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Ultra low Cost Interactive Whiteboard using Computer Vision Techniques: A Review

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Abstract— Whiteboard has played a vital role in our education system, teachers have been using this prop to deliver the daily knowledge capsules using presentations, slide after slide, which has surely left the dusty old chalkboard at par. This whiteboard also allows presenters the ease of annotating as they continue with the slides by using marker and stuff. But this practice has been revolutionized since the introduction of touch sensitive interactive panel. The classes become more interesting and involvement of students grow stronger, the presenters hold a better control on delivering a good session. But unfortunately, it is not accessible to all due to the cost of these fancy boards, which does not help the mass. Since the usage of whiteboard has emerged as a smart classroom property and adopted by various digitally sound organizations, it is therefore in need of cost effective smarter interactive display. Therefore, in this review, the objective is to identify minimal cost of installation of an interactive whiteboard or means to achieve this ideal system preferably with the help of Computer Vision (a trending perception realistic technology in minimizing cost).

Keywords—Computer vision, Image processing, IWBS, Camera, Infrared light

I. INTRODUCTION

Computer vision is an interdisciplinary field that deals with how computers can be made to gain high-level understanding from digital images or videos. From the perspective of engineering, it seeks to automate tasks that the human visual system can do. The low cost system will be using this technology to determine and identify the interaction of the human with the static whiteboard [1].

The way of presenting deliverables has been evolving since the usage of blackboard to plot deliverables, and then came the whiteboard which is a simple plane board used as a screen for visuals to be projected from computers as well used as drawing board. Using this static whiteboard, a sensitive-like panel can be generated with computer vision techniques [6] [10].

The problem of interactive whiteboard carries huge significance in various organisations as numerous presentations are being presented using the whiteboard. It is just a matter of time that we require to nullify this disadvantage and provide the conductors the ease of interactive whiteboard in order to present as desired. It would help create more engaged audience in the understanding of the deliverables.

An interactive whiteboard (IWB) is a special system that consists of a computer, a projector and/or a large display, a stylus, and a number of different types of sensors [2] [6]. Whiteboard with array of wires and setting provides a touch sensitive display which enables to gather user actions by sensing the touch on the board, and then they send the gathered data to computer using several types of connection style such as wired or Wireless or Bluetooth, TUIO. Next, computer processes the data sent by sensors, and reflects the changes to whiteboard by means of projector [2] [11]. The general structure and working style of whiteboards and their costs vary depending on the producers' choices.

The simplest interactive whiteboard consists of a touch screen setup which enables instructor to use his/her finger [14] or IR led pen as a computer mouse [15]. This also permits touching the screen in order to select things, click menu items and/or drag objects on the screen.

Although, there are many different characteristics of Interactive whiteboard System(IWBS), many of the schools, in their selection of IWBS, firstly consider the cost of IWBS, because educational systems of many underdeveloped and developing countries (and even a number of developed countries) have very limited funds and governmental support, and consideration of touch sensitive panel is call for luxury [5]. Thus, to find cheapest and an easy-to-use solution to

IWBS is crucial for these schools and corporations. In the light of this reality, this review is to gather information on systems that are cheaper, more efficient and portable IWBS with Low costing devices than the conventional IWBS.

Computer Vision: Computer Vision will hold a significant role in this work because of its inheriting perception process of multidimensional arrays or images captured by sensors transforming analog data to digital data (computer relevant data). It portrays the fundamental way that a machine can perceive the way a human does on its environment. First off, it has to perform image acquisition in order to retain the data received by the sensor (camera) to its digital form, then the secondary phase of processing of the data (image) is done which represents edge detection, segmentation, as such. Finally, the system has to give meaning to the low level information gathered by analyzing using complex algorithms. Therefore, the system needs to perform these tasks in order to analyze the environment to track the source medium.

It is also an emerging field in virtual vision. It has been used in many futuristic projects involving depth, color, 3d arrays. It can be incorporated in programming languages like python by importing the OpenCV library and is a cross-platform library written in C/C++ [1]. It has to work with the images that will be input by user followed by segmentation, extraction, formulation of meaning based on the purpose of the application itself.

Cost Influence: Since the objective of this review is to research on efficient low cost Interactive Whiteboard System, the paper suggests various techniques proposed by different authors in mitigating the usage of commodity hardware IWBs to low cost systems by means of application of computer vision techniques, free/open source software and minimal hardware setting.

II. BASIC MODEL OF VIRTUAL INTERACTIVE WHITEBOARD

A basic low cost interactive whiteboard model can be portrayed using firstly the two obvious requirements i.e., the projector and the computer system. In order to sense the environment or the projected plane, a sensor (camera, wiimote[8], IR sensor, Kinect[9]) will be used.
On basis of different technical aspect, the interaction can be done using hand gestures, body movements, IR pointer, LASER pointer, [3], etc.

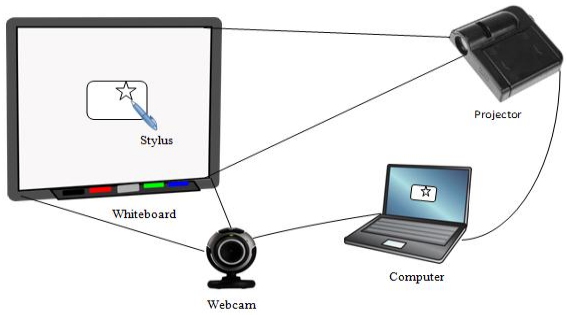

Fig 1: *Model of a basic Interactive Whiteboard*

The model in fig 1 suggests the basic Interactive Whiteboard consist of the following hardware configuration. The projector as shown will illuminate the whiteboard with the data provided by the system, and the sensor (webcam) will sense the whiteboard to track the movement and activity of the stylus in order to find the location on the whiteboard/the projected plane. This extracted location will be treated to the computer system wireless [8] or wired which will be followed by mapping of the projection to that of the system coordinate. Thus, the activity done by the user using stylus or hand gesture should reflect on the system.

III. EXISTING INTERACTIVE WHITEBOARD MODELS

A conventional interactive whiteboard consists of a touch sensitive whiteboard where the whiteboard sends location data on touch by the user with fingertip or stylus onto the board to the computer system to be mapped to the system coordinate.

Resistive panel: Resistive touch screens are made out of two adaptable sheets covered with a resistive material and isolated by a micro thin air hole. At the point when contact is made to the outside of the touch screen, the two sheets are squeezed together, enrolling the exact area of the touch. This innovation enables one to utilize a finger, a stylus, or some other pointing gadget on the outside of the board.

Active Electromagnetic board: These smart whiteboards include a variety of wires installed behind the board surface interfaces with a curl in the stylus tip to decide the (X, Y) facilitate of the stylus. Styli are either active (require a battery or wire back to the whiteboard) or passive (adjust electrical sign created by the board, however contain no batteries or other power source). At the end of the day, there are magnetic sensors in the board that respond and communicate something specific back to the PC when they are actuated by a magnetic pen.

Passive Electromagnetic board: As opposed to an active electromagnetic board this one doesn't contain the detecting

innovation in the board itself, yet in the pen. Modest magnetic fibres are implanted in the whiteboard and structure an example that an electromagnetic curl in the pen can detect. In this manner, the pen can ascertain its area on the whiteboard and sends this data to a PC.

Capacitive panel: Much the same as the electromagnetic sort, the capacitive kind works with a variety of wires behind the board. For this situation anyway the wires collaborate with fingers contacting the screen. The association between the various wires (overlaid in a patented X-and Y-axis form) and the tip of the finger is estimated and determined to a (x, y) facilitate. Different sorts incorporate Projected Capacitive, which utilizes an Indium Tin Oxide (ITO) framework placed between clear film and the most current type utilizing Transparent Electrodes supplanting the ITO.

Wii Remote [8]: In this technology, there is no electronic or electrical appliances attached to the whiteboard. It works on the principle of computer vision techniques, an optical approach. The Wii remote is the Infrared sensor which senses the infrared source or the IR pen on the projected screen which helps the sensor to analyze the location the stylus is pointing to with the intimation of calibration of the projection.

Ultrasonic: This system has two ultrasonic transmitters in two corners and two collectors in the other two corners. The ultrasonic waves are transmitted by the whiteboard surface. Some little stamps in the whiteboard fringes make reflecting waves for each ultrasonic transmitter at various and conspicuous separations. Contacting with a pen or even the finger in the whiteboard causes these direct waves toward be smothered, and the collectors impart the data to the controller.

EyeRIS: It is also an optical based interactive whiteboard by Cybernetyx. It tracks objects in the 3D space and has both the filters of visual light band pass filter and Infrared band pass filter. Using the colour filter it can perceive the pattern of the image, thus calibration can be done automatically. It basically tracks the infrared light emitted by the pen to sense the location of the light source for interactive behaviour.

IV. RELATED WORK

Works reviewed on the basis of minimal expense in creation of the system using Computer vision as tool to achieve the desired system:

In the work presented by Seth Sandler in his blog [3], he devised different ways of creating a touch sensitive panel using Acrylic surface. In one of his work, he used the phenomena of total internal reflection in order to deviate light from the area of contact of the finger. It was done by taking the Acrylic surface, where the light source used was an infrared. The light was passed through the edges of the glass and thus the light could enter the glass or stay trapped in the projection material causing the light to perform total internal reflection from one end to the other end of the edge of the glass panel. In doing so, the purpose of sensing the touch to the panel was achieved by causing a frustration of the light passing through the panel as another object or finger is pressed onto the surface which would obstruct the light and the finger will reflect it to the infrared camera placed parallel to the surface providing it with the location of the frustration and thus it can be used in mapping the area of touch to the system. The system proposes a panel which can be used as multitouch projection plane by simply using the phenomena of Frustrated Total internal reflection of infrared light source in an Acrylic glass panel which is sensed by an infrared band pass filtering camera.

He also proposes some other similar alternatives in creating a multitouch panel using a laser light source, where instead of the frustration on internal reflection [3], he proposed emitting laser light just at the edge just above the surface of the glass. The cohesive light is spread over the surface using a line generating lens, thus when the finger is placed on top of the surface it reflects light to the infrared camera to detect the location at the panel of touch which can be then mapped to the actual system display provisioning the interaction between the human and computer.

This contribution of Johnny Chung Lee [8], also shines light on how wii remote can be tweaked to sense on any surface having infrared light source which can track up to 4 points at a time. The open source software has been published in Microsoft Server in Visual C# code that can be used for further work on wiimote applications on different grounds. He has beautifully demonstrated how four points can be tracked using the wiimote and IR reflectors that were attached on the finger tips to detect finger movements. He also suggests that it can be used as a tool for implementing Interactive whiteboard system. He proposes wii remote for processing the data captured is because of its agile characteristic of obtaining high refresh rates of upto 100Hz is a very positive mark in processing data in real time where large bits of IR dots are sensed, whereas typical camera offers upto 30Hz.

Koray YUCEL, et al. in 2010 conference of ICETC proposed an IWBS model [13], which would give a more accurate annotation contradicting the previous IWB works where the IR source was scattered due to reflection on the surface plane, whereas Koray YUCEL, et al. thought of using two wiimotes instead of one to have a better line of sight with the IR source and they also used splint (generally used in health conditions) instead of an IR pen covering the index finger and providing a direct projection of light to the wiimotes.

Shuai Zhang, et al. in 2012 [9] used Microsoft's Kinect motion sensing device consisting RGB and Depth sensors, the depth sensor is a combination of IR laser projector and a monochrome CMOS sensor. Using the depth sensor, they were able to simulate the right mouse click. Since the depth sensor projects an IR laser, there had to be filtering done to detect IR pen pointer and also to reduce noise. Using CUDA platform combination with the OpenCV functionalities the system tends to have operated fast and efficient in real-time.

In 2014, Toshiyuki Amano [12] explains how he positioned camera and projector in common optical plane which is separated by a beam splitter providing platform for various other augmented applications. He improves the accuracy of the alignment by performing/including an interactive calibration technique which outperforms the conventional calibration.

S. Şimşek and P.O. Durdu [11] uses Kinect to recognize hand gestures in conducting interaction with the whiteboard. It tracks the movement of the hand in front of the projection plane. Kinect as we know has depth sensors availing the option of 3D [9] [11], this advantage is taken in this paper to process the hand in 3D and analyze the mouse activities via the hand gestures. It also uses an environment ILA for the ease of accessing lecturer based learning materials.

Taking in mind the robustness [7] of 3D representation due to its complication and no standard algorithm for accurate recognition of gestures, it is limited to adaptive users with a preset of guidelines. Hand gesture implementations are often sensitive to low resolution, frame rates, lighting, etc [7] [14].

Dai and Chung in this [10] article proposed the use of just the projector and camera to turn any plane of projection interactive/touch-sensitive with finger as an input.

Andre Kellerman, et al. in their conference displayed their work on creating a PC suite for industrial technological growth in the use of Interactive White Board where they chose the cost efficient Whiteboard based on Nintendo wii remote [6]. The work was done to make learning and education for students as simple as possible for a more involved audience [5].

V. SUITABLE DEPLOYMENT PLATFORM

The work on the interactive whiteboard using computer vision provides solution to various aspects of technology. It promotes portability, energy efficiency, innovation, as well reducing the cost contradicting to the conventional method of using interactive whiteboard.

Business meeting: In various business group meetings this days encourage presenting the growth, statistics, etc of the company digitally as presentations, this technology will most probably reach to most and promote interactive sessions. Proper training should be included as for a better accessment of the system.

Classrooms: As the question and survey done [5] on how interactive sessions influence people of different age group, it can be concluded that the more sessions are made interactive the more likely is the participation of students as well as a better platform for the teachers to deliver what was meant to reach the students. As this includes people of different age groups using the system, a periodic training session should be provided by the technical team to ensure proper usage of the system.

Conference hall: This technology can also contribute to the presentation of papers by research scholars and reviewers in conferences for a powerful intimation of deliverables calculated by the author on their work. It would also help promote an active participation.

VI. CONCLUSION

The work proposed in all the literatures are all novel ideas put by enthusiasts in the field of Computer Vision for Cost mitigation and technological advancements. All the works demonstrate the use of photo sensors and their individual aspect of efficient data transformation using Computer Vision techniques. The overall purpose of reducing cost to deliver an interactive system has been achieved by the authors in their work. The paper identifies the need of the titled IWB systems and the vast usage of the Computer vision technology in bringing efficiency to cost and multi disciplinary adaptation of the low cost IWB. Thus, inspiring pioneers in this field to work on similar cost efficient systems for the users.

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