Available online at www.sciencedirect.com
ScienceDirect
Procedia Computer Science 22 (2013) 717 – 726
Procedia Computer Science

17th International Conference in Knowledge Based and Intelligent Information and Engineering Systems - KES2013

Detecting eye blinking of a real-world student and introducing to the virtual e-Learning environment

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Abstract

The approach of e-Learning has become a powerful way to deliver knowledge considering the increase in on-line users. Virtual classes that utilize the method of synchronous e-Learning have an Avatar to represent the human user. However, the Avatar in virtual class acts like a puppet, and it has a very small connection with the real user. All of the participants of the virtual class are represented by a naturalistic Avatar without any expressions. Non-verbal communication is a very essential element in the educational process, and it increases the student's performance. One of the main non-verbal communications is by facial expressions, which have been introduced to the virtual world previously. This paper discusses the method of introducing students' Eye Blinking (EB) into the Avatar in the virtual world because EB is one of the major non-verbal communication methods, and it can be used to identify the student's status during the e-Learning sessions. Therefore, an Eye Blinking Visualization System (EBVS) is constructed to establish a rich connection between the Avatar and the real user, as an implementation of non-verbal communication in a class of virtual e-Learning. A system of EB detection in the real world was constructed in which eye blinks are represented through the animations of furry Avatar in the virtual world. The real world and the virtual world are connected by an external server to transfer the EB from the real world to the virtual world. Ultimately, the EB pattern of the real user is visualized in the virtual e-Learning environment through the furry Avatar. When the system is implemented, it takes an average of 2.5 seconds to transfer the information, which is a comparatively short time. When the real user is blinking his/her eyes, the eye blink appears in the virtual e-Learning environment within a very short period of time. Students can communicate more smoothly, friendly, effectively and they feel as a real world classroom environment even though they are engaging with e-Learning through the EBVS. This system can be supplied eye contact and non-verbal communications which are very essential elements in the learning field.

Keywords : Eye blinking; Avatar; Virtual environment, e-Learning

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doi:10.1016/j.procs.2013.09.153

1. Introduction

Currently, the Internet makes a huge effect to the society and it creates a new revolution in the 21st century. Everything and everyone is getting on-line. With the development of information and communication technology, the field of education cannot be isolated without getting involved to the Internet. Computer based learning or on-line learning that can be referred as e-Learning.

e-Learning refers to the use of different ways in different sectors and different peoples. In universities, it is used as a specific method to convey a content of a course or a program to the on-line students. e-Learning is used to give training through a company network in the field of business. On-line education is a fast developing area in the field of education and it is widely used in many universities and for many researches. When the traditional education system transformed to e-Learning, it carries several benefits. It can produce great results by decreasing costs and improving performance [1]. e-Learning allows for a learning environment where there is a better focus on study due to the effect of saved efforts, time and lesser hassles.

e-Learning is a broad concept and it consists with different types, namely Synchronous and Asynchronous e-Learning [2]. Both methods have different characteristics and they use different methods to broadcast the learning materials. Asynchronous e-Learning occurs when students begin and complete their training courses at different times according to their own schedule. Synchronous e-Learning allows real-time interaction and raises a sense of community among learners. The characteristics and the conducting way of e-Learning types are shown in Table 1[3-5].

Synchronous e-Learning is very effective than Asynchronous e-Learning. Because the student commitment and motivation can be enhanced with Synchronous e-Learning this includes features like face to face format and quick responses with instant messaging. Students with a sense of presence in a Synchronous, the on-line class will have a higher degree of satisfaction with the course [6].

In this research, one of the Synchronous e-Learning types called virtual classroom is utilized to share knowledge among the students since it is duplicated most of the capabilities found in a real classroom. The virtual class is used as a meeting place and the students and the instructors use their computers to go to a virtual meeting place instead of a classroom. The instructor can choose the different teaching methods including slide presentation, shared

Table 1. Details of the Asynchronous and Synchronous e-Learning

E-Learning types	Common features	Conducting ways
Asynchronous e-Learning	Intermittent on-demand access	Message boards
	Previously recorded or pre produced	Discussion groups
	Just in time □	Self-paced courses
	Individual or poorly collaborative □	Computer aided system
	Independent learning	podcasting
	Self-paced	Web-based training
Synchronous e-Learning	Real-time □	Shared whiteboard
	Live □	Virtual classrooms
	Scheduled	Audio and Video Conferencing
	Collaborative □	On-line chat
	Co-presence of learners and	Application sharing
	Concurrent learning	Instant messaging

whiteboard, application sharing etc. The instructor and the students can use voice, instant messaging and chat to communicate their learning matters. The students can work together within a group wise and the instructor can present his questions to the students.

Nagaoka University of technology in Japan has an island in Second Life which is used as a virtual space in this research. It is a three dimensional space which is nearly closer to the real world environment. In that space, classrooms were built and it looks like a real world classrooms. The Avatars are active on behalf of the human users in the virtual e-Learning class. But the problem is the connection between the Avatar and the real user. If the user types in a command or clicks a button, the Avatar can be made to run, fight, fly, chat, or change into another form. The Avatar functions as the user's agent of action in the virtual world. It acts like a puppet according to the real user commands. Further, the emotional context is often lost when communicating over a distance through media tools in the virtual class and the ability to express the emotional states in the way one is accustomed to a face-to-face conversation. Not only the emotion but also the body movements are difficult to connect between the real user and the virtual Avatar. Therefore, the real user has very low connection with his/her Avatar in the virtual world.

In this paper, we discuss the way of establishing a rich connection between the real user and the Avatar through a one of non-verbal communication method called eye blinking. We try to develop a system to acquire the real user EB information and to transfer it to the virtual learning environment. When the students and the instructor are engaging with in the virtual e-Learning environment, their EB is visualized through an Avatar is the ultimate effort of this research.

2. Previous work

An Avatar is an electronic image that represents and is manipulated by a computer user [7]. When the users enter to the virtual e-Learning environment to the Interact with others at the first time, they have chance to select their Avatar. They present themselves by selecting a preferred Avatar. When user represents by their Avatars, it is affected to the others perceptions based on the appearance of the Avatar [8]. Another researcher found that the effect of behavioral confirmation clearly plays a crucial role in social interactions. They conducted an experiment and participants who were assigned more attractive Avatars tended to move closer towards the other Avatars than did those with less attractive Avatars. Finally, participants with more attractive Avatars exhibited increased self-disclosure and presented more information about them compared to participants with less attractive Avatars. They showed that peoples' behaviors based on their Avatars were independent of others' perceptions of the Avatars [9]. Another finding indicates that clothing of the Avatar influences not only for the way people are perceived, but also for the way they act as well [10].

Our virtual e-Learning environment, Second Life indicates that they can change the Avatar appearance using over 150 unique sliders and they can change everything from their foot size to their eye color [11]. Self-representation is very important thing in the on-line environment and the fundamental thing for the virtual identity. There is a direct relation between the ability to interact with the environment with each other and the quality of a user's representation. [12]

Through the previous findings, the way of Avatar appearance and the representation way is highly affected to the virtual education environment. This research focuses the change of the appearance of the Avatar with some characteristics of a real human; especially the nonverbal features through the connection between user and his/her Avatar. Because of the following evidences indicate that the non-verbal features play a major role in the educational field. Researchers found that the instructor can decide whether there is a need to check for comprehension, provide more or a different kind of instruction, or assign more practice through the observation and interpretation of students' body language and expressions [13]. The instructor can use the non-verbal cues to refocus their teaching and to help students to make their learning more efficiently and more effectively [14].

There are many ways to humans to display their expressions. The most natural way to display expressions is using facial expressions [15]. In the initial stage of this research, the facial expression was introduced to the virtual learning world. The system was established to display real user facial expressions in the virtual learning environment through a face of Avatar using the mirror technique [16]. Then the other non-verbal features need to be considered to introduce to the virtual e-Learning world.

Another research has indicated that the eye behavior is one of the potent nonverbal gestures and it has ability to create impressions on people [17]. They have investigated the effect of eye contact, gaze and gaze avoidance on impressions. Eye contact and eye gaze are frequently related with a positive impression and the opposite way reflects the negative impression [18]. They discovered that the more pleasant and attractive person has dilated-pupils [19]. In addition, EB can be used to identify the person's state and EB rate is differ from person to person. The EB rate was analyzed during a lecture session and an exercise session using university students. There was a good relationship between students' EB and their activities. Student status can be predicted based on the eye blinking. When the EB frequency increased, students become more nervous and more careless [20]. Another researcher reported a significant increase in EB frequency when subjects were required to solve anagrams than when resting [21]. In addition, when the people are conversing or involving in an interview also showed increased in blink frequency [22]. Increased blink frequency generally reflects negative mood states such as nervousness, stress and fatigue. Negative emotional states that accompany poor performance have been related to increase in blinking. Higher frequency of eye blinks can be observed in stressful situations [23].

The low eye blink rate can be observed during reading and engaging with computer. More positive states are accompanied by decreased blink frequency. The Blink rate slows after hypnotic relaxation and successful problem solving. Hedonia-blink hypothesis indicates that the decreased blinking is related to pleasant feelings, whereas increased frequency of blinks accompanies unpleasant mood states [22]. The blink frequency decreased when individuals gave close attention to outside visual events, perhaps to facilitate information processing. The blink rate generally decreases under conditions of high visual and/or cognitive load [24]. The lower blink rate was found for a 6-item than a 2-item memory set [25]. The blinks are delayed until decisions about external stimuli have been made and responses to those stimuli completed. So, the blink rate and duration may be related to cognitive functions such as decision-making and discrimination. This suggests that a lower blink rate reflects the greater attention demanded for performing more difficult task.

The rate of the EB is important not only for the education but also for the other areas especially in identifying diseases and safety in driving. The blink rate and duration of the blink were both less in a visual task than an auditory one. The time eyes remain closed during blinking also has the relation to the activity which is carried by that person [26].

Based on the literature review, it is identified that the Avatar appearance and the way of representation are highly affected to the behavioral pattern and it makes the huge effect to the other's perceptions. In addition, the importance of the non-verbal communication in the learning process is recognized. Although facial expression is a major category of nonverbal communication, it is already introduced to the virtual learning environment. Then another non-verbal communication method EB was discussed and identified the importance of analyzing it. Eliminating the non-verbal communication barriers and improving the effectiveness of virtual learning are the access point of this research. It can be done through the creating of expressive Avatar for establishing non-verbal communication between the instructor and the student through extracting the real user EB in an effective way. Then student status can be identified through an analysis tools during the learning sessions with the expressive Avatar. These are the major tasks of this research as a contribution to increase the use-fullness of e-Learning and overcome the present drawbacks.

3. Methodology

The EBVS of the real user in the virtual world is needed to be constructed to improve the connection between the student and the instructor. A part of the system is considered the real user in the real world and the remaining part is fulfilled by the Avatar in the virtual world. The process which is used to complete this target is included four major steps. Those steps are indicated as follows.

- Detection of the real user EB
- Preparation an Avatar changing modes
- Establishment of the connection between the real world and the virtual world
- Construction an EB analysis tools

3.1. Architecture of the system

The architecture of the whole system including the EBVS and the way of processing is shown in Figure 1. Initially, the students and the instructors can directly enter to the virtual learning place. The EB detection system is also activated to identify the real user EB as a parallel process. The obtained EB information need to be delivered to the virtual learning environment to change the Avatar appearance based on the real user. But it is difficult to transfer the information directly to the virtual world without any intermediair.

In this system, a server is utilized as an intermediair as shown in Figure 1. Therefore the relevant information is transferred through the external server which is located in Nagaoka University of Technology. In this process, the server helps to transfer the information to the virtual world and it stores the user's information. When the information delivered to the virtual world, the relevant states of the eyes are appeared. This is the real time process and instantly, the real user information was delivered. Then the Avatar blinks his eyes based on the relevant user's blinking pattern. Then the next activity is to analyze the EB patterns of the student. The stored information is utilized and student the status can be identified. During the learning session, the student status need to be appeared which is helpful to the instructor to conduct the learning session effectively. In addition, having the finished learning session, the EB information of the student can be extracted and behavior of the each student can be evaluated based on the EB information.

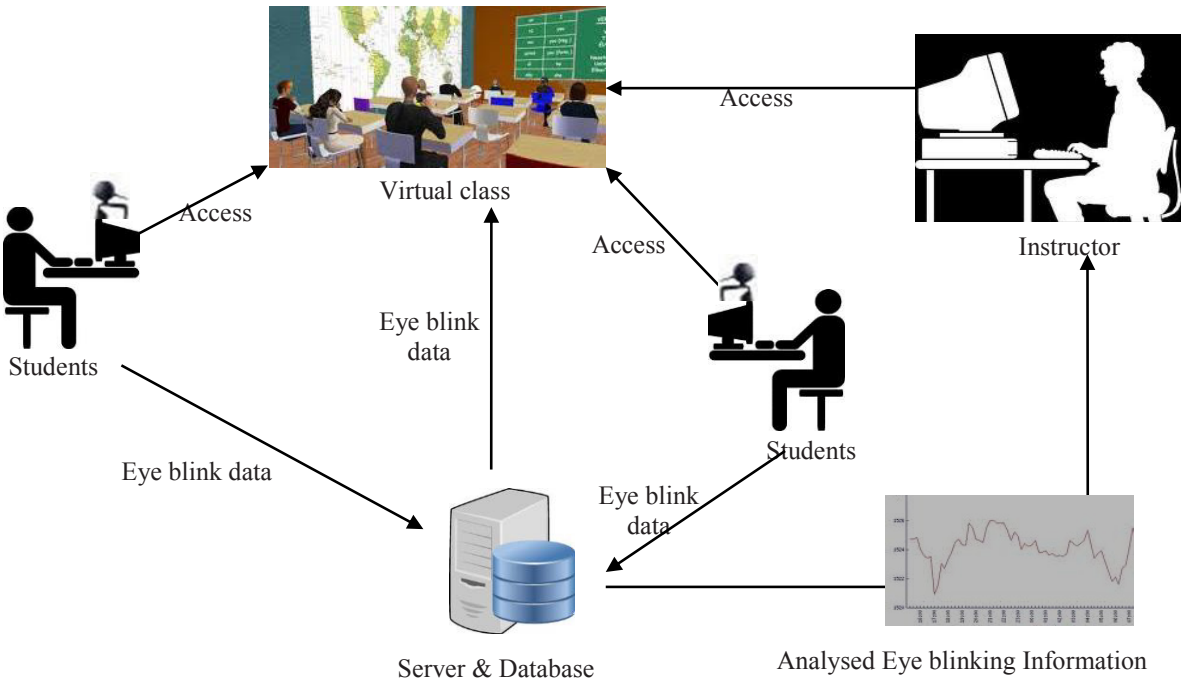

Fig. 1. Architecture of the system

3.2. Eye blinking detection system

This is the first step to establish the Avatar EB with the connection of the real user. In this research, a complex method cannot be used to detect the EB since it may take some time to detect the EB and reduce the reality of the process because of the time delay between the EB of the real user and the Avatar. The process is described using the following Figure 2. Initially, a video of the real user needs to be obtained at the real time. Then the frame should be captured from a video. Instead of the video, one by one frame is obtained for the further analysis. Before detecting the eye blinking, the face of the user should be identified. Haar feature cascade classification is used to detect the face area of the user. When the face of the user is detected, the eyes should be available. Otherwise the frame is neglected and the process starts from the beginning with the next frame.

If the face is detected, then the eyes area can be defined in rough way, because it is easy to identify the eyes without finding in the entire face. Threshold and Haar feature cascade classification are also used to detect the eyes of the user. When the eyes are detected, the states of the eyes need to be identified to clarify whether the eyes are open or not. Threshold concept is used to determine whether the eyes are open or not. When the face is detected and the eyes are closed means the user is blinking. When the face is detected and open eyes mean the user is not blinking. If the user is not available in the seat, the face is not detected. If the face is detected and eye blink is not appeared in a long time means the user may utilize an image instead of the user. The EB can be detected when those steps are followed.

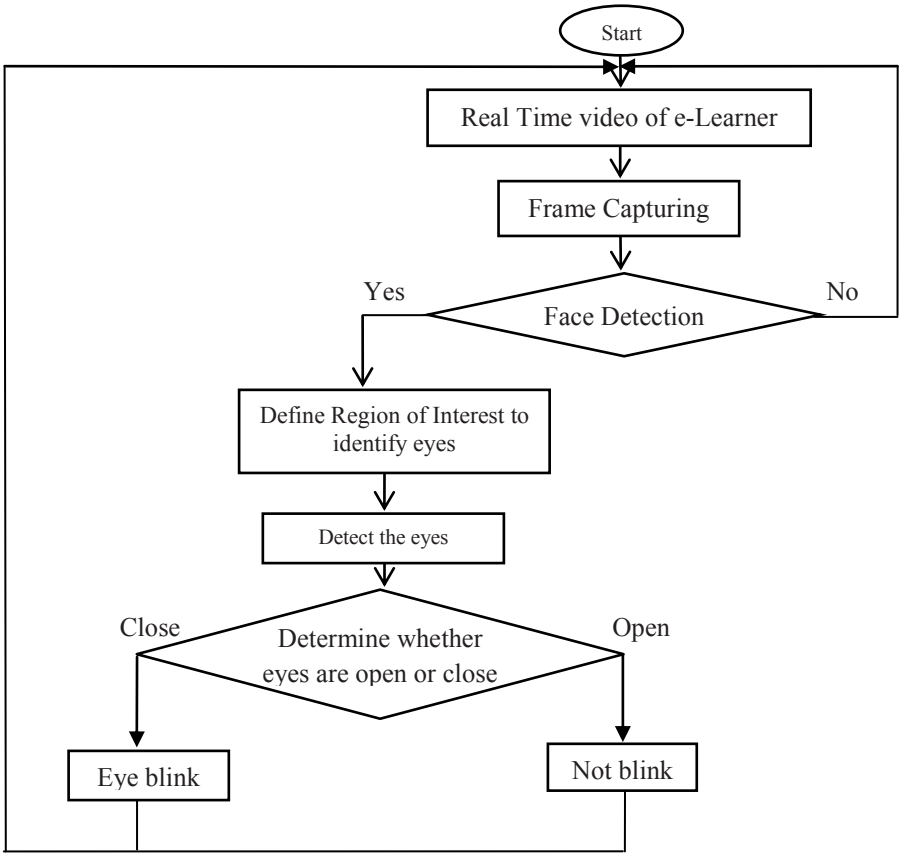

Fig. 2. Eye blinking detection system

3.3. Avatar models

In the virtual environment, the Avatar represents a natural way without any special expressions or any characteristics belong to the real user. The Avatar modification related to the appearance is possible through an outfit changing and wearing items. User can change the appearance before or after the learning session, but not during the learning session and it is based on the real user's preference. It is not the actual appearance of the real user is a main issue. The virtual world provides the methods of changing Avatar appearance in a static way. But it is based on the user preference and not dynamic. In here, a dynamic Avatar changing system is necessary to visualize the real user face changes in the virtual world. So there are no simple ways to do the Avatar face changes in a dynamic way.

This is the second major step of this process to construct the Avatar models for visualizing the eye blinking. Although the target of this research is to implement the EB to the virtual Avatar, creating Avatar modules to represent the EB is not an easy task. Therefore, initially we tried to construct a furry Avatar EB module. In the virtual environment, the furry Avatar EB models are also not available. But it can be prepared using prims (objects) which are available in the virtual world. Therefore we constructed the EB modules of a furry Avatar.

A primitive, or prim, is a single-part object. There are eight primitive shapes are available in the virtual environment and it is indicated in Figure 3(a). Multi-part objects can be developed using these prims. Objects are made from prims are usually created in-world using the built-in object editing tool. A different type of object which is needed to construct the head of the furry Avatar is designed using available limited prims through the editing tools. The developed objects are appeared in Figure 3(b). Next activity is to link the developed objects to represent the ears, face area including the head, hair, mouth and nose as shown in Figure 3(c). When the head and the parts of the head are finished, the texture and the color of the prims need to be adjusted to represent the head of the furry Avatar. The color, texture of the prims can also be adjusted, and some images (textures) can be applied to each surface (face/side) of a prim to change its appearance. The object with textures and colors to represent the head of the furry is shown in Figure 3(d). Finally, the prepared objects are linked together as displayed in Figure 3(e). Although the model is prepared now, the eye doesn't blink without any modifications. It is needed to apply the texture animation to the model using a script. The texture of the head or surface of the face can be changed based on the texture animation of the model. The texture animation is worked based on a message which is transferred from the user computer. According to the message, the face or surface of the linked object appearance is changed and it looks like an eye blink of a furry Avatar which is appearing in upper part of the Figure 4.

3.4. Establish the connection between the real world and the virtual world

Most of the applications that are related to the virtual world use to transfer the information from the virtual world to the real world. But this research focuses on the data transfer from the real world to the virtual world. After identifying the real user eye information, it is needed to send to an external server through the Wide Area Network (WAN). The external server works as an intermediate between two worlds. The result of the facial

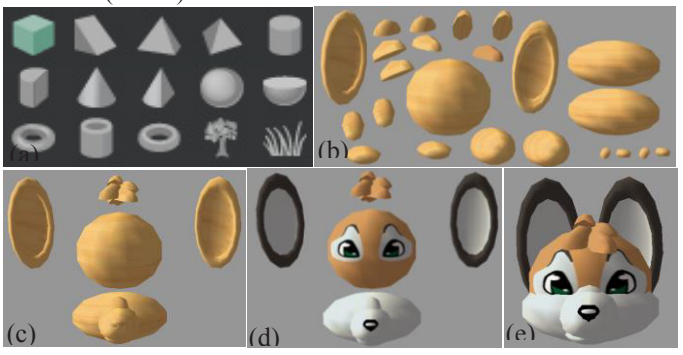

Fig. 3. Method of preparing Furry Avatar head in virtual world

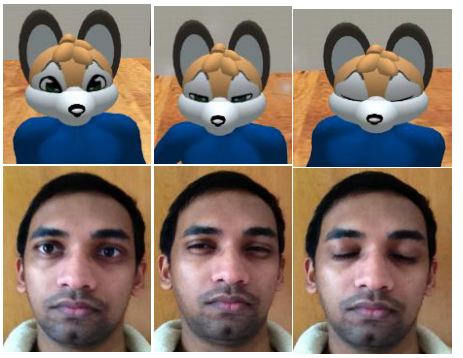

Fig. 4. Visualize eye blinking in virtual world

expression of the real user is obtained from http protocol and the acquired data is transferred to the virtual environment through the server. When the relevant eye information is acquired by the server, it is transferred to the virtual environment via http request. The relevant details are stored in the database, which is located in the external server. This http protocol provides some advantageous to this system as follows. When the instructor or the teacher wants to analyze the facial expression of a student, the formatted data can be acquired from the server. In this process, the server plays a major role through establishing a connection between the real world and the virtual world.

3.5. Visualize the eye blinking in the virtual world

Finally the EB of the real user could be visualized via the furry Avatar in the virtual world after fulfilling several steps. When the student is blinking eyes, it is appeared through the Avatar as shown in Figure 4.

4. Pros and cons of the system

There are several benefits can be acquired through the implementation of this EBVS. This system acts as a tool, which is providing EB information to their instructor and peers. In addition, the status of the student can be derived through the EB information. The relevant decisions can be taken in the aspect of the instructor to conduct the learning sessions effectively using student information. The connection between the instructor and the student is increased than the normal Synchronous e-Learning class with non-verbal communication with this system.

This system deals with two worlds and instantly the information cannot be transferred. The EB information is transferred from the real user in the real world to the furry Avatar in the virtual world through the EB detection system. Although the EB detection system is continuously processing, it takes some time to acquire the eye information. The EB detection system takes averagely one second to obtain the eye information to identify whether the blink is happen or not. But we obtain the web cam video continuously. Therefore the every blink incidents can be captured and the only drawback is the time delay. Then it should be transferred to the server and it takes around one second. Finally, the server takes 0.5 second to transfer the eye information to the virtual world. This system provides the information within 2.5 seconds and it is a major benefit of this system as shown in Table 2. There is another system which is transfers the information of the basic activity through a mobile phones and it takes comparatively long time to transfer information among the world [27]. Although the average time is measured to transfer the information, the required time to transfer the information through the server is depended on the network condition especially on the data volume. Therefore the time of the information transferring variation based on the network condition is measured. The result is available in the Table 3, which is considered the changes in different data volume and the required time to transfer the information. Based on that analysis, we can identify that the time to transfer the information is increased with data volume. Therefore we can conclude that it takes at least 0.1255 second to visualize EB in the virtual world and it is gradually increased with data volume.

The process of visualizing EB of the real user or creating a mirror of the real user in the virtual environment is discussed. These are the covered area of this study and now required to evaluate the behavior of the student using their EB and to identify the status of the student.

Table 2. Time duration for transfer eye information

Transfer locations		**Average Time taken (seconds)**
From	To	
Real user	EB detection system	1
EB detection system	Server	1
Server	Avatar	0.5
Total time		2.5

Table 3. Network condition Vs Time for transfer data

Network condition (b/s)	Average time to transfer(s)
1-250	0.1255
250-500	0.3755
500-750	0.6255
750-1000	0.8755
1000-25000	2.96

5. Discussion

In this research, the consideration is focused on one category of e-Learning called virtual class. Increase the efficiency of a virtual classroom with overcoming existing drawbacks is the aim of this research. Although the virtual class is conducted with face to face layout with an Avatar, it doesn't have any rich connection between the real world participants. In addition, it is somewhat difficult to identify the student behavior during an e-Learning session is another issue of this virtual classroom since it has not non-verbal communication among the students and the instructor. Those are the existing barriers in the virtual education and accessed through this research.

The major task of this research is to visualize EB of the real user in the virtual learning environment through a furry Avatar has successfully completed through this study. Finally we established the connection between the instructor and the students over the non-verbal communication through visualizing real user EB in the virtual world. In addition, the stored data is very helpful to analyze the student behavior after a learning session as an indirect method and it is a solution to identify the student behavior instantly during a learning session.

6. Conclusion

With the growing interest of e-Learning, the three dimensional virtual learning methods become popular. Although it provides more advantageous than the traditional learning method, it tries to implement positive features of the traditional method. In this study, the several aspects of e-Learning has been considered and gave strong solutions to the identified drawbacks of the virtual class with a purpose of increasing the efficiency level of knowledge delivering method. The EB, which is one of the non-verbal communication methods, is considered in this study.

Although the non-verbal communication plays a massive role in the learning process, the virtual e-Learning has not any procedure to acquire the non-verbal gestures. In this study, one of the main parts of the non-verbal communication called EB was transferred to the virtual learning environment to visualize the EB of the real user through the furry Avatar in the virtual learning environment. The EB of the real user was detected using a real time video with a webcam. To represent the patterns of the real user EB in the virtual learning environment, a furry Avatar were created with the EB patterns. The connection was established between the real world and the virtual world through a web interface and the server. The information of an eye blink was transferred to the virtual learning environment to visualize EB pattern of the real user through the furry Avatar during the learning sessions. Ultimately, the eye blinks of the real user were visualized in an e-Learning session through the furry Avatar. It had low time duration to visualize the real user expression in the virtual world. As a result of this research, the live Avatars for the e-Learning with EBs were successfully implemented and increased the effectiveness of the e-Learning.

7. Future work

In this system, the EB is visualized in the virtual world through a furry Avatar. But it is needed to implement for a human Avatar. Before that it is needed to create an EB model for a human Avatar in the virtual environment. Therefore the next step is to implement a model for a human Avatar in the virtual environment which is suited to represent the eye blinking. Then EB of a real user can be visualized through a human Avatar in the virtual e-Learning environment.

When the human Avatar with EB will be constructed, an analysis tool for the EB data will be required to construct. The actual advantageous of EB visualization tool cannot be obtained without an EB analysis. The EB information is already stored in the server. Then, an analysis tool needed to be developed using the stored information to check the student status during and after a lecture session.

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