Applying New Interaction Paradigms to the Education of Children with Special Educational Needs

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Abstract. The proliferation of new devices over the last decade has introduced new ways of interaction such us tactile (iPhone [1]) or touchless gesture (Kinect [2]) user interfaces. This opens up new opportunities for the education of children with special needs. However, it also raises new issues. On the one hand, children have to be able to manage different technologies, some of which do not enable natural ways of interaction. On the other hand, software developers have to design applications compatible with many different platforms. This paper offers a state-of-the-art discussion about how new interaction paradigms are being applied in the field of education. As a preliminary conclusion, we have detected the need for a standard on gesture-based interfaces. With this in mind, we propose a roadmap setting out the essential steps to be followed in order to define this standard based on natural hand movements.

Keywords: SEN, Education, Touch, Touchless, Gesture, User Interface, Kinect, Interaction Paradigms.

1 Introduction

Computing has been successfully applied to education over the last few decades [3] [4]. This idea can be extended to education for children with special educational needs (SEN) [5]. However, interaction has been a barrier to applying computing to education for some student profiles. The use of the mouse or keyboard to control software does not come as naturally to younger learners as it does to adults. If the user is a motor impaired child, interaction becomes an accessibility issue.

Human computer interaction (HCI) research is a fast evolving field. These advances have been driven by improvements in user interface (UI) design and the definition of new forms of interaction. Interaction must be supported by devices that enable users to interact more naturally and communicate directly with the computer. Lately, the proliferation of tactile devices and the definition of new ways of interaction based on touchless gesture UIs, such us Kinect [6], are laying the

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groundwork for gesture-based interaction with machines. These interaction mechanisms appear a priori to be more natural than their conventional counterparts.

Up to now, however, no gesture-based interface standard has been defined. It can be confusing for users if different applications use different gestures and actions to enable the same kind of interaction. Users are likely to find applications based on standard gestures easier to use. This calls for the definition of a standard.

But, like many innovative technologies in the past, touch and touchless gesture UI technologies are raising optimistic expectations about how they could change education and have started to be applied in the field of education [7]. Two mistakes have been made over and over again every time a new technology has been introduced into education in the last forty years: over-generalization and over-expectation [7]. Delivering a technology does not by itself turn students into smart, motivated knowledge producers. The technology has to be contextualized, set against educational goals, and fitted into broader processes of learning. Therefore, the new ways of interacting with machines must be analysed in order to define the best way to apply interaction depending on the context. This analysis should be the starting point for introducing new interaction technologies into the education system.

New HCI technologies, such as gesture UIs, are even more important in teaching children with SEN. They, especially, could benefit from the improved accessibility to education offered by these technologies, which could break down some of the barriers still existing today. But before they do, rigorous research should be conducted in order to determine the contexts in which gesture UIs are more likely to be applied with success. As a result, guidelines should be defined for developing and implementing these new interaction techniques in the learning process of children with SEN.

This paper offers a state-of-the-art discussion about how new interaction paradigms are being applied in the field of education. This discussion will be the groundwork for examining the issues that we are likely to come across when teaching children with SEN supported by new interaction devices. Finally, we will describe a roadmap setting out the essential steps for successfully developing teaching tools for children with SEN based on the use of the new interaction paradigms.

2 State of the Art

In recent years, many of the new devices that have come onto the market have changed the face of human-machine interaction. Clear examples are products commercialized by companies such as Nintendo (Wii and DS), Apple (iPad and iPhone) or Microsoft (Surface and Kinect). In this section, we will look at new approaches in this field and their educational applications.

First of all, let us define some terms that will be used in this paper:

- A **gesture** is movement of part of one’s body (e.g. finger, hand, head) that a software application interprets as an action.
- **Touch:** act of bringing a part of one's body (e.g. hand) into contact with an interaction component (e.g. tactile screen). The tactile device may be activated by one touch or several touches (**multi-touch**).

- **Touchless gesture UI:** UI based on contactless gestures (e.g. Kinect).
- **Touch gesture:** contact gesture on a tactile device (e.g. pinching to zoom).

2.1 Standards

We think that standards play an important role in providing a reference for developing accessible systems, especially at the present time when individual companies are going their own separate ways and commercializing devices using different forms of interaction. Standards are necessary to guarantee that we are sure to find the best way of interaction with different devices and electronic systems, depending on the time, environment and user profile.

To the best of our knowledge, the most related standard in this field is ISO/IEC 14754 [8]. ISO/IEC 14754 defines a set of basic gesture commands and feedback for pen interfaces. The gestures include select, delete, insert space, split line, move, copy, cut, paste, scroll and undo. However, ISO members recognize the importance and need for a standard on gesture-based interfaces, and members of Joint Technical Committee 1/Sub Committee 35/ Working Group 1 are working on defining a gesture-based interface standard.

2.2 Multi-touch Gesture and Touchless Gesture UIs

Not long ago Apple revolutionized the field of mobile devices by providing support for user interaction via gestures and actions. Apple introduced two concepts [9]: touches and gestures. Touches are important for keeping track of how many fingers are on the screen, where they are and what they are doing. Gestures are important for determining what users are doing with their two fingers on the screen, that is, pinching, pushing or rotating.

To do this, Apple developed Cocoa [1]. Cocoa is a native object-oriented application programming interface (API) for the Mac OS X operating system and iOS. The Cocoa Touch layer defines the basic application infrastructure and support for key technologies such as touch-based input for gesture recognition (e.g. swipes, pinches). Developers can define their own custom gesture recognizers based on the following standard gestures: tapping (any number of taps), pinching in and out (for zooming), panning or dragging, swiping (in any direction), rotating (moving fingers in opposite directions), and tapping and holding.

Microsoft has developed a similar effort for interacting with Microsoft software using gestures (from Windows to Kinect) [2]. Kinect is to officially interact with Windows and will support better skeletal tracking and improved speech recognition.

2.3 Gesture-Based Screen Reader

The iOS 5 system includes innovative tactile device assistive and accessibility technology. Apple developed the first gesture-based screen reader.

In response to a single tap on the screen, for instance, the screen reader will read what the user’s finger is touching, whereas two taps activate the selected control.

Additionally, users can adjust controls by moving their finger up or down. To move through different controls, all users have to do is just touch the screen and move their finger left or right (panning). This way they will move from one object to another on the screen. The screen reader also provides a control called rotor. This control is useful for changing the way users move from one object to another on the screen. Note, finally, that iOS 5 provides accessibility features not only for sight-impaired people but also for users with other types of disability.

The a priori weakness of this solution is that, for the time being at least, it is only applicable to iOS systems. Also, it would be worthwhile evaluating whether these are the best gestures and settings for devices to be used by children with SEN.

2.4 New Interaction Paradigms in Education

Multi-touch desks [10] or interactive tabletops [7] are tools that help children in the learning process. They are good tools for empowering general competences, such as collaboration and group work.

An interactive tabletop is a computer interface that, as its name indicates, resembles a table: it is usually a horizontal (sometimes oblique) surface and is usually large enough to enable several users to interact simultaneously. User inputs are captured from the position of their fingers and dedicated objects using a wide variety of techniques. The system output is displayed on the tabletop surface.

3 Advantages and Disadvantages

The generalization of new ways of interacting with computers (touch and touchless gesture interfaces, interactive tabletops, ubiquitous devices, tangible UIs, etc.) bids us consider introducing this kind of tools in the classroom to support the learning process. In regard to HCI for education, however, it is more important to examine the roles of pervasive UIs in broader and real-world contexts, especially in classrooms, rather than just in lab settings [11].

Gesture-based interaction furthers the use of both touch and touchless devices for many kinds of applications in education. It can be especially useful for teaching motor impaired students with upper limb impairment unable to make independent finger movements to type, hold, move, or click the mouse, etc. These users are capable of making gestures that can, thanks to gesture-based interaction, be interpreted as specific interaction commands. Note, however, that the gesture recognition algorithms used in interaction devices are based on natural hand movements [12]. Therefore, we expect it to be necessary to (a) define new gestures, which will then have to be (b) carefully tested with real users and, finally, (c) standardized whenever possible.

People with cognitive difficulties, such as children with learning disabilities or developmental disabilities, find it hard to learn to use a mouse. To do this, they have to understand that the same object has more than one function, e.g. left-button click to select, double-click to run, drag and drop, etc. People find these functions easier to understand using hand or body part gestural interaction, as they use their body in the same way as in other everyday situations, i.e. using a hand gesture to point out something, ask for something or pick up something.

To sum up, using body parts (arms, hands, face, head, etc.) instead of external devices (mouse or keyboard, etc.) to interact with computers can improve the use of interactive systems. Like many other advances in the HCI field, its introduction and adoption will be an obstacle course. Most of the hurdles stem from the choice of vocabulary used to define well-known gestures. This does not take into account the diversity of potential users.

Table 1 below summarizes the commonly accepted gestures together with the associated action and users for which these gestures can pose a problem. This table will be extended as the research and standardization process advances.

Table 1. Some gestures and related constraints

Gesture	Associated action	Required ability	User constraints
One/two finger taps (tapping)	Execute	Tap surface with finger/hand sequentially twice with pause between taps	Motor impairment Small children Severe cognitive impairment
Side-to-side slide finger movement (panning	Page up, page down	Rapidly move fingers over surface	Severe mental disorder Small children Motor impairment
Pinching movement (pinching)	Zoom out	Move two fingers toward each other	Severe mental disorder Small children Motor impairment
Circular movement (rotating)	Turn objects	Touch the surface with two fingers and move one finger around the other in a circle	Severe mental disorder Motor impairment
Movement of outstretched hand from one side to another around an axis (wave)	Greet. Start up Kinect	Move hand from side to side from wrist or elbow	Severe mental disorder Motor impairment
Positioning of outstretched arm at a 45º angle with respect to vertical body axis (hover)	Guide/Pause Kinect	Keep outstretched arm in a raised and rather unstable and artificial position	Severe mental disorder Motor impairment
Short, rapid and sudden sideways movement of the hand (swipe)	Scroll Kinect	Move hand rapidly and precisely within a small space	Severe mental disorder Motor impairment
Movement of two fingers to form a circle (rotate)	Move to next semantic item iOS VoiceOver	Simultaneously move two fingers, thumb and forefinger, clockwise or anticlockwise around a central pivot	Motor impairment.
Up and down stroking movement of one or two fingers (scroll)	Move to next control iOS Voice Over	Move one or more fingers up and down	Motor impairment
Combination of a drag and up, down or side-to-side movement	Drag, move objects	Two-movement sequence.	Severe mental disorder Motor impairment
Movements of several body parts at once	Game-specific activities	General dynamic coordination	Severe mental disorder Motor impairment

4 Standardization Procedures

We consider it to be necessary to run several studies in order to determine how suitable different gestures and devices are for use with children with SEN. The results of such studies could be useful for compiling a gesture vocabulary suited for the special needs of each user type for later standardization.

To do this, we design a framework (Fig. 1) to be used to collect data. These data will be the basis for the process of selection and later standardization. Also, the devised framework could be useful for developing final systems that are capable of recommending the best gestures depending on user characteristics.

One of the characteristics of the proposed framework is composed of an interaction vocabulary specifying the different actions that a device can be used to perform, their associated gestures, manipulations and interactions and their purposes. The system will be composed of a module (interaction broker) that will select the best vocabulary depending on the user profile, the available devices and the application requirements.

In the early phases of the study, the interaction broker module will be very simple, and selection will be based on the preliminary hypotheses stated by the accessibility experts (Table 1). Interaction data will be collected from test applications. These data will be evaluated and used to refine the interaction vocabulary database. The interaction broker module will also be improved by defining new interaction vocabulary selection processes for use in an application.

This vocabulary, plus the context in which it was applied (user profile, application domain, operating system, etc.) and the resulting suitability measures, and success and error rates, will provide an important groundwork for standardizing gestures and determining their fitness in different contexts.

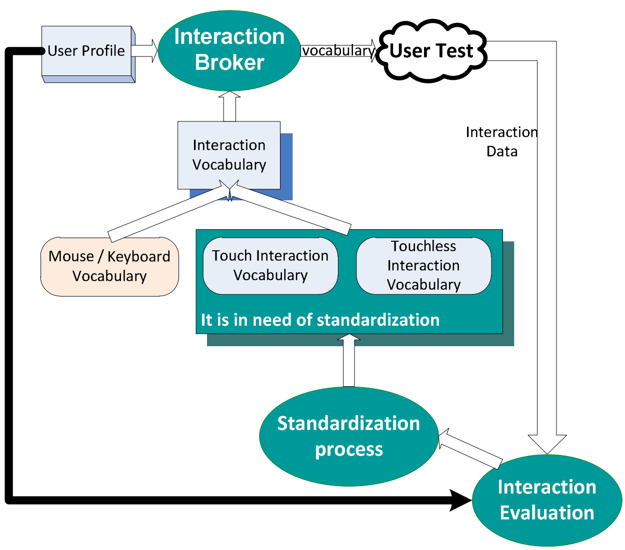

Fig. 1. Proposed architecture

5 Conclusions

New ways of interaction like tactile screens or touchless gesture UIs are becoming popular in personal devices such as smart phones, PCs or video consoles. In order to determine if the new interaction paradigms are suitable for use in education, and particularly for teaching children with SEN, we propose a roadmap with stages that must be carefully negotiated before we can answer this question.

First of all, the new devices should be tested in the classroom by students working on regular teaching activities. These tests will provide valuable feedback about how to apply these interaction paradigms and some guidelines for developing educational tools for classroom use.

For a full and fair assessment, educational UI technologies should be evaluated against learning outcomes bearing in mind the classroom experience. Based on the results of the classroom experience, it will be necessary to define which gestures are best for each and every action (interaction command) and profile. This should be a flexible set of associations where one set of gestures may turn out to mean the same action, whereas similar gestures may mean different actions.

This catalogue of gestures and actions will determine how humans interact with machines. It will be very important for the educational developer community to take into account this catalogue when they start to develop software tools adapted to a wide range of profiles.

This research should provide useful information for establishing standards related to gesture-based interfaces. First, it will help developers to adapt systems to different user profiles. Second, it will help to standardize gestures that make users feel more comfortable when interacting with machines.

References

1. Apple Inc.: Cocoa Touch Layer, `https://developer.apple.com/library/ios/#documentation/Miscellaneous/Conceptual/iPhoneOSTechOverview/iPhoneOSTechnologies/iPhoneOSTechnologies.html#//apple_ref/doc/uid/TP40007898-CH3-SW1`
2. Microsoft. Windows Touch Gestures Overview, `http://msdn.microsoft.com/en-us/library/windows/desktop/dd940543%28v=vs.85%29.aspx`
3. Bruckman, A., Bandlow, A.: Human-computer interaction for kids. In: The Human-Computer Interaction Handbook, pp. 428–440. L. Erlbaum Associates Inc., Hillsdale (2003)
4. Tse, E., Schöning, J., Rogers, Y., Shen, C., Morrison, G.: Next generation of HCI and education: workshop on UI technologies and educational pedagogy. In: Proceedings of the 28th of the International Conference Extended Abstracts on Human Factors in Computing Systems (CHI EA 2010), pp. 4509–4512. ACM, New York (2010)
5. Burgstahler, S.: Computing Services for Disabled Students in Institutions of Higher Education. Ph.D. Dissertation, University of Washington (1992)

6. Grandhi, S.A., Joue, G., Mittelberg, I.: Understanding naturalness and intuitiveness in gesture production: insights for touchless gestural interfaces. In: Proceedings of the 2011 Annual Conference on Human Factors in Computing Systems, pp. 821–824. ACM, New York (2011)
7. Dillenbourg, P., Evans, M.: Interactive tabletops in education. Int. J. Comput.-Support Collab. Learn. 6(4), 491–514 (2011)
8. International Standards Organization, ISO/IEC 14754 Pen-based interfaces - Common gestures for text editing with pen-based systems (1999)
9. SitePen Inc.: Touching and Gesturing on the iPhone, `http://www.sitepen.com/blog/2008/07/10/touching-and-gesturing-on-the-iphone/`
10. Rothman, W.: Education's Many Problems Solved With Multitouch Desks, `http://gizmodo.com/5051486/educations-many-problems-solved-with-multitouch-desks`
11. Do-Lenh, S., Jermann, P., Arn, C., Zufferey, G., Dillenbourg, P.: Classroom-experience evaluation: Evaluating pervasive technologies in a classroom setting. In: Child Computer Interaction: Workshop on UI Technologies and Their Impact on Educational Pedagogy, the ACM International Conference on Human Factors in Computing Systems, CHI 2011 (2011)
12. Yuan, Y., Liu, Y., Barner, K.: Tactile gesture recognition for people with disabilities. In: ICASSP 2005 (2005)