From Interaction to Intervention: An Approach for Keeping Humans in Control in the Context of socio-technical Systems

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Abstract. This paper transfers the concept of human-computer intervention to the context of routinized socio-technical processes. Intervening interaction is defined as activities that alter the behavior of a process that is regularly highly automated and /or continuously proceeds according to a plan. Rules and principles of interaction design and socio-technical design are taken into consideration to derive hints and requirements of how intervention interfaces should be designed in the socio-technical context.

Keywords: Interaction by Intervention, Intervention Interfaces, Highly Automated Processes, Routinized socio-technical processes

1 Introduction: Challenges in Times of Automation

Computer science has been driving automation of work routines in many areas. The recent discussions on the potentials and risks of automated cars has shed light on the social challenges that accompany this development. Driving in slow moving traffic is a striking example for boring but as well stressful tasks that can be taken over by machines and algorithms. However, the human-machine interaction between driver and car is in most cases embedded into systems that are more complex: Traffic is a phenomenon of cooperation between many participants. Communication is necessary to negotiate actions, rules have to interpreted, resources to be shared, and so forth. We therefore focus on this higher level perspective, i.e. on complex socio-technical systems (Baxter & Sommerville, 2011; Ackerman, 2000) that people interact with or take part in and that may appear to them as partially automated.

To meet this challenge, we built on recent work in the context of automated systems – for example to deal with self-driving cars – that proposes the intervention-only interface paradigm (Schmidt & Herrmann, 2017). This paradigm refers to technologies that are predominantly based on automation or artificial intelligence. Roughly, intervention means that automated processing is interrupted for a defined period of time during which the user takes over control. We argue that intervention is also a possible type of action that is relevant when dealing with or participating in socio-technical processes or systems. A "socio-technical process" (Herrmann et al., 2016) can be defined as the

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coordinated interplay between human-computer interaction on the one hand and collaboration and communication between humans on the other hand. Thus, it covers all kinds of flows of actions that result from dealing with or behaving as part of a socio-technical system. That is the interplay between

a) human cooperation and collaboration,
b) human- computer interaction and
c) information processing within technical infrastructure.

Defining socio-technical systems (STS) by considering human-computer interaction is in accordance with the development of the theory of socio-technical systems. According to Mumford (2006), action research in the socio-technical realm was focused on the introduction of computers since the 1960s and there was an overlap between ergonomists' interest in man-machine interaction and the socio-technical perspective.

The paper pursues the position that the concept of intervention – as proposed by Schmidt & Herrmann (2017) – should be raised from the level of human-computer-interaction to the level of socio-technical processes and deals with the question of how this can influence socio-technical design. Therefore, in the second section we demonstrate with examples how the underlying concepts and definitions can consider the socio-technical context; the third section describes rules and guidelines for socio-technical intervention.

2 Concepts and definitions

To better understand the background of the concept of intervention and intervening usage, we describe related work from various research areas, define necessary concepts and relate them to examples.

2.1 Related concepts

The intervention user interface is inspired by concepts of interaction design and other disciplines, especially in human-computer interaction research. These differences trigger a more precise understanding of intervention.

Implicit interaction

Schmidt (2000, 191) defines implicit human computer interaction "…an action, performed by the user that is not primarily aimed to interact with a computerised system but which such a system understands as input." The original idea was to allow contextual information to be used in human computer interaction, e.g. by adapting system behavior to those that are in the same room as the system. Implicit effects are also common within socio-technical constellations. People provide messages or recommendations for others although they do not explicitly intend to do so. Within e-commerce applications, goods are recommended to be taken into account because other users have ordered them etc. Intervening interactions complement implicit interaction to help users to be in control if the interpretation of their or others activities is inappropriate or inefficient. Thus, support of intervention can be a consequence of implicitness.

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Intervening usage

According to Herrmann (1992), intervening use enables the users to explore an interactive system by themselves, to modify it and to find individual ways of using it that cannot or have not be anticipated by the designers of the system. There is a polarity between "regular task performance" and "non-anticipated use"; “the user aims at an anticipated subgoal using a non-anticipated dialogue-sequence, or … aims at a non-anticipated sub-goal by her/his own methods.(p. 290)”. Herrmann’s concept of intervention does not refer to autonomous systems or socio-technical processes but to the pre-planned trajectories within dialogue sequences as part of the interface design. What is still relevant for the discussion of routinized socio-technical processes is the proposed interplay between exploration (e.g. by what-if scenarios) and intervention. This interplay requires that the effects of intervention must be immediately visible and understandable and an immediate revision must be possible. Further, intervention as altering a pre-defined plan can also be applied to workflow-management systems.

Intervenability and privacy:

Rost and Bock (2011) describe interventions from a data privacy perspective. In the data protection discourse, which is driven by legal requirements, “intervenability” refers to the rights of the individual to withdraw consent, object to the results of an automated decision or request the deletion of their data. To implement these rights in the socio-technical processes of organizations, Rost and Bock suggest to e.g. implement a Single Point of Contact to which data subjects can address their requests. On a higher level the idea is to allow them to infuse contingency into the data and data processing so that possible conclusions drawn from data in the context of other data does not necessarily lead to deterministic or solicited results. In the socio-technical context, for example, been argued that tracking users on the web to create profiles has a significant privacy impact as these profiles can effect what services users can access and what price they pay. One successful way of intervening in these profiles, besides blocking the tracking, has been to intentionally obfuscate the data to influence the profile in a specific direction (Degeling, 2016).

Workarounds

The phenomenon of workarounds – that can be considered as noncompliance with expected behavior – is another example of people’s need to deviate from routines or typical patterns of interacting with technology. Alter (2014) characterizes a workaround with the following description: “The scope of a broadly applicable theory of workarounds should cover all situations in which people intentionally perform or enable action X even though routines, instructions, expectations, requirements, software specifications, and/or regulations imply or state they should not perform action X. In some cases, X seems totally appropriate to most observers in terms of business priorities, customer needs, and ethical considerations. In other cases, X is controversial in relation to business priorities and perhaps personally opportunistic, unethical, or even illegal. (1042)” Thus, workarounds imply that something unexpected happens. By contrast, intervention is not unexpected. Possibilities for intervention are considered as a design requirement. Rules for appropriate intervention have to be considered for the design of informations systems and the management of socio-technical processes. The similarity is that in both cases – workarounds and intervention - it cannot be foreseen how 'action X' concretely looks like.

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Collaboration between man and machine

Increasing interests arise in how the interaction between humans and autonomous systems can become part of a socio-technically optimized collaboration (cf. Behymer & Flach, 2016; Kamar, 2016). The challenge is to find an appropriate task distribution that keeps people in control especially if it is necessary to avoid mishaps or to exploit opportunities for increasing the performance of a socio-technical system. Design for interventions is one facet of such a socio-technical concept that pursues the optimizing of the interplay between humans and automated processes. It allows people to use technical systems or routinized workflows without an own contribution or by implicit interaction during certain phases while they influence the used processes only at those moments where their specific needs or potentials require a more fine-grained interaction.

2.2 Definition of central concepts in the context of intervention

Traditional human computer interfaces started out as dialog systems, where humans are in a continuous exchange with the computer. Similarly, participating in a socio-technical system or being a customer of such a system, originally included a lot of interaction work e.g. in technologically mediated communication with service agents.

With the shift towards a higher degree of automation and to autonomously acting agents, the dialogue concept has changed towards less continuous and less fine-grained interaction, relying more on automated context awareness and implicit interaction**.** In contrast to the direct manipulation principle, if proactive systems are applied, either humans or the technical infrastructure can take the initiatives for interaction. Similarly, on the level of socio-technical systems processes where initiated by humans and can, but need not, be influenced or interrupted depending on problems or requirements that become apparent during runtime. Furthermore, people who act within a socio-technical process follow certain routines that they only change if problems require attentiveness and conscious action – i.e. intervention. For instance, customers might have become used to automatically follow hints such as "Customers who bought this item also bought". However, if it becomes apparent that the list of recommended items might be manipulated, customers might become more attentive and cautious instead of following these recommendations.

The concept of continuous monitoring and interaction is not appropriate anymore for two reasons. First, we are embedded in and relying on too many automated systems and routinized socio-technical processes and therefore it is impossible to be in control of all of them. A striking example is that we accept such a high number of "terms of service" agreements and privacy policies when we use internet-based services that our available time would not be sufficient to read all of them (Obar & Oeldorf-Hirsch, 2016). Comparably, we would not have the time to accompany all routinized socio-technical services – such as delivering electrical power through a highly decentralized

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grid system – by fined grained interaction. Secondly, and consequently, time consuming effort is not the most important argument, since the systems rely on modelled expectations to be met, there is – in most cases – no extra benefit if we stayed in a permanent loop of monitoring and interaction.

Apparently, the concept of granularity of control is important to understand how we deal with and behave within socio-technical systems: There are phases when we just rely on others and there are phases when we want to switch back to fine-grained control for a limited period of time.

Intervening interaction

We share the view of Schmidt and Herrmann (2017) that a new style of employing highly automated or routinized systems is required that limits fine-grained interaction to exceptional situations. When defining the central concepts, they write: "*Intervention* … takes place during the usage of an automated system and initiates a diversion from the predefined behavior. *Intervening interaction* allows the user to alter the behavior of a process that is regularly highly automated, and continuously proceeds according to a plan or to situational awareness without the need for any interaction. (42)"

This view can also be transferred to intervening interaction into those kinds of socio-technical processes that include automated technical systems, software-driven workflows for task completion or that are highly routinized and self-regulated. In these cases, an *intervention interface* has to be provided that allows for awareness to identify the need for interventions, and supports activities by tools and communication media to execute an intervention. In the socio-technical context, the addressees of intervening actions are not only algorithms but also people who run a socio-technical process.

To give an example, (Schmidt & Herrmann, 2017) refer to automatic parking of a car. The granularity of control decreases from self-controlled to highly assisted to completely automated parking of a car. In an autonomous car the user exits the car, and the car autonomously finds a parking space, parks, and comes back in time to pick the person up. If the driver wants to avoid that a car will park itself at a certain spot or area, s/he has to intervene.

An example on the socio-technical or collaborative level is related to Facebook: Facebook uses highly automated processes to determine what advertisements are shown to which users. After these processes have been heavily criticized for being privacy invasive, non-transparent and manipulative, the social network has introduced two levels of intervention. First, users that feel uncomfortable with a particular ad can select it to be hidden from them in the future. Second, those that get the impression that there is something generally wrong with how they are targeted with ads can review and change ("Why am I seeing this ad") the underlying profile Facebook has created about them. Obviously, both types of intervention, one being more spontaneous and more systematic, do not just serve the purpose of giving control back to users. Facebook also benefits from the feedback as it allows them to adapt their algorithms and make supply more accurately target ads in the future.

Interventions and (re-)configuration

If the same type of intervention happens more often, this can be an indicator that a reconfiguration of the socio-technical system is necessary or reasonable. Based on an initial configuration of a socio-technical system (see fig. 1), regular usage of or collaboration within a system can be interrupted by casual intervention. Repetitive interventions of the same type can initiate adaptation. Here, the socio-technical view differs from Schmidt and Herrmann (2017) since it has to include two options. First, the technical system can adapt itself or a user can directly execute an adaptation as it is suggested by end-user development (Lieberman et al., 2006). Second, a reconfiguration can be proposed but has to be approved either by negotiation between the community of potentially affected users or by an authorized role. Within socio-technical arrangements, configuration and re-configuration can also be delegated to various roles.

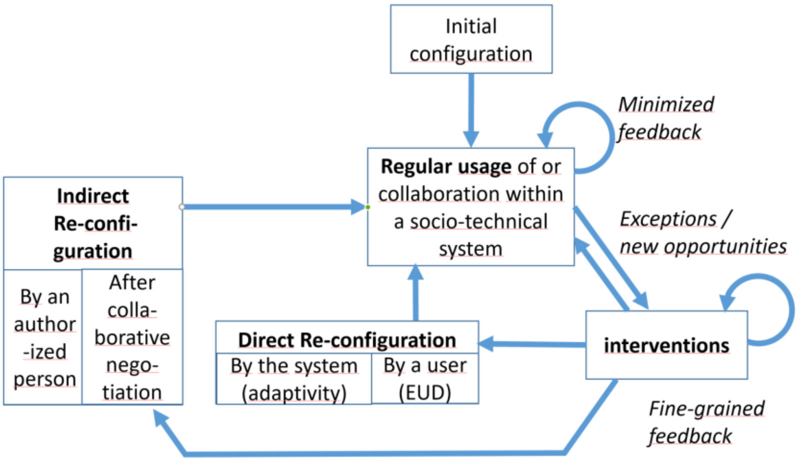

Fig. 1. The relationship between regular usage, intervention, and configuration.

Characteristics of intervention into socio-technical systems

In accordance with Schmidt and Herrmann (2017) and with respect to the socio-technical context, interventions have the following characteristics:

- There is no pre-specified plan when and whether they occur; they are exceptionally and compensate a lack of anticipation during the phase of configuration.
- Interventions can address automated technical systems as well as people who contribute to completing a routinized workflow.
- People must be able to start interventions fast enough by applying technical means or via communication so that the solicited effects take place in time.
- Situations that require intervention are emergent and contingent (Pederson, 2000), and they contribute to the emergence of new patterns of behavior.

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- In alternation with re-configuration, they cyclically help to improve automated or routinized behavior. Permanent intervention is not possible but is a re-configuration that has to be negotiated.

Practical relevance

The concept of design for intervention is of high practical relevance since it allows for offering users the usage of automated processes also in those cases where not every situation or exception can be foreseen. In the non-anticipated cases the user can switch back to fine grained interaction by intervention. This concept is faced with the challenge whether the user can timely recognize that an intervention is necessary and whether s/he is attentive enough to do so. This challenge makes clear that possibilities for intervention require deliberate design that explicitly deals with providing timely alarms and with triggering the attention of those who use a or participate in a socio-technical system. Referring to the case of driving in autonomous cars, the socio-technical perspective is not restricted to the focus of whether and how the car itself can warn a driver early enough. From a socio-technical perspective, this task can be supported by all vehicles and people who participate in a traffic context. Therefore, specific means of communication have to be provided (cf. Färber, 2016).

Another example is the problem with Advanced Emergency Braking System, AEBS, that are used in trucks to avoid dangerous collisions. These systems are frequently switched off since they produce too many false-positive warnings (Örtlund, 2017; Inagaki, 2011). Intervention is an alternative to switching off, if it is properly designed. In the case of AEBS, it is especially reasonable that interventions are only active for a limited period of time, e.g. in relation to specific traffic situations. Thus, a permanent deactivation of an AEBS would not be possible; also, a high repetition rate of deactivation could be impeded by design. On the socio-technical level, collaboration-oriented rules could be added, such as that an intervention can only be started by two people and be immediately terminated by only one of them. Furthermore, it is of high practical relevance that the design enables users to understand the status of an intervention and its effects clearly and at every time. A striking example for this requirement is the crash landing of Asiana AirlinesFlight214 in 2013 at San Francisco Airport[1].

3 Rules and principles

The design and evaluation of interactive systems is guided by various sets of rules. One set that is well acknowledged consists of Shneiderman's golden rules (https://www.cs.umd.edu/users/ben/golden rules.html, Shneiderman, 2017). Also in the area of socio-technical systems, various principles and rules are proposed; Clegg (2000) gives a substantiated overview. Mumford (1983) presents a very concise set of five socio-technical principles that are closely related to job design and focus the fit between human's characteristics or expectations and the job they have within a socio-technical system. These kinds of principles have to be taken into account when we think about

[1] https://en.wikipedia.org/wiki/Asiana_Airlines_Flight_214

the details of how intervention could be made possible. Similar to Shneiderman's golden rules, we focus on the following aspects:

Strive for consistency

Consistency requires the same or similar sequences of actions in similar situations. The perceptible behavior socio-technical processes should be consistent and understandable across different situations. If inconsistency is perceived, this is an entry point for intervention. Intervention must be designed in a way that makes sure that the ongoing behavior of a system after an intervention is in accordance with the user's expectations.

Enable frequent users to use shortcuts.

Experienced users employ shortcuts to make frequent and repetitive actions more efficient. Short cuts should also be available to start interventions. In socio-technical context, short cuts can be compared with immediate access to decision makers or to people who can initiate immediate action. The success of intervention interfaces depends on their support of experiencable immediateness.

Offer informative feedback.

In the case of fine-grained interaction, feedback is needed to guide the action of the user. With automated and self-regulated socio-technical processes, feedback for the participants is needed at the beginning of being involved and can be reduced if trust has developed. Since intervention takes place if trust is challenged or expectations are not met, the fine-grained feedback has to accompany the phase shortly before intervention starts. This includes that switching from an inattentive mode to an attentive mode, quickly assessing a situation, and quickly making decisions is supported. Furthermore, the options for intervention have to be clearly communicated, and not hidden as it may happen in the social context. Furthermore, the beginning and the end of the intervention have to be recognizable as well as the effects of the intervention. Perceptibility of the effects is necessary to support exploration.

Design dialogue to yield closure.

Users have to understand how they can contribute to a complete cycle of tasks to achieve a certain and reasonable goal. With respect to socio-technical design, interventions should not exclusively be allowed for certain roles but for all participants. to offer them an appropriate mix between regular and challenging tasks. Tasks and control have to be shared between people and between persons and machines in a way that intervention is an integral part of all people's tasks to give them the experience of being in control (cf. "Support internal locus of control", Shneiderman, 2017).

Offer simple error handling.

Intervention is a means that helps to prevent or to correct errors but it can also be a source for errors since it takes place exceptionally and cannot be realistically practiced or trained. Especially initiating and terminating of interventions must be clearly recognizable. In the socio-technical context, errors cannot only be prevented by technical features but also by people or by organizational routines. Intervention must take place as fast as possible to avoid the occurrence or repetition of unsolicited behavior. Since interventions are not a matter of regular routine, they can be stressful and error-prone. Therefore, easy reversal of the impact of intervening actions is required. The easier this

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reversal can take place, the more users will use interventions to explore new, more efficient ways and unfamiliar features when dealing with socio-technical processes.

The examples of this guidelines for design clarify that intervention in this paper is not used to just describe certain types of human behavior, e.g. as they occur in workarounds. By contrast, - and this is the new perspective of Schmidt and Herrmann (2017), - intervention is considered as a mode of using systems that has to be carefully designed. The new message of this paper is that the design of intervention should not be restricted to autonomous computer systems but should address the socio-technical level. This extension allows for a broader use of intervention but also for more options of how the possibility for intervention can be designed.

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