Intuitive Multi-touch User Interface for Visualization of and Interaction with Product and Process Information to Enhance Product Lifecycle Management

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Abstract: Today's products more and more turn into systems which are built up of different kinds of linked components that communicate among each other. The resulting complexity brings today's information management technologies, user interfaces and information visualizations to their limits. This paper presents a research idea which proposes the use of modern touch devices with multi-touch multi-user enabled graphical user interfaces in order to handle the named complexity explosion in a new and better way.

1 INTRODUCTION

The capability of companies to be innovative on today's global markets is essential for their survival. In the end, the success of an innovation depends on the company's capability to transform innovative ideas into salable products in an efficient and effective way. Against this background, the product creation process (PCP) is of special importance. Tracing product creation in the last thirty years, the amount of functionalities and thereby product complexity (Fig. 1) have strongly increased (Eigner, 2009). Today's products more and more turn to systems which are built up of different kinds of linked components that communicate among each other. Accompanying, process and product complexity have risen by multidisciplinarity in mechatronic products and cyber-physical systems (maybe in combination with hybrid bundles of services), by a stronger federation of the supply chain as well as by external surrounding conditions like product liability or sustainability. As a result, the users involved in the product creation process perceive a massive complexity and information overload today.

Today's standard PLM (Teamcenter, Windchill, Enovia, etc.) / ERP (SAP, ORACLE, etc.) solutions that shall help the user to cope with the complexity fail due to user interfaces that are not designed for usability.

A user-friendly visualization has to align to the ability of a human to recognize visual information (patterns, trends, characteristics and groups) very efficient. A human is able to remember images, to recognize and scan them quickly and precisely. Furthermore he has the ability to recognize subtle changes in color, shape, motion and texture. Therefore, the most natural representation of product and process information for a human is a graphical representation. (Brodbeck et al., 2009)

Considering the present common forms of representation there are mainly tables and lists, so textual forms, which is contradictory to the recommendations for developing user-friendly graphical interfaces. (Shneiderman, 1997)

In detail, the above named IT systems simply reflect the storage structure - namely tables - to the user interface. Usually one would expect that there exists a separation layer between the structure in which information is stored and the structure that is presented to the user. Furthermore, for interaction with the system the user is offered standard input devices (mouse, keyboard, etc.). However, these interfaces (input and output) are not natural and native human-centered user interfaces (Wigdor, 2011).

For a native human-oriented access to a machine the barriers called input devices (mouse, keyboard, etc.) have to fall down. These devices are prosthesis for humans to interact with the machine. The

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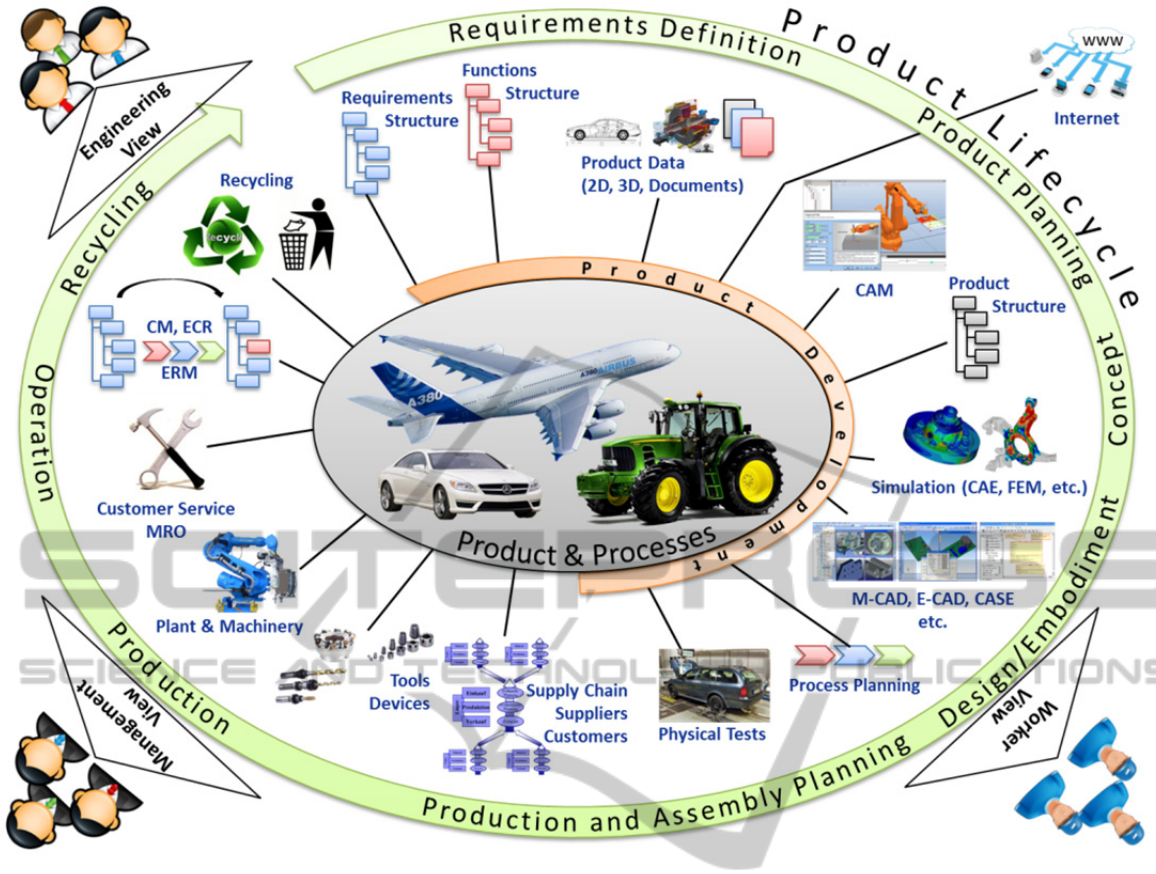

Figure 1: Complexity in the product lifecycle.

machine is not able to interact with a human in a direct way. Machines don't understand natural spoken language. They don't react if one touches them. Gestures, feelings, views and all the other human signals are not perceived. The reason lies in the lack of natural human-oriented hardware interfaces and in the lack of algorithms that give the machine a human-like behavior.

Developing the future workplace, it will be a great challenge to transform today's business IT systems into systems that allow an easy and intuitive – ideally role-/view-based – access to a company's information. Beside this challenge the transformation of today's business IT systems with single-user interfaces to a business IT system with a collaborative multi-user interface that supports group collaboration and group interaction in a local or globally distributed meeting poses an even greater challenge.

Fortunately, in the field of Human Computer Interaction there exists a broad range of excellent works that could support the development of the future workplace. For example (Jetter et al., 2011) (Heilig et al., 2011), (Prewett et al., 2006) and (Hoggan et al. 2008) prove the usefulness of touch interaction in comparison to mouse/ keyboard interaction and provide examples and prototypes on how an intuitive, human-oriented and context-sensitive interface could be designed. Using touch interaction, gestures and tangible physical objects for interaction (in the following of this paper named as *a tangible* or *tangibles*), a large field of new possibilities is opened. With more new technologies to come in the next years like real speech recognition, 3D cameras (e.g. Microsoft's Kinect) and many more promising technologies, the prerequisites for the future workplace are laid.

To promote the application of these new techniques in the field of product creation a research idea for the development of an intuitive multi-touch user interface for the visualization of and the interaction with product and process information to enhance product lifecycle management (InuVis) is presented in the next chapter. In the context of future workplace research, InuVis aims at developing new concepts and techniques for a better handling and

control of the named complexity explosion, to reduce the users feeling of being overwhelmed and to provide concepts and technologies for natural and intuitive interaction with information for PLM/ERP solutions by using human-oriented graphical interfaces.

2 INUVIS

With InuVis, the target user groups engineers, administration and management people shall be enabled to access all existing information in a company in a very easy and intuitive way. The goals are to reduce the time for accessing information significantly, to allow the user to view more information without overwhelming him, to increase the joy in using IT systems (PLM, ERP, etc.) and therefore to extend the time the user can work with them without getting tired and mentally exhausted. It is the goal to create an overall concept for a new user interface that is so simple to use, that only a very short training is necessary to be able to use the full functionality of the systems. All these goals will bring a completely new user feeling to the current business software world. The focused application areas are engineering collaboration and coordination in the creation process of complex products (e.g. decision or change processes). The disciplines involved in the research are virtual product development, interaction design, user interface design, ergonomics and work psychology/human factors.

Remark: Because of the limited space in this paper, in the following sections only a small part of the overall concept is presented.

2.1 Engineering Network

As today's corporate IT suffers from a variety of distributed legacy systems, the first step towards an easy information access is the aggregation and federation of the spread information. For this purpose the *Engineering Network (EN) concept* was developed. The EN concept is an enhanced flexible object-oriented meta-model for the modeling of composite and integrated multi-disciplinary product data and process models and it supports the mapping of data into data management systems. The product data models and process models derived from the meta-model provide user-specific views and flexible variant-rich development processes. With its flexibility and customizability, the EN concept contributes to handle the complexity in today's product creation processes. It is based on the following two core components (Mogo Nem, 2011), (Dankwort et al., 2012):

2.1.1 Enhanced Object (EO):

Enhanced Objects (EO) are used for the modeling of product-related information and allow a user-specific, individual presentation of the data. Today, different models are used for this purpose. Different disciplines (software, electronics and mechanics) have various different models. Some of them are defined in ISO 10303 (STEP). An EO is a virtual object which is fed by information from models of various globally distributed systems. The position of the user (viewer) determines which information is included. For this purpose, the EO component includes and offers Viewpoints which are linked by different *Views* to the virtual EO. By taking a *Viewpoint*, a real object is created which holds and presents real data.

An EO has *properties* which carry the specific values of the EO. Furthermore, the EO has interdependencies/relations to other EOs. Relations can be of types EO ⇔ EO, EO ⇔ Property, EO ⇔ View, View ⇔ View and Property ⇔ Property. The Property ⇔ Property relations are fully programmable and offer the possibility to attach algorithms, methods, etc. to them (e.g. to execute operations such as transformation, calculation, check, etc.). This for example allows an automatic update functionality by which a value change of the source property is automatically transferred to and/or compared with other properties related to it (within defined and valid constraints. Exceeding the constraints has to stop the process).

2.1.2 Engineering Process (EP)

Engineering Processes (EP) are used to model the business processes associated with the EOs. In the EN concept the assumption is made that there is a strong correlation between a product and its associated processes. Thus, the EO is the processes' data context. According to the concept of object orientation, a process is defined as a dynamic behavior of an object. Therefore, in EN processes are mapped to object methods and reside in the EOs. EPs can access other EOs by traversing the relation¬ships between EOs. Thereby a process can change not only its own EO but also related EOs. In the context of engineering design, EPs serve for capturing the various design processes and for mapping them onto some formal and executable structure.

2.2 Interaction

Having the aggregated information at hand, in this section the process of interacting with InuVis will be sketched.

The interaction with the system can be split into an input and an output channel. As InuVis focuses on the application of new touch technologies, the input channel incorporates every possible type of touch contact or touch gesture, every kind of a tangible and other kinds of objects that can be identified by the used hardware (e.g. a touch display, a touch table, a powerwall, etc). Also multimodal input is taken into account. The elements of the output channel can be visualizations, sound, force feedback and others. However, to keep the scope of the research manageable on the output channel, the research idea is limited to visualization and sound.

2.2.1 Phases of Interaction

To interact with the future workplace the following phases are proposed. With every phase change the graphical user interface can change its appearance to provide the user with the controls needed at a specific moment. This is essential for offering a large amount of functions without cluttering the user interface.

Phase 1: User Login

For the user login the idea is to make use of tangibles as a personal token that the user always carries with him/her. This can be for example a special object created only for the purpose to log into the system. But the token also can be a smartphone with a QR-Code on the back or something similar. By placing the physical token on a tangible enabled surface the system reads the user's ID, fetches the user's EO and logs him/her in. Depending on his/her access rights and roles the visualization changes and presents a cloud of EOs to the user. These EOs symbolize all information in the company's systems that are accessible for this user. As this might be a real large amount of EOs, the visualization has to be pure and simple (e.g. a pictogram) to show as many EOs as possible on the restricted screen space without overwhelming the user.

Phase 2: Object Search

The next step in the interaction process flow will be usually the search for a special piece of information – for one dedicated EO. InuVis offers the user several ways to perform this. First, there will be regular full text search. Without using a physical keyboard this can be done by a soft-keyboard that can be accessed by placing a special tangible on top of the touch device. Secondly, it will be possible to filter the EO cloud by the use of tangibles (Jetter et al., 2011). And third, the user shall be able to navigate by touch gestures. The combination of tangibles, touch gestures and textual full text search will be possible too.

Phase 3: Object Enrichment

Searching for objects with an easy and simple visualization maybe will not lead to a satisfying success. So the user needs a possibility to enrich his/her selection with additional information when needed. This shall be done by zooming into the EO cloud.

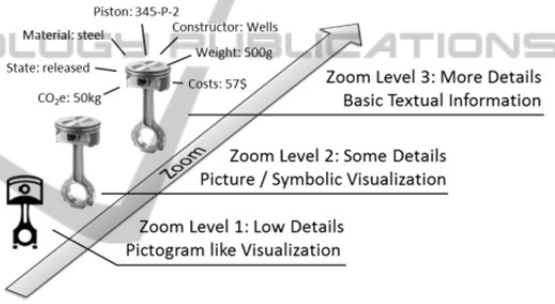

Figure 2: EO enrichment.

The more the user zooms in, the more information will be displayed (Fig. 2). As for the object search, the zooming can be done in several ways: by a touch gesture and by a tangible.

Phase 4: Object Usage

Once the user has found his/her object he/she can view its role-dependent information. The information is presented in views which can be scrolled freely, pulled apart and rearranged (Fig. 3).

By using a tangible or a special touch gesture or simply by dragging the object to a special location on the touch device, the user can switch to an enhanced interaction mode that provides more options. As the Engineering Network allows the live connection to systems, e.g. cyber-physical systems, machines, etc., the user now can view and manipulate the parts of the selected EO that are live enabled. For the passive parts of the EO editing functions are provided.

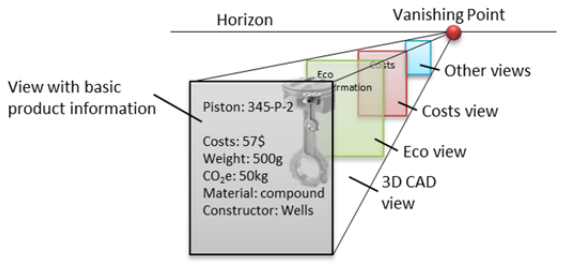

Figure 3: EO with views.

Switching between the different phases will be possible so that the user feels completely free when he/she "surfs" in the EO cloud. The change from the visualization in one specific phase to the next visualization in another phase will thereby be smooth.

3 SUMMARY AND OUTLOOK

In this paper, a proposal for a new field of research is given. The research idea InuVis focuses on handling the increasing information complexity in today's information management systems by the use of rich visualizations and multi-touch technologies. As part of InuVis a concept for a graphically rich multi-touch multi-user interface for a natural and intuitive interaction with complex product and process information has been presented.

According to the research idea first concepts and prototypes have already been created. In this paper, the necessary information aggregation layer and a brief overview over the process of interacting with InuVis has been presented. In the next future a prototype for evaluating different interaction concepts will be developed.

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