Committee Member, D. L. Scapin)
- AICT 2005, Advanced Industrial Conference on Telecommunications, Track E-learning on Telecommunications (ELETE), Lisbon, July 17-20, 2005 (Program Committee Member, N. Carbonell)
- UAHCI 2005, 3rd International Conference on Universal Access in Human-Computer Interaction, HCI International 2005, Las Vegas, July 22-27, 2005 (Program Board Member, N. Carbonell)
- UM 2005, 10th International Conference on User Modeling, Edinburgh, UK, July 24-30, 2005 (Program Committee Member, N. Carbonell)
- ISDA 2005, 5th International Conference on Intelligent Systems Design and Applications, Wroclaw, September 8-9, 2005 (Program Committee Member, N. Carbonell)
- INTERACT’05, IFIP TC13 International Conference on Human-Computer Interaction, Rome, September 12-16, 2005 (Program Committee Member, D. L. Scapin)

- International Workshop on Recommender Agents and Adaptive Web-based Systems at ISDA2005, Wroclaw, September 8-9, 2005 (Program Committee Member, N. Carbonell)
- TAMODIA 2005, International Workshop on TAsk MOdels and DIAgrams for user interface design) Gdansk, Poland, September 26-27, 2005. (Programme Committee Member, D. L. Scapin)
- ICMI'05, 7th ACM International Conference on Multimodal Interfaces, Trento, Italy, October 4-6, 2005 (Area Chair for Multimodal data collection, corpora and evaluation, N. Carbonell)
- OZCHI 2005, Annual conference of the Australian Computer-Human Interaction Special Interest Group, Canberra, Australia, November 21-25, 2005 (Program Committee Member, D. L. Scapin)
- Atelier Modélisation de l'utilisateur at EGC 2005, 5èmes Journées d'Extraction et Gestion des Connaissances, Paris, January 19-21, 2005 (Program Committee Member, N. Carbonell)
- EPIQUE'05, 3èmes Journées d'Etude en Psychologie Ergonomique, Toulouse, 26-28 septembre 2005, (Scientific Committee Member, D. L. Scapin)
- IHM'05, Conférence Francophone sur l'Interaction Homme-Machine, Toulouse, France, September 27-30, 2005 (Program Committee Members, N. Carbonell, D. L. Scapin; Meta-reviewer, D. L. Scapin)

7.1.4. Others

- ARA "Masses de données", 1st call for projects (July 2005): review of one project (N. Carbonell)
- Advisory Board for the 2nd Edition of the "Human-Computer Interaction Handbook", (Member, N. Carbonell)

7.1.5. Ph.Ds and Habilitations examining boards

- Xavier Lacaze: "Design Rationale for Interactive Systems", Doctorat de l'Université de Toulouse I, spécialité Informatique, 20/06/05, D. L. Scapin examinateur.
- Amélie Schyn: "Une approche fondée sur les modèles pour l'ingénierie des systèmes interactifs multimodaux", Doctorat de l'Université de Toulouse III, spécialité Informatique, 21/06/05, N. Carbonell examinateur.
- Ouriel Grynszpan: " Interfaces Homme-Machine multimédias : conception d'applications éducatives adaptées à l'autisme de haut niveau,", Doctorat de l'Université de Paris XI Orsay, spécialité informatique, 09/12/05, N. Carbonell rapporteur.
- Laurent Magnien: "Saisie de texte sur dispositifs nomades : Propositions et évaluations de solutions pour la saisie sur claviers logiciels", Doctorat de l'Université de Toulouse III Paul Sabatier, spécialité informatique, 10/12/05, N. Carbonell rapporteur.

7.2. Teaching

- Institut Supérieur de Technologie et de Management (ISTM), Module IHM: T. Blanc-Brude, M. Baron (12h).
- Université de Poitiers, Master Professionnel mention Sciences et Technologies de l'Information et de la Communication (STIC): M. Baron (8h).
- DEA d'Informatique, Ecole Doctorale IAEM-Lorraine, N. Carbonell, responsable de la filière "Perception, raisonnement, traitement automatique des langues", membre permanent du jury de soutenance des stages.
- Maîtrise d'Informatique Fondamentale, Université Henri Poincaré, Module Perception, raisonnement: N. Carbonell (12h).
- Master Informatique, Universités de Nancy, N. Carbonell responsable de la spécialité recherche "Perception, raisonnement, interaction multimodale (PRIM)". M1: U.E. "Conception et évaluation d'interfaces utilisateur" (30h); M2: UE "Modélisation de l'utilisateur" (15h).

7.3. Participation to conferences, workshop, invited talks

- MAUSE (COST Action 294: Towards the Maturation of Information Technology Usability Evaluation) internal Workshop, University of Sunderland, U.K., May 3-4, 2005 (D. L. Scapin)
- IWIPS 2005, 7th Annual International Workshop on Internationalisation of Products and Systems, Amsterdam, July 7-9 (D. L. Scapin)
- UAHCI 2005, 3rd International Conference on Universal Access in Human-Computer Interaction, HCI International 2005, Las Vegas, July 22-27, 2005 (N. Carbonell)
- UM 2005, 10th International Conference on User Modeling, Edinburgh, UK, July 24-30, 2005 (N Carbonell, S. Kieffer)
- INTERACT'05, IFIP TC13 International Conference on Human-Computer Interaction, Rome, September 12-16, 2005 (N. Carbonell, D. L. Scapin, J. Simonin); MAUSE Workshop (D.L. Scapin)
- Human Factors and Ergonomics Society 49th Annual Meeting, Orlando, USA, September 26-30, 2005 (D. L. Scapin)
- ICMI'05, 7th ACM International Conference on Multimodal Interfaces, Trento, Italy, October 4-6, 2005 (Area Chair for Multimodal data collection, corpora and evaluation, N. Carbonell)
- IHM'05, Conférence Francophone sur l'Interaction Homme-Machine, Toulouse, France, September, 27-30, 2005 (N. Carbonell, V. Lucquiaud, J. Simonin)
- PaRISTIC, Panorama des Recherches Incitatives en STIC 2005, Bordeaux, November 21-23, 2005 (talks: T. Blanc-Brude and N. Carbonell; poster and demonstration: O. Christmann)
- Fête de la Science - Village des Sciences, Henri Poincaré University, October 14-15: "Gaze tracking applications - Demonstrations and videos", (N. Carbonell, M. Hategan, J. Simonin)

8. Bibliography

Major publications by the team in recent years

[1] R. AMALBERTI, N. CARBONELL, P. FALZON. *User representations of computer systems in human-computer speech interaction*, in "International Journal of Man-Machine Studies", vol. 38, 1993, p. 547-566.

[2] J. M. C. BASTIEN, D. L. SCAPIN. *A validation of ergonomic criteria for the evaluation of human-computer interfaces*, in "International Journal of Human-Computer Interaction", vol. 4, 1992, p. 183-196.

[3] J. M. C. BASTIEN, D. L. SCAPIN. *Evaluating a user interface with ergonomic criteria*, in "International Journal of Human-Computer Interaction", vol. 7, 1995, p. 105-121.

[4] A. CAPOBIANCO. *Questioning the effectiveness of contextual online help: some alternative propositions*, in "Ninth IFIP TC13 International Conference on Human-Computer Interaction - INTERACT'03, Zurich, Switzerland", M. RAUTERBERG, M. MENOZZI, J. WESSON (editors). , IOS Press, Amsterdam, Sep 2003, p. 65-72.

[5] A. CAPOBIANCO, N. CARBONELL. *Online help for the general public: specific design issues and recommendations*, in "Universal Access in the Information Society", vol. 2, nº 3, 2003, p. 265-279.

[6] A. CAPOBIANCO. *Stratégies d'aide en ligne contextuelles : Acquisition d'expertises, modélisation et évaluation expérimentale*, Ph. D. Thesis, Université Henri Poincaré, spécialité Informatique, octobre 2002.

[7] A. POLLIER. *Évaluation d'une interface par des ergonomes : diagnostics et stratégies*, in "Le Travail Humain", vol. 55, 1992, p. 71-96.

[8] S. ROBBE. *Étude ergonomique de contraintes d'expression orales et gestuelles dans un environnement multimodal d'interaction homme-machine*, Ph. D. Thesis, Université Henri Poincaré, décembre 1998.

[9] D. L. SCAPIN, J. M. C. BASTIEN. *Ergonomic criteria for evaluating the ergonomic quality of interactive systems*, in "Behaviour and Information Technology", vol. 16, 1997, p. 220-231.

[10] D. L. SCAPIN, C. PIERRET-GOLBREICH. *Towards a method for task description*, in "Proceedings of Working With Display Units, Amsterdam, The Netherlands", L. BERLINGUET, D. BERTHELETTE (editors). , Elsevier, 1990, p. 371-380.

[11] D. L. SCAPIN. *Situation et perspectives en ergonomie du logiciel*, in "L'Ergonomie dans la conception des projets informatiques, Toulouse, France", J.-C. SPERANDIO (editor). , Octares, 1993, p. 7-68.

[12] D. L. SCAPIN. *The need for a Psycho-engineering approach to HCI*, in "II Congresso Latino Americano e VI Seminario Brasileiro de Ergonomia, Florianopolis, Brasil", 10-13 octobre 1993, p. 3-22.

[13] S. SEBILLOTTE, D. L. SCAPIN. *From users' task knowledge to high level interface specification*, in "International Journal of Human-Computer Interaction", vol. 6, 1994, p. 1-15.

[14] S. SEBILLOTTE. *Décrire des tâches selon les objectifs des opérateurs. De l'interview à la formalisation*, in "Le Travail Humain", vol. 54, 1991, p. 193-223.

Doctoral dissertations and Habilitation theses

[15] S. KIEFFER. *Assistance multimodale à l'exploration de visualisations 2D interactives*, Thèse en informatique, Université Henri Poincaré Nancy 1, Juillet 2005.

[16] V. LUCQUIAUD. *Sémantique et outil pour la modélisation des tâches utilisateur : N-MDA*, Thèse en informatique, Université de Poitiers, LISI/ENSMA, December 2005.

Articles in refereed journals and book chapters

[17] C. BACH, E. BRANGIER, D. SCAPIN. *Exigences ergonomiques, méthodes, et normes pour la conception de Systèmes d'Information centrés humain*, in "Le management des hommes au travail", to appear, Eyrolles.

[18] N. CARBONELL. *Multimodal Interfaces - A Generic Design Approach*, in "Universal Access in Health Telematics - A Design Consortium Code of Practice", C. STEPHANIDIS (editor). , Springer-Verlag Berlin Heidelberg, 2005, p. 209-223.

[19] S. KIEFFER, N. CARBONELL. *Apport d'indications spatiales orales à la recherche de cibles dans des affichages complexes*, in "Revue d'Interaction Homme-Machine (RIHM)", to appear, December 2005, p. 1-29.

[20] D. SCAPIN. *Exigences ergonomiques, méthodes, et normes pour la conception de Systèmes d'Information centrés humain*, in "Encyclopédie des Systèmes d'Information", to appear, Vuibert.

Publications in Conferences and Workshops

[21] N. CARBONELL. *Ambient Multimodality: towards Advancing Computer Accessibility and Assisted Living*, in "Proceedings of the 3rd International Conférence on Universal Access in Human-Computer Interaction, Las Vegas, USA", July 25-27 2005, p. 789-794.

[22] W. CYBIS, D. L. SCAPIN, M. MORANDINI. *ERGOMANAGER: a UIMS for monitoring and revising user interfaces for web sites*, in "WEBIST (Web Information Systems and technology), Miami, USA", May 26-28 2005.

[23] W. CYBIS, D. L. SCAPIN, M. MORANDINI. *ERGOMANAGER: um sistema gerenciador de interfaces com o usuário para sites web transacionais*, in "CLIHC'05 (Congresso Latino-americano de Interacao Humano-Computador), Cuernavaca, Mexico", October 23-26 2005.

[24] E. LAW, E. HVANNBERG, J. VANDERDONCKT, C. STARY, M. SPRINGETT, D. L. SCAPIN, P. PALANQUE, G. COCKTON. *MAUSE: Network of Usability Excellence*, in "BCS HCI, Poster, Edinburg, Scotland", Springer-Verlag, September 2005.

[25] E. LAW, E. HVANNBERG, J. VANDERDONCKT, C. STARY, M. SPRINGETT, D. L. SCAPIN, P. PALANQUE, G. COCKTON. *Towards the Maturation of IT Usability Evaluation (MAUSE)*, in "Interact 2005 Short Paper, Roma, Italy", Lecture Notes in Computer Science, Springer-Verlag, September 2005.

[26] V. LUCQUIAUD. *Proposition d'un noyau et d'une structure pour les modèles de tâches orientés utilisateurs*, Proceedings of the 17th French-speaking conference on Human-computer interaction, Toulouse, France, September 27-30 2005, p. 83-90.

[27] J. SIMONIN, S. KIEFFER, N. CARBONELL. *Effects of display layout on gaze activity during visual search*, in "Proc. IFIP TC13 International Conférence on Human-Computer Interaction (INTERACT'05), LNCS 3585, Rome, Italy", M.-F. COSTABILE, F. PATERNO (editors). , September 12-16 2005, p. 1054-1058.

[28] J. SIMONIN, S. KIEFFER, N. CARBONELL. *Influence de l'organisation spatiale des affichages sur l'efficacité de la recherche visuelle*, New York, ACM PRESS, Toulouse, IHM (17th French-speaking Conférence on Human-computer interaction), Toulouse, September 27-30 2005, p. 35-42.

Internal Reports

[29] C. BACH, D. L. SCAPIN. *Critères Ergonomiques pour les Interactions Homme-Environnements Virtuels : définitions, justifications et exemples*, INRIA Research Report, March 2005, http://www.inria.fr/rrrt/rr-5531.html.

[30] T. BLANC-BRUDE, D. L. SCAPIN. *Etude de la mémoire des documents chez l'utilisateur pour la conception des systèmes d'aide à leur récupération*, INRIA Research Report, 2005, http://www.inria.fr/rrrt/rr-5785.html.

[31] N. CARBONELL. *Livrable Phase 1 : Revue de l'état de l'art scientifique et technique*, 24p., Contrat de Prestation de Recherche Externalisée num: 46 131 092, 2005.

[32] N. CARBONELL. *Livrable Phase 2 : Conception du protocole expérimental*, 13p., Contrat de Prestation de Recherche Externalisée num: 46 131 092, 2005.

[33] W. CYBIS. *ErgoManager : a UIMS for monitoring and revising user interfaces for Web sites*, INRIA Research Report, July 2005, http://www.inria.fr/rrrt/rr-5639.html.

[34] V. LUCQUIAUD. *Modèles et outils pour la description de l'activité orientée tâches*, Convention de Recherche INRIA-SNCF-RATP, Technical report, Rapport de contrat INRIA, Projet PREDIT, Rocquencourt, Janvier 2005.

Miscellaneous

[35] T. BLANC-BRUDE, D. L. SCAPIN. *Étude de la mémoire des documents chez l'utilisateur pour la conception des systèmes d'aide à leur récupération*, Exposé, 21-23 novembre 2005, Conférence Panorama des Recherches Incitatives en STIC (PaRISTIC).

[36] N. CARBONELL, O. CHRISTMANN, D. GEPNER, S. KIEFFER, J. SIMONIN. *Recherche visuelle et navigation dans des ensembles non structurés d'images*, Exposé, 21-23 novembre 2005, Conférence Panorama des Recherches Incitatives en STIC (PaRISTIC).

[37] O. CHRISTMANN. *Deux métaphores d'interaction avec des présentations 3D de collections de photographies : immersive et non immersive.*, Démonstration, 21-23 novembre 2005, Conférence Panorama des Recherches Incitatives en STIC (PaRISTIC).

[38] O. CHRISTMANN. *Recherche visuelle et navigation multiéchelle dans des collections de photos*, Poster, 21-23 novembre 2005, Conférence Panorama des Recherches Incitatives en STIC (PaRISTIC).

Bibliography in notes

[39] N. CARBONELL, S. KIEFFER. *Do oral messages help visual search?*, in "Natural, Intelligent and Effective Interaction in Multimodal dialogue systems", N. BERNSEN, L. DYBKJAER, J. VAN KUPPEVELT (editors). , Kluwer Academic Publishers, December 2005, p. 151-176.

[40] E. DUBOIS, B. MANSOUX, C. BACH, D. L. SCAPIN, G. MASSERAY, J. VIALA. *Un modèle préliminaire du domaine des systèmes mixtes*, in "Proceedings of IHM'2004, 16ème Conférence Francophone sur l'Interaction Homme-Machine, Namur", New York, ACM, Septembre 1-3 2004, p. 61-68.

[41] A. DUCHOWSKI. *Eye Tracking Methodology: Theory and Practice*, Springer, 2003.

[42] D. L. SCAPIN, J. M. C. BASTIEN. *Ergonomic criteria for evaluating the ergonomic quality of interactive systems*, in "Behaviour and Information Technology", vol. 16, 1997, p. 220-231.