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The impact of changing graphic settings on performance in selected video games

Wpływ zmian ustawień graficznych na wydajność w wybranych grach komputerowych

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Abstract
This article presents the results of research into the impact of changing graphics settings on the performance of PC games. Three leading titles were selected for the study, each representing a different type of gameplay: Assassin's Creed Odyssey, Shadow of the Tomb Raider, and Cyberpunk 2077. The key parameter for evaluation was the frame rate (frames per second, FPS). The findings allow for an assessment of how changes in settings such as texture quality, anti-aliasing, and special effects influence game performance. Based on the results, recommendations were developed for both gamers and game developers.

Keywords: performance; graphics settings; FPS

Streszczenie
Artykuł przedstawia wyniki badań nad wpływem zmiany ustawień graficznych na wydajność w grach komputerowych. Do analizy wybrano trzy wiodące tytuły, reprezentujące różne rodzaje rozgrywki: Assassin's Creed Odyssey, Shadow of the Tomb Raider oraz Cyberpunk 2077. Kluczowym parametrem oceny była liczba klatek na sekundę (FPS). Wyniki badań pozwalają ocenić, w jaki sposób zmiana ustawień takich jak jakość tekstur, antyaliasing czy efekty specjalne wpływa na płynność działania gry. Na tej podstawie opracowano rekomendacje zarówno dla graczy, jak i dla twórców gier.

Słowa kluczowe: wydajność; ustawienia graficzne; FPS

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1. Introduction

Developments in technology are allowing developers to push further boundaries in creating ever more visually advanced worlds. This translates into more and more graphic settings and having the latest components to run productions. The increase in hardware requirements forces players to search for optimal settings to ensure comfortable gameplay and to accept simplifications in graphics. The most aggravating settings are texture quality, antialiasing (AA) or special effects. These settings directly affect the number of frames per second displayed.

The aim of this study is to analyse in detail how settings for texture quality, anti-aliasing and special effects affect frame rates in computer games on different hardware configurations. The research will provide information on what relationships exist between settings and game fluidity. Such information is a guide for developers as well as gamers themselves.

2. Literature review

The analysis of the influence of graphic settings on the performance of computer games has been the subject of much previous research. Many studies have highlighted the importance of optimising graphics in a hardware context. Hubert Żukowski's research shows that one of the key aspects is adjusting the level of detail of texture quality. For the Unreal Engine, the effect of texture quality is noticeable, which can cause an increase or decrease in fluidity depending on the platform being run [1].

In their article, authors Chalmers and Debattista address the issue of benchmarking graphics engines. The authors focused on how the type of special effects affects the load on the CPU and graphics card. During the research, the authors focused on the study of dynamic shading and particle effects, which are among the quite popular settings. The results of the study indicated that these two settings are the main factors affecting frame rate drops [2].

Wang et al. are investigating the impact of frame rate on user experience in virtual reality environments. Experiments were conducted at different FPS values (15, 30, 60, 90, 120), analysing their effects on task performance, user experience and the occurrence of simulator sickness symptoms. The results showed that a higher FPS improves both performance and comfort in VR applications, while reducing symptoms such as nausea and dizziness. A particularly large difference was noticeable between values of 30 and 60 FPS. The authors emphasise that a stable and high frame rate is crucial for the quality of immersion and the overall perception of the virtual environment [3].

Another important technology that is being developed dynamically all the time and will have an increasing impact on performance is Ray Tracing. The technology

significantly affects the load on the graphics card while improving visual realism [4].

Politowski et al. review computer game testing methods, highlighting that despite technological advances, manual testing remains the dominant method. The analysis covers key areas of testing such as bug detection, regression testing, performance testing and gameplay balancing. The authors point out that the increasing complexity of games makes the testing process more demanding than for other applications. A particular challenge is testing multiplayer gameplay, which further complicates the number of possible interactions [5].

Liu et al. examines the relationship between the quality of gamers' experience and frame rate variability. In the experiments, participants evaluated their gameplay experience with stable and variable FPS, and their impact on game performance. The results indicate that an unstable frame rate negatively affects player efficiency and satisfaction. Most participants preferred a lower but stable FPS value to a higher but erratic one. The impact of FPS variability also depended on the genre - in dynamic games requiring fast reflexes, the effect was more noticeable than in turn-based strategies [6].

Claypool et al. analysed the impact of frame rate and resolution on the quality of the player experience in FPS games. The research included tests with different FPS and resolution values, with participants evaluating comfort and gameplay effectiveness. The results indicate that FPS stability significantly influenced player effectiveness, while changes in resolution were significantly less important. This suggests that smoothness of gameplay is a key factor affecting the quality of the experience [7].

Messaoudi et al. analysed the performance of different game engines depending on the target platform, focusing on desktop and mobile devices. The research assessed graphics optimisation, resource management and the impact of hardware configuration on performance. Several titles were analysed, taking into account loading times, RAM consumption, FPS stability and power consumption. The results show that Unity and Unreal Engine provide high performance on PC, but perform less well on mobile devices. The Cocos2D-X and Godot engines, on the other hand, adapt better to limited mobile resources [8].

Jumani examines the impact of graphics quality on user experience, exploring the correlation between graphics settings and player satisfaction. Experiments included changes in resolution, anti-aliasing, texture quality and lighting effects, and participants rated their gameplay experience. The results indicate that higher graphics quality increases immersion, but at the same time higher hardware load can lead to a drop in FPS. The authors emphasise that a stable frame rate is crucial for a positive gameplay experience [9].

Gerling et al. conducted a study with 48 participants analysing the impact of graphics quality on player experience in casual games. The results indicate that graphics with high visual fidelity can improve the perception of the game, but this does not always translate into increased gameplay satisfaction. Furthermore, in games with simpler mechanics, lower graphics quality did not significantly reduce the player experience, suggesting that smaller development studios may focus on aspects of the game other than advanced graphics [10].

Schauhuber et al. investigated the effects of network latency and in-game perspective (first-person, third-person, top view) on player performance and gaming experience. The study found that high latency negatively affected both performance and player satisfaction, regardless of the perspective used. This suggests that minimising latency is key to improving the player experience, regardless of how the game is presented [11].

Andrade conducted a review of fourteen popular game engines, analysing their features, capabilities and applications. The article highlights the importance of game engines as tools that enable efficient game development by separating game logic from graphical assets and other elements. This review provides valuable information for game developers, helping them to choose the right engine depending on the needs of the project [12].

3. Research hypothesis

The paper formulates the following hypotheses:

1. H1: Changing the graphics settings in computer games, particularly the settings for textures, anti-aliasing, and special effects, will have a significant impact on the frame rate.
2. H2: A computer with significantly better hardware specifications will be able to maintain higher and more stable frame rates even at the highest settings.

4. Methodology

Two computers with different hardware specifications were selected for the study. The computers represent two segments. The first is from the mid-range segment, while the second is representative of high-end computer hardware.

Computer A: mid-range, aimed at the average gamer. Specifications included Intel Core i5-12450H, NVIDIA GeForce RTX 3050 graphics card, 16GB of RAM and Windows 10 operating system.

Computer B: high end, aimed at the gaming enthusiast. Specifications included AMD Ryzen 5 7600, NVIDIA GeForce RTX 4070 graphics card, 32GB of RAM and Windows 10 operating system.

Three new and graphically demanding PC games were selected for testing, which allowed for numerous changes to the graphics settings:

1. Assassin’s Creed Odyssey – an open-world action game characterised by high graphics requirements [13].
2. Cyberpunk 2077 – an open-world RPG characterised by high-quality graphics [14].
3. Shadow Of Tomb Raider – an open-world action adventure game characterised by high graphics requirements [15].

Testing included changes to the graphic settings of texture quality, anti-aliasing level and intensity of special

effects. Each game during the study was tested at four setting levels low, medium, high and ultra.

Each test was repeated three times and the results were averaged to ensure greater reliability of the measurements. The MSI Afterburner tool was used to record the frame rate and other performance metrics, enabling accurate real-time monitoring of graphics performance.

Each test session lasted 15 minutes, and during the measurements the only software running was the game under test and the monitoring tools. All tests were conducted at Full HD resolution (1920×1080), ensuring consistent conditions across all scenarios.

5. Results

5.1. Results for Assassin's Creed Odyssey

Test results on a high-end computer show that turning off anti-aliasing and setting the textures to low quality allows higher performance (Table 1) to be achieved, with an average of 136 FPS. With ultra textures and special effects set to low, the average frame rate is 116 FPS. This is quite a high result, but there is a clear drop in the frame rate. The enabled anti-aliasing option clearly loads the computer which results in a reduction in the maximum frame rate.

Table 1: Results for Assassin's Creed Odyssey

Assassin's Creed Odyssey					
Textures	Effects	AA	AVG FPS	MIN FPS	MAX FPS
Low	Low	Off	135.7	104.3	208.6
Low	Mid	Off	129.0	104.4	158.0
Low	High	Off	127.2	104.2	157.9
Low	Low	Low	136.2	107.8	224.6
Low	Low	Mid	136.5	107.6	168.1
Low	Low	High	135.6	104.7	169.2
Mid	Low	Off	132.0	103.3	222.0
High	Low	Off	128.3	102.4	225.4
Ultra	Low	Off	116.2	87.9	144.2

The test results on the mid-range PC indicate a clear decrease in performance compared to the high-end configuration. The most favorable outcome (Table 2) was recorded with low texture quality and anti-aliasing disabled, yielding an average of 86 FPS. Switching to ultra settings reduced the average frame rate to 66.8 FPS one of the lowest results in this series. Interestingly, enabling the highest level of anti-aliasing while maintaining low texture quality produced a relatively stable 83.6 FPS. The most substantial performance degradation occurred when special effects were set to their maximum, with textures still on low and anti-aliasing disabled — in this scenario, the frame rate dropped to an average of 51.3 FPS.

Table 2: Results for Assassin's Creed Odyssey

Assassin's Creed Odyssey					
Textures	Effects	AA	AVG FPS	MIN FPS	MAX FPS
Low	Low	Off	83.1	68.7	117.8
Low	Mid	Off	77.4	58.6	103.5
Low	High	Off	51.3	39.2	89.9
Low	Low	Low	86.8	66.9	101.3
Low	Low	Mid	86.9	55.5	106.1
Low	Low	High	83.6	67.3	103.5
Mid	Low	Off	82.2	53.4	109.5
High	Low	Off	76.2	50.8	99.1
Ultra	Low	Off	66.8	48.7	93.4

5.2. Results for Cyberpunk 2077

The high-end computer delivered consistently high and stable frame rates throughout the tests. The best performance (Table 3) was achieved with low-quality textures, minimal special effects, and anti-aliasing turned off, resulting in an average of 121.8 FPS. At the opposite end, setting special effects to high while keeping textures low led to a notable drop in performance, with an average of 88.6 FPS. A configuration combining low textures with medium-level effects yielded 110.9 FPS on average, demonstrating a good balance between visual fidelity and smooth gameplay.

Table 3: Results for Cyberpunk 2077

Cyberpunk 2077					
Textures	Effects	AA	AVG FPS	MIN FPS	MAX FPS
Low	High	Off	88.6	67.9	127.2
Low	Low	Off	121.8	80.8	160.1
Low	Mid	Off	110.9	75.5	150.3
Mid	Low	Off	119.7	81.2	161.8
High	Low	Off	117.7	77.3	162.0

The mid-range PC exhibited a noticeable decline in performance compared to its high-end counterpart. The most favorable configuration (Table 4) combined low texture quality and minimal special effects with exclusive anti-aliasing, resulting in an average frame rate of 69.6 FPS. In contrast, the lowest performance was observed when using low textures, high special effects, and anti-aliasing disabled, with the frame rate dropping significantly to 37.5 FPS. A balanced compromise between visual quality and smoothness was achieved by setting medium textures, low special effects, and disabling anti-aliasing this setup yielded an average of 66.8 FPS.

Table 4: Results for Cyberpunk 2077

Cyberpunk 2077					
Textures	Effects	AA	AVG FPS	MIN FPS	MAX FPS
Low	High	Off	37.5	26.3	116.0
Low	Low	Off	69.6	51.3	92.1
Low	Mid	Off	56.3	41.1	117.2
Mid	Low	Off	68.8	50.8	90.8
High	Low	Off	68.5	49.8	89.1

5.3. Results for Shadow Of the Tomb Raider

The high-end PC delivered excellent performance with consistently high and stable frame rates. The most optimal configuration (Table 5) involved ultra texture quality, low special effects, and anti-aliasing turned off, reaching an average of 217 FPS. Surprisingly, lowering both texture and effects settings with anti-aliasing also disabled resulted in slightly lower performance, averaging 211 FPS. Activating high-intensity special effects led to a moderate drop, reducing the average to 201 FPS. A near-peak result of 216 FPS was also achieved with medium textures, low effects, and no anti-aliasing, indicating minimal impact from texture reduction at this hardware level.

Table 5: Results for Shadow Of the Tomb Raider

Shadow Of the Tomb Raider					
Textures	Effects	AA	AVG FPS	MIN FPS	MAX FPS
Low	Low	Off	211.9	142.7	291.9
Low	Mid	Off	208.1	126.4	292.8
Low	High	Off	201.1	117.4	286.3
Low	Low	Mid (TAA)	194.8	123.5	310.1
Low	Low	Low (SMAA)	195.8	121.8	272.0
Low	Low	High (SMAA4x)	179.3	115.3	255.9
Mid	Low	Off	216.5	143.9	320.1
High	Low	Off	211.9	129.4	297.8
Ultra	Low	Off	217.6	133.9	312.2

On the mid-range computer, performance dropped significantly compared to the high-end setup. The best results (Table 6) were achieved with two configurations: the first with low texture quality, minimal special effects, and anti-aliasing turned off, the second with medium texture quality, low special effects, and no anti-aliasing. Both configurations delivered an average of 127 FPS. Increasing the level of anti-aliasing progressively reduced performance. Likewise, raising texture quality to ultra settings or intensifying special effects led to consistent declines in frame rate.

Table 6: Results for Shadow Of the Tomb Raider

Shadow Of the Tomb Raider					
Textures	Effects	AA	AVG FPS	MIN FPS	MAX FPS
Low	Low	Off	127.2	66.3	231.2
Low	Mid	Off	96.9	58.9	168.4
Low	High	Off	69.2	42.1	126.8
Low	Low	Mid (TAA)	94.0	62.0	150.3
Low	Low	Low (SMAA)	96.4	70.4	147.5
Low	Low	High (SMAA4x)	79.8	53.2	123.7
Mid	Low	Off	127.5	85.3	218.4
High	Low	Off	111.7	63.4	174.9
Ultra	Low	Off	104.5	67.0	169.7

6. Discussion

Analysis of the results confirms the significant impact of graphics settings on the performance of the games studied. In particular, changing the quality of textures, the level of anti-aliasing and the intensity of special effects had a noticeable effect on the number of frames per second, with the scale of these changes depending on the hardware specification.

Lowering the texture quality resulted in an increase in performance, which was particularly noticeable on the mid-range configuration, where the differences between low and ultra settings amounted to dozens to dozens of FPS. On the high-end PC, the impact was less significant, suggesting that modern GPUs are better able to process high quality textures without significant loss in smoothness.

Equally important was the use of anti-aliasing. Enabling this feature, especially at a high level, led to a significant load on the GPU, resulting in a drop in FPS, especially in the mid-range configuration. This effect was most noticeable in Shadow of the Tomb Raider, where SMAA4x caused performance drops of several tens of percent relative to settings with anti-aliasing disabled.

Special effects, such as dynamic shading and advanced lighting, had an equally large impact on the fluidity of the gameplay. Their high intensity significantly reduced FPS, especially in Cyberpunk 2077, confirming that these types of effects are among the most computationally demanding.

A comparison of the results for both hardware configurations supports the hypothesis that a higher specification provides greater stability and higher performance, even at the highest graphics settings. In the case of the mid-range PC, settings had to be adjusted to achieve smooth gameplay, indicating the importance of

optimising graphics settings in the context of available processing power.

Each test was conducted at Full HD resolution (1920×1080), ensuring consistency in the measurements across all scenarios. Although resolution was not a variable in the study, research by Claypool et al. indicates that increasing resolution can significantly affect performance [7].

In summary, the findings highlight the key role of choosing the right graphics settings in terms of gaming performance. They also point to the need to optimise graphics technologies, such as anti-aliasing and special effects, to provide users with the best compromise between visual quality and smooth gameplay.

7. Conclusions

An analysis of the influence of graphic settings on the frame rate allows several conclusions to be drawn. Textures, special effects and anti-aliasing, depending on the level of the settings, have a significant impact on production performance. The higher the settings, the more computing power is required for a stable display of frames per second.

An important factor in the performance of individual productions is the hardware configuration. On a high-end hardware configuration, titles can be run on the highest settings. On mid-range hardware, however, lower settings are required to maintain stable frame rates.

An important element is the optimisation of specific productions on the part of the developers through the use of the latest technologies, which enable titles to be run on mid-range hardware with a stable frame rate and good visual quality at individual settings.

Changing graphics settings such as texture quality, special effects and anti-aliasing affect the number of fps. This confirms the hypothesis of an effect of graphics settings on frame rate.

Higher-end hardware configurations will provide greater stability, higher frame rates and better graphics effects than hardware with lower hardware configuration. This also supports the hypothesis that higher performance is offered by higher specification hardware.

8. Research limitations and directions for further development

The research conducted provides important information on the impact of graphics settings on game performance, but has some limitations.

The main one is the limited number of titles tested - three games using different graphics engines, but not enough to fully generalise the results. A similar limitation applies to the hardware configurations tested, which only covered the medium and high performance segments. Analysis of additional hardware, including low-budget laptops and integrated graphics chips, would have allowed a more complete assessment of the impact of graphics settings.

The research also did not consider the impact of other parameters, such as screen resolution or image scaling technologies (e.g. DLSS, FSR), which can significantly alter results.

Another limitation was that only one resolution was analysed in this case, Full HD (1920×1080). Limiting the number of resolutions ensured consistent testing conditions but prevented the assessment of how increasing or decreasing resolution affects performance under various graphics settings. Including different resolution levels in future research would allow for a more comprehensive understanding of their impact on both performance and graphical quality.

Further research development should include a broader range of games and hardware, and the analysis of dynamic mechanisms for adjusting graphics settings in real time. The increased importance of optimisation using artificial intelligence and advanced rendering algorithms points to the need for further analysis of the impact of these technologies on performance and visual quality in computer games.

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