2018 IEEE International Symposium on Multimedia (ISM)

Towards Applying Game Adaptation to Decrease the Impact of Delay on Quality of Experience

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***Abstract*— With emerging delay sensitive gaming services such as cloud gaming and online gaming, the importance of understanding and reducing the effect of delay on the gamer's Quality of Experience (QoE) becomes highly important for the success of these services. In this paper, the findings of two subjective experiments investigating the relationship between delay and QoE are reported. In the first study, it was shown that in addition to the direct effect of the delay on QoE, there is a significant indirect effect between delay and QoE through the relationship with performance. In the second part of the paper, we illustrate that adapting characteristics of a game can strongly mitigate the negative effect of delay on gaming QoE due to increased player performance. This adaptation in addition to compensation the effect of the delay, in contrast to the other difficulty adjustment systems, does not require to track the gamer's interaction, behaviors, and profile.**

Keywords—Delay, Cloud Gaming, Quality of Experience, QoE, Performance, Adaptation

I. Introduction

The growth of the gaming industry has increased the competition around delivering better products and services to the market. On the other hand, services such as Cloud Gaming (CG) and online gaming in the gaming industry have emerged. The idea behind CG is to run the game in a cloud server and stream the rendered scenes as videos to the client. Although CG and online gaming both have many advantages, they require a very low network delay in order to meet high Quality of Experience (QoE), which cannot be guaranteed by the best effort networks.

Many researchers have investigated the effect of delay on the gaming experience. There is evidence that delay reduces the users' QoE considerably. In addition, the existence of delay can lead to a degradation of gamers' performance [1]. As a result, as gamers get more enjoyment when they are performing better [2], this performance degradation itself can be a source of QoE degradation. In this paper, the relationship between performance, delay, and QoE is investigated in detail.

The performance of players can be deduced both subjectively and objectively. Players provide a subjective self-assessment of performance under the impression of their objective scores [3], and these scores turn out to be very highly correlated. In terms of subjective self-reporting methods, gamers are asked to rate their performance after playing a session of the game. To measure the gamer performance objectively, the game's scoring system could be used. A game's scoring system consists of rewards and punishments acquired by a gamer during the gameplay and may differ from game to game. It can be classified based on three characteristics of scoring systems: preservability, controllability and the relationship to achievement [4]. Games with perceivable scores on the game screen are more easily measured objectively.

Gaming QoE can be assessed through passive or interactive tests. In the passive tests, videos of games are shown to participants, and they are asked to rate the video quality. To assess other aspects of the gaming experience, interactive tests are used. Many methods and questionnaires for evaluation of QoE in gaming exist [5]–[8]. So far, Game Experience Questionnaire (GEQ)[9], which is also used in the current study, has been one of the most popular for assessing game experience, and it is recommended by ITU P809 [10].

To date, to the best of our knowledge, the relationship between these three factors; delay, performance, and QoE have not been investigated. Understanding this relationship might be necessary for game designers, network planners, and cloud providers. Game designers need to understand the effect of performance on the QoE to design a better scoring system. Network planners and cloud providers can continually control both QoE and Quality of Service (QoS) of the network by monitoring the gamer's performance. By using such a monitoring system, proper network setting can be chosen and in case of a low QoE attempt to resolve the issue can be started. Also, by using the relationship between these three factors an adaptation technique for increasing QoE is proposed. By using the proposed technique, QoE can significantly be improved at the same level of delay.

978-1-5386-6857-3/18/$31.00 ©2018 IEEE
DOI 10.1109/ISM.2018.00028

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The proposed adaptation technique in contrast to previous Dynamic Difficulty Adjustment (DDA) systems does not require any information about the gamer's profile, performance, and interaction. However, in most dynamic adaptation systems, gamers' interaction with games should be tracked and analyzed to find the proper amount, time and duration of the adaptation. Otherwise, it can decrease the flow, which is considered to be a balance between boredom and fear, between the amount of challenge and abilities, and it is a dynamic experience of complete dissolution of an acting person in his/her activity [11], [12]. Moreover, the proposed technique can compensate for the effect of delay on QoE; however as other difficulty adjustment systems were not developed for this purpose, they cannot be used in delayed conditions.

The rest of the paper is organized as follows: in Section II the related works are studied. Section III presents the details of the first experiment followed by a discussion on the result and findings. In Section IV by using the findings in section III, a new approach to compensate for the delay by removing the effect of performance is proposed. In Section V a discussion is made, and the future works are discussed. Section VI finally concludes the paper with a discussion on the limitation and future works.

II. Related Works

Effect of delay on a gamer's QoE is widely investigated in many papers [13]. Early studies are related to the inconsistency of the positions of objects in the presence of delay, which decreases the QoE by creating paradoxical situations [14]. Quax et al. [15] showed that delay has different influence in different game genres. For instance, First Person Shooter (FPS) games are more sensitive to delay than platform games. Also, Beyer et al. [16] showed that within the same genre, depending on the game rules and implementation, the sensitivity of games may differ significantly. Moreover, Schmidt et al. [17], showed that even within the same game, different scenarios might lead to different delay sensitivities.

Delay does not only influence the gaming QoE but also affects the gamer's performance [18]–[20]. As earlier mentioned, gamers' performance can be measured objectively. In [4], a classification for a game's scoring system is proposed. The author categorized games' scoring system based on three characteristics: *preservability*, which refers to the visibility of the scores on the screen, for example number of laps on a racing game, *controllability,* which is the increment of the control over the game by earning power for the characters, for example by earning money in the gameplay and buying more faster cars on a racing game. Moreover, lastly *relationship to achievement,* which is defined as the importance of the earned score for the progression of the game's story, for example by winning a race and going to the next level in a racing game.

Similar to QoE, users' factors influence performance. Erfani et al. [21] investigated the effect of users age and gender on the performance of sixty kids. They found a significant influence of age and gender on the performance. Their result showed that males perform better overall than females. However, the main reason for this result can be the differences between the gaming experience levels of their participants or the gender-specific appeal of the games.

Harwell et al. [22], in a more comprehensive study, invited men and women with less and no experience in gaming. Participants were given 30 hours of training to acquire the same level of gaming experience. The result showed that men had significantly better performance than women during and before the training phase. However, this effect disappeared after the training phase. Hopp et al. [23], tried to explore the influence of gender and performance on the level of enjoyment for a first-person shooter game. Their result showed that in a game like Counter-Strike: Global Offensive (CSGO), which supposedly is more suitable for males, females enjoy more than males with earning more performance.

All of the studies mentioned above tried to investigate the effect of delay and performance on the gamers' experience. However, to the best of our knowledge, no research has investigated the relationships between delay, performance, and QoE combined. In this paper, these relationships are studied in two separate experiments and based on the relationship between these three factors a new technique to improve the QoE on a delayed network is proposed. The proposed technique can be considered as a game DDA system.

Games' difficulty can be adapted both statically and dynamically. In the static difficulty adjustment, difficulty levels are set before entering into the game by gamers, by choosing levels such as easy, medium and hard. In a DDA, game difficulty levels are set dynamically based on gamer's interaction with the game. Hunicke et al. [24] described Hamlet as a DDA system. In this system, which is a library for the Half-Life game engine, the difficulty of the given obstacles based on gamer's performance is evaluated, and then the game is adapted for that gamer.

Chanel et al. investigated the use of emotion assessment by Electromyography (EMG) for game difficulty adjustment. They defined three levels of difficulty for the game Tetris and asked players to play different levels of games. Their result shows that playing the game on a different difficulty level led to a different experience [25]. Changchun et al. used players' physiological signals to estimate the level of a player's anxiety and adapt the game in real time based on the player's status [26].

The above-mentioned adaptation systems are not designed to compensate for the effect of delay on QoE. We proposed a technique that improves the QoE where the delay exists. Also, our proposed adaptation technique does not need to keep track of gamer's performance, behaviors, and profiles, while other DDA systems have to track evolution and regression in the player's performance and adapt based on the gamer's skills [27]. Another advantage of the proposed technique is that the game will be adapted just in the presence of the delay, as one of the challenges of a DDA system is to find the proper moment for applying an adaptation without disturbing the flow.

III. Relationships Between Delay, Performance, and QoE

In this section, relationships between delay, performance and a variety of gaming QoE aspects are investigated. For this study, two games from different genres were used: the racing game Need for Speed Shift 2 (NFS) and the sports game Table Tennis from London 2012: The Official Video

Game of the Olympic Games. The gamer's performance was measured objectively by in-game scores. Performance on both games was perceivable [4] for gamers, in NFS as the number of laps and Table Tennis difference between gamer's points and the opponent's points.

To introduce delay to the games, we used a cloud gaming setup combined with a network emulator. This was done to make a controlled study of the effects of network delay on QoE and performance, as it is one of the most important factors which degrades the performance of players. In Section A, this platform is elaborated. In Section B, the details of the experiment are shown. In Sections C and D, data is analyzed, and the relationships between delay, performance, and QoE are discussed.

A. Experiment Platform

In order to have a controlled network free from external influences, the cloud gaming system is set up using a local network. The test platform is shown in **Fig 1**. Steam's in-home streaming application was used on the client and server side. In this configuration, the game videos from the server (cloud) are sent to the network emulator WANem [28] and then redirected to the client side. For this experiment, the cloud server was equipped with an Intel i7 CPU with 16GB of RAM and a GeForce GTX 1080 graphics card, the client machine had an Intel i7 with 8GB of RAM and a GeForce GTX 850m graphics card alongside a 24 inch monitor, and the WANem machine had an Intel Core 2 Duo CPU with 2GB of RAM.

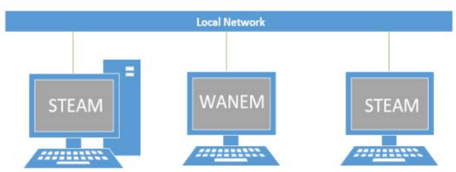

Fig 1: The local cloud gaming system. The left PC runs the games and sends the game scene to the STEAM client through the WANEM PC.

B. Experiment Details

In total 27 gamers participated in the first experiment, 13 females and 14 males, aged between 20 to 29 years (median 23.48 years). The subjective experiment was performed following the guidelines described in the ITU-T work item P.Game [10]. Before the test, gamers were asked to fill out a pre-questionnaire, Table 1 shows the demographic data of test participants based on this pre-questionnaire. **Fig 2** shows a snapshot of the two chosen games, Need for Speed Shift 2 and Table Tennis from London 2012: The Official Video Game of the Olympic Games. Each participant played six rounds of both games which each round took 4 minutes.

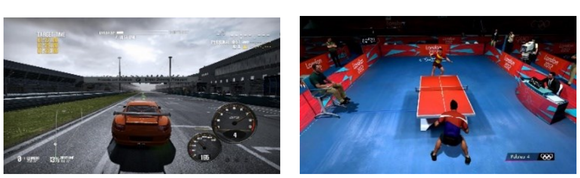

Fig 2: Snapshot of the chosen games for the experiment. Left side is a snapshot from NFS and the right side is a snapshot from Table Tennis.

After each round of the game, gamers were asked to fill out the in-game Game Experience Questionnaire (iGEQ) [9]. In each round of the game, the same amount of delay with different durations and conditions was simulated. In order to choose the proper amount and duration of the delay, a pretest is done with three pro gamers. For NFS the amount of delay was 350ms, and in Table Tennis, it was 380ms, both plus about 35ms of the test platform delay. The following conditions were used in the test:

- Condition 1: No delay was simulated
- Condition 2: Delay simulated in the first 30 seconds of the video
- Condition 3: Delay simulated between 2:30 and 3:00
- Condition 4: Delay was simulated between 3:00 and 3:30
- Condition 5: Delay was simulated in the last 30 seconds of the game
- Condition 6: Delay was simulated in the whole of the game

TABLE 1 DEMOGRAPHIC OF TEST PARTICIPANTS

Gaming Experience (Novice to Expert)				
1	2	3	4	5
11%	37%	11%	29%	11%

Weekly Game Play in Hour					
0	0-1	1-5	5-10	10-20	>20
22%	22%	22%	18%	11%	3%

Size of using the display in inch				
<5	5 - 8	8-12	12 - 18	>18
1	3	7	12	5

Gaming Platform (Already Played on)			
PC	Console	Tablet	Cellphone
77%	55%	11%	51%

Genres (Already Played)			
FPS	TPS	Platform	Fighting
74%	59%	92%	70%
Adventure	Strategy	Sports	Race
62%	51%	62%	77%

C. Influence of gamers' performance on gamers' QoE

In this section, the influence of performance on different aspects of QoE is investigated. Among a few other possibilities, we defined the performance in NFS as the number of the laps completed in the given time and the difference between the player's points and the opponent's points in Table Tennis. Both of the mentioned scores were perceivable for participants on the screen. However, as gamers with different skills and experience may have different performances and expectations, we clustered the gamers to analyze these user factors into two clusters. The optimum number of clusters was found to be two based on a silhouette analysis [29] (silhouette value in NFS = 0.65 and Table Tennis = 0.48). We named the cluster with higher performance as pro gamers and the lower performance as the casual gamers. This clustering is done by k-means [30], based on the gamer's actual performance during the whole test season.

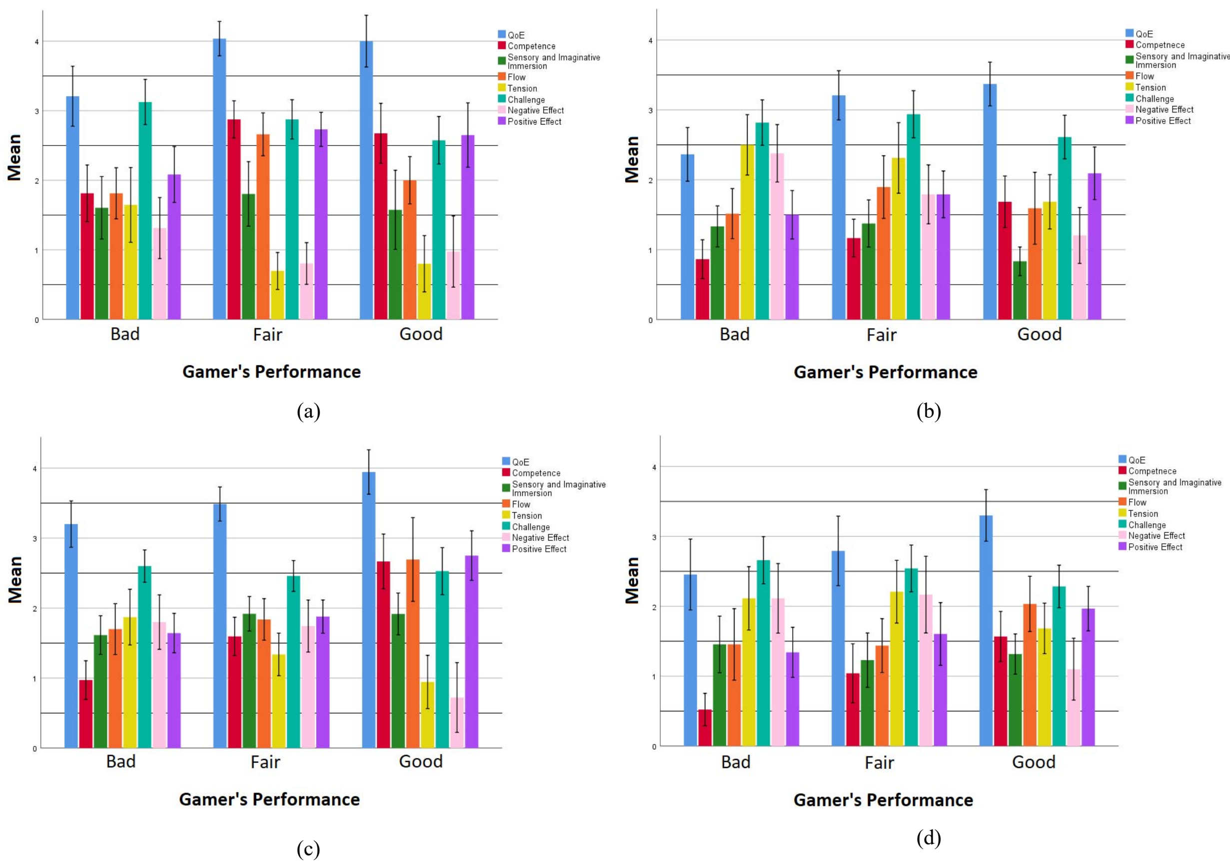

Figure 3 QoE aspects in different score ranges. (a) shows the pro gamers on table tennis game, (c) casual gamers in table tennis, (b) pro gamers on NFS and (d) casual gamers on NFS.

To perform Analysis of Variances (ANOVA) [31], gamers' performance in each cluster (pro and casual gamers) was divided into three categories; bad, fair and good. As the data were normal the first 33% in the distribution of gamers' performance was assigned to the category bad, the second 33% to fair, and the last 33% assigned to good. Subsequently, Analysis of Variances (ANOVA) was performed. The hypotheses are:

- Null Hypothesis: The means of all the QoE aspects in different performance ranges are equal, implying that there is no relationship between performance and QoE aspects

  H0: Bad = Fair = Good

- Alternative Hypothesis: Not all performance ranges means are equal, implying that there is a relationship between performance and QoE aspects

  H1: Not all performance ranges' means are equal

Fig 3 shows QoE aspects in different score ranges. The aspects are QoE in addition to seven aspects of the iGEQ; these aspects are Competence, Sensory and Imaginative immersion, Flow, Tension, Challenge, Negative and Positive effect. It can be observed in **Fig 3** that the degradation in performance changes these aspects. The following are the result of the ANOVA tests:

In **Fig 3 (a)** aspects for the pro gamers on Table Tennis games are shown in which the following aspects were significantly influenced by gamers performance: QoE [F (2,69) = 7777, p= 0.00], Competence [F (2,69) = 10830, p= 0.00], Flow [F (2,69) = 8032, p= 0.01], Tension [F (2,69) = 7139, p= 0.002], Positive Effect [F (2,69) = 4214, p= 0.019]. **Fig 3 (b)** shows these aspects for the pro gamers on NFS in which the following aspects were significantly influenced by performance: QoE [F (2,81) = 10245, p= 0.000], Competence [F (2,81) = 7935, p= 0.001], Sensory Immersion [F (2,69) = 4596, p= 0.013], Tension [F (2,81) = 3997, p= 0.022], Negative effect [F (2,81) = 8993, p= 0.000].

Fig 3 (c) shows these aspects for casual gamers on table tennis in which the following aspects are significantly influenced by performance: QoE [F (2,69) = 4977, p= 0.009], Competence [F (2,69) = 26158, p= 0.000], Flow [F (2,69) = 6022, p= 0.004], Tension [F (2,69) = 5718 p= 0.005], Negative Effect [F (2,69) = 6551, p= 0.002], Positive Effect [F (2,69) = 13152, p= 0.000]. **Fig 3 (d)** shows the QoE aspects in different score ranges for casual gamers on table tennis in which the following aspects were significantly influenced by performance: QoE [F (2,73) = 3930, p= 0.024], Competence [F (2,73) = 9161, p= 0.000], Negative Effect [F (2,73) = 6791, p= 0.002].

Based on the results, the alternative hypothesis H1 is accepted. Performance has a considerable influence on all QoE aspects. Of the aspects, competence, and QoE are always significantly influenced by performance. However, delay separately can reduce gamers' QoE. Moreover, these influences are not necessarily due to the effect of the performance degradation. Therefore, in the next section, the joint influence of delay and performance on gaming QoE will be investigated.

D. Relationship Between Delay, Performance, and QoE

In this study, the delay was employed to create different levels of performance, and the influence of different levels of performance on QoE was investigated. Since the delay is a source of QoE degradation as well as performance degradation, a meditation analysis [32], is performed to investigate the relationship between delay, performance, and gaming QoE. **Fig 4** shows the relationship between delay, performance, and QoE specifically for the two games that were studied. Both delay and performance separately have a significant effect on QoE. Also, the delay has an indirect effect on QoE through the relationship with performance. This means that in a network with latency, the gamer's QoE is significantly lower when their performance is degraded. In the table tennis game b= 0.23, BCa CI [0.10, 0.37] and in the NFS b=0.15, BCa CI [0.02, 0.31].

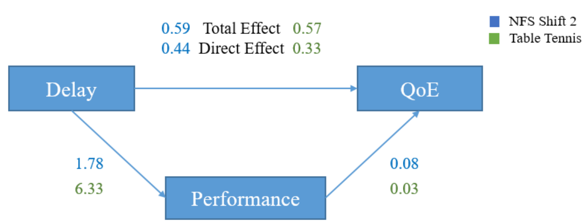

Fig 4: Relationship between delay, QoE, and performance

IV. Increasing Quality of Experience by Increasing Performance

In Section 3, the indirect effect of delay on QoE through performance is shown. Moreover, it is shown that the effect of delay on QoE is stronger when a gamer's performance degrades. By keeping this conclusion in mind, in this section of the paper, a technique to decrease the influence of delay on QoE is proposed. We adapted the characteristics of a game that influences the spatial and temporal accuracy needed to play the game successfully. This approach is based on the deadline-precision model proposed by Claypool [1]. By changing the size and speed of game objects, the delay sensitivity of the game can be reduced and the impact of delay on performance reduced.

A. Experiment Platform

For this study, we used part of a dataset that we collected earlier for another purpose [33]. In this experimental game, QoE is assessed with iGEQ for different levels of delay, 0 ms, 200 ms, and 400 ms while changing the characteristics of the open source game Somi [33]. The adaptation in this game is made by changing the deadline and precision [1]. Precision is changed by modifying the size of objects, and deadline is changed by modifying the game pace. **Fig 5** shows a snapshot from the game, Somi. Four different paces, one slower and two fasters than the original pace, and three different object sizes, one smaller and one larger than the original size, were used.

Fig 5: A snapshot from the Somi.

B. Experiment Details

In total 25 participants, ten females and 15 males aged between 19 and 33 years (MDN = 27 years), participated in this experiment. The subjective experiment was performed following the guidelines described in the ITU-T work item P.Game [10]. Each participant played 36 rounds of Somi, which each took about 90 seconds and had a different combination of delay, size, and speed. In this study, six conditions out of these 36 conditions are used. The following are the used conditions in this study:

- Condition 1: 400ms Delay, no Adaptation is made
- Condition 2: 400ms Delay, Adaptation is made by increasing the size of objects
- Condition 3: 400ms Delay, Adaptation is made by reducing the speed of the game
- Condition 4: 400ms Delay, Adaptation is made by both increasing size and reducing speed
- Condition 5: No Delay, no Adaptation is made
- Conditsion 6: No Delay, Adaptation is made by reducing speed

C. Compensating the Effect of Delay on QoE by Reducing the Precision

In this section, the first and second conditions are used. Gamers were asked to play the game with 400ms delay before and after this adaptation. **Fig 6** shows gamers' performance before and after the adaptation. In both scenarios, gamers were experiencing the same level of delay, 400ms, however, as an adaptation the size of the targets was increased to improve the performance.

For the condition with lower precision, gamers could get a higher score within the same level of the delay. This higher performance led to an improvement in most of the QoE aspects.

Fig 7 shows the improvement in these aspects, in which there are a significant difference between the QoE after (M=2.32, SD=0.17) and before (M=1.78, SD=0.12) adaptation; t(24)=2635, p =0.015 , Positive affect after (M=2.42, SD=0.15) and before (M=1.78, SD=0.12) adaptation; t (24) =2308, p =0.03 and competence after (M=2.48, SD=0.15) and before (M=2.05, SD=0.12) adaptation; t (24) =2792, p =0.01.

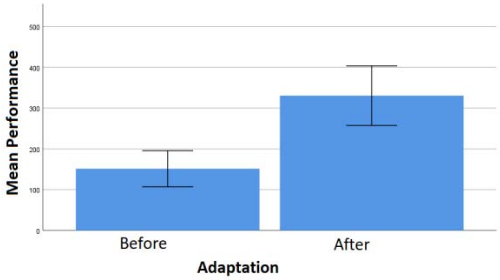

Fig 6: Gamer's performance before and after adaptation. Adaptation here is made by reducing the precision. 400ms delay was simulated.

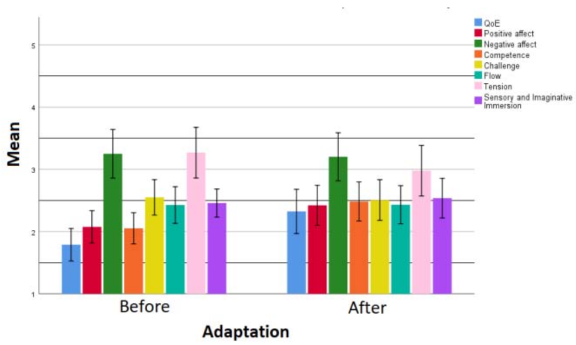

Fig 7: QoE aspects before and after adaptation. Adaptation here is made by reducing precision. 400ms delay was simulated.

D. Compensating the effect of Delay on QoE by Increasing the Deadline

In this section, the first and third conditions are compared. In condition 1, 400ms delay is simulated, and in condition 3, the same amount of delay adaptation is performed by relaxing the deadline. **Fig 8** shows the increase in performance after changing the pace of the game. In both scenarios, gamers were experiencing a 400ms delay.

For the condition with a relaxed deadline, gamers could get a higher score at the same level of delay. This higher performance led to a higher QoE.

Fig 9 shows the increase in different aspects of QoE. There exists a significant difference between the QoE after (M=2,54, SD=0.15) and before (M=1.78, SD=0.12) adaptation; t (24) =4741, p =0.000, in Competence after (M=2.63, SD=0.12) and before (M=2.05, SD=0.12) adaptation; t (24) =4152, p =0.000 and in Positive affect after (M=2.68, SD=0.12) and before (M=2.07, SD=0.12) adaptation; t (24) =4243, p =0.000.

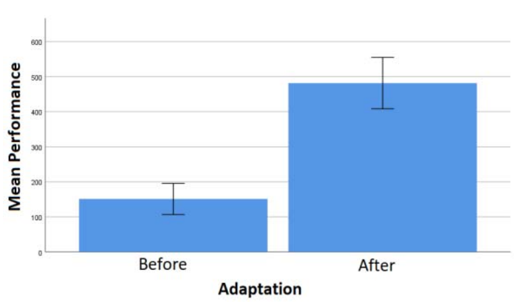

Fig 8: Gamer's performance before and after adaptation. Adaptation here is made by increasing the deadline. 400ms delay was simulated.

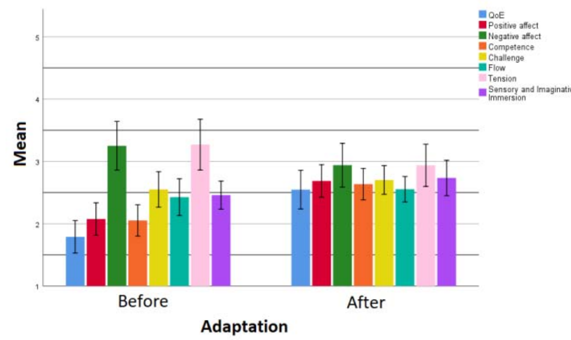

Fig 9: QoE aspects before and after adaptation. Adaptation here is made by increasing the deadline. 400ms delay was simulated.

E. Increasing deadline and reducing precision at the same time

In this section, the effect of the delay is mitigated by adapting the game based on deadline and precision. In this section, condition four is compared with the first condition. The significant improvement of the gamers' performance is shown in **Fig 10**. In both scenarios, gamers were experiencing a 400ms delay.

For the condition with both relaxed deadline and lower precision, gamers could get a higher score at the same level of delay. This higher performance led to a higher QoE.

As shown in **Fig 11**, a significant difference in the QoE after (M=2.84, SD=0.18) and before (M=1.78, SD=0.12) adaptation exists; t (24) = 5485, p =0.000. There was a significant difference in the Positive affect after (M=2.92, SD=0.15) and before (M=2.07, SD=0.12) adaptation; t (24) = 4704, p =0.000 and Competence after (M=3.09, SD=0.15) and before (M=2.05, SD=0.12) adaptation; t(24)= 5525, p =0.000.

In the Somi game, the relaxed deadline led to higher performance than the lower precision (**Fig 6** and **Fig 8**). As a result, in the Somi game relaxing the deadline can improve QoE more than the precision. In **Fig 7** and **Fig 8** the difference between the precision and the deadline can be seen. The relaxed deadline improved the QoE more than the reduced precision, which shows the importance of the deadline in the Somi game.

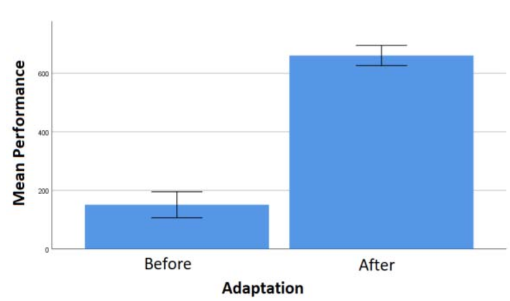

Fig 10: Gamer's performance before and after adaptation. Adaptation here is made by reducing the precision and increasing the deadline. 400ms delay was simulated.

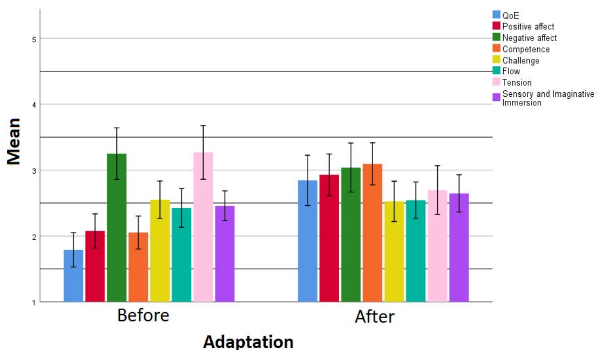

Fig 11: QoE aspects before and after adaptation. Adaptation here is made by reducing the precision and increasing the deadline. 400ms delay was simulated.

F. Where to use Adaptation

The increment of performance does not always result in a higher QoE. In a delay condition, the difficulty of the game increases. Adaptation should be made to set the difficulty of the game as the no delay condition. There is evidence that gamers have more fun experiencing a challenging task. When they do not feel challenged anymore, there is a lower fun [2]. The adaptation of games should not make the game too easy, which may result in boredom, but not too difficult, either, which may result in anxiety [2].

Fig 12 shows the increment of performance by reducing the deadline in the no-delay scenario. In both scenarios, no delay was simulated, just the pace of target movement was reduced. Although gamers' performance is significantly improved, as this modification on the game makes the game easy, the QoE did not increase but decreased instead due to the boredom. **Fig 13** shows the changes in different aspects of QoE after this modification.

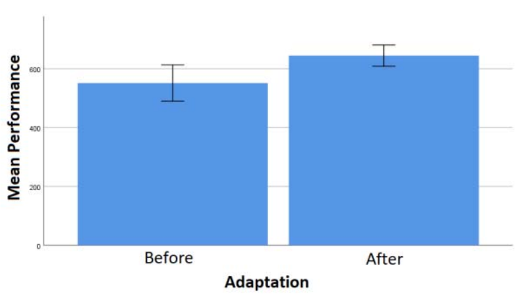

Fig 12: Gamer's performance before and after adaptation. Adaptation here is made by reducing the precision and increasing the deadline. No delay was simulated.

V. DISCUSSION AND FUTURE WORKS

This paper shows that human's experience of a game's quality, their QoE, is influenced by their performance while playing it. As the user's performance can be assessed objectively in many games, it can be used as a quality indicator. In our future work, we will try to predict the QoE through its relationship with performance. In addition, the relationship between delay and performance is shown. Based on the result, we can conclude that the more sensitive a game is, the more users' performance is degraded. By keeping that in mind, it might be possible to determine the delay sensitivity of games based on performance degradation.

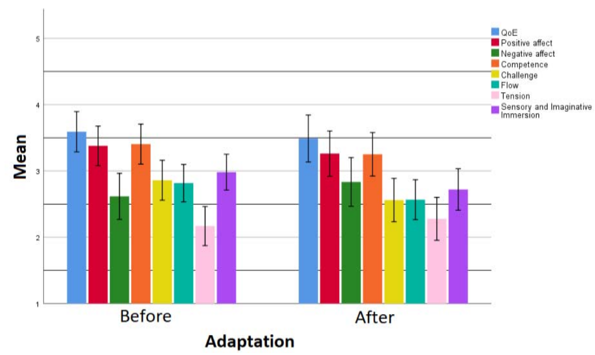

Fig 13: QoE aspects before and after adaptation. Adaptation here is made by reducing the precision and increasing the deadline. No delay was simulated.

In the second part of the paper, we illustrate that adapting characteristics of a game can strongly mitigate the negative effect of delay on gaming QoE due to increased player performance. One of the most important concepts that should be considered is the flow of adaptation. In the presence of delay, the game gets more challenging, and gamers feel anxiety. The optimum adaptation resets the level of difficulty to the challenge at delay-free conditions. Although even this adaptation cannot achieve a QoE that is identical to the no-delay condition, it can significantly improve the QoE, as we showed in section 3.

We believe the proposed adaptation technique is only suitable for single player games. A DDA system in a multiplayer game reduces the fairness of the scoring system as some players are playing an easier version of the game. However, adaptation in multiplayer games as long as gamers are not aware that adaptation is applied can balance the gamer's skills and increase the challenge [34]. In our future work, we will investigate the effects of this adaptation in a multiplayer scenario.

VI. CONCLUSION

In the first part of this paper, the relationships between performance, delay, and gaming quality of experience were investigated. The result showed a significant indirect effect of performance on QoE, meaning in a delay scenario gamer's QoE is significantly lowered by the degradation of their performance. Based on this relationship, an adaptation technique is proposed in the second part of the paper which significantly increases gamers' QoE by reducing the indirect effect of delay that comes from reduced performance. Our proposed technique that relaxes deadlines and required precision tries to allow the gamers to perform under delay conditions similarly well as under the no-delay condition. In contrast to DDA systems, our proposed technique does not require tracking or saving any information about gamers, the time and duration of applying the adaptation are determined, and it can be employed in a delay condition.

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