Interactive Environments Supporting User and System Co-Evolution

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Abstract: This paper presents an original model of the interaction and co-evolution processes occurring between humans and interactive systems. This model is at the basis of an approach that, by exploiting the "artisan's workshop" metaphor, aims at creating interactive systems that support people activities. Such novel systems should be easily adaptable to specific needs of the user communities and they should allow users to personalize the system to better fit with their evolving needs.

1 Introduction

Our experience in studying people and the activities they perform in their daily work has shown that, in various domains, activities are performed by experts who do not constitute a uniform population, but belong to different communities characterized by different cultures, goals, tasks and contexts of activity. For example, in the medical domain, physicians with different specializations cooperate to come out with a common diagnosis; they are members of different communities who must analyse and manage the same data (e.g., X-Ray images) with different tools, on the basis of different knowledge they possess and from different points of view. In this activity, as in many others, members of different communities reach a common understanding and co-operate to achieve a common purpose [DW96]. Moreover, work organizations are often characterized by increasing environmental complexity and dynamics [WR95]. As a consequence, interactive systems supporting people activities, even those designed for a specific application domain, should be very flexible, i.e., easily adaptable to specific needs of the user communities and capable to be personalized by the users themselves, to better fit with their evolving needs.

Many authors have pointed out an important phenomenon that must be considered in Human-Computer Interaction (HCI): the *user evolution*. Nielsen says in [Nj93] that "using the system changes the users, and as they change they will use the system in new ways". More recently, Norman says in [Nd05] that "the individual is a moving target". This means that a design of an interactive system may be good today, but no longer appropriate tomorrow. Once people gain proficiency in system usage, they would like to use the system in different ways and need different interfaces than those they required when they were novice users. These new uses of the system force the designers to evolve the system to meet these new needs. Therefore, it is more appropriate to speak about *co-evolution of users and systems* [As02][BD01][CR92][Cm06a].

The work presented in this paper discusses a model of the Interaction and Co-Evolution processes (ICE model) occurring between human and system, which helps to identify the causes of usability difficulties affecting current interactive systems. This model is at the basis of an approach to design novel interactive systems capable to support people activities and to face users and systems co-evolution.

2 The ICE model

In [BC99], HCI is modelled as a cyclic process, in which the user and the interactive system communicate by materializing and interpreting a sequence of messages (the images on the screen in visual interaction) at successive points in time. These messages are subject to two interpretations: one performed by the user, depending on her/his role in the task, as well as on her/his culture, experience, and skills, and the second internal to the system, as determined by the programs implemented in the system.

In our experiments with users, we found that several usability problems depend on the rigidity of the interactive systems, which are not able to take care of the changes occurring in users' activities and/or in their organizational context. A model-based approach to the design of usable interactive systems must then consider the co-evolution process as well. Indeed, in a working environment augmented by the support of software systems, two processes occur. The first process - the interactive use of the system to perform activities in the application domain - occurs in a short time scale: every activity is the result of a sequence of interaction cycles in which the user applies her/his knowing and reflects on the obtained results, gaining new experience. The second process is the co-evolution of user and system occurring during the use of an interactive system in a long time period.

The ICE model we propose encompasses both interaction and co-evolution processes. The interaction process is modelled as in [BC99], while the co-evolution process is modelled by refining the models in [CR92] and in [BD01]. Specifically, the task-artefact cycle in [CR92] implicitly referred to the co-evolution process by describing that software artefacts are produced to support some user tasks. However, such artefacts suggest new possible tasks so that, to support these new tasks, new artefacts must be created. This task-artefact cycle is denoted as "cycle 1" in Figure 1, indicating a first co-evolution cycle. Technology advances give computer scientists ways of improving interactive systems

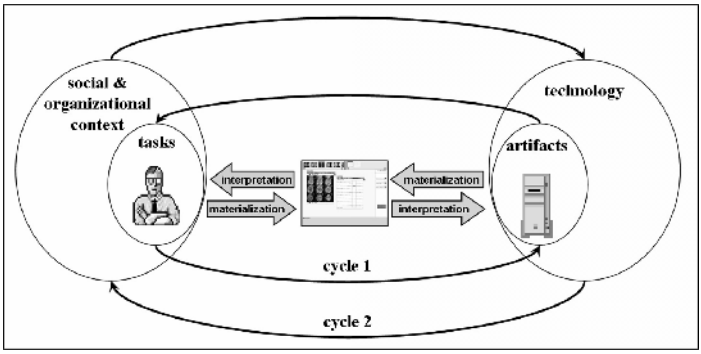

Figure 1. The Interaction and Co-Evolution model.

once they are already in use: this leads to new interaction possibilities that might change users working habits. For example, recently improved voice technology allows software engineers to add voice commands to their systems and this might provide an easier and more natural way of interaction. Also the user socio-organizational context is evolving during time, often requiring new ways of performing tasks. Therefore, technology and socio-organizational contexts repeatedly affect each other: this is represented in our ICE model with a second co-evolution cycle ("cycle 2" in Figure 1). Software engineers are required to produce the tools to support both interaction and co-evolution processes, i.e. they must not only produce interactive systems supporting user activities, but also the tools that permit to tailor [SK97] and evolve the system according to user and organization evolution.

3 Designing Interactive Environments Supporting Co-Evolution

The methodology to design novel interactive systems capable to support people needs has been already presented in [Cm06a]. We briefly recall it here to show its capability of supporting the co-evolution process. In this methodology, software environments are designed in analogy with artisan workshops, i.e., small establishments where artisans, such as blacksmiths and joiners, manipulate raw materials in order to manufacture their artefacts. At each step of their activity, artisans can extract from a repository the tools necessary for the current activity and set back those ones no more needed. In this way, every artisan adapts the environment to her/his needs and has available all and only the tools needed in the specific situation. In analogy, a software environment is designed as a *virtual workshop*, in which the user finds a set of (virtual) tools whose shape, behaviour and management are familiar to her/him. Such an environment allows users to carry out their activities and adapt environment and tools without the burden of using a traditional programming language, but using high level visual languages tailored to their needs. Moreover, users get the feeling of simply manipulating the objects of interest in a way similar to what they might do in the real world. Obviously, while traditional artisans shape real supplies, users shape software artefacts. For this reason we call these environments *Software Shaping Workshops* (SSWs) [Cm06a]. The SSW approach provides each user community with a workshop, called *application workshop*, which supports people in their daily work. An application workshop is customized to users' culture, background and skills, and can possibly be tailored by the users themselves, also by creating new artefacts [Cm06a]. Application workshops are not directly created (and successively evolved) by software engineers, but their design, development and modification are carried out by an interdisciplinary team that, besides software engineers, includes representatives of end users and HCI experts. Each member of the team of experts uses a type of workshop, called *system workshop,* customized to her/his culture, background and skills, in order to carry out the design, development and evolution of other workshops.

Overall, an interactive system to support the work practice in a given application domain is not a monolithic piece of software but it is developed as a network of system and application workshops, each one specific for a community of users. In order to favour the co-evolution process in Figure 1 there are communication paths among application and system workshops. In this way, once the overall interactive system (all workshops of a network) isare in use, the design team has the possibility to observe user activities, the new

usages of the system, the new procedures induced by the evolving organization. Thanks to the communication possibilities the network offers, the design team also receives user complaints and suggestions about the workshops they interact with. The design team updates the system and sometimes also the underlying software technologies. Co-evolution thus results into a cyclic process, in which system usage induces an evolution in the user knowledge, culture and socio-organizational contexts, which in turn induces the evolution of the system functionalities and possibly some changes in the technology on which the system is based. Tailoring and customization tools facilitate this process, allowing users to be active partners in it. The co-evolution process never ends until the interactive system is in use, and it encompasses all stakeholders and workshops in the network.

4 Conclusions

This paper has presented an original model of the interaction and co-evolution processes occurring between humans and interactive systems. This model is at the basis of the SSW methodology to design novel interactive systems that support people activities and are capable to actuate the co-evolution. The feasibility of the SSW methodology has been illustrated through various case studies in the mechanical engineering domain [Cm03] and in the medical domain [Cm06a]. The case study presented in [Cm06b] specifically illustrates how the SSW methodology actually supports users and systems co-evolution. Other examples are under development.

Bibliography

[As02] Arondi, S.; Baroni, P.; Fogli, D.; Mussio, P.: Supporting co-evolution of users and systems by the recognition of Interaction Patterns. Proc. AVI 2002, ACM Press, pp. 177-189.

[BC99] Bottoni, P.; Costabile, M.F.; Mussio, P.: Specification and Dialogue Control of Visual Interaction through Visual Rewriting Systems. ACM TOPLAS, 21(6), 1999; pp. 1077-1136.

[BD01] Bourguin, G.; Derycke, A.; Tarby, J.C.: Beyond the Interface: Co-evolution inside Interactive Systems - A Proposal Founded on Activity Theory, Proc. IHM-HCI 2001.

[Cm03] Costabile, M.F.; Fogli, D.; Fresta, G.; Mussio, P.; Piccinno, A.: Building environments for End-User Development and Tailoring. Proc. IEEE Symposium HCC 03, Auckland, New Zealand, October 28-31, 2003; pp. 31-38.

[Cm06a] Costabile, M.F.; Fogli, D.; Mussio, P.; Piccinno, A.: End-User Development: the Software Shaping Workshop Approach. In (Lieberman, H.; Paternò, F.; Wulf, V. Eds.): End user development. Springer, Dordrecht, The Netherlands, 2006; pp. 183-205.

[Cm06b] Costabile, M.F.; Fogli, D.; Marcante, A.; Piccinno, A.: Supporting Interaction and Co-evolution of Users and Systems. Proc. AVI 2006, ACM Press, pp. 143-150.

[CR92] Carroll, J.M.; Rosson, M.B.: Deliberated Evolution: Stalking the View Matcher in design space. Human-Computer Interaction, 6 (3 and 4), 1992; pp 281-318.

[DW96] Dillon, A.; Watson, C.: User analysis in HCI: the historical lesson from individual differences research. Int. Journal of Human-Computer Studies 1996, 45(6), pp. 619-637.

[Nd05] Norman, D. A.: Human-Centered Design Considered Harmful. Interactions, 12(4), 2005; pp. 14-19.

[Nj93] Nielsen, J.: Usability Engineering, Academic Press, San Diego, 1993.

[SK97] Stiemerling, O.; Kahler, H.; Wulf, V.: How to Make Software Softer - Designing Tailorable Applications. Proc. ACM Symposium DIS 1997, ACM-Press, pp. 365 – 376.

[WR95] Wulf, V.; Rohde, M.: Towards an Integrated Organization and Technology Development. Proc. ACM Symposium DIS 1995, ACM-Press, pp. 55 – 64.