Authentic, Vicarious & Embodied Computer Learning Experiences

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Abstract

This research proposal will investigate new solutions for addressing the problem of acquiring computer skills. Our main hypothesis is that a rich observational experience for users which unfolds not in a video-recorded form (screencasts) but as a real-time imitation of user actions inside the software application to learn, together with a haptic guidance device which mechanically guides the user's hand and signifies the meaning of the interaction with multimodal cues and tactile sensations, can trigger the effortless process of embodied simulation, reduce surface processing strategies of learners, and enhance the efficiency and the effectiveness of the learning process.

We support that if a software application opens up its interface description to developers then it is feasible to program real-time demonstrational scenarios inside the application by firing the suitable user events. We propose that the authentic context of the demonstration together with the different modes of learning interactions being feasible will have a significant influence on all aspects of the learning results. The diffusion of user interface mark up languages such XUL, XAML, etc., make similar solutions realistic in the near future.

We also propose that haptic guidance may significantly improve learning by allowing the subject to more easily make a connection between the verbal and screen instructions and the movement requirements. We will study and reassess several attributes of haptic guidance literature since most related studies have inspected perception rather than situated learning, they did not refer to the computer learning domain and have been conducted with tasks of little value to the participants. We will develop two haptic devices: a haptic mouse with a close resemblance to a mouse and a haptic glove which will transform events and movements in an abstract stimulus through figure movements, gestures formations and tactile sensations.

Extended Synopsis

[Introduction]

Although human-computer interaction research has strived to facilitate the acquisition of software skills, firstly through the design and exploitation of interfaces which have clear intentions, anticipated semiotics, direct manipulations, real world metaphors and various other exciting qualities and, secondly, by designating 'learnability' as one of the most fundamental usability attributes of software applications, most idiosyncratic problems related to computer learning remain unsolved. The "paradox of the active user" (Fu & Gray, 2004) endures since users persist in realizing tasks in an inefficient way even when demonstrably more efficient procedures exist. Computer learning continuous to be a complex task that puts a tremendous burden on all computer users, experienced or not and results in a multiplicity of 'frustrating experiences' and extensive time losses (Lazar, Jones & Shneiderman, 2006).

In this research proposal, we intend to delve into and integrate two approaches for addressing the computer learning problem: a) The first approach refers to software animated demonstrations (SADs or screencasts). SADs, in their primitive form, reproduce a screen-captured usage scenario of a software application and constitute a unique tool for e-learning design, since they promote an easy and affordable way of producing material which is authentic, situated and motivating. b) The second approach refers to haptic learning and haptic guidance. A common concept is that the physical demonstration of a movement may help people learn how to perform it since haptic guidance quickly conveys the actions, while the user gets to do a sort of practice run. Both of these streams of research have indicated that there are several impediments in achieving the goal of acquiring computer skills. We propose that an alteration of the first approach in conjunction with an improved application of the second one for computer learning can create a revolutionary computer learning paradigm.

More specifically, the main hypothesis that we will try to address in this proposal is that a) a richer observational experience for computer learning than SADs, which unfolds not in a video-recorded form but as a real time reproduction of user actions inside the application under investigation and which results in authentic products and experiences b) together with a haptic guidance device which mechanically guides the user's hand in order to demonstrate the required user actions and provides haptic cues for the interpretation of the interaction can trigger the effortless process of embodied simulation, reduce surface processing strategies of learners, help active inferring, provide a safe learning environment and enhance the efficiency and the effectiveness of the learning process. Both of these routes of development are partially explored and their combination is underestimated for different computer user segments.

[Literature Review]

The relevant research is multidisciplinary and includes the fields of screencasts, observational learning (or vicarious learning), multimedia learning, mirror–neuron system, haptic learning, haptic guidance and haptic mouse. The synthesis of these different research fields is by itself innovative since there are no such references yet.

Screencasts: Screencasts are praised mainly for their authenticity (Despotakis, Palaigeorgiou, & Tsoukalas, 2007; Palaigeorgiou & Despotakis, 2010; Palmiter & Elkerton, 1993; Spannagel et al. 2008), since they show transparently and directly the objects manipulated, their transitions and transformations, as well as position and timing information, focus orientation and mouse movements. As students have commented, SADs convey information that is only tacitly communicated by other knowledge sources (Despotakis et al., 2007; Palaigeorgiou & Despotakis, 2010), facilitating the development of a better mental model of human-interface interactions. The primary learning value of SADs is the elimination of the 'referential step' required for the comprehension of textual instructions. Hence, initial learning is fast since students do not spend time interpreting the steps (Palmiter & Elkerton, 1993) and avoid the laborious trial-and-error process. All in all, most users appear to be very willing to use SADs and appreciate their motivational potential. However, SADs have also several weaknesses identified (Palaigeorgiou & Despotakis, 2010; Palmiter & Elkerton, 1993; Spannagel et al. 2008).

Screencasts as an observational learning paradigm: Screencast-based learning constitutes an application of observational learning to computers. The promise in observational learning is that behaviour patterns can be learnt via observation without immediate performance since through observation one forms a conception of how new behaviour patterns are performed, and symbolic construction serves as a guide for action on future occasions (Bandura, 1986). Research on observational learning and computer learning tries to identify the relevant component processes, such as attention, retention, motor reproduction, and motivation, as well as analyzes the results of observational learning in terms of changes in performance, the acquisition of new operants, the acquisition of higher-order operants, the acquisition of conditioned reinforcement by observation and the acquisition of observational learning repertoires (Davis & Yi, 2004; Greer, Dudek-Singer, & Gautreaux, 2006). It also examines approaches to achieving improvement, such as practice, retention enhancement, symbolic mental rehearsal and enactive learning, all of which have been exploited in the evaluation of screencasts from the behavioral modeling perspective.

Screencasts as multimedia learning: Screencasts are based on the multimedia presentation of the demonstrated procedures and hence research on multimedia learning is highly relevant. The cognitive theory of multimedia learning (Mayer, 2005; van Merriënboer & Sweller, 2005) tries to adapt the structure of information, and the way it is presented, to human cognitive architecture, with the goal of developing design guidelines that enable learners to use their full cognitive capacity. In this context, multimedia theory has studied various parameters which influence the effectiveness of multimedia learning presentations which are similar to those mentioned for SADs, such as pacing, split attention effect, modality, segmentation, pre-training, temporal contiguity effects, etc.

Mirror-Neuron System: Recently, the theory of observational learning has acquired a neurobiology counterpart which highlights even more its educational value. Several studies, mainly focused on motor learning, suggest that observation engages the learner in cognitive processes similar to those occurring during physical practice (Blandin et al., 1999). It has been proposed that observation of an action evokes activity in areas of the brain associated with execution of the action, what has been referred to as a "mirror–neuron system" in the human brain. The proposal is that when we observe, we are actually involved in a degree of simulation, perhaps activating a motor program for action. The mirror neuron system seems to play a role in understanding action, that is, in inferring intentions of actions (Rizzolatti 2004). Understanding action enables learning by observing not only what another individual is doing but also why he is doing it. This is assumed critical for attaining transfer, that is, the application of acquired knowledge in new tasks and contexts. New neurobiological research results continuously update our understanding of observational learning.

Haptic learning: It is known that the sense of touch is one of the most informative senses and is inevitable to understand the real world. Nonetheless, the importance of the hand-brain relationship and of the haptic sense modality for learning is not commonly acknowledged and not understood enough. Several theories have been developed that are related to haptic learning. Under the heading of "embodied cognition", a number of theoretical contributions from adjacent fields can be subsumed such as (a) motor theories of perception which indicate that we mentally simulate movements and actions even though we only see them, (b) the enactive approach to cognition and conscious experience which argues that experience is something that humans actively enact as they explore the environment in which they are situated, and (c) sensorimotor contingency theory which suggests that perception is based on the laws relating motor activity and the resulting sensory input and that a conscious experience is something that is done.

Haptic guidance: Haptic guidance is a branch of haptic interaction literature which focuses on devices which physically interact with the participant's limbs during movement training, guiding them along the trajectory of the target motion (Feygin et al. 2002; O'Malley et al. 2006), thus giving the subject a kinesthetic understanding of what is required. A common concept is that physically demonstrating a movement may help people learn how to perform it since it is like offering through the haptic simulation system, the role of an expert in the reinforcement stage. Relatively little research with inconclusive results has been carried out to examine haptic training and it is mostly concerned with motor learning or perception. In several studies, many advantages of haptic training have been identified. Nonetheless, there is also the "guidance hypothesis", which states that providing too much guidance may impair motor learning because it changes the input-output relationship of the task under investigation, and, consequently, prevents the motor system from learning to deal with the actual relationship. A number of studies have validated this hypothesis and this observation is not too far from the "couch potato attitude" identified in screencast-based learning. However, it seems that there is a simplistic interpretation of the guidance hypothesis.

Haptic Mouse: Mouse has long been a platform for exploring haptic interactions. Adding haptic functionality to the mouse is a natural extension of its existing interface capabilities. One of the earliest research applications of the haptic mouse was the layering of haptic cues on conventional graphical interfaces. The Logitech WingMan force feedback mouse was one of the first commercial available devices to mechanically simulate haptic feedback. A number of researchers have proposed different mouse-type haptic interfaces.

[Our aims]

A) Our first aim is to examine the learning effects and the new available affordances of screencasts when the demonstrations of the tasks occur inside the software applications and are not replayed in a video format. Our main hypothesis is that if a software application opens up its interface description to developers then it is feasible to program real-time demonstrational scenarios inside the application by firing the suitable user events. We propose that the authentic context of the demonstration together with the different modes of learning interactions being possible will have a significant influence on all aspects of the learning results (attitudes, learning strategies, pacing selections, learning effectiveness and efficiency). Significant differentiations from the characteristics of screencasts include:

• a better manageable and adaptable learning pace since the reproduction will be based on a semantically enriched scenario of events and actions and the learner will be in control of the speed and the contents of the presentation,

• new modes of instructional interactions since the user and the coaching system can both initiate actions, demonstrate and exercise tasks in the real environment,

• new encoding opportunities for the learners since different algorithms can represent events and actions

in unique ways (by exploiting velocity, focus, coloring paths, thermal maps, etc.),
• freedom for the learner to deviate from the predetermined learning path and take control of examples and exercises whenever he wishes,
• elimination of the intra-presentation split attention effect since learning and practice will be blended in the same environment.

The diffusion of user interface mark up languages such XUL, XAML, HTML etc., makes more feasible similar solutions where third-party software will demonstrate tasks in the original software. We will test the specific concept in rich web-based applications that incorporate a variety of interaction styles (menus, toolbars, point and click, dragging, etc) and tasks. The development of three software components will be required:
• An authoring environment for developing expert usage scenarios which will incorporate typical web-recording mechanisms such as WebInspector (Despotakis, Palaigeorgiou & Tsoukalas, 2003) or ClickTale© and an editor for the scenarios. The authoring environment will record mouse movements in different sampling rates and its recordings will be later transformed in haptic positioning information.
• A XML file format which will describe the mouse pointer positions, the user invoked events and textual, audio or video descriptions that will be presented together with the demonstrations.
•The learning environment which will present and replay the available recordings of the experts' usage, and enable the different modes of interactions inside the original software.

B) Our second aim is to examine the learning effects of the haptic mediation in observational computer learning. In the explanatory stage of learning, haptic training may significantly improve learning by allowing the subject to more easily make a connection between the verbal instruction and the movement requirements. We hypothesize that the haptic cues can trigger the effortless process of embodied simulation by the mirror neuron system. We will study and reassess several attributes of haptic guidance literature since most related studies have inspected perception rather than situated learning, they did not refer to the computer learning domain and have been conducted in laboratory settings with tasks of little value to the participants. We will develop two open-loop impedance controlled systems:
• a haptic mouse with a close resemblance to a mouse in terms of type of grasp, functionality and haptic sense – this device will help us explore the design space from a convergent perspective,
• a haptic glove which will transform events and movements in an abstract stimulus through figure movements, gestures formations and tactile sensations - this device will help us explore the design space from a divergent perspective.
The design process of the haptic devices will involve all relevant steps for designing meaningful and satisfying interaction experiences and will be documented (user analysis, user modeling, scenario-based design, activity theory, task analysis, prototyping, usability evaluation). We are not aiming only to passively reproduce experts' usage scenarios but also to signify the meaning of the interaction with multimodal cues and tactile sensations and, finally, examine significant alterations of the basic model (e.g. disturbance model of haptic guidance, isotonic replay, etc.). New books on haptic devices offer an excellence coverage of technical solutions (Kern 2009; Zadeh 2010) and it is important to note that the mechanical workings will not be of major research interest to us and that the construction will be based on prototyping hardware (ardruino, phidget, etc.). Studies show that even while using an imperfect haptic device, a user quickly adapts to its obstructions, ignores its imperfections and connects haptic stimulation to graphically displayed objects.

C) Our third aim is to examine the combining effects of the two previous proposals.

For each of the first two approaches there will be needed a literature review, a design phase, an attributes exploration phase and comparisons with typical screencasts and "one to one" teaching. Our experiments will be conducted with three user groups: older adults, who are mostly novice users and confront the most difficulties when learning about computers, children who assimilate technology with easiness and undergraduate students which will be indicative of typical users. Data will be collected through multi-factor controlled experiments, logging and automatic metrics, interviews, verbal protocols and questionnaires. We intend to control our results for several aspects of multimodality, influential psychological variables in observational learning (self-efficacy, self-regulation, computer anxiety, achievement motivation), the effects of age, the selection of instructional methods (e.g. guided error training, process-oriented worked examples), the effect of computer experience and task complexity. Our ultimate intention is to understand the conditions under which authentic demonstration of computer tasks with haptic guidance is beneficial for the acquisition of computer learning skills. In contrast to current studies, we will try to develop strong synergies between haptic guidance, screencasts and educational theories.

[Deliverables]:

-A review study synthesizing multidisciplinary research about observational learning, screencasts, multimedia learning, mirror-neuron System, haptic guidance and haptic mouse.
-A software platform for recording and replaying expert's usage scenarios inside web apps.
-Two haptic guidance devices.
-Explorative studies for all products in their design phase. The products will be examined in a variety of forms and attributes before selecting their final configurations for testing.
- Studies that will compare the three products with typical screencasts and one-to-one instruction.
- The proposal for an interface markup language and a generic architecture that will make feasible the authoring and delivery of third-party demonstrational applications.

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