Multi-Layered Design
– Theoretical Framework and the Method in Practise

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Abstract

Multi-Layered Design (Ben Shneiderman) is a way to adapt applications to multiple user categories with different knowledge and skills. The application is divided into layers which could be activated one by one. Each layer holds a set of functionality. When the users have gained confidence and learned the first layer they can progress to layers with more task functionality. We are conducting a study at the Clinic of Oral Medicine at Sahlgrenska University hospital in Gothenburg, Sweden. The user group is heterogeneous and there are many different needs. The environmental context is also affecting the productivity within the applications used. The design of the interfaces should be adapted to the various types of users at hand. Multi-Layered Design has therefore been tested for a new application, MedImager, within the MedView project. In this paper the theoretical framework of the Multi-Layered Design will be presented and the application in which the method is used. The user groups have been identified and a prototype has been produced. We are also presenting the work towards a general work process for identification of the layers in the Multi-Layered Design. Future work and plans for Multi-Layered Design will be outlined.

Keywords: Multi-Layered Design, User Centred Design, Case Study, and Work Process.

1. Introduction

When a new system is designed it is very common that the interface design and interaction are designed last when the functionality is already completed. The importance of the users and the contextual requirements should be in focus [2, 11] and they should be considered in an early stage of the development and design process, the earlier the better [5, 8]. But even if the users are involved early in the design of applications the developers have to consider that the involved users are not all users of the completed system. It is a common mistake that developers underestimate the variety of end-users [10]. They have to take into consideration the designing for a large group of users, all with different knowledge of computers and different needs of tasks; some are novices and some are more experienced [2]. It is then important to work by a structured method that considers the differences [2, 14]. The context in which the system is going to be used is also affecting the users' ability to work with the system. The design should therefore also consider contextual or environmental requirements [2].

Lately the Multi-Layered Design (MLD) has been proven to provide a viable alternative for a flexible and differentiated interface-design [7, 9, 12-13]. A Multi-Layered Design implies that the software is split into several layers to reduce complexity where each layer offers one or more tasks. By adding more layers the possibilities of the application increase and the user can perform more difficult tasks. The users are given a possibility to use the application in an individual way by using MLD and they have the ability to evolve their learning curve.

In this study, we will present the background of MLD and how to use it in a practical case, where MLD is used for a user centered application for oral medicine. In the case we have an environment with complex tasks and a large amount of specific data, and a number of users with different knowledge. The users want to retrieve and sort the information in a better and more efficient way, but they also want a system that supports the differences and allows them to handle the system under stress. The contextual constraints are affecting the users and must therefore be designed for. We discover several difficulties when using MLD in practice and to solve the problems we are working with defining a process. The work towards a general work process to define the layer structure will be presented, largely following the work submitted to CHI2005 [4]. Finally future work in the project will be argued.

2. Background

"Designing for one class is easy; designing for several is much more difficult".

A quote by B. Schneiderman [13], to illustrate the difficulties of designing for many types of users. He categorizes users into three classes; Novice or first-time users, Knowledgeable intermittent users, and Expert frequent users. The first class of users is assumed to have only little knowledge about the interface concept and the functionality within, which should be considered in the design of dialogs, instructions and graphical objects. The second class of users has knowledge of interface concepts and the tasks they want to perform, they do not use the application frequently and therefore forget where to find and how to perform actions. They have difficulties with location of functionalities or alternatives in menus. The design should help this type of user by offering structure and interfaces that guide and encourage them to perform tasks as well as help them remember where to find functions. The last category has large knowledge about the interface concepts and the functionality; they want to perform their tasks quickly. For this type of user the information, dialogs and feedback should be minimal and fast. The interface should give alternative quick options like shortcut commands [13].

B. Shneiderman suggests the use of Multi-Layered Design to adapt the application to multiple user categories, the design method have lately been used in several studies [7, 9, 12-13]. The knowledge and skills of the users are focused in MLD and the users are given the possibility to develop their own learning curve. The application is divided into layers which could be opened one by one. Each layer holds a set of functionality and a certain amount of complexity. When the users have gained confidence and learned the first layer they can progress to layers with additional functionality. The application will then be more complex when new layers are opened. In a complex system, like an information system, the complexity could be then divided so that the user could learn gradually [13].

The learning plan in MLD is focused on the users' progress through tasks and functionality. New interface concepts are only introduced when they are needed to support more complex tasks. The learning process is individual and is divided into steps which the user can chous when to take. Some users will go through the different layers very quick and start at a high level and others will start at the first level and then slowly progress. For expert users a rapid progress is possible by giving them the possibility to start at the top level right from the beginning [13].

Figure 1 illustrates an example of a Multi-Layered Design where the application is split into six layers. In the first layer (upper left corner) there are only two graphical objects, the number of functionality is limited. The novice user will quite easily be able to get an overview of the functionality and the possibilities offered in the interface. As shown in figure 1 the interface will be more and more complex as the user progresses to layer number six. All functionalities from a previous layer will still be in the higher layers so the user will still have use for the knowledge gained in an earlier stage. In the example in figure one the layers are opened by a click in the toolbar were the numbers one to six are visible. This is only one way of opening layers, other methods can also be used [7].

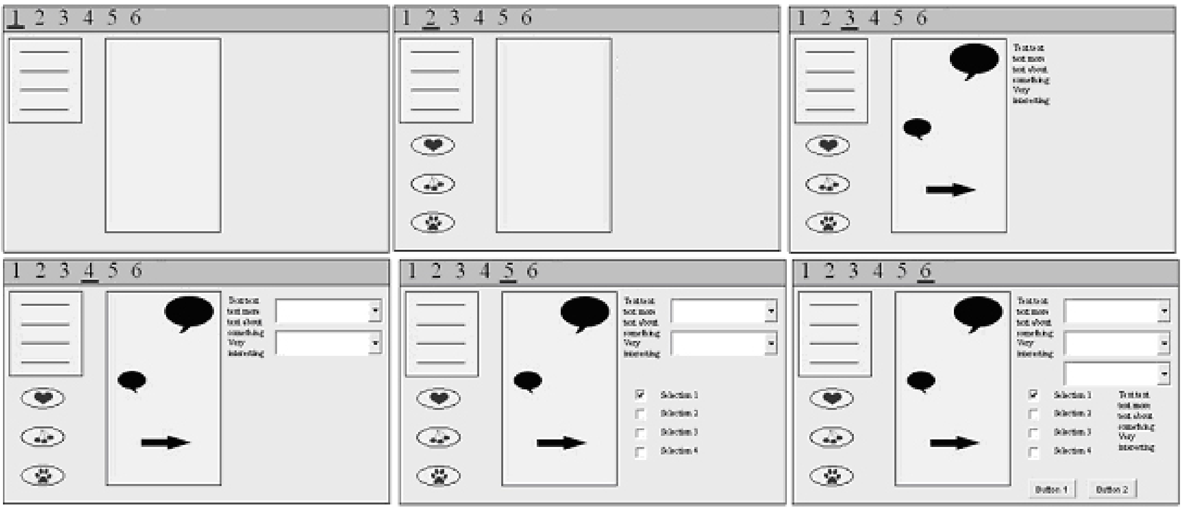


Figure 1. Six layers opened one by one with more functionality added in each layer [4].

3.1 Definition

It is necessary to define what constitutes a proper design layer and applications suitable for the MLD approach to be able to use the method in a more formal way. In this section definitions will be given to how we formally use the MLD [4].

A layer is in our definition a set of complexity, which could be functions, data, graphical components, security levels, or different levels of abstract information. The complexity increases when a user is adding or opening new layers in a structure. In our use of MLD there must always be at least two layers; one Novice Knowledge Layer (NKL) and one Full Knowledge Layer (FKL). The NKL holds only the minimum set of complexity a novice or first time user could easily understand and work with. The FKL holds full complexity adapted to fit the needs and skills of an expert or very frequent user. To use the user distinctions presented by B. Shneiderman [13], mentioned above when dividing the layers, one or several layers can be put in between the NKL and the FKL, there can be N-2 number of layers. N is decided based on the complexity of the application and the users working with it [4].

If the application only holds e.g. two layers, the MLD usually becomes ineffective, however. In a relatively extensive application the difference between the first and second layer is going to provide a too big change for the user and the novice users will have a hard time to adjust when they open the second layer. If the application is simple enough to support the beginner in his/her personal development and ability to learn with only two layers on the other hand MLD could be a limitation and a disturbance to the user. The method will then increase complexity instead of simplify it. A preferable solution for a simple application could then be to use another type of adaptive interface.

On the other hand N must be adjusted to fit the category of users working with the application and the purpose of the application. If the application does not have novice users there will be no use for layers based on novice knowledge. In this case the layers have to focus on different skilled expert users and support their work. The number of layers must therefore be adapted to the requirements of the users [4].

The greatest use of the method is in our definition applications with high complexity and large groups of heterogeneous users.

To be able to divide the application, N must be decided based on the users and the requirements. Each layer must then have a specific content. Next section will describe how the theory was put into practice.

3. The method in practise

In the practical implementation of MLD a case study is being performed at the Clinic of Oral Medicine at Sahlgrenska university hospital in Gothenburg, Sweden. The focus of the case study is to create a better system for handling images of the oral mucosa. By using MLD we want to create a more suited application adapted to the knowledge level at the clinic.

The case study performed is within the framework of the ongoing research project MedView and therefore affected by earlier results and the technical solutions already implemented. The study is performed in collaboration with users at the clinic, consisting of oral specialists, nurses and administrative personnel. The specialists at the clinic take digital photos of the patients' oral mucosa. The images are uploaded to the clinician's computer and attached to the patient's electronic record. Through the applications implemented within the MedView project the photos can be viewed by any clinician treating that patient. The problem is that these photos cannot be ordered, grouped, sorted or searched for in an efficient way. Today, all those actions have to be performed manually, which motivates the need for a new application.

To be able to select or create an appropriate image management tool, an interview session was performed to get a solid knowledge base. In the interview cognitive and environmental parameters were collected at the clinic. The information gathered can later be used as a first step in the general work process we have introduced and are about to test. The first step in the case study was then to create a MLD based prototype to test the method on. Continuously we will test and evaluate the prototype, make extensive user test on it and adapt it accordingly to the work process.

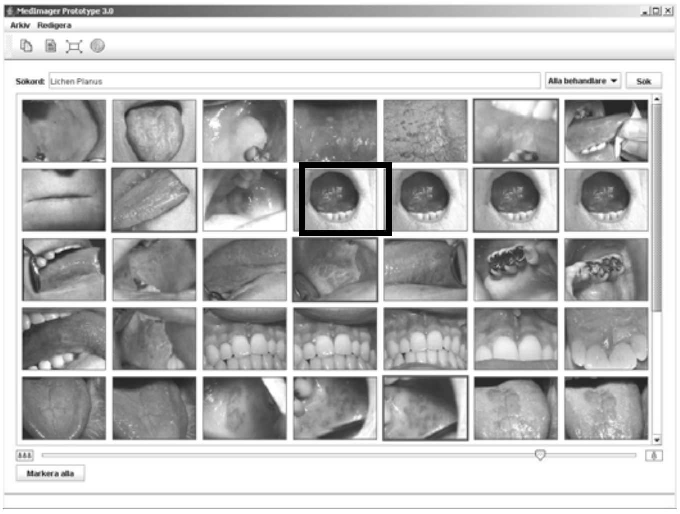
3.1 Background of case study

At the clinic an interaction design research project, called MedView [3], is in progress and have been for several years. Participants from both oral medicine and computer science are involved in MedView. The overall goal of the project is to develop models, methods, and tools to support clinicians in their daily work and research [3]. MedView is focused on identifying how information technology can be used to model and manage clinical knowledge, giving the clinicians opportunity to more systematically learn from the gathered clinical data. The project is working towards an understanding of how the chain of formalize-collect-view-analyze-learn should be used and implemented in the given area of clinical medicine [3, 1]. The results of the project so far is a number of applications, collecting, summarizing, sorting, presenting or making statistical comparisons of patient data.

Two examples of applications affecting the case study performed are MedRecords and MedSummary. In MedRecords the clinicians put in the information gathered from the patients. The application collects the patient data and creates files for the electronic patient record. MedSummary is gathering information from the files produced in MedRecords and creates different reports according to templates adjusted to different purposes given by the clinicians. The photos are added to the patient information in MedRecord and viewed in the reports in MedSummary. The information added in MedRecords will be a foundation to the search queries used in the new application to find and order photos of a certain type. The new application created with MLD must therefore be compatible with MedRecords and MedSummary [1].

3.2 The MLD Prototype

The resulting prototype, created during the first step of the case study, is designed with six layers, and based on the technology of the MedView project [1]. The prototype uses a Microsoft Windows metaphor since all the users at the clinic are familiar with Windows and work that operating system at the clinics computers. It uses the same data source for images and the records created by MedRecords and MedSummary (all patient data in this article is fabricated due to personal integrity) [7].



Sökord: Lichen Planus

Figure 2. The prototype with the first layer visible [7].

The first layer is presented in figure 2. In the interface there is only one toolbox with four buttons, a textbox for search strings and a panel where photos can be displayed. In the lower part of the panel there is a slider to give the user the opportunity to decide the visible size of the found photos. The slider uses the digital camera metaphor for zoom. The user can click on one or several images to mark them (the black rectangle in figure 2.) and then use one of the four buttons in the toolbox to perform an action on the marked image. The first button copies the marked image, the second opens the patient record associated with the image, the third gives a full-size version and the fourth button gives technical information about the image-file. By enlarging the image, it is possible to better see details in the photo. The patient record can give additional information about the diagnosed disease or syndrome visualized in the image.

The first layer can for example help the dentist to find images comparable with a current patient's diagnosis or to explain a syndrome or a diagnosis to a student. When preparing lecture notes the clinicians can use the first layer to find relevant images. The simplicity of the layer gives novice users the ability to work with images in an easy way. Novice users that have learned the first layer can continue to the second layer where they can store photos they found interesting so they can use them in lectures or research.

The second layer adds functionality to the first layer and is illustrated in figure 3. Advanced search is available in this new layer, where Boolean operators can be used to specify a more complicated search string. A new panel is also added in the right part of the first layer. In the panel the user can put interesting photos found in a search. The photos in visible in the panel has a description tag, the patient's

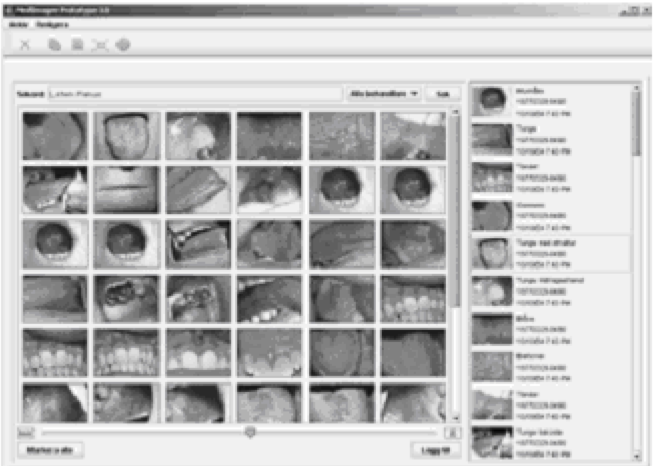
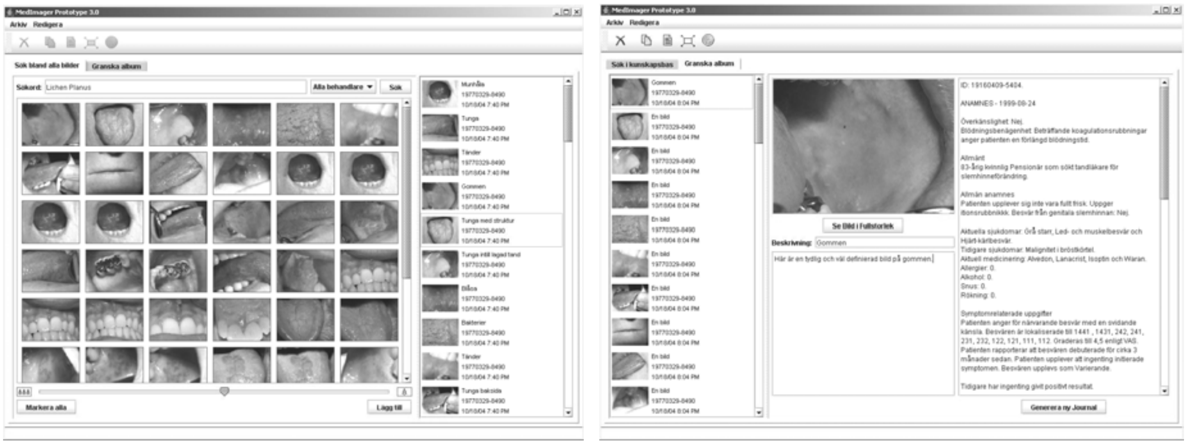


Figure 3. The second layer with an additional panel to save interesting photos in.

social security number and a date for when the photo was taken. The description can be altered by clicking at the letters in the description, similar to the functionality to change a file-name in Microsoft Windows. The photos will be saved as personal selected photos and can later be used in for example lecture notes. One button is added in the toolbox and it gives the user the ability to remove photos from the panel. The button is not available when photos are selected in the big panel to the left where search results are visible. The photos can thus not be deleted from the main database.

In figure 4 the next, third layer is presented. The interface is now split into two modes visualized through two tabs also using the Windows metaphor. The first tab (to the left in figure 4.) consists of the same functionality and graphical objects as in the first and the second layer. In the second tab (to the right in figure 4) the new panel from the first tab is still visible but the user can now add comments to the photos put into the panel. The user selects or marks a photo by clicking on it in the panel and the enlarged view of the photo will be visible in the middle of the screen. Comments can now be added or viewed and altered if there are old comments to the photo. The comments are written into the white textbox under the enlarged



Beskrivning: Gommen

Här är en tydlig och väl definierad bild på gommen.

ID: 19160409-5404.

ANAMNES - 1999-08-24

Överkänslighet: Nej.
Blödningsbenägenhet: Beträffande koagulationsrubbningar anger patienten en förlängd blödningstid.

Allmänt
83-årig kvinnlig Pensionär som sökt tandläkare för slemhinneförändring.

Allmän anamnes
Patienten upplever sig inte vara fullt frisk. Uppger ifbonsrubbnikkk. Besvär från genitala slemhinnan: Nej.

Aktuella sjukdomar: Grå starr, Led- och muskelbesvär och Hjärt-kärlbesvär.
Tidigare sjukdomar: Malignitet i bröstkörtel.
Aktuell medicinering: Alvedon, Lanacrist, Isoptin och Waran.
Allergier: 0.
Alkohol: 0.
Snus: 0.
Rökning: 0.

Symptomrelaterade uppgifter
Patienten anger för närvarande besvär med en svidande känsla. Besvären är lokaliserade till 1441 , 1431, 242, 241, 231, 232, 122, 121, 111, 112. Graderas till 4,5 enligt VAS. Patienten rapporterar att besvären debuterade för cirka 3 månader sedan. Patienten upplever att ingenting initierade symptomen. Besvären upplevs som Varierande.

Tidigare har ingenting givit positivt resultat.

Figure 4. The first and second tab with additional functionality.

photo. To the right the electronic patient record is visible. The patient record can not be altered from this application only viewed.

In this third layer the complexity is higher since the user has to handle two tabs but still easy enough so that a beginner that have worked through the first two layers can handle it. The graphical objects are new but the additional functionality is rather small. By this gradual extension of complexity the user can slowly progress with new tasks.

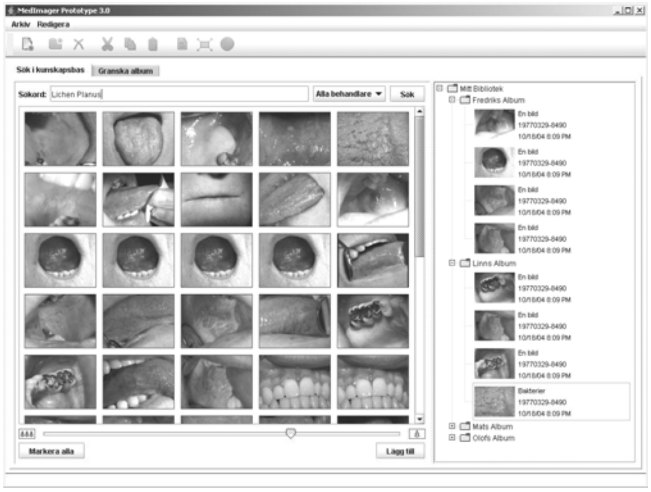
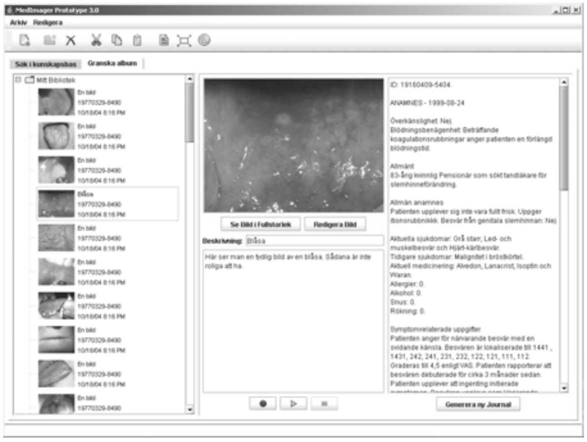


Figure 5. Layer number four with ability to create folders and arrange the photos into the folders and subfolders.

Layer number four is visible in figure 5. The functionality is now extended with the ability to create folders and organized the photos found and saved in the right panel. The folders and subfolders are arranged in a tree structure, which ads a new set of terms to the application. The user must create a personal mental model on how to sort the images into folders with intelligent names and order the tree structure. This increases the level of abstract understanding of the information structure necessary for the user to be able to work with or adjust to the tree structure. The names of the folders are set when creating the folder and can later be changed in the same way as the photo description in previous layer. The folders also use the Windows metaphor as well as the new buttons added in the toolbar. The new buttons added in the toolbox gives the user the ability to cut and past photos from one folder to another and create new folders in the tree structure. Depending on if a folder or a photo is marked the effect of the buttons will be slightly different. If a folder is marked and the delete buttons then is used both the folder and the photos will be deleted. Shortcuts for cut, paste and copy is available in this layer as well as ability to drag and drop. The mental workload has increased but the earlier knowledge is still useful in this layer, and the graphical structure is consistent.



Beskrivning: Blåsa

Här ser man en tydlig bild av en blåsa. Sådana är inte roliga att ha.

ID: 19160409-5404.

ANAMNES - 1999-08-24

Överkänslighet: Nej.
Blödningsbenägenhet: Beträffande koagulationsrubbningar anger patienten en förlängd blödningstid.

Allmänt
83-årig kvinnlig Pensionär som sökt tandläkare för slemhinneförändring.

Allmän anamnes
Patienten upplever sig inte vara fullt frisk. Uppger itonsrubbnikkk. Besvär från genitala slemhinnan: Nej.

Aktuella sjukdomar: Grå starr, Led- och muskelbesvär och Hjärt-kärlbesvär.
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Graderas till 4,5 enligt VAS. Patienten rapporterar att besvären debuterade för cirka 3 månader sedan.
Patienten upplever att ingenting initierade

Figure 6. Layer number five

In layer number five the user has the ability to dictate comments to the photos (see figure 6.). Three buttons are added on the second tab, where the user can record and listen to earlier recorded notes. The third button is to stop a recording or note being played. In this layer an additional button under the enlarged photo in the middle also give the user to ad markings like arrows or circles to the photo. The markings can be complementary to written or oral notes to pin-point the important details of the photo. The fifth layer can be used to create more advanced help for lecture notes or research data. The notes can also be an important tool in the daily work to increase the quality of the care provided by for example record thoughts of the clinician or the patient.

The last layer is visualized in figure 7. All functionality and full complexity is visible in this layer. Two new buttons are added in the toolbox and they give the user the ability to share personal folders or photos. The first button makes the photo shared with other clinicians within the local network and the second button shares the photo with other clinics via Internet. As shared objects in Windows the shared photo or folder in this application will be market with a little hand.

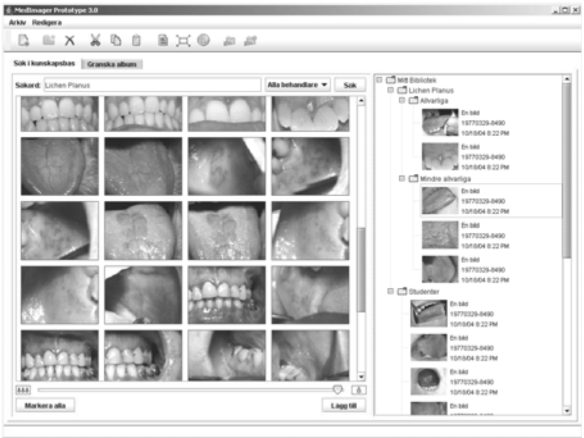

Figure 7. The last layer with full functionality.

The seven layers can be opened, one by one, depending on the tasks the knowledge level the user has. The functions gradually get more complex and the users then have the ability to perform more complicated tasks. A novice or first time user can start by using the program to find photos and then gradually learn how to handle folders and complementary notes. When all layers are visible the application has full capacity and full functionality but also full complexity. The expert user can go directly to the last layer the FKL. For the expert user the application also offer quick shortcuts like the use of drag and drop as well as short commands.

3.3 Experiences of the MLD in practice

Through the practical case study we experienced a number of difficulties on how to create the layered structure in a usable and effective way so that the users could benefit from this design approach. The first problem that occurred was how to study the users and the environment they are in to get an overview of the complex socio-technical system and the cognitive constraints within. Interviews were conducted to better understand the users and three days of observing the users gave us a better understanding of the environment. Next problem we encountered was how to prioritize the requirements and how to transform the knowledge about the users and the environment into layers. A summarizing report of the interview was put together to better see the requirements and a brainstorming session was then conducted within the development team to try to prioritize the requirements and create layers that would match. We found that the layered structured could be based on several parameters depending on how we prioritized. The structure could also be multi dimensional if the parameters where interlinked. For example could knowledge or skills be interlinked with work tasks where all the different work tasks could have their own set of layers based on the knowledge required for their tasks [7].

Another problem was how to combine the knowledge and the tasks; what functionality each layer should have. The requirements for functionality were looked over and combined with the cognitive and environmental constraints. In the prototype presented above we have tried to create a beneficial layer structure to fit both functionality and knowledge level. The MLD method is based on the knowledge and the skills of the users and how they can progress through tasks. But when designing an application the technical functionality also must be considered.

From talking to developers and users about the method and testing the method in practice we have come to an understanding that novice users seam to like the approach better then expert users. Many of the expert users do not se the reason for such a design. Therefore we have concluded that the expert users must not be forgotten when designing an application. The expert users must have a possibility to use the application in a fast and efficient way and be able to use advanced features like short commands or command prompts.

By using a general structured work process to define the parameters, on which the layered design could be based on, we believe that the usability and the development process could be improved. Many of the difficulties encountered during the practical case study could have been avoided if we have had a better work process to fallow. Next sections will go deeper into the work process suggested for MLD [4].

4. Theoretical framework

The primary criteria for effectiveness in a complex system are safety, productivity and health [15]. To fulfill the criteria the system design must consider cognitive characteristics, individual interaction, technical, social, psychological, environmental and organizational factors. These parameters could then be used as a foundation to define the optimal number of layers in an application. In order to achieve this, our suggested work process consists of three steps; Identification, Categorization, and Design Realization. Figure 8 shows the work flow of our process. In the identification step Work Analysis (WA) is used to identify the parameters needed to create an application behaving as intended. WA is a formative model focused on requirements needed to make a system behave in a desired way [15]. The categorization of the resulting parameters from WA is performed by a modified approach of the method of Kujala and Kauppinen that presents five steps on how to select and divide [10]. A definition of the number of layers can be decided, structured information of the contents of each layer is then provided. Finally the design of the Multi-Layered application is based on the structure of the categorization step and a first design is implemented. The first and second step can be complemented by a separate task analysis after the initial identification process. The last step must also be complemented with real user tests where the layered structure can be improved and tuned in to fit the work environment.

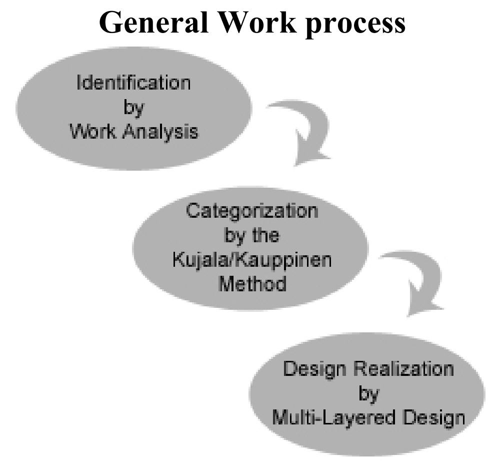
General Work process
Identification by Work Analysis
Categorization by the Kujala/Kauppinen Method
Design Realization by Multi-Layered Design

Figure 8. The three steps in the of the work process [4].

The developer is given a large number of parameters from the work process to consider when implementing the design of the Multi-Layered structure in the application. In the second step of the process the parameters are divided into groups and subgroups depending on priority. The priority is based on the environmental and cognitive constraints defined in the first step. Depending on the organization and the type of users at hand the layer structure can be very different. Through this method the application can be better suited for the individual use [4].

The work of creating a general work process is ongoing and the future work will be dedicated to test and gradually improve the process.

5. Discussion and Conclusions

Multi-Layered Design has appeared to be a useful approach for handling complex system where the user group is heterogeneous. The theoretical framework for how the users' knowledge and skills should be considered is very solid. But there are still several difficulties with using the method in practice. It is hard to get a full understanding of the users and the environment they work in, it is easy to underestimate the diversity of the users or interpret there requirements wrong. It is also hard to implement all individual requirements to create a solution that fits a whole group of users. By prioritizing and divide the requirements between the layers the difficulties can be decreased. We have concluded though that a general work process to fallow is needed. The ongoing work is therefore to create such a process to make MLD an easier method to work with.

6. Future work

The Multi-Layered Design can be further developed and improved. Next step in the case study is to test the prototype in real work and let the clinicians use the application for their photos. The prototype will then most likely be improved in an iterative process were new features are added and bugs are corrected. To further improve the prototype the first version of the work process will be tested within the MedView project. The Work process will then be evaluated and updated accordingly. Next large step in the project is to look at the other applications within MedView and adapt them to MLD if possible.

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