ISTANBUL TECHNICAL UNIVERSITY ★ GRADUATE SCHOOL

ANALYZING SPATIAL DESIGN PATTERNS OF THIRD-PERSON SHOOTER VIDEO GAMES

M.Sc. THESIS

Ayça METİN AKŞAHİN

Department of Informatics

Architectural Design Computing Programme

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ISTANBUL TEKNİK ÜNİVERSİTESİ ★ LİSANSÜSTÜ EĞİTİM ENSTİTÜSÜ

ÜÇÜNCÜ ŞAHIS NİŞANCI VİDEO OYUNLARININ MEKANSAL TASARIM ÖRÜNTÜLERİNİN ANALİZİ

YÜKSEK LİSANS TEZİ

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Ayça METİN AKŞAHİN, a M.Sc. student of İTU Graduate School student ID 523201014, successfully defended the thesis entitled "ANALYZING SPATIAL DESIGN PATTERNS OF THIRD-PERSON SHOOTER VIDEO GAMES", which she prepared after fulfilling the requirements specified in the associated legislations, before the jury whose signatures are below.

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To all the unexpected discoveries on a journey
that we let them illuminate our paths,

FOREWORD

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June 2024

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ABBREVIATIONS

AI	: Artificial Intelligence
CA	: Cellular Automata
CPU	: Central Process Unit
CS	: Modeling and Simulation of Complex Systems
FPS	: Frames per Second
GG	: Generative Grammars
GPU	: Graphics Processing Unit
IF	: Image Filtering
MMORPG	: Massively Multiplayer Online Role-Playing Game
PCG	: Procedural Content Generation
PRNG	: Pseudo-Random Number Generators
SA	: Spatial Algorithms
TPS	: Third-Person Shooter

SYMBOLS

C	: Connection
$_x$**C**	: Connection – X type
Cn	: Complex connection
E	: Elevator
M	: Cinematic
R	: Room
R_{combat}	: Room with combat content
$R_{narrative}$	: Room with narrative content
R_{puzzle}	: Room with puzzle content
$R_{resource}$	: Room with resource content
$R_{tutorial}$	: Room with tutorial content
${}^{t}{}_{x}R^{Zn}$	: Room with t difficulty, n level and x type.
S	: Stair
t1	: Low-level challenge, simple room
t2	: Moderate challenge, medium room
t3	: Higher level of challenge, large room
t4+	: Significant level of difficulty, boos room
z0	: Flat floor, even terrain within a room
z0,n	: Room within platform on flat floor
zn	: Room within multiple levels

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ANALYZING SPATIAL DESIGN PATTERNS OF THIRD-PERSON SHOOTER VIDEO GAMES

SUMMARY

The rapid growth and financial dominance of the video game industry have driven the development of procedural content generation (PCG) to meet the demand for fast production and diverse game environments. While PCG offers significant advantages, such as player customization, endless content creation, and unpredictability, it also faces notable challenges. These include time-consuming generator design, lack of quality assurance, difficulty in balancing gameplay, and the production of repetitive and uninspired content. Moreover, existing PCG studies often focus on 2D environments, leaving a significant gap in understanding and formalizing the design of complex 3D spaces.

This research addresses these challenges by developing a model framework to analyze and extract spatial design patterns from Metacritics-validated successful third-person shooter video games, which can further be used as an input for PCG algorithms. By borrowing insights from architectural and urban design patterns, particularly inspired by Christopher Alexander’s “A Pattern Language,” the study aims to provide guidelines that enhance video game level design. Six games - *Max Payne 3, Mass Effect 3, Gears of War 4, Dead Space, Control, and Tom Clancy’s Splinter Cell Conviction* - were selected for their high Metacritic scores and relevance to the genre.

The research method involves a detailed spatial analysis and decoding of the selected games. 3D game levels are translated into 2D layouts, labeling each space by gameplay content attributes, vertical complexity, challenge level, and layout categorization. A structured grammar is developed to represent the dynamic gameplay order, transforming gameplay sequences into readable sentences using a linguistic framework, and formalizing a spatial language for PCG algorithms.

The analysis reveals commonalities in room types and their impact on gameplay. Despite diverse settings, the analyzed games exhibit enclosed boundaries and layouts, categorizing their environments as 'rooms.' Common room types are identified based on content: narrative, quest, combat, puzzle, resource, and tutorial. Spatial layouts include square, rectangle, semicircle, L-shape, and circle. Rooms are further analyzed by their third dimension and scale, correlating to challenge levels and time spent. Unique rooms, featuring customized designs and high challenge levels, often include multi-level structures that enhance gameplay complexity and vertical navigation.

Patterns regarding the rooms reveal that dominant mechanics influence the layout, verticality offers tactical advantages, and prop placement affects player navigation. Decoded rooms follow Frank Ching's architectural principles, emphasizing symmetry, hierarchy, rhythm, and repetition to guide player movement and maintain spatial coherence. Additionally, aesthetic elements such as color, texture, light, and sound shape the atmosphere and immersion, guiding the player's attention and setting the emotional tone.

Traversal spaces between rooms, defined as connections, are categorized into three groups based on their verticality. Horizontal connections facilitate movement across the same plane, ranging from simple directional routes to more complex U-shaped and L-shaped paths. Vertical connections, including various stair designs and elevators, enable traversal between different levels, offering unique experiences such as rest spaces or cinematic interactions. Complex connections, which combine multiple simple connections, are strategically designed to link high-challenge combat rooms, providing rest periods and optimizing game performance by preventing simultaneous rendering of large-scale rooms.

By symbolically representing rooms and connections and converting them into sentence-like sequences, the analysis uncovers recurrent spatial design rules. Using BNF notation and standardized grammar, the study examines fundamental structures across the selected games, revealing the relationship between spatial organization and gameplay experience.

The study exemplifies two primary types of level progression in the analyzed games: linear and hub-and-spoke. Linear progression, seen in action-packed games like Max Payne 3 and Mass Effect 3, involves a predetermined order of rooms, restricting backtracking. Conversely, the hub-and-spoke progression in games like Dead Space and Control allows players to unlock and revisit interconnected areas. These progression types significantly influence spatial arrangement and overall player experience.

This study contributes to the scholarly discourse on video game spatial design, emphasizing its importance in structuring player experience and progression. Furthermore, it presents an interdisciplinary approach, combining level design and architecture, and highlights the relevance of architectural theories in understanding video game space.

In conclusion, this study provides insights that advance the understanding of spatial design in third-person shooters and offers guidelines that can inform the development of more sophisticated PCG algorithms. It opens avenues for future research aimed at improving PCG algorithms by integrating sophisticated spatial design principles derived from existing games.

ÜÇÜNCÜ ŞAHIS NİŞANCI VİDEO OYUNLARININ MEKANSAL TASARIM ÖRÜNTÜLERİNİN ANALİZ EDİLMESİ

ÖZET

Video oyun sektörü, küresel endüstride son yıllarda hızla büyüyen ve her geçen yıl daha fazla harcama yapılan bir sektör olarak yer almaktadır. Bu sebeple dijital oyunların üretim hızının arttırılması ve oyuncuya daha fazla ve çeşitli içerik sunulabilmesi adına prosedürel içerik oluşturma (PCG) yöntemleri doğmuştur. PCG, oyunculara kişiselleştirme, sonsuz içerik ve öngörülemezlik gibi büyük avantajlar sunarken, geliştirilmesi ve oyunlara adaptasyonunda bazı zorluklar bulunmaktadır. Bu zorluklar arasında PCG sistemlerinin tasarımının zaman alıcı olması, kalite güvencesi eksikliği, oyunun dengesini sağlama zorluğu ve tekrarlayan, ilhamsız içerik üretimi gibi unsurlar yer almaktadır. Ayrıca, mevcut PCG araştırmaları genellikle 2D ortamlar üzerine odaklanmakta ve karmaşık 3D mekanların tasarımını anlamada ve oluşturmada önemli bir boşluk bulunmaktadır.

Bu araştırma, oyuncular tarafından başarılı bulunmuş üçüncü şahıs nişancı video oyunlarının mekansal tasarım modellerinin analizlemesinin ardından tekrarlayan mekansal örüntüleri ortaya koyarak PCG algoritmalarına katkı sunmayı amaçlamaktadır. Analizlenen mekansal modeller ile seviye tasarımlarının sıralanışları, PCG algoritmalarında bir girdi olarak kullanılabilirliği ve prosedürel olarak oluşturulan mekansal içeriğin kalitesini, çeşitliliğini arttırabileceği ön görülmüştür. Mimari ve kentsel tasarım modellerinden, özellikle Christopher Alexander'ın "Bir Desen Dili" çalışmasından ilham alarak, çalışma, video oyunu seviye tasarımını geliştiren yönergeler sağlamayı amaçlamaktadır. Araştırmanın ana hedefleri, ayrıntılı bir mekansal analiz yöntemi geliştirmek, dinamik oyun sırasını temsil eden yapılandırılmış bir dilbilgisi oluşturmak ve oyuncu deneyimini daha tutarlı hale getiren ortak mekansal tasarım modellerini tanımlamaktır.

Ana oyun mekaniği ve kamera açısı oyun mekan üretimini etkileyen önemli parametreler olması sebebiyle sabit tutularak, çalışma yalnızca üçüncü şahıs nişancı video oyunları ile sınırlandırılmıştır. Metacritic platformunda 85'in üzerinde puan almış, tek oyunculu üçüncü şahıs nişancı oyunu filtrelemesinin ardından, Max Payne 3, Mass Effect 3, Gears of War 4, Dead Space, Control ve Tom Clancy’s Splinter Cell Conviction, oyunları seçilerek analizlenmiştir.

Seçilen oyunlar iki saatlik bir oynanışın ardından, video olarak kaydedilen oyun seviyeleri iki boyutlu plan şemalara sadeleştirilmiş ve her mekan oyun içeriği özelliklerine, üçüncü boyuttaki karmaşıklığına, zorluk seviyesine ve plan kategorizasyonuna göre sınıflandırılmıştır. Dinamik oyun düzenini temsil etmek için yapılandırılmış bir dilbilgisi geliştirilmiş, oyun dizilerini dilsel bir çerçeve kullanarak okunabilir cümlelere dönüştürmüştür. Bu süreçle, mekansal zenginlik sunabilen PCG algoritmalarının geliştirilmesine yardımcı olabilecek mekansal örüntü ve modellerini ortaya çıkarmaya yardımcı olmayı amaçlanmaktadır.

Analiz, oda türleri arasındaki ortak noktaları ve bunların oynanış üzerindeki etkilerini ortaya koymaktadır. Seçilen oyunlardaki mekanların kurgularının (dış mekan, avlu, iç mekan vb.) farklı oluşuna rağmen, sadeleştirildiklerinde sınırlarının mimari anlamda 'oda' olarak kategorize edilen kapalı sınırlar ve düzenler sergiledikleri gözlemlenmiştir. Daha sonra bu odalar oynanış içeriklerine göre altı alt sınıfta kategorize edilmiştir: anlatı, görev, kombat, bulmaca, kaynak ve eğitsel. Odalar iki boyutlu düzlemde plan biçimlerine göre; kare, dikdörtgen, yarım daire, L-biçim ve daire olmak üzere sınıflandırılmıştır. Odalar, üçüncü boyuttaki hacimleri ve ölçeklerine göre daha ayrıntılı olarak analiz edilmiş, zorluk seviyelerine ve mekan içerisinde geçirilen zamana göre etiketlenmiştir. Özelleşmiş tasarımlara ve yüksek zorluk seviyelerine sahip odalar, genellikle oyun karmaşıklığını ve dikey gezinmeyi artıran çok seviyeli yapılar olarak gözlemlenmiştir. Odaların tasarımlarında alınan kararlardan, mekaniğin planlamayı etkilediği, yüksekliğin taktiksel avantajlar sunduğu ve oda içi dekor yerleşiminin oyuncuların navigasyonunu etkilediğini gibi çıkarımlar yapılmıştır. Analizlenen oyunlardaki deşifre edilen odalar, oyuncu hareketini yönlendirmek ve mekansal tutarlılığı korumak adına Frank Ching'in mimari ilkelerini takip ettiği gözlemlenmiştir. Bu mekanlarda simetri, hiyerarşi, ritim ve tekrar mimari elemanlarla vurgulanmaktadır. Ayrıca renk, doku, ışık ve ses gibi estetik unsurlar, mekanlar içerisindeki atmosferi ve sürükleyiciliği şekillendirerek oyuncunun dikkatini yönlendirmekte ve duygusal tonu belirlemektedir.

Odalar arasındaki geçiş mekanları, yatay, düşey ve kompleks bağlantılar olamk üzere üç grupta kategorize edilmiştir. Yatay bağlantılar, aynı düzlemde hareketi kolaştırmakta ve basit yönlü rotalardan daha karmaşık U ve L biçimli yollara kadar çeşitlilik göstermektedir. Dikey bağlantılar, çeşitli merdiven tasarımları ve asansörler dahil olmak üzere, farklı katlar arasında hareketi sağlamakta ve oyuncular için dinlenme alanları veya sinematik etkileşimleri gibi deneyimler sunmaktadır. Birden fazla basit bağlantıyı birleştiren karmaşık bağlantılar, yüksek zorluktaki savaş odalarını birbirine bağlamak, dinlenme süreleri sağlamak ve büyük ölçekli odaların aynı anda oluşturulmasını önleyerek oyun performansını optimize etmek için stratejik olarak konumlanmaktadır. Bu bağlantılar, oyun içi gezintiyi yönlendirmek ve mekansal tutarlılığı korumak için kritik öneme sahiptir. Odaları ve bağlantıları sembolik olarak temsil edip cümle benzeri dizilere dönüştürerek yapılan analiz, tekrarlayan mekansal tasarım kurallarını ortaya çıkarmaktadır. BNF notasyonu ve standartlaştırılmış dilbilgisi kullanılarak, seçilen oyunlardaki temel yapılar incelenmiş ve mekansal organizasyon ile oyun deneyimi arasındaki ilişki ortaya konmuştur.

Çalışma, analiz edilen oyunlarda iki ana seviye ilerlemesi türünü örneklemektedir: lineer ve hub-and-spoke. Max Payne 3 ve Mass Effect 3 gibi aksiyon ağırlıklı oyunlarda görülen doğrusal ilerleme, önceden belirlenmiş bir oda dizisini içerir ve geri izlemeyi kısıtlamaktadır. Bu tür ilerleme, odaklanmış ve yönlendirilmiş bir oyuncu deneyimi sağlamaktadır. Öte yandan, Dead Space ve Control gibi oyunlarda hub-and-spoke ilerlemesi, oyuncuların birbirine bağlı alanların kilidini görevleri tamamladıkça açarak ilerlemesine ve aynı mekanları yeniden ziyaret etmesine olanak tanımaktadır. Bu tür ilerleme, daha açık uçlu bir deneyim sunarak keşif ve oyuncu özgürlüğünü teşvik etmektedir. Bu ilerleme türleri, mekansal düzenlemeyi ve genel oyuncu deneyimini önemli ölçüde etkilemekte, seviye tasarımının ilgi çekici oyun ortamlarının geliştirilmesindeki önemini vurgulamaktadır.

Bu çalışmada, video oyunu mekansal tasarımına ilişkin akademik söylemlere katkıda bulunmak ve bunun oyuncu deneyiminin ve ilerlemesinin yapılandırılmasındaki önemini vurgulamak hedeflenmiştir. Çalışma, seviye tasarımı ve mimariden elde edilen içgörüleri birleştirerek, video oyunu mekanını anlamada mimari teorilerin önemini vurgulamaktadır. Bu disiplinlerarası yaklaşım, mekansal tasarımın oynanış ve oyuncu sürükleyiciliği üzerindeki etkisini daha derinlemesine anlamayı sağlamaktadır. Tezin bir diğer önemli bileşeni, oyun mekansal tasarımını analiz etmek ve formüle etmek için kullanılan yöntemlerin ve araçların ayrıntılı bir açıklamasını içermektedir. Bu bölüm, özellikle yapılandırılmış dilbilgisi ve BNF notasyonunun nasıl kullanıldığını ve oyun dizilerinin okunabilir cümlelere nasıl dönüştürüldüğünü ayrıntılarıyla açıklamaktadır.

Sonuç olarak, bu çalışma, üçüncü şahıs nişancı oyunlarında mekansal tasarımın anlaşılmasını ilerleten ve daha sofistike PCG algoritmalarının geliştirilmesine rehberlik edecek yönergeler sunan içgörüler sağlamaktadır. Başarılı video oyunlarından mekansal tasarım modellerini analiz ederek ve çıkararak, araştırma, PCG ile ilgili zorlukları ele almakta ve prosedürel olarak oluşturulan içeriğin kalitesini artırmaya katkıda bulunmaktadır. Bulgular, oyun geliştirmede mimari ve kentsel tasarım ilkelerinin dikkate alınmasının önemini vurgulamakta ve disiplinlerarası iş birliğinin oyun deneyimini geliştirme potansiyelini ortaya koymaktadır. Gelecek araştırmalar, bu çalışmada geliştirilen model çerçevesini rafine etmeye ve genişletmeye odaklanarak mekansal tasarım ilkelerinin PCG algoritmalarına entegrasyonunu sağlayacaktır. Bu şekilde, araştırmacılar ve geliştiriciler, prosedürel olarak oluşturulan oyun ortamlarının kalitesini, yaratıcılığını ve ilgi çekiciliğini daha da iyileştirebilir, PCG'nin sürekli gelişen video oyunu endüstrisinde değerli bir araç olarak kalmasını sağlayabilirler.

1. INTRODUCTION

The origins of academic game studies can be traced back to the late 1990s to Murray's *Hamlet on Holodeck* and Espen Aarseth's *Cybertext (1997)*. The term ludology emerged in 1982, yet was popularized in the late 1990s by Gonzalo Frasca to define the study of games, particularly video games. Jesper Juul (2011) defined games as "rule-based systems with a variable and quantifiable outcome" and indicated the fundamental notion of games as "rules" that reach a consensus by the theorists.

The video game industry, although relatively young in the entertainment area, has swiftly risen the dominance, surpassing the oldest sectors in both expenditure and market influence. In 2020, the production cost of Cyberpunk 2077 was announced as $62.8 million and an additional $21.7 million for the marketing campaign, totaling $84.5 million by the developer CD Projekt (CD Project, 2020). In 2023, the gaming industry's global revenue reached approximately $365.6 billion, overshadowing the total revenue of filming and music industries (Newzoo, 2024). This financial predominance highlights the gaming industry's growth and investment attraction with excessive competition.

As computer graphics have evolved, and the investment in the gaming industry growth drastically, interactive text-based computer games have shifted to millennium computer games with hyperrealistic three-dimensional game environments with eternal content. The need for rapid and stunning game productions has increased due to the high stakes involved; a traditional workforce falls short to meet this demand. In response to industry demands, novel production techniques including procedural content generation (PCG) have emerged.

PCG is widely used for crafting video game maps. Johnson et al. (2010) asserted the necessity of PCG for designing game maps for four main reasons. First, levels become less predictable which contributes to the curiosity of players. Second, the core mechanic of certain games requires the real-time generation of maps. Parametrizable maps produced with PCG allow player-centric customization. Finally, PCG can serve designers as an assisting tool to enhance their creativity (Johnson et al., 2010).

Gellel and Sweetser (2020) designed a level generator for playable 2D top-down dungeons inspired by the roguelike genre, using a hybrid approach combining context-free grammars for defining missions and cellular automata for crafting space. They highlighted that the current attempts to generate the levels in a 3D environment feel unnatural comparing the 2D counterpart levels (Gellel and Sweetser, 2020).

Evolutionary algorithms are widely used in procedural-level generation studies in literature. Walton et al. (2022) developed a mixed-initiative tool to support the human design process that generates 2D dungeon levels by using interactive evolutionary optimization. Tanagra (2010) is developed as a mixed-initiative design tool for 2D platformer games allowing designers to manipulate the geometry and pacing. It is discussed that there is a need for objective measurement metrics for procedurally generated levels (Smith et al., 2010). Sorenson and Pasquier (2010) used the FI-2Pop genetic algorithm to develop a level generator tool that can produce 2D platformer and 2D top-down action games. A constructive 2D level generator is defined by the Marahel language (Khalifa and Togelius, 2020).

Silva et al. (2022) have developed a PCG tool that generates levels from pre-designed game components by level designers with a snappable mesh method for multiplayer 3D combat games. However, they discussed the limitations such as weak configurations with dead ends, invalid paths, and unsupported jumping mechanics through navigation (Silva et al., 2022). Tutenel et al. (2010) proposed a high-concept layout language to allow designers to describe elements presented in the 3D virtual scene arising from a question “how to create procedure?”.

In the gaming market, 2D roguelike and 2D action RPG games such as Rogue, Spelunky Classic, The Binding of Isaac, and Diablo levels or maps powered by PCG. Minecraft (2011) ensures player-controllable sandbox gameplay with procedurally generated worlds. No Man's Sky (2016) aimed to provide players with a procedurally generated galaxy featuring eighteen quintillion planets, each with unique flora and fauna. Despite its technical achievements, the game faced significant criticism upon release. Players found the worlds within the game to be repetitive and lacking interest

(Mailberg 2016). This disappointment highlighted the substantial limitations of existing procedural content generation (PCG) technology.

1.1 Problem Statement

Five desirable properties of a PCG solution are asserted by Toglius et al. (2016) speed, reliability, controllability, expressivity/diversity, and creativity / believability. However, while PCG offers vast and diverse gaming experiences, several drawbacks are underlined in the literature. (Short and Adams, 2017; Tutenel et al. 2010; von Rymon Lipinski et al., 2019; Ruela and Valdivia Delgado, 2018; Snodgrass and Ontanon, 2017)

Notably, in AAA games, PCG may fall short in quality assurance, the time-consuming nature of generator design, and the intricate task of balancing gameplay in multiplayer settings (Short and Adams, 2017). Furthermore, procedurally generated content is criticized for frequently having limited originality, structure, or meaning, which leaves game elements visually empty and generic (Togelius, 2013). The perception of being computer-generated, random, and boring originates from the challenge of insufficient human designer control within most generators (Ruela & Valdivia Delgado, 2018). Zhu et al. (2018) explained the algorithmic complexity of PCG methods and the consequences of designers being likely to avoid PCG techniques. Suggested PCG techniques and methods should be simple and designer-oriented.

Additionally, PCG studies are criticized for being restricted to a single game genre (Snodgrass and Ontanon, 2017) and only applicable to rigid geometries (Tutenel et al., 2010; von Rymon Lipinski et al., 2019). Complexities arising from the third dimension and volume, contribute to a relative lack of studies in 3D levels as opposed to their 2D counterparts for procedurally generated levels. Since 3D environments are inherently complex, a deeper understanding is required, and this calls for consideration of architectural discourse—which has a longer history and focus on 3D space than game studies.

There is no universally applicable rulebook for level design as it intricately depends on each game's game design. Even if consensus is reached on general design principles, crafting a game level with spatial characteristics involves a significant degree of subjectivity to the designer's vision and game design decisions. Therefore, designers must engage more deeply with the PCG algorithms, extending beyond adjusting parameters, which raises fundamental questions about the essence of a "good" level design. A notable absence of formalization of spatial design exists in level design studies. This lack of formalization, which highlights the intuitive nature of the level design process, presents an obstacle to the field of procedural level generation.

1.2 Aim and Scope

This study aims to enhance an understanding of video game level design by borrowing insights from architectural and urban design patterns inspired by Christopher Alexander's foundational study, A Pattern Language (1977), which we believe can serve as a guiding framework for level design. A language builds communication in the real world, likewise, a spatial language ensures players to navigate the game world. By decoding the complexities of 3D video game environments, our goal is to contribute to PCG algorithm development and the issues addressed in the literature.

The study focuses on highly ranked third-person shooter games on the Metacritic platform, whether the presence or absence of a level design pattern. While not claiming to establish a complete language, our aim is to present a framework with broader applicability across various genres, emphasizing enhanced spatial comprehension of game levels. This research aims to contribute to the formalization of a spatial language for PCG algorithms in video games.

1.3 Research Method

Metacritic's top 85+ scored third-person shooter games (six games) with specific criterias such as single-player and not open-world, were chosen for in-depth examination and deciphering. Each game underwent approximately 2 hours of gameplay, during which key spatial aspects were observed. Subsequently, the 3D game levels were translated into 2D plan layouts, accompanied by appropriate labels. Recognizing that spatial configuration alone does not fully convey level design, additional elements such as room context (combat, puzzle, tutorial, etc.) and the room's scale associated with gameplay time (t0, t1, t2, t3) were considered as a label. To address the often-neglected third dimension in existing literature, the levels within the room (z0, z1, z2) were indicated as labels. The drawn layouts are simplified into 2D plan schemes, with attention to outlining entrance and exit routes based on the player's path. For enhanced readability and systematic categorization, symbols were assigned to represent the simplified spaces forming a vocabulary for a spatial language. To capture the dynamic gameplay order a grammar was devised within these symbols, providing a structured representation of the level designs. The methodology will be covered in detail in section 3.

2. BACKGROUND

This chapter delves into the concepts and frameworks in the literature regarding the video game environments and their design. It explores the evolution of video games, the interplay between game design and level design, the role of procedural content generation in the game production, and the application of architectural theories level design.

2.1 Overview of Video Games, Space and Structure

There are several definitions of game with various perspectives from both academia and industry veterans. While there is no consensus on a general definition of a game, Avedon and Sutton-Smith (1971) asserted that *games are an exercise of voluntary control systems in which there is an opposition between forces, confined by a procedure and rules in order to produce a disequilibrial outcome.*

Meanwhile, Fullerton (2008) stated that *a game is a closed, formal system, that engages players in structured conflict and resolves in an unequal outcome.* These definitions underscore the fundamental elements of games emphasizing the role of rules and procedures that shape the overall experience and outcome. In the Book of Lenses, Schnell (2008) creates of a definition *a problem-solving activity, approached with a playful attitude*, and highlights the intrinsic connection between fun, challenge, and the essence of a game.

Games, as interactive media, dynamically engage players individually or in interpersonal, and their inherent challenge is a crucial aspect. When combined, these definitions offer a comprehensive understanding of the complex nature of games, acknowledging their interactive dynamics, structured systems derived from procedures and rules, conflict, and the fun of problem-solving in an immersive environment.

When video games topic come up in discussion in recent years, images of highly detailed three-dimensional graphics, impressive visual effects, and immersive virtual environments are often evoked. However, the origins of video games trace back to a more abstract form, the text-based games in the mid-1970s. Despite the lack of a virtual environment of modern gaming, these text-based adventures were prospering to make players experience the spatiality of the environment through descriptive texts and interactions. In *Colossal Cave Adventure(1976),* players explore cave systems, hunting treasures and solving puzzles through descriptive text.

Over time, video games progressed through phases of 2D graphic games like *Pong,* and *Space Invaders* in the early 1980s, 8-bit console games like *Super Mario Bros* in the early 1990s, and 16-bit and more advanced 3D graphic games like *Wolfenstein 3D* and *Doom*. The computer graphics developed incrementally parallel to the capacity of the hardware. Regardless of how, from the inception of text-based adventures to sophisticated 3D worlds today, spatiality is a fundamental component of the gaming experience evolving with each breakthrough in technology.

Space is a defining element of computer games, according to Aarseth (1997), who classified computer games based on how they represent or implement space. According to Nietsche (2009), space in video games is the environment where the game takes place and players navigate between game bits. He disserted that the game space plays a crutial role in creating a dynamic gameplay experience deduced from the player's constructing their interpretation starting from the game space.

Nietsche (2008) classified the spatial form of games into four categories, *tracks and rails, labyrinths and mazes, arenas*, and *driven by space*. Tracks are visible, and rails are relatively abstract single axes that guide players through attractions, where movement occurs. Labyrinths and mazes are composed with growing complexity and repetitive rhythm of tracks, yet loose visual cues. Unlike labyrinths, mazes are multicursal, offering more than one defined path. Arenas, high visibility open spaces with predetermined enclosures without dominant movement paths. A space-driven model is an abstract structure where structural force shapes interactive events. With the space-driven model, Nietsche highlights the advantage game designers have in shaping player experiences through spatial structures, offering a level of control and precision that goes beyond the capabilities of traditional architecture (Nietsche, 2008).

Schell (2008) schematized five common ways that designers organize the game space: linear, grid, web, points in space, and divided space (Figure 1.1) according to the movement of players. Fundamentally, linear game space is where a player can move along a line, grid game space is where players can move along grids based on rules, and web game space is composed of several points connected with paths. Points in space organizations are where players define their game space, and finally, divided game space resembles real-world maps crafted from irregular sections.

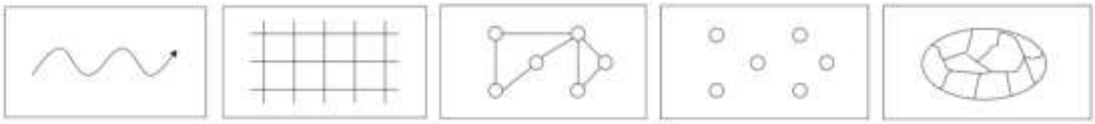


Figure 1.1 : Schell's game space organization illustrations, from left to right: linear, grid, web, points in space, divided space (Schell, 2008).

The concept of space is frequently encountered in architectural literature as the term place. The differentiation between space and place was expressed by Kalay and Marx as follows: Without function and behavior, any virtual place is merely a 3D geometry that people can walk through and observe. A functional virtual environment needs to be navigable for its functions to become useful. The way-finding principle needs to be considered in a virtual environment that requires a detailed study of environmental cognition. (Lau and Maher, 1999)

Related to environmental cognition, Kevin Lynch has categorized the major legible elements for urban cognitive maps for the physically built environment as *paths, edges, districts, nodes,* and *landmarks* (1960). Paths connect other elements, edges create the boundaries between regions and districts. Districts are the groups that compose the urban landscape when united. Nodes are the intersection or junction points between paths where an observer can enter an enclosed space from that point. Landmarks are considered as reference urban elements defined by a well-known physical object. A landmark should be distinguished from a far distance by the observer.

A generally accepted assertion by Frank Ching (1979) emphasizes the essential elements of physical architecture including, *shape, size, color, texture, position, orientation,* and *visual inertia*. Furthermore, Ching establishes ordering principles as *axis, symmetry, hierarchy, rhythm/repetition, datum,* and *transformation*.

Based on Ching's and Lynch's studies and combining their theories, it is possible to analyze and design video game spaces using architectural principles because the visual properties align with the geometric information. However, the challenge of designing a virtual space lies in its absence of physical space constraints, opening up new possibilities and considerations for the design of game environments (Nietsche, 2008)

2.2 Design of Game Space: Game Design and Level Design Interplay

To analyze comprehensively game space, it is inevitable to establish a foundational understanding of video game bits and their hierarchy. Hendrikx. et. all have constructed a six-layer pyramid of video game contents (Figure 2.1) akin to Maslow's hierarchy of needs. At the foundational level, game bits encompass elements of textures, sound, vegetation, buildings, and dynamic entities like fire, water, stone, and clouds. Ascending through the pyramid, at the second layer the game space, an amalgamation of indoor maps, outdoor landscapes, and bodies of water. Continuing the top, the next layer unfolds as game systems, composed of networks of ecosystems, road systems, urban environments, and the behaviors of in-game entities. The fourth layer, game scenarios, incorporates puzzles, storyboards, overarching narratives, and the focal point of our research, game levels. Navigating further, game design takes precedence, embodying both system design and world design. Finally, at the top of the pyramid, we encounter derived content, characterized by dynamic elements of news broadcasts, and leaderboards.

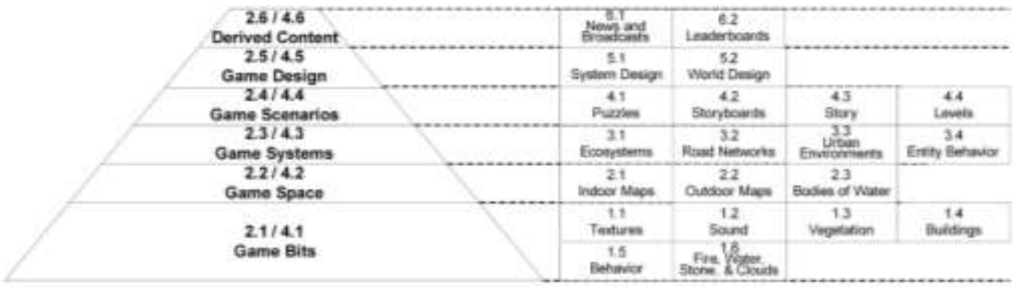


Figure 2.1 : Hierarchy of game content that can be procedurally generated (M. Hendrikx et al., 2012).

To be able to internalize the following sections of this study, it is crucial to clarify the definitions and hierarchy of game design, and level design. Schell defines game design as an act of deciding what a game should be. (2008) Game designers craft immersive worlds with embedded rules and dynamic relationships among objects, as discussed by Jenkins and Squire (2002). Game design acts as a holistic construct, encapsulating both level design, game development, and game art.

In parallel, Rudolf Kremer emphasizes that level design is an applied form of game design, interpreting game rules and translating them into constructs that facilitate gameplay (Kremer, 2009; Seifert, 2013). Totten emphasizes that level designers utilize spatial design principles and interactions, ensuring the thoughtful execution of gameplay into gamespace for player immersion in his seminal study (2014).

Salmond underscores the fundamentals of level design as, player engagement, aesthetic appeal, and outcomes shaped by the mechanics and overall game design. Dan Taylor's principles of good-level design, inspired by Dieter Rams, provide valuable insights about this discipline, emphasizing aspects such as fun, navigation, narrative, storytelling, surprise, emotions, and the empowerment of players (Taylor, 2013).

The concept of flow, as proposed by Csikszentmihalyi, emphasizes the balance between challenge and skill, leading to an immersive state where players react instinctively, unaware of their surroundings. He created this concept according to the observations of players and challenge engagement. If the challenge is excessively easy, the player passes the boredom state, likewise, if the challenge is too hard, it causes frustration. (Csikszentmihalyi) The level designer plays a pivotal role in controlling player flow, dictating the player's path, and ensuring a seamless balance between challenge and skill.

Salmond (2021) classified conceptual level design models as linear models, (Figure 2.2) branching or non-linear models (Figure 2.3), hub-and-spoke models, and open or emergent models. The linear model illustrates a player's movement on a single, predetermined path that offers control to the designer. Branching or non-linear model refers to player exploration with defined merging points, achieving a balance between linearity and freedom. Hub-and-spoke model, featuring a central hub connecting to multiple branches or quests, fostering player choice. The open or emergent model characterizes nonlinear games, mostly in MMOs, allowing diverse, player-driven experiences. Each model presents unique challenges and advantages, influencing player engagement and interaction within virtual spaces. (Salmond, 2021)

Salmond exemplifies a level design model, the classification is a high concept due to the nature of level design intricacy. Even though the foundational design principles are common, plenty of constraints and influential elements directly affect the outcome of a level such as camera perspective, genre of the game, mechanics, and narrative.

Therefore, there is no certain rulebook or comprehensive classification of level design.

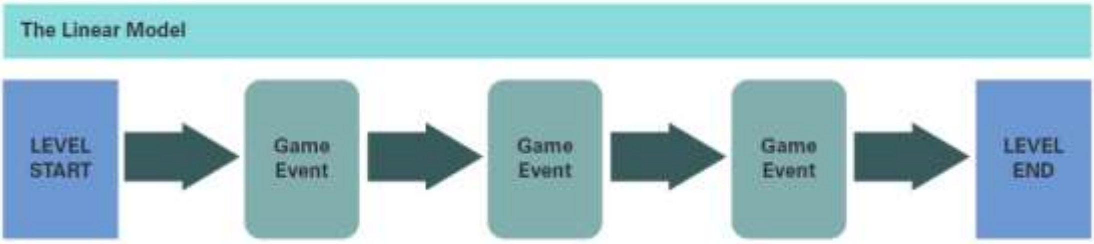


Figure 2.2 : Linear level design model (Salmond, 2021).

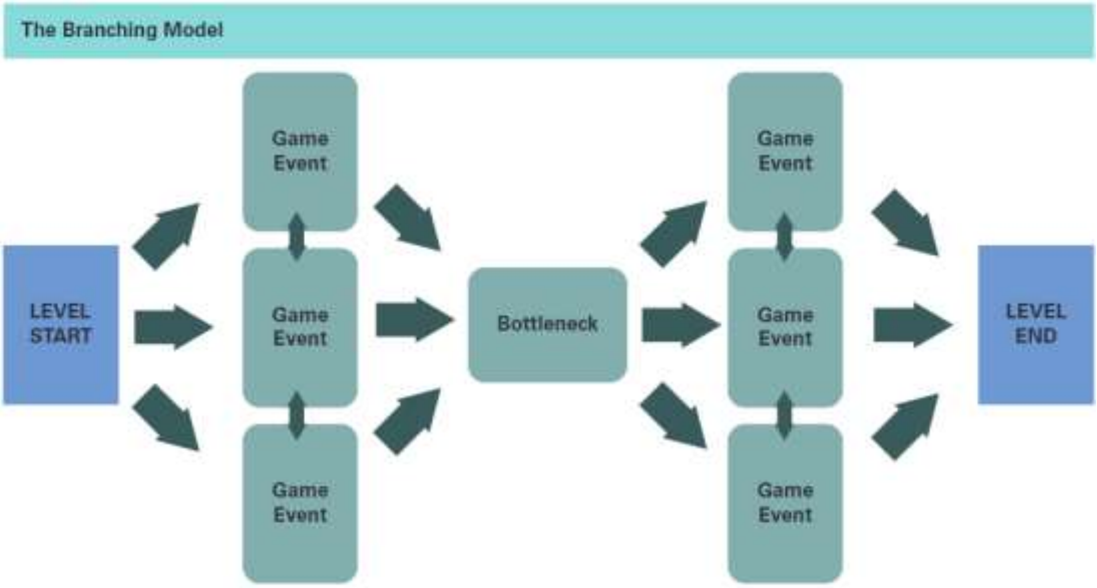


Figure 2.3 : Branching level design model (Salmond, 2021).

2.3 Procedural Content Generation In Video Games

As computer graphics and hardware evolved over time, the content demanded from the gaming industry increased massively. Large content and hours of play should be put forward to compete in the gaming industry by competitors. The scenario of manually constructing each game element in such a competitive industry is labor-intensive, time-consuming, and costly. The requirement of fast production, replayability with prosperous content seeks the developers to adopt algorithmic production methods.

Procedural Content Generation (PCG) is a production method widely used in video game development with algorithmic data generation instead of manual creation and input. This generation method requires utilizing computer programs with limited human intervention. (Togelius, Kastbjerg, Schedl, &Yannakakis, 2011) PCG offers replayability with almost infinite content and variation. The appeal of PCG lies in its ability to let the player create their own content and make a unique experience for the game referred to as emergence in games in literature. (Sweetser, 2008)

Johnson et. al (2010) disserted the key reasons for using PCG in game maps are listed as enhanced player curiosity, the mechanical requirement for real-time map generation, player-centric customization, and assisting authoring tools. Moreover, PCG serves as a powerful tool for game developers due to its efficiency, ease of use, and the ability to create consistent and less predictable content rapidly.

Rogue, a well-known ASCII graphic role-playing game, pioneered the use of PCG back in the 1980s with the implementation of randomly generated maps and its core gameplay loop. This classic dungeon crawler, which generates an infinite number of unique dungeon levels without human designer intervention was a paradigm shift in level design. The significance of roguelike and roguelite genres is the randomization of levels and the introduction of permanent player death. Using PCG in roguelike/rogue-lite games has become essential commercially to ensure unpredictable dynamic level design order and unique experience on each session.

Following the legacy of Rogue, Diablo II and Civilization exemplify the integration of PCG to create vast and various levels in video games. No Man’s Sky is one of the archetypes that expanded the implementation of PCG by generating all galaxies, star systems, planets and moons, biomes, creatures, ships likewise, and all the names of those.

2.3.1 Procedural content generation approaches

PCG is a miscellaneous subject that unites several approaches. The most comprehensive classification of PCG approaches are asserted by Toglius et al. (2011) as online vs. offline, constructive vs. generate-and-test, necessary vs. optional, random seed vs. parameter vectors, and stochastic vs. deterministic. Online generators dynamically craft real-time content during gameplay. On the other hand, offline generators serve as a pre-generated content tool for designers (Toglius et al. , 2011).

In constructive approaches, methods and rules are defined to correspond to the quality criteria. Conversely, in the generate-and-test method, a content pool is created, then the adequate options are eliminated based on the predefined criteria like in search-based algorithms. Necessary content is crucial to the game's functioning and vital issues to be generated without failure. Optional content is less constrained and allows divergence in content generation (Toglius et al. , 2011).

Random seed generators function based on the rules and starting seed, thus they offer narrow configurations, unlike the parameter vectors. Advanced analytical techniques utilized in parameter vector generators provide higher configurability. Stochastic methods embrace randomness, while deterministic methods seek consistent results from identical initial data (Toglius et al. , 2011).

2.3.2 Procedural content generation methods

The choice of procedural generation method significantly influences the efficiency and the success of generation process. Hendrikx et al. (2012) proposed a taxonomy of common PCG methods into six key types: Pseudo-Random Number Generators (PRNG), Generative Grammars (GG), Image Filtering (IF), Spatial Algorithms (SA), Modeling and Simulation of Complex Systems (CS), and Artificial Intelligence (AI) (Figure 2.4).

The selected procedure must align with the specifications of the desired game content, ensuring that the procedural generation method serves its purpose efficiently. This choice is crucial for two reasons: first, it will speed up the creation of game elements; second, it will prevent time waste that could arise from using improper PCG techniques. Therefore, utilizing the taxonomy proposed by Hendrikx et al. (2012) becomes crucial to the strategic application of procedural content generation.

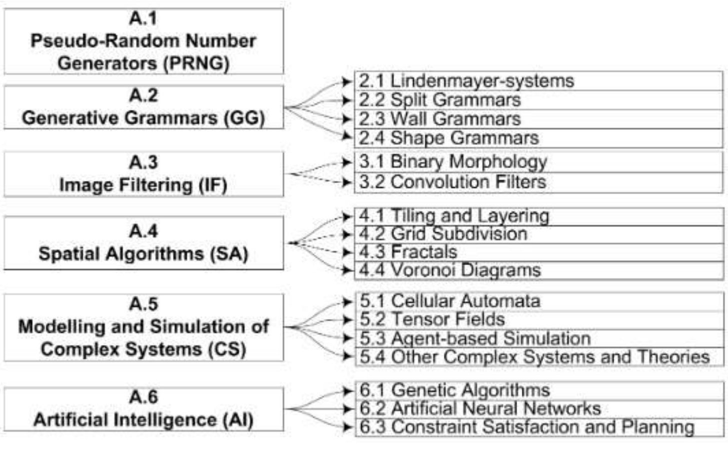


Figure 2.4 : Taxonomy of common methods for generation game (Hendrikx et al., 2012).

2.3.2.1 Pseudo-random number generators

The idea behind the use of pseudo-random number generators (PRNGs) is based on mimicking the randomness that can be observed in nature frequently, such as in the forms of clouds, mountains, and flowers. (Hendrikx et al., 2012)

One notable example of a PRNG-based noise generator used is Perlin noise, which was first introduced by Perlin in 1985 and further developed in 1990. Using a seeded PRNG, Perlin noise creates maps of data points through interpolation. Through the use of scaling techniques and layering multiple Perlin noise instances, this algorithmic approach can produce complex noise maps with increased detail. (Hendrikx et al., 2012)

PRNG plays a pivotal role in shaping player experiences in numerous games, exemplified by the recent popular video game Baldur's Gate 3 (2023). In Baldur's Gate 3, players engage in dice rolls to determine the outcomes of various actions. For instance, when faced with a guard at a door, a dice roll influences the charisma score, impacting the player's ability to convince the guard and proceed through the door.

2.3.2.2 Generative grammars

Originating from the linguistic studies of Noam Chomsky in the 1960s, generative grammars provide a systematic set of rules that act on individual words to produce sentences that are grammatically correct. (Hendrikx et al., 2012) This concept often likened to the structure of natural languages, involves a finite vocabulary compounded by letters or geometric primitives (Figure 2.5).

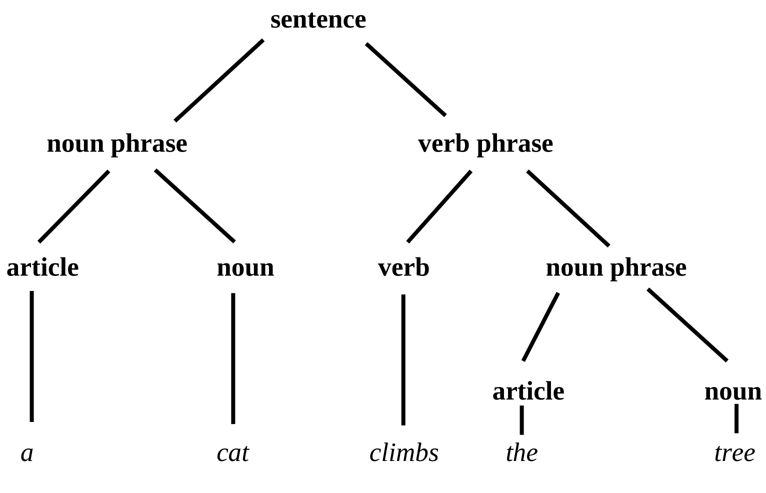


Figure 2.5 : Phrase structure grammar, production of a sentence (Chomsky, 1960).

Liebich (1994) underscores the importance of principles or grammar, coded with specific rules, in both design and language systems.

> *Design is often compared with the structure of a natural language. Both consist of a rich but finite set of vocabulary (i.e., words or objects), which is compounded by letters or geometrical primitives. In dealing with these systems, either the design or the language, some principles or the grammar, coded by a certain amount of rules, have to be taken into consideration.* (Liebich,1994)

Grammars are used in natural language to parse sentences and guarantee their syntactic validity. As an example of the opposite, Chomsky (1957) used grammar to create sentences in "Syntactic Structures" to transform elements between different abstractions. His phrase structure grammar uses vocabulary elements, rewriting rules, and a start state. (Liebich,1994)

Generative grammars find application in PCG, offering rule-based, structured generation. Lindenmayer-systems (L-systems) take advantage of a grammar that utilizes a generated string to describe the properties of an object. Split grammars operate on string-encoded shapes with rewriting rules governing shape-to-shape conversion, identical to L-systems. Wall grammars manipulate shapes to create intricate structures; they are specifically made for the exterior of buildings. Shape grammars, originating from Stiny's work, are context-sensitive and sequential, determining symbol replacement based on the symbol and its neighbors in the string. (Hendrikx et al., 2012)

PCG uses generative grammar to enable rule-based, structured generation. Grammars use terminal and non-terminal symbols; they are typically used in code parsers for syntactical validation. They are useful in PCG for organizing player actions into sequences, especially when defining game missions. Their stringent guidelines guarantee accuracy and the ability to produce content.

Generative grammar models have been employed in prior works for various purposes in game design. Doran and Parberry (2011) used them to facilitate the pseudo-random selection of components for MMORPG-style quests, such as characters, locations, and items. The application of generative grammar to mission and space generation was expanded upon in other studies (Dormans 2010, 2011) (Dormans and Bakkes, 2011). These papers provide complex content structure by using graph grammar to generate linear lock-key pairs and branching substructures of optional content. Then, space grammars were used to maintain the original graph's structure on a physical level. To highlight the hierarchical and structured nature of grammar, Dormans (2010) provides an example of a simple Legend of Zelda-style dungeon structure using grammar. When it comes to content organization, Dormans' model works especially well, providing benefits that are difficult to obtain with other approaches.

Dorman’s model:

1. Dungeon -> Obstacle + treasure

2. Obstacle -> key + Obstacle + lock + Obstacle

3. Obstacle -> monster + Obstacle

4. Obstacle -> room

2.3.2.3 Image filtering

Image filtering (IF) stands out as a crucial technique with the primary goal of enhancing images based on subjective measures or emphasizing specific characteristics to reveal partially hidden information (Hendrikx et al., 2012).

Hendrikx et al. (2012) outline two fundamental image-processing techniques within this context: binary morphology and convolution filters. Binary morphology involves a set of techniques for binary operations on images, often starting with the conversion of an image into binary form through thresholding. In this process, pixels below a certain intensity are set to zero, while the rest are set to one, creating a binary image. Binary morphology operations include dilation and erosion, where pixels are added or removed, respectively, from the edges of elements in an image. (Hendrikx et al., 2012).

On the other hand, convolution filters, are represented by simple images, functions, or discrete datasets. Convolution, a mathematical operator on two signals, involves using one signal to modify the other, creating a new signal. These filters play a versatile role in image processing, serving functions such as noise removal, smoothing, sharpening, edge detection, and even discerning movement direction in images. (Hendrikx et al., 2012).

2.3.2.4 Spatial algorithms

Hendrikx et al.(2012) classified spatial algorithms according to the manipulating space relying on inputs with structural characteristics such as grids or self-recurrence. Spatial algorithms demonstrate the adaptability and use of fractals, Voronoi diagrams, layering, tiling, and grid subdivision in procedural content creation. By providing insights into their individual applications and computational considerations, these techniques aid in the efficient diverse creation of game content.

Tiling involves decomposing a map into a grid creating a 2D data structure. By overlapping elements from each layer, layering combines several grids or layers into a single map. With a limited number of source terrain textures, this technique allows overlay effects and a 3D appearance to be produced (Hendrikx et al., 2012). Müller (2006) highlights the use of tiling and layering in large-area city modeling and visualization, which makes it easier for the entertainment industries to quickly create complex environments in the study City Engine. (Parish and Müller, n.d.).

Grid subdivision is an iterative and dynamic object generation technique, demonstrated most effectively by the Patch-LOD algorithm. Using a grid subdivision algorithm, iteratively adding detail based on the point of view, it divides an object into a uniform grid. In particular, when rendering procedurally generated terrain, this dynamic approach optimizes computational resources by ensuring that only grid cells close to the current point of detail are subdivided (Hendrikx et al., 2012).

Voronoi diagrams identify the size and shape of the components by breaking down metric spaces based on seed points. To define the areas surrounding each seed point, borders are set at equal distances from the seed points (Hendrikx et al., 2012). Aurenhammer (1991) highlights that voronoi diagrams are important because they naturally occur in a variety of situations and their valuable in aiding human understanding through visual perception and their intriguing mathematical properties. Aurenhammer (1991) underscores that they are common in nature and that they are effective tools for resolving computational issues. Even so, he notes that effective methods of computer construction have been developed, which confirms their wide range of applications. (Aurenhammer, 1991)

Fractals, recursive figures with self-similar patterns, offer infinite detail with a few parameters controlling diverse results. The book "Algorithmic Architecture" written by Terzidis (2006) emphasizes the recursive or iterative nature of fractals, where a base shape and a generator interact in each iteration. Fractals provide intricate details and a self-similar structure at different magnification levels, showcasing their resource-intensive, yet powerful, generation process (Terzidis, 2006).

2.3.2.5 Modeling and simulation of complex systems

A cellular automaton is a structure made up of individual cells, each of which represents a different state. The states of the cells that surround them affect how these cells behave and they follow certain rules. This system functions within predefined time and grid parameters (Terzidis, 2006). In the context of video games, Cellular Automata finds widespread utility in the generation of natural-looking cave environments. This is primarily due to their remarkable speed of generating content, making them particularly well-suited for online generation scenarios. However, the application of cellular automata frequently calls for complementary methods and techniques in order to create meaningful and engaging game content.

Tensor Fields are two-dimensional extensions of vectors that Chen et al. (2008) introduced. They provide a way to describe the direction of map elevation and thus, the shape of a game space. Hendrikx et al. (2012) highlight that sensor lines are particularly useful for interactive road network design and manipulation because they enable visualization.

Davidsson (2001) described a modeling technique called agent-based simulation (ABS). ABS uses individual entities, or agents, to model complex situations. Taking a different approach from traditional modeling techniques, this method makes use of emergent behavior, where complex patterns emerge from relatively simple interactions among agents. Hendrikx et al. (2012) acknowledge the transformative potential of ABS in capturing intricate dynamics within simulated environments.

2.3.2.6 Artificial intelligence

Artificial Intelligence is a key component that improves player experiences in video games through a variety of applications. Behavior trees control decision-making processes, and pathfinding algorithms are used by Non-Player Characters (NPCs) to intelligently follow players. AI's influence is further demonstrated by Dynamic

Difficulty Adjustment (Hunicke), which adjusts the game pace and difficulty according to players' skill levels to keep the player in flow (Csikszentmihalyi).

Genetic Algorithms, a well-known AI technique that is used in video games, are inspired by biological evolution and are used to solve optimization problems (Goldberg, 1989). This method involves encoding possible solutions as chromosomes and assessing the quality of those strings using a fitness function. To produce new solutions, crossover and mutation functions are applied during the process. Khalifa and Togelius (2020) stress the use of a fitness function as a stand-in for assessing the generator's overall efficacy when determining the caliber of generated game levels. This demonstrates the wide range of ways AI, in particular Genetic Algorithms, can be used to optimize and shape different aspects of video game design.

2.4 Theorotical Foundation: A Pattern Language

“All patterns form a language” (Alexander, 1977). Language is essential for us to communicate with the world, it is also essential for players to navigate the game world. Design patterns, proposed by Alexander (1977), serve as a formalized approach to organizing design knowledge and understanding. The fundamental idea behind the pattern language of Christopher Alexander (1977) is that even though distinct cultures and individuals may have unique patterns, a common pattern system can be recognized. Alexander offers a framework for understanding the archetypical core of all possible pattern languages through his collection of 253 patterns, which range from mezzo-scale regional concepts to micro-scale details like wall decorations.

Even though those patterns have their roots in architecture, they can be applied to software design and game design (Dahlskog and Bogelius, 2014). Liebich (1994) draws a parallel between design and the structure of natural language, highlighting their shared characteristics of a rich but finite set of vocabulary compounded by principles or grammar coded by rules. This comparison emphasizes the significance of principles and grammar in both design and language.

Will Wright, the creator of The Sims, refers to the pattern language as an inspirational guide to creating the Sims. LucasArts' former level designers, Steven Chen, and Duncan Brown, view Alexandrian patterns as guiding principles for crafting meaningful environments.

There are several studies that adopt the formalism for game design based on the work of Christopher Alexander in literature (Björk et al., 2003; Björk and Holopainen, 2005; Kreimer, 2002). Gomez et al. (2021) assess the impact of 4 level design patterns to induce curiosity-driven exploration for 3D game environments. Their main focus was the player's behavior and emotional experience throughout the game. Compton and Eateas (2006) focus on representing repetition, rhythm, and connectivity to propose a four-layer hierarchy to represent 2D platformer game levels. Dahlskog and Togelius (2014) emphasize the need for exploring this integration, especially within Procedural Content Generation (PCG). They illustrate how practical game design patterns can combine with PCG to mimic specific design styles, demonstrated through experiments using a platform game benchmark.

Beaupre's work (2018) delves into a design pattern approach for multi-game level generation in 2D games, specifically focusing on collectibles and harmful entities. Their research highlights a critical call for the research community to reassess and reflect on declarations of "generality", emphasizing the need to scrutinize implicit assumptions about what constitutes a "normal" game and the reasons behind such categorizations (Beaupre et al. 2018). Additionally, Togelius et al. (2013) contribute to the formulation of abstract level design patterns adaptable to concrete metrics for different level types, expanding the understanding of patterns in gaming contexts.

3. METHODOLOGY

This study employs a reverse engineering approach to analyze and decode the spatial design patterns of existing video game levels, focusing on high-ranked third-person shooter games. The methodology follows a systematic order (Figure 3.1), starting with gameplay sessions to understand spatial designs and existing patterns. During these sessions, the game environment is recorded in video format to capture dynamic interactions, spatial configurations, and player movement. Subsequently, recorded gameplay is translated into 2D level layouts using free-hand drawing techniques, representing rooms, corridors, encounters, interactables, and props. These layouts are then simplified to uncover recurring patterns and design principles while reducing complexity. Additionally, they are labeled according to structural characteristics, content attributes, challenge levels, and vertical layers to decode existing third-person shooter game levels for providing insights for procedural generation algorithms and building meaningful environments.

Figure 3.1 : Order of the study

3.1 Data Collection - Selection Criterias Of The Analyzed Video Games

Genre – Shooter, Action:

The study's primary focus is identifying the presence or absence of level design patterns to enhance procedural content generation (PCG) algorithms, with an emphasis on the shooter genre. Despite existing criticism in the literature regarding the genre-specific nature of PCG algorithms (Snodgrass & Ontanon, 2017), this research narrows its focus to the shooter genre, drawing inspiration from Totten's statement (2018), "form follows core mechanics." The term core mechanics in game design describes the basic actions that players take in a game. The study acknowledges that level design is highly influenced by core mechanics. It is unreasonable to expect similar spatial patterns in a shooter game, and a platformer game due to distinct actions such as shooting and jumping directly affect the spatial design metrics.

Camera Perspective – Third-person :

The camera perspective is a further aspect to take into account. In this study, games are analyzed from a third-person perspective. This choice is consistent with Totten's (2014) reasoning, which highlights that the third-person perspective provides a coherent view by allowing players to see the world from the character's shoulder behind. Besides, the third-person perspective offers a unique scaling perspective for environment comparison to designers. Consequently, the study specifically narrows the case study materials labeled as "third-person shooter" to maintain a focused and relevant analysis.

First, 52 games with a score of 85 or higher were listed after a filtering mechanism focused on the "third-person shooter" genre on the Metacritic platform (Table 3.1), where players vote for the games. Downloadable content (DLC) packs were left off of this original list. Afterward, one game from each game series with the highest score was chosen and produced after 2010 in order to guarantee technological relevance and consistency without repeating the design style. This approach led to a final set of 16 games for in-depth analysis.

The subgenres of open world, stealth, adventure, and survival horror were also considered in the initial selection. However, games with these subgenres (*Red Faction Querilla, GTA V, LA Noire, Alan Wake II, Resident Evil 4, Metal Gear Solid V, Red Dead Redemption II, Hogwarts Legacy, and Hitman 3*) were excluded from the study due to their distinct spatial characteristics compared to the majority of pure action games. Particularly, open-world and adventure subgenres exhibited variations in spatial design influenced by additional mechanics such as vehicle driving and stealth, impacting the structure and scale of environments. The study focused on the "shooting" mechanic, and the identified subgenres were excluded from pattern analyses. On the other hand, the game *Returnal*, despite its alignment with the study's genre scope, is excluded from the analysis due to limitations in the readability of spatial layout caused by the game's lighting setup.

Additionally, subgenres were observed to present variable spatial characteristics resulting from additional mechanics beyond shooting. For instance, the involvement of adventure elements enriched spatial design and space content beyond the shooting mechanic, while open-world genres spatial scale expanded from rooms, and corridors to macro levels such as cities or natural environments.(Red Dead Redemption II, Grand Theft Auto V, LA Noire, Red Faction) In survival horror, spatial structures were observed to be non-linear, (Resident Evil 4, Dead Space) consisting of interconnected clustered spaces that unlock progressively as the player advances. Despite these observations, the number of games in these subgenres was deemed insufficient for a comprehensive pattern analysis. Future research is recommended to explore these subgenres independently, incorporating other games within the genre to enhance the study's scope.

In the end, six games from the list of third-person shooters, action genre — namely, *Gears of War 4, Mass Effect 3, Max Payne 3, Control, Tom Clancy's Splinter Cell Conviction*, and *Dead Space*— were chosen for in-depth pattern analysis. These games collectively contribute to the generation of patterns and serve the overarching objectives of the study.

Table 3.1 : Additional criteria of the games with “third-person shooter” label

Best Games of All Time filtering TPS	Release Year	Metacritic Score	Subgenre	Study Material
Grand Theft Auto IV	2008	98	open-world, action-adventure	
Grand Theft Auto V	2014	97	open-world, action-adventure	
Red Dead Redemption II	2018	97	open-world, action-adventure	
Metal Gear Solid II: Sons of Liberty	2001	96	stealth action (DLC)	
Resident Evil 4	2005	96	survival horror	
Grand Theft Auto Vice City	2002	95	open-world, action-adventure	
Grand Theft Auto San Andreas	2004	95	open-world, action-adventure	
Metal Gear Solid V: The Panthom	2015	95	stealth action-adventure	
Red Dead Redemption	2010	95	open-world, action-adventure	
Resident Evil: Code Veronica	2000	94	survival horror action (DLC)	
Metal Gear Solid	1998	94	stealth action-adventure	
Metal Gear Solid 3: Subsistence	2006	94	stealth action-adventure (DLC)	
Alan Wake II	2023	94	survival horror, adventure	
Mass Effect 3	2012	93	action RPG	+
Grand Theft Auto Chinatown Wars	2009	93	open-world, action-adventure	
Gears of War 2	2008	93	tactical shooter	
Tom Clancy’s Splinter Cell	2002	93	stealth action-adventure	
Resident Evil 2	2019	93	survival horror action	
Resident Evil 4	2023	93	survival horror action	

Table 3.1 (continued): Additional criteria of the games with "third-person shooter" label

Best Games of All Time filtering TPS	Release Year	Metacritic Score	Subgenre	Study Material
Gears of War 3	2011	91	tactical shooter	
Resident Evil	1996	91	survival horror action	
Resident Evil 3 Nemesis	1999	91	survival horror action	
Resident Evil Remake	2002	91	survival horror action	
Metal Gear Solid 3: Snake Eater	2004	91	stealth action-adventure (DLC)	
Resident Evil 4: Seperate Ways	2023	91	survival horror action (DLC)	
Mass Effect Legendary Edition	2021	90	action RPG	
Grand Theft Auto IV: The Lost and	2009	90	open-world, action-adventure	
Tom Clancy's Ghost Recon	2006	90	stealth action-adventure	
Max Payne	2001	89	action	
Resident Evil 2	1998	89	survival horror action	
Dead Space	2008	89	survival horror action	
Metal Gear Solid: Peace Walker	2010	89	stealth action-adventure (DLC)	
Grand Theft Auto IV: The Ballad of	2009	89	open-world, action-adventure	
LA Noire	2011	89	open-world, action-adventure	
Star Wars: Jedi Knight II: Jedi	2002	89	adventure, fps	
Dead Space	2023	89	survival horror action	+
Horizon Zero Dawn	2017	89	open-world, adventure	
Rachet & Clank	2021	88	open-world, platform	
Grand Theft Auto Liberty City	2005	88	open-world, action-adventure	
Armored Core VI: Fires of Rubicon	2023	88	open-world, action	
Tom Clancy's Rainbow Six Vegas	2006	88	stealth action-adventure	
Mass Effect 2: Lair of the Shadow	2010	87	action RPG (DLC)	
Hitman 3	2021	87	stealth action-adventure	
Max Payne 3	2012	87	action	+
Red Dead Redemption Undead	2010	87	open-world, action-adventure	
Returnal	2021	86	roguelike, action	
Gears of War 4	2016	86	tactical shooter	+
Red Faction Querilla	2009	85	adventure, vehicular combat,	
Tom Clancy's Splinter Cell	2010	85	stealth action-adventure	+
Syphon Filter: Logans Shadow	2007	85	stealth (DLC)	
Control	2019	85	action	+
Hogwarts Legacy	2023	85	open-world, RPG, puzzle	

3.2 Identifying And Categorizing The Space In The Gameplay

In examining the selected video games, a comprehensive approach was adopted to ensure a thorough exploration of both level design processes and spatial patterns of video games, considering both the designer and player perspectives. Recognizing the inherent interplay between player experience and level design, the analysis covered dual viewpoints to provide a holistic understanding. Additionally, acknowledging the impact of game mechanics on spatial design, particular attention was given to perceiving the game space in motion during gameplay.

During approximately two hours of gameplay per selected game, an easy/story game mode was intentionally chosen to minimize gameplay challenges and enhance spatial awareness. These gameplay sessions were recorded in video format to capture the dynamic evolution of the game space during interaction. The recorded videos served as the basis for 2D mapping, where 3D spatial details are translated into comprehensive plans (Figure 3.2).

Figure 3.2 : A screenshot taken from a room of Mass Effect 3 during gameplay

In the 2D mappings, the contour of the game environments and interior props are outlined. Besides, player navigation paths, interactable objects, and resource locations are interpolated into the mapping to provide a holistic view of player interactions within the game environment. Enemy encounters are depicted in orange color, with orange dots representing enemies and orange lines indicating cover locations where players can seek refuge during combat. Resource locations are highlighted in green, while collectibles and narrative elements are marked in purple. The player's shortest route is illustrated using red splines (Figure 3.3, left).

The free-hand drawing technique is employed to translate gameplay experiences into 2D level layouts. By incorporating the scale of the human-character at the third-person camera perspective, the drawings are able to reflect the environmental scale and proportions more accurately. This approach enhances the visualization of the game space, aiding in the analysis of level layouts, context and spatial relationships within the game world.

The 2D maps are further simplified to basic shapes outlining the borders of the game environment, including rooms, corridors, and courtyards, based on the order of entrance and exit (Figure 3.3, right). Each outline is carefully examined, and common shapes are grouped under the same label, such as Room B, Corridor A. Given that the complexity of the player's trajectory is dependent on individual gameplay, the route is drawn from the entrance to the exit of the room, represented by the shortest right-angled blue dashed splines (Figure 9, right).

Figure 3.3 : 2D layout of the room (Figure 8) in Mass Effect 3 (left), simplified drawing overlapped on the 2D mapping and labeling (right).

In his work, Dorman (2011) proposes a separation between a level's mission and its spatial layout, arguing that current level design practices often blend the two. He suggests that by seperating missions from spaces, game developers can employ a wider range of level design strategies, such as reusing the same space for different missions, as seen in games like System Shock II. This separation not only offers economic benefits by reducing the need to create entirely new spaces for each mission but also enhances gameplay by allowing players to leverage previous knowledge of the environment (Dorman, 2011). He emphasizes the importance of model transformations in formalizing level design principles (Figure 3.4) and suggests that designing levels as a series of model transformations enables designers to focus on creative aspects while reducing the chance of design flaws. This approach can lead to the creation of more flexible frameworks where missions and spaces can be generated interchangeably.

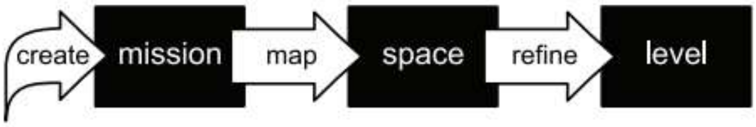


Figure 3.4 : Dorman’s scheme of level design as series of model transformations for action-adventure games (2011).

In this study, Dorman's model of separating mission and space for action-adventure games has been adopted for analyzing the spatial design patterns of video game levels. Additionally, considering the action-shooter genre for varied room content beyond missions, rooms have been classified at a higher level according to the content attributes such as a puzzle, narrative, combat, etc.

To facilitate the creation of meaningful sentences from gameplay and provide specific details about the levels to a PCG algorithm, three labels have been introduced additionally. First, the spatial layouts of the environments have been categorized according to their 2D plans, enabling an examination of their structural composition. Second, to increase the readability of the 3D space not only at the x and y axes but also z axes, vertical layers within the levels are labeled. Lastly, scale of the room relative to gameplay time which is majorly associated with the challenge of the game is indicated. Each room is encoded using the following system: A/B/C/D/E for layout type, t1/t2/t3/$t4^{+}$ for scale/challenge of a room, z0/z0,n/zn for defining the vertical layers in a room (**Table 3.2**). Labels will be further explained in section 4.

Table 3.2 : A brief explanation of room symbol codes.

Content	**Room Layout**		**Time/ challenge**		**Vertical layers**	
	Symbol	Definition	Symbol	Definition	Symbol	Definition
Rnarrative	A	square	t1	easy	z0	flat
Rquest	B	rectangle	t2	mid challenge	z0,n	flat + platforms
Rcombat	C	semicircle	t3	challenging	z1	suspended floor
Rpuzzle	D	L-shape	$t4^{+}$	hard	zn	(n) floors
Rresource	E	circle				
Rtutorial						

Furthermore, a systematic approach is employed to decode the video game levels. Rooms are abbreviated as "R" , corridors as "C", and cinematic sequences as “M”. Each space is assigned a symbol indicating its type, along with labels showing additional attributes as explained in Table 2. For instance, a room with a platform (z0,n), and a B type with a t3 challenge is represented as $^{t3}{}_{B}R^{z0,n}$, shown in Figure 3.5. These symbols are utilized for each space to create a readable sequence of spaces, akin to a sentence from start to end, revealing repetitive patterns and orders throughout the gameplay.

Figure 3.5 : Detailed symbol coding of a room.

Sequences are uninterruptable units of functionality within a game that advance the story as defined by Shelley et al. (2013). In this study, we employ symbolic representations of gamespaces to transform gameplay sequences into coherent sentences. For example, the sequence **"** $^{t1}{}_{A1}\mathbf{R}^{z0}$ $_{A}\mathbf{C}$ $^{t2}{}_{B2}\mathbf{R}^{z0,n}$ **M "** can be interpreted as follows: a room with A type, featuring t1 difficulty and has a flat floor, is connected to a B type room with t2 difficulty and has a platform, with an A typed corridor. The sequence concludes with a cinematic event.

Subsequently, these symbol sequences are proceed to more contextual-relevant sentences that describe the space's content, such as puzzle-solving, narrative progression, or combat encounters (Figure 3.6).

$$R_{context}$$

Figure 3.6 : Contextual symbol coding of a room.

For instance, the previously mentioned sequences may be converted into high-concept sentences like **"** $\mathbf{R}_{\mathbf{narrative}}$ **C** $\mathbf{R}_{\mathbf{combat}}$ **M "**, which signifies a narrative room connected to a combat encounter via a simple corridor, concluding with a cinematic event. This secondary layer of sentences is derived from detailed space analyses represented by symbols, aiding in the decoding of gameplay's context order and spatial structure. Such two-layered sentences enable a readable analysis of spatial configurations and design principles within game levels, offering insights for procedural generation algorithms.

3.3 Defining the Level Progression

In this study, a linguistic framework is adapted to analyze and interpret the spatial patterns of video game levels, aligning with Slonneger & Kurtz's (1995) three components of language: syntax, semantics, and pragmatics. Syntax refers to the structural rules governing the combination of symbols to form well-formed sentences, analogous to the systematic arrangement of symbols representing game spaces in our methodology. Semantics, on the other hand, pertains to the interpretation and meaning derived from these syntactically valid sequences, mirroring our process of decoding gameplay sequences into contextual-relevant descriptions of game space content. Pragmatics considers user-related factors, similar to ease of implementation in programming languages. (Slonneger & Kurtz, 1995).

In this study, syntax plays a crucial role in governing symbol combinations, similar to the systematic representation of game spaces we employ. This involves defining the rules for how symbols, representing various features within the game environment, can be combined to form coherent sequences, similar to how grammar dictates the formation of sentences in natural language. For instance, the symbol " $^{t1}{}_{A1}\mathbf{R}^{z0}$ " represents a room with its specific spatial characteristics such as layout type (A1), difficulty level (t1) and vertical layer (flat). This representation of game spaces through symbols is analogous to syntax in language, as it establishes the structural rules for assembling meaningful sequences. Semantics, on the other hand, refers to the interpretation and meaning derived from these syntactically valid sequences. In our study, semantics involves decoding gameplay sequences into descriptions. By interpreting the symbolic sequences, such as " $\mathbf{R}_{\mathbf{narrative}}$ **C** $\mathbf{R}_{\mathbf{combat}}$ **M** ", we can understand the narrative progression, combat encounters, and other aspects of the game space in a meaningful way.

Backus-Naur Form (BNF) serve as essential tools for defining syntax in the context of formal methods in programming languages that emerged from Chomsky's grammar (1960) proposed for natural languages (Figure 3.7). Programming languages are composed of terminal symbols, which are individual language elements, and nonterminal symbols, which are groups of language elements (Slonneger and Kurtz, 1995).

A grammar is composed of four parts <Σ,N,P,S> :

- Σ, a finite set of terminal symbols, forms the language's alphabet and is used to construct sentences.
- N, a finite set, consists of nonterminal symbols or syntactic categories, each representing groups of sentence subphrases.
- P, a finite set, comprises productions or rules dictating how each nonterminal is constructed from terminal symbols and other nonterminals, influencing the meaning of language phrases.
- S, a distinguished nonterminal known as the start symbol, specifies the primary category being defined, like a sentence or program (Slonneger and Kurtz, 1995).

Productions or rules describe how nonterminals are defined in terms of terminals and other nonterminals, with a start symbol specifying the principal category being defined, like a sentence or program. BNF notation simplifies the formalization of syntax by representing syntax rules as equation (3.1):

<category> ::= <expression> (3.1)

where " ::= " (or " → ") signifies " is defined to be " or " may be composed of ". BNF facilitates the specification of programming language syntax, aiding in the clear definition of language constructs and their combinations (Slonneger and Kurtz, 1995). Common symbols of the BNF are figured by Teufel (1991) (Figure 3.7).

symbol	meaning
→	"is defined as"
.	end of a definition
|	"or", alternative
[x]	one or no occurrence of x
{ x }	an arbitrary occurrence of x (0, 1, 2, ...)
(x | y)	selection (x or y)

Figure 3.7 : Common symbols of the BNF, Teufel (1991).

Teufel (1995) discusses the representation of the syntactical structure of languages through syntax diagrams, offering a graphical alternative to the commonly used BNF (Backus-Naur Form) notation. Syntax diagrams provide a visual means to represent the syntax of a language. Teufel (1995) introduces six rules for transforming BNF notation into syntax graphs:

1. Productions of the form: $\mathbf{N \rightarrow a_1 \mid a_2 \mid . .. \mid a_n}$

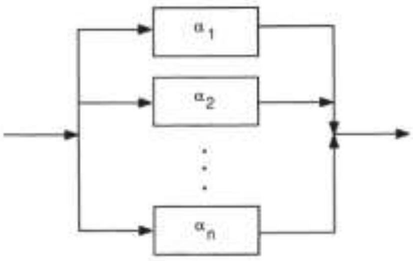


Figure 3.8 : Graph representation of the productions of the form, Teufel (1991).

2. Terms of the form: $\boldsymbol{\alpha} = \mathbf{a_1\ a_2\ ...\ a_n}$

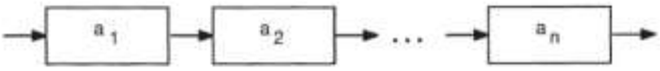


Figure 3.9 : Graph representation of the terms of the form, Teufel (1991).

3. When an element has one or no occurence: **[α]**

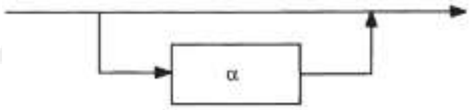


Figure 3.10 : Graph representation of an element has one or no occurence, Teufel (1991).

4. When an element is arbitrarily repeated (inclusive 0 times) : **{α}**

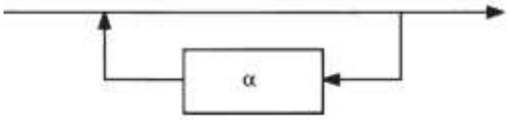


Figure 3.11 : Graph representation of an element is arbitrarily repeated, Teufel (1991).

5. Non terminal symbols: **N**

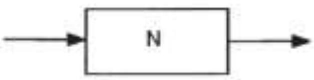


Figure 3.12 : Graph representation of non terminal symbols, Teufel (1991).

6. Terminal symbols: **T**

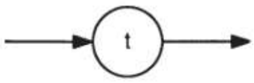


Figure 3.13 : Graph representation of terminal symbols, Teufel (1991).

In this study, Teufel's (1995) approach of syntax graphs are adopted to analyze and interpret the spatial organization of game space from their 2D drawings. These syntax graphs serve as a visual tool for comprehending the structural rules governing the arrangement of game elements within levels. For instance, a branching level layout, where players have multiple paths to follow, can be represented using syntax graphs as $\mathbf{N \rightarrow a_1 \mid a_2 \mid . .. \mid a_n}$, denoting the various possible routes. Similarly, a linear level layout, characterized by a single path from start to finish, can be expressed as $\boldsymbol{\alpha} = \mathbf{a_1 a_2 ... a_n}$. Additionally, side mission rooms, which deviate from the main path, can be depicted as **[α]** or **{α}**. By employing these rule sets, it is aimed to systematically analyze and interpret the organization rules governing game space layouts.

As illustrated in Figure 3.14, players have the option to pursue two distinct paths during gameplay. These paths are RoomX- CorridorX- RoomZ- CorridorX- RoomX or RoomX- CorridorX- CorridorY- RoomY- CorridorY- CorridorX- RoomX. Such branching level layouts are translated into sentences, denoted by $\mathbf{{}_XR\ {}_XC\ {}_YC\ {}_YR\ {}_YC\ {}_XC\ {}_XR \mid {}_XR\ {}_XC\ {}_ZR\ {}_XC\ {}_XR}$, indicating the possible routes players can take within the game space.

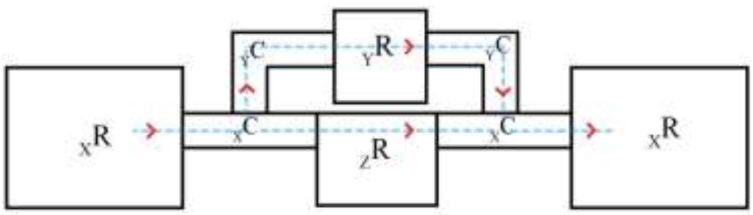


Figure 3.14 : A branching level structure.

In another scenario, a linear level structure is depicted with a side mission room denoted as Room Y, accessible only through Room Z. Some players may bypass this room and proceed with the linear progression. In the sequence depicted in Figure 3.15, the gameplay transformed into syntax as $\mathbf{{}_XR\ {}_XC\ {}_ZR\ [{}_YR]\ {}_XC\ {}_XR}$, representing the optional side mission room within the linear progression.

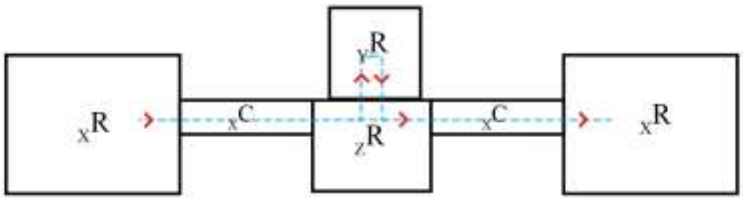


Figure 3.15 : A linear level structure with a side-mission room ($_{Y}R$).

Following the generation of two-layered sentences —spatial descriptions and context definitions— from gameplay drawings utilizing BNF rules, recurrent patterns are extracted. These patterns are represented using a mutually understandable grammar and BNF notations, facilitating a standardized framework for comprehending the underlying structures of the game levels.

This multifaceted methodology, integrating gameplay experience, video recording, detailed 2D mapping, and comprehensive labeling, and creating sentences from gameplay sequences aimed at a comprehensive investigation into the spatial design of third-person shooter action video games.

4. SPATIAL DESIGN PATTERNS OF TPS GAMES

In this section, we analyze the spatial design patterns observed in six selected third-person shooter (TPS) games—*Gears of War 4, Mass Effect 3, Max Payne 3, Control, Tom Clancy's Splinter Cell Conviction,* and *Dead Space*. The aim is to identify common room types, their contextual classifications, and the connective elements that shape the gameplay experience with the spatial patterns of the third dimension.

4.1 Rooms

This study conducts a thorough analysis of game environments in order to identify potential patterns by concentrating on both their content and spatial layout with a third dimension, challenge and scale parameters. The study reveals an observation regarding the game environments analyzed, where despite varying environement settings such as interior rooms, exterior courtyards, training areas or open landscapes, the games examined do not belong to the open-world genre. Thus, these game environments, despite their diverse appearances and exterior settings, exhibit characteristics akin to interior rooms, implying enclosed boundaries and layouts. Consequently, the game environments with enclosed boundaries are categorized as "room" within the context of this study, highlighting the overarching design principles governing spatial organization and player navigation across diverse game settings.

4.1.1 Common room types

In this section, we focus on the common room types, characterized by basic shape borders, and delve into its sub-types to understand their significance in gameplay dynamics, as observed from analyzed studies.

Initially, each room is classified based on its content attributes, such as combat encounters or puzzle-solving elements, aiming to recognize the correlations between content and spatial organization in future analyses. The following contextual classifications are found in the analyzed games:

Narrative Room (**R**$_{\mathbf{narrative}}$): Rooms focusing on narrative elements.

Quest Room (**R**$_{\mathbf{quest}}$): Rooms where quests or missions are assigned.

Combat Room (**R**$_{\mathbf{combat}}$): Rooms designed for combat scenarios.

Puzzle Room (**R**$_{\mathbf{puzzle}}$): Rooms featuring puzzles for players to solve.

Resource Room (**R**$_{\mathbf{resource}}$): Rooms containing valuable in-game resources.

Tutorial Room (**R**$_{\mathbf{tutorial}}$): Rooms dedicated to teaching gameplay mechanics.

Furthermore, rooms are classified based on their spatial layout. Five common room types are identified in the selected games and classified from A to E based on their outlines: square (A), rectangle (B), semicircle (C), L-shape (D), and circle (E) (Figure 4.1).

The aim of this spatial classification is to provide guidance for procedural generation algorithms, particularly concerning player movement within the rooms. Recognizing the subjective nature of player movement is dependent on player preferences and skills, this study adopts a standardized approach, defining player movement as the shortest 90-degree path which is closely linked to the movement controls typically used in games W, A, S, D keys on a keyboard, between the entrance and exit of each room. This method not only establishes clear entrance and exit points but also facilitates linear room ordering for procedural generation algorithms. Thus, most common player circulations, represented with blue dashed lines at Figure 21, in the selected games are sub-categorized as Z-shaped (1), L-shaped (2), I-shaped (3), rooms that embed in a room with circulation in and out (4), and U-shaped circulations (5) (Figure 4.1).

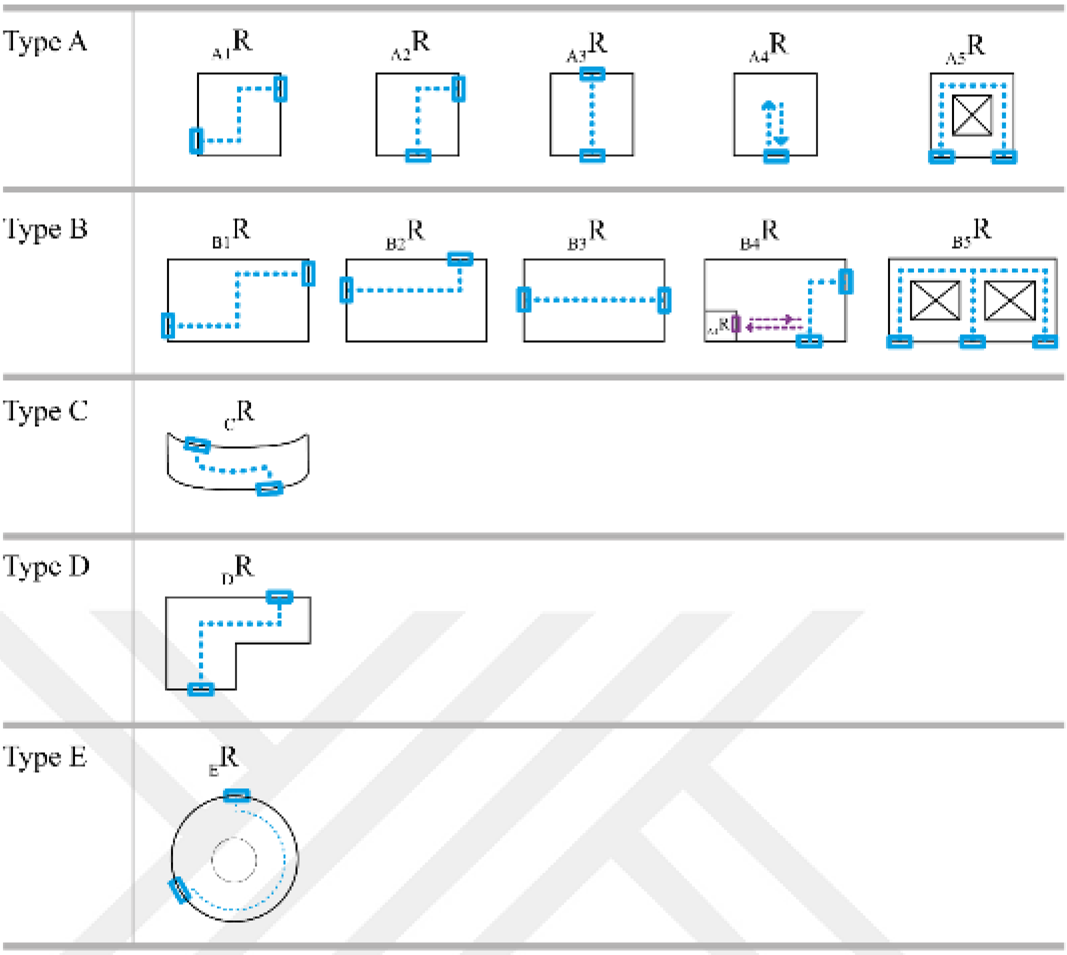


Figure 4.1 : Common room classifications based on the spatial layout and player movement path.

In addition to spatial layout considerations, the design and the perception of game space are linked with the third dimension (z-axis), as well as the scale of the room, often corresponding to its challenge and the time that spent in it. To encapsulate these aspects, parameters such as room levels and scale/challenge levels are integrated into the symbol coding system for rooms. Room levels include descriptors such as "z0" for flat, single-level terrain, "z0,n" for flat terrain with additional platforms, "z1" for suspended rooms, and "z2" for rooms with multiple floors. In the selected games, challenge of the rooms range from "t1" for small rooms with simple challenges suitable for beginners, through "t2" mid-scale room for moderate difficulty, "t3" large rooms for challenging experiences aimed at experienced players, to "t4+" extra large rooms denoting significant difficulty tailored for advanced players. These additions enhance the symbol coding scheme, providing a comprehensive representation of the spatial and time/challenge-related attributes of each room. (Table 4.1).

Table 4.1 : Explanation of room symbol codes.

Symbol	Definition	
z0	Flat	- Single-level, even terrain within a room
z0,n	Flat + Platforms	- Flat design with additional elevated platforms or stages.
z1	Suspended	- Room with a floor elevated or suspended above ground level.
zn	Multiple Floors	- Room with multiple levels or floors.
t1	Simple	- Low-level challenge, suitable for beginners
t2	Medium	- Moderate challenge, providing balanced difficulty.
t3	Challenging	- Higher level of challenge, suitable for experienced players.
t4+	Hard	- Significant level of difficulty, designed for advanced players.

Room Type A1 (Figure 4.2) is distinguished by its Z-shaped circulation defining opposed entrance and exit points. Notably, these rooms commonly appear at the beginning of games, exemplified in Mass Effect (Room 1.1, Room 1.3, Room 2.1**(**Figure 4.3**)**), Max Payne 3 (Room 1), Gears of War 4 (Room 1), and Gears of War (Room 3). It is evident that Room Type A1 is mainly utilized as a tutorial room to introduce players to the basic mechanics of the game. All Room Type A1 instances have a flat floor configuration (coded as z0) and a low challenge level (t1), aligned with the tutorial's educational objectives without distracting the player with spatial details, facilitating a smooth learning curve for players.

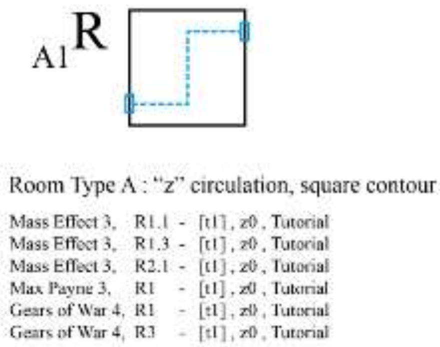


Figure 4.2 : Room type A1 with the labels observed at the analyzed games.

Figure 4.3 : Mass Effect Room 2.1, an example of Room type A1 with tutorial content.

Room type A2 **(**Figure 4.4**)**, characterized by square borders and an L-shaped player movement path where the exit is positioned at a 90-degree angle opposite the entrance, appears in a variety of contexts within the examined games. These rooms typically have t1 or t2 tags on, indicating their relatively small to medium size and the time spent within them. Notably, rooms labeled with t2 tend to feature more intricate spatial layouts, often incorporating platforms (z0,n) along the z-axis. While t1-tagged rooms predominantly serve as tutorial or resource areas, t2-tagged rooms are primarily combat-oriented. Despite serving as combat arenas, t2 tagged type A2 rooms offer moderate challenges, featuring relatively short encounters that are usually found in the early to mid stages of gameplay.

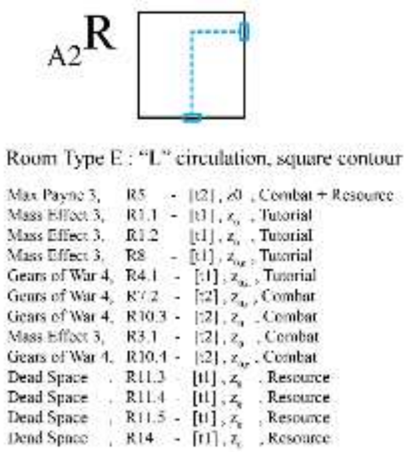


Figure 4.4 : Room type A2 with the labels observed at the analyzed games.

Room type A3 (Figure 4.5), characterized by a square layout with directional player movement, where the entrance and exit are positioned at opposing sides, hosts as combat or resource functions within the analyzed games. Resource rooms, aimed at providing players with essential items for the gameplay or restoring their health, are marked by a low level of complexity and a flat spatial layout (tagged as z0), reflecting their function as t1-tagged areas. Conversely, combat rooms, with the exception of Control Room 6, offer moderate challenges and feature flat floors (z0), typically labeled as t1 or t2 for moderate to low challenge levels. Notably, Control Room in the game "Control" stands out as a spatially complex and challenging environment, designated with t3 and z0,n labels.

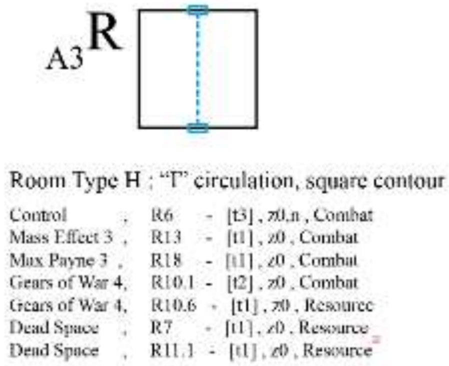


Figure 4.5 : Room type A3 with the labels observed at the analyzed games.

Room type A4 (Figure 4.6), characterized by square borders embedded within larger rooms or hubs with a single entrance, serves two functions in the analyzed games: quest progression or resource acquisition. These rooms require players to enter and return to the larger container room to continue gameplay. In quest-functionated A4 rooms, players must accomplish specific tasks before returning to the hub room, while resource-functionated A4 rooms offer items for health restoration or ammunition refill. Both quest and resource rooms are characterized by basic layouts with no z-axis movement (z0 tagged) and pose zero to low challenges. Resource rooms were observed to require minimal time investment (t1), with players swiftly entering and exiting (Figure 4.7). Conversely, quest-related A4 rooms may vary in time spent (t1 to t2), depending on quest complexity. Movement in the z-direction is notably absent in these rooms across the analyzed games.

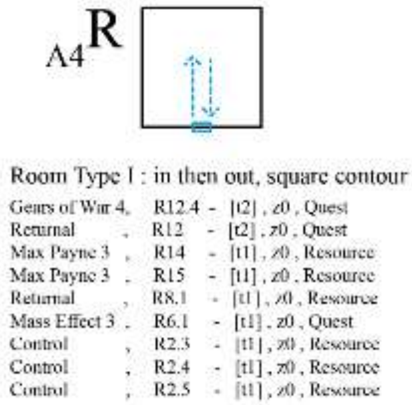


Figure 4.6 : Room type A4 with the labels observed at the analyzed games.

Figure 4.7 : Max Payne 3, Room 14, an example of type A5 resource room that embedded in a larger room.

Room type A5 (Figure 4.8) is characterized by square contours, although it can also shown as a rectangle when two are adjoined. These rooms feature a central blockade, akin to a gallery space or a large mass blocking the middle, creating a circulation path reminiscent of a corridor. Players navigate around this blockade to reach the exit, which is aligned along the same line as the entrance. A5 rooms serve various functions, including narrative progression, resource acquisition, and combat encounters in the analyzed games. In the game "Control," both narrative and resource rooms are observed, tagged as t2 and z0, indicating moderate time spent and flat layouts. Conversely, combat functions are witnessed in "Max Payne 3," featuring t2 or t3 tags and flat layout (z0) characteristics, suggesting moderate to high challenge levels.

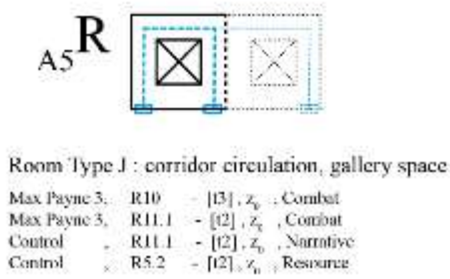


Figure 4.8 : Room type A5 with the labels observed at the analyzed games.

Room type B1 (Figure 4.9) is characterized by its rectangular shape and inner z-circulation pattern, with the entrance and exit positioned on opposing sides. These rooms predominantly serve as hosts for combat encounters, often tagged with t2 or t3 which indicate moderate to high challenge levels. While most B1 rooms exhibit a moderate level of complexity, some feature elevated platforms or stages (z0,n), adding an additional layer of substantiality to the gameplay. Rarely, room type B1 diverges from its typical combat function and serves as a narrative space, as seen in Gears of War room 10.2, or a quest room, such as in Dead Space room 17. In these instances, the rooms are tagged with t1 or t2 to signify low to moderate challenge levels, providing players with a different gameplay experience compared to their usual combat-oriented counterparts.

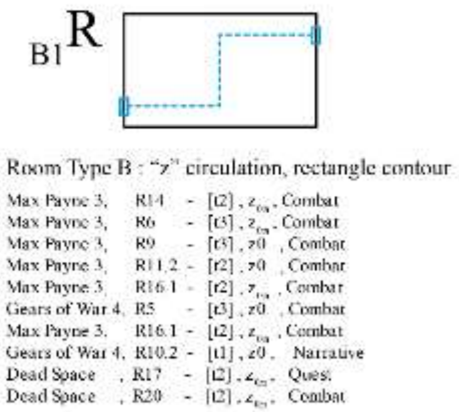


Figure 4.9 : Room type B1 with the labels observed at the analyzed games.

Room type B2 (Figure 4.10), characterized by a rectangular spatial layout with an L-shaped circulation pattern, and mostly functions as combat spaces. B2 rooms that serves as combat rooms are observed to be tagged with t2 or t3 that indicate moderate to high challenge levels. It's noteworthy that all t3 tagged rooms are also labeled as z0,n, suggesting that the time spent in the room aligns with both the challenge and complexity of the room volume, particularly in the z direction. While uncommon, there are instances where B2 rooms serve as resource or narrative spaces, marked with t1 and t2 tags due to the lower challenge requirements in those specific rooms.

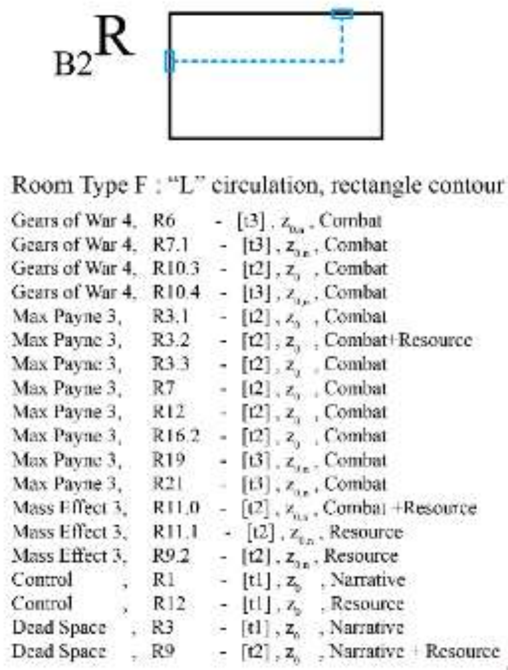


Figure 4.10 : Room type B2 with the labels observed at the analyzed games.

Room type B3 (Figure 4.11) exhibits a rectangular layout with directional player movement, featuring entrances and exits positioned at opposing sides. Throughout the analyzed games, B3 rooms are predominantly observed as moderately challenging combat encounter levels with no z-directional complexity, tagged with z0 and t2. However, there are rare instances where B3 rooms serve as tutorial spaces, as seen in Tom Clancy's Room 1.1 and 1.2, as well as Gears of War 4 - Room 2 (Figure 4.12). These tutorial rooms are characterized by t1 and t2 tags, indicating low to moderate challenge levels.

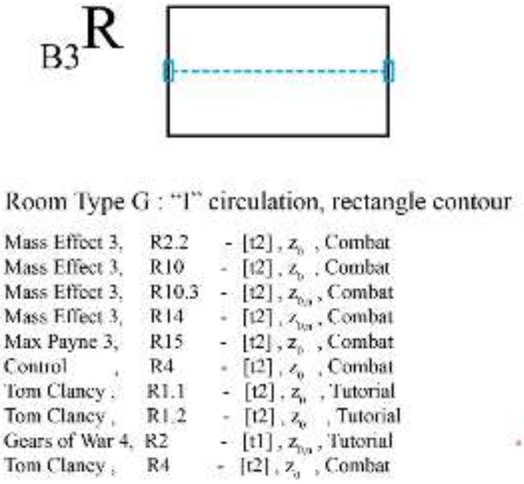


Figure 4.11 : Room type B3 with the labels observed at the analyzed games.

Figure 4.12 : Gears of War 4, Room 2, an example of type B3 tutorial room with directional player movement in exterior setting.

Room type B4 (Figure 4.13) features a rectangular spatial layout, serving as the larger hub room in which A4 type rooms (Figure 4.6) are embedded. These B4 rooms are observed as narrative spaces embedded with a side quest rooms, providing players with additional details about the game world's story, in Mass Effect 3 (Room 6 and 9.1). Additionally, in Max Payne 3 (Room 13) and Control (Room 5), B4 rooms host combat encounters with embedded A4 type side quest rooms. Type B4 rooms are characterized by their larger scale, moderate to high challenge levels (tagged as t2 or t3), and often feature platform complexity in their layout.

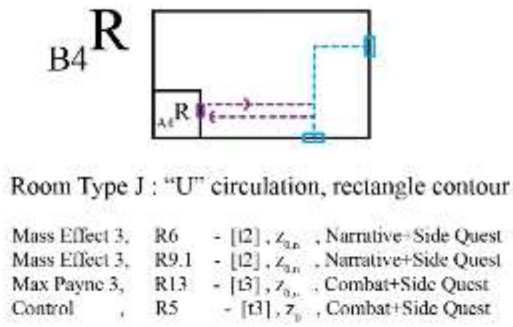


Figure 4.13 : Room type B4 with the labels observed at the analyzed games.

Room type C (Figure 4.14) features an arc-shaped spatial layout with a z-shaped player movement pattern from entrance to exit, positioned on opposing sides. All C type rooms are consistently observed as combat spaces, characterized by their high challenge levels and tagged as t3. Additionally, these rooms exhibit complexity in volume along the z-direction, corresponding to the level of difficulty, with either a platform (z0,n) or a suspended floor (z1) included in their design.

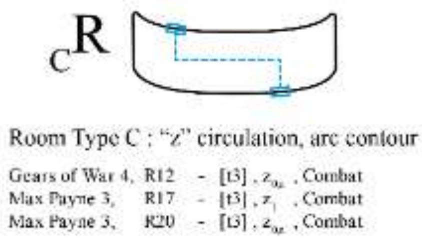


Figure 4.14 : Room type C with the labels observed at the analyzed games.

Room type D (Figure 4.15) has an L-shaped spatial layout, with player entry and exit positions located at opposite directions and z-shaped player movement within the room. These rooms consistently serve as combat arenas, offering moderate to high challenge levels and tagged as t2 or t3. Additionally, certain D type rooms exhibit platform complexity, labeled as z0,n, adding further intricacy to the gameplay experience.

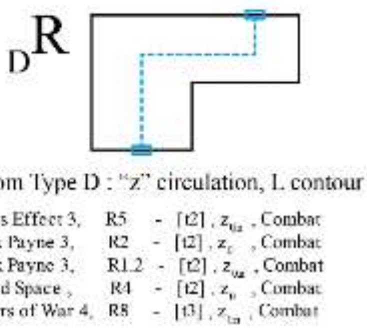


Figure 4.15 : Room type D with the labels observed at the analyzed games.

Room type E (Figure 4.16), identified solely in Max Payne 3 as room 8 (Figure 4.17) and Mass Effect 3 as Room 9. E type rooms feature a circular spatial layout with circular player movement. These rooms observed with a high level of challenge, marked with a t3 tag, and are characterized by the presence of circular platforms in the middle of the room (z0,n), adding complexity to the gameplay dynamics.

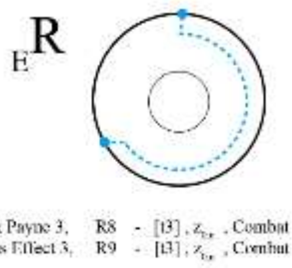


Figure 4.16 : Room type E with the labels observed at the analyzed games.

Figure 4.17 : Max Payne 3, Room 8, an example of type C combat room with circular layout.

4.1.2 Unique room types

After categorizing the most common room types in section 4.1.1., Table 4.2 presents the unique rooms, which differ from standard classifications due to their customized designs while following common design principles observed in the analyzed games. These rooms are primarily used as combat encounters or combat hybrids with resource, puzzle, and narrative elements. They typically have high to very high challenge levels (t3 or higher) and extended gameplay durations. Compared to common room types, unique rooms have significantly larger volumes in terms of spatial dimensions. They frequently feature multi-level structures with z-directional movement made feasible by suspended floors and platforms.

Combat encounters are placed strategically at different levels, making them challenging for players to navigate and emphasizing the value of vertical navigation. Notably, in some cases (Mass Effect 3, Room 6; Control Rooms 8, 10, and 13) enemies/boss are positioned at higher altitudes, making the game more challenging to play. These rooms serve as key locations in the game's progression and convey a sense of challenge and importance upon entry. It is frequently observed that these rooms mark the resolution of conflicts or the conclusion of game chapters. While common room types follow pre-designed didactic paths for player movement, unique rooms are more expansive and flexible, giving players more freedom to move around the room while still offering obvious directional cues.

The majority of unique rooms adhere to Frank Ching's architectural principles (1979), emphasizing elements like symmetry, hierarchy, rhythm, and repetition to guide player movement and enhance spatial coherence, even though their spatial layouts vary, will be detailed in section 4.1.3.

Table 4.2 : Unique Rooms were observed in the analyzed TPS games.

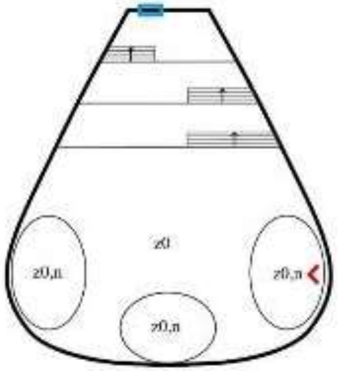
Game	Content	Layout	Screenshot	Time/Challenge (t)	Level (z)
Max Payne 3 Room 4	Combat			t4	z0,n
Mass Effect 3 Room 6	Combat + puzzle			t3	z1

Table 4.2 (continued) : Unique Rooms were observed in the analyzed TPS games.

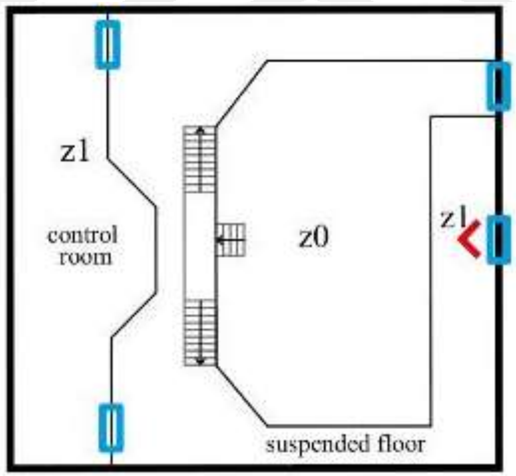
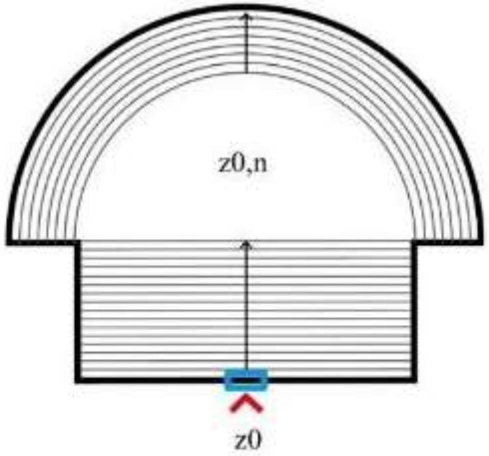
Game	Content	Layout	Screenshot	Time/Challenge (t)	Level (z)
Mass Effect 3 Room 14	Combat + resource			t3	z1
Gears of War 4 Room 8	Combat (boss)			t3	z0,n

Table 4.2 (continued) : Unique Rooms were observed in the analyzed TPS games.

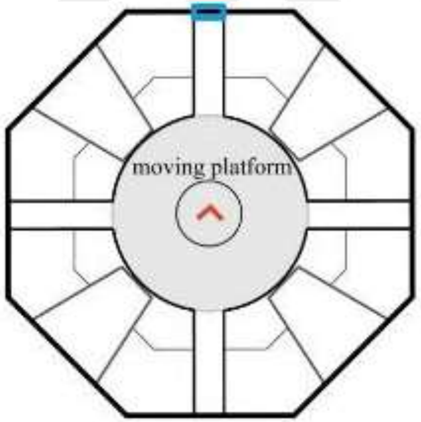
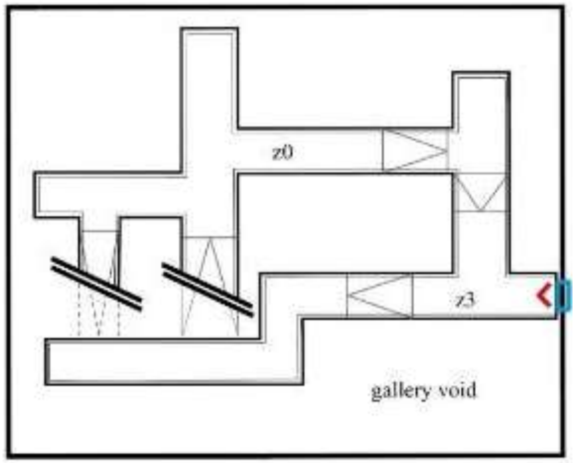
Game	Content	Layout	Screenshot	Time/Challenge (t)	Level (z)
Gears of War 4 Room 12	Combat			t6	z3
Dead Space Room 11, 12, 13, 14, 16	Combat + resource			t8	z4

Table 4.2 (continued) : Unique Rooms were observed in the analyzed TPS games.

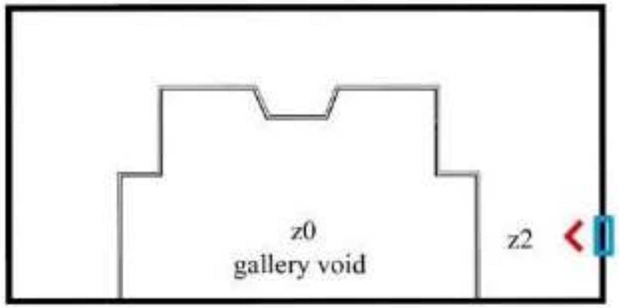
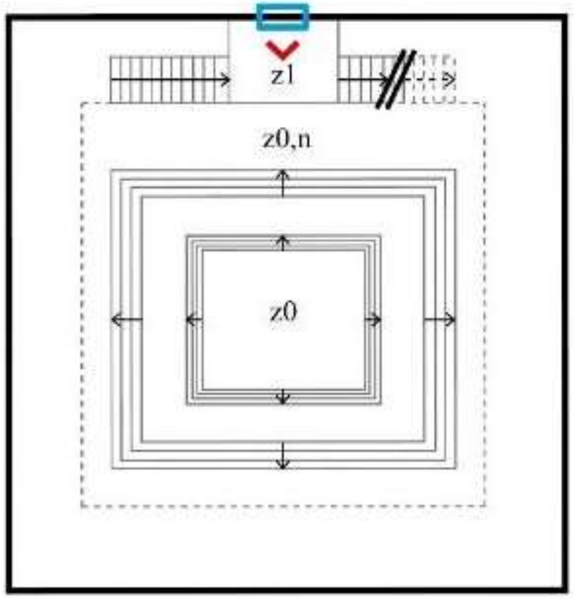
Game	Content	Layout	Screenshot	Time/Challenge (t)	Level (z)
Dead Space Room 19	Combat + puzzle + resource			t3	z1
Control Room 6	Combat			t3	z0,n

Table 4.2 (continued) : Unique Rooms were observed in the analyzed TPS games.

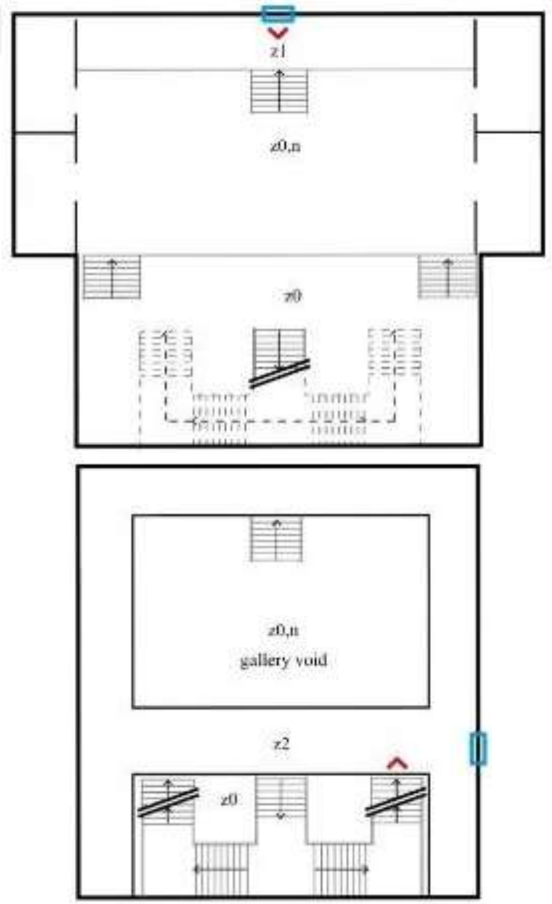
Game	Content	Layout	Screenshot	Time/Challenge (t)	Level (z)
Control Room 8	Combat + resource + narrative			t3	z1

Table 4.2 (continued) : Unique Rooms were observed in the analyzed TPS games.

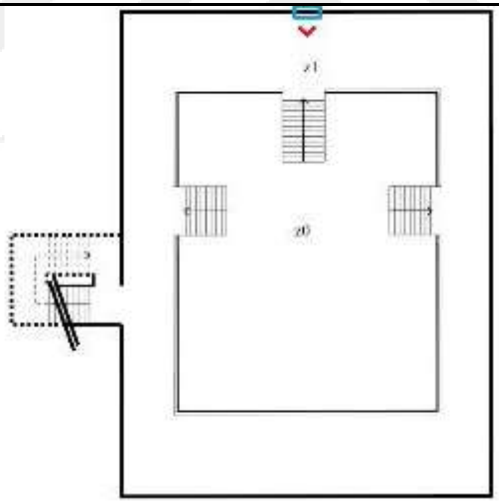
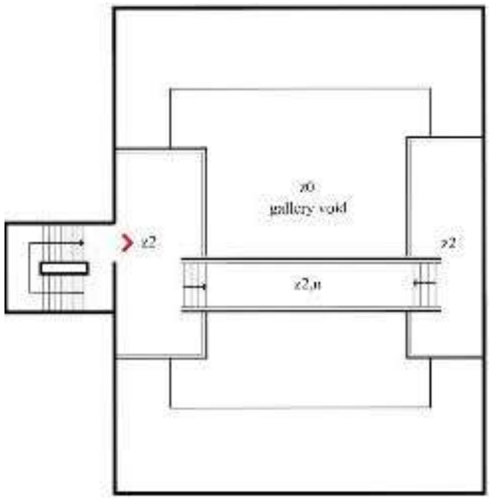
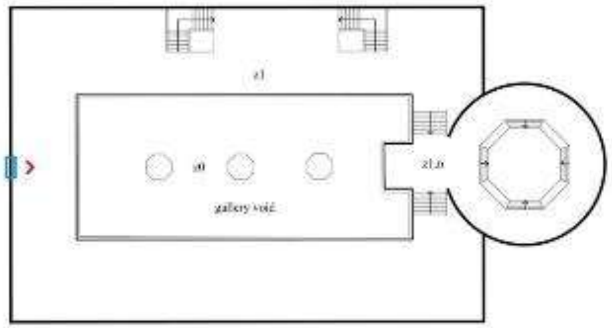
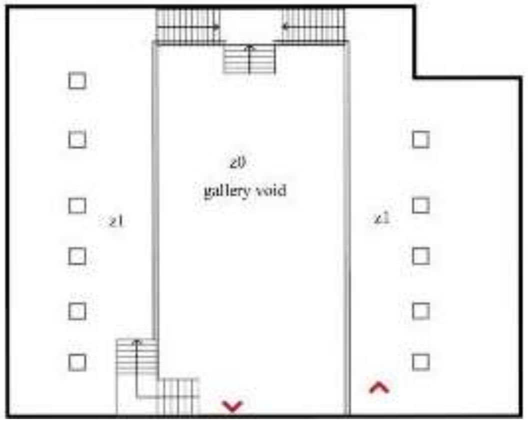
Game	Content	Layout	Screenshot	Time/Challenge (t)	Level (z)
Control Room 10	Combat	 	 	t6	z2

Table 4.2 (continued) : Unique Rooms were observed in the analyzed TPS games.

Game	Content	Layout	Screenshot	Time/Challenge (t)	Level (z)
Control Room 13	Combat (boss)			t8	z2
Tom Clancy	Combat + narrative + puzzle			t4	z1

4.1.3 Room patterns

In this section, we will conduct a comprehensive review of the room patterns observed across the room types outlined in sections 4.1.1 and 4.1.2. This analysis aims to provide a holistic understanding of the common spatial configurations and design characteristics present in the analyzed games. By synthesizing the findings from both common and unique room types, we seek to identify recurring patterns that contribute to the overall gameplay experience and level design principles. Through this review, we aim to gain insights into the spatial organization, functional layouts, and gameplay dynamics prevalent in the game environments under study.

4.1.3.1 Action-driven structural layouts

It is evident that the nature of the action occurring within a room influences the spatial design decisions, and conversely, the spatial layout of a room can impact the gameplay experience (Figure 4.18). Tutorial rooms, observed in A1, A2, and B3 room types, exhibit low to moderate challenge levels and minimal complexity in volume design. This simplistic design emphasizes their role in introducing new game mechanics to players without overwhelming them with spatial intricacies. Similarly, resource rooms, intended for collecting essential health or ammunition resources, feature basic designs reflecting their utilitarian function. This principle extends to narrative rooms, where players immerse themselves in the game world's details and quest rooms where players focus on the mission.

Figure 4.18 : Dead Space, spatial complexity and scale difference between a resource room (left) and a combat room (right).

Quest rooms, typically A4 and B1 types embedded within B4 rooms, maintain low to moderate challenge levels and minimal z-direction complexity. In contrast, combat rooms, seen in various room types, exhibit moderate to very high challenge levels and moderate to high volume complexity. This reflects the need for maneuvering space during combat encounters, resulting in significantly larger-scale rooms compared to others (**Table 4.3**) .

Table 4.3 : Room content matches the room types, challenges, and levels observed in the analyzed TPS games.

Content	Room Type													Time/Challenge (t)				Level (z)		
	A1	A2	A3	A4	A5	B1	B2	B3	B4	C	D	E	Unique	t1	t2	t3	t3+	z0	z0,n	zn
Tutorial	+	+						+						+	+			+	+	
Resource		+	+	+	+		+						+	+	+			+		
Narrative					+	+	+		+				+	+	+			+	+	
Puzzle													+			+	+			+
Quest				+		+			+					+	+			+	+	
Combat		+	+		+	+	+	+	+	+	+	+	+		+	+	+	+	+	+

4.1.3.2 Characteristics of large-scale combat rooms

Rooms hosting large-scale combat encounters or boss battles exhibit distinct planar shapes not captured by conventional room layouts classified as unique. Although those rooms are observed in different layout shapes, there are shared common threads. These unique spaces were observed to have a layout created by a basic shape such as a hexagon or a union of basic shapes such as a half circle and rectangle. It is observed that all layouts adhere to Frank Ching's ordering principles (1979), featuring both planar and sectional symmetry. Symmetries are observed in different types such as one-axis symmetry, two-axis symmetries, and point symmetry **(**Figure 4.19**).**

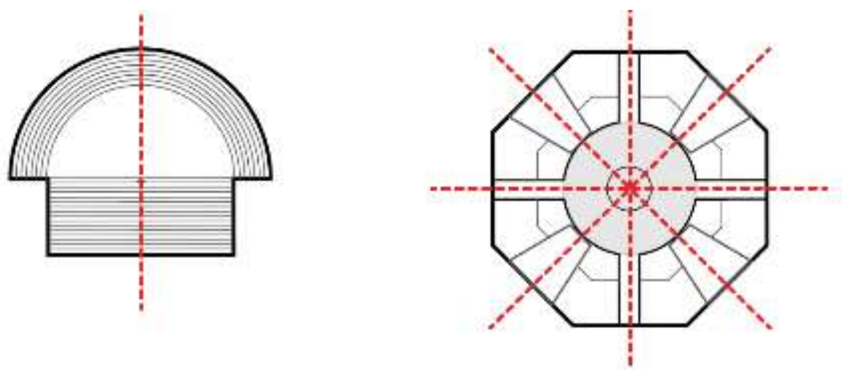


Figure 4.19 : In Gears of War 4, the layout of Room 8 is created by the union of a half circle and a rectangle that has y-axis symmetry (left). The layout of Room 12 is created by a hexagon that has a point symmetry (right).

Ching’s ordering principles (1979) are observed in both plan and section of the large-scale combat rooms. Defined pathways guide player movement along axes, while rhythmic placement of structural elements, such as columns or pipes, enhances realism and adds visual interest. The rhythm and repetetiveness provided with interior props creates solid paths and navigation clues for the players. A clear hierarchy of levels, including ground, suspended, and elevated floors, also aids player navigation within the room **(**Figure 4.20**).**

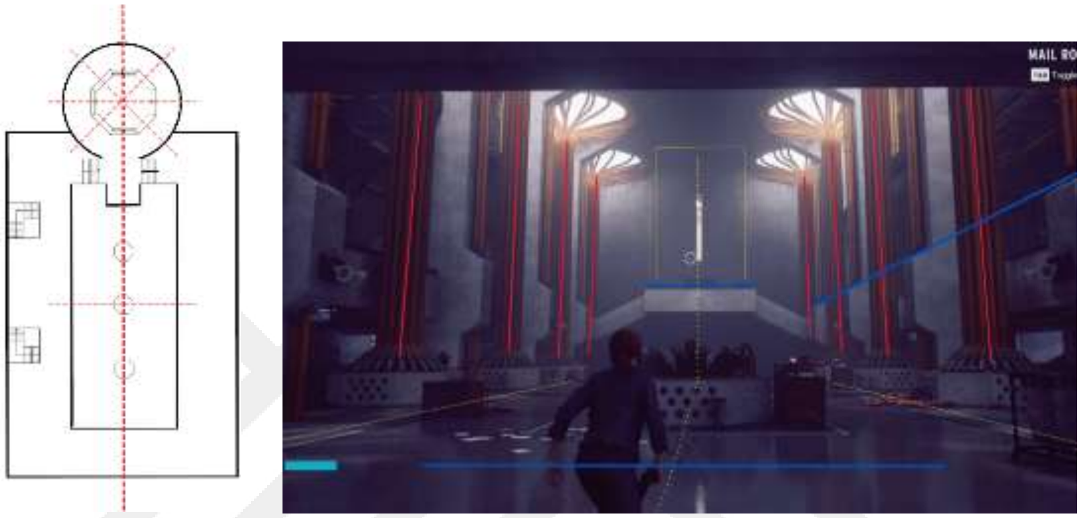


Figure 4.20 : Control Boss room analyzed with Ching’s architectural ordering principles, plan (left) and gameplay screenshot (right).

Additionally, large-scale combat rooms often incorporate multiple platforms or suspended floors, creating a dynamic spatial environment reminiscent of an arena. This design choice not only deepens combat encounters but also contributes to the overall gameplay experience by providing strategic vantage points and fostering player engagement.

4.1.3.3 Leveraging verticality for tactical advantage

In shooter games, the vertical dimension plays a pivotal role in determining the outcome of encounters due to its impact on shooting mechanics. When both player and enemy are positioned at the same level, the encounter is balanced, offering equal opportunities. However, gaining elevation relative to the enemy provides a significant advantage, enabling the player to aim more effectively and take cover more efficiently. Conversely, being located below the enemy puts the player at a disadvantage in terms of both shoot and take cover (Figure 4.21).

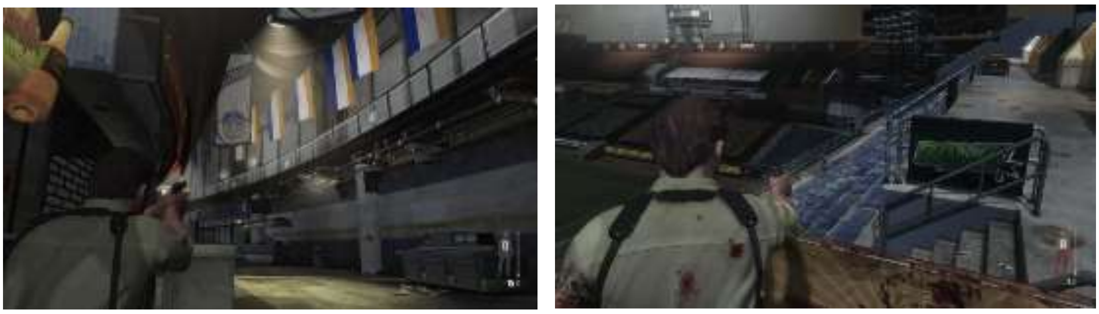


Figure 4.21 : Max Payne 3, player located below the enemy (left) and player located at vantage point (right).

To enhance gameplay strategy, encounter spaces often incorporate flexible verticality, allowing players to strategically climb up to higher positions for a tactical advantage. On the other hand, designers may intentionally introduce challenging scenarios, such as chokepoints where enemies attack from elevated positions, forcing players to adapt and create alternative strategies for success (Figure 4.22). This design decision emphasizes the value of dynamic gameplay elements beyond vertical positioning by forcing players to rely on alternate strategies and adaptability to overcome approaching threats.

Figure 4.22 : Dead Space, player located at a chokepoint where leveraging verticality for tactical advantage is not feasible.

4.1.3.4 Interior design dynamics in gameplay spaces

The interior design and placement of props within rooms directly impact player navigation and movement strategies in various ways. Combat rooms often feature barriers and obstacles that provide cover for players, allowing them to engage enemies strategically while minimizing damage. Games like Mass Effect 3 and Gears of War 4, where players have NPC allies, utilize movable box barriers that enable dynamic movement between cover points. In contrast, titles like Max Payne 3 and Tom Clancy's games incorporate repetitive columns, bars, and furniture for individual players to take cover behind while facing enemies (Figure 4.23).

Figure 4.23 : Covers that blocks vision and damage in Gears of War 4 (left) and Max Payne 3 (right).

Combat room settings typically feature large-scale, hardcover props that offer protection and obstruct vision. In stealth-focused sub-genres like Tom Clancy's games, softer cover elements such as bushes obscure vision without providing substantial protection. Certain props, like wooden chunks or large boxes, are strategically placed to block off areas and discourage player entry, indicating restricted access.

Tutorial rooms often feature semi-open training areas with ruined-looking interior props, allowing players to practice movement mechanics like jumping and running. Resource and quest rooms commonly resemble office spaces or warehouses, where players search for health resources, ammunition, or clues to progress through puzzles or quests. Specific quest rooms may have unique objectives, such as repairing a tram in Dead Space, adding variety to gameplay experiences.

4.1.3.5 Proportion, scale and environmental impact

One important finding from the analysis of the room layouts in various games relates to the size and proportion of these spaces. The size and dimensions of a room play a crucial role in shaping the player's experience and interactions within the game world. Rooms are typically sized to support particular gameplay features and difficulties, with these goals being the focus of their design.

Moreover, the scale of rooms may vary depending on the stage of gameplay progression or narrative context. Early-game areas or tutorial sections typically feature smaller, more contained spaces to ease players into the mechanics and challenges gradually. As players advance through the game or enter pivotal moments in the story, they may encounter larger, more expansive environments that reflect heightened stakes and increased complexity.

Boss rooms and large-scale combat areas, in particular, feature thoughtful design decisions meant to evoke depth and imposing scale. Large columns and other repeating structural elements (Figure 4.20) highlight the enormity of these settings and give players a sense of challenge and wonder. The enormity of these rooms, as seen from a third-person viewpoint comparing the character scale with environment, can arouse emotions of helplessness and vulnerability, consistent with the dramatic tone of boss encounters. Tutorial and resource rooms, on the other hand, put an emphasis on player-friendly scaling and proportionality, looking more like comfortable, one-player areas like real-world homes. These settings are intended to encourage a feeling of familiarity and comfort, which makes player interaction and navigation easier. But in boss rooms, purposeful manipulation of scale and proportion ups the tension and challenge, making players feel somewhat lost and small in these massive environments. The intentional approach taken in the design enhances the immersive gameplay experience.

For example, in horror games such as Dead Space, combat rooms are distinguished by notably large gallery spaces that have expansive voids, but the movement actually takes place on narrow bridges. Players experience a real sense of claustrophobia and tension as a result of this design decision because they feel trapped and open to attacks from all directions (Figure 4.24). Through the careful manipulation of proportion, scale, and environmental elements, game developers can effectively shape the emotional impact and intensity of gameplay experiences, thereby improving player engagement and immersion.

Figure 4.24 : Dead Space, large-combat room.

Furthermore, the spatial relationships between rooms within a game environment contribute to its overall coherence and navigational flow. Consistent scaling and proportionality across interconnected spaces ensure a seamless transition between areas, promoting player engagement and exploration.

4.1.3.6 Aesthetic patterns: color, texture, light, and sound

Beyond spatial layout and proportion, the aesthetic elements of color, texture, light, and sound play pivotal roles in shaping the atmosphere and ambiance of game environments. These elements contribute to the overall mood, immersion, and emotional impact experienced by players as they navigate through various rooms within the game world.

The choice of color palette influences the emotional tone and atmosphere of a room. Developers strategically utilize color psychology to evoke specific emotions or set the tone for different gameplay scenarios. For example, dark and muted colors are observed employed in horror-themed environments in games like Dead Space, Resident Evil to instill a sense of fear, while vibrant hues are used in lively and energetic settings in games like Gears of War 4, Max Payne 3 to enhance excitement and engagement (Figure 4.25).

Figure 4.25 : Color pallette choice in Dead Space (left) and Gears of War 4 (right).

Textures add depth and realism to game environments, enhancing immersion and tactile feedback for players. From rough stone walls to smooth metal surfaces, the choice of textures can convey information about the environment's materials, history, and function. It is observed that by incorporating a variety of textures, developers create visually rich and engaging spaces that invite exploration and interaction. Additionally, textures can be used strategically to guide player attention, highlight points of interest, or convey narrative elements. A pattern that stands out in the examined games is the intentional placement of floor textures to point players in the direction of specific locations within the game world. Floor textures act as natural guides that help players make their way through challenging environments and accomplish their goals rapidly, whether by placing arrows, footprints, linear lines to follow or other visual cues (Figure 4.26).

Figure 4.26 : Linearity of the floor texture navigating the player in Gears of War 4 (left) and Mass Effect 3 (right).

Lighting design in games serves as a powerful tool for directing player attention and shaping the overall mood and atmosphere of the gameplay experience. One of its primary functions is to draw players' focus towards specific points of interest or objectives within the game environment. By strategically illuminating key areas or objects, developers can guide players along intended paths or prompt them to interact with certain elements essential to progressing through the game.

Furthermore, lighting creates the mood and ambiance of the game world; changes in brightness, color, and intensity can cause players to feel differently. For example, Dead Space uses shadows and darkness to build tension, which increases players' sense of fear and immerses them in a more intense experience. In addition, as players progress through the Control game, variations in lighting dynamics that turns red, serve as crucial cues, indicating changes in gameplay states or warning them of impending dangers like combat encounters (Figure 4.27).

Figure 4.27 : Local lighting used for taking players attention in Control (left) and Dead Space (right).

Video game sound design is an effective instrument that can be used to improve gameplay, immersion, and atmosphere. A visible sense of tension and anxiety is created by ambient noises in horror-themed video games like "Dead Space," which warn players of potential threats and lurking dangers. The roar of gunfire and explosions immerses players in the chaos of battle in action-packed shooters such as "Max Payne 3" and "Gears of War 4," while dynamic sound effects heighten the intensity of combat encounters.

4.2 Connections

In this study, we delve into the connections that bind together the game environments, rooms, observed in Section 4.1. These connections, serve as linking individual rooms both vertically or horizontally. Horizontal connections specify pathways that facilitate movement between rooms on the same plane, while vertical connections comprehend those that traverse different levels within the game world. Moreover, we explore the concept of complex connections, which are composed of multiple simple connections. This section examines each type of connection, shedding light on their functions, implications, and observed patterns.

4.2.1 Horizontal connections

Horizontal connections serve as the links between rooms situated on the same plane (x, y direction) within the game environment. Utilizing a methodology akin to the analysis of room patterns, we define player movement within these connections as the shortest 90-degree path, commonly associated with standard movement controls such as the W, A, S, and D keys on a keyboard, which dictate the entrance and exit points of these connections. In our visual representations, blue dashed lines represents the trajectory of player movement within the connection areas. We identify five main types of horizontal connections (A, B, C, D, and E) based on our analysis. These connections have different spatial arrangements and design elements. In addition, these primary horizontal connections are further separated according to vertical movement considerations, such as the addition of ramps or stairs (Figure 4.28).

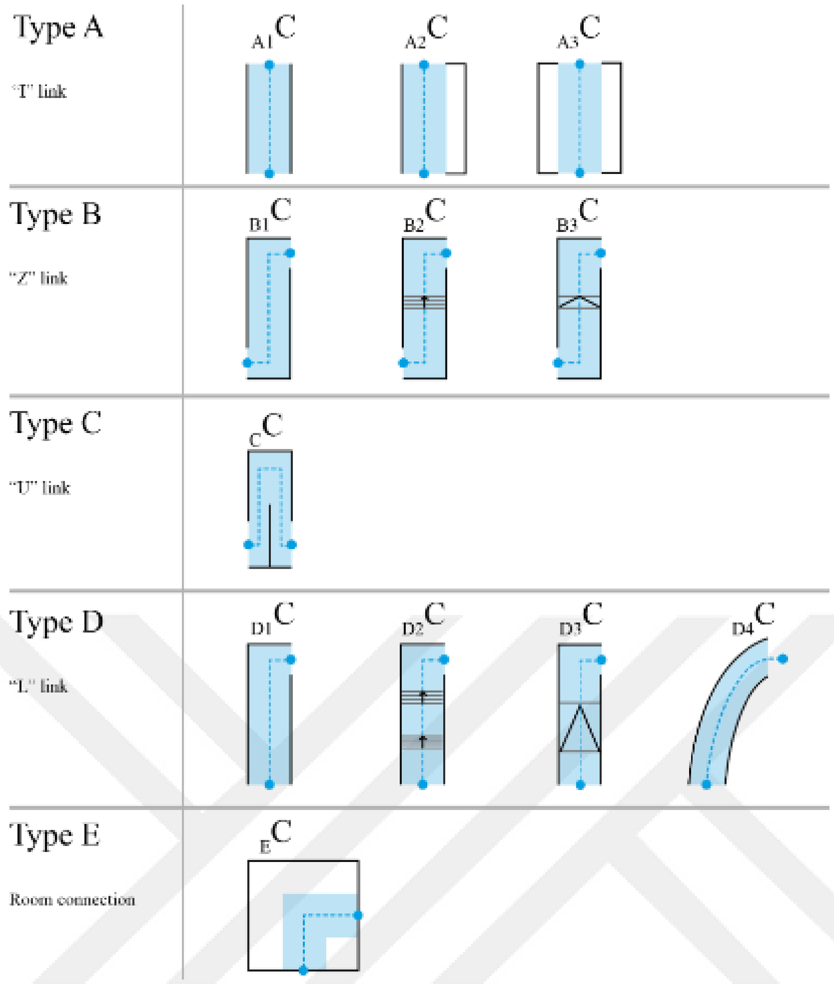


Figure 4.28 : Common horizontal connection classifications based on the spatial layout and player movement path.

Type A connections are simple directional routes that create connections between two rooms in the game world. There are multiple variations of these connections, one of which is $_{A1}C$, which represents straight paths without any extra features. On the other hand, $_{A2}C$ connections have a single-sided pocket extension that can hold different in-game components. In addition, $_{A3}C$ connections are made up of straight paths with pockets on both sides, giving players plenty of room to position game props. Additionally, all of these kinds of connections are seen to link rooms with low to moderate difficulty levels, which facilitates easier movement through the game world.

Type B connections are distinguished by having a Z-axis movement pattern, in which players move vertically through corridors that make it impossible to view the connected room when they first enter. There are also variations in these connections: $_{B2}C$ connections have stairs, while $_{B3}C$ connections have ramps. Type B connections are usually found connecting rooms with moderate difficulty levels, which makes it easier to move between the game's spatial environments.

Type C connections involve a U-shaped path that requires players to navigate around a barrier to access the connected room. Although the players are facing the entrance and exit of the connected rooms, they are unable to move directly due to a dividing wall or obstructions, so they must make a U-shaped detour. This kind of connection is commonly seen connecting rooms with a moderate level of difficulty, which gives the gameplay experience an extra degree of spatial complexity.

Type D connections involve an L-shaped movement pattern, where players navigate through a corridor that turns at a right angle. There are four variations of this connection type: $_{D1}C$ features a flat L connection, while $_{D2}C$ includes a z-directional element with stairs, and $_{D3}C$ incorporates a ramp. Additionally, $_{D4}C$ presents a specialized contour with an arc shape. These D types are commonly observed linking rooms with low-to-moderate challenge levels, providing players with diverse spatial layouts and traversal experiences.

Type E connections also feature an L-shaped movement pattern, resembling a square contour that may initially appear as a room type A2. However, these connections lack the action content defined in **section 4.1.1**, serving solely to link two rooms together. Despite their room-like appearance, these spaces exhibit distinct connection characteristics, facilitating traversal between adjacent areas without offering gameplay content.

4.2.2 Vertical connections

In addition to horizontal connections, the analyzed games feature vertical connections (Figure 4.29) that traverse players between different levels within the game environment. One common type of vertical connection is stairs, which come in four variations: type A consists of U-shaped stairs, type C features straight stairs, type D includes curved stairs, and type B comprises deck ladders. Each type of stairway offers a unique traversal experience, with type B requiring a specialized mechanic for players to ascend or descend between levels. Another vertical connection observed is the E-coded elevator, which serves as a short rest space where players can briefly pause gameplay to watch cinematics, interact with NPCs, or receive clues about the game world and narrative.

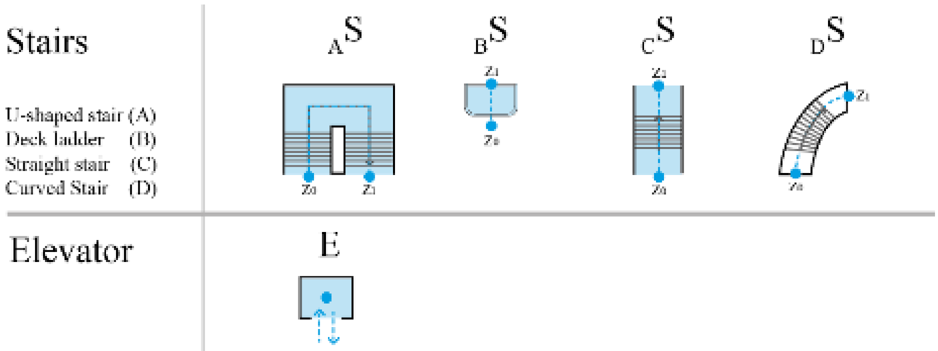


Figure 4.29 : Common vertical connection classifications based on the spatial layout and player movement path.

4.2.3 Complex connections

Complex connections, comprising two or more simple horizontal or vertical connections, are common in the analyzed game environments. These connections vary in shape and composition, yet they consistently link combat rooms or unique rooms containing high-challenge combat content. From a game design standpoint, these structures often include long corridor segments between combat encounters, allowing players a brief rest time to recover before facing the next challenge. Additionally, from a technical perspective, complex connections serve to connect large-scale rooms in a manner that optimizes performance by ensuring that connected rooms are not rendered simultaneously, thereby preventing potential FPS drops. This dual function underscores the strategic design considerations employed to enhance both gameplay experience and technical performance within the game environment.

Different combinations of decoding techniques might produce different versions of connection structures in complex corridors. A long Z-shaped corridor, for example, can be broken down into various atom combinations, like $_{A1}\mathbf{C}$ $_{D1}\mathbf{C}$ $_{A1}\mathbf{C}$ $_{D1}\mathbf{C}$ $_{A1}\mathbf{C}$ or $_{D1}\mathbf{C}$ $_{A1}\mathbf{C}$ $_{D1}\mathbf{C}$ (Figure 4.30). Despite representing the same complex connection, these combinations may manifest as distinct structures within the game environment. In the context of procedural generation, where various combinations can result in the creation of unique and dynamic game environments, this representational flexibility not only permits diverse variations but also enriches the content.

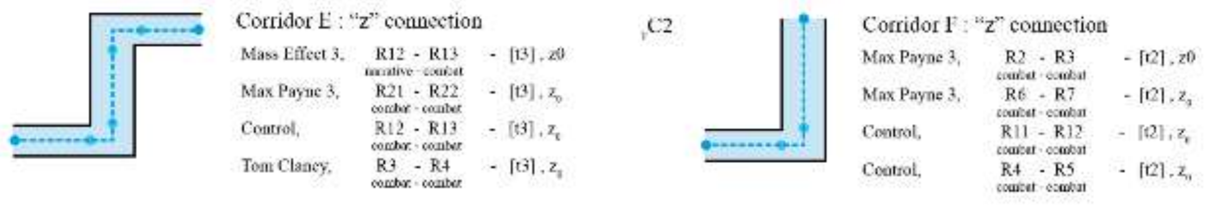


Figure 4.30 : Complex connection examples from analyzed games.

4.2.4 Connection patterns

Connections serve as vital components of gameplay flow, linking not only spaces but also narrative and thematic elements within the game world. In contrast to the horror-themed Dead Space, where connections often serve as sites of tension and encounters, other games typically maintain consistency with the overall game world and setting without combat encounters. While traversing these connections, players may encounter elements that contribute to the narrative immersion, such as bloodstains on walls or warning messages foreshadowing imminent danger.

Simple connections primarily link rooms with low to moderate challenge levels, such as narrative or tutorial spaces. Conversely, complex connections often connect two rooms featuring large-scale combat content. These connections serve both technical and gameplay purposes, providing players with a brief rest between encounters while also avoiding potential frame rate drops by rendering connected rooms separately.

In the context of three-dimensional space, connections adhere to principles outlined by architectural theorist Frank Ching, maintaining structural hierarchy and symmetry to establish visual coherence. Linear pathways are often filled by repetitive structural elements like pipes, columns, and floor tiles, reinforcing the spatial organization and guiding player movement (Figure 4.31).

Lighting and width within connections are carefully calibrated to align with the game's thematic tone. For instance, connections intended to evoke tension and horror may feature narrow passageways and dim lighting, heightening the sense of tension for players as they navigate these spaces.

Figure 4.31 : Connections with repetetive structural elements that supports the linearity, DeadSpace (left) and Mass Effect 3 (right).

4.3 Syntax

In this section, we outline decoding the gameplay of video game levels, focusing on the spatial syntax component of language analysis. The systematic approach involves symbolically representing game spaces, converting them into coherent sequences akin to sentences, and analyzing their structural arrangements. Through the application of linguistic framework-inspired principles, our goal is to identify recurrent patterns and organizational rules in game environments.

Recurrent spatial design rules are extracted through a systematic analysis of gameplay sequences and then transformed into syntax. Because these rules are expressed using BNF notation and a standardized grammar, an extensive examination of the fundamental structures of game levels is made possible. By applying this methodology, we seek to shed light on the complex relationship between gameplay experience and spatial organization by identifying the principles of spatial design that support third-person shooter action video games.

Using the methodology described in **section 3**, the first two hours of gameplay from six selected games - Max Payne 3, Mass Effect 3, Gears of War 4, Dead Space, Tom Clancy's Splinter Cell, and Control - have been examined. In the first sentences, the symbolic explanation of the rooms and connections provides insight into the game's spatial layouts and gameplay flow. After that, an additional sentence gives a conceptual overview of the content featured in these rooms, giving the complete picture of the gameplay experience.

4.3.1 Max Payne 3

Max Payne 3 is a third-person shooter video game published by Rockstar Games. While the main character Max Payne, navigates through a violent underworld, players witness cinematic storytelling, intense action sequences and bullet-time gameplay mechanics.

Notably, Max Payne 3 adopts a linear level progression (Salmond, 2021), guiding players through interconnected rooms with no option to backtrack once cleared. This spatial organization enhances the game's pacing, immersing players in Max Payne's journey without interruption.

In the first two hours of Max Payne 3 gameplay, there were eight different sequences (Figure 4.32, Figure 4.33, Figure 4.34, Figure 4.35, Figure 4.36, Figure 4.37, Figure 4.38, Figure 4.39, Figure 4.40) that could be distinguished from one another by means of cinematics that both indicated changes in the setting and the story's development. The opening scene takes place inside a building, laying the groundwork for Max Payne's adventures. Later scenes transport players to a variety of settings, such as a disco bar and a parking lot, each of which offers special obstacles and chances for Max Payne to demonstrate his abilities. Cinematic interludes help to smoothly transition between scenes and give players a peek into Max Payne's world.

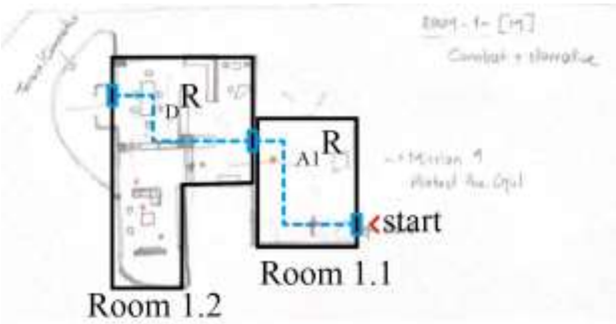


Figure 4.32 : Layout of Max Payne 3 from sequence 1.

- Spatial Sentence:

  $^{t1}{}_{A1}R^{z0}$ $^{t2}{}_{D}R^{z0,n}$ M

- Contextual Sentence:

  $R_{tutorial}$ R_{combat} M

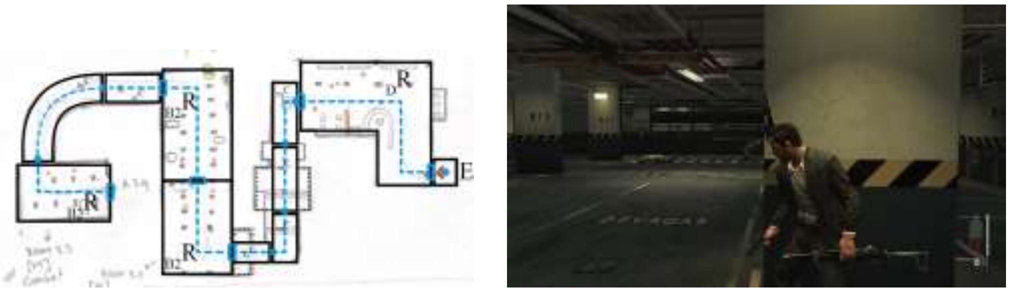


Figure 4.33 : Layout of Max Payne 3 (left), $_{B2}R$ room (right) from sequence 2.

- Spatial Sentence:

$E \quad {}^{t2}{}_{D}R^{z0} \quad ({}_{D1}C\ {}_{A3}C\ {}_{D1}C\ {}_{A3}C) \quad {}^{t2}{}_{B2}R^{z0} \quad {}^{t2}{}_{B2}R^{z0} \quad ({}_{A1}C\ {}_{D4}C) \quad {}^{t2}{}_{B2}R^{z0} \quad M$

- Contextual Sentence:

$C \quad R_{combat} \quad Cn \quad R_{combat} \quad R_{combat+resource} \quad Cn \quad R_{combat} \quad M$

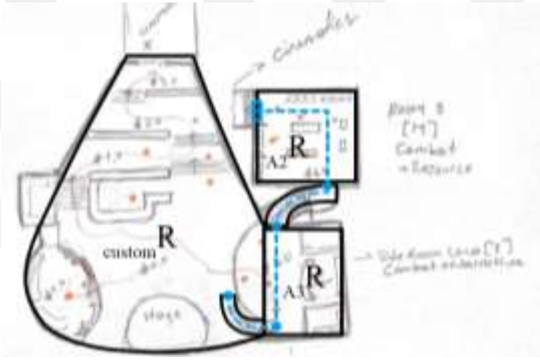


Figure 4.34 : Layout of Max Payne 3 from sequence 3.

- Spatial Sentence:

$M \quad {}^{t4}{}_{CUSTOM}R^{z0,n} \quad {}_{D}S \quad {}^{t2}{}_{A3}R^{z0} \quad {}_{D}S \quad {}^{t2}{}_{A2}R^{z0} \quad M$

- Contextual Sentence:

$M \quad R_{combat} \quad C \quad R_{combat} \quad C \quad R_{combat} \quad M$

Figure 4.35 : Layout of Max Payne 3 from sequence 4.

- Spatial Sentence:

$({}_{D4}C\ {}_{D4}C\ {}_{C}S)\quad {}^{t3}{}_{B1}R^{z0,n}\quad ({}_{A2}C\ {}_{D1}C)\quad {}^{t2}{}_{A2}R^{z0}\quad {}_{D1}C\quad {}^{t3}{}_{E}R^{z0,n}\quad {}_{E}C\quad M$

- Contextual Sentence:

$Cn\ \ R_{combat}\ \ Cn\ \ R_{combat}\ \ C\ \ R_{combat}\ \ C\ \ M$

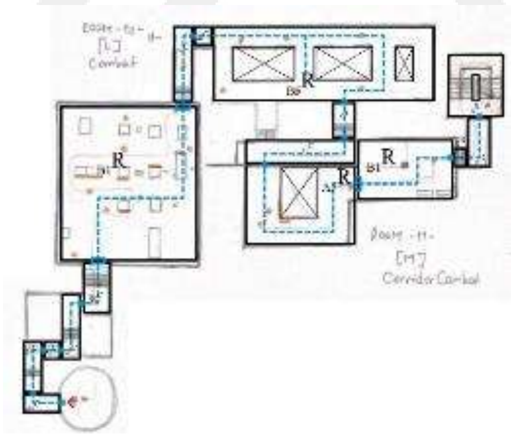


Figure 4.36 : Layout of Max Payne 3 from sequence 5.

- Spatial Sentence:

$({}_{D1}C\ {}_{D2}C\ {}_{A1}C\ {}_{B2}C\ {}_{D2}C)\quad {}^{t3}{}_{B1}R^{z0}\quad ({}_{D2}C\ {}_{A1}C)\quad {}^{t3}{}_{B5}R^{z0}\quad ({}_{C}S\ {}_{B1}C)\quad {}^{t2}{}_{A5}R^{z0}\quad {}^{t2}{}_{B1}R^{z0}\quad ({}_{C}S\ {}_{D1}C\ {}_{A}S)\quad M$

- Contextual Sentence:

$Cn\ \ R_{combat}\ \ Cn\ \ R_{combat}\ \ Cn\ \ R_{combat}\ \ R_{combat}\ \ Cn\ \ M$

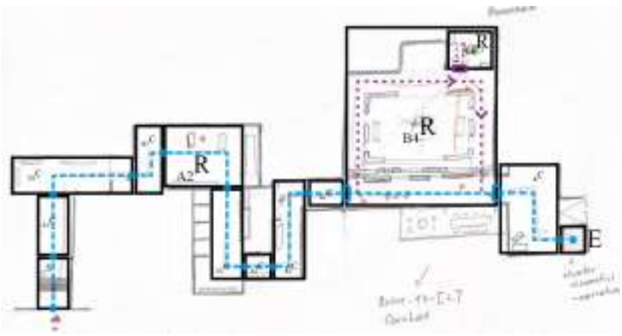


Figure 4.37 : Layout of Max Payne 3 from sequence 6.

- Spatial Sentence:

$({}_{C}S\ {}_{A1}C\ {}_{D1}C\ {}_{B1}C)\quad {}^{t2}{}_{A2}R^{z0}\quad ({}_{D1}C\ {}_{A1}C\ {}_{B1}C\ {}_{A1}C)\quad M\quad {}^{t1}{}_{A4}R^{z0}\quad {}^{t4}{}_{B4}R^{z0,n}\quad {}_{E}C\quad E\quad M$

- Contextual Sentence:

Cn R_{combat} Cn M R_{quest} R_{combat} Cn M

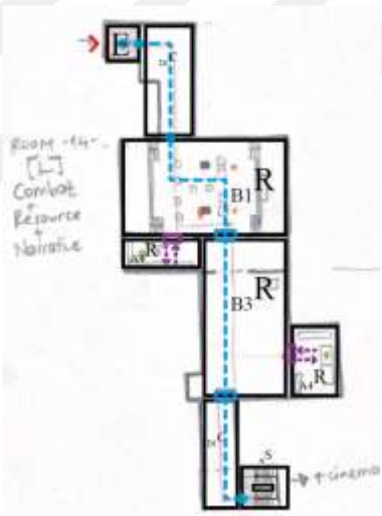


Figure 4.38 : Layout of Max Payne 3 from sequence 7.

- Spatial Sentence:

$E\quad {}_{D1}C\quad {}^{t3}{}_{B1}R^{z0,n}\quad [\ {}^{t1}{}_{A4}R^{z0}\ ]\quad {}^{t2}{}_{B3}R^{z0}\quad [\ {}^{t1}{}_{A4}R^{z0}\ ]\quad ({}_{D1}C\ {}_{A}S)\quad M$

- Contextual Sentence:

Cn R_{combat} [$R_{resource}$] R_{combat} [$R_{resource}$] Cn M

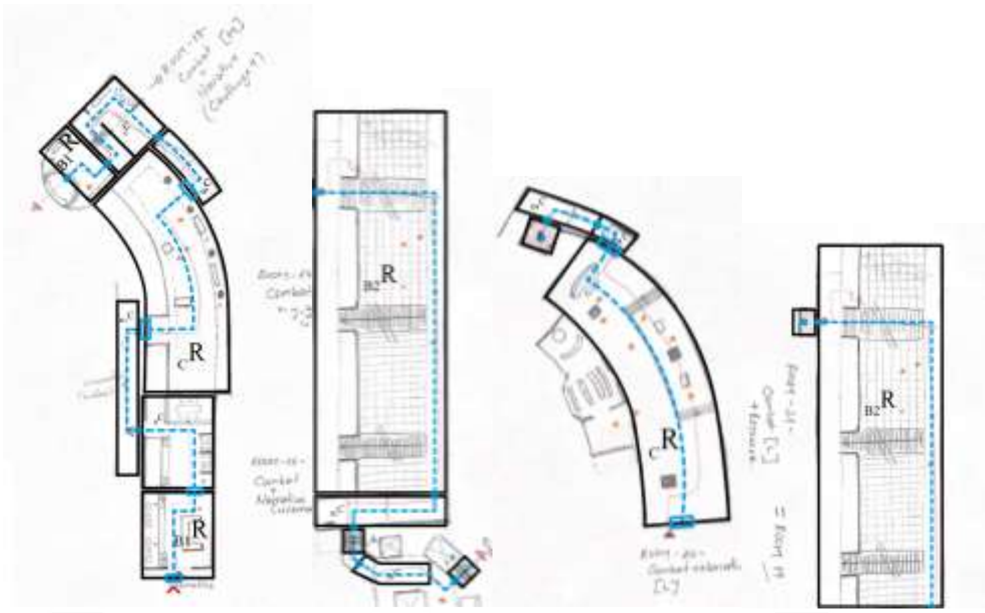


Figure 4.39 : Layout of Max Payne 3 from sequence 8.

- Spatial Sentence:

M ${}^{t2}{}_{B1}R^{z0,n}$ (${}_{E}C$ ${}_{D1}C$) ${}^{t3}{}_{C}R^{z1}$ (${}_{D4}C$ ${}_{C}C$) ${}^{t1}{}_{B1}R^{z0}$ M ${}^{t3}{}_{B2}R^{z0,n}$ (${}_{B1}C$ ${}_{C}S$ ${}_{D1}C$ ${}_{C}S$) ${}^{t3}{}_{C}R^{z0,n}$ (${}_{D4}C$ ${}_{D4}C$) E ${}^{t3}{}_{F}R^{z0,n}$ M

- Contextual Sentence:

M R_{combat} Cn R_{combat} Cn R_{combat} M R_{combat} Cn R_{combat} Cn R_{combat} M

Figure 4.40 : ${}_{C}R$ room in Max Payne 3 sequence 8.

4.3.2 Mass Effect 3

Mass Effect 3, developed by BioWare and published by Electronic Arts, immerses players in an epic sci-fi universe where they take on the role of Commander Shepard, humanity's last hope against the Reapers, ancient machines bent on galactic destruction.

Similar to Max Payne 3, Mass Effect 3 employs a linear level progression (Salmond, 2021), guiding players through interconnected rooms and environments as they solve the mysteries of the galaxy and face the threat of the Reapers.

In the initial two hours of Mass Effect 3 gameplay, four distinct sequences were identified (Figure 4.41, Figure 4.42, Figure 4.43, Figure 4.44, Figure 4.45, Figure 4.46). The opening scene introduces the player character, Shepard, to the controls and game mechanics through an outdoor training session. The game switches to an interior setting inside a facility as Shepard gains combat proficiency. This setting features strategic gameplay elements and linear progression. Sequences are ended with cinematic interludes that provide players with a brief break from keyboard inputs so they can take in the story.

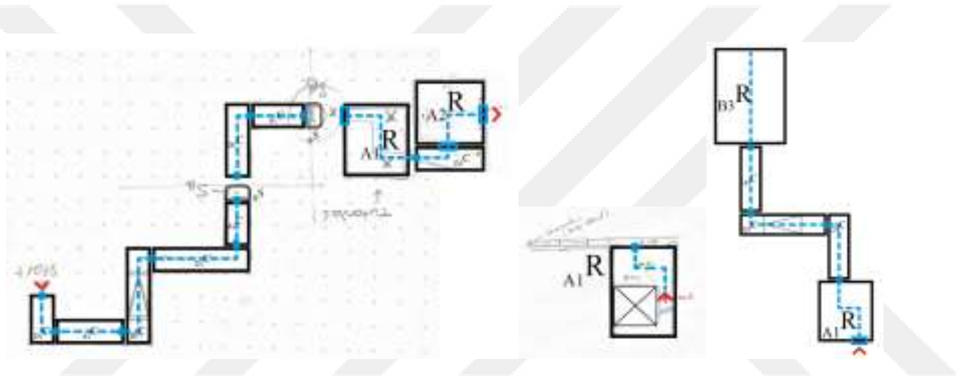


Figure 4.41 : Layout of Mass Effect 3 from sequence 1.

- Spatial Sentence:

$M \;\; ({}_{D1}C\;{}_{A1}C\;{}_{B3}C\;{}_{D1}C\;{}_{A1}C) \;\; {}_{B}S \;\; ({}_{D1}C\;{}_{A1}C) \;\; {}_{B}S \;\; {}^{t1}{}_{A1}R^{z0} \;\; {}_{D1}C \;\; {}^{t1}{}_{A2}R^{z0} \;\; M \;\; {}^{t1}{}_{A1}R^{z0} \;\; M \;\; {}^{t1}{}_{A1}R^{z0} \;\; ({}_{D1}C\;{}_{D3}C\;{}_{A1}C) \;\; {}^{t2}{}_{G}R^{z0} \;\; M$

- Contextual Sentence:

$M \;\; Cn \;\; R_{tutorial} \;\; C \;\; R_{tutorial} \;\; M \;\; R_{tutorial} \;\; M \;\; R_{tutorial} \;\; Cn \;\; R_{combat} \;\; M$

Figure 4.42 : Scene from Mass Effect 3 sequence 1.

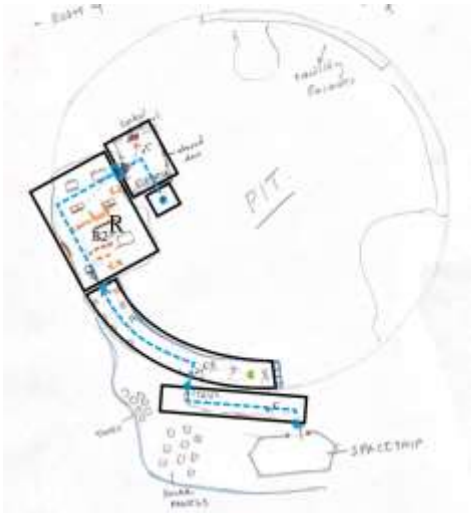


Figure 4.43 : Layout of Mass Effect 3 from sequence 2.

- Spatial Sentence:

$({}_{B1}C\ {}_{D4}C)$ $^{t2}{}_{B2}R^{z0}$ $_{A3}C$ E M

- Contextual Sentence:

Cn R_{combat} Cn M

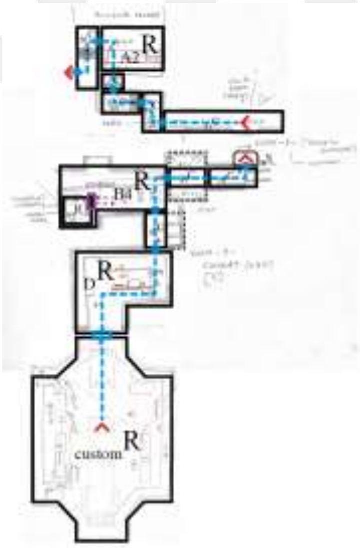


Figure 4.44 : Layout of Mass Effect 3 from sequence 3.1.

- Spatial Sentence:

$^{t3}{}_{CUSTOM}R^{z1}$ $^{t2}{}_{D}R^{z0,n}$ $_{A2}C$ $^{t2}{}_{B4}R^{z0,n}$ [$^{t1}{}_{A4}R^{z0}$] $({}_{A3}C\ {}_{D1}C)$ $_{B}S$ $({}_{A1}C\ {}_{B1}C\ {}_{D2}C\ {}_{D3}C)$ $^{t1}{}_{A2}R^{z0,n}$

- Contextual Sentence:

R_{combat} R_{combat} C $R_{narrative}$ [R_{quest}] Cn $R_{tutorial}$

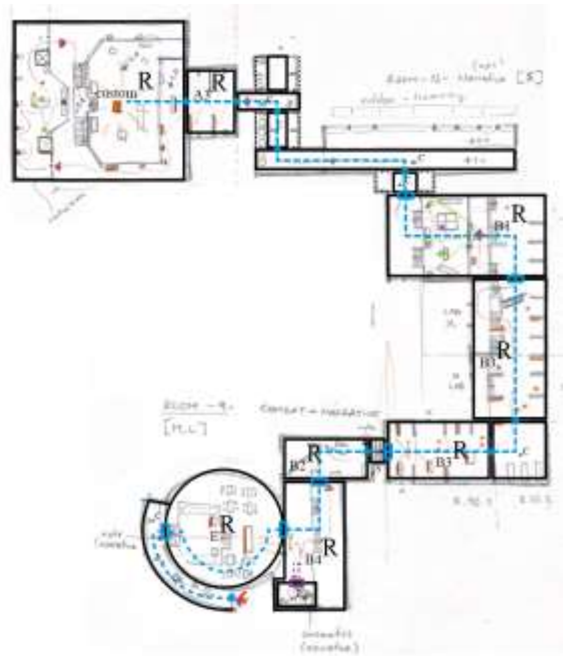


Figure 4.45 : Layout of Mass Effect 3 from sequence 3.2.

- Spatial Sentence:

$({}_{B2}C\ {}_{D4}C)$ ${}^{t3}{}_{E}R^{z0,n}$ ${}^{t1}{}_{A4}R^{z0}$ M ${}^{t2}{}_{B4}R^{z0,n}$ ${}^{t2}{}_{B2}R^{z0,n}$ ${}_{C}S$ ${}^{t2}{}_{B3}R^{z0}$ ${}_{E}C$ ${}^{t2}{}_{B3}R^{z0,n}$ ${}^{t2}{}_{B1}R^{z0,n}$ $({}_{A3}C\ {}_{B1}C\ {}_{A3}C\ {}_{D1}C)$ ${}^{t1}{}_{A3}R^{z0}$ ${}^{t3}{}_{CUSTOM}R^{z1}$ M

- Contextual Sentence:

Cn R_{combat} $R_{narrative}$ $R_{resource}$ C R_{combat} C R_{combat} $R_{resource}$ Cn R_{combat} R_{combat} M

Figure 4.46 : ${}_{B3}R$ room in Mass Effect 3 sequence 3.2.

- Full Contextual Sentence of Sequence 3:

R_{combat} R_{combat} C $R_{narrative}$ $[R_{quest}]$ Cn $R_{tutorial}$ Cn R_{combat} $R_{narrative}$ $R_{resource}$ C R_{combat} C R_{combat} $R_{resource}$ Cn R_{combat} R_{combat} M

4.3.3 Gears of War 4

The Coalition's game Gears of War four sends players into a post-apocalyptic, war-torn world. Players take on the role of members of the COG (Coalition of Ordered Governments), setting out on a mission to save humanity by learning the truth behind the creation of this new threat.

Similar to Max Payne 3 and Mass Effect 3, Gears of War 4 follows a linear level progression (Salmond, 2021) that leads players through rooms and environments that are connected as they move across the maps. The game's pacing and narrative coherence are improved by this spatial organization, which keeps players engaged.

In the first two hours of Gears of War 4 gameplay, five sequences are identified (Figure 4.47, Figure 4.48, Figure 4.49, Figure 4.50, Figure 4.51, Figure 4.52 Figure 4.53, Figure 4.54, Figure 4.55). Sequence 1 begins with outdoor training, allowing players to learn basic mechanics through moderate combat. Sequence 2 features the first boss battle in a different environment and timeline. Sequence 3 shifts to another timeline, revealing past wars through gears' perspectives. In sequence 4, players navigate indoor and outdoor environments within a facility. Sequence 5 takes place indoors, presenting challenging combat missions. These sequences showcase the diverse gameplay elements of Gears of War 4. Cinematics separate the sequences.

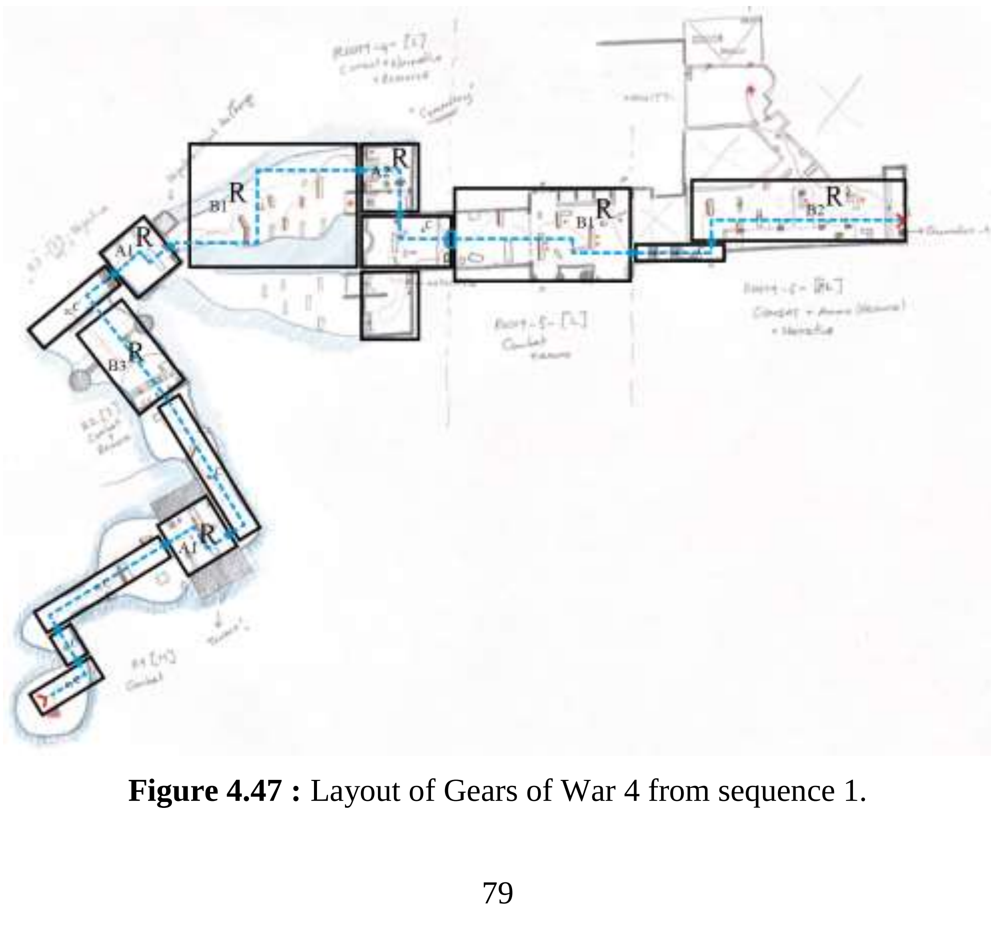


Figure 4.47 : Layout of Gears of War 4 from sequence 1.

- Spatial Sentence:

$({}_{D1}C\ {}_{A1}C\ {}_{D1}C)$ $^{t1}{}_{A1}R^{z0}$ ${}_{D1}C$ $^{t1}{}_{B3}R^{z0,n}$ ${}_{D2}C$ $^{t1}{}_{A1}R^{z0}$ $^{t3}{}_{B1}R^{z0}$ $^{t1}{}_{A2}R^{z0,n}$ ${}_{E}C$ $^{t3}{}_{B1}R^{z0}$ ${}_{D2}C$ $^{t3}{}_{B2}R^{z0,n}$ M

- Contextual Sentence:

Cn $R_{tutorial}$ C $R_{tutorial}$ C $R_{tutorial}$ R_{combat} $R_{tutorial}$ C R_{combat} C R_{combat} M

Figure 4.48 : ${}_{B1}R$ room in Gears of War sequence 1.

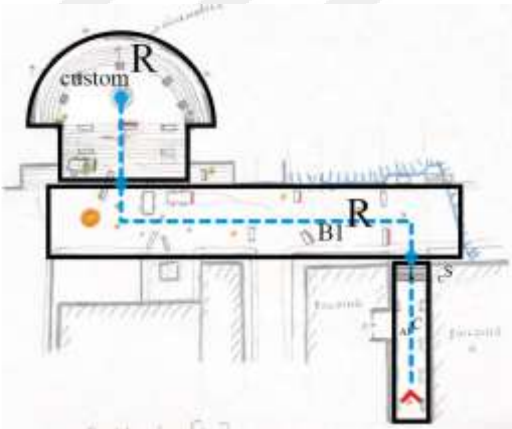


Figure 4.49 : Layout of Gears of War 4 from sequence 2.

- Spatial Sentence:

M ${}_{A1}C$ ${}_{C}S$ $^{t3}{}_{B1}R^{z0}$ $^{t3}{}_{custom}R^{z0,n}$ M

- Contextual Sentence:

M Cn R_{combat} R_{boss} M

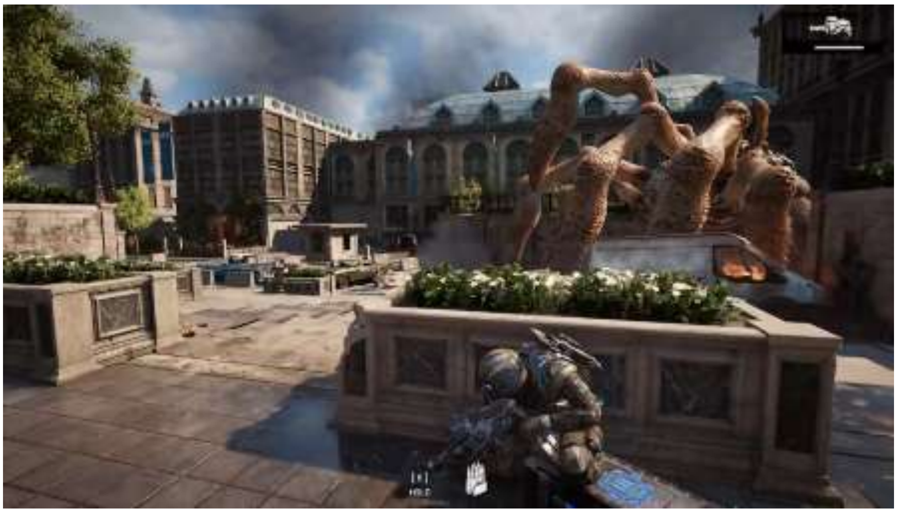


Figure 4.50 : ${}_{CUSTOM}R$ room in Gears of War sequence 2.

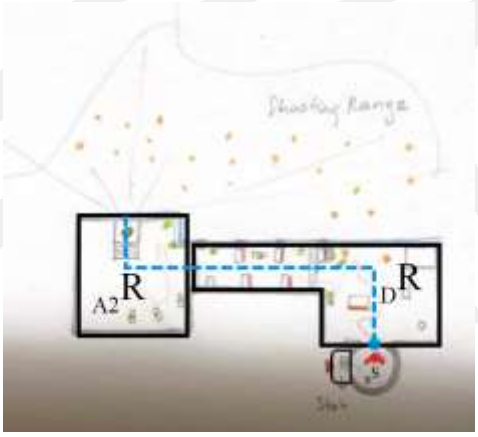


Figure 4.51 : Layout of Gears of War 4 from sequence 3.

- Spatial Sentence:

${}_{B}S \quad {}^{t3}{}_{D}R^{z0,n} \quad {}^{t2}{}_{A2}R^{z0,n} \quad M$

- Contextual Sentence:

$C \quad R_{combat} \quad R_{combat} \quad M$

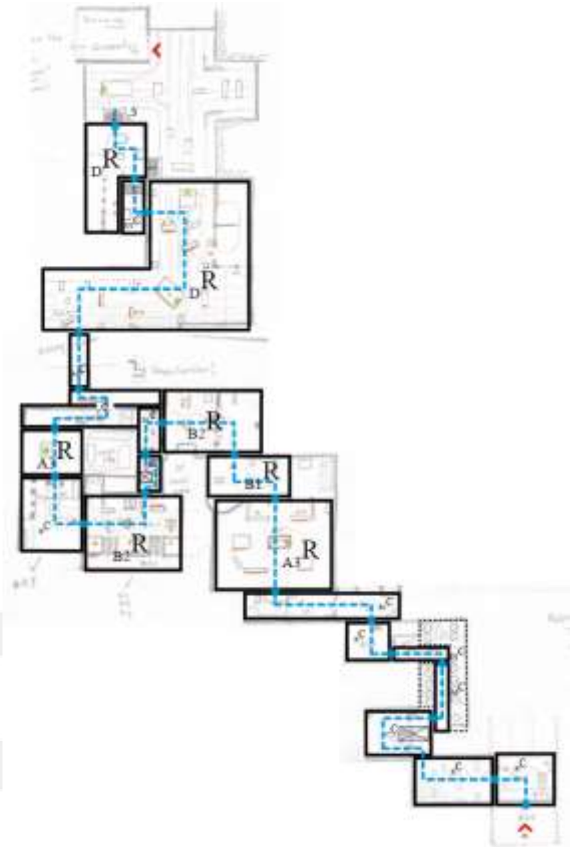


Figure 4.52 : Layout of Gears of War 4 from sequence 4.

- Spatial Sentence:

$M \quad ({}_{E}C\ {}_{E}C\ {}_{C}C\ {}_{A3}C\ {}_{D1}C\ {}_{E}C\ {}_{B1}C) \quad {}^{t2}_{A3}R^{z0} \quad {}^{t1}_{B1}R^{z0} \quad {}^{t2}_{B2}R^{z0} \quad ({}_{D1}C\ {}_{C}C) \quad {}^{t2}_{B2}R^{z0,n} \quad {}_{E}C \quad {}^{t1}_{A3}R^{z0}$
$({}_{C}C\ {}_{A1}C) \quad {}^{t4}_{D}R^{z0,n} \quad {}_{D2}C \quad {}^{t4}_{D}R^{z0} \quad {}_{C}S \quad M$

- Contextual Sentence:

$M\ \ Cn\ \ R_{combat}\ \ R_{narrative}\ \ R_{combat}\ \ Cn\ \ R_{combat}\ \ C\ \ R_{resource}\ \ Cn\ \ R_{combat}\ \ C\ \ R_{narrative}\ \ C\ \ M$

Figure 4.53 : ${}_{D}R$ room in Gears of War sequence 4.

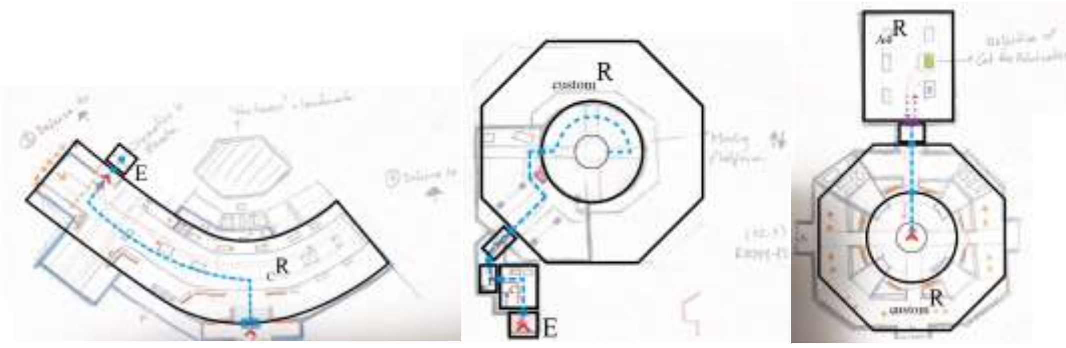


Figure 4.54 : Layout of Gears of War 4 from sequence 5.

- Spatial Sentence:

M ${}^{t3}{}_{C}R^{z0,n}$ E M ($_{E}C$ $_{D1}C$ $_{A1}C$) ${}^{t6}{}_{CUSTOM}R^{z3}$ ${}^{t2}{}_{A4}R^{z0}$ M

- Contextual Sentence:

M R_{combat} C M Cn R_{combat} R_{quest} M

Figure 4.55 : $_{CUSTOM}R$ room in Gears of War sequence 5.

4.3.4 Dead Space

Dead Space is a survival horror video game developed by EA Redwood Shores and published by Electronic Arts. In this sci-fi game set in a futuristic world, players take on the role of engineer Isaac Clarke, who gets stuck on a broken spacecraft home to hideous alien creatures. The game is well known for its sound design, atmospheric tension, and survival-based gameplay mechanics that revolve around enemies. During the game, players must navigate dangerous environments as they piece together a terrifying story.

The level progression in Dead Space departs from the linear design found in games such as Mass Effect 3 and Max Payne 3. Instead of a linear path, the progression follows a hub-and-spoke layout (Salmond, 2021), where players unlock interconnected rooms upon completing missions. This non-linear progression introduces a sense of exploration and backtracking as players navigate through the corridors and rooms of the spacecraft, unlocking new areas and uncovering the mysteries of the game world. In Dead Space, the 2 hours of gameplay takes place in four distinct sequences (Figure 4.56, Figure 4.57, Figure 4.58, Figure 4.59, Figure 4.60, Figure 4.61, Figure 4.62) each set within the spacecraft. Connection structures such as elevators serve as primary markers for sequences, indicating when a user enters a new floor or level of the spacecraft. Players utilize these connections not only to progress further into the game but also to revisit previously cleared areas for new missions and objectives.

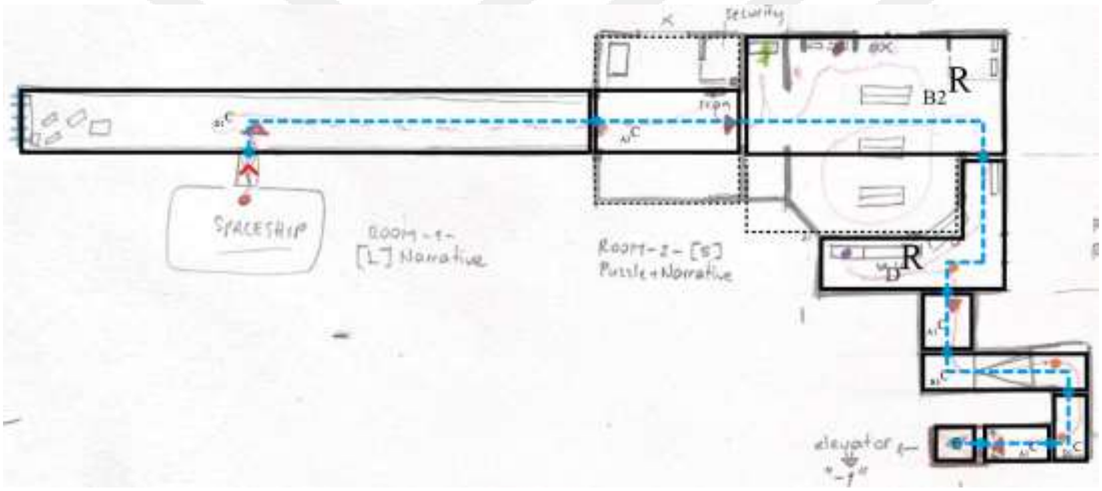


Figure 4.56 : Layout of Dead Space from sequence 1.

- Spatial Sentence:

M ($_{D1}C$ $_{A3}C$) $^{t1}{}_{B2}R^{z0}$ $^{t2}{}_{D}R^{z0}$ ($_{A1}C$ $_{B3}C$ $_{D1}C$ $_{A1}C$) E

- Contextual Sentence:

M Cn $R_{tutorial}$ $R_{tutorial}$ Cn

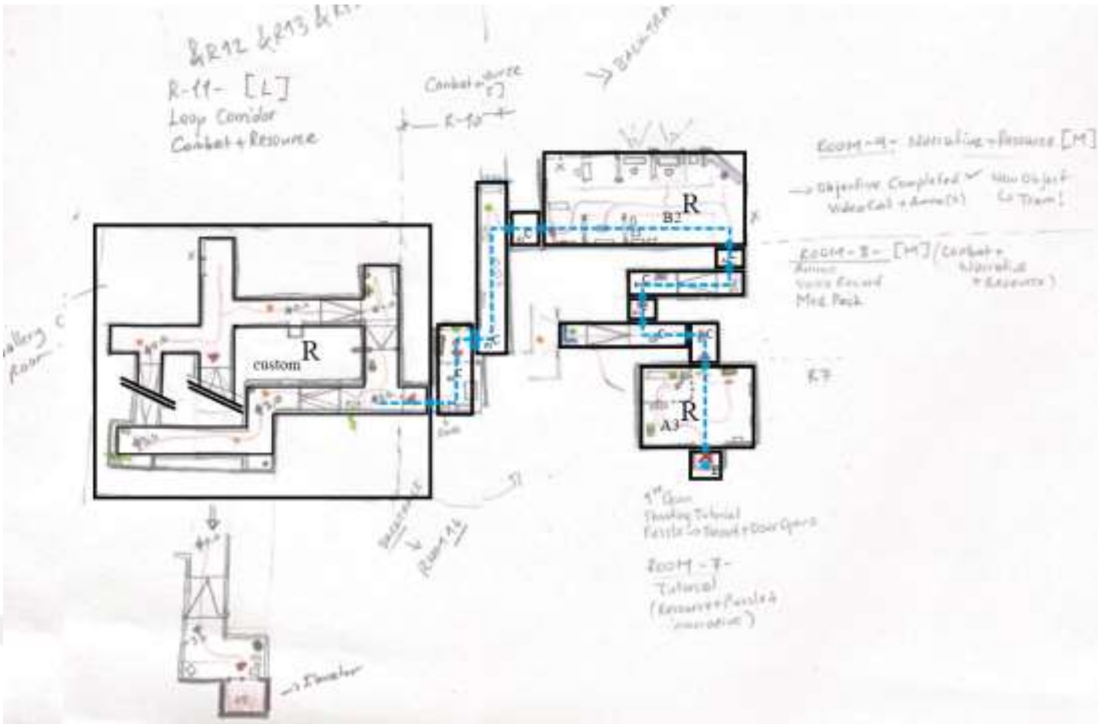


Figure 4.57 : Layout of Dead Space from sequence 2.

- Spatial Sentence:

${}^{t1}_{A3}R^{z0}$ $({}_{D1}C\ {}_{D3}C\ {}_{A1}C\ {}_{B3}C\ {}_{A1}C)$ ${}^{t2}_{B2}R^{z0}$ $({}_{A1}C\ {}_{B1}C\ {}_{B1}C)$ ${}^{t8}_{custom}R^{z4}$ E

- Contextual Sentence:

$R_{resource}$ Cn $R_{resource}$ Cn R_{combat} C

Figure 4.58 : $_{CUSTOM}R$ room in Dead Space from sequence 2.

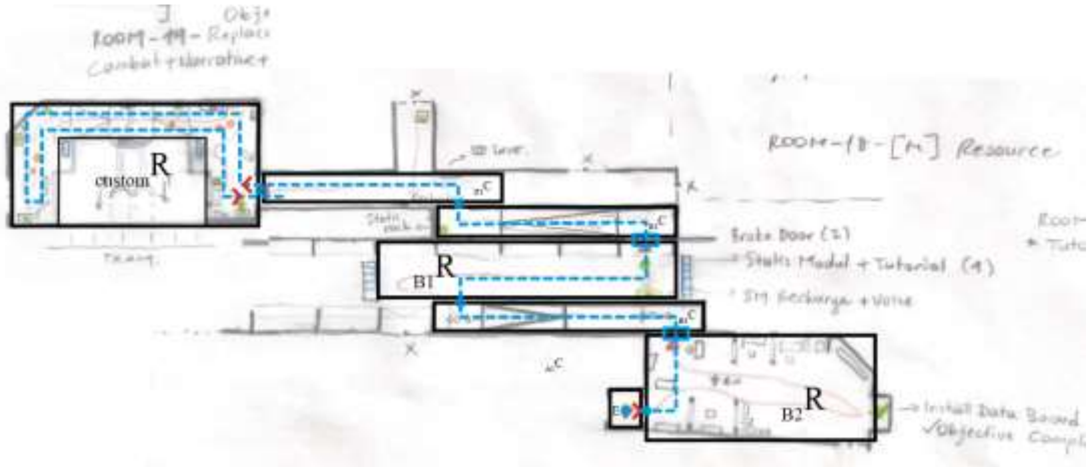


Figure 4.59 : Layout of Dead Space from sequence 3.

- Spatial Sentence:

$^{t2}{}_{B2}R^{z0}$ $_{D3}C$ $^{t2}{}_{B1}R^{z0}$ ($_{B3}C$ $_{D1}C$) $^{t3}{}_{custom}R^{z1}$

- Contextual Sentence:

R_{quest} C $R_{tutorial}$ Cn R_{combat}

Figure 4.60 : $_{B2}R$ room in Dead Space from sequence 3.

At sequence 4, player trace backwards to the spaceship following the Sequence 2, Sequence 1 backward order with different missions & directions.

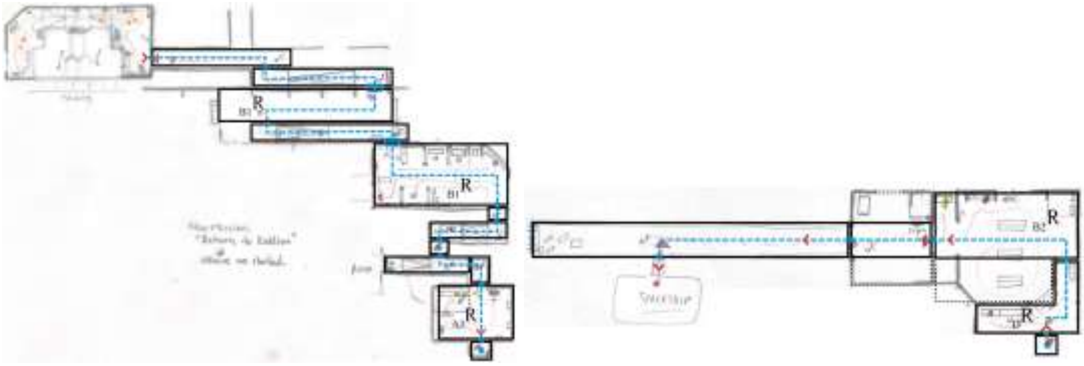


Figure 4.61 : Layout of Dead Space from sequence 4.

- Spatial Sentence:

$({}_{D1}C\ {}_{D3}C)\quad {}^{t2}{}_{B1}R^{z0,n}\quad {}_{D3}C\quad {}^{t2}{}_{B1}R^{z0}\quad ({}_{D2}C\ {}_{A1}C\ {}_{B1}C)\quad {}^{t2}{}_{A3}R^{z0}\quad E\quad {}^{t1}{}_{D}R^{z0}\quad {}^{t1}{}_{B2}R^{z0}\quad {}_{D1}C\quad M$

- Contextual Sentence:

Cn R_{combat} C R_{quest} Cn R_{combat} C $R_{narrative}$ $R_{narrative}$ C M

Figure 4.62 : ${}_{B1}R$ room in Dead Space from sequence 3.

4.3.5 Control

Control, developed by Remedy Entertainment, presents a unique narrative experience set within the Federal Bureau of Control (FBC). Players take on the role of Jesse Faden and explore the Oldest House, coming across paranormal activity and learning the secrets of the Bureau's workings.

Similar to Dead Space, Control features a hub-and-spoke level structure (Salmond, 2021). Players unlock new areas as they progress through the game, occasionally revisiting previous locations to complete additional missions or uncover secrets. This dynamic level design encourages exploration and rewards players for thoroughness.

During a two-hour gameplay session of Control, five distinct sequences (Figure 4.63, Figure 4.64, Figure 4.65, Figure 4.66, Figure 4.67, Figure 4.68, Figure 4.69, Figure 4.70, Figure 4.71, Figure 4.72, Figure 4.73) were identified. Each sequence is marked out by cinematic interludes, maintaining continuity within the timeline and setting, that predominantly takes place within the mysterious Bureau. This consistent setting provides a cohesive backdrop for the narrative and gameplay progression in Control.

Figure 4.63 : Layout of Control from sequence 1.1 (left) and sequence 1.2 (right).

- Spatial Sentence:

$^{t1}{}_{B2}R^{z0}$ $({}_{A2}C\ {}_{A}S)$ $({}_{A1}C\ {}_{B1}C)$ $[\ ^{t1}{}_{A4}R^{z0}\ ]$ $(\ {}_{A1}C\ {}_{D1}C)$ $^{t2}{}_{A5}R^{z0}$ $[\ ^{t1}{}_{A4}R^{z0}\ ]$ $[\ ^{t1}{}_{A4}R^{z0}\ ]$ $[\ ^{t1}{}_{A4}R^{z0}\ ]$ ${}_{D1}C$ E

- Contextual Sentence:

$R_{narrative}$ Cn Cn $[R_{resource}]$ $R_{narrative}$ $[R_{narrative}]$ $[R_{narrative}]$ $[R_{narrative}]$ Cn

Figure 4.64 : ${}_{D1}C$ connection in Control from sequence 1.2.

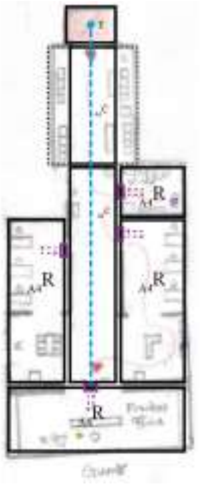


Figure 4.65 : Layout of Control from sequence 1.3.

- Spatial Sentence:

$({}_{A3}C\ {}_{A1}C)$ $[\ {}^{t1}{}_{A4}R^{z0}\ ]$ $[\ {}^{t1}{}_{A4}R^{z0}\ ]$ $[\ {}^{t1}{}_{A4}R^{z0}\ ]$ ${}^{t1}{}_{A4}R^{z0}$ M

- Contextual Sentence:

Cn $[R_{resource}]$ $[R_{resource}]$ $[R_{resource}]$ $R_{resource}$ M

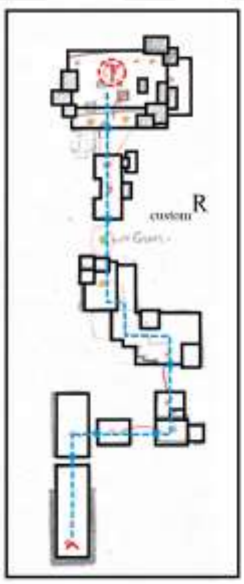


Figure 4.66 : Layout of Control from sequence 2.

- Spatial Sentence:

${}^{t4}{}_{custom}R^{z1}$ + M

- Contextual Sentence:

$R_{tutorial}$ + M

Figure 4.67 : $_{CUSTOM}R$ space in Control from sequence 2.

Figure 4.68 : Layout of Control from sequence 3.

- Spatial Sentence:

${}^{t2}{}_{B3}R^{z0}$ $({}_{E}C\ {}_{A1}C\ {}_{E}C)$ ${}^{t2}{}_{A5}R^{z0}$ [${}^{t1}{}_{A4}R^{z0}$] ${}^{t3}{}_{B2}R^{z0}$ [${}^{t1}{}_{A4}R^{z0}$] ${}_{A1}C$ [${}^{t1}{}_{A4}R^{z0}$] [${}^{t1}{}_{A4}R^{z0}$] ${}^{t3}{}_{custom}R^{z0,n}$ M

- Contextual Sentence:

R_{combat} Cn R_{combat} [$R_{resource}$] R_{combat} [R_{quest}] C [$R_{resource}$] [$R_{resource}$] R_{combat} M

Figure 4.69 : $_{B2}R$ room in Control from sequence 3.

Figure 4.70 : Layout of Control from sequence 4.

- Spatial Sentence:

$({}_{C}S\ {}_{C}C\ {}_{B1}C\ {}_{A1}C\ {}_{A}S)\quad {}^{t3}{}_{B2}R^{z1}\quad {}_{A1}C\quad {}^{t3}{}_{custom}R^{z1}$

- Contextual Sentence:

Cn $\quad R_{combat}\quad C\quad R_{combat}$

Figure 4.71 : ${}_{\text{CUSTOM}}R$ room in Control from sequence 4.

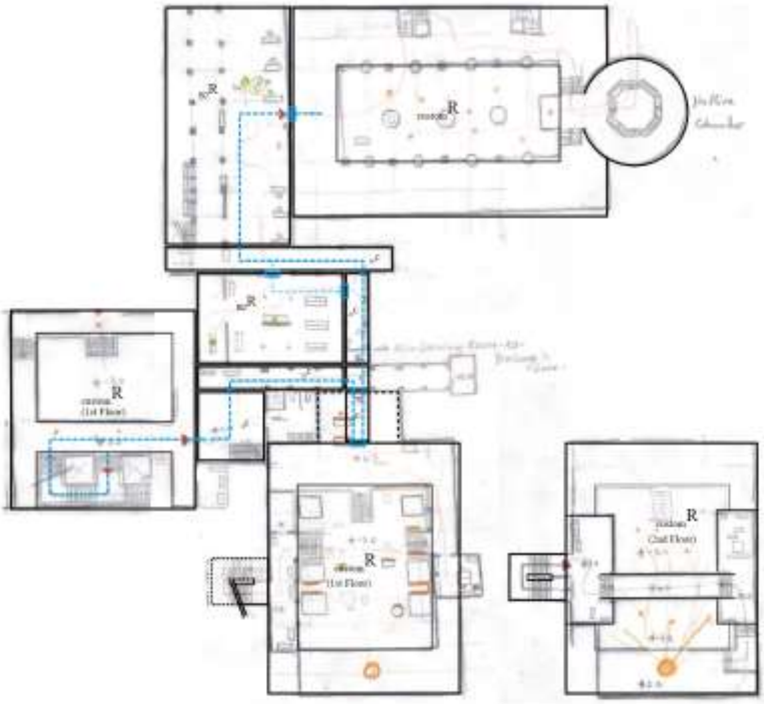


Figure 4.72 : Layout of Control from sequence 5.

- Spatial Sentence:

$({}_{E}C\ {}_{D1}C\ {}_{E}C\ {}_{A3}C)$ $^{t6}{}_{custom}R^{z2}$ $({}_{A3}C\ {}_{A1}C\ {}_{B1}C)$ $[\ ^{t1}{}_{B2}R^{z0}\ ]$ $^{t1}{}_{B2}R^{z0}$ $^{t8}{}_{custom}R^{z2}$ M

- Contextual Sentence:

Cn R_{combat} Cn $[R_{resource}]$ $R_{resource}$ R_{boss} M

Figure 4.73 : CUSTOMR room in Control from sequence 5.

4.3.6 Tom Clancy's Splinter Cell Conviction

In the stealth-action video game Tom Clancy's Splinter Cell Conviction, players take on the role of Sam Fisher, a highly qualified agent working on secret missions. The story of the game takes place in a variety of settings, requiring players to advance through sabotage and stealth. Strategic decision-making and storytelling are prioritized throughout the gameplay.

In terms of gameplay analysis, Tom Clancy's Splinter Cell is divided into three separate sequences (Figure 4.74, Figure 4.75, Figure 4.76, Figure 4.77, Figure 4.78) the last two of which take place in the same location. The opening scene takes place in an outdoor training area and acts as a tutorial for players to become comfortable with the fundamentals. Later scenes take place in a single structure that provides plenty of room for exploration, much like the one seen in Control.

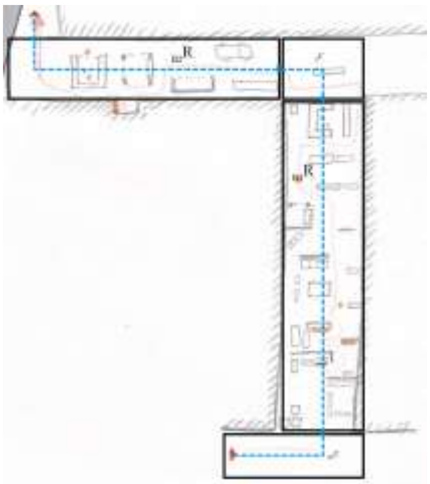


Figure 4.74 : Layout of Tom Clancy from sequence 1.

- Spatial Sentence:

${}_{D1}C$ ${}^{t2}{}_{B3}R^{z0}$ ${}_{E}C$ ${}^{t2}{}_{B2}R^{z0}$ M

- Contextual Sentence:

C $R_{tutorial}$ C $R_{tutorial}$ M

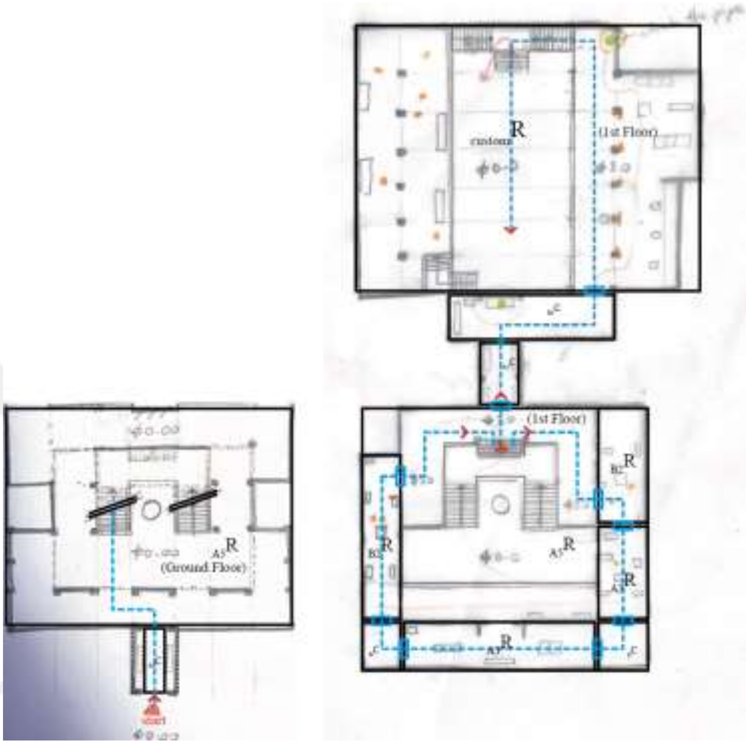


Figure 4.75 : Layout of Tom Clancy from sequence 2.

- Spatial Sentence:

${}_{A3}C$ ${}^{t2}{}_{A5}R^{z1}$ ${}^{t2}{}_{B2}R^{z0}$ ${}^{t2}{}_{A3}R^{z0}$ ${}_{E}C$ ${}^{t2}{}_{A3}R^{z0}$ ${}_{E}C$ ${}^{t2}{}_{B2}R^{z0}$ $({}_{A1}C\ {}_{B1}C)$ ${}^{t4}{}_{custom}R^{z1}$ | ${}_{A3}C$ ${}^{t2}{}_{A5}R^{z1}$ $({}_{A1}C\ {}_{B1}C)$ ${}^{t4}{}_{custom}R^{z1}$

- Contextual Sentence:

C $R_{narrative}$ R_{combat} R_{combat} C R_{combat} C R_{combat} Cn R_{combat} | C $R_{narrative}$ Cn R_{combat}

Figure 4.76 : ${}_{CUSTOM}R$ room in Tom Clancy from sequence 2.

Figure 4.77 : Layout of Tom Clancy from sequence 3.

- Spatial Sentence:

$({}_{D1}C\ {}_{A}S\ {}_{D2}C)$ $^{t2}{}_{B3}R^{z0}$ $({}_{A3}C\ {}_{C}S\ {}_{D1}C\ {}_{D2}C)$ M

- Contextual Sentence:

Cn R_{combat} Cn M

Figure 4.78 : B3R room in Tom Clancy from sequence 3.

4.4 Syntax Patterns

In this section, we aim to explore the spatial progression in games through syntactical structures, focusing on how game levels are designed and interconnected. Previously, we decoded the types of rooms and connections in the analyzed games individually. Now, we will explore the repetitive patterns observed in the syntactical expressions of gameplay progression.

4.4.1 Level progression structures

The analyzed games exhibit two primary types of level progression: linear and hub-and-spoke (Salmond, 2021). A linear progression involves players moving through a series of rooms or environments in a predetermined order, usually with no opportunity to backtrace once a room is cleared. This linear progression is observed in the Max Payne 3, Mass Effect 3, and Gears of War 4. In contrast, hub-and-spoke level progression involves a more non-linear approach, where players unlock interconnected rooms or areas as they progress through the game. This makes it possible to go further on missions or objectives and backtracing to previously visited areas for more exploration. This hub-and-spoke level progression is observed in Dead Space, Control, and Tom Clancy's Splinter Cell Conviction. The way these progression types differ affects how the game environments are connected and arranged spatially, which affects how players experience the game as a whole.

4.4.2 Sub-genre influence

The analyzed games' level structures and design choices are shaped by the sub-genres in which they are established. For instance, in action-oriented games like Gears of War 4 and Max Payne 3, the emphasis on intense combat encounters and set-piece moments often results in more linear progression paths and controlled environments in the level designs. On the other hand, level structures in horror-themed games like Dead Space are designed to evoke feelings of tension and suspense, with narrow corridors and claustrophobic spaces that increase the player's sense of danger. Similarly, games with a stealth element, such as Tom Clancy's Splinter Cell Conviction, use complex level designs with multiple routes and hidden spots to encourage stealht mechanic and strategic thinking. These variations in sub-genres not only shape the spatial organization of the game environments but also contribute to the overall tone and atmosphere of the gameplay experience.

4.4.3 Syntactical expression of rooms

In section 4.1, we have visually analyzed the common room types observed in the selected games (Figure 4.1). In this section, we will briefly give the syntactical expressions of those room types.

In the analyzed games, rooms are classified into distinct types based on their content attributes, facilitating an understanding of gameplay progression and narrative development. These room types include tutorial, puzzle, resource, combat, narrative, and quest rooms, each serving a specific function within the game environment.

$$R ::= R_{tutorial} \mid R_{combat} \mid R_{resource} \mid R_{narrative} \mid R_{quest} \mid R_{puzzle} \tag{4.2}$$

This categorization is represented syntactically, with a combination of symbols identifying a set of attributes that define each type of room. For example, the tutorial rooms syntactical expression ($R_{tutorial}$) includes a number of configurations, including Room type A2 with flat floor level and low challenge (${}^{t1}{}_{A2}R^{z0}$) , which each denote room challenges, spatial layouts, and spatial characteristics.

$$R_{tutorial} ::= {}_{A1}R \mid {}^{t1}{}_{A2}R^{z0} \mid {}^{t1}{}_{A2}R^{z0,n} \mid {}^{t2}{}_{B3}R^{z0} \tag{4.2}$$

Additionally, we constructed more generalized sentences from part to whole that cover broader categories of spatial layouts by zooming out from the particular tutorial room configurations. By zooming out from details, we aim to enriched the representation of tutorial room content, allowing designers to specify desired difficulty levels and spatial volumes. This abstraction creates a more flexible framework for analyzing and interpreting tutorial segments, accommodating variations in gameplay mechanics and narrative pacing across different games.

- Simplification 1:

$$R_{tutorial} ::= {}_{A1}R \mid {}_{A2}R \mid {}_{B3}R \tag{4.3}$$

- Simplification 2:

$$R_{tutorial} ::= {}_{A}R \mid {}_{B}R \tag{4.4}$$

Tutorial Rooms ($R_{tutorial}$): Tutorial rooms are designed to introduce players to the game's mechanics and controls. These rooms feature various configurations, such as Room A1 or Room A2 with t1 difficulty and a flat layout (z0) or with platforms (z0,n). Additionally, they can include Room B3 with t2 difficulty. The tutorial rooms can be more broadly classified as A1R, A2R, and B3R, or even more broadly as AR and BR. This gives designers more freedom to create a variety of introductory experiences while keeping the level of challenge and spatial design constant.

$$R_{tutorial} ::= {}_{A1}R \mid {}^{t1}_{A2}R^{z0} \mid {}^{t1}_{A2}R^{z0,n} \mid {}^{t2}_{B3}R^{z0} \tag{4.5}$$

$$R_{tutorial} ::= {}_{A1}R \mid {}_{A2}R \mid {}_{B3}R \tag{4.6}$$

$$R_{tutorial} ::= {}_{A}R \mid {}_{B}R \tag{4.7}$$

Combat Rooms (R_{combat}): These rooms are designed for engaging in combat encounters, featuring various configurations such as Room A, Room B, Room C, and Room D. The difficulty levels may range from t1 to t3, with different spatial layouts indicated by z0 (flat) or z0,n (with platforms). Additionally, custom combat rooms can be tailored to specific gameplay requirements and challenges such as t8.

$$R_{combat} ::= {}_{B1}R \mid {}_{C}R \mid {}_{D}R \mid {}^{t2}_{A2}R^{z0} \mid {}^{t2}_{A2}R^{z0,n} \mid {}^{t2}_{B2}R^{z0} \mid {}^{t3}_{B2}R^{z0,n} \mid {}_{B3}R \mid {}^{t1}_{A3}R^{z0} \mid {}^{t2}_{A3}R^{z0} \mid {}_{custom}R \quad (4.8)$$

$$R_{combat} ::= {}_{B1}R \mid {}_{C}R \mid {}_{D}R \mid {}_{A2}R \mid {}_{A3}R \mid {}_{B2}R \mid {}_{B3}R \mid {}_{custom}R \quad (4.9)$$

$$R_{combat} ::= {}_{A}R \mid {}_{B}R \mid {}_{C}R \mid {}_{D}R \mid {}_{custom}R \quad (4.10)$$

Resource Rooms ($R_{resource}$): Resource rooms are designated areas where players can acquire items, ammunition, or other resources to aid them. They may feature different layouts such as Room A2, Room A3, or Room A4, with difficulty levels ranging from t1 to t2. These rooms may be situated at different vertical layers (z0 or z0,n) and can also be customized as needed.

$$R_{resource} ::= {}^{t1}_{A2}R^{z0} \mid {}^{t2}_{B2}R^{z0} \mid {}^{t1}_{A3}R^{z0} \mid {}^{t1}_{A4}R^{z0} \mid {}^{t2}_{B2}R^{z0,n} \mid {}_{custom}R \quad (4.11)$$

$$R_{resource} ::= {}_{A2}R \mid {}_{A3}R \mid {}_{A4}R \mid {}_{B2}R \mid {}_{custom}R \quad (4.12)$$

$$R_{resource} ::= {}_{A}R \mid {}_{B}R \mid {}_{custom}R \quad (4.13)$$

Narrative Rooms ($R_{narrative}$): The purpose of narrative rooms is to progress the game's plot and draw players into the virtual world. These rooms, which have layouts like Room B2 or Room B4, may contain crucial plot points or explanation. Narrative rooms can be customized to match the tempo and tone of the game's story, and difficulty levels range accordingly.

$$R_{narrative} ::= {}^{t1}_{B2}R^{z0} \mid {}^{t2}_{B2}R^{z0} \mid {}^{t2}_{B4}R^{z0,n} \mid {}^{t1}_{B1}R^{z0} \mid {}^{t2}_{A5}R^{z0} \mid {}_{custom}R \quad (4.14)$$

$$R_{narrative} ::= {}_{A5}R \mid {}_{B1}R \mid {}_{B2}R \mid {}_{B4}R \mid {}_{custom}R \quad (4.15)$$

$$R_{narrative} ::= {}_{A}R \mid {}_{B}R \mid {}_{custom}R \quad (4.16)$$

Quest Rooms (R_{quest}): Quest rooms are designated spaces where players complete tasks or goals that are essential to the game's development. These rooms are usually associated with lower difficulty levels (t1 or t2) and observed only as a layout of Room A4.

$$R_{quest} ::= {}^{t2}{}_{A4}R^{z0} \mid {}^{t1}{}_{A4}R^{z0} \tag{4.17}$$

$$R_{quest} ::= {}_{A4}R \tag{4.18}$$

$$R_{quest} ::= {}_{A}R \tag{4.19}$$

Puzzle Rooms (R_{puzzle}): Puzzle rooms are made to test players by presenting them with a variety of riddles, puzzles, and obstacles that they must solve in order to move forward. These rooms might have been tailored to fit the puzzle, there is no common room type observed. In the analyzed third-person shooter games, puzzle rooms are the least observed room types when compared to the other room contents.

$$R_{puzzle} ::= {}_{custom}R \tag{4.20}$$

$$R_{puzzle} ::= {}_{custom}R \tag{4.21}$$

Room A (${}_{A}R$) encompasses various configurations and difficulty levels. These rooms can range from simpler layouts like Room A1 with t1 difficulty and flat layout (z0) to more complex structures such as Room A5 with t3 difficulty. The general representation simplifies these to ${}_{A1}R$, ${}_{A2}R$, ${}_{A3}R$, ${}_{A4}R$, and ${}_{A5}R$, providing a range of challenges and spatial layouts under the Room A category.

$$\begin{gathered} {}_{A}R ::= {}^{t1}{}_{A1}R^{z0} \mid {}^{t1}{}_{A2}R^{z0} \mid {}^{t1}{}_{A2}R^{z0,n} \mid {}^{t2}{}_{A2}R^{z0} \mid {}^{t2}{}_{A2}R^{z0,n} \mid {}^{t1}{}_{A3}R^{z0} \mid {}^{t2}{}_{A3}R^{z0} \mid \\ {}^{t1}{}_{A4}R^{z0} \mid {}^{t2}{}_{A4}R^{z0} \mid {}^{t2}{}_{A5}R^{z0} \mid {}^{t3}{}_{A5}R^{z0} \end{gathered} \tag{4.22}$$

$$ {}_{A}R ::= {}_{A1}R \mid {}_{A2}R \mid {}_{A3}R \mid {}_{A4}R \mid {}_{A5}R \tag{4.23}$$

Room B (${}_{B}R$) features a variety of configurations, often involving moderate to high difficulty levels, covering simpler rooms like ${}_{B1}R$ and more complex ones such as ${}_{B4}R$. The general representation includes ${}_{B1}R$, ${}_{B2}R$, ${}_{B3}R$, and ${}_{B4}R$, allowing designers to create diverse navigation in Room B experiences.

$$\begin{gathered} {}_{B}R ::= {}^{t2}{}_{B1}R^{z0} \mid {}^{t2}{}_{B1}R^{z0,n} \mid {}^{t1}{}_{B1}R^{z0} \mid {}^{t1}{}_{B2}R^{z0} \mid {}^{t1}{}_{B2}R^{z0,n} \mid {}^{t2}{}_{B2}R^{z0} \mid {}^{t3}{}_{B2}R^{z0,n} \mid \\ {}^{t2}{}_{B3}R^{z0} \mid {}^{t2}{}_{B3}R^{z0,n} \mid {}^{t2}{}_{B4}R^{z0,n} \mid {}^{t3}{}_{B4}R^{z0} \mid {}^{t3}{}_{B4}R^{z0,n} \end{gathered} \tag{4.24}$$

$$ {}_{B}R ::= {}_{B1}R \mid {}_{B2}R \mid {}_{B3}R \mid {}_{B4}R \tag{4.25}$$

Room C ($_{C}$R) is typically associated with high difficulty levels and complex layouts. Examples only include ${}^{t3}{}_{C}R^{z1}$ (Room C with t3 difficulty and a raised layout) and ${}^{t3}{}_{C}R^{z0,n}$ (Room C with t3 difficulty and platforms). The simplified representation of Room C is denoted as CR.

$$_{C}R ::= {}^{t3}{}_{C}R^{z1} \mid {}^{t3}{}_{C}R^{z0,n} \tag{4.26}$$

$$_{C}R ::= {}_{C}R \tag{4.27}$$

Room D ($_{D}$R) consists of configurations with varying levels of complexity and difficulty. The general notation for Room D is $_{D}$R, covering the different variations within this category.

$$_{D}R ::= {}^{t2}{}_{D}R^{z0} \mid {}^{t2}{}_{D}R^{z0,n} \mid {}^{t3}{}_{D}R^{z0,n} \tag{4.28}$$

$$_{D}R ::= {}_{D}R \tag{4.29}$$

Room E ($_{E}$R) is generally associated with the highest difficulty levels and intricate layouts. An example is ${}^{t3}{}_{E}R^{z0,n}$ (Room E with t3 difficulty and platforms). The simplified representation for Room E is $_{E}$R.

$$_{E}R ::= {}^{t3}{}_{E}R^{z0,n} \tag{4.30}$$

$$_{E}R ::= {}_{E}R \tag{4.31}$$

4.4.4 Syntactical expression of connections

Connections within the analyzed games are crucial for understanding spatial navigation and progression. They include both vertical connections, such as stairs (S) and elevators (E), and horizontal connections, such as corridors. The syntactical structure for connections is defined as follows:

$$C ::= {}_{A}C \mid {}_{B}C \mid {}_{C}C \mid {}_{D}C \mid {}_{E}C \mid S \mid E \tag{4.32}$$

This notation indicates that connections can be of type A, B, C, D, or E, in addition to stairs or elevators. Stairs are further categorized into four distinct types, represented as below, where each type (A, B, C, D) denotes different variations observed in the games.

$$S ::= {}_{A}S \mid {}_{B}S \mid {}_{C}S \mid {}_{D}S \qquad (4.33)$$

Complex connections, which involve the union of at least two connection types, are denoted as Cn. This structure implies that complex connections can be recursive (CnC), involve a connection followed by a complex connection (CCn), or consist of two connections forming a complex connection (CC).

$$Cn ::= CnC \mid CCn \mid CC \qquad (4.34)$$

This framework for connections allows for a detailed understanding of how players navigate between the game environment, providing insights into level design and navigation.

4.4.5 Analysis of gameplay sequences

Complex connections (Cn) are a critical element in the spatial design of game levels. They frequently occur between high difficulty combat rooms, creating intricate navigational paths that enhance the gameplay experience by adding layers of complexity and challenge. These connections are designed to give players a rest between encounters. Besides, from the technical perspective placing long and intricate connections between rooms is a performance-friendly method which decreases rendering time and load.

In Max Payne 3 sequence 4, players navigate through a number of high challenged combat rooms linked with complex connections during this sequence, which ends with a cinematic. This pattern keeps players engaged and challenged by establishing a rhythm of rest and action.

- Spatial Sentence:

$({}_{D4}C\ {}_{D4}C\ {}_{C}S)\quad {}^{t3}{}_{B1}R^{z0,n}\quad ({}_{A2}C\ {}_{D1}C)\quad {}^{t2}{}_{A2}R^{z0}\quad {}_{D1}C\quad {}^{t3}{}_{E}R^{z0,n}\quad {}_{E}C\quad M$

- Contextual Sentence:

$Cn\quad R_{combat}\quad Cn\quad R_{combat}\quad C\quad R_{combat}\quad C\quad M$

Cinematics (M) are transitional elements that connect gameplay sections, they either starts or ends gameplay sequences. They frequently come after combat sequences or complex connections. These cutscenes give players a little break from the action-packed gameplay while also advancing the story and providing context. Cinematics are frequently inserted after fight scenes to keep the pacing balanced and give players a chance to reflect on the narrative and get ready for new challenges.

Mass Effect 3, sequence 1, is an example of how cinematics are interspersed with tutorial and combat rooms, ensuring that narrative elements are integrated seamlessly with gameplay.

- Spatial Sentence:

$M \ ({}_{D1}C\ {}_{A1}C\ {}_{B3}C\ {}_{D1}C\ {}_{A1}C) \ {}_{B}S \ ({}_{D1}C\ {}_{A1}C) \ {}_{B}S \ {}^{t1}{}_{A1}R^{z0} \ {}_{D1}C \ {}^{t1}{}_{A2}R^{z0} \ M \ {}^{t1}{}_{A1}R^{z0} \ M \ {}^{t1}{}_{A1}R^{z0} \ ({}_{D1}C\ {}_{D3}C\ {}_{A1}C) \ {}^{t2}{}_{G}R^{z0} \ M$

- Contextual Sentence:

M Cn $R_{tutorial}$ C $R_{tutorial}$ **M** $R_{tutorial}$ **M** $R_{tutorial}$ Cn R_{combat} **M**

Resource rooms ($R_{resource}$) are essential for player progression, providing items, ammunition, and other resources necessary for survival. These rooms are typically placed after sequences of combat, offering a reward for overcoming challenges and preparing players for future encounters. They are often connected by both simple corridors (C) and complex connections (Cn), allowing for varied navigational experiences. In Dead Space, resource rooms follow intense combat sequences, giving players much-needed supplies and a moment to regroup.

In Control sequence 2.2, resource rooms are strategically placed between challenging combat encounters and connected by complex paths, ensuring that players are well-equipped for ongoing challenges.

- Spatial Sentence:

$({}_{E}C\ {}_{D1}C\ {}_{E}C\ {}_{A3}C) \ {}^{t6}{}_{custom}R^{z2} \ ({}_{A3}C\ {}_{A1}C\ {}_{B1}C) \ [\ {}^{t1}{}_{B2}R^{z0}\ ] \ {}^{t1}{}_{B2}R^{z0} \ {}^{t8}{}_{custom}R^{z2} \ M$

- Contextual Sentence:

Cn R_{combat} Cn [$R_{resource}$] $R_{resource}$ R_{boss} M

Narrative rooms ($R_{narrative}$) play a crucial role in advancing the game's story, often positioned between combat encounters to deepen the plot and a break for players.

These rooms are connected by both simple and complex connections, creating a varied spatial experience that balances action with storytelling. Narrative rooms are frequently interspersed with combat and resource rooms, enriching the player's understanding of the game world and its characters.

Gears of War 4, sequence 4, highlights the integration of narrative rooms within the gameplay, connected by complex corridors to maintain a balanced game pace.

- Spatial Sentence:

  $M \quad ({}_{E}C\ {}_{E}C\ {}_{C}C\ {}_{A3}C\ {}_{D1}C\ {}_{E}C\ {}_{B1}C) \quad {}^{t2}{}_{A3}R^{z0} \quad {}^{t1}{}_{B1}R^{z0} \quad {}^{t2}{}_{B2}R^{z0} \quad ({}_{D1}C\ {}_{C}C) \quad {}^{t2}{}_{B2}R^{z0,n} \quad {}_{E}C \quad {}^{t1}{}_{A3}R^{z0} \quad ({}_{C}C\ {}_{A1}C) \quad {}^{t4}{}_{D}R^{z0,n} \quad {}_{D2}C \quad {}^{t4}{}_{D}R^{z0} \quad {}_{C}S \quad M$

- Contextual Sentence:

  $M \quad Cn \quad R_{combat} \quad R_{narrative} \quad R_{combat} \quad Cn \quad R_{combat} \quad C \quad R_{resource} \quad Cn \quad R_{combat} \quad C \quad R_{narrative} \quad C \quad M$

Tutorial rooms ($R_{tutorial}$) are observed mostly placed at the beginning of the game or new sections to introduce players to mechanics and controls. They are connected by simple corridors or complex connections to ease the player into the game’s environment. The presence of tutorial rooms in the analyzed games ensures that players are well-prepared for the challenges ahead, often transitioning smoothly into more complex gameplay sequences. In Tom Clancy’s Splinter Cell sequence 1, tutorial rooms are connected by corridors, gradually introducing players to game mechanics before moving into cinematic sequences.

- Spatial Sentence:

  ${}_{D1}C \quad {}^{t2}{}_{B3}R^{z0} \quad {}_{E}C \quad {}^{t2}{}_{B2}R^{z0} \quad M$

- Contextual Sentence:

  $C \quad R_{tutorial} \quad C \quad R_{tutorial} \quad M$

4.5 Findings and Outcomes

In this section, we discuss the findings on the level progression in the analyzed third-person shooter video games, focusing on how spatial design patterns influence player experience, and gameplay.

The findings reveal that, despite diverse environmental settings such as interior rooms, exterior courtyards, training areas, and open landscapes, the analyzed games exhibit enclosed boundaries and layouts, categorizing them as "rooms." These rooms are classified based on their content, including narrative, quest, combat, puzzle, resource, and tutorial elements, as well as their spatial layouts, which include square, rectangle, semicircle, L-shape, and circle configurations. Each room type is further detailed by its player movement patterns, such as Z-shaped, L-shaped, I-shaped, embedded, and U-shaped circulations.

Significant patterns emerged regarding the relationship between room layouts and their functions. For instance, tutorial and resource rooms typically feature simpler designs with lower challenge levels to facilitate player learning and resource collection, while combat rooms exhibit more complex spatial designs and higher challenge levels to enhance gameplay dynamics. The study also highlights the importance of verticality in room design, noting that elevated positions often provide tactical advantages in combat scenarios.

Additionally, unique room types, characterized by their customized designs and high challenge levels, were identified. These rooms often feature multi-level structures and adhere to architectural principles such as symmetry, hierarchy, rhythm, and repetition, contributing to player movement guidance and spatial readability. The analysis also underscores the impact of room size and proportion on player experience. Larger rooms evoking a sense of scale and challenge, particularly in boss encounters, while smaller rooms facilitate familiar and comfortable gameplay experiences. Furthermore, aesthetic elements such as color, texture, light, and sound play crucial roles in shaping the atmosphere and emotional impact of game environments. The study observes that designers strategically use color palettes to evoke specific emotions, textures to add depth and realism, and lighting and sound to enhance immersion and guide player attention.

It is observed that connections play a crucial role in level progression and the overall design of the analyzed games. Horizontal and vertical connections, including pathways, ramps, stairs, and elevators, guide player movement. These connections not only link rooms but also contribute to the game's narrative and spatial coherence by incorporating repetitive structural elements such as pipes, and floor tiles, which reinforce the game's architectural rhythm and symmetry. Complex connections, composed of multiple simple connections, often link high-challenge combat areas and provide necessary rest periods, ensuring both gameplay flow and technical performance by optimizing rendering processes.

After analyzing the rooms and connections individually, this study delves into the systematic decoding of level progresssion in the analyzed games, emphasizing the spatial design and content attributes. The analysis reveals that recurrent spatial design rules can be effectively transformed into syntax using BNF notation and standardized grammar.

Decoding gameplay sequences from selected games reveals recurrent patterns and organizational rules, including linear and hub-and-spoke level progression structures, variations in room types, and categorization of connections. Moreover, the analysis underscores the influence of sub-genres on syntactical structures, with action-oriented games emphasizing linear progression for intense combat encounters and horror-themed games employing nonlinear progression to evoke tension.

Recurrent strategic placement of rooms and connections are observed. Resource rooms ($R_{resource}$) positioned strategically after combat sequences offer essential items, ensuring players are prepared before challenges. Narrative rooms ($R_{narrative}$) deepen the plot and provide rest time between combat encounters, contributing to a balanced gameplay experience. Tutorial rooms ($R_{tutorial}$) typically introduce players to game mechanics and controls, placed at the begining of the gameplay progression. Gameplay sequences are mostly divided by cinematics.

The syntactical representation of rooms and connections allows for a flexible framework for analyzing and interpreting gameplay sequences. Simplifying room and connection types into broader categories are aimed to give freedom to designers for constructing diverse gameplay experiences with procedural content generation while maintaining consistency in spatial design.

Significant potential exists for improving procedural content generation (PCG) algorithms with the findings from this study. Through an understanding of the spatial syntax and design patterns in gameplay contexts, PCGs may use the outputs as input to create more varied game environments. By employing pre-existing patterns of room types, PCGs can effectively design a variety of spaces that accommodate various gaming styles, improving the overall experience for players. Additionally, adding a z-axis level design to PCGs opens up new possibilities for gameplay. Based on the player's progress, PCGs can strategically create multi-level rooms that dynamically adjust in terms of complexity and challenge levels. This adaptive approach may support dynamic difficulty adjustment studies, ensuring that the game remains engaging and accessible to players of varying skill levels.

4.6 Discussion and Limitations

Today, creating hyper-realistic game worlds with open-source engines is possible without spending a fortune. While the game industry hires more people every day, indie studios and solo developers are also increasing. Despite many studios achieving hyper-realism in graphics, they often miss key spatial design principles that make games truly captivating. This is evident in how games like Fear and Half-Life remain popular even today, despite being considered old-school.

The study shows that the feeling of a game is not just about visual realism. Architectural principles like proportion, scale, and spatial organization are crucial in creating engaging and memorable experiences. Properly scaled spaces can evoke a range of emotional responses. The patterns and syntax from the analyzed games show how these design principles shape the environment's overall feeling. For example, in "Mass Effect 3" and "Gears of War 4," combat rooms are designed with specific proportions and scales to enhance the gameplay experience. These rooms feature large open areas for movement and cover mechanics, along with vertical elements that add tactical depth. Balancing the size and complexity of these spaces allows designers to create environments that are both challenging and immersive.

Architectural principles such as symmetry, hierarchy, rhythm, and repetition improve the spatial coherence and navigability of game environments. These principles help create a sense of order and predictability, allowing players to understand and navigate the space intuitively. For example, decoded rooms in the analyzed games often follow Frank Ching's architectural principles, emphasizing symmetry and hierarchy to guide player movement.

Navigation is essential for players and the overall game feeling. It involves how players move through spaces and how they find their way in the game world. Effective navigation helps players feel more connected to the environment and enhances their gaming experience. Designers can guide navigation through spaces by using clear pathways, landmarks, and intuitive level layouts. Horizontal connections, like corridors and pathways, guide players between key areas, while vertical connections, such as staircases and elevators, introduce variety and complexity to navigation. Combining these elements ensures players can easily move through the game world and remain engaged.

The patterns and syntax from successful third-person shooter games highlight the importance of these design elements in creating immersive and engaging experiences. By focusing on spatial design principles, level designers can craft game environments that not only look realistic but also feel alive and captivating.

While this study offers valuable insights into level design, it has several limitations. One major limitation is the focus on a specific genre: third-person shooters. This genre-specific focus means that the findings might not be directly applicable to other types of games, such as role-playing games or platformers. Additionally, the study analyzes a limited number of games, which may not represent the full diversity of spatial design techniques used across the industry.

Another limitation is the potential for subjective bias in interpreting spatial design principles and their application to game design. The process of decoding and categorizing game spaces relies on the researcher's interpretation, which may vary between different analysts.

The use of syntax words (rooms and connections) to describe spatial patterns and structures provides a structured way to analyze game environments. However, whether these syntax words can reliably produce the same game sequences when applied in different contexts or by different designers is uncertain. This variability can impact the consistency and generalizability of the study's findings.

5. CONCLUSION AND FUTURE WORK

Within the development of computer graphics, the spatial design of video games has become a crucial design issue, which deserves better understanding and in-depth exploration. In this study, we examined and applied spatial design patterns in third-person shooter video game levels, in order to improve procedural generation algorithmss. By focusing on a select group of highly acclaimed games on the tps genre -Max Payne 3, Mass Effect 3, Gears of War 4, Dead Space, Control, and Tom Clancy's Splinter Cell Conviction- we aim to uncover the design patterns that contribute to their success. Through detailed spatial analysis, we translated 3D game environments into structured layouts and identified recurring patterns in room types, layout configurations, and the impact of aesthetic elements on gameplay experience.

This research is significant for the literature as it bridges the gap between architectural theories and level design, particularly in the realm of 3D spaces, an area often overlooked in existing PCG studies. Our findings contribute to an understanding of how spatial design influences player engagement and immersion. By borrowing from architectural principles, we have provided a framework for interpreting game spaces.

By formalizing a spatial language for PCG algorithms, this research offers a systematic approach to generating diverse and high-quality game environments. This study serves as a guideline for level designers, highlighting how the strategic placement of rooms and connections can enhance player experience and maintain spatial coherence. Moreover, our work demonstrates how PCG can be enhanced by incorporating well-established design patterns, ensuring both quality and variety in procedurally generated content.

As a future work, the next step is to design an algorithm that leverages the outcomes of this analysis. Such an algorithm would take the identified design patterns as inputs, facilitating the creation of procedurally generated levels that adhere to the successful design principles observed in the analyzed games. This algorithm would not only streamline the level design process but also ensure that the generated content maintains a high level of engagement and coherence.

Furthermore, the framework established in this study can be extended to other game genres. By analyzing successful games across different genres, validated by high Metacritic scores, researchers can develop a comprehensive understanding of what makes these games appealing to players. Extracting and implementing these design patterns into PCG algorithms will allow for the creation of diverse and genre-specific game environments that resonate with players' preferences.

In conclusion, by merging architectural insights with level design, we have provided a framework that not only enhances the quality of procedurally generated content but also paves the way for future research in the field. The insights gained from this research have the potential to revolutionize PCG, offering level designers a valuable tool for creating diverse, challenging, and engaging gameplay experiences, adjusting to player.

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- 2021 Spirala Community Home International Architectural Competition Honourable Mention

PUBLICATIONS, PRESENTATIONS AND PATENTS ON THE THESIS:

- **Metin A., Çolakoğlu B.** 2023: Spatial Design Patterns of Third-Person Shooter Games. 2nd International Graduate Research Symposium (IGRS'23), May 16-18, 2023 Istanbul, Turkey.