3.6 USER INTERFACE DESIGN ASSISTANT

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Empirical surveys have shown that an average of 48% of the code in new business applications with graphical user interfaces (GUIs) is devoted to the user interface portion (Myers & Rosson 1992). Of the user interfaces of new applications, 74% were implemented using a tool kit, an interface builder, or a user interface management system (UIMS), and 26% were implemented using no tools. These results show that most software development projects spend significant time and resources on designing and programming the user interface and that most projects are using user interface development tools. The use of such tools does not guarantee GUIs of high ergonomic quality.

To reach GUIs of high ergonomic quality standards (e.g., ISO 9241; EN 29241), style guides (e.g., IBM, 1992; OSF, 1992; Microsoft, 1992) and guidelines (e.g., Mayhew, 1992) based on human factors knowledge have been developed. The volume of available standards, style guides, and design guides is enormous. Closely related to this circumstance is the fact, that today user interface designers need more and more competence, knowledge, and experience to handle this enormous amount of information. For many user interface designers this means that the execution of their jobs requires taking into account far more information than they can possibly keep in mind or apply. Empirical results have shown that most of the software designers have no or only very limited knowledge about human factors (Molich & Nielsen, 1990; Beimel et al., 1992). Therefore most of them were not able to apply standards, style guides, or guidelines in the design process, even though they have information or get information about their existence. In Beimel et al. (1992), designers were asked what kind of support they prefer to overcome their lack of human factors expert knowledge. A large number of them said that they would prefer computer-based design aids that should be integrated in their development tools.

However, the problem is how to capture and encode design knowledge relevant to the designers' tasks and how to present it to them in formats that support their mode of work. The result is a need for user interface development tools with domain competence based on human factors knowledge (e.g., standards, style guides, design guides), which may be encountered, learned, practised, and extended during ongoing use—in other words, tools

in which users learn on demand (Eisenberg & Fischer, 1993). An important research goal in the area of user interface development tools is therefore to discover helpful, unobtrusive, structured, and organized ways to integrate the use of principles, guidelines, standards, style guides, and design rules into the tools without stifling creativity (Hartson & Boehm-Davis, 1993). These research issues should include methods and tools for offering the designer assistance in understanding, searching, and applying design principles, guidelines, and standards. This leads to the questions, what is the best presentation format for communicating user interface design knowledge, and how could we ensure that it will be observed?

Design Aid Tools for Communicating User Interface Design Knowledge

The development of design aid tools for offering the user interface designer assistance in understanding, searching and applying ergonomic design knowledge was the starting point for the GMD project IDA (User Interface Design Assistant) (Reiterer, 1993, 1994). The primary goal of this project is to incorporate domain competence in user interface development tools to empower the user interface designers. This means the development tools and the designers are bringing complementary strengths and weaknesses to the job. Rather than communicating with tools, the designers should perceive the use of the development tools as communication with an application domain (Fischer & Lemke, 1988). To shape the tools into a truly usable and useful medium, the tools should let the designers work directly on their problems and their tasks. The following design aid tools assisting the designers of GUIs during the design process have been developed in the IDA project:

- A library of reusable ergonomic interface software (construction tool).
- An adviser for ergonomic design support (advice tool).
- A tool evaluating the ergonomic quality of GUIs (quality assurance tool).

All design aid tools are integrated in a user interface management system (UIMS). The integration of the design aid tools into the UIMS is important. Separate systems for construction and enabling have major deficiencies. If the argumentation of the enabling system is to serve design, it must do so by informing construction. This can happen only if construction, argumentation, and evaluation are explicitly linked in an integrated design environment.

Presentation of the Design Aid Tools

To present the different design aid tools to the designer in an integrated fashion, a control panel called IDA-Toolbar has been developed, which is permanently placed on the screen. Figure 3.31 shows the IDA control panel placed over the UIMS and a small example of a GUI, which is shown under the UIMS. The designer can communicate with the IDA design aid tools by the help of the control panel and its icons. If the designer wants some advice during the design of a GUI, he or she activates the relevant icon in the IDA control panel and gets a global or context-sensitive support through the selected design aid tool. A control program behind the IDA control panel controls the communication and the data flow between the UIMS and all the design aid tools. This control program defines a clear interface between the different UIMS and the design aid tools. The control program is also responsible for the coordination of the different design aid tools. All project results have been developed under Motif/UNIX and Windows/DOS.
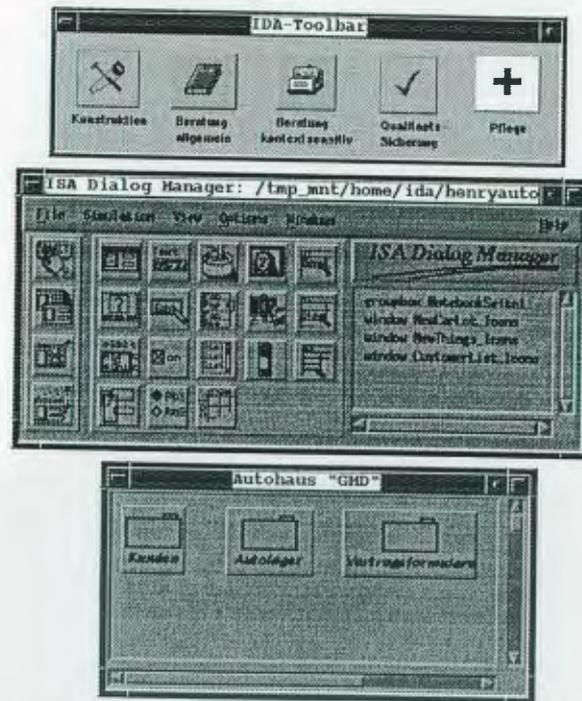

FIG. 3.31 Presentation of the IDA design aid tools.

An important requirement for the project was to develop prototypes of tool-independent design aid tools. In principle it should be possible to integrate the features of the design aid tools in each commercially available UIMS. Therefore different UIMS have been used as platforms for the integration of the design aid tools. It is the task of the manufacturers of the UIMS to integrate the features of the different design aid tools into their UIMS.

Support During the Construction of the User Interface

The IDA construction tool offers domain-oriented templates in a library, such as generic and domain-specific interface objects ("look") and dialogue scripts ("feel"). Based on object-oriented mechanisms of the UIMS, templates of generic and domain-oriented building blocks are constructed—under consideration of the relevant ergonomic standards, style guides and guidelines—and saved as object classes in the library. Using the library the designer generates an instance from each template. This instance will be integrated in the interface under design. Therefore designers construct interfaces by obtaining predefined templates from the library and placing them into the working area of the UIMS. Now the designer can modify the instance of the template, based on specific application requirements. This allows a "design by modification approach."

An important requirement for the usefulness of the library is the available information retrieval mechanism. Without powerful information retrieval features the designer won't be able to find any relevant template for the specific design situation. Different information retrieval mechanisms have been built in the construction tool to assist the designer during the search for relevant interaction objects. One information retrieval mechanism integrated in the IDA construction tool is a graphical browser, shown in Fig. 3.32.

The browser is based on a semantic tree, structuring the templates. This structure differentiates the templates from a designer's point of view and is based on typical tables of content that one can find in style guides or guidelines. The designer has the possibility to browse through the library by using the semantic tree structure to find a relevant interaction object or dialogue script. If the designer prefers an alphabetic presentation of the predefined templates, there is the possibility of changing to an alphabetic listing of all predefined templates of the library. The designer can now browse through the listing or can use a query function to find a template.
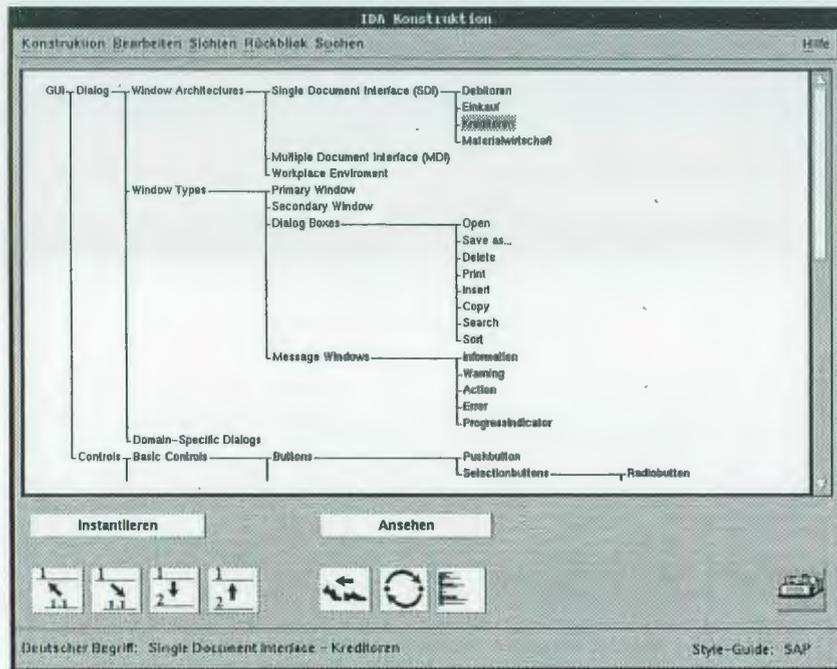
FIG. 3.32 IDA construction tool—graphical browser.

The query function is another information retrieval mechanism based on keywords (e.g., typical use of the templates, typical attributes of the templates, names of the templates) to search for a specific template. In a dialogue box, typical keywords are presented in a drop-down combination box to the designer, who can select one of the predefined keywords or use self-defined ones. The results of the search are shown as items in a list box. That allows a specific selection of templates.

If the designer wants to see the look and feel of a template before making a selection, he or she can start a simulation mode that shows the look and feel of the selected template. A visualization of the template, a list of all dialogue scripts attached to this template, and important attributes of the template are presented in separate windows. Figure 3.33 shows an example.

In the left window (entitled "<Arbeitsgebiet> <Operation>") the look and feel of a template for typical data entry purposes is shown. In the right window (entitled "Regeln – Funktionen – Attribute") the attached dialogue scripts, application functions, and important attributes are shown. The
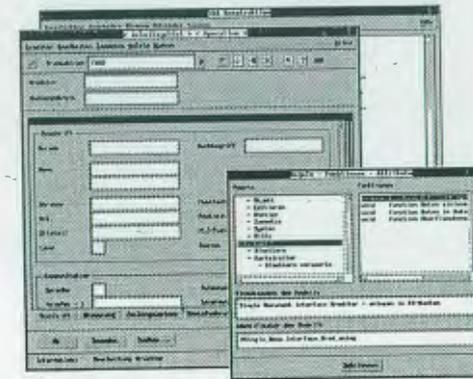
FIG. 3.33 IDA construction tool—look and feel of a template.

designer can now explore all important characteristics of the template, such as its look and feel, because the presented visualization can be used in the same way as the instance of the template. If the designer has found a template with the relevant look and feel, he or she can make a sample of the template. This sample will appear in the working area of the UIMS and can then be used in the construction process of the user interface. If the designer needs further information when and how to use a specific template, he or she can activate the context-sensitive advice tool with the help of the advice icon ▨ (see Fig. 3.32).

The IDA construction tool does not help designers to perceive the shortcomings of an interface they are constructing; it includes only passive representatives. Constructions of user interfaces in the work area of the UIMS do not talk back unless the designer has the skill and experience to form new appreciations and understandings when constructing. Designers who are unaware of human factors knowledge about user interface design do not perceive a breakdown if one of the design guidelines is violated. To support designers in this situation, two other design aid tools were developed in the IDA project.

Advice During the Design Process of the User Interface

The IDA advice tool assists the designer during the design of the user interface. If the designer needs support in the area of ergonomic user interface design, there is global or context-sensitive advice through activating the advice tool. The aim of the advice system is to determine an analogy between

the examples of the adviser and the current task of the designer. The designers are aided in building an analogy by assuming that the presented example or information is relevant to their current task. If the designer wants deeper information—for example, why the "look" and "feel" of a specific interaction object should be designed in a certain way—the designer gets it in a form of a hypertext advise based on multimedia documents that are developed with the help of multimedia tools.

An important aspect in multimedia systems is the navigation support to prevent users from getting "lost in hyperspace." Therefore different powerful navigation mechanisms have been integrated in the advice tool. A graphical browser, an index, and a text query function are available as global navigation tools. The graphical browser is based on the same structure as the browser of the construction tool and structures the design knowledge in different sections. With the help of this browser the designer can browse through all sections of the advice tool searching for an interesting topic. The index and the text query function allow direct access to interesting topics.

A different concept to present design knowledge in a global way is the guided tour of user interface design. The purpose of this guided tour is to explain how graphical user interfaces should be designed considering human factors. Figure 3.34 shows the start window of the guided tour. Based on an object-oriented GUI development life cycle—consisting of six steps—all necessary design activities are described.
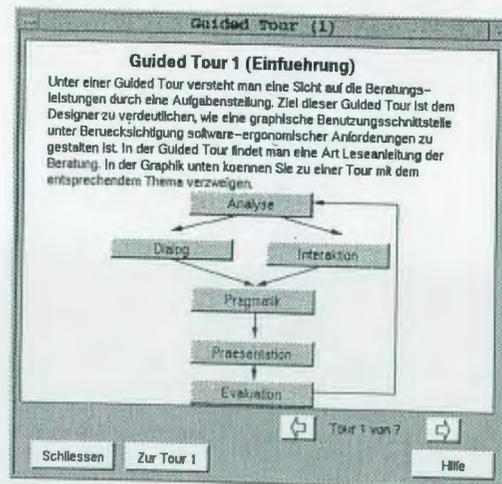

FIG. 3.34 IDA advice tool—guided tour of user interface design.

For each development step a predefined sequence of sections that the designer should follow is established. If the designer goes through all six development steps; he or she will have visited all sections of the global advice. This form of presentation allows a guided use of the advice tool and is useful for the novice designer in the area of GUI design.

Activating the context-sensitive advice, the designer gets some information on when and how to use the selected interaction object in the UIMS and what should be the ergonomic "look" and "feel" of this interaction object. The selected object could be a generic interaction object (e.g., push button, list box, edit text), a sample of a template, or a part of a complex dialogue object. The necessary context information is transferred from the UIMS to the advice tool to select the relevant section of the multimedia advice system. After activating the advice tool the designer gets a short definition of important features of the selected interaction object. Figure 3.35 shows a typical example of a multimedia document. Each document includes different navigation controls (menu items, icons, push buttons, hot spots), which allow a differentiated presentation of knowledge.

If the designer wants a detailed presentation of all relevant design guidelines for this interaction object, it is possible to open a follow-up window with the help of the push button "Richtlinien" (see Fig. 3.35). Figure 3.36 shows the related guideline window of Fig. 3.35. It offers in a textual and graphical form an explanation of all important guidelines that have to be considered in using or designing this interaction object. Different colors are used to distinguish the different sources of guidelines (e.g., style guide, standard, literature). The guideline text on the right side will appear after clicking in the graphical example on the left side. Depending on the selected area, the relevant guidelines appear.

If the designer needs further information on when and how to use an interaction object, there is specific support with the help of the push-button "Anwendung" (see Fig. 3.35). In a new window a question and answer dialogue appears. Depending on the answers, the designer gets recommendations about the use of available interaction objects and templates. In the main window of the advice tool the recommended interaction object or templates are shown.

For some interaction objects an animated presentation of its use is available. The designer could activate the animation with the help of the push button "Animation" (see Fig. 3.35) getting an explanation of the use and the behavior of the interaction object. The animation is developed as a small movie
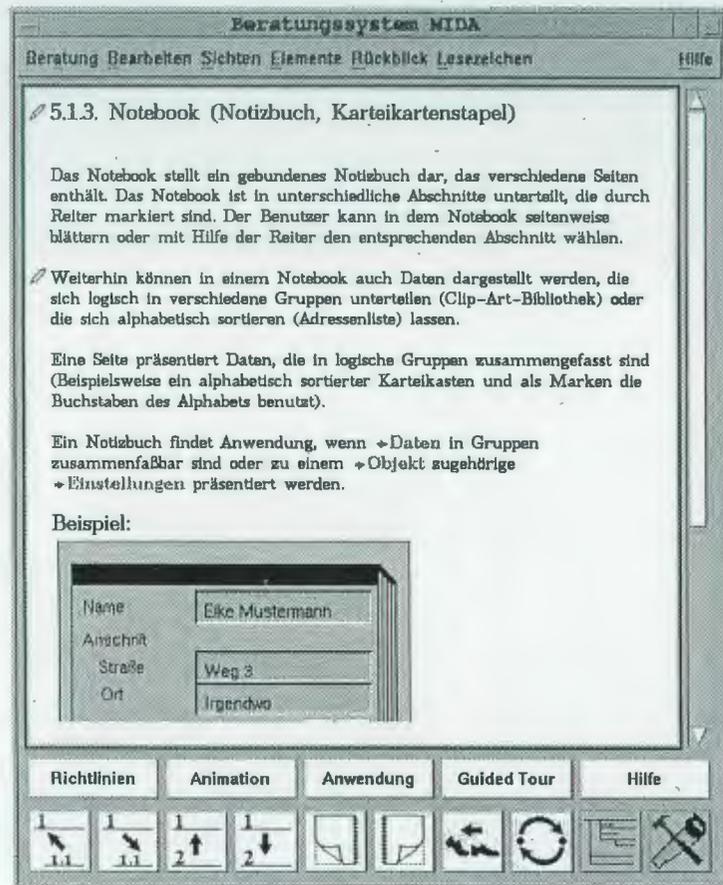
FIG. 3.35 IDA advice tool—definition.

that can be played, stopped, rewound, and so on, using a video player control panel.

Whenever a relevant template in the library of the IDA construction tool is available, the designer can retrieve it from the multimedia documents activating the construction icon ⚒ (see Fig. 3.35). The instance of this template is automatically placed in the working area of the UIMS. Thus the designer always has the possibility of switching between the advice and the construction tool, which gives a maximum of flexibility in using the design aid tools.
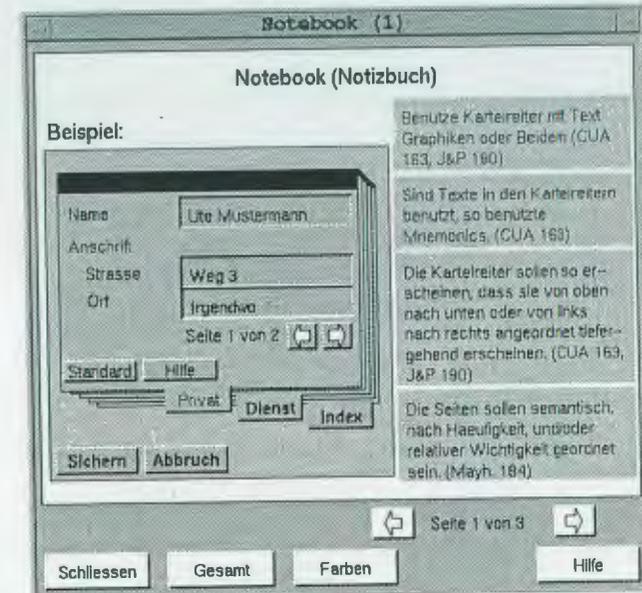
FIG. 3.36 IDA advice tool—guidelines.

Quality Control of the User Interface Design Results

The IDA quality assurance tool identifies potential problems in the artifact being designed. It detects and critiques partial solutions constructed by the designer. These critiques are based on human factors knowledge and design principles for user interface design. It is a form of performance critics whose prime objective is to help users create high-quality products in the least amount of time using as few resources as possible (Fischer et al., 1991). Learning is not the primary concern of the performance critic but may occur as a by-product of the interactions between users and critics. With the help of an expert system the knowledge is implemented in a knowledge base as interface objects and condition–action rules, which are tested whenever the designer asks for a quality control. A very similar approach is found in Löwgren and Nordquist (1992).

The passive quality assurance (critique) is explicitly invoked by the designer when desiring an evaluation. The result of the current design process is saved in a tool-dependent dialogue definition language (DDL) file of the UIMS. With the help of a parser this DDL file is translated in a tool-independent

DDL file. The expert system of the IDA quality assurance tool uses this file as input and represents the result of the dialogue design with the help of an object tree. Using the rules of the knowledge base and controlled by an inference mechanism the expert system analyses the conformance of the user interface with the human factors knowledge (analytic critique).This passive form of quality assurance usually evaluates the (partial) product of the design process, not the individual user actions that resulted in the product.

The results of the analytic critiquing process are presented in a special window shown in Fig. 3.37. The window of the explanation component contains a short description of all discovered ergonomic deficiencies (heading "ergonomische Abweichungen"), the source of the short description (heading "Quelle der Regel"), and the identifier of the evaluated object (heading "Instanz des Designs"), which contains some ergonomic deficiencies. Now the designer has different possibilities to continue the work. The designer who needs further explanation of the comments can activate the IDA advice tool with the help of the advice icon 🔲. If a specific template is available, the designer can activate the IDA construction tool with the help of the construction icon 🔲. If the designer selects the identifier of an object, he or she can activate the object editor of the UIMS (double-clicking the identifier) and can reimplement the interaction object that contains some ergonomic defi-
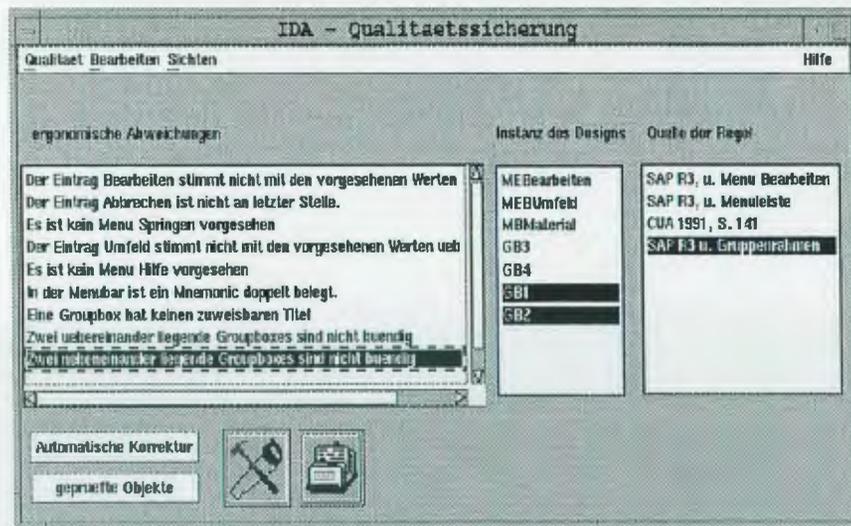

FIG. 3.37 IDA quality assurance tool—window showing ergonomic deficiencies.

FIG. 3.38 IDA quality assurance—dialogue box for automatic correction.

ciencies. In some situations it is possible to change the detected deficiencies automatically. In this case the designer can activate a separate dialogue box (activating the button "Automatische Korrektur"), which gives the opportunity to correct the deficiency. Figure 3.38 shows an example of such a dialogue box that presents a faulty mnemonic of a menu item (labeled "Gefundene Daten") and the necessary correction (labeled "Geforderte Daten"). The benefit for the designer is in not having to branch into the editor of the UIMS reimplementing the mnemonic of the menu item.

The set of currently implemented rules covers different groups. The first group of rules represents user interface design principles of controls (e.g., list box, drop-down list, push-button, group box, entry field, check box, radio button). The second group of rules checks the content and structure of menus (e.g., menu bar, pop-up menu, pull-down menu, cascaded menu, mnemonics, short-cut keys). The third group of rules checks the general layout of a window (e.g., title, placement of group boxes, placement of push-buttons) and the layout of specific dialogue boxes (e.g., warning message, open dialogue, save as dialogue). The content of the actual rules is restricted to more static aspects of a GUI. It is intended to extend the rule base with rules that also covers the more dynamic aspects of a GUI (e.g., typical dialogue sequences) and with rules that represent application domain-specific knowledge (e.g., attachment of database functions to interface objects).

Conclusion and Outlook

Based on cooperations with scientific (Fachhochschule Darmstadt; University of Bonn) and industrial partners (Software AG, Darmstadt; SAP AG,

Walldorf; Hoechst AG, Frankfurt), prototypes of all design aid tools have been developed and connected with a commercial UIMS (ISA-Dialog Manager from ISA GmbH, Stuttgart). The usefulness and usability of these prototypes will now be evaluated from UI designers in the realistic context of their application domains. The following benefits for the designer using the UIDE are expected and will be evaluated:

- Designers will be able to learn human factors knowledge during their daily work using their development tool ("learning and use on demand").

- Designers will be enabled to apply ergonomic style guides and guidelines ("usability").

- Designers will be able to use predefined ergonomic interaction objects ("reusability").

- Designers will be able to evaluate the ergonomic quality of their design during the design process ("quality assurance").

All results of the evaluation process will be considered in the ongoing development process of the design aid tools to improve them.

A further intention of the ongoing development process is to build a specific design aid tool supporting the design decision process. With the help of such a tool the rationale for the various user interface design decisions can be made explicit and recorded for later reference. Having access to an audit trail through the design rationale is important during iterative development. Because changes to the interface will often have to be made, it is helpful to know the reasons underlying the original design. Design rationales can be captured in a hypertext structure or with the help of video records of design meetings and selected user tests. It is planned to extend the IDA advice tool with special features for capturing design rationales based on a special repository including hypertext documents and videos.

Acknowledgment