Easing Students' Participation in Class with Hand Gesture Interfaces

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Abstract. Students' participation in traditional classroom settings may be hindered due to various reasons, which interrupt the class flow or cause distraction among the rest of the class members. To tackle that problem, we propose using applications based on touchless hand gestures (THG) that would allow students to interact from their own places. The feasibility of this proposal is analyzed in this work. To do it, we requested students to use two applications from their physical locations. Obtained qualitative results suggest the proposal may be used in an acceptable way as the use of applications based on THG becomes widespread. Actually, students who participated recommend the use of this proposal, since they may be more motivated to participate actively in the development of classes, which would result in better teaching-learning processes.

Keywords: Classroom teaching · Touchless hand gestures · Natural user interface

1 Introduction

Encouraging students' participation in traditional classroom lectures frequently makes teachers ask questions, require students to solve a problem on the blackboard or suggest them to ask questions about the lecture [1]. However, some students may be reluctant to participate in class because they may be shy or nervous, or simply they may be afraid of making mistakes or seem unintelligent. Actually, teachers may experience a drop in participation when these practices are not properly applied [2]. These problems can appear when the teacher asks a student to perform a task on the board in front of the class. This may also interrupt the normal flow of the lecture and cause distraction. One way to tackle the problem is to equip the classroom with enough computers so that each student may use one of them [3]. Alternatively, each student may use her own laptop (e.g., [1]). Given the accessible costs of mobile devices, the teacher could permit the use of students' personal devices, tablets or smartphones instead of laptops to participate in class [2]. Unfortunately, these settings also let students perform activities different than those required for the class [4].

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The interaction using touchless hand gestures (THG) for educational purposes is another option that has been studied especially in recent years. Works reporting about user interfaces (UIs) based on THG are described in [5]. They can be applied with the aim of enhancing classrooms and immersing students in their learning [6–9]. However, most of them require students stand in front of a screen at a certain distance to interact with the applications. This approach has the same problems than the classical one in which a student works in front of the class. The fact that the student has to go to the right place may interrupt the class flow, and cause disorders and students' distraction.

Alternatively, the interaction using THG from students' location may help to promote participation in class, but this approach has yet to be explored. Therefore, and as a first step, the goal of this paper is to analyze the feasibility of using UIs based on THG in classrooms from students' own physical location. We report on initial qualitative results that support this proposal and provide the basis to further investigate it.

2 Touchless Hand Gestures in the Classroom

The development of devices like Kinect and Leap Motion (LM) has induced the emergence of applications allowing users to interact without using intermediate input devices such as mice and keyboards [10]. Applications of this type use as input the information conveyed by gestures performed in the air, and hence, physical contact is not required to manipulate content. Though gestures can be executed with various body parts, we focus only on THG. This interaction style can be "natural" to users [10], and it can be used in scenarios where other interaction styles are inadequate.

Education is an application field where the use of THG can be advantageous. UIs of this type can ease and improve teaching and learning by fabricating meaningful classroom interactions [5]. They may contribute to increase participation, provide a better way to present and manipulate teacher's material, create opportunities for discussion, and overall create enjoyable classes [5]. Several works have been proposed to support/complement/improve the learning of different subjects and languages at the various educational levels [6, 7], to control presentations [8], etc.

Although THG can be employed in several scenarios, we focus just on classrooms. The most frequent use is the learning of specific topics. In this case, a student is required to stand on a specific place in the classroom (e.g., between the whiteboard and the other students) to interact with the application. For example, she can use the hands to manipulate 3D models of organs [9] in an anatomy class. An approach slightly different is the simulation of educational scenarios; e.g., a virtual laboratory [6]. Additionally, devices that enable the use of THG can also ease the development of interactive whiteboards. Works of this type demonstrate that THG can be used to increase the participation and/or motivation of students in classrooms. However, their main disadvantage is that they require a physical space reserved specifically to allow students to use the applications. Alternatively, we propose the use of THG to allow students to interact with applications from their own physical locations.

Our interaction model consists of three phases (Fig. 1): *transferring control* (TC), *participation* (P) and *finishing* (F). A teacher controls the application, and hence, she must transfer control to a student who will perform the required task. Therefore, *transfer control* means the teacher stops being the user who controls the application and the student is able to use it from that moment onwards. Next, the student starts the interaction to carry out the task. Several aspects should be considered for this goal: interaction style (i.e., type of gestures to use), gesture space (i.e., the space to input gestures), gesture set (e.g., see [10]), and student representation (i.e., how a user recognizes her actions). Finally, the student concludes the interaction and control returns to the teacher, who continues with the class or transfers control to another student.

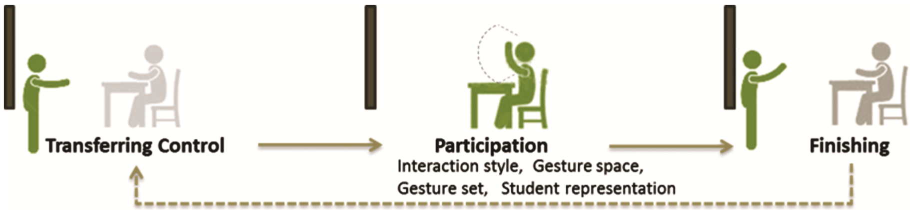

Fig. 1. Proposed concepts for designing hand gesture interfaces for classrooms

A couple of hypothetical examples can further explain our proposal. A teacher is showing slides projected on a screen. A student has a question which refers to the content presented some slides back, but the student does not remember exactly which one. Instead of having the teacher going slides back one by one, the student could take control (TC) of the presentation from his/her spot, and browse through the slides quickly with hand gestures until finding the right one (P). Also, the student can move a cursor over the slide and make marks to highlight the part the question refers to. After this, another student or the teacher can take control (F) and perform other tasks. Another scenario is a Grammar class in primary school. The teacher shows a sentence and asks about mistakes it contains. The teacher selects a student (TC) who starts interacting with the application to answer the question. The student can use various options (P), such as selecting one from several answers via a push gesture, encircling the answer, highlighting it with a marker, etc. Another student or the teacher can then correct a wrong answer, or the application itself can automatically give feedback (F).

3 Initial Evaluation

Taking into account that we were interested in learning about the students' feelings, beliefs, etc. regarding the proposal, we decided to carry out a focus group to collect qualitative data about student perceptions as a starting point. The major goal was to get students' opinions about the proposal by using the developed prototypes.

3.1 Design

The hardware setup consisted of a notebook, a projected display, and two gesture input devices, mounted in a classroom in our university campus. Taking into account there are several devices that can be used to track users' hand positions and recognize gestures, we decided to use and test two of them: Kinect and LM. Both devices were connected to a notebook equipped with an Intel Core i7 processor, 8 GB of RAM. The Kinect was placed at a height of 1 m, and 2.5 m in front of participants, whereas the LM was placed on participant's desk. The wall-projected display, connected to the notebook, had a size of 2 × 2 m and a resolution of 1360 × 768 pixels.

Two prototypes were developed to verify our proposal. Both used a gesture space in front of the user, and students were represented with a hand cursor and a silhouette (at the bottom right). A first application (A1, Fig. 2a) allows users to control a program for presentations (specifically, we used MS Power Point) performing several THG. Students may also make some annotations like circling a word or answer, drawing a shape, etc. Thus, the application allows browsing between slides using swipe gestures; sketching on a slide by tapping a button to enter to and exit from the drawing mode, gripping to start drawing, and releasing for finishing; and erasing the sketch by a wave gesture, all when the Kinect is used. Tap gesture is exchanged for a *thumb gesture* (that is recognized when the user extends her thumb) when the LM is employed. The second application (A2, Fig. 2b) is more specific. It was developed thinking on students of a Data Structures course. A2 allows the building of binary trees based on tap, grip, and release gestures using Kinect, and thumb gestures using LM (the user opens the thumb for gripping and hides it for releasing). To do this, the teacher enters the value of a new node and the student has to insert it in the right place by gripping the node, moving it to the right place, and releasing it. The application lets students perform node rotations to balance the tree according to the AVL-tree rules, make tree traversals and show them, clean the working area, and undo actions.

a) b)

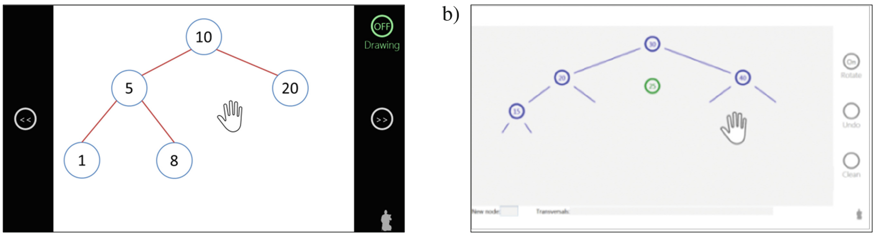

Fig. 2. The developed applications: (a) control a presentation program; (b) build binary trees.

Nine male computer science students (who were not UI designers) volunteered in the focus group. Seven undergraduate students were attending a course on Data Structures; two graduate students completed the group. All participants declared having a basic experience using Wii or Kinect for playing games.

The focus group started with the moderator's (a researcher) explanation about the goal and the use of THG. The moderator explained the idea of using applications based on THG from students' spot, and then he asked the participants to sit down only on the first row to start using the applications. First, the moderator explained the goal and use of A1, and the participants then tried it, first using Kinect, and secondly using LM.

Afterwards, A2 was introduced and used but interchanging the order of the devices. Finally, the moderator encouraged the participants to have a discussion on their preferences, beliefs, and general opinions about the possibility of using this interaction style according to our proposal, the elements included in the applications, the used devices, the perceived comfort, and the interaction (in general) by asking open-ended questions. The focus group lasted about 2 h.

Each participant had to perform several tasks when they were trying the applications. With three slides they had to advance forward and go backwards, and draw their initials (two letters) using A1. Concerning the other application (A2), each participant had to add a node and make a rotation (the options clear and undo were used occasionally when they were needed). Also, the participants took turns performing each task as they would do in a class; i.e., there was a moderator assuming the teacher's role who *transferred control* to each student to participate at the proper moment.

3.2 Results

The results described in this section were obtained from the discussion between the participants after performing the tasks. In general, they gave initial evidence of the feasibility of using THG to interact with applications from students' locations.

Concerning the main topic of interest, all participants agreed this style of interaction could help encourage students to participate in class, and they had no suggestions about the elements of the interfaces. A few comments in this sense were: "*classes will be more interesting if software of this type is used*", "*this proposal is ideal for students like us who love technology*", and "*this proposal could encourage students from secondary and maybe primary schools to participate in class*".

Concerning the used devices, it was not easy to get an agreement because the participants experienced greater precision using LM than using Kinect, but they said they preferred the Kinect interaction. At the end, they decided to choose Kinect as the input device suggesting that it was *fun*, *intuitive*, *involved more body parts*, and they expected an improvement in device precision in the near future.

Despite participants considered the applications as not difficult to learn and use, they mentioned the need to have a short learning curve for best results. They also provided further comments on the interfaces that led to the corresponding improvements. Some examples of this fact were: using both swipe gestures and buttons to navigate, moving the initial node to another place, and changing a couple of colors.

4 Discussion and Conclusion

With the aim of easing students participation during traditional classes and avoiding negative aspects (e.g., distraction and nervousness), we propose to use applications based on THG to allow students to interact from their physical locations. We have thus requested students to use two applications in the proposed manner, and the initial results demonstrate this type of applications could be used in an acceptable way. This proposal takes advantage of the benefits that THG can offer in the learning process. For instance, some activities/tasks could be done in a playful and interactive way contributing to enhance classroom interactions and to ignite student creativity [5].

This proposal may help manage some of the common problems experienced during the delivery of face-to-face classes, but today there are some practical limitations to implement it in real classrooms. They mainly refer to gesture acquisition devices. For example, LM offers acceptable precision to track hands and recognize gestures. However, its tracking space may be not large enough to allow recognizing some gestures. Moreover, student locations would have to be equipped with LMs, which could be comparable with having a mouse on each desktop. On the other hand, current versions of Kinect (and similar devices) can only track up to six people and the performance worsens with a distance over four meters. An alternative may be to use more than one Kinect to track more students and put the sensors at different places (e.g., on the ceiling). This configuration could be tried in the future, but we envision new and better gesture input devices that will track more people, at greater distances and fields of view, and with lower noise levels (e.g., Google's Project Soli).

This work has reported initial results, but it is necessary to perform further research. For example, we should analyze the degree at which this kind of applications would help encourage students to participate in class and avoid negative aspects. We also consider important to ask teachers their opinions about our proposal.

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