An Empirical Evaluation of Gesture Recognition System for Education Purposes

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Summary
Most education lectures at universities are presented these days using a presentation tool to help lecturer remember the points that should be presented and the audience, to follow the presentation. The traditional methods of controlling such presentations, mouse and keyboard, restrict the movement of the lecturer, as s/he needs to stay close to the keyboard and mouse to run and control the presentation. However, such traditional techniques lack the naturalness of communication and cumbersomeness. This paper presents a solution for these problems using an intuitive gesture recognition system for education purposes called TeachMe for controlling presentation and mouse pointer movement. The system depends on Microsoft Kinect® device in capturing the gestures. An empirical study was conducted to evaluate the system by comparing between the gesture technique implemented into TeachMe, and traditional technique for controlling MS PowerPoint presentation and mouse pointer movement with respect to flexibility, performance and user satisfaction. Controlling presentation results show that there is a significant difference regarding the flexibility to the favor of gesture technique. However, such difference does not exist in case of performance. Some differences exist in the user satisfaction results. Controlling mouse pointer results show that difference exist in performance and user satisfaction the favor of mouse technique over the gesture one.

Keywords
Microsoft Kinect® . MS PowerPoint . Gesture recognition system . Presentation

1. Introduction

In the education domain, presentation tools are important to run lectures. Lecturers use presentation tools such as MS PowerPoint and Prezi to facilitate presenting the lecture in a predefined order and arrangement. Presentation software such as MS PowerPoint or OpenOffice support control the flow of presenter (speaker) discussion [1]. Traditionally, controlling a presentation is done using keyboard and mouse [2]. However, using such traditional technique for controlling presentation tools has some disadvantages. Using such traditional input techniques enforce the lecturer to be close to the computer machine that is running the presentation for controlling moving slides, starting and finishing the presentation. [2] introduces that using keyboard and mouse for presentation restrict the presenters because “when the presenter needs to point some area of the slide and the projection plane is further away from the computer, then walking back and forth between the computer and the projection plane is imminent”. On the other hand, the presenter needs sometimes, if not most of the time, to be close to the audience. This is important to ensure good communication between the presenter and the audience through body language and eye contact. For [2] and [3], this is an important problem that justifies replacing the traditional technique, keyboard and mouse, with gesture technique for controlling MS PowerPoint presentation in lectures. [2] reports that “traditional keyboard and mouse based presentations prevent speakers from freely and closely interacting with the audiences, because the speaker continuously has to go to the computer to manage the presentation”. Another problem for using keyboard and mouse technique is the lack of interactive communication with human and lack of naturalness. This problem was introduced as the major problem justifying introducing new techniques to substitute keyboard and mouse by [4] and [5].

One substitute for traditional techniques is the Bluetooth connected device that controls the slides of the lecture. However, such devices also have some problems, which include the limited functionalities and actions they can provide due to limited number of buttons available. Just an example, Bluetooth devices cannot control the mouse movement [2]. Drawbacks of presentation wireless control devices are mentioned by [1] as they offer too small touchpad to control the mouse freely while the presenter is walking around. In addition, they do not allow the presenter to control the presentation using their gestures and do not allow him/her to connect more than one controlling device. Only one device is allowed in one computer. One more human prone problem of using Bluetooth devices is that lecturers forget to bring their devices to lectures. This problem was noticed subjectively between lecturers at universities. In conferences, the host usually supplies Bluetooth devices for presenters expecting that they have forgot to bring their own devices.

An introduced solution for the above problems is controlling the presentation using gestures. Gesture capture devices facilitates implementing such solutions. These devices originally implemented for video games to

Manuscript received March 5, 2017
Manuscript revised March 20, 2017

make them more interactive. Gesture recognition becomes an important field of study as one way of communication between human and machine in the context of Human-Computer Interaction (HCI). Its powerful comes from the intuitive way of delivering messages to the machine and it has a wide range of applications including games and virtual reality [6]. Gesture solution with its intuitiveness and naturalness motivated (Change, 2013) research to introduce and enhance new natural ways for communication between human and computer other than mouse and keyboard. Although the solution has been introduced, investigation and development of it still need more improvement and research. An empirical study conducted by [7] to compare two interaction styles, tangible user interactions and gestural interactions, was motivated by the lack of comparative investigations for the newly emerged styles of interaction.

This research presents a solution for the above addressed problems using a new gesture recognition system in the field of education developed for controlling PowerPoint presentation and mouse pointer using hands' gestures. The system is evaluated through an empirical study using parameters and variables that were not been used before in evaluation a gesture system. The aim of this research, which this study is part of, is to improve the efficiency and naturalness of presenting a lecture presentation by allowing the lecturer control the presentation and the mouse pointer in a more interactive way with the presentation and the audiences without being forced to be close the computer keyboard and mouse. The aim for this research extends to include investigating the effect of implemented gesture feature on the flexibility, performance and user satisfaction for controlling MS PowerPoint as a presentation tool and controlling mouse pointer. The system was evaluated against traditional way of controlling a presentation using keyboard and mouse. Keyboard and mouse are selected as they are considered the standard and most frequently used input devices for presentation control [2].

Next section of this paper presents the general structure of the TeachMe gesture recognition system. The first empirical study is then presented and discussed to evaluate the flexibility, performance and user satisfaction of the implemented tool in controlling a presentation. A second empirical study for evaluating the system in controlling the mouse is then presented and discussed. Finally, related work, conclusion and future work are listed.

2. TeachMe Gesture Recognition System

TeachMe is a research gesture recognition prototype that has been developed as a graduation project at Applied Science University. It depends on Microsoft Kinect® device as an interface to capture lecturer body gestures. Captured gestures are sent to the system for analysis. The system mainly recognizes the hands gestures. The shape, movements and poses of the gestures is out of the scope of this paper. Each hand(s) gesture is mapped into an action that is sent for execution. TeachMe recognizes two types of hand gestures. The first controls Microsoft PowerPoint presentation while the second controls the mouse pointer. Gestures controlling Microsoft PowerPoint includes starting a slideshow, moving slides forward and backward, and ending the slideshow. Gestures controlling mouse include moving mouse over the desktop, selecting an object (file or folder) by clicking on it, dragging an object, and double click on an object to open a file or explore a folder.

3. Experimental Methodology

3.1 Aim

The general aim of this research is to increase the flexibility, performance and user satisfaction of controlling MS PowerPoint presentation and the mouse pointer using a gesture recognition technique. For this purpose, TeachMe was implemented and three experiments were conducted to evaluate it. Each experiment is discussed separately in the following sections.

3.2 Controlling an MS PowerPoint Presentation Experiment

The aim of this experiment is to evaluate the developed gesture recognition technique for controlling a presentation in comparison to the common used technique, keyboard and mouse. The following dependent variable measurements were tested for each technique.

- The flexibility in terms of the number of footsteps required by the lecturer to reach a suitable position and location for moving the slideshow.
- The performance in terms of the time required for accomplishing slide movement. This is the time needed to reach the required slide, which includes moving one or more slides, time wasted in mistakes and the incorrect response of the system.
- The user satisfaction with each technique.

The null hypothesis of this experiment is that, there is no difference between the two techniques, gesture and traditional, regarding the variables to be measured. In order to accept or reject this hypothesis an evaluation has been conducted to investigate the flexibility, performance, and user satisfaction in accomplishing a lecture presentation task using each of the techniques.

3.2.1 Collection and Tasks

The study assigns each participant a task of giving a lecture using MS PowerPoint presentation. The lecture is composed of 20 slides in the context of loop structures (For, While and Do-While loops) in C++ programming language. Loop structures and C++ programming language were selected because all the participants are familiar with them. The slides were designed to simulate a normal lecture as they cover the idea of loop structures and comparing between them. Three examples on each loop structure were also provided in the slides. As each lecturer may explain loop structures in different style and the time required for each slide may vary from lecturer to another, the time of the lecture and the time spent on each slide was not taken into consideration in this experiment. In each lecture, some audience students were invited to attend the lecture. The 20 slides were divided for each lecturer on both techniques. Meaning that each participant experienced 10 slide for each technique. To enforce specific number of slides movements forward and backward:

- Slide 5 in each technique asks to go back to slid 4.
- Slide 7 in each technique asks to go back to slide 4 again.
- Slide 9 in each technique asks to go to slide 8.
- In each case of returning backwards, the lectures were instructed, as part of the task, to return forward to the original slide.

Note that each time the subjects move slides backward to a specific slide there will be something to explain. Meaning that the subject should talk about the slide moved backward to. This would be a reminder about the loop general structure. In case the subject moves forward to the original slide, there is always some points left to discuss. Meaning that the subject moves backward to a slide, discusses something, then moves forward to the original slide and continues in that slide the discussion before moving forward again to the next slide. The experiment was conducted at Applied Science University, private (ASU) in Amman, Jordan.

16 participants were selected from Faculty of Information Technology (FIT) at ASU undergraduate students in their third or fourth year of study where student gets their degree normally in four years (called lecturers at different locations of this research to be distinguished from the audience students). In addition to the 16 participants, 2 subjects were used in preliminary study, with no audience, to avoid any unexpected problems in the real experiment. The result of the preliminary study were not taking into consideration for data analysis. All the participants get the same task material, the 20 slides. The invited audience students were from FIT also. They were selected from first and second year students who were studying at structured programming course that uses C++ as an application language. 7 – 15 audience students attended each lecture (experiment). The lecturers were not allowed to attend lectures as audience before their experiment to prevent affecting the learning ability. Audience students were allowed to ask questions and the lecturers were allowed to answer but without moving the slides to avoid affecting the experiment design and task slides moving sequence.

3.2.2 Experiment Design

For evaluation purposes, within subject design was adopted. As each subject has a task of presenting 20 slides, 10 slides were presented using traditional technique, mouse and keyboard, while the other 10 were presented using gesture technique. All slides were in English. Half of the 16 subjects started the experiment with the traditional technique while the other half started with the gesture technique to avoid any technique order effect. Experiments were numbered and assigned the starting technique, then they were randomly distributed on the subjects.

The experiment was explained for each subject alone. Each subject was trained using 10 slides presentation on both techniques for 15 minutes and allowed to use the system freely by moving slides using any technique for another 10 minutes. All subjects did not practice training on traditional technique during the free 10 minutes as they considered themselves familiar with it. Instead, they used the free 10 minutes for exploring the gesture technique. Slides used for training are in the context of C++ programming but totally different from those used for the experiment. However, slides of the real experiment lecture, were given to the subjects one day before the training and the experiment to prepare for the lecture at home. Training was conducted in the same experiment classroom and with the same devices 30 minutes before the time audience were invited to attend the lecture. All participants' questions about the system were answered during the training session and they informed that no answers will be provided during the experiment time. Before the experiments start, a layout for the classroom was set. The following figure shows the designed layout.

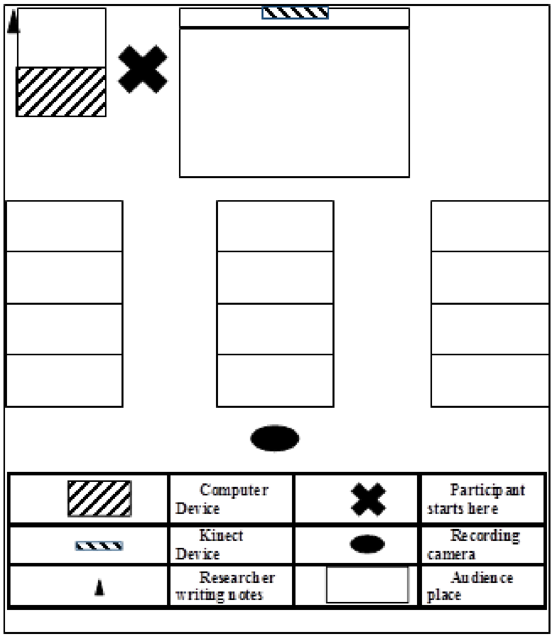

Fig. 1: Classroom layout with key

The Kinect device was placed above the whiteboard almost at the middle of the classroom. The whiteboard here represents the area where the data show projects slides. This layout design was adopted because it is the real layout exists at all classrooms in Applied Science University and, it is believed, in other universities.

Scotch tape was placed at the floor of the room to specify two important areas. The one around the computer machine which appears at the left part of the layout and one around the area that Kinect can recognize in front and around the whiteboard (Fig. 1). To simulate the real lecture, the participants were allowed to move freely in the lecturing area, which includes any free space available in the classroom including the designated areas for controlling the computer machine and the Kinect device. In both cases, the subject requires to walk several footsteps from the area of lecturing, that is any point in the room, to the designated area for reaching computer machine or Kinect device. The number of footsteps a lecturer walks starting from the intention to move from any point in the classroom until both feet are inside any of the two areas was counted and the average for each technique was calculated. In case the subject exists in the required area for moving a slide, the footsteps count is considered as zero. Counting the time required for moving the presentation to a required slide for measuring the performance starts once the lecturer's two feet are inside the designated area for each technique. Counting ends once the required slide is reached. The time counting included any mistakes done by the subject and the incorrect response of the gesture system. In case the subject exists in the required area for moving slides, the time count starts when the subject has the intention to move the slide and ends once reaching the required slide. To avoid affecting the footsteps count in any of the techniques, participants were asked to start their movement at the beginning of the experiment from a point between the designated areas for both techniques, marked with (X) in the layout.

All the experiments were recorded using a video camera placed as the end of the lecturing room and raised up to capture all the lecturer gestures, movement and position for later data extraction and analysis. The camera appears as oval shape in the classroom layout (Fig. 1). Raising the camera up also prevented the effect of audience heads from not capturing the lecturer position, gestures or the presentation screen. No time limit was imposed to finish the experiment (lecture).

To be able to collect data precisely, the participants were instructed to say the sentence “let's move” before heading to move a slide. The sentence must be said when the participant decide to move from their current place to go to another place suitable to control the presentation. In case of gesture the lecturer should move to be in the area in front of the presentation screen, while in the computer area to the left of the layout for traditional technique. The sentence was introduced to reflect the intention of the lecturer to perform some footsteps towards the designated areas for presentation controlling. The need of knowing the lecturer intention was noticed during watching a playback for preliminary studies as difficulties faced of starting counting the footsteps. One of the researchers was standing behind the computer area, marked as black triangle, to write notes that my not captured by the video camera when the subjects are using the keyboard and mouse.

To measure the user satisfaction, participants were asked to fill out a questionnaire designed to compare qualitatively between the two techniques.

3.2.3 Results and Discussion

All the participants considered themselves experts in using traditional technique, keyboard and mouse, with an average of 5 on a scale of 5. 4 of them are used to give volunteer lectures for first year students and they used MS PowerPoint in many of these lectures. In traditional technique, it was noticed that many participants (75%) were using the spacebar for moving one slide forward and the arrow keys for moving more than one slide forward and backward. However, few of them were using the arrow keys only for one forward slide movement. Again, all the participants considered themselves have excellent knowledge in the context of the lecture, C++ programming language, with an average of 5 on a scale of 5.

All the experiments were finished within an hour. The longest period for an experiment lasts for 54 minutes with an average of 49 minutes. The normal lecture time at ASU ranges from 50 – 75 minutes. The total time for each experiment including the training time took approximately

80 minutes. The results for the users' attempts were analyzed with respect to the above mentioned hypothesis. Log-ranked test was used to analyze the flexibility, performance and satisfaction results. The comparison between the two techniques regarding the measurements is presented in the following sections.

3.2.3.1 Flexibility

The number of footsteps required to perform a PowerPoint slide movements for each participant was gathered from the recorded videos. As previously discussed, counting the number of footsteps starts when the subject say the sentence "let's move" and ends when both feet are inside the designated area for a technique. Almost all the subjects, in one or more of the slide movements, forgot to say the sentence. Only one participant did not forget to say the sentence all the time. To overcome forgetting to say the sentence problem, each subject was asked to specify his or her intention of moving a slide directly after the lecture on the recorded video. Fig. 2 compares the number of footsteps required to move one or more MS PowerPoint slides using gesture and traditional techniques, 10 slides for each technique. All the participants achieved lower number of footsteps using the gesture technique. The highest number of footsteps required in the traditional technique was 59 footstep for participant 6. The average number of footsteps for traditional technique was 48. This means about 5 footsteps for each slide(s) movement. Compared to gesture technique, the average is about 2 footsteps for each slide(s) movement. The maximum number of footsteps was 22 for participant 11.

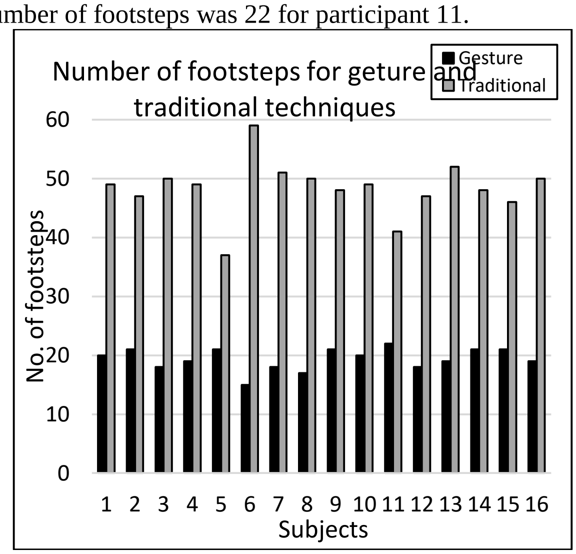

Fig. 2: Number of footsteps required to move MS PowerPoint slide(s) using gesture and traditional techniques.

A significant lower number of footsteps was required to perform 10 slides movement using gesture technique than using the traditional one ($P < 0.0001$). Participant number 6 scored the highest number of footsteps using traditional technique and the lowest number of footsteps using gesture technique. He is a 3rd year male student who gave volunteer lectures for new students before. After revisiting the recorded video for him, it was found that he has a habit during teaching of moving to the far end of the classroom away from the keyboard and mouse area (right of the layout Fig. 1). This keeps him always closer, or even within, the gesture-designated area, which resulted of lower number of footsteps in gesture technique. Table 1 shows some basic statistical results for both techniques. According to the results in this section, flexibility study rejects the null hypothesis and accept the alternative hypothesis as there is a significant difference between the two techniques.

Table 1: Basic statistics for number of footsteps required to move MS PowerPoint one or more slides using gesture and traditional techniques.

	Gesture Technique	Traditional Technique
Average	19.38	48.31
Median	19.50	49.00
Standard	1.86	4.73
Max	22.00	59.00
Min	15.00	37.00

3.2.3.2 Performance

The time required for moving slides to reach the required slide was gathered from the recorded videos and the average for each participant was calculated. The average time calculated includes the time for moving one or more slides forward or backward, mistakes done by the participants, and the incorrect response of the gesture system. There was no incorrect responses in the traditional technique. The time measured also includes the time required to reach the keyboard and the time required for detecting the subject body by Kinect after the subject enters the traditional technique and the gesture technique designated area respectively. This is because, for each slide(s) movement, the time counting starts once the lecturer's two feet are inside the designated area and ends once the required slide is reached. The time was measured in seconds and rounded for the closest integer number to make calculations easier. Fig. 3 shows the average time, in seconds, needed by each participant to move to the required slide using both techniques. There was no significant difference ($P = 0.086$) between the two techniques regarding the performance. 4 (25%) participants scored the same average for both techniques while 3 (18.8%) participants scored less average time in gesture technique. The rest, 9 participants (56.3%), scored less average time in traditional technique. Table 2 shows some basic statistical results for both techniques.
It was noticed that the 7 participants who got equal or less average time in gesture technique compared to traditional

one had problems in moving slides using the keyboard. 4 of the 7 participants used the keyboard arrow keys instead of the spacebar for moving one slide. Surprisingly, they made many mistakes while moving the slides, although they consider themselves experts in using keyboard for running a MS PowerPoint presentation. Mistakes can be summarized in pressing the wrong arrow key, which moves the slideshow to the opposite of the required direction and pressing the arrow key more or less times than required. The rest 3 participants of the 7, made mistakes while using the arrow keys to perform more than one slide move as they used the spacebar for one slide move. It is also important here to mention that some other participants made mistakes when used the arrow keys for moving one or more slides, that did not affect their average time with the advantage of the traditional technique, however. Cuccurullo, et al (2012) expected almost the same type of mistakes while using keyboard for slideshow. Number of mistakes is considered as one of the dependent variables studied in an empirical study compared using gesture and keyboard for running a presentation. Results of [1] showed that only a subject made 1 mistake using the keyboard as he pressed more than once on the next button. Although mistakes occurrence is not a dependent variable in this paper, mistakes were counted from the video playback. 39 mistakes were counted in moving slides. All of them were in traditional technique. No mistakes were detected in moving slides using gesture technique. Again, for many users, mistakes did not affect the performance of the traditional technique.

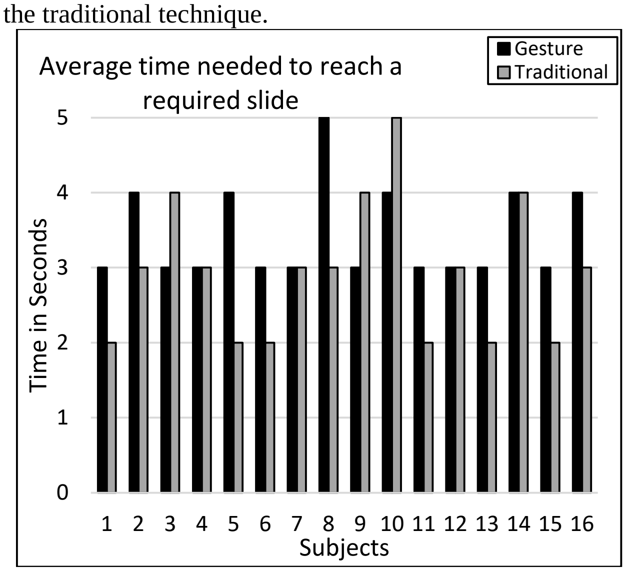

Fig. 3: Average time needed by each participant to reach the required slide using gesture and traditional techniques.

Table 2: Basic statistics for average time needed by each participant to reach the required slide using gesture and traditional techniques.

	Gesture Technique	**Traditional Technique**
Average	3.44	2.94
Median	3.00	3.00
Standard	0.63	0.93
Max	5.00	5.00
Min	3.00	2.00

Problems faced the gesture technique and reduced its performance can be summarized in delay of the body detection by Kinect and wrong response or not responding at all because of wrong interpretation of the gesture to an action or command as [8] calls. It is believed that the delay of body detection by Kinect comes from two sources, the actual delay itself, which is the time required for Kinect to detect the subject body when entering its recognition range (2.4 meters in average [2] with best results in about 2 meters). This can be about a second. The second source of delay comes from the lack of confidence of subjects in the gesture system that Kinect has detected him/her. This was recorded as notice during the experiments in almost with all the subjects. The lack of trust syndrome continued from the training session to the end of the experiments. Meaning that such trust in using a system or adaptation to a new technology needs long time. However, this requires further investigation. Accordingly, the user spends one or more seconds waiting to ensure s/he has been detected. Although participants in this study were not questioned about this, it was clear in the videos that this factor affected the performance variable in gesture technique. Based on the above results, this part of the study accepts the null hypothesis.

3.2.3.3 User Satisfaction

In questionnaires after the experiments, participants' opinions about the lecturing task using each technique were investigated. A Likert 5-point scale was used and some of these were inverted to reduce bias.

Table 4 and

Table 4 below show some of the questions and the average answer numbers on the scale. Table 3 shows questions where the higher scale answer is better while

Table 4 shows questions where the lower scale answer is better.

Table 3: Average user satisfaction of Gesture and Traditional techniques for controlling an MS PowerPoint presentation. (higher = better, bolded = significant difference)

Questions	**Gesture Technique**	**Traditional Technique**
How successful were you in accomplishing what you were asked to do?	4.6	4.7
The technique was powerful enough to allow me to complete my presentation.	5	5
It was easier to use this technique for controlling my presentation.	4.1	4.3
It was enjoying to use this technique for presentation.	**4.9**	**3.6**

The technique gave me the freedom to walk between students and being closer to them during my presentation with better eye contact.	**4.7**	**2.3**
I believe that the technique allows better interaction with students.	**3.9**	**3.1**
I would like use this technique next time I do a presentation.	**4.9**	**2.2**

Table 4: Average user satisfaction of Gesture and Traditional techniques for controlling an MS PowerPoint presentation. (lower = better, bolded = significant difference)

Questions	Gesture Technique	Traditional Technique
How mentally demanding was the task using the technique?	2.2	2.4
How hurried or rushed was the pace of the task using the technique?	2.6	3
How hard did you have to work to accomplish your level of performance?	**4.1**	**3.3**
How uncertain, discouraged, irritated, stressed, and annoyed were you?	**1.9**	**1.2**
While I was working, I felt that I needed help from an expert.	1.1	1

Results listed above show that the users enjoyed using gesture technique over the traditional one with significant difference. Subjects also believe that gesture technique significantly keep them closer to students, which allows better contact than traditional technique does. Similar results collected when subjects were asked if they are willing to use the technique again. Enjoyment results conforms to pleasantness results at [9] research. In the contrast, the subjects found that gesture technique puts significant load on the lecturer to accomplish the task. This is what [9] called it fatigue in their empirical study and got similar results. Regarding easiness, results show no significant difference between traditional and gesture techniques in controlling the presentation, which contradicts with the results of [9]. In both cases, the advantage was to the favor of tradition technique. [1] Reached similar survey results as mouse technique outperformed gesture technique regarding ease of use variable. They did not mention if there was a significant difference between the techniques.

There is a significant difference between the techniques regarding the uncertainty to the favor of traditional technique. It is believed that this is because the subjects are not used to the gesture system and they have practiced it for the first time. It is also believed that this is because the lack of confidence of subjects in the gesture system that Kinect has detected him/her, mentioned earlier, as there is no indication or sign from the system that it recognizes the body or not. However, this requires further investigation to be proofed. An indication of such effect was introduced by [1] who concluded that it is easier to learn using mouse than using gestures. Regarding the rest of the questions, there was no significant differences between the two techniques. Results of user satisfaction accepts the null hypothesis and reject the alternative hypothesis.

3.3 Controlling the Mouse Pointer Experiment

The aim of this experiment is to evaluate the developed gesture technique for controlling the mouse pointer in comparison to the common used technique, the mouse itself. The following dependent variable measurements were tested for each technique.

- The performance in terms of the time required for accomplishing a beginning and finishing a presentation task.
- The satisfaction of the user with the technique.

The null hypothesis of this experiment is that there is no difference between the two techniques regarding the variables to be measured. In order to accept or reject this hypothesis, an evaluation has been conducted to investigate the performance, and user satisfaction in accomplishing a beginning and finishing a PowerPoint presentation task using each of the techniques.

3.3.1 Collection and Tasks

The study assigns each participant a task of beginning and finishing an MS PowerPoint presentation.

Beginning a presentation includes the tasks of:

- Opening a folder on a computer desktop in which the MS PowerPoint presentation file already exists.
- Opening the presentation file by double click on it.
- Starting the presentation by pressing F5 or the start presentation icon at the bottom right corner of MS PowerPoint.

Finishing a presentation includes the tasks of:

- Ending the presentation slide show by right click and selecting “End Show” option.
- Closing PowerPoint by pressing the close button at the top right corner of the title bar.
- Deleting the presentation file by moving it to the recycle bin.

Note that starting a presentation and ending a presentation tasks can be performed using hand gestures without the need for the mouse pointer. However, the subjects were asked to perform these tasks using mouse for this experiment purpose.

3.3.2 Experiment Design

Within-subject design was adopted for this experiment. The dependent variables were compared for starting and finishing the presentation task using each technique.

To measure the time required to perform the tasks, participates were asked to perform the beginning task first then the finishing task. Participants who started with gesture technique performed the tasks in front Kinect device. After finishing the tasks, they moved to repeat the tasks using the mouse of the computer device. The experiments were recorded for data collection and analysis. The time required to perform the tasks, beginning and finishing, for each technique was gathered. Of course, the time to move from one technique to another was not counted.

Subjects were trained on both techniques and allowed to use the system freely. The total training session time for each participant was about 20 minutes. Training on using the mouse included tasks of opening a folder using double click, using right click and moving a file on the desktop. All the training sessions and experiments were conducted after the completion of the previous experiment, discussed above, and with the same subjects. 15 minutes break was given between this experiment and the previous one. 8 participants started using the traditional technique, the mouse only in this experiment, the other 8 started with the gesture technique. Starting with a specific technique was randomly selected. The same computer device was used for performing all the experiments to avoid the device performance itself. For each single experiment and technique, the computer device was restarted to ensure equal PowerPoint loading time.

3.3.3 Results and Discussion

All the participants considered themselves experts in using traditional technique, the mouse, for managing folders and moving and opening files with an average of 5 on a scale of 5.

All the experiments were finished in less than 2 minutes for each participant. The total time for each experiment including the training and filling a questionnaire time took around 30 minutes. Log-ranked test was used to analyze the performance and satisfaction results. The comparison between the two techniques regarding the measurements is presented in the following sections. The gestures and associated actions used in this experiment are similar to those implemented by [9] prototype except the resizing action. Their prototype was empirically evaluated for controlling WIMP (Windows, Icons, Menus, and Pointers) user interface.

3.3.3.1 Performance

The time required to begin and finish a presentation for each participant was gathered from the recorded videos. Results are shown in Fig. 4. There was a significant difference ($P < 0.001$) between the two techniques regarding the performance to the advantage of traditional mouse technique. All the participants finished the tasks using mouse technique in less time than gesture technique. Table 5 shows some basic statistical results for both techniques.

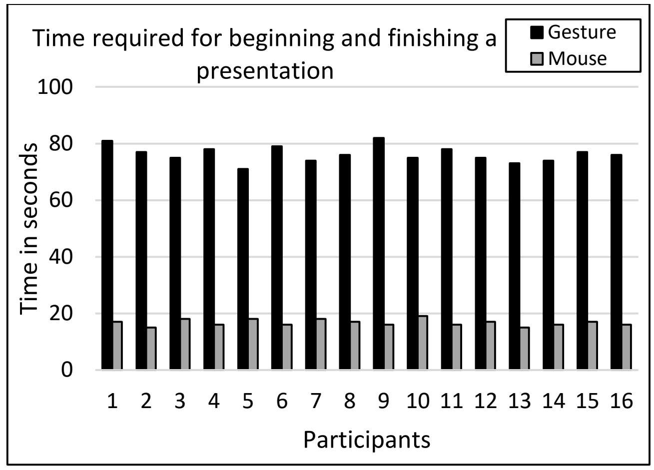

Fig. 4: Time required for beginning and finishing a presentation task for each participant.

Table 5: Simple statistical results for the performance (in seconds) using the two techniques for mouse controlling

	Gesture	Mouse
Average	76.31	16.69
Median	76.00	16.50
Standard	2.87	1.14
Max	82.00	19.00
Min	71.00	15.00

It is clear from the results that using gesture technique for controlling the mouse pointer takes much longer than using the mouse itself. The reason behind such results is the need for several hand gestures and placing the two hands into different positions to control the mouse in gesture technique. It is believed that programming gesture recognition for controlling mouse pointer in a different way would lead to different results. In the current version of TeachMe, moving the user hand faster, leads to losing the control of the mouse pointer. This happened with 4 participants who required longer times to finish their tasks. None of the participants required more than 20 seconds to perform the tasks using mouse technique, however, all of them required more than 1 minute using the gesture technique. [1] reached to similar results in an empirical study comparing the average time for doing a presentation using Kinect in comparison with using wireless mouse. This part of the experiment results reject the null hypothesis and accept the alternative hypothesis as there is a significant difference between the two techniques regarding performance variable.

3.3.3.2 User Satisfaction

Post experiments questionnaires filled out after each experiment by the participants were analyzed to discover the user opinion and satisfaction regarding gesture technique in comparison with traditional one (using the mouse in this case).

Table 6: Average user satisfaction of Gesture and Mouse techniques for beginning and finishing an MS PowerPoint presentation. (higher = better, bolded = significant difference)

Questions	Gesture Technique	Traditional Technique
How successful were you in accomplishing what you were asked to do?	**3.9**	**5**
The technique was powerful enough to allow me begin and finish a presentation.	**3.1**	**5**
It was easier to use this technique for begin and finish a presentation.	**2.2**	**5**
It was enjoying to use this technique for controlling the mouse pointer.	**4.3**	**2.7**
I would like use this technique next time to control the mouse pointer.	**4.7**	**3.9**

A Likert 5-point scale was used and some of these were inverted to reduce bias.

Table 7: Average user satisfaction of Gesture and Mouse techniques for beginning and finishing an MS PowerPoint presentation. (lower = better, bolded = significant difference)

Questions	Gesture Technique	Traditional Technique
How mentally demanding was the task using the technique?	**4.3**	**1.6**
How hurried or rushed was the pace of the task using the technique?	**4.7**	**1.9**
How hard did you have to work to accomplish your level of performance?	**4.8**	**1**
How uncertain, discouraged, irritated, stressed, and annoyed were you?	**4.6**	**1**
While I was working, I felt that I needed help from an expert.	**3.2**	**1**

Table 6 and A Likert 5-point scale was used and some of these were inverted to reduce bias.

Table 7 above show some of the questionnaire questions and the average answer numbers on the scale. Table 6 shows questions where the higher scale answer is better while

Questions	Gesture Technique	Traditional Technique
How successful were you in accomplishing what you were asked to do?	**3.9**	**5**
The technique was powerful enough to allow me begin and finish a presentation.	**3.1**	**5**
It was easier to use this technique for begin and finish a presentation.	**2.2**	**5**
It was enjoying to use this technique for controlling the mouse pointer.	**4.3**	**2.7**
I would like use this technique next time to control the mouse pointer.	**4.7**	**3.9**

A Likert 5-point scale was used and some of these were inverted to reduce bias.

Table 7 A Likert 5-point scale was used and some of these were inverted to reduce bias.

Table 7 shows questions where the lower scale answer is better.

Results show that there were significant differences between the two techniques in all the questions' answers. Participants significantly enjoyed using gesture technique and they would like to use it again, more than the traditional technique. This could be similar to the results recorded by [1] as gesture technique outperformed mouse technique regarding usefulness and overall satisfaction.

In all other questions, the advantage was to the favor of mouse technique. This result can be justified as controlling the mouse pointer using gesture requires longer time and physically and mentally demanding. The users need to recall the gestures that performs required mouse pointer actions. This point studied through a survey by [1] and subjects recorded that easy of learning is better in case of mouse technique over the gesture one. Additionally, in gesture technique, if hands move fast, the user may lose the control of the mouse pointer, which may have stressed the user, reduced their performance and certainty. Similar results were reached by [9] when used mouse and keyboard for manipulating WIMP (Windows, Icons, Menus, Pointer) interface. User satisfaction results rejects the null hypothesis. Consequently, the null hypothesis is rejected for this experiment as there is a significant difference between the two techniques in all the measured variables.

4. Related work

The most related work is the one presented by [1]. They used Kinect as an interface for a gesture recognition system that controls MS PowerPoint presentation through an approach called Kinect Presenter. In an empirical study, they compared their system with wireless mouse-based interaction approach regarding the performance, in terms of time required to accomplish a task, and number of mistakes, in addition to the user satisfaction. The task was reading a sequence of 9 slides with jumps backward and forward. Mistakes counted are those done by the subjects in controlling the slides during the tasks. They also compared the user satisfaction in both approaches. Their results showed that wireless mouse outperformed the gesture approach. Although time and number of mistakes were not used in this research as dependent variables, some of their performance results were compatible, and were conformed to, the results in this research as shown above in the discussion parts. For their user satisfaction results, the gesture approach got better scores regarding the usefulness and satisfaction. However, mouse approach scored better than gesture approach in case of ease of use and ease of learning. They did not provide statistical analysis to show significant differences between the compared approaches and their system does not implement mouse control option.

[9] implemented a vision-based prototype to compare gesture input method to the conventional (mouse / keyboard) input devices for controlling and performing actions on WIMP (Windows, Icons, Menus, Pointers) user interface. It is not an educational oriented prototype or designed for controlling presentations as TeachMe. An advantage of their prototype is its ability to control the mouse pointer. The have evaluated their prototype empirically. Their experiments included the difficulty level of the task (simple task vs. difficulty task) and output device (desktop vs. big screen) as independent variables in addition to the input method (gesture vs. mouse and keyboard). They compared the variables regarding time to complete a task, easiness of using the input method, fatigue, naturalness, pleasantness, and satisfaction. Their experiment tasks included selecting objects, opening and closing, moving and resizing. In results, gesture method was significantly slower than conventional methods as input devices. On the contrast, gesture method outperformed conventional method in naturalness and pleasantness, especially on big screen output device, although gesture cause more fatigue than mouse. Their results also showed that using the mouse is significantly easier than using gesture. In general, they concluded that overall user satisfaction has no significant difference between the two input methods. They justified that the when one of the variables, such as naturalness, is an advantage for the gesture, fatigue comes as a disadvantage. Some of their results conform to results collected in this research. It is important to note here that [9] used three independent variables together in one experiment and used ANOVA for statistical analysis which complicated the experiment and the analysis. One more comment is that they used t-test although their sample is 20 subjects only.

[2] introduced very similar problem that this research introduces and used as a justification for proposing the gesture controlling technique as a replacement for the traditional, keyboard and mouse, technique. They have developed a gesture recognition system called Ki-Prez that uses Kinect as an interface. It was only able to recognize two gestures, swiping right and swiping left that move slides forward and backward. Their research focused on evaluating the system to recognize the gestures at different distances. As a result, Kinect scored higher recognition results at 2.1 meters. [10] and [3] proposed the idea of using gesture recognition system using Kinect in the domain of education. [10] considered it as a presentation for the future e-learning system. They have developed a prototype that allows personalizing gestures. [3] used Kinect to control Microsoft PowerPoint in their system that can recognize postures, gestures and voice commands. Both research did not include any empirical evaluation for their prototypes. A gesture and voice recognition system to control PowerPoint presentation using Kinect was developed by [11]. They provided several features to control their presentation with gestures and voice commands similar to features exists in TeachMe such as starting and ending a presentation. However, their system does not control the mouse as they believed that gestures and voice commands are enough for controlling the presentation without the need for mouse.

[12] introduced a gesture system that controls the mouse pointer. The system was not directed for teaching or presentation purposes as in case of TeachMe. Their system was evaluated empirically using MS Paint application. 10 subjects were used to perform a task of writing something in MS Paint using specific pen size, shape and color. They tested two types of interfaces, 2D and 3D. Their results indicated that using 3D interface for controlling mouse is more suitable for novice users. 2D interface suits trained users, however.

5. Threats to Validity

One major threat to validity is the design and programming of gestures and their recognition in TeachMe. As discussed above, it is believed that designing the gestures and their associated actions could leads to different results. Gestures were designed based on discussion between the researchers to agree on the suitable gesture(s) for the required action or command. Another major threat to validity of the results of this empirical study is that the results depends on the classroom layout (Fig. 1). Meaning that if the classroom layout change, some results may also change. However, this layout was selected and designed to be exactly the same layout used in all the classrooms at Applied Science Universities and many other universities in Jordan. One more threat to validity is the habits of the lecturers of moving while giving their lecture. This threat appeared clear in case of one of the subjects who was moving to the far end of the classroom away from the keyboard and mouse area, which affected negatively his score in traditional technique of the first experiment. This threat could not be avoided as instructing the subject how to move would generate other significant threats to validity of the experiment. However, this behavior was noticed extremely in one subject case. In general, walking during the lecture is a general habit between lecturers. Moving was not limited to the entire subject body, instead, subjects were moving their hands during lecturing. There was a fear that these movements would be captured by the gesture system and interpreted as gestures. This did not happen during the experiments discussed in this research. However, this does not mean that there was no chance to happen. This misunderstanding from the gesture system side will add threat to validity to any empirical study in the field of gesture systems. Finally, allowing the audience to ask questions during the lecture could be a threat to validity. However, since the lecture time is not an affecting factor or dependent variable in the experiment, this threat had no significant effect. The only noticed effect is that the lecturer (subject) was sometimes distracted by the questions. They had to think if they are allowed to move the slides or not to explain and answer the audience questions.

6. Conclusion

A gesture recognition prototype, called TeachMe to control MS PowerPoint presentation and mouse pointer was developed. TeachMe uses Microsoft Kinect® as an interface for capturing the gestures. To evaluate the system and compare between the gesture technique and traditional (keyboard and mouse) technique, an empirical study was conducted. Flexibility, performance and user satisfaction variables were measured to compare the two techniques in controlling a presentation. Performance and user satisfaction variables were used to compare the two techniques in controlling the mouse pointer. Empirical studies were designed and results were analyzed statistically using log-ranked test. Results showed that there is a significant difference between the two techniques regarding the flexibility in controlling a presentation. Significant difference disappeared when performance of controlling the presentation measured. Differences between the techniques were not always significant when the qualitative user satisfaction was measured. Satisfaction results showed that subjects found gesture technique more enjoyable, allows better interaction with students and would like to use it again in their presentations. However, they recorded that they needed more effort and they were more stressed when using gesture technique. The controlling presentation study rejected the null hypothesis stating that there is no difference between the two techniques, traditional and gesture, regarding the variables to be measured. Similar rejection for the null hypothesis is reached in controlling the mouse pointer experiment. Performance in controlling the mouse pointer showed significant differences between the two techniques to the favor of tradition one over the gesture technique. Significant differences also appeared when comparing the two techniques regarding the user satisfaction for controlling the mouse pointer. In general, research concludes that gesture technique is different from the traditional technique regarding flexibility, performance and user satisfaction in controlling a presentation and mouse pointer. Most users reported their enjoyment and willing to use gesture technique. This indicates that this technique is promising in the field of presentation and education. This also encourages further invitation and system development in the field of gesture recognition systems that are controlled in a more natural way. However, the technique still requires further development to overcome usability obstacles and challenges for moving the use of such systems into commercial level.

7. Future Work

The future work of this research can be summarized as introducing customizing ability to TeachMe through programming by example. It has been noticed that using programming by example in the field of gesture recognition for education purposes is very limited and had very little research attention. The future work will focus on including this feature in TeachMe for purposes of customizing gestures to specific users. Voice commands also is something that other systems practiced but had very little empirical studies and evaluation. Future work will consider this feature also to be implemented in TeachMe.

Acknowledgement

The authors are grateful to the Applied Science Private University, Amman, Jordan, for the full financial support granted to this research.

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