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INSTITUT NATIONAL DE RECHERCHE EN INFORMATIQUE ET EN AUTOMATIQUE

Project-Team MErLIn

Methods for Interactive Software Ergonomics

Nancy - Grand Est - Paris - Rocquencourt

THEME COG

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2. Overall Objectives

2.1. Introduction

Keywords: *3D interactive visualisations*, *User interface design and evaluation methods: Formal task description*, *adaptive user interfaces*, *ergonomic criteria*, *ergonomic quality of interactive software*, *gaze)*, *gestures*, *mixed reality*, *multimodal interaction (speech*, *standardization. New forms of human-computer interaction: Hypermedia*, *user assistance (online help)*, *user modelling*, *user testing*, *visual search.*

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], of 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, that is, ergonomic optimization of interactive software, requires to make progress both in fundamental knowledge and in methods in HCI (Human-Computer Interaction), and Ergonomics. The scientific contributions of the MErLIn project include scientific literature on users and task modelling, on empirical studies, on design and evaluation methods, on ergonomics recommendations, as well as software (e.g., mock-ups, test-prototypes, tools for 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 life cycle of computer systems. 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.

2.2. Highlights of the year

This year it is worth noticing:

- The participation of MErLIn to the publication of the very comprehensive Encyclopédie de l'Informatique et des Systèmes d'Information, Vuibert.
- The publication of novel results in the area of PIMs (Personal Information Management systems); and the involvement of MErLIn in the first definition of an ergonomic certification process.
  Both activities had a role in a successful bid for a new ANR project.

3. Scientific Foundations

3.1. Scientific Foundations

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

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

Ergonomics or Human Factors[2] 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. 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 to musculoskeletal disorders, workplace layout, safety, and health).

- 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 socio-technical 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.

Human-Computer Interaction (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, as the MErLIn project is 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 [38] 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, thatis, the extent to which 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 modelling 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.

[2] Definition from IEA (International Ergonomics Association) (http://www.iea.cc/ergonomics/)
[3] Definition from AFIHM (Association Francophone d'Interaction Homme-Machine) (http://www.afihm.org)

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 who 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.

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 general 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; task modelling; interaction with visualizations of large sets of multimedia information; personal information management systems, text and picture visual search, 3D interactive visualization metaphors, picture browsers; online help; Embodied Conversational Agents (ECAs); gaze-contingent displays.

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

5. New Results

5.1. Introduction

The research work carried out this year is presented along two main topics: ergonomics methods for the evaluation and design of software interactions and interactive visualizations.

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.

A book chapter [16] has been finally published this year. The goal was to introduce various human issues in the design and evaluation of information systems, with an ergonomic perspective. Without being fully thorough, it provides a survey of the main issues, focusing on methodological aspects. 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 systems context.

The European project COST294-MAUSE "Towards the MAturation of IT USability Evaluation" (see http://www.cost294.org), comprises four working groups (WGs). Our participation has mainly concerned WG1 (Leader: D. L. Scapin) whose goal is to build a refined, substantiated and consolidated knowledge-pool about usability evaluation. WG1 has extended the coverage of its initial method descriptions. Using its "UM Generic Description" template and its "Case Study Description" template, WG1 work has led to the description of over forty methods (including methodologies consisting of several methods, and "case studies"). This work has been presented and discussed during the COST294-MAUSE 3rd International Workshop, Athens, March 5, 2007 [15].

Further WG1 work will include extending coverage of computer-based methods (coordination with WG4 in progress), and exploring new mechanisms in order to further disseminate the results obtained.

In the context of AFNOR (Association Française de Normalisation) standardization activities, a dedicated working group has contributed to the issue of ergonomics certification. A paper [28] was presented at the 2007 SELF congress. It explains the interest and potential impact of certification for final users and for the ergonomics profession ; it reviews certification activities in industry, explains relationships with current ISO standards and offers new directions for ergonomics process certification. It also describes the nature of the proposed approach and the main characteristics of a certification reference document [30] planned as a basis for the effective implementation of national certification.

5.2.2. Personal Information Management : an investigation of user's practice

Participant: D. L. Scapin.

Through collaboration with T. Blanc-Brude (a post-doc in the project in 2005, now with SQLI), further editing has led to publications on PIMs (Personal Information Management systems) [22], [19]. In summary, the study aimed at finding out which attributes (e.g., names, location etc.) people actually recall about their own documents (electronic and paper), and how they recall them, in order to provide recommendations on how to design tools that allow users to retrieve their electronic files more effectively and more easily. An experiment was conducted with fourteen participants at their workplace. They were asked first to recall features about one (or several) of their own work document(s), and secondly to find these documents. Results correlate with the need for better tools for documents retrieval. In addition, results indicate which attributes are candidate for facilitating file retrieval and how search tools should use these attributes.

The topic of PIMs will be followed-up within a new upcoming three year study sponsored by ANR (project myCitizSpace).

5.2.3. Comparing methods for the evaluation of HVEIs (Human-Virtual Environments Interactions)

Participant: D. L. Scapin.

Through collaboration with C. Bach (Ph.D. in the project in 2005, now with IRIT), further analysis of experimental data has led to a paper submission to an international journal [31].

The initial research work dealt with the design and evaluation of the Ergonomic Criteria (E.C.) applied to HVEIs (Human-Virtual Environments Interactions). Further analyses focused on the comparison between three usability evaluation methods for virtual environments: User testing, Inspection with Ergonomic Criteria (EC) and Free inspection. This comparison is based on multiple quantitative and qualitative metrics for experimentally assessing and validating both utility and effectiveness aspects of these evaluation methods. Twenty-nine subjects participated in the evaluations of two virtual environments (a training VE and a 3D map). Ten subjects participated in User Testing, nineteen subjects participated in the inspections (ten with EC inspection and nine with Free inspection). Results of the comparison show a significant difference between EC inspection and Free Inspection effectiveness. Results show the overlap of problems identified by each method, the diversity of problems and inter- as well as intra- homogeneity of the methods. The qualitative analysis that was conducted identified 35 classes describing the nature of problems found with each method. Some of the main results are:

- a significant difference between using the E.C. and free inspection, in terms of number of usability problems found over time.
- the performance is rather similar for both the user test and the inspection using the EC.
- a "gender" effect for the training application evaluated by the user test.
- the inter- application variability as observed in the user test and free inspection, is being significantly attenuated (for the inter methods common problems) with the use of EC.
- the proportion of common problems between inspection and user tests is twice more when the EC are used (approximately 22%).
- the EC have the highest power of diagnosis, together with the largest identification spectrum. Overall, these characteristics lead to a high and stable evaluation performance (about 60% of all problems).

5.2.4. User centred design and evaluation of mixed systems

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

This thesis work is based on a collaboration with IRIT (E. Dubois, R. Bastide). Mixed Interactive Systems (MIS) constitute an advanced form of interactive systems and result from the fusion of the physical world and the digital world, thus gathering mixed and augmented reality, augmented virtuality, and tangible user interfaces systems. Because of this fusion, multiple objects take part in the user task. Furthermore, the continuous use of digital and physical objects has an impact on the interaction and its dynamics, thus creating new issues in terms of design.

Developing a design process suitable for MIS is an issue for HCI research. To enrich the design approaches dedicated to MIS, two complementary design aspects are of interest: (1) the description of the global user activity and dynamics aspects of mixed interactive situations; (2) the description of mixed interaction in a way that takes into account the heterogeneity and richness of MIS. These two aspects are partly addressed by specific models such as sequence diagrams or task models, and class diagrams or mixed interaction models, respectively.

Following a Model Driven Engineering (MDE) approach, the aim is to explore and characterize the articulation of task models (such as K-MAD) with mixed interaction models (such as ASUR) to contribute to the development of a MIS design process. First, we studied each notation thus extracting the foundation of the articulation. This work was applied in 2006 to a design case for the museum of natural history of Toulouse. A second application was investigated in 2007 for an inventory of fixtures case study for the GT CESAME of the GDR I3 (CNRS-STIC).

Once established the complementary points of the models, the K-MAD and ASUR metamodels were described, as well as the common aspects and links between elements of the metamodels. A first set of rules constitutes a basis for the articulation of the models. Two types of rules defining the boundaries between K-MAD descriptions and ASUR descriptions were described, as well as the correspondences between the models. These results were published in TAMODIA'07 [25].

Additional aspects will be further investigated, such as the fact that ASUR does not take into account the order of subtasks, while K-MAD operators allow expressing the dynamics of the activity; the selection and matching of various ASUR mixed alternatives from high level K-MAD modelling: the study of mixed interaction sequences will highlight recommendations concerning interaction functionalities and their impact on the user activity; the definition of rules to check the consistency between the models and the rules through the different steps of the development process. Overall, the goal will be to support a model-based predictive evaluation of MIS at the design stage.

5.2.5. Formal design and validation of the dialogue in interactive software

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

This work was carried out in collaboration with University of Poitiers and ENSMA (P. Girard). It is a follow up of other collaborative efforts that ended up with the development of K-MAD and SUIDT. This thesis aims at studying the link between the dialogue and task models in interactive software in order to effectively use task models during the development of interactive software. Current trends in task modelling are looking into software generation from task models. However, dialogue controllers cannot be completely derived from task models. Transformations must be defined during the design of this part of software. Keeping track of links during these transformations is essential. The issue is how task models can help the design and validation of the dialogue in interactive applications. The plan is to study how to establish a communication between such models using MDE (Model-Driven Engineering) approaches as metamodels.
In a first step, the design needs to be addressed in the task models were derived from observations of design case scenarios. Following a literature survey on current approaches of software generation from task models as well as two case studies (a webmail system and a biological system) the main challenges for designing interactive software with a task orientation were identified. These challenges are presented at TAMODIA'07 [24]. In addition, a case study on an entertainment application dialogue based on task model specifications highlighted the difficulties in performing automatic processing. This was presented at IHM07 [23]. At the same time, a state-of-the-art review was carried out on task models and dialogue models in order to express dialogue control. In order to be based on usable tools, we chose a dialogue model usable in the implementation process: hierarchical interactors. This model was developed at ENSMA and is based on a complete software cycle (H^4). It allows the structuring of the dialogue with state machines.

The following steps will be the study, in more details, of the mechanisms of this dialogue model and the correspondence between the K-MAD model and the hierarchical interactors. This should support establishing and maintaining communication between task and dialogue models during the whole design process. Maintaining the communication between task models and the final software through the dialogue controller enables the verification of its correlation with user needs. As an example, it should help verifying that the application is consistent with user specifications, such as checking that a task may be performed only when another one has been carried out. This verification can be performed at different levels of abstraction in order to allow the validation in these different levels.

5.2.6. Towards effective online help to the use of software for the general public

Participants: J. Simonin, P. Freund, A. Roy, N. Carbonell.

To improve the effectiveness of online help, we are currently investigating two research directions: adaptivity and multimodality.

User modelling is an active, fast developing research area. According to [36], recent scientific advances make it possible to consider the implementation of effective adaptive user interfaces, that is, interfaces capable of adapting their behaviours to the evolution of the current user's profile, namely their competences, interests, preferences and/or goals. However, specific usability issues are yet to be investigated; see [13]. To react predictably is a major usability requirement for interactive software according to Shneiderman. Hence, how will users, especially novice users, react to, and accept, user interfaces whose behaviours evolve during interaction autonomously? What amount of control over the interface evolution users should be given?

As for multimodality, we have shown that multimodal contextual help that combines oral messages with graphics is well accepted by novice users, stimulates help consultation, and improves its effectiveness [5], mainly because oral help messages do not disrupt novices' interactions with new software contrary to textual messages. Embodying advanced online help systems and endowing them with speech capabilities may further increase their effectiveness. Using an Embodied Conversational Agent (ECA) for assisting novice users, has the potential to enhance their motivation to consult online help systems more frequently, hence to facilitate and improve learning of the new software operation.

This year, efforts have been focused on the analysis of two empirical studies: one was meant to assess the ergonomic quality of adaptive online help (9 participants), and the other aimed at identifying the actual contributions of ECAs to the efficiency and usability of help systems intended for novice users in the general public (22 participants). An animation creation software (Flash) was used for both studies. The functionalities

of the two help systems were partly simulated using the Wizard of Oz technique, the Wizards being assisted in their activities by a generic software platform which also recorded participants' interaction traces. The adaptive help system could dynamically adapt the content of text+graphics messsages to the evolution of novice users' knowledge of Flash operation and use; it also anticipated novice users' information needs based on the Wizard's detection of their goals and intentions from their interactions with Flash. Oral messages illustrated with Flash screen copies were implemented in the multimodal help system; they were activated on the user's initiative exclusively. In one condition, oral messages were spoken by an ECA, a female talking head developed by FT R&D; in the other condition the same multimodal messages without the ECA were presented to participants.

Results of these studies are presented and discussed in Jérôme Simonin's PhD thesis [17]. They indicate that the presence of the ECA increased help consultation sensibly. Comparisons between adaptive and multimodal help show that subjective judgements were more positive for the adaptive system than for the multimodal one, while learning Flash operation proved to be less effective with the adaptive system than with the multimodal one.

5.3. Interactive visualizations

The design of interactive visualizations of large collections of pictures has not yet raised much interest in the HCI research community. This lack of interest seems to be based on the implicit assumption that visualization techniques designed for large data sets can be used for visualizing large collections of pictures. For instance, [32] experimented tree-maps for displaying pictures taken at CHI 2001. As for designers of photo browsers, they usually present picture collections in the form of scrollable 2D arrays of zoomable thumbnails.

However, specific visualisation techniques need to be developed for the presentation of collections of photographs, especially personal collections. User motivations for browsing picture collections are indeed different from those of users who explore digital or textual data sets. Search for a visually familiar photograph or for unfamiliar photographs matching sets of criteria are two of the most frequent activities that motivate browsing through a picture collection, especially a personal one.

For several years, our research in this area has been focusing on the design, implementation and ergonomic evaluation of 2D and 3D interactive visualisations of picture collections, using standard interaction devices and modalities (i.e. mouse or joystick)[4]. This year, research efforts have been focused mainly on navigation and search in 3D visualisations of large photograph collections. See [21] to get an insight into our work on visual search in 2D displays of small collections including 30 photographs.

Concerning gaze, our main working hypothesis is that gaze may prove to be more appropriate than mouse or standard devices for designating objects and positions on the screen in contexts where the user interacts with very large displays, such as electronic walls, reality centres and caves. We have been working for two years on the implementation of gaze as a pointing modality in multimodal interaction environments where commands/actions can be expressed using speech or, in some application contexts, gestures (e.g., use of a joystick). We use a head-mounted eye tracker (ASL-501).

2007 activities and results in these two areas are presented in the following subsections.

5.3.1. Interactive 3D representations of large collections of pictures

Participants: O. Christmann, L. Prost, N. Carbonell.

Entertainment 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. 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 (e.g., ACDSee, PhotoSuite or ThumbsPlus) for searching large sets of pictures amounts to scrolling 2D arrays of zoomable thumbnails.

[4] Our participation to the Micromégas project on multiscale visualisation of, and interaction with, familiar information sets was an opportunity to develop research in this area. Micromégas was a 3 year national project (July 2003 - July 2006) in collaboration with the In Situ team at INRIA-Futurs and LRI (Orsay), and the LPM Laboratory in Marseille (Yves Guiard); it was supported by the ACI 'Masses de données'.

We have designed and implemented two 3D metaphors for visualising and browsing large collections of photographs (e.g., landscapes, portraits, complex objects). Both metaphors visualise a collection of pictures or multimedia documents in the form of a vertical 3D cylinder. One cylindrical representation incites users to view it as a virtual 3D object that can be freely manipulated (manipulation metaphor). The other representation may induce them to feel as if they were surrounded by a virtual cylindrical wall. In fact, this second representation suggests two different interaction metaphors: users may feel as if they were moving in front of the picture "wall" (locomotion[5]), or they may have the impression that they are moving the wall around themselves (manipulation).

These metaphors have been compared regarding their respective efficiency (i.e., task execution times, success and failure rates, etc.) and usability (user subjective satisfaction especially). Participants carried out two types of search tasks: search for a visually familiar photograph or search for an unfamiliar photograph matching a verbal description; see [8].

This year, we performed an experimental study which aims at comparing these two 3D representations with standard 2D array displays. Comparisons were focused on the contributions of the three types of visualisations to search efficiency and comfort, and picture location memorisation; see [37], which claims that 3D visualisations of large information sets facilitate memorising item location compared to 2D representations. Tasks and experimental protocol were similar to those implemented in the previous study. That is, 20 participants carried out two types of realistic visual search tasks: looking for a visually familiar picture, and searching for an unfamiliar picture matching predefined criteria specified verbally. Each collection included about 1000 photographs, 150 of which (or so) being displayed simultaneously. Actions on the three representations included left and right rotations, forward/backward adjustments and zooming facilities. Participants' eye movements were recorded in addition to traces of their interactions, so as to increase the number of objective measurements available for assessing the comfort and efficiency of visual search activities in each representation. Eye tracking data may also provide useful qualitative information on the possible influence of each representation on participants' visual exploration strategies and subjective judgements. Analyses are now completed. One of the main results is that the immersive 3D visualisation improves memorisation of target location in the visual representation.

We are currently writing a submission to AVI'08. In parallel, we are preparing a large scale usability study of the two 3D representations, in collaboration with the 'Centre Virtuel pour la connaissance de l'Europe' (CVCE) in Luxembourg. Both representations will be used to visualise multimedia documents in the CVCE database on large touch screens at international scientific forums.

5.3.2. Gaze as a pointing modality in multimodal interaction environments

For the last three years our research efforts on gaze interaction have been focused on the investigation of two complementary research directions: (i) the implementation of gaze-contingent displays, (ii) the design and implementation of multimodal, speech- and gaze-based, command languages.

Prior to addressing these two research themes we had to develop a real time algorithm for computing fixations; this algorithm in C++ takes head movements into account. This year's progress is presented in the next two paragraphs. For a summary of our scientific activities on gaze interaction, see [27].

5.3.2.1. Gaze-contingent displays

Participants: D. Gepner, F. Valdenaire, N. Carbonell.

By definition, the resolution of gaze-contingent displays varies according to the user's current point of gaze, information density being higher around the current point of gaze than elsewhere on the display. The size of the high resolution area includes the foveal and para-foveal visual fields. To be effective and acceptable, gaze-contingent display algorithms should change display resolution as fast as the natural pace of human visual exploration of scenes. Research on gaze-contingent displays is developing rapidly. See [34], pages 211-217 for a review of current research in this area. Potential application areas include: (i) interaction with complex remote visualizations or animations the reactivity of which is still insufficient, due to transmission technique

[5] More precisely, they may feel as if they were turning round on themselves, or as if they were "walking" along the virtual wall.

limitations; (ii) interaction with virtual reality environments such as reality centres or caves where display evolutions (e.g., viewpoint changes) often entail time-consuming computations.

Last year, we designed and developed a gaze-contingent prototype (60 Hz gaze sampling rate). 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 90 ms) for ensuring smooth scan paths; users 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. In particular, we are considering guiding gaze during scene exploration, since predicting the landing position of the next fixation from the speed and direction of eye movements during the current saccade yields unreliable results [35]. To our knowledge, gaze guidance, a difficult but promising research direction, has only been explored by a few research groups; see [33], for instance. This year, we have experimented with a prototype that generates stimuli in the peripheral visual field, and observed that gaze is often, but not always, attracted by these stimuli. To achieve robust guidance of gaze movements, we have refined the implementation of this strategy and designed an experimental study meant to assess its effectiveness and determine which properties (e.g., distance to current point of gaze, size, duration, blinking frequency) peripheral stimuli should possess in order to ensure efficient and robust control of gaze moves. Methodology and design issues have been solved; the visual material has been carefully selected and prepared; software tools necessary for implementing the designed setup have been developed and tested; see [29]. Next year, a pilot study and the full experiment will be performed.

We are also analysing a corpus of scan paths (240 Hz sampling rate, 8 participants) collected during unconstrained visual exploration of realistic scenes (130 photographs), with a view to identifying inter-individual similarities. Results of this analysis will be later used to implement gaze guidance that induces scan paths fitting in with human spontaneous visual exploration strategies as well as possible. The influence of such "natural" scan paths on the efficiency of gaze guidance will be assessed by using them within the same experimental framework as the one presented in [29], and comparing results obtained with those of the experiment which will take place next year.

The scope of this research is a priori limited to realistic scene exploration activities. Observation of scan paths during other activities, such as visual search, will be performed later, so as to determine whether and to what extent scan paths and gaze strategies may be influenced by the type of visual activity users are currently engaged in.

5.3.2.2. Multimodal speech- and gaze-based interaction

Participants: M. Divjak, D. Gepner, N. Carbonell.

Spoken natural language may appeal to users in the general public, since it is the main modality used, together with gaze and pointing gestures, in face-to-face human communication. Our work on multimodal human-computer interaction is based on the following observation. Pointing hand gestures have the same expressive power as gaze in some contexts of use, namely, the selection of objects on very large displays (e.g., electronic walls, reality centres or caves, etc.), or in "Ambient Intelligence" environments [20]. In these contexts, both modalities can only specify directions, if used spontaneously as in real life. Our current work on multimodality addresses the main following issue: how to design multimodal command languages that use information on spontaneous or controlled gaze movements to disambiguate oral commands, especially those including deictic phrases and ambiguous nominal references to elements in the current, virtual or real, scene?

This year, we have completed the analysis of a corpus collected earlier, with a view to gaining an insight into users' gaze strategies during oral and multimodal interaction with 3D virtual environments. This corpus includes realistic data on spontaneous and controlled eye movements concomitant with speech commands; participants had to use a restricted vocabulary, there was no other constraint on their spontaneous oral expression. A gender balanced group of 4 participants interacted during half an hour with various 3D applications, using first speech, then multimodal (speech+gaze) commands. Participants could move their eyes freely during the first 4 tasks while they had to look at the displayed objects they wanted to act upon during the fifth task, since they could not refer to the virtual objects they had to arrange unambiguously, due to vocabulary size limitation. Animations of 3D virtual objects were created using the oRis virtual reality

development tool, and the user interface was simulated using an advanced implementation of the Wizard of Oz technique (i.e., the human wizard benefited from appropriate software assistance for simulating the multimodal interface). The recorded multimodal interactions have been analysed using a specific software tool which we developed (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 speech signal and temporal evolution of the pupil diameter. It also displays the names of the graphical application objects looked at by the user (automatic labelling), as well as automatic speech recognition results in both orthographic and phonetic forms. All these data (including oral commands) are "replayed" simultaneously thanks to fine careful synchronisation. Analyses have been based on phonetic and orthographic transcripts of participants' spontaneous speech utterances done by an expert phonetician and "manual" annotations of participants' gaze fixations[6] . Results of analyses performed on this corpus have been presented at ECEM 2007 [26].

We are currently designing a real time algorithm that can, robustly and accurately, (i) interpret fixations occurring simultaneously (loose concomitance) with speech commands as designation gestures towards the displayed objects involved in these commands; (ii) use this information for solving ambiguous linguistic references and deictic phrases included in oral commands (multimodal fusion). The next step will be to integrate this algorithm into a software demonstrator with a view to (i) assessing its actual efficiency (accuracy and run time speed) in realistic virtual reality environments, and (ii) testing the acceptability of the constraints forced upon users' spontaneous gaze movements and oral expression.

6. Other Grants and Activities

6.1. National projects

- Participation to the Working Group CESAME (Conception et Exécution de Systèmes interactifs Adaptables et/ou Mixtes en Évolution) GDR I3 (D. L. Scapin).
- Coordination of the MODIS[7] research project selected in March 2007, within the MISN Research Program[8] (Contrat de plan Etat - Région Lorraine 2007-2013). This project aims at providing biochemists with an appropriate multimodal (3D hand gestures, gaze and speech) user interface for interacting with 3D stereo visualisations of molecular models and their temporal evolution, on large screens (reality centres or caves). Three research groups are involved in this multi-disciplinary project: eDAM (biochemistry, Nancy), ETIC (ergonomics, Metz) and MErLIn.

6.2. Networks and international working groups

- WWCS (Work With Computer Systems conference) Group (D. L. Scapin).
- Standards in ergonomics and HCI[9]
  - 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).

[6] Two experts in eye movement analysis determined which virtual objects attracted participants' visual attention successively during scenario execution; fixations during speech commands and fixations preceding and following them (2 seconds before, 1 second after) were given particular attention.

[7] MODIS: Modélisation Interactive de Systèmes biologiques Complexes en Réalité Virtuelle Immersive.

[8] MISN: Modélisation, Information et Systèmes Numériques.

[9] see also article (29/08/06: http://www.inria.fr/valorisation/standardisation/ergonomie/index.fr.html

  - CEN/TC 122/WG 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).
- ERCIM Working Group "SESAMI" created in September 2006 (N. Carbonell, member).
- ACM Special Interest Group SIGACCESS (N. Carbonell, Board Officer).
- Scientific Committee of the CVCE Research Centre, Luxembourg (N. Carbonell, member).

7. Dissemination

7.1. Animation of the scientific community

7.1.1. Editorial Boards of Journals

- Behaviour and Information Technology. (Member of the Editorial Board: 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).
- Interacting with Computers. (Member of the Editorial Committee: D. L. Scapin; Reviews: N. Carbonell).
- ACM Transactions on Accessibility. (Members of the Editorial Board: N. Carbonell).
- International Journal of Universal Access in the Information Society. (Members of the Editorial Board: N. Carbonell, D. L. Scapin).
- International Journal of Information Database Systems. (Member of the Editorial Board: N. Carbonell).
- Revue d'Interaction Homme-Machine. (Membre du Comité de Rédaction: D. L. Scapin; Evaluation d'articles : N. Carbonell).
- Revue Information, Interaction, Intelligence. (Membre du Comité de Rédaction: N. Carbonell).
- Le Travail Humain. (Membres du Comité de Consultants: N. Carbonell, D. L. Scapin).
- Transactions On Informations Systems (TOIS). (Reviews: D. L. Scapin)
- International Journal of Knowledge an Informations Systems. (Reviews: N. Carbonell).
- International Journal of Virtual Reality and Broadcasting. (Reviews: N. Carbonell).
- New Generation Computing. (Reviews: N. Carbonell).

7.1.2. Conference Programme Committees

- HCII'07, Human-Computer Interactions International Conference, July 22-27, Bejing, China. (Programme Committee Members, N. Carbonell, D. L. Scapin)
- WWCS'07, Working With Computer Computers Conference, May 21-24, Stockholm, Sweden. (Programme Committee Member, D. L. Scapin)
- TICA 2007 1st Intl. conference on Technologies of Information and Communication and Accessibility, 12-14 April 2007, Hammamet, Tunisie. (Programme Committee Member, D. L. Scapin)

- 6th International workshop on TAsk MOdels and DIAgrams (TAMODIA'2007) Toulouse, November 8-9, 2007. (Programme Committee Member, D. L. Scapin)
- IWIPS2007, 9th International Workshop on Internationalisation of Products and Systems, June 28-30, Merida, Mexico. (Programme Committee Member, D. L. Scapin)
- INTERACT2007, September 10-14, Rio de Janeiro, Brasil (Programme Committee Member: D. L. Scapin).
- ACM 9th International Conference on Computers and Accessibility (ASSETS 2007), Tempe, AZ, October 14-17, 2007. (Programme and Steering Committee Member, N. Carbonell)
- ACM 9th International Conference on Multimodal Interfaces (ICMI 2007), Nagoya, Japan, November 12-15, 2007. (Programme Committee Member, N. Carbonell)
- IADIS Multi Conference on Computer Science and Information Systems MCCIS 2007), Interfaces and Human-Computer Interaction (IHCI 2007), Amsterdam, Netherlands, July 25-27, 2007. (Programme Committee Member, N. Carbonell)
- 1st KES International Symposium on Agent and Multi-agent Systems - Technologies and Applications (KES-AMSTA 2007), Wroclaw, Poland, May 31 - June 1, 2007. (Programme Committee Co-Chair, N. Carbonell)
- 3rd yearly Usability Symposium of the WG HCI&UE of the Austrian Computer Society (USAB 2007), Graz, Austria, November 22nd, 2007. (Programme Committee Member, N. Carbonell)
- Invited Session on Recommender Agents and Adaptive Web-based Systems (RAAWS 2007), at 11th International Conference on Knowledge-Based and Intelligent Information and Engineering Systems (KES 2007), Vietri sul Mare, Italy, September 12-14, 2007. (Programme Committee Member, N. Carbonell)
- 3rd International Workshop on E-learning and Mobile Learning on Telecommunications (ELETE 2007), at the 3rd Advanced International Conference on Telecommunications (AICT 2007), Mauritius, May 13-19, 2007. (Programme Committee Member, N. Carbonell)
- Workshop on Usability of User Interfaces from Monomodal to Multimodal, at 21st British HCI Group Annual Conference, September 3-7, 2007, Lancaster, UK. (Programme Committee Member, N. Carbonell)
- 20th ACM Symposium on User Interface Software and Technology (UIST 2007), Newport, RI, USA, October 7-10, 2007. (Reviews, N. Carbonell)
- IHM'07, Conférence Francophone sur l'Interaction Homme-Machine, Paris, France, November 13-15, 2007 (Programme Committee Member, D. L. Scapin; Meta-reviewer, D. L. Scapin)

7.1.3. Others

- Advisory Board of the LEA "The Universal Access Handbook", (Members, N. Carbonell, D. L. Scapin)
- Participation to a scientific TV programme (FR3, "Heureux qui communique") on gaze interaction research and applications. (J. Simonin, O. Christmann, N. Carbonell)
- Participation to a scientific exhibit and joined conference series, "L'émoi de l'Image", Nancy, October 2007. (O. Christmann, J. Simonin)

7.1.4. Ph.Ds and Habilitations examining boards

- Hoai Minh Le (2007). Modélisation et optimisation non convexe basées sur la programmation DC et DCA pour la résolution de certaines classes de problèmes en fouille de données et cryptologie. Thèse de l'Université Paul Verlaine, spécialité Informatique, Metz, 24 octobre 2007, N. Carbonell examinateur.

- Meriam Horchani, Vers une communication humain-machine naturelle : stratégies de dialogue et de présentation multimodales. Thèse de l'Université Joseph Fourier, spécialité Informatique, Grenoble, 17 décembre 2007, N. Carbonell examinateur.

7.2. Teaching

- Master Informatique, Universités de Nancy, M1, U.E. d'ossature "Modèles de perception et raisonnement": N. Carbonell (24h).
- Master Informatique, Universités de Nancy, M1, U.E. de différenciation "Conception et évaluation d'interfaces utilisateur": N. Carbonell (30h).
- Master Informatique, Universités de Nancy, M2, spécialité à finalité recherche "Perception, Raisonnement, Interactions Multimodales", U.E. de différenciation "Modélisation de l'utilisateur et flexibilité des interfaces" N. Carbonell (15h).
- Master Information et Communication, Université Nancy 2, spécialité à finalité professionnelle "Information Scientifique et Technique et Intelligence Economique", UE d'ossature "Informatique générale": N. Carbonell (20h).
- Master Informatique, Universités de Nancy, Responsabilité de la spécialité recherche "Perception, Raisonnement, Interactions Multimodales": N. Carbonell.
- Master Informatique, Universités de Nancy, Membre de l'Equipe de formation du Master et membre permanent du jury de soutenance des stages (M2) pour les 4 spécialités recherche : N. Carbonell.
- Master Information et Communication, Université Nancy 2, Co-responsabilité de la spécialité à finalité professionnelle "Information Scientifique et Technique et Intelligence Economique": N. Carbonell.

7.3. Participation to conferences, workshop, invited talks

- MAUSE (COST Action 294: Towards the Maturation of Information Technology Usability Evaluation) Workshop, Athens *Review, Report and Refine Usability Evaluation Methods (R^3 UEMs)* COST294-MAUSE 3rd International Workshop, Athens, March 5 (D. L. Scapin)
- 6th International workshop on TAsk MOdels and DIAgrams (TAMODIA'2007) Toulouse, November 8-9, 2007 (S. Charfi, S. Caffiau)
- 1st KES International Symposium on Agent and Multi-agent Systems - Technologies and Applications (KES-AMSTA 2007), Wroclaw, Poland, May 31 - June 1, 2007. (N. Carbonell)
- 12th International Conference on Human-Computer Interaction (HCI International 2007), Beijing, China, July 22-27, 2007. (D. Gepner)
- 14th European Conference on Eye Movements (ECEM 2007), Postdam, Germany, August 19-23, 2007. (M. Divjak)
- ACM 9th International Conference on Computers and Accessibility (ASSETS 2007), Tempe, AZ, October 14-17, 2007. (N. Carbonell)
- Meeting of the Scientific Committee of the Centre Virtuel de la Connaissance sur l'Europe (CVCE), May 11, 2007 (N. Carbonell)
- IHM'07, Conférence Francophone sur l'Interaction Homme-Machine, Paris, France, November 13-15, 2007 (D. L. Scapin, S. Charfi, S. Caffiau, O. Christmann, D. Gepner, J. Simonin)
- Deuxièmes Journées de l'Association française de Réalité virtuelle, Marseille, 25-26 Octobre 2007. (O. Christmann, D. Gepner, J. Simonin)

8. Bibliography

Major publications by the team in recent years

[1] 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", Eyrolles, 2005.

[2] M. BARON, V. LUCQUIAUD, D. AUTARD, D. L. SCAPIN. *K-MADe : un environnement pour le noyau du modèle de description de l'activité*, in "Actes 18ème Conférence Francophone sur l'Interaction Homme-Machine (IHM), Montréal, Canada", April 18-21, 2006.

[3] T. BLANC-BRUDE, D. L. SCAPIN. *What do people recall about their documents? Implications for desktop search tools*, in "IUI (10th Intelligent User Interfaces Conference), Honololu, HI, USA", pp. 102-111, January 28-31 2007.

[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), Amsterdam: IOS Press, September, 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(3), 2003, p. 265-279.

[6] N. CARBONELL. *Recommendations for the design of usable multimodal command languages*, in "Universal Access in the Information Society Int. Journal (UAIS), Special issue "Multimodality, a step towards universal access",", vol. 2/2, 2003, p. 143-159.

[7] N. CARBONELL, S. KIEFFER. *Do oral messages help visual search?*, in "Advances in Natural Multimodal Dialogue Systems", J. VAN KUPPEVELT, L. DYBKJAER, N. BERNSEN (editors), vol. Vol. 30, Dordrecht (NL): Springer, "Text, Speech and Language Technology" Series, 2005, p. 131-157.

[8] O. CHRISTMANN, N. CARBONELL. *Browsing through 3D representations of unstructured picture collections: an empirical study*, in "Proceedings ACM Working Conference on Advanced Visual Interfaces, Venezia, Italy", pp. 445-448, A. Celentano, P. Mussio (Eds.), May 23-26, 2006.

[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 Conference on Working With Display Units", L. BERLINGUET, D. BERTHELETTE (editors), Amsterdam, The Netherlands : Elsevier, 1990, p. 371-380.

[11] D. L. SCAPIN. *Exigences ergonomiques, méthodes, et normes pour la conception de Systèmes d'Information centrés humain*, Vuibert, 2007.

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

[13] J. SIMONIN, N. CARBONELL. *Interfaces Adaptive -Adaptation dynamique à l'utilisateur courant*, in "Interfaces numériques", I. Saleh, D. Regottaz (Eds.), Paris: Hermès-Lavoisier, 2007, 16.

[14] J. SIMONIN, S. KIEFFER, N. CARBONELL. *Effects of display layout on gaze activity during visual search*, in "Proceedings of 10th IFIP TC13 International Conference on Human-Computer Interaction (INTERACT'05), LNCS Series num: 3585, Rome, Italy", M.-F. COSTABILE, F. PATERNO (editors), Springer, September 12-16, 2005, p. 1054-1058.

Year Publications

Books and Monographs

[15] D. L. SCAPIN, E. LAI-CHONG LAW (editors). *Review, Report and Refine Usability Evaluation Methods (R^3UEMs)*, COST294-MAUSE 3rd International Workshop, Athens, Greece, March 5, 2007.

[16] D. L. SCAPIN. *Exigences ergonomiques, méthodes, et normes pour la conception de Systèmes d'Information centrés humain*, Vuibert, 2007.

Doctoral dissertations and Habilitation theses

[17] J. SIMONIN. *Aide en ligne adaptative et assistants conversationnels animés : mise en oeuvre et évaluation ergonomique*, Ph. D. Thesis, Université Henri Poincaré, Nancy, October 2007.

Articles in refereed journals and book chapters

[18] Y. AÏT-AMEUR, M. BARON, N. KAMEL. *Encoding a process algebra using the Event B Method. Application to the validation of user interfaces*, in "Software Tools for Technology Transfer Special Section", Accepted, 2006.

[19] T. BLANC-BRUDE, D. L. SCAPIN. *Etude de la mémoire des documents chez l'utilisateur pour la conception de systèmes d'aide à leur récupération*, in "Revue d'Interaction Homme-Machine (RIHM)", In print, 2007.

[20] N. CARBONELL. *Contributions of "ambient" multimodality to Universal Access*, in "The Universal Access handbook", C. STEPHANIDIS (editor), Human Factors and Ergonomics, 35 pages, to appear, Lawrence Erlbaum Associates, Inc. (LEA), 2007.

[21] S. KIEFFER, N. CARBONELL. *How really effective are multimodal hints in enhancing visual target spotting? Some evidence from a usability study.*, in "International Journal on Multimodal User Interfaces (JMUI)", vol. 1(1): 1-5, 2007.

Publications in Conferences and Workshops

[22] T. BLANC-BRUDE, D. L. SCAPIN. *What do people recall about their documents? Implications for desktop search tools*, in "IUI (10th Intelligent User Interfaces Conference), Honolulu, HI, USA", pp. 102-111, January 28-31 2007.

[23] S. CAFFIAU. *Conception du dialogue d'une application interactive*, in "Rencontres Doctorales-IHM07, Paris, France", November 13-16, 2007.

[24] S. CAFFIAU, P. GIRARD, D. L. SCAPIN. *Generating Interactive Applications from Task Models: a Hard Challenge*, in "6th International Workshop on TAsk MOdels and DIAgrams, TAMODIA, Toulouse, France", TAsk MOdels and DIAgrams (TAMODIA), November 07-09, 2007.

[25] S. CHARFI, E. DUBOIS, R. BASTIDE. *Articulating Interaction and Task Models for the Design of Advanced Interactive Systems*, in "TAMODIA'07, Toulouse, France", November 07-09, 2007.

[26] M. DIVJAK, N. CARBONELL. *Analysis of realistic speech and gaze interactions inside a VR environment*, in "14th European Conference on Eye Movements (ECEM 2007), Postdam, Germany", Poster, August 19-23, 2007.

[27] D. GEPNER, J. SIMONIN, N. CARBONELL. *Gaze as a supplementary modality for interacting with ambient intelligence environments*, in "Proceedings of 12th International Conference on Human-Computer Interaction (HCI International), Beijing, China", C. STEPHANIDIS (editor), Universal Access to Ambient Interaction. LNCS-LNAI Series n° 4555, Springer-Verlag, July 22-27 2007, p. 848-857.

[28] L. TODESCHINI, D. L. SCAPIN. *De l'intérêt de la certification en ergonomie et des pistes sur son contenu*, in "42ième Congrès de la Société d'Ergonomie de Langue Française, SELF, Saint-Malo, France", Congrès de la SELF, Septembre 05-07, 2007.

Internal Reports

[29] F. VALDENAIRE. *Modulation de la précision de l'affichage en fonction de la direction du regard*, 23 pp., Mémoire de stage de recherche, Septembre 2007.

Miscellaneous

[30] AFNOR. *AFNOR. PROJET DE CERTIFICATION EN ERGONOMIE, "Processus de conception centré sur l'opérateur humain", Matrice de référentiel (version 07-2007). Groupe de travail "certification et ergonomie " de la commission de normalisation AFNOR-X35A*.

[31] C. BACH, D. L. SCAPIN. *Comparing Inspection with/without Ergonomic Criteria and User Testing in the evaluation of Virtual Environments*, Submitted for publication, 2007, 2007.

References in notes

[32] B. B. BEDERSON. *PhotoMesa: A Zommable Image Browser Using Quantum Treemaps and Bubblemaps*, in "CHI Letters", n^{o} 3(2), 2001, p. 71-80.

[33] M. DORR, T. MARTINETZ, K. GEGENFURTNER, E. BARTH. *Guidance of Eye Movements on a Gaze-Contingent Display*, in "Proceedings of the 5th Workshop on Dynamic Perception, Tübingen, Germany", H. BÜLTHOFF, H. MALLOT (editors), IOS Press, November 18-19, 2004, p. 89-94.

[34] A. T. DUCHOWSKI. *Eye Tracking Methodology: Theory and Practice*, 250 p., Springer, 2003.

[35] T. GRINDINGER. *Eye Movement Analysis and Prediction with the Kalman Filter*, 19 p., Master thesis (Advisor: A. T. Duchowski), Clemson University, SC, 2006.

[36] A. JAMESON. *Adaptive Interfaces and Agents*, in "The human-computer interaction handbook: Fundamentals, evolving technologies and emerging applications", J. JACKO, A. S. SEARS (editors), Mahwah, NJ: Lawrence Erlbaum, 2003, p. 305-330.

[37] G. ROBERTSON, M. CZERWINSKI, K. LARSON, D. C. ROBBINS, D. THIEL, M. VAN DANTZICH. *Data mountain: Using Spatial Memory for Document Management*, in "Proceedings of 11th ACM Annual Symposium on User Interface Software and Technology (UIST'98), San Francisco, CA", New York: ACM Press, November 1-4 1998, p. 153-162.

[38] D. L. SCAPIN, J. M. C. BASTIEN. *Ergonomic criteria for evaluating the ergonomic quality of interactive systems*, in "Behaviour and Information Technology", vol. 16, n^{o} 4–5, 1997, p. 220-231.