Engineering User Centered Interaction Systems for Semantic Visualizations

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Abstract. For intuitive interaction with semantic visualizations, gesture-based interaction seems a promising way. However, the development of such ensembles is costly. To cut down the engineering effort, we propose a development model for interaction systems with semantic visualizations. In addition, we provide a set of evaluation tools to support the interaction developer engineer evaluating the engineering process.

Keywords: semantic visualization, gesture, interaction, universal access.

1 Semantic Visualizations and Gesture Based Interaction

The research questions we focus on are how people interact with semantic visualizations using other devices than traditional ones, and what types of gestures support users work with semantic information. We show a framework how semantic visualization interaction developer can engineer such ensembles efficiently.

Semantic visualization, or ontology-based visualizations [13], is a special field of information visualization [3][4][5] and focuses on visualizing classes, instances, properties, and their multiple relations. It is part of the top layer of the semantic web stack [15] - the user interface and application layer.

By now, the World Wide Web is designed for human reading and referencing of information through linking. The information and the context of information are not understandable for computers. The Semantic Web [2], as an extension of the WWW, computers will be capable to "understand" the information and thus will help to find and combine information more automatically. To avoid that only specialized people can participate in benefits of the Semantic Web, we have to provide tools, which abstract from the technical details. This is maybe similar to the development of the Web 1.0 to the Web 2.0. Within the early stages of the internet, people with some technical background were capable to use the technology for their needs. With the development of tools, like blogging systems or content management systems, who hide the details of the web technology, users can actively participate on the creation of content. For the Semantic Web, several approaches to visualize the relations of semantic information and to abstract from the technical details have been developed, for example, graph visualizations [6][7], hierarchies [8], facets [9][10], or timelines [11].

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In addition to semantic visualization, we have to undertake efforts to providing users with intuitive ways to interact with the semantic web. The success of interaction devices apart from mouse and keyboard indicate a change of the user interaction needs with computer-based systems towards Post-WIMPs [20]. In contrast to WIMP GUIs, that is graphical user interfaces mainly based on menus, forms, icons, and pointing devices, like a mouse, Post-WIMPS rely on gesture and try to avoid using icons as representation for functionality. With the raise of mobile duo-touch displays, multi-user interactive walls and tabletops, with multi-touch sensing [1], or new controller for computer games, the master vendors of consumer hardware industry push the availability of such devices for a broader audience.

With these devices, new ways of interaction with the computer become possible. People will use a wide range of gestures, which are more natural to solve certain task, when possible with a mouse controller. We are following the notion of Kendon [22], that "… gesture is a name for visible actions, when it is used as an utterance or part of an utterance". We see gestures as natural form of humans to express themselves to achieve certain task. Humans developed a wide variety of gestures. According to a classification of gesture based computer interaction [21], we focus on gestures styles, enabling technology, and system response. For the solving of tasks within semantic visualizations, several gesture styles has to be considered, like deictic gestures (e.g. pointing to an object), manipulative gestures (e.g. moving a node by hand), semaphoric gestures (e.g. thump up for accepting an dialogue), or language gestures (e.g. sign language). In addition we take enabling technologies, like touch surfaces, electronic pens, or system response from e.g. visual displays or audio output enable multiple gestures into account.

2 Challenges of the Engineering of Interaction Systems for Semantic Visualizations

Considering the outlined trends, a broader audience will get access to semantic visualizations on modern devices. This also implies that the developer of semantic visualizations have to bear in mind the "average" typical user [2], who has few or no experiences with semantic visualizations or new interaction devices or computer interaction gestures, like hand-gestures, speech-interaction, multi-touch, and specialized intelligent objects.

In contrast to posteriori adaption of interactive software, we will present proactive strategies [2] for the design of semantic visualizations using formative and summative evaluation methods [14].

One of the problems of user interactions studies is that the sole working with a system a user is likely to adjust the user's behavior to the application logic and to the interactions styles necessary to use the interaction devices. A more human centered way would be to look first at the natural interactions styles of users and then adjust technology to serve users interaction styles. This bias between user adjustment and technology adjustment is not completely reducible, but we can strengthen user-centered approaches with an appropriate research design.

3 Research Design for the Development of Interactive Semantic Visualizations

To avoid that users adopt their interactions to technical parameters of the interaction devices or to the logic of the semantic visualization, we have developed a three-phase model to obtain the user interaction style. In the first phases, users have a high degree of freedom to interact with semantic visualizations and therefore can use gestures natural for them without dealing with technical constraints. Users do not have to adjust their behavior to the technology. Rather the opposite, technology is build step wise from stage to stage to serve the needs of users.

The Semantic Visualization Interaction Model comprises three phases in cyclic manner (see Fig. 1). Through formative evaluation of each stage, we use the results for continuous development of the product. During the formative evaluation stage, the interaction designer conducts short investigations with a small number of participants to gain insight of the usage of the users to solve tasks with gestures. If the development of the interaction design project reaches a satisfying level, the evaluation of the last phase serves as a summative evaluation of the whole development process. For this evaluation stage, an external team of evaluators tests a significant number of people. The goal of this evaluation is to rate the product efficacy. As an example for the product efficacy, this could be the usefulness of the supported interaction styles of the used gestures to solve certain tasks. In the following, we will discuss the cyclic development process of gesture-based interaction with semantic visualizations.

The interaction designer uses the first phase to get an early quick overview of the gestures people will naturally use for solving their tasks. At this stage, there is no need for a working software or hardware product. The requirements for building the products evolve from this early stage. This also helps, that we can tailor the product more to users needs. Thus we only provide the user on the one hand a static version of the visualization, for example a picture, and on the other hand an input device with no technical functionality, e.g. a switched of electronic pen, or a real pen. With these tools, we gave the user several tasks to solve. This task can include navigation, zooming, scrolling in an information space, or manipulating information. Since the visualization and the device have no functionality, we can minimize the feedback loops between the GUI and the user, which would shape the behavior of the user to the specific logic arising from the special usage of a working software or hardware. This frees the user from the product constraints and he can then use interaction styles natural for him solving given tasks.

Starting with this phase, the semantic visualization interaction developer gains an insight what interactions are intuitive for the user. With this information, the developer can generate assumptions about the logic of the semantic visualization and the technical possibilities the interaction device has to provide. Before the next stage, we formulate hypotheses derived from the first experiences. A hypothesis could be for example: “Most people will prefer using their hand, than an electronic pen to navigate from one concept to another”, or “most people will move their body towards the visualization to zoom into it, than moving backwards”. These hypotheses guide the next evaluation steps. The hypothesis will be proven, refined, dismissed, accepted, or even new hypotheses will be generated. The tools and methods supporting this process follow in the next section.

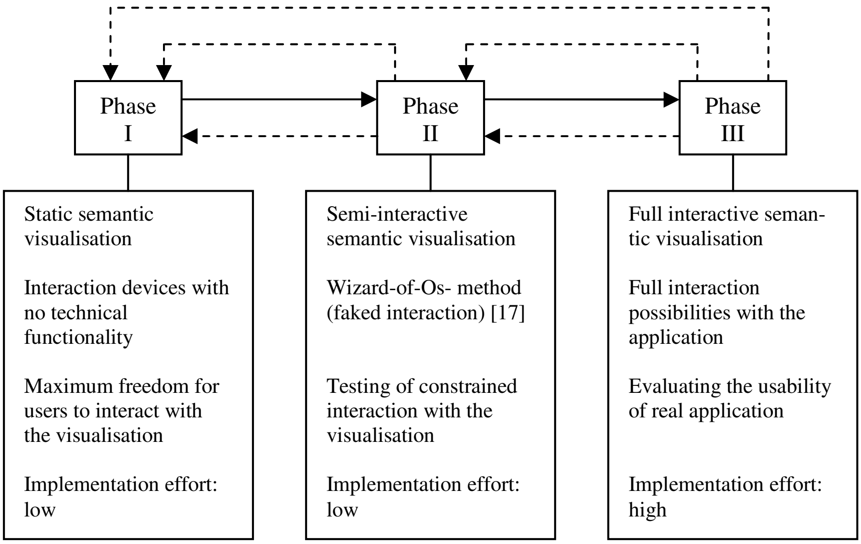

Fig. 1. The three phases of the cyclic development process of gesture-based interaction with semantic visualizations (dotted arrows indicate possible repetition steps for each phase, solid ones the optimal process without repetition steps)

The second phase is a proof of the assumptions of the first phase with the technical constraints of the future real application, but without developing the actual software or hardware. In this phase the developer can decide based on the information of the first phase what semantic visualization logic the user expects and what gestures the interaction device must be capable to track. To avoid high development effort and costs, this phase uses a wizard-of-oz method (see [17] for an example on natural-language dialogue systems), faking the real interaction with the semantic visualization. For this stage, we tell the user, with what gesture he can achieve a certain task. For example, we tell the user, that with a special move of both hands, he can zoom into the visualization. The special type of gesture bases on the experiences of the first stage. While the user tries to solve the given task with this gesture, we provide a visual feedback of the correctness of the gesture. We achieve this with another person watching the gesture and then according to the correctness provide the user the visualization for the right or for the wrong gesture. Since one person is faking the interaction for the user, we do not have to develop the software or hardware in depth. We use mainly prototypes. In this stage, we can evaluate the satisfaction of the users and the usability of the system as if they would work with a fully developed system, that reacts in the right way with a correct input or does not react with wrong input. Based on these new insights, we test the hypotheses of the first stage (see also the method section of this article), refine them, or add new one for the third stage. The developer repeats this process until reaching a satisfying solution. If this is not possible, he has to return to the first phase in order to change the initial hypotheses otherwise we can step to the next stage.

With the results of the first two phases, the developer can now build the logic of the semantic visualization and the interaction devices to a working system. This last phase is finished with the third observation of test users to refine and evaluate the final usability of the application. The test persons now interact with a full functioning application. The results of this phase serve as feedback for the next development loops for the further improvement of the product. The last step can serve as summative evaluation to assess qualities of the product.

During each phase, we support the interaction designer by a set of methods helping to gather relevant data for hypothesis guided designing decisions.

4 Methods

For each phase of the Semantic Visualization Interaction Model, a set of research methods is used. The method toolkit comprises video analysis [16], a newly developed questionnaire (Semantic Visualization Gesture Interaction Questionnaire, short SVGIQ), and a new developed Acceleration Gesture Tracking Device, for the unobtrusive recognition of accelerator values, generated by the interaction performed by users.

SVGIQ bases on general usability criteria [19] and gesture interaction research [18]. Based on this we extended the questionnaire to the needs of semantic visualizations. It consists of a set of three independent questionnaires. The first one is used before, one during, and the third after the treatment.

The first part collects data about sex, age, occupation, general experience with computers and computer games, semantic visualizations, and computer devices. We use this data for clustering users according to their background and experience. After the users have fulfilled one task within the semantic visualization with an interaction device, the investigator presents them the second questionnaire. It contains question about satisfaction, efficiency, and effectiveness with a semantic visualization and gesture. The third part gathers data about the general liking of the semantic visualizations and devices/gestures. In addition, subjective valuations of the interaction, like intuitive usability, learn ability, naturalness, controllability, practicability, and fun.

We record the interactions of the persons on video for a later video analysis. During the treatment, the investigator let the people describe why they use a certain gesture for solving a task, and what gesture "feels right" for this. The most significant gesture was later used for the analysis of the data. With standardized interview instructions, we assure a consistent way to provide the instructions to the subjects.

In addition to the video capturing, we developed a gesture-tracking device based on acceleration for the unobtrusive recognition of accelerator values, generated by the interaction of users. We use the video analysis, the SVGIQ data, and the data from gesture-tracking device for the analysis of statistical correlations of user characteristics with the semantic visualizations and input devices/gestures.

Each phases of the Semantic Visualization Interaction Model use these methods (see fig. 2).

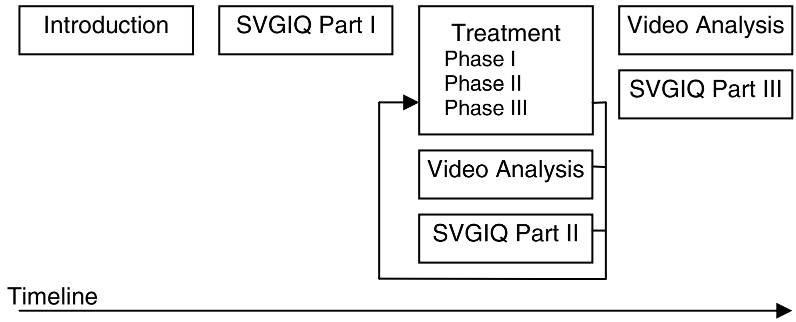

Fig. 2. Schedule of activities in each phase of the Semantic Visualization Interaction Model

After a short introduction into the general idea of semantic visualizations, the test users fill out the first part of the SVGIQ. After that every users becomes an interaction device and the order to fulfill a task within the semantic visualization. Depending of the phase of the process model, the shown visualization, and interaction device were more or less developed, as described above. During the treatment, the examiner asked several questions according to the standardized video instructions. In addition, we capture the whole treatment with a video camera for further examination. For acceleration-based devices we additionally use the gesture-tracking device. After the treatment, the users filled out the second part of the questionnaire, containing questions to the semantic visualization, the interaction device, and the task. For each task, we repeat the steps of the treatment phase. The examination ends with a short interview captured with video and the third part of the questionnaire containing questions to the general experience with semantic visualizations and interaction devices.

With this quantitative and qualitative measurement toolkit, we provided a framework for the empirical analysis of Semantic Visualization Interaction Model and an efficient software engineering process for developing semantic visualization interaction techniques.

5 Case Study

To exemplify the method we present the essential parts of an interaction study of semantic visualization conducted 2008. The goal of the study was to investigate gestures of users interacting with SeMap [23] and SemaSpace [24], semantic visualization for fast navigation in semantic knowledge worlds with several interaction devices and gestures. According to the first phase of our proposed process model, we showed a static semantic visualization (screenshots) and an option dialogue to our test persons (see fig. 3).

During the working on the tasks we record the persons on video, interviewed them, and they filled out the questionnaire. We gave the person the instruction to stand in front of a large screen, where we displayed the visualizations. We introduced the visualization with a short note about concepts, and that concepts have relations to other concepts. After that, the persons had some time to familiarize with the system (see fig. 4).

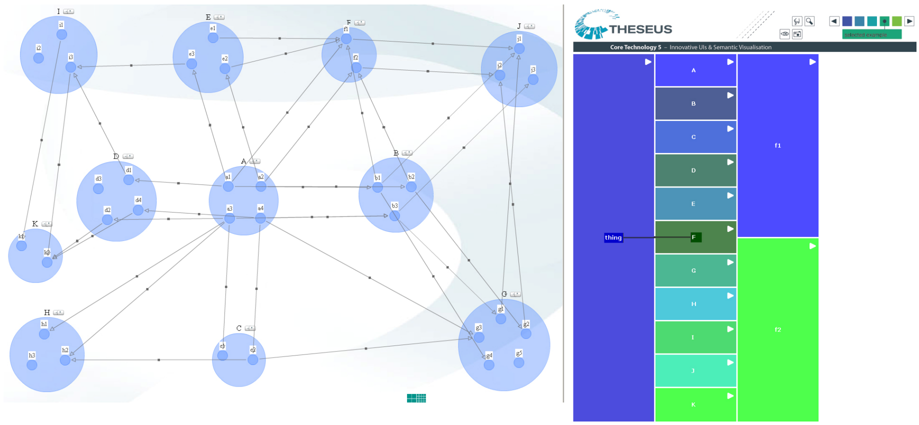

Fig. 3. Semantic Visualization SeMap and SemaSpace

Fig. 4. Interaction devices and gestures: Electronic pencil, hand gesture, accelerator based controller

They are supposed to use the electronic pencil like an ordinary pen and the controller like a bar. For hand gestures, we made no restriction. With these instructions, the persons fulfilled tasks like navigation from one concept to another, zoom in and zoom out, and accepting and declining options. The persons had some time to try several gestures to solve a task. After a while, we asked what the significant gesture was for them. We also asked them to verbalize why they chosen this gesture.

6 Discussion

In consequence of the complex nature of the relations between user interaction and semantic visualizations, we have to adjust the proposed methods to the special needs of each research setting. The proposed method of the Semantic Visualization Interaction Model can serve as a foundation for research, but for the individual requirements of each software product, we have to tailor the methods accordingly. A common set of methods could also serve as a way to compare different semantic visualization interaction studies. Further examinations with different visualizations and interaction devices are now necessary to examination universality of the proposed.

7 Conclusion

With this approach, we are able to build systems based on the preferences of users. We can reduce the problem that the users have to adjust their interaction to the needs of the technology. The users can use their natural gestures to interact with the semantic visualizations, and do not have to learn the logic of the system. Thus, we can lower the barriers to use such systems. This enables more people to participate and decreases the exclusion of people not capable or willing to learn the technical details of interactive semantic visualizations. The advantages in explicitly defining hypothesis at the beginning of each phase and then testing the hypotheses assures an empirical guided development process and help to make reasonable decisions.

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