Developing and Establishing a Painting Program Controlled by Hand Motions Using Kinect

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Abstract

With the development on computer hardware and software, computers have become a part of the education. Students perform most of the learning and practical training with computer programs. Using keyboard and mouse is not practical for interaction with computer in classroom. In this study we present a real time painting application by means of which users paint via their hand motions without using mouse or keyboard. The project aims to teach basic shapes and painting to children. This can be an enjoyable teaching method. It can also be used for fun by everyone. In the application; users can select different pens, shapes and colors on interface before painting process. This project is supported by Microsoft Kinect Sensor. Kinect can find 20 skeleton joints on a person's body and it is benefitted from right and left hand skeleton joints

Key words: Virtual painting, Virtual reality, Kinect for Windows, Computer based education, Natural User Interface

1. Introduction

Human Computer Interaction (HCI) is a field of research focusing on the ways people interact with computer. The main purpose of HCI is providing a basis to design and implement computer systems for people to do their activities in a more efficient and safer way [1]. Researches proved that hand gestures play an important role in nonverbal human communication. Therefore, applications allowing to use human hand as an input device became notably popular along with the emergence of virtual reality (VR) field. In those years, many input device sensing hand gesture were designed such as Cyber Glove 2 and IGS-190 [2]. In a study by Dr. Kavaklı et. al., a virtual hand using data gloves was developed. Degree of bending of the toes was calculated by having the user wear data gloves and in this way; recognition of the user's movement was studied. With this method, the figure, which was drawn by the user with his fingers, was plotted on the screen. [3]. Using a standard webcam in their study, Dr. Narejo et. al. carried out real time finger counting and virtual drawing application. For this, they benefited from color detection and shape recognition techniques. For counting fingers; the upper part of each finger are marked with circular shapes, when the user opens his hand in front of the camera round marks are counted with color sensing; in this way, the number of fingers is determined. For virtual drawing, index finger was found by utilizing image processing techniques. Drawing was carried out by determining coordinates that index finger exist on each frame [2].

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While these studies detect hand movements by attaching additional parts (markers) to body; naturalness recently has drawn more attention among the researchers. In particular, development of high-tech devices like Kinect has opened a new horizon in HCI and Natural User Interface (NUI) area has emerged [4]. NUI aims to provide interaction of human capabilities such as touch, sight, sound, movement with the computer without requiring an additional device on user's body. It provides the ability of virtual use to interact with the objects which has complicated and restricted interaction in real life [5]. In their studies, Lee and his team created a new NUI with counting fingers and finger gesture recognition. They used Kinect in their studies. Thanks to depth-based sensors such as Kinect; strong recognitions can be performed even in poor conditions such as rough background, less light [4].

NUI studies are implemented in the field of education as in many areas. In recent years, classical training methods have given place to practical training. NUI studies have been conducted in recent years to ensure that students learn enjoyably. In a study conducted by Echeverria and his team, they developed NUI to teach mathematics to high school students. After that, their survey conducted on users showed that the system affect education in a positive way [6]. Shrawankar and his team allow users to use the system just with their voice in the education portal developed for people with disabilities. In their studies, they benefited from HTK toolkit [7].

The primary purpose of this study is to create a NUI that will allow pre-school and primary school students to learn color and shapes enjoyably. In addition, the system caters to adults with recreational use of it. The user in front of the wide screen monitor in the project draws with hand movements without using any control stick or remote control. Kinect sensor was utilized in the recognition of the person`s hand gesture.

2. System Hardware

There exist a wide variety of equipment and systems developed to detect human motions. Special dresses with sensors providing the coordinates of human joints were employed in the early applications, and then in time, human joints locations were obtained by using marker-supported Computer Vision (CV) applications. Currently, vision based motion sensing systems become prominent without using any markers and special dresses.

Kinect device is a sensor developed by Microsoft to detect human joints. Kinect was originally developed for Xbox game console then adapted to the computer world [8]. In order Kinect to work integrated with computer, it needs to connect to the computer with USB (Universal Serial Bus) and also requires 5V power from an external source [8]. In applications, Kinect device act as camera and transmit the image as photos. In this way, the image is much more easily accessible within the application.

The most significant feature of the Kinect sensor is being able to calculate distance of each point in an image to the camera. For this calculation, Kinect primarily sends infrared rays to user and then calculates turnaround time of these rays to the camera after reflected from the user. In this way, it can calculate the depth information of objects. Depth information can provide great convenience in object segmentation and background removal [9]. Figure 1 shows the images of a scene acquired by Kinect RGB (a) and depth (b) cameras, respectively.

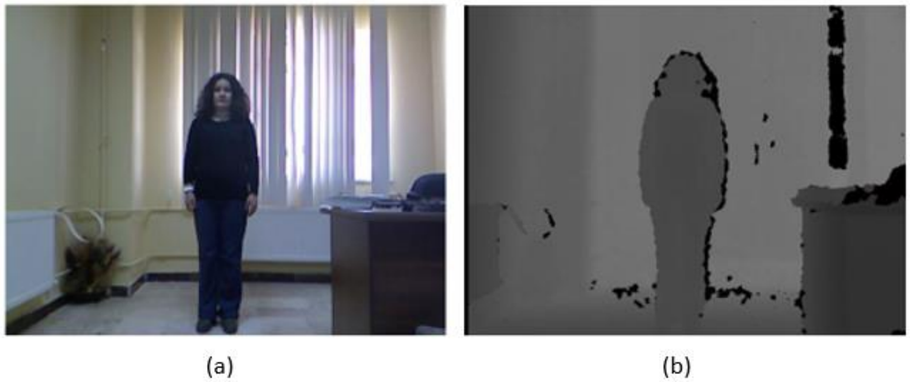

Figure 1. Photograph samples taken from (a) Kinect RGB camera (b) Depth camera [10]

Kinect sensor is capable of detecting 6 persons simultaneously, however, it can monitor only 2 person’s active movements through the equipped camera emitting infrared rays. Many movements that human can perform are defined in Kinect`s software. This software defines the performed movement and sends corresponding specific codes to the computer system. If a movement of person is not detected by the Kinect system or if not defined in the software, Kinect remains constant at the final movement of human [8].

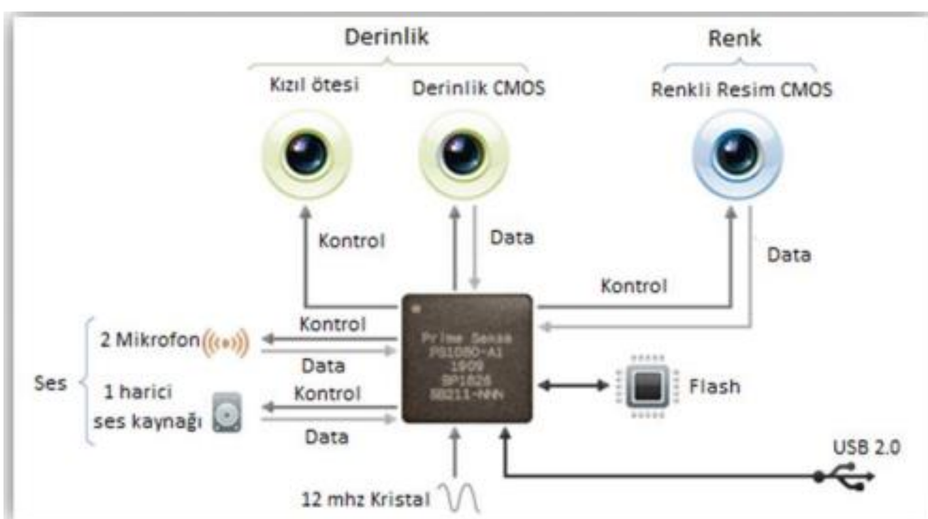

Figure 2. Hardware structure of Kinect sensor [8]

As shown in Figure 2, Kinect has 1 RGB camera, 1 depth camera, 1 infrared radiation source, 4 microphones and an engine mechanism that provides motion. Infrared light source on the left makes laser projection while the sensor on the right shows the distance of each point by calculating the round trip time of these rays. The software within the Kinect calculates the skeletal structure in the light of these data and sends it to XBox or computer. Skeletal postures, which are defined in the Kinect software, used to estimate the invisible part of the skeletal structure even a portion of the human body moves out of sight. [8]. The eye located in the middle of Kinect is a RGB camera with a resolution of 640 x 480 [11]. Currently, there are two drivers for Kinect; Microsoft's official SDK and PrimeSense's OpenNI [12].

Kinect can find 20 joint points of human body. A lot of movement that a person can do is defined on microprocessor software within the Kinect. With giving motion sensing command to Kinect, IR camera emits infrared rays to the points where human`s hand, arm and foot could go. If human is detected at these points, CMOS sensors open and movement begins to be defined. If this movement is defined in microprocessor software, signal is sent to the computer, if not, Kinect is put on hold. [8]. Figure 3 shows the joint points of human skeleton.

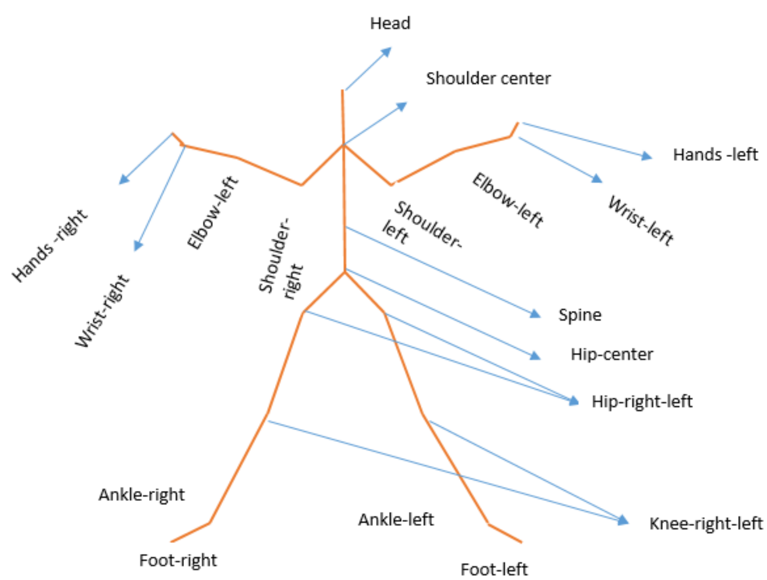

Figure 3. Human skeletal joints that Kinect Sensor found [8]

3. Real Time Painting program with Kinect

In this study, a Kinect-based NUI interface has been carried out and applied on a developed painting program. Although painting program is for general purpose, it aims the use of primary school students and children in accordance with Fatih Project. System was designed for teaching basic shapes and colors to the children. Therefore, system interface contains available geometric shapes and color selection tool. As well as the user can draw shapes taking advantage of available tools, he/she can prefer utilizing different pen options such as ink, spraying and solid. The user can also paint the shapes which were drawn using the color setting tool.

Painting and drawing program contains basic drawing tools such as; brush, filling, spraying, painting, etc. that user can chose with his movements, and basic graph drawing tools such as; color selection and circle, rectangle, etc. User selects the drawing tool or drawing object, to provide stability for selection, the hand is kept still for a certain time on the object or tool that have been chosen. During this period a slide bar starts to fill and when this bar exceeds 50%, the selection is performed. After performing selections and adjustments, passed to the drawing screen and drawing is applied with the use of right or both hands.

3.1. Detection of hand gestures

Using Microsoft Kinect SDK, x, y, z position information of user`s 20 joints was obtained. In application, the joints in the upper part of the body were used. The distance between the joints of the hands and neck with Kinect is calculated. For this calculation, depth map obtained from Kinect is utilized. Z value differences between the user's neck and hands are calculated. For the system to have a stable structure, cursor control is achieved when the distance difference of neck and hands is 40 cm. In other words, when the difference falls below 40 cm, cursor control will be released. Required rules have been created and realized with success for classification of human movements and the tasks of these movements in the program.

Kinect program captures 30 frames per second. In each frame, depending on the distance between the hands and the neck, command selection or drawing is continued. In Figure 4, the program and it`s interface were given. Color selection screen shots were given in Figure 5.

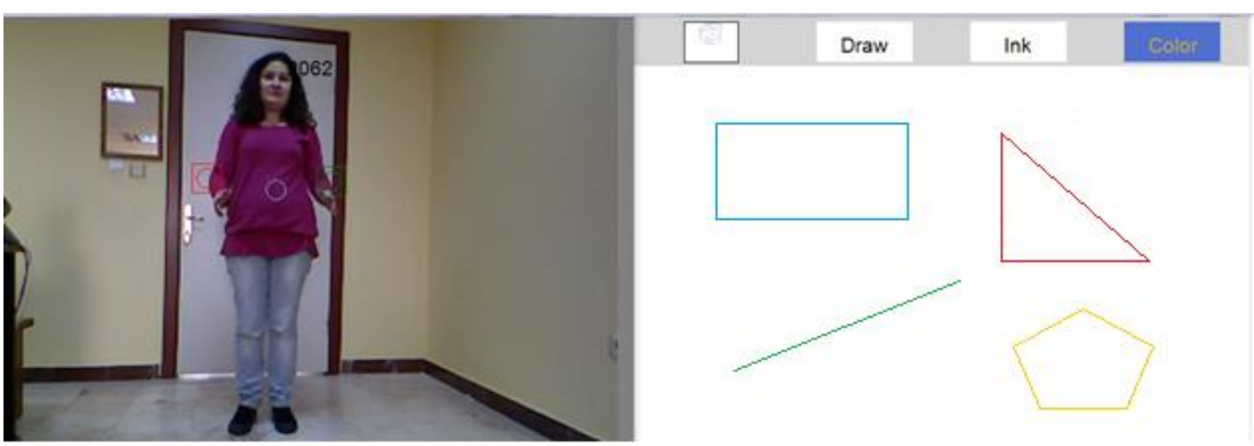

Figure 1. Drawing trials in application

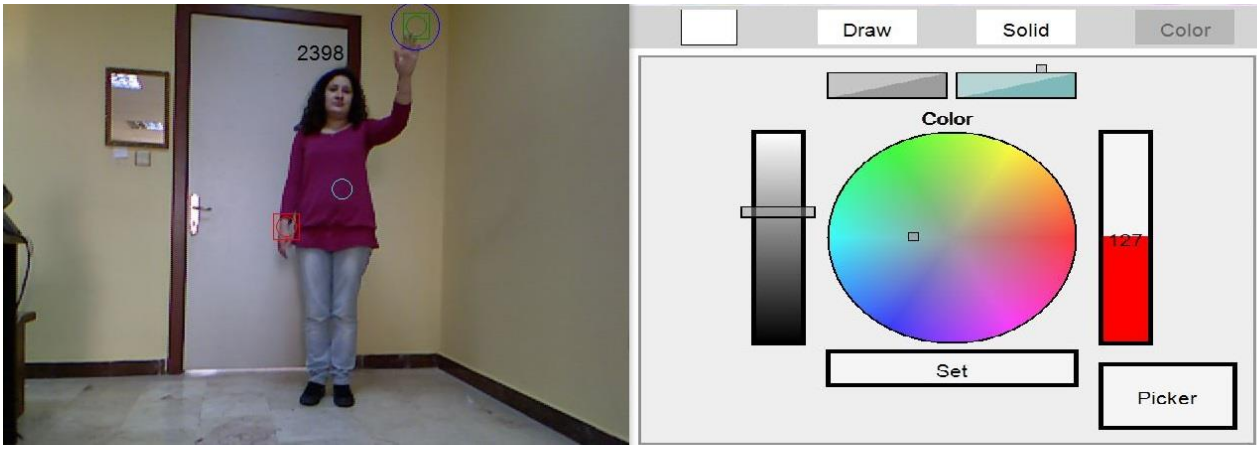

Figure 2. Color selection interface of application

Conclusions and Recommendations

In this study, NUI approach was presented for the real-time drawing and painting program. The Kinect sensor was used in the study. Hand joint coordinates was calculated with Kinect skeleton map data without requiring additional sensor in user`s body. Drawing and painting was provided with hand gestures on the screen. To make drawing in case the user's hand is in front, Kinect depth map data were utilized. If the hand is ahead of at least 40 cm from shoulder, drawing operation is triggered.

The primary objective of the study is teaching basic shapes and colors to pre-school and elementary school students and having them adopt the habit of painting enjoyably. Adults also can use the program. New tools and drawing objects can be added to the program. By making the rule base flexible, objects and features added can be performed by user and automatically. For drawing basic shapes such as square, rectangle, etc., automatic correction mechanisms of drawing can be given.

Also, features such as saving and deleting of drawings or updating may be added to the application. Using artificial intelligence, providing feedback to the users can be possible regarding how a shape drawn by user resembles it`s true state. Thus, more effective learning for children can be achieved. In addition, for the user, looking at the pre-drawn shapes and making comparisons can be achieved by creating database. Furthermore, the application may appeal to a wider audience.

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