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Exploring former interaction qualities for tomorrow's control room design

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Abstract

This paper addresses the lack of interaction qualities in control rooms by investigating the potential use of Hybrid Surfaces. As an emerging trend with strong real-world references, they offer the combination of both, the qualities of physical interaction and the potentials of the digital world. To determine their applicability in the given context we applied the theoretical framework 'Reality-Based Interaction' in line with an expert focus group. As the primal finding tangible forms have aroused great interest as they embody the feature to express ongoing processes states and allow multimodal interaction.

1 Background and Motivation

Control rooms are facilities that serve as operations centers to monitor and control complex processes, e.g. in power plants or industrial production plants. One essential task in operating control rooms consists in the manipulation of process variables, which represent the physical state of the supervised process. According interfaces have to provide an adequate presentation of these ongoing processes. In practice, however, the actual process does not coincide with the real world process (Herczeg 2003). As a result, the interface may therefore not provide an adequate mental model for the operator (Wickens 2004). Hence, a crucial factor in control room interfaces is the ability to express the underlying process sufficiently. Control rooms and interfaces have changed over time. Before digital technology found its way into the domain, processes were monitored by electromagnetic displays and variables were manipulated by electro-mechanic control actuators. These interfaces provided multimodal feedback such as inertia and sound, e.g. when an actuator clicks into place. In the course of digitization these physical artifacts were replaced by virtual control elements that are operated through desktop computers. However this kind of interaction does not provide the qualities of the multimodal interfaces, nor does it utilize associated body skills. Hence, operators no longer experience process changes on a holistic-cognitive base. This circumstance is often linked with an incomplete mental model (e.g. Herczeg 2003) and the lack of situation awareness (Wickens 2004) which both are of vital importance for system maintenance and appropriate reactions on safety-critical events.

2 Reality-based Interaction Styles on Hybrid Surfaces

By looking at the history of control rooms we identify a relationship between power and reality as stated by Jacob et al. (2008): While digitization gave control rooms more processing power it also set off a drift from former interaction qualities that were strongly related to real-world phenomena. “Reality-Based Interaction” (RBI) (Jacob et al. 2008) discusses these opposing dimensions in the light of user interfaces and provides respective design implications. RBI presumes that building interaction upon informal real-world knowledge which is summarized by four RBI themes reduces the required mental efforts: “Naïve Physics”(NP) assumes that humans have a common understanding of fundamental physical principles such as gravity, “Body Awareness & Skills” (BAS) addresses the humans’ motor skills, “Environment Awareness & Skills” (EAS) points out that human interaction occurs within the individual’s structural environment while “Social Awareness & Skills”(SAS) highlights that interaction naturally takes place within a social context. At the same time RBI suggests that building interaction exclusively on realism may limit the power of an interface. Thus, desired interface qualities can only be achieved by adding digital functionality.

Regarding former interaction qualities and today’s requirements in control room design we consider Hybrid (Interactive) Surfaces as defined by Kirk et al. (2009) as a promising candidate to achieve interaction styles that combine real-world qualities (such as multi-sensory feedback) with today’s digital potentials. Furthermore, Hybrid Surfaces offer a wide design space where virtual and physical expression may be combined in various ways. For later discussion we defined two major interaction styles. Hancock et al. (2009) refer to the ends of the continuum as direct-touch and tangible user interfaces (TUIs). Both forms enable “direct manipulation” as defined by Shneiderman (1983) and avail themselves of real-world knowledge. Direct-touch interfaces express real-world objects and their properties metaphorically. Thus, they are commonly attributed to “Natural User Interfaces”. With respect to the directness of manipulation, direct-touch interfaces can be considered to be more direct than mouse and keyboard scenarios (Jacob et al. 2008) as no mediating device is necessary for the manipulation of the visual model. TUIs primarily base on physical expression due to their materialistic properties. Unlike direct-touch interfaces they do not mimic Naïve Physics but instantiate them. Numerous qualities are attributed to TUIs of which intuitiveness (Ishii & Ullmer 1997) may be the most preeminent in terms of affordances. Regarding their physical properties Klemmer et al. (2006) found prove that tangible interaction facilitates motor memory. In practice TUIs are usually composed in a way that includes direct-touch features. Hence, the balance of both spheres plays a major role in interface design. For this reason we distinguish “active tangibles” that receive and express the state of a process variable and “passive tangibles” that do not embody such functionality. While Inami et al. (2010) highlight the motor property of active tangibles (such as “tangible bots” by Pedersen & Hornbæk (2011)), we propose that activeness should refer to the ability to retrieve and express any kind of information that is relevant for the underlying model or variable.

3 Focus Group

As RBI presupposes a profound design background and adequate domain knowledge, the session was conducted with usability experts (N=5, energy sector) from a leading company in the field of control room design. The procedure of the session (5 hours) was motivated by the RBI paper (Jacob et al. 2008). At first the four RBI themes and the Hybrid Surface interaction styles were introduced (0.5 hours). The first part of the session focused on the question of how the manipulation of process variables on Hybrid Surfaces could be supported by means of the four RBI themes (1.5 hours). In the second part the experts had to think of the task-specific aspects and associated desired qualities. Here, the six exemplary categories of Jacob et al. (2008) were presented and the experts were asked to think of additional categories that they were missing (1.5 hours). In the last part the experts had to formulate design requirements by weighing up if additional digital power was necessary for their generated ideas in order to meet the desired qualities (1.5 hours).

In sum most ideas (e.g. "smoking tokens") incorporated tokens, where the state of a process variable is physically expressed by a tangible. As a result of the second step, "operational safety" was added, which was explained by the fact that control rooms are highly safety-relevant environments where mal-operations may have fatal consequences. The most relevant categories have been discussed and weighted up in terms of design implications as follows:

- **Reality vs. operational safety:** To avoid mal-operation interaction design would need to consider three functions: tangibles would (1) require sufficient adhesion to prevent unintentional translation when interacting on the surface, (2) have to provide a confirm button to avoid accidental value manipulation, (3) have to be equipped with some kind of alert to prevent tangibles from getting lost or carried away from the surface.
- **Reality vs. expressive power:** Increasing expressive power by means of real-world features was considered skeptic as it would assumedly reduce manipulation speed and efficiency. The experts supposed that expressiveness could be increased by fitting up tokens with features that correspond to the underlying process. E.g. tokens to control temperatures may embody a thermo element that reflects a variable's state.
- **Reality vs. efficiency:** Efficiency was defined as a matter of speed and the memorability of manipulated variable values. While NP may be utilized by tangible interaction, some physical principles (e.g. latency or inertia) may reduce efficiency. To rapidly change variable states digital functionality should be added to set the respective lowest and highest value. Interacting bimanually with tokens would allow blind operation and assumedly increase efficiency by allowing a single operator to manipulate more variables at once.
- **Reality vs. ergonomics:** Ergonomics has been seen skeptic with respect to NP and BAS as some real-world features may not be appropriate for frequent use. Interaction styles that allow operators to ultimately feel process changes, may not only conflict with ergonomic principles (e.g. size of actuators and the necessary operation effort) but may also be dangerous (e.g. temperature). As a consequence, some physical features should rather be expressed using a different physical scale or in a metaphoric way.

4 Conclusion

In this paper we explored the potential use of Hybrid Surfaces as an interaction technology to revive former interaction qualities. To gain first insights we conducted an RBI-driven expert focus group. With respect to the initial question if Hybrid Surface interaction applies to the control room domain we found that they were fully accepted as a way to preserve today's flexibility and revive former interaction qualities. Beyond that, the experts had a clear tendency towards tangible scenarios. Here we gained extra insights into ways to express process states e.g. by means of smoking tokens reflecting a boiler's state. Except for ergonomic issues, active tangibles have been privileged due to their capacity to physically transport process states into the real-world.

We consider this as an initial step towards reality-based interfaces in control rooms with Hybrid Surfaces. Further efforts will therefore concentrate on proof-of-concept prototyping focusing on the major design implications as well as on the evaluation metrics speed and the memorability of performed manipulations on process variables.

Literaturverzeichnis

Hancock, M., Hilliges, O., Collins, C., Baur, D., & Carpendale, S. (2009). *Exploring tangible and direct touch interfaces for manipulating 2D and 3D information on a digital table*. In Proceedings of ITS'09, S. 85-92.

Herczeg, M. (2003). Sicherheitskritische Mensch-Maschine-Systeme: Rahmenbedingung für sicherheitsgerichtetes Handeln. In *Deutsches Atomforum e.V.: Berichtsheft der Jahrestagung Kerntechnik, Verlags- und Verwaltungsgesellschaft.*

Inami, M., Sugimoto, M, Thomas, B.H., & Richter, J. (2010). Active Tangible Interaction. In Müller-Tomfelde, C. (Editor) *Tabletops - Horizontal Interactive Displays.* Springer, S. 171-18

Ishii, H. & Ullmer, B. (1997). *Tangible bits: towards seamless interfaces between people, bits and atoms.* In Proceedings of CHI`97, S. 234–241.

Jacob, R. J. K., Girouard, A., Hirshfield, L. M., Horn, M. S., Shaer, O., Treacy, E. S., & Zigelbaum, J. (2008). *Reality-based Interaction: a framework for post-WIMP Interfaces.* In Proceedings of CHI`08, S. 201-201.

Kirk, D., Sellen A., Taylor, S.,Villar, N. & Izadi, S. (2009). *Putting the physical into the digital: Issues in designing hybrid interactive surfaces*. In Proceedings of HCI`09, S. 35-44.

Klemmer, S. R., Hartmann, B., & Takayama, L. (2006). *How bodies matter: five themes for interaction design.* In Proceedings of DIS '06, S. 140-149.

Pedersen, E. W. & Hornbæk, K. (2011). *Tangible Bots: Interaction with Active Tangibles in Tabletop Interfaces.* In Proceedings of CHI'11, S. 2975-2984.

Shneiderman, B. (1983). *Direct Manipulation: A Step Beyond Programming Languages*. In: IEEE Transactions on Computers, 16 (8), S. 93-102.

Wickens, C. D., Lee J. & Liu Y. D. (2003). *Introduction to Human Factors Engineering,* 2nd ed. Newark, Prentice Hall.