

MARKER BASED INTERACTIVE WRITING BOARD FOR PRIMARY LEVEL EDUCATION

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ABSTRACT: White board with marker and black board with chalk are teaching aids without which no one can think of a class room but these traditional teaching aids are currently being replaced by computer based tools. Computer based tools are changing the face of education, the classroom and the teaching methodology. This paper presents a computervision based interactive writing board, which is low cost, easy to use and easy to implement. This writing board enables teachers to attract students to classroom and teach them in an interactive method. Both teachers and students can actively interact with the system during the class. Subjective evaluation revealed that the board was very useful and was easily implementable in educational institutions.

Keywords: Interactive White Board, Information Communication Technology (ICT) based learning, ARToolKit, Augmented Reality and Vision based tracking.

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INTRODUCTION

Traditional teaching aids such as white boards with marker or black boards with chalk are currently being replaced or supplemented by Information Communication Technology (ICT) based modern tools. ICT based tools increase students' motivation in classroom which consequently enhance their learning (Ezziane, 2007). Although, Interactive White Boards (IWBs) have been used in different institutions, particularly for primary level education, since last decade (Northcote *et al.*, 2010). Their use in educational institutions is still limited because of their cost and requirement of training for their use (Manny-Ikanet. *al.*, 2011).

Virtual Reality and Augmented Reality (AR) researchers are working to develop different interactive learning environments for teaching purposes. In these environments, students actively interact with the system than passive one-way of teacher-centered learning style (Yang *et al.*, 2010). Modern technologies brought many changes in learning and teaching methodology. Researchers believe that AR applications will change the teaching environments by adding additional information (Mauro *et al.*, 2014). The AR based education is better than traditional as it provides self-paced learning, which enables individual learners to manage their way of exploration. Students are attracted to computer based interactive classrooms because of their enjoyable nature (Ivanova and Ivanov, 2011). Different methods are used while interacting with AR based applications including direct touch of the hand, tracking of hand and gesture recognition (Radkowski and Stritzke, 2012).

Interactive White Boards are computer based large screens that allow user interaction via touch-screen, used for teaching and learning purposes (Bennett and Lockyer, 2008; Betcher and Lee, 2009). Currently they are used in different educational institutes with different names such as SmartBoards and Webster Boards and electronic white boards (Northcote *et al.*, 2010). With the arrival of IWBs in classrooms, researchers started work to study the technical change, pedagogical change that they may bring to the class room and the way they are used (Higgins *et al.*, 2007). IWBs are becoming popular and are supported by the government funds in some of the countries in the world such as United Kingdom and Australia (Bennett and Lockyer, 2008). On its positive aspects, IWB enhances the learning process and quality of education through active students' interaction and immersion. It enhances the technological skill of the teachers and enables them to become professional. On the negative aspects, it requires pedagogical training of the teachers (Manny-Ikanet. *al.*, 2011; Northcote *et al.*, 2010). Generally, users agree with the use of IWB and they recommend it as a useful tool that helps teachers in delivering their thoughts to students as well as students understanding. On the other hand, teachers cannot make the classroom where students are actively interacting with computers (Turel and Johnson, 2012). Now a days, while using IWBs, all students and teacher in the classroom feel that no other technology can go forward in education than IWBs (Bennett and Lockyer, 2008). Although the IWB may change the way of teaching, and motivate teachers and students, still this may have no significant or measurable impact on achievement (Higgins *et al.*, 2007). The challenging problem with the use of computer based interactive boards is that both teachers

and students need to be fully trained for these boards. The proper placement of these boards in the classroom is also problematic because the visibility to all the students is sometimes impractical due to high light intensity (Smith *et. al.*, 2005).

This paper deals with a low-cost computer vision based interactive writing board that will not only motivate students but will also make their time more valuable. The board has been developed using ARToolKit (Kato *et. al.*, 2000), which allows low cost interaction through fiducial markers. For different types of interactions with the board, different types of fiducial markers are used (see Fig. 1). The board provides the facility of writing, clearing, editing, saving the contents of a lecture, opening an existing lecture snapshot for recap of the previous lectures and closing the board. For each of these interactions, the distance between the marker and camera needs to be less than a predefined threshold which is termed as touch distance.

MATERIALS AND METHODS

The aim of the board was to bring the ICT based teaching to our schools with low cost and in easy fashion. Formaking the board costeffective, it was developed usingARToolKit(Kato *et. al.*, 2000). Different markers were used for different types of interactions including writing, editing, saving, clearing, undo, opening and closing (see Fig. 1).

Each marker was stored in the markers' library and each one was having its event handling module. When a marker was identified and was found near to

camera i.e. in a given region called touch distance the corresponding interaction became active i.e the writing on the board took place with the free movement of the *WRITE* marker in front of the camera in the touch distance. This board consisted of six different modules including Write Edit module, Clear Undo module, Open Save module, Display module, Keyboard module, and Close module. A screen shot of the proposed interactive writing board is shown in Fig.2. Referring to the general working mechanism of the board as is shown in Fig.3, the video camera was continuously fetching the video frame by frame. Whenever a black and white rectangular region was detected, it was then compared with existing markers in the library for marker identification

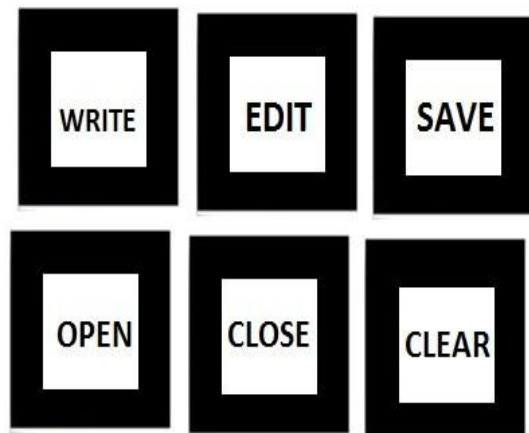


Figure 1. Different types of markers used for interaction with the writing board.



Figure 2. A screen shot of the proposed writing board.

After marker identification, the position and orientation (pose.) of the identified marker relative to the camera was calculated and its corresponding handler was called. The display module continuously changed the contents of the writing board according to the handler

under execution. Different modules of the board are described in the following subsections.

Write Edit Module: Write and Edit Module was the main functionality of the proposed writing board. Both Write and Edit mechanisms consisted of capturing the coordinates of the corresponding detected markers.

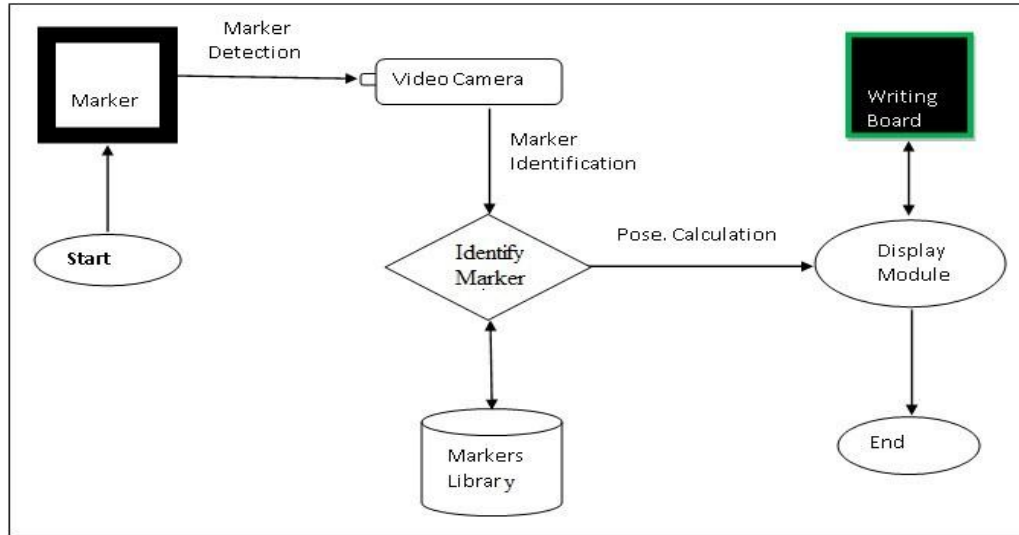


Figure 3. Working mechanism of the writing board

These mechanisms were about the storing or removing of the 3D coordinates and their plotting on the screen.

Write Mechanism: When a marker was detected then it was matched with the specified marker patterns stored in the library. When *write* marker was identified, its x, y and z coordinates were calculated. If the calculated touch distance (in term of z coordinate) was less than or equal to the threshold then the x and y coordinates of the corresponding marker were plotted on the screen. During this time the corresponding button with *write* caption in red background was highlighted on the display screen as shown in the Fig. 2.

Edit Mechanism: Edit mechanism was related to erasing of the text from the display screen. Edit mechanism started when the id of the detected marker was matched with the pattern id of the edit marker in the library. When the identified edit marker was near to the camera in the touch distance, the corresponding x and y coordinates of the edit marker were erased from the screen.

Clear and Undo Module: When the marker was identified as *clear* marker and it was near to the camera in the touch distance, the clear module was executed. During this execution all the plots over screen were removed. When the marker was identified as *undo* marker and it was near to the camera in the touch distance, the *undo* module was executed. During this execution all the removed plots were restored on their respective positions.

Open and Save Module: Open and save module was about the saving of text and shapes in a file and its opening by retrieving of all the coordinates again from the file and its redisplay on the screen.

Open mechanism: Open mechanism consisted of the code which created a virtual keyboard and a file list which showed the list of saved files. When the user entered the file name of the saved file then it was opened and all its coordinates were retrieved and displayed on the screen. When the marker was identified as the *open marker* and its position was within the touch distance, the system began to execute the open module. The name of file that was desired to be opened, was also entered through virtual keyboard.

Save mechanism: When the marker was identified as the *save marker*, and its position was within the touch distance, the save module was called. A dialog box appeared like common file saving where the name of the file was written via keyboard and the snapshot was saved in the list of files for future use.

Display Module: The display consisted of a tool bar with 7 buttons including OPEN, SAVE, CLEAR, EDIT, WRITE, CLOSE and UNDO. The remaining area was reserved for writing and displaying the texts and other shapes. A button was highlighted to red color when its corresponding marker was identified and an event was triggered. For example when the *write marker* was identified the WRITE button became red.

Keyboard Module: Virtual keyboard in our system consisted of a list of the saved files and a text field for entering the file name to open or save the text. Furthermore, keyboard consisted of 3 special keys; enter, backspace and space buttons. In addition, it contained ten numeric buttons and 26 alphabetic buttons as shown in the Fig. 4. The virtual keyboard was displayed whenever the save or the open markers were identified, in this way, it was possible to name a file for saving or to pick an existing file name for opening.

Close Module:When the detected marker was identified as the close marker, the corresponding close module was called. The close module terminated the current application.

For testing the board, a quantitative descriptive research method was used as reported in (Turel and Johnson, 2012) to examine the opinions of teachers about the realism, attractiveness, user satisfaction, skill improvement and usability (recording and reusability of

content), applicability and benefits of the board. Questionnaires were given to the teachers for data collection. In most of the related researches such as (Northcote *et. al.*, 2010; Turel and Johnson, 2012), the data about the board was gathered from the teachers. The board was developed for primary level students but they were kids and could not understand questionnaire, therefore, data was not collected from them.



Figure 4.Screenshot of the keyboard module

At different schools and home tuition centers, the board was evaluated by 45 different teachers among which 9 teachers were female and the remaining were male. Their opinion was collected through a questionnaire, eight questions. For each question four or five options were given from which they had to select one.

RESULTS AND DISCUSSION

Results of the present study are given in Fig.5 and Fig.6. Referring to Fig.5, it was found that the proposed board was highly realistic and attracted users towards the activity. It means that teachers faced no difficulty in using the

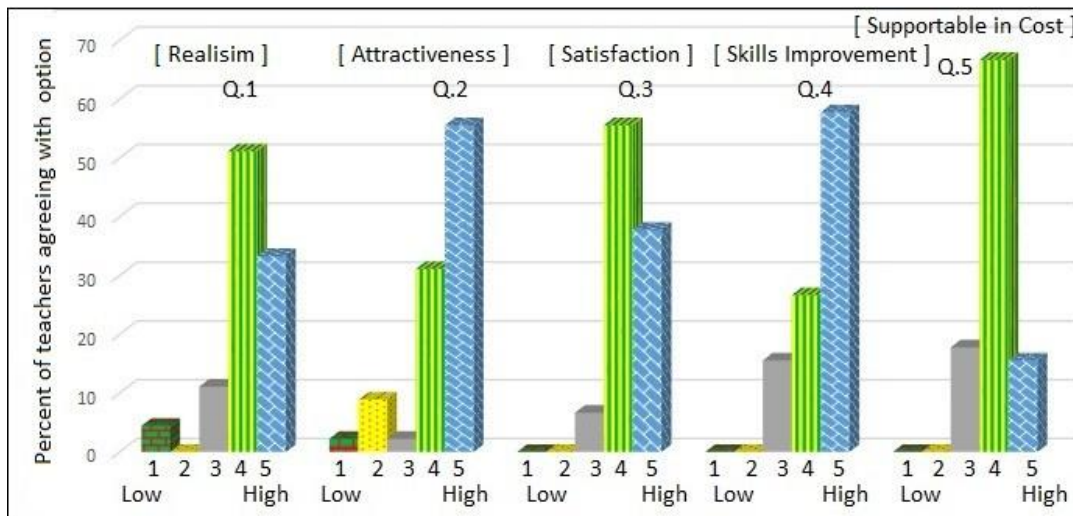


Figure 5.Results of teachers responses on Q.1 to Q.5

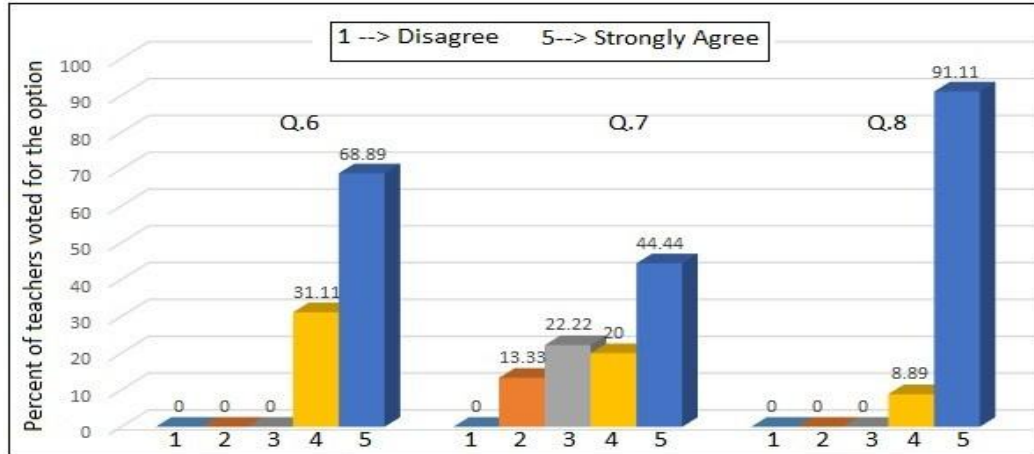


Figure 6. Teachers' responses on Q.6, Q.7 and Q.8

proposed board because they used it without taking prior training and took it like a real board (traditional white board). In contrast, Interactive White Boards were difficult to be used by teachers and students without prior training (Manny-Ikanet. *al.*, 2011; Smith *et. al.*, 2005). In addition, it was found that the proposed board, due to its interactive style, attracted users towards the activity/learning. This result was almost similar to the findings of Ivanova and Ivanov in which they stated that students were attracted to computer based interactive environments because of their enjoyable nature (Ivanova and Ivanov, 2011). The use of IWBs in educational institutions was found to be very limited because of their high cost (Manny-Ikanet. *al.*, 2011). On the other hand, computer vision based writing board was found inexpensive because it did not use any complex hardware except a video camera and a display screen connected to a computer. In this regard, majority of the survey participants agreed to use the proposed board in their educational institutions as is shown in Fig.5. Similarly, it was also found that users' skill improved with successive use of computer vision based writing board and majority of the users were satisfied from its overall performance as shown in Fig.5. Another important attribute of any interactive writing board, was its ability to record the content written on it (Bennett and Lockyer, 2008 and Betcher and Lee, 2009) that was effectively found in the computer vision based writing board as is shown in Fig.6. In pedagogy, it is recommended to recap the previous lecture before starting, it was found that SAVE module in this regard was very beneficial and helped teachers in delivering lectures as is shown in Fig.6.

Conclusion: This paper discussed computer vision based interactive writing board. For making the board cost effective, fiducial markers were used for different types of interactions such as writing, editing, saving, clearing, undo, opening and closing. Evaluation of the board revealed that it will motivate students toward the

classroom and will increase their interest in study. The future aim is to extend the usability of the board to high level classes and provide interactive based virtual environments to the students, especially in the field of Mathematics.

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