

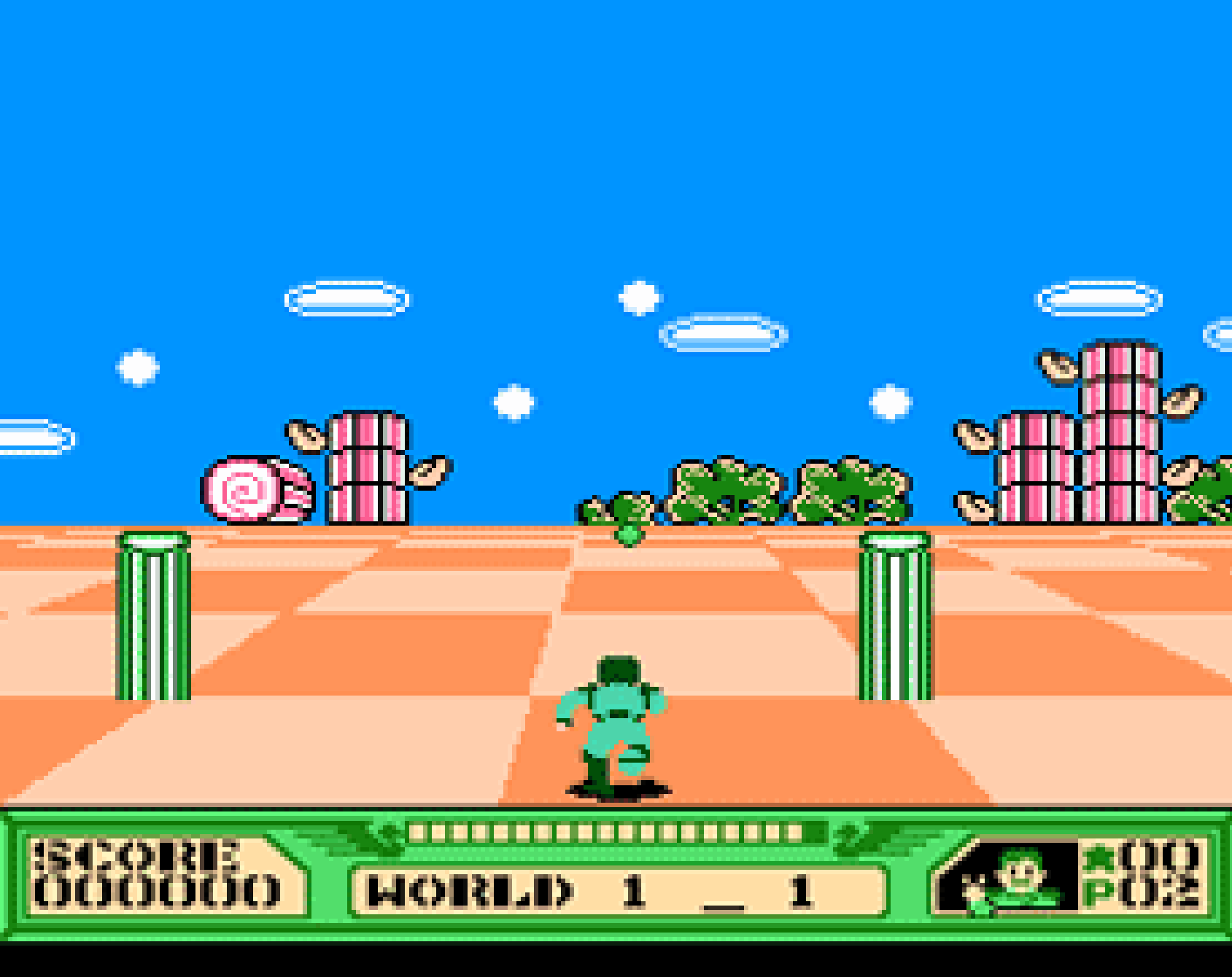
# Evaluating State of the Art Upscaling Technologies

Performance, Image Quality and Gaming Scenario  
Suitability



## Motivation

- Modern video games with detailed graphics and realistic lighting demand powerful graphics cards (GPUs) to run well
- Challenges such as transistor miniaturization limits and increased energy consumption, raising sustainability and environmental concerns.
- Upscaling technologies help address these challenges by enabling games to maintain high-quality visuals while running on lower-resolution inputs:
  - reducing the strain on GPUs and thus contributing to energy efficiency and environmental sustainability
- It is not clear which Upscaling technology works the best in practice or is the most efficient one. There is need for further investigation.



- 3D World Runner: 1988

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• GTA IV: 2008

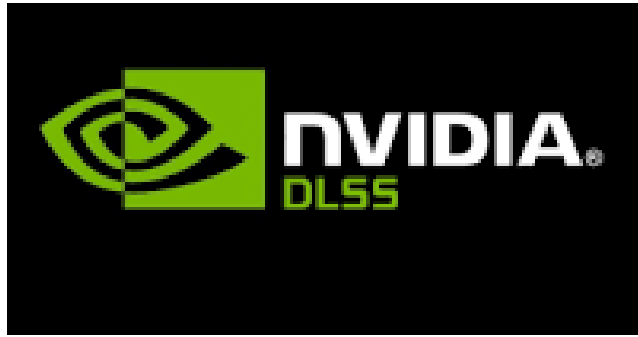




Alan Wake II: 2023

# What are Upscaling Technologies?

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- Upscaling technologies are methods used to increase the resolution of digital content such as images and videos.
  - Used for a clearer and more detailed image on higher-resolution displays without the need for native high-resolution rendering.
  - Upscaling technologies have gained increased relevance in video games in recent years to enhance visual fidelity without the high computational cost of native rendering.
  - State-of-the-Art upscaling technologies use artificial intelligence to convert lower-resolution images into higher-resolution ones.
  - By rendering fewer pixels and then upscaling, these technologies reduce the workload on the GPU.



State-of-the-Art Upscaling Technologies

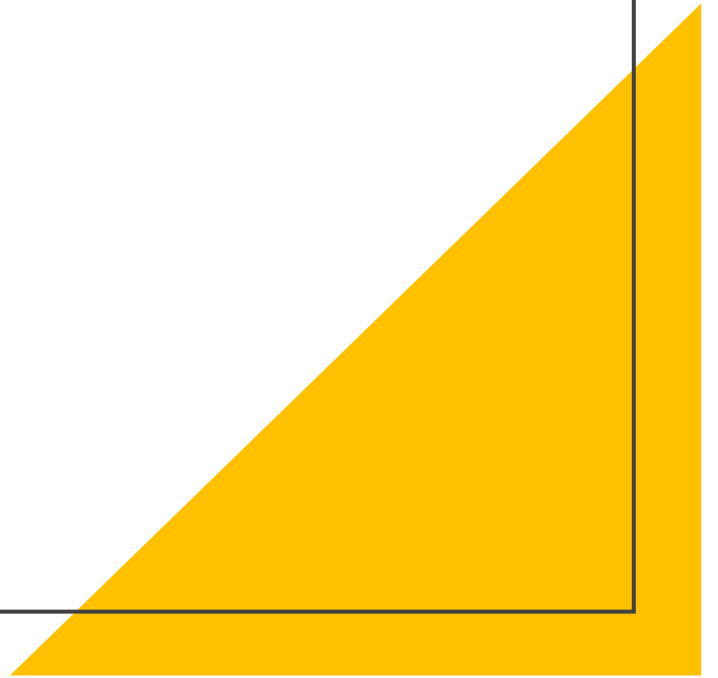
# State-of-the-Art Upscaling Technologies

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- DLSS (Deep Learning Super Sampling) by Nvidia uses artificial intelligence and machine learning to upscale images, improving game performance with minimal loss in image quality.
  - XeSS (Xe Super Sampling) by Intel also employs AI to enhance image resolution and quality, aiming to deliver better visuals with efficient processing.
  - FSR (FidelityFX Super Resolution) by AMD increases game resolution without AI, focusing on maintaining high performance across a wide range of hardware.



# Main Research Question

- How do various state-of-the-art upscaling technologies compare in terms of performance, image quality and suitability in the context of modern video games?



# Research Method

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- Benchmark tests across a range of different video games
- Benchmark metrics include:
  - Frames per Second, Frametimes, GPU Utilization as well as Energy Consumption
- Testing of the Image Quality involves a qualitative assessment with Screenshots
- Evaluation includes all three technologies: Nvidia DLSS, Intel XeSS, and AMD FSR against Native Rendering.
- Testing across various performance modes (Quality, Balanced, Performance)

# Benchmark Games

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Call of Duty Modern Warfare III

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Diablo IV

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Assassin's Creed Mirage

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Cyberpunk 2077

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The Witcher 3

# Objectives of the Master Thesis

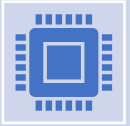


Conducting a comparative analysis of the upscaling technologies: exploring performance and sustainability aspects of the technologies



Introduction of an advanced benchmarking methodology that goes beyond conventional performance evaluation

# Conclusion and Recommendation



Assessing the energy efficiency of DLSS, XeSS, and FSR, critical for modern gaming sustainability.



Determining which upscaling technology optimally balances performance enhancement, image quality and energy efficiency



Providing a recommendation on the superior upscaling technology based on comprehensive testing and analysis



Thank you for your attention