User-friendly Visualization of Object Versions and Archives in Collaborative Computer Work

Gert Zülch (1), Sascha Stowasser (2)
(1) + (2): ifab-Institute of Human and Industrial Engineering, University of Karlsruhe, Kaiserstrasse 12, D-76128 Karlsruhe, Germany, E-mail: Sascha.Stowasser@mach.uni-karlsruhe.de

Abstract

Data, states, events, information, experience and knowledge are present in all production enterprises in a vast array of forms. There is a common trend for storage, administration and processing of these in a distributed and connected information system for collaborative computer work. Work objects and data in a shared computer application can be continually changed and modified by different users working simultaneously with this application. Due to the different versions and the history of a common working object it becomes more and more important to be aware of the various states of the object. Within a recently completed comparative investigation study at the "Laboratory for Human-Machine-Interaction" of the ifab-Institute, different ways of visualizing object versions and archives were evaluated. The investigation was based on different structured visualization forms.

1 Introduction

Work objects (for example a text document or a drawing of a new product) and data in a shared computer application can be continually changed and modified by different users working simultaneously with this application. Due to the different versions and the history of a common working object it becomes more and more important to be aware of the various states of the object. The version of an object is the explicit notation of a changing- or development level of this object. The following example should explain this in detail: within the shared development process of the design of a new product by different design engineers distributed over distant locations, different object versions (drawings) will be created and must be administrated by the computer application.

Moreover, the notification and visualization of different temporary modifications of an object, the so-called object history, is essential for the users in many application areas (e.g. CAD, CASE or CSCW). The object history can be realized with the use of time-orientated attributes for the transaction time, the so-called time marks. Object versions and their historical evolutions stored in archives are quite meaningful for engineering applications. The concept of object versions and archives presents new and comprehensive possibilities for cooperative computer work in distant working groups.

When using the construct of object versions and archives in shared work organizations importance must be attached to the user-friendly visualization of these attributes. A user-friendly design of object versions and archives requires an integration of human information processing aspects. The state of a work object must be visualized in a comprehensive, actual, process-orientated, perceptible, interpretable and user-friendly way in order to fulfil the ergonomic transparency requirement.

2 Design of the investigation of archives and versions of objects

2.1 Participants and methods of the investigation

The ifab-Institute of Human and Industrial Engineering at the University of Karlsruhe is occupied with the structured development and the cognitively-orientated experimental evaluation of human-computer interfaces in work environments. Within a recently completed comparative investigation study at the "Laboratory for Human-Machine-Interaction" of the ifab-Institute, different ways of visualizing object versions and archives were evaluated. Twenty test persons from several industry enterprises took part in this examination. In this way it could be verified to what degree the developed representation variations fulfilled the demand for industrial relevance.

In order to achieve the results, several evaluation techniques were used: eye mark registration, key stroke recording, video-taped observation of the test subjects and interview with checklists. The eye mark registration with a SMI Headmounted Eyetracking Device System (SMI 1999), for example, is very useful in finding out which spot on the interface the user is looking at, which type of information representation he prefers or, generally speaking, in which way the cognitive information processing is proceeding. In particular, key data give objective hints on aspects of a user-friendly visualization. Key stroke recording was used to examine interactions of the test subjects

and to record e.g. the time the user needed to perform a specific task. Thus, this method was suitable for the analysis of the tactile actions of a user on the keyboard or mouse. Furthermore, other methods, such as video recordings of the test subject's actions and structured interviews, were used to obtain subjective information.

2.2 Investigated variants of archives and versions of objects

The identification of components, their state of validity and time of transactions on them can be called upon for the representation and assessment of temporal aspects in object modelling (see Schreiber 1995; Saake *et al* 1997).

- Identification of object versions:

Normally, as soon as an object is created for the first time, only one valid version of this object should be displayed to the user. If modifications to the object are carried out, the user must be made aware of the version sequence in such a way that the versions can be distinguished from one another and can be arranged according to their historical context.

- State of validity of a version:

In the representation of data the user must know whether the object version is valid, outdated or invalid. The state of validity of a version generally changes with time.

- Transaction date:

The transaction date (also called "time of registration") indicates when a specific version of the object was saved in the database. Fundamentally, the transaction date can neither changed retroactively, nor can it lie in the future.

Fundamentally different forms of visualization can be chosen for presenting object versions, the state of validity and the transaction date. In the choice of a representation variant, it is important that the user can locate the sought data quickly, securely as well as perceive and process it without error. Various characteristics such as form (e.g. fonts, pictograms, graphics), colour (e.g. red, yellow, green) and location (e.g. object proximity) can be used for the optical coding of object variants.Generally, the variants differ with respect to the coding of their position on the screen (fig. 1). The object attributes are usually visualized either in direct proximity to the object (e.g. version number directly beside the object name) or at a greater distance to it (e.g. version number in an information bar). The coding of version identification and transaction date were implemented numerically. According to this, a version is described clearly by a version number as well as a transaction date (date and time). Other forms of graphical visualization of these quantitative specifications, e.g. with symbols or diagrammes, are, from an ergonomics point of view, not suitable (see DIN 66 234, part 5, 1988; Shneiderman 1998).

Component	Investigated variants	Examples
Identification of versions	letters, in direct or distant position to the object	version number: V1, V2, ...
State of validity	letters, traffic light visualization, filling beams visualization, each in direct or distant position to the object	Version: Aktuell Version: Gültig Version: Ungültig
Transaction date	letters, in direct or distant position to the object	data entry time: 12.04.1998 / 13.31 h

Figure 1: Visualization of object versions and archives

In comparison, qualitative statements about the state of validity can be represented by means of alphanumeric symbols, colours or pictographical symbols (see DIN 66 234, part 5, 1998). The state of validity of a version could assume the characteristic "current" (current version with the most recent date of transaction), "valid" (not the current version, some attributes however are still valid) or "invalid" (outdated version, attributes are no longer valid). An object can, according to this definition, posses one or more actual versions, one or more valid versions as well as one or more invalid versions. Three variants with alphanumeric symbols (current, valid, invalid), one colour coded "traffic light"-representation (green denotes current, yellow denotes valid, red denotes invalid) and one abstract bar graph representation (full denotes current, half full denotes valid, empty denotes invalid) were examined for the representation of the state of validity. These three variants were, in one case, positioned directly beside the object, and in the other case, positioned at a distance (in the information bar).

Each test person was given a series of tasks including 21 tasks of identifying versions, validity states as well as times of transaction for various objects. In this test, the objects were instanced using condensed key figures from the areas of personnel, technology and organization (key figure system defined by Groth 1992). In different scenarios from order scheduling and operations planning the test persons were then required to process various of data archives aspects (e.g. identification of the oldest and still valid version of an object, identification of the instance with transaction data 13.11.97 etc.). Initially, the different variants were presented to the user separately. In a final scenario all variants were then integrated into the user interface in order to sort out the user's preferred variant.

3 Results of the investigation

The questions posed were:

- Which spatial position is preferred for the representation of version number, transaction date or state of validity with respect to the representation position of the object?
- Which representation of the state of validity are preferred?
- Which strategy is used preferentially for searching historical data?

The assessment of the interviews and the eye movement registration showed that all test persons preferred the coding of the version number, transaction date and state of validity in direct proximity to the object. A representation of these attributes in the information bar (e.g. after the mouse pointer was moved over the object) was proven to be unsuitable; this form of coding led to a 25 % longer search time. Furthermore, it was observed that an indirect positioning of the temporal attributes increased the strain on the visual system due to more frequent glance changes, which is proven by the average eye path of 20800 mm with an indirect positioning, compared with 16700 mm with positioning in close proximity. Thus, the attributes for the representation of versions or archives should be placed relatively close to the object. For example, in a list representation of all objects, the version number should be aligned directly adjacent to the represented object.

The examination showed clear preferences for the representation of the state of validity. The use of colour coding (the traffic light representation in this examination) substantially improves the performance with respect to orientating, searching and discovering of the state of validity. A colour coding can be detected more quickly in a set of objects than other forms of coding, such as alphanumerical characters or abstract graphic representations (e.g. bar graphs). This advantage of colour coding is in part a result of the fact that colour signals can be discovered and differentiated well, even in the periphery of the fixation point.

The comparison of the identification durations of the sought objects (averaged for all test persons and tasks) resulted in 17 s for colour coding, 22 s for bar graph representation and 23 s for representation with written characters. Thus, invalid objects should be coded, for example, in red, either with red characters for the name in the object list or with an abstract colour labelling (e.g. a red circle beside the object name). However, it should be mentioned that the sole use of colour as a coding characteristic can not be recommended, for several reasons (e.g. colour weakness of user, monochrome screens). It should rather be supplemented with a further form of coding (e.g. alphanumerical signs).

During the survey of the test persons and the assessment of the eye mark registration it was discovered that various different strategies were used to solve the given tasks. It could thereby be differentiated between a structured approach to identifying the object's historical data and an unstructured one. In a structured approach the presented set of objects is searched systematically for the wanted attribute. Test persons with unstructured approaches shift their gaze to randomly chosen objects in the hope of finding the right one in this manner.

Characteristic number	All test persons	Test persons with structured approach	Test persons with unstructured approach
Total processing time (in s)	383	356	409
Fixation rate (1/s)	4.4	3.3	5.5
Average saccadic length (in mm)	27	35	18
Total view path (in mm)	40,191	37,904	42,477

Figure 2: Key data of the eye mark registration of object versions and histories

The rate of fixation can be called upon in the description of glance behavior during task processing (Stowasser 2002). It has been shown that a much smaller fixation rate can be ascertained with those individuals who use a structured strategy (fig. 2). Glance transfers, so-called saccades, occur between two fixations. The average saccadic length was substantially longer when a the structured approach was used than when an unstructured approach was used. This behavior can be explained by the fact that the test persons with a structured strategy let their eyes flow over the rows or columns. A visual information uptake can obviously not always be assumed with this "wandered" gaze so that the saccades between two fixations are longer. The eye path behaves differently: the more difficult the pattern of stimuli is to identify, the longer is the length of eye paths. Individuals with an unstructured approach should be directed by a structured arrangement of the objects on the screen and a correspondingly clear representation of the associated attributes.

4 References

DIN 66 234, Teil 8 (1988), *Bildschirmarbeitsplätze. Grundsätze ergonomischer Dialoggestaltung*, Beuth-Verlag, Berlin.

Groth, U. (1992), *Kennzahlensystem zur Beurteilung und Analyse der Leistungsfähigkeit einer Fertigung*,VDI-Verlag, Düsseldorf. (Technik und Wirtschaft; Reihe 16)

Saake, G., Türker, C., Schmitt, I. (1997), *Objektdatenbanken*, International Thomson Publishing, Bonn et al.

Schreiber, D. (1995), *Objektorientierte Entwicklung betrieblicher Informationssysteme*, Physica Verlag, Heidelberg.

Shneiderman, B. (1998), *Designing the User Interface*, Addison-Wesley, Reading MA et al.

SMI (1999), *iView*, SensoMotoric Instruments, Teltow.

Stowasser, S. (2002), *Vergleichende Evaluation von Visualisierungsformen zur operativen Werkstattsteuerung,* Shaker Verlag, Aachen. (ifab-Forschungsberichte aus dem Institut für Arbeitswissenschaft und Betriebsorganisation der Universität Karlsruhe, Band 26)